Solar PV Electrification Programs in Developing Countries:
Towards an Holistic Approach

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This thesis is presented for the degree of Doctor of Philosophy,

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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

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Solar PV Electrification Programs in Developing Countries: Towards an Holistic Approach Abstract

Rural renewable electrification programs are increasingly being used as a means of providing the rural poor in developing countries with access to electricity. Those programs have varied significantly in design and implementation, as well as in their degrees of success. The explanations for the lack of success and the non-sustainability of the earliest programs are widely accepted as these tended to be technical demonstration projects that relied totally on funding from donor organisations or governments. These projects ignored or overlooked the vital question of how ongoing operational, maintenance and replacement costs would be met. Many genuine programs, however, also met with limited success and much effort has been invested in attempting to understand the reasons for this lack of success. To increase the rates of success of these programs, best practice guidelines were developed. Despite these efforts, many programs have continued to meet with limited success. These points required better explanations of the reasons for program success and failure, which requires a greater understanding of these programs.

This thesis looks more closely at solar PV electrification programs being undertaken in the Asia-Pacific region to understand why some programs continue to be more successful than others. It aims to understand the decisions behind the planning and implementation of the programs and the reasons that are being implemented in the way that they are, the selection of program objectives, the actual benefits of the programs the and causes of any factors that contribute to their apparent success or lack of success. This understanding is obtained by undertaking in-depth comprehensive field surveys to obtain the views of all program stakeholders. The outcomes of these field
surveys are then used to develop a comprehensive set of success criteria and a set of indicators that can be used to measure the success of rural renewable electrification programs. A roadmap that could be followed by the program planners and implementers to ensure program success is also provided.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AUSAID</td>
<td>Australian Government Overseas Aid</td>
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<tr>
<td>BAEC</td>
<td>Bangladesh Atomic Energy Commission</td>
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<tr>
<td>BCSIR</td>
<td>Bangladesh Council of Scientific and Industrial Research</td>
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<td>BDT</td>
<td>Bangladeshi Taka</td>
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<td>BIWTA</td>
<td>Bangladesh Inland Water Transport Authority</td>
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<td>BPDB</td>
<td>Bangladesh Power Development Board</td>
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<td>BRAC</td>
<td>Bangladesh Rural Advancement Committee</td>
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<tr>
<td>CFL</td>
<td>Compact Fluorescent Light</td>
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<td>CI</td>
<td>Corrugated Iron</td>
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<td>CMES</td>
<td>Center for Mass Education in Science</td>
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<td>DBP</td>
<td>Development Bank of the Philippines</td>
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<td>DFID</td>
<td>Department for International Development</td>
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<td>ESCO</td>
<td>Energy-Service-Company</td>
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<tr>
<td>FDoE</td>
<td>Fijian Department of Energy</td>
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<td>FEA</td>
<td>Fiji Electricity Authority</td>
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<td>FGD</td>
<td>Focus Group Discussion</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GEF</td>
<td>Global Environment Facilities</td>
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<td>GoB</td>
<td>Government of Bangladesh</td>
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<td>GS</td>
<td>Grameen Shakti</td>
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<td>IDA</td>
<td>International Development Association</td>
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<td>IDCOL</td>
<td>Infrastructure Development Company Limited</td>
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<td>IEA</td>
<td>International Energy Agency</td>
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<tr>
<td>IPP</td>
<td>Independent Power Producers</td>
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<td>IREP</td>
<td>Integrated Rural Energy Program</td>
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<td>JICA</td>
<td>Japan International Cooperation Agency</td>
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<tr>
<td>KiW</td>
<td>Kreditanstalt für Wiederaufbau</td>
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<tr>
<td>kWh</td>
<td>Kilowatt hour</td>
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<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
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<tr>
<td>MEMR</td>
<td>Ministry of Energy and Mineral Resources</td>
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<td>MFIs</td>
<td>Microfinance Institutions</td>
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<td>M&amp;M</td>
<td>Maintenance and Monitoring</td>
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<td>MOA</td>
<td>Market Oriented Approach</td>
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<td>MOU</td>
<td>Memorandum of Understanding</td>
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<td>MW</td>
<td>Megawatt</td>
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<td>NEP</td>
<td>National Energy Policy</td>
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<td>NGO</td>
<td>Non-Government Organization</td>
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<td>O&amp;M</td>
<td>Operation and Maintenance</td>
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<td>PBS</td>
<td>Palli Biddult Samity</td>
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<td>PICHTR</td>
<td>Pacific International Center for High Technology Research</td>
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<td>POs</td>
<td>Partner Organizations</td>
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<tr>
<td>PPP</td>
<td>Public Private Partnership</td>
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<td>PSL</td>
<td>Prakaushali Sangsod Limited</td>
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<td>PV</td>
<td>Photovoltaic</td>
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<td>PVPS</td>
<td>Photovoltaic Power System</td>
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<td>PWD</td>
<td>Public Works Department</td>
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<td>RCF</td>
<td>Revolving Credit Fund</td>
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<td>RE</td>
<td>Renewable Energy</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<td>REB</td>
<td>Rural Electrification Board</td>
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<td>RERC</td>
<td>Renewable Energy Research Centre</td>
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<tr>
<td>REREDP</td>
<td>Rural Electrification and Renewable Energy Development Project</td>
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<tr>
<td>RES Ltd</td>
<td>Renewable Energy System Limited</td>
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<tr>
<td>RESCO</td>
<td>Rural Electrification Service Companies</td>
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<tr>
<td>REU</td>
<td>Rural Electrification Unit</td>
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<tr>
<td>RPGs</td>
<td>Recommended Practice Guidelines</td>
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<tr>
<td>SJCU</td>
<td>Saint Joseph’s Credit Union</td>
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<tr>
<td>SEC</td>
<td>Solar Energy Company</td>
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<tr>
<td>SHS</td>
<td>Solar Home System</td>
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<td>SPGP</td>
<td>Small Power Generation Policy</td>
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<tr>
<td>TCF</td>
<td>Trillion Cubic Feet</td>
</tr>
<tr>
<td>TMSS</td>
<td>Thengamara Mohila Songsad Somity</td>
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<tr>
<td>VAT</td>
<td>Value Added Tax (VAT)</td>
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<tr>
<td>VSSPV</td>
<td>Village Scale Solar Photovoltaic</td>
</tr>
<tr>
<td>WB</td>
<td>World Bank</td>
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<tr>
<td>WBREDA</td>
<td>West Bengal Renewable Energy Development Agency</td>
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Chapter 1

Overview and Background
Chapter 1- Overview and Background

1.1 Introduction

The World Summit on Sustainable Development (WSSD, 2000) explicitly identified having access to electricity as essential for achieving the UN Millennium Development Goal of reducing poverty by 50% in the world’s poorest countries by 2015 (Modi et al., 2006). The multiple benefits that access to electricity brings are now so well known and accepted that it has been said that there is no longer a need to list them seriatim. Among these significant benefits, for example, is the use of electricity to pump water. Improved access to drinking water can improve personal hygiene as well as increase the productivity of women by reducing the amount of time they spend collecting water. This will enable them to undertake more productive and income generating activities (Cecelski, 2000).

The traditional economic view is that providing access to electricity involves a ‘virtuous energy cycle’ that starts with supplying energy to underpin industrial development and commercial activities. This generates wealth, which in turn, stimulates increased demand for more and better energy services that require even larger amounts of electricity (IEA, 2006).

The strongest contribution that access to electricity makes to the Human Development Index, however, is provided by the first kilowatt-hour supplied (EDF, 2002). The greatest benefit per unit of electricity therefore would be achieved by providing small amounts of electricity to the 1.6 billion people in the world that do not have access to electricity (GNESD, 2006). For these people, the traditional economic model for providing access to electricity to alleviate poverty does not apply (Aeck et. al. 2005, p. 17). The critical question, therefore, is what are the options for
providing electricity to those living in rural and remote areas that cannot rely on economic development to bring the electricity to them?

One option would be to extend electricity grids. The cost of doing so, however, is usually prohibitively high (ACE, 2003, Institution of Engineers Australia., 2001, FAO, 2000, Ibrahim et al., 2002). Therefore, supplying access to electricity to those in less densely populated rural areas by using stand-alone household or village scale distributed generation systems (either fossil fuel or renewable energy based) is usually the only practical or realistic option.

For these applications renewable energy systems have several important advantages over fossil fuel generators. They require less maintenance; avoid the risks of high and increasing fuel and transport costs and reduce the risk of environmental pollution. For these and other reasons, small stand-alone household (SHS) or village-scale solar photovoltaic (VSSPV) systems have emerged as one of the preferred electricity options to the rural areas in developing countries (Cabral and Martinot, 2000, Williams, 2005). Recent experiences in China, India and Bangladesh have consolidated the view that for many applications solar PV is the least cost and the most environmentally preferred option for increasing access to electricity for rural households and small enterprises in these rural and remote areas (WB, 2007).

1.2 Rationale of the research

Within the Asia-Pacific region, the number of people that still lack access to electricity remains very large. Although access to electricity statistics is somewhat unreliable, the information that is available makes some interesting suggestions. Despite the fact that 90% of the population in countries such as China, the Marshall Islands and Thailand have access to electricity, less than 40% of the populations in other countries in the region (such as Bangladesh, Cambodia, Myanmar and the
Solomon Islands) are un-electrified (GNESD, 2006). Increasing access to electricity, however, is a common policy objective of the governments of most of these countries. In most cases there is also some level of commitment on the part of these governments to decrease dependence on fossil fuels, particularly imported petroleum products such as kerosene, diesel and petrol, and to increase national reliance on renewable energy.

In many cases, the rural renewable electrification programs that have been implemented in the Asia-Pacific region to date have not managed to keep pace with population growth. Consequently, the number of people in the region without access to electricity has been increasing despite these programs.

These rural renewable electrification programs have also varied significantly in design, implementation and take up rates. Not all of the programs implemented in the region to date have been successful. As a consequence, the scarce resources that are available for this purpose are not being used as effectively as they could be and the number of people being assisted through these programs is lower than it could be. This has a knock-on effect as the degree to which these programs are expanded in the future will depend to a large extent on how effective those programs currently being implemented are perceived to be. Poor results will not help in the fundraising for future programs.

This raises the first and the overarching research question that led to this study; why are some programs more successful than others and how can the less successful programs be changed to make them more successful. While this is the fundamental question motivating this study it is not an original question. This issue represents the fundamental motivation of most of the research effort undertaken in this field to date.
Much of the relatively large body of literature that exists on rural renewable electrification programs consists of conference papers, reports and published articles that ask more or less the same question. Why then does the question need to be repeated? The argument that will be developed in this study attempts to find the answer to this question as neither simple nor straightforward. The number of issues involve are large and the situations in which they are planned and implemented are complex and varying, as does the cultural, social, economic, geographic and political circumstances in which these programs are being delivered. This makes the development of a comprehensive program impossible to produce (IEA PVPS, 2003a). It also means that research on program successes and failures needs to be grounded in specific cultures, politics, institutions and history (Martinot et al., 2002: p. 340). As a result, most of the previous attempts at answering this question have not been based on a complete understanding of these programs or how they are planned, designed and implemented. Furthermore, they have not assessed the benefits and the problems associated with the programs from the perspective of all participants and all stakeholders. Hence, the answers that previous studies have provided have been partial and incomplete.

It is necessary to pause at this point to define what is meant by the terms successful or unsuccessful. For the purposes of this study, the term successful is used to describe a program where the systems are reliable and working and the program results in anticipated benefits and significant increase in number of installed systems over time. A sustainable program, on the other hand, is one that is self-funded or capable of continuing without the continued injection of funding support from government or donor organisations. Program success measures the long-term impacts of the
program, while sustainability refers to the capacity of the program to continue into the future.

The explanations for the lack of success and the non-sustainability of the earliest programs are widely accepted. These tended to be technical demonstrations rather than comprehensive programs undertaken with the intention of being either sustainable or replicable. They were not successful as they relied totally on funding from donor organisations or governments to cover the upfront capital costs of the systems while ignoring or overlooking the vital question of how ongoing operational, maintenance and replacement costs would be met. Many of those projects were considered to be failures due to poor technical performance, poor attention to the needs of users and the local conditions (Martinot et al., 2002). The lack of success and the non-sustainability of those early programs is said to have resulted in disillusionment on the part of international donor organisations. Confidence was lost with renewable energy rural electrification programs in developing countries which resulted in a withdrawal of donor and government funding (AFRODAD, 2007).

Most of those problems, however, have now been recognised and addressed. Attention turned to improving the way in which renewable rural electrification programs were planned and implemented. In the mid-1990s, the World Bank developed a set of best practice guidelines (Cabraal et al., 1996). This was followed in the 2000s by the International Energy Agency’s (IEA) development of a series of Recommended Practice Guidelines (RPGs) (IEA-PVPS 2002a, 2002b, 2003a, 2003b, 2003c). These RPGs, developed through the International Energy Agency’s Photovoltaic Power Systems (PVPS) committee, aimed to increase the deployment of PV systems in developing countries (IEA-PVPS, 2003a). This is especially apparent in the Millennium Development Goals section (Ahm, 2007).
Chapter 1: Overview and Background

The second research question behind this study now becomes evident. Why do some programs continue to fail or experience limited success even though best practice guidelines and recommended practice guidelines have been developed to guide the planning, design and implementation of these programs? The argument that will be put forward in this study is that the adoption of best practice guidelines is a necessary but insufficient condition for program success. It impossible to explain program failure on the basis of best practice or recommended practice guidelines as these guidelines are fairly complex and cover a large number of issues (IEA PVPS, 2003). Best practice guidelines are based on studies that have focused narrowly on barriers to the uptake of renewable energy systems and have not been based on a complete understanding of all of the issues associated with these programs. In addition, they do not take into account the perspectives of all of the participants and stakeholders involved.

Along with the development of Best Practice Guidelines by the World Bank and the Recommended Practice Guidelines by the IEA’s PVPS Committee, there has also been a paradigm shift in the way in which some programs are being designed and implemented. While the old paradigm relied on government or donor subsidies and had a technical orientation, the new paradigm focuses on the development of markets for renewable energy systems and the involvement of the private sector. This includes private financial institutions, the use of micro-credit and a focus on using the SHS primarily to increase income-generation activities (Barua, 2005).

This has added a new layer of complexity to the above research questions and delineates two broad types of programs. It is already apparent that existing literature only provides partial answers to the question of why some programs are more successful than others and why some programs continue to experience only limited
successes despite the development of best practice guidelines. It also raises the question of why programs are planned, designed and implemented on the basis of an old paradigm that has proven only limited success rates and sustainability while others are planned, designed and implemented on basis of this new paradigm. This study will argue that the factors are political and institutional in nature and that a pre-condition of program success is a well coordinated political and institutional framework at the national level.

While the new approach to planning and implementing programs has resulted in some programs now being described as “outstanding achievements”, many other programs are met with more limited success. Up to a third of the PV systems installed through some programs have been reported to be not working within a few years of installation (Nieuwenhout et al., 2004).

Furthermore, it has been claimed that the continued failure of some programs is due to a repetition of the same mistakes that were made in earlier programs (Gunning et al., 2002, ). This has led some field research to conclude that no further studies attempting to explain the reasons behind program failure are needed because the answer is clear; the knowledge and information required to make a program successful is available, but this information and knowledge are not being used (Zahand, 2007). This explanation of the continued failure of some programs has led to the view that further research effort applied in this field should be expended in explaining the reasons for program successes rather than explaining the failures of the less successful programs (Zahand, 2007, Gonelevu, 2006).

This view, however, is an oversimplification as the real situation is more complex. It has been claimed, for instance, that many programs assume that certain benefits will be achieved. While this is perhaps a safe assumption for some benefits, such as the
social benefits obtained from improved lighting, access to TV and radio, the veracity of other claimed benefits are more contentious. A common assumption that underpins many programs, for example, has been that rural households in developing countries buy solar home systems to reduce their energy costs or increase income rather than to improve their quality of life through better quality lighting or increased hours watching TV. This assumption, however, has been called into question (GTZ, 2000). If this is the case, it raises the question of how program success, or lack of success, can or should be measured.

It has also become clear from the research undertaken to date that we still know relatively little about the capacity of SHS and other rural electrification programs in developing countries to raise incomes and to provide other social benefits (Martinot et al, 2002: p. 326). It is also unclear what the primary driver is for those that do participate in such programs whether it is to increase their quality of life or to increase their income or some other driver (GTZ, 2000). These uncertainties make it difficult to either define program success or to explain program failure.

1.3 Research Questions

In summary, three questions guide this research. These are:

i. Why are some programs more successful than others and how can the less successful programs can be changed to make them more successful?

ii. Why do programs continue to fail or experience limited success even though best practice guidelines and recommended practice guidelines have been developed to guide the planning, design and implementation of these programs?
iii. Why do many programs continue to be implemented using the old paradigm approach when it is unlikely to result in program sustainability and/or program success?

1.4 Research aims and objectives

What led to this research was the observation that some rural renewable electrification programs being undertaken in developing countries are more successful than others. These programs and the contexts in which they are designed and implemented are complex and an attempt to gain an understanding of the reasons for this therefore requires an understanding of:

- the program objectives;
- the ways in which the program is planned, designed, implemented and why;
- an understanding of the technology used, and
- the suitability of the program to user needs.

Explaining the differences in the successfulness of programs also requires an understanding of the political and institutional contexts in which programs are implemented and the constraints on program implementers.

Most of all, the understanding of the above issues needs to be from the perspective of all program stakeholders, including program implementers, donor organisations, the users or potential users, and the small business community. The primary objective of the study is to use such an understanding of the reasons that lie behind program success or lack of success and from that understanding, to develop a set of criteria to measure the success of rural renewable electrification programs in terms of program
planning, design, implementation and impact. The intent of the thesis is to develop this set of criteria, and a corresponding set of program success indicators, that can be used to assist in making programs more successful and sustainable. Developing this set of criteria requires identifying the factors that appear to be critical in determining whether a program will be successful or not and understanding which of these factors appear to be commonly neglected. The comprehensive set of success criteria and a set of indicators are then used as a road map that needs to be followed to ensure program success.

1.5 Research boundaries

In order to make the study manageable, it is necessary to confine the study focus to a particular area or region. The study focus selected was rural renewable electrification programs undertaken in the Asia-Pacific region. The reason for selecting this region was the author’s close involvement in the design and implementation of a number of programs in this region. The author’s decade of experience working in this region was instrumental in facilitating the study, especially the field survey components.

Programs that have only recently been implemented were omitted from this study. This is due to the fact most of the problems usually begin to emerge three years after implementation due to the limited lifespan of system batteries. It has therefore been suggested that the minimum period that a program should run before being investigated is five years (Nieuwenhout et al., 2004).

1.6 Structure of the research

To achieve the above aims and objectives, the study is structured in the following way:
Chapter 1: Overview and Background

The preceding sections of this Chapter have been used to outline the background and importance of the research, to explain why the research is needed, to state the aims and objectives of the present thesis and to set the research boundaries.

The following chapter is used to present the methodology used in the study and to describe the tools used to analyse the data obtained through the surveys.

Chapter Three presents the review of the literature on rural renewable energy electrification programs. It is used to describe the delivery approaches and implementation mechanisms used in the solar (photovoltaic) programs in Asia-Pacific region and to identify the benefits ascribed to these programs. In addition, Chapter Three will list and categorise the barriers to the successful implementation of these programs as identified within the literature. It will also discuss in greater depth the development of best practice or recommended practice guidelines and the reasons that a more market oriented approach has been adopted in many programs. From this review a set of check lists was developed which were used as a criteria to measure program success. These criteria were used to develop the email survey questionnaire.

The results of the first survey used in the study, an e-mail survey of program implementers, are then presented in Chapter Four. This survey is used to examine the issues and factors relating to program design and implementation as identified by program implementers. This is used to refine the set of criteria developed to assess renewable based rural electrification programs.

Chapter Five describes and presents results of the first of the two case studies used in this study: the Fijian rural renewable energy electrification program. The field study includes a survey of program implementers, policy makers, service providers and program users. The results are used to discuss the weaknesses and strengths of the
program, the extent to which it can be considered a successful or an unsuccessful program, the primary reasons behind this success or lack of success, and the factors that have constrained its capacity to expand and its long-term sustainability.

Chapter Six describes and provides the results of the survey undertaken as a part of the second case study, the solar PV program in Bangladesh. The approach used in designing and implementing the Bangladeshi program are examined and the program impacts from the perspective of program users are analysed at length.

Chapter seven summerises the major findings from the literature review, the email survey and the two field studies. This information is then used to construct a road map for planning, design, implementation and monitoring of SHS programs, with the road map being adapted to suit the two different types of program.

Chapter eight conclude the research. This chapter discusses the extent to which the research aims and objectives have been met and make some suggestions for further research.
Chapter 2- Research Methodology

2.1 Introduction
The purpose of this chapter is to explain the methodology used in this research in the sense of the ‘logic of the research’ in order for those not connected with the research to be able to understand the research approach and to assess the rigour and the value of the research (Burrell & Morgan, 1979). The term ‘methodology’ is taken to be an 'umbrella' term for the 'collective of concepts’ that together make up the research approach and includes both the research strategy and the research process.

2.2 Steps of the research
The fundamental research question guiding this study is that “Why some rural electrification programs in developing countries using solar photovoltaic systems are more successful than are others”. An exploratory, multi-method approach was adopted to tackle this question. The approaches involved in the research (Fig. 2.1) are discussed in further detail below.

Step 1: Desktop Study
A comprehensive literature review was undertaken on rural and remote area renewable electrification programs in the Asia and the Pacific regions. The literature review was used to obtain background information on degree to which these programs have been successful, the problems or barriers identified to the success of programs, comparison of NGOs/private dealers and donor driven program and the various strategies and approaches that have used to overcome these problems.

It was also used to obtain information relating to the design and implementation of these programs, the financial and other mechanisms that have been employed, the
reason of slow uptake of Renewable Energy (RE) electrification program. The information obtained from the literature review is summarised and presented in Chapter 3. A list of essential or useful requirements for ensuring RE electrification programs success was made from the literature review.

Figure 2.1: Flow chart on Broad Methodology
Step 2: E-mail Survey

Based on the list derived from literature review on program success criteria, a survey questionnaire were prepared for the program organizer to find their views on their program. The email survey were used find the information which were not available in literature like: whether current programs are developed and implemented on the basis of the best practice guidelines, is there any new approaches or mechanism applied in the existing program.

So the e-mail survey of individuals from organisations involved in the implementation of rural renewable energy programs in the Asia and the Pacific regions was undertaken to obtain a preliminary understanding of the issues that program implementers perceive to be important or critical for program success. The following information sought from program implementers through the e-mail survey:

- The objectives of their programs;
- Program target groups;
- The degree to which guidelines/best practice documents were followed prior to program implementation;
- The program implementation mechanisms employed;
- Program outputs achieved;
- Issues perceived to be essential for program success;
- Perceived barriers to program expansion; and
- Factors seen to be favourable to achieving the objectives of the program.

The email survey used both structured and semi-structured survey techniques. A small number of documents providing information on the implementing organisations that
were supplied by the survey participants were also used. The results were analysed using quantitative analysis techniques and were used to develop a set of factors or criteria that appear to form the essential requirements for program success. Indicators were then developed for each of these criteria. The criteria were based on the literature review and socio-economic parameters as shown in the human development index (UNDP, 2007).

**Step 3: Case Studies**

The third step in the research strategy involved the use of two case studies. The case study research method, which has been used extensively across a variety of disciplines but by social scientists in particular, has been defined as an empirical inquiry that investigates a contemporary phenomenon within its real-life context in which the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used (Yin, 1884). The case study method was used in this study to:

- Develop a deeper understanding of the programs;
- Gather information about users’ attitudes towards the systems that had been installed under the program, their monthly expenditure on lighting and the role of service providers;
- Study the social, economic and environmental impacts of the program;
- Measure the outcomes of a program in terms of living standards; and
- Understand the factors that determine the effectiveness of rural renewable energy programs implemented in developing countries.
Chapter 2: Research Methodology

Obtain an insight, based on the views of program implementers, on the policy frameworks and the institutional arrangements within which the programs operate and the issues associated with these, as well as effectiveness of the delivery mechanisms, financial mechanisms and the products and services offered through program implementers

Gain an understanding of the views and opinions of various stakeholders (experts, officials from government ministries, researchers, implementing agencies, internationally funded institutions, etc.) on policy initiatives; and

Obtain the views of program implementers on the factors essential to program success as measured by the achievement of the program’s objectives.

2.3 Selection of Case Studies

The selection of two case studies used for this study was based on the information obtained through the literature review and the e-mail survey. The case studies selected represented extremes in terms of program success as measured by the rate of growth in the number of solar home systems installed through the program over time. Two extreme case studies were chosen due to the capacity for such case studies to be used to explain and illustrate points that can be difficult to demonstrate within a more normal context (Platt, 1988).

The case study selected as the less successful program was the Fijian government’s solar home program. This program was identified as a suitable case study from a recent field survey of users of SHS in Fiji which found this program to have been relatively unsuccessful to date as only 700 systems had installed over the period 2000 to 2007 (Gonelevu, 2006).
That survey, however, did not attempt to obtain information that could be used to explain the reasons behind the slow take-up of SHS through the program or to describe such features as the implementation mechanisms used, the role of rural electrification service companies (RESCO) or the policy framework within which the program is implemented.

The survey area used in this study (Annex 5-I) was selected in consultation with the Fijian Department of Energy (FDoE) and the energy service company that provides the SHS maintenance and monitoring service on behalf of the FDoE. The survey was conducted in only those areas within Fiji that were easily accessible.

The program used as the second case study was the Rural Electrification and Renewable Energy Development programme in Bangladesh implemented by Infrastructure Development Company Limited (IDCOL) and operated through partner organizations (POs). This program was identified through the literature as a relatively successful programme, as the number of SHS installed under the program increased from 5,000 to 150,000 systems over a five-year period.

The survey area within the Bangladeshi SHS program area used in this study was selected purposively (Annex 6-I). The selection was based on the author’s familiarity with the culture, and suggestions from IDCOL and those agencies responsible for administrating renewable energy programmes in Bangladesh.

In both case studies, participants were selected randomly from the selected area. The word "random" has always raised interesting debates between mathematicians and philosophers. Random sampling is the purest form of probability sampling. Each member of the population has an equal and known chance of being selected. When there are very large populations, it is often difficult or impossible to identify every
member of the population. In this case the samples are selected based on the accessibility of the area.

### 2.4 Determination of sample sizes

Using appropriate sample sizes is an important aspect of the survey research methodology. Using samples that are too small results radices confidence in the accuracy of the results, while using samples that are too large wastes resources (time and money). The ‘right’ sample size for a particular application is determined by many factors (Raosoft, 2007), including the following:

- Cost considerations (e.g., maximum budget, desire to minimize cost);
- Administrative concerns (e.g., complexity of the design, research deadlines);
- Minimum acceptable level of precision;
- Confidence level; and
- Variability within the population or subpopulation of interest (e.g., stratum, cluster).

As solar home system users tend to be widely dispersed throughout any particular country, a stratified random sampling method was used. The formulae used to determine the total sample size, \( n \), and margin of error, \( E \), are given by formula 1 (Foster et al., 2006, Raosoft, 2007):

\[
n = \frac{N x}{\left[(N - 1)E^2 + x\right]} \quad \text{.................................................................}(1)
\]

where,

\( n \) is the sample size
N is total population size, and

E is the margin of error and

\[ x = \left[ Z \left( \frac{C}{100} \right) \right]^2 r(100 - r) \] \hspace{1cm} \text{...(2)}

where

r is the response of distribution, and the value of \( Z \left( \frac{C}{100} \right) \) depends on the confidence level and is obtained from the standard statistical tables. The confidence level is the maximum level of uncertainty that can be tolerated. For 95% confidence level the value of \( Z \left( \frac{C}{100} \right) \) is 1.96.

In this survey, the value of r, that would be tolerated, was taken to be 50. The lower margin of error, the larger the sample size required. A 5% margin of error is used for this case.

The target sample size was determined after pilot testing the questionnaire and by considering administrative issues and costs. In Bangladesh as of 31st January 2007, a total of 101,016 systems have been installed under the program. Using Equations 1 and 2, the sample size that was required was calculated to be 383.

For Fiji a total of 650 systems had been installed at the time of survey. Due to time and resource constraints, a 10% margin of error was used to calculate the sample size. Using the above equations, the sample size Fiji was calculated to be 101.


2.5 Qualitative and Quantitative Research

The field research undertaken as a part of the case studies made use of both quantitative and qualitative research techniques. These techniques, and the reasons for using them, are explained below.

2.5.1 Quantitative Research

Quantitative research involves the use of structured questions for which the response options have been predetermined and a large number of respondents are involved. Quantitative research seeks explanatory laws and assumes there to be a static reality. Its aim is to develop universal laws and uses measurements that are statistically valid. It is about numbers and objective, hard data. The minimum sample size for a survey is calculated using statistical formulas to determine how large a sample size will be needed from a given population in order to achieve findings with an acceptable degree of accuracy. Generally, researchers seek sample sizes that yield findings with at least a 95% confidence level (i.e. if the survey is repeated 100 times, the same response should be obtained at least 95 times) and an error margin of +/- 5%. Many surveys are designed to achieve results with smaller margins of error.

Quantitative survey techniques are useful in this study in order to obtain information on households size, income, expenditure, etc., where predetermined responses are appropriate.

2.5.2 Qualitative Research

Qualitative research aims at in-depth description. It is an exploration of what is assumed to be a dynamic reality and does not claim that what is discovered in the process is universal or, therefore, replicable. Qualitative research is subjective and the main methods used to collect information are individual, in-depth interviews and
focus groups (Silverman, 2005). Qualitative research is, by nature, exploratory and open-ended. It tends to involve in-depth interviews with relatively small numbers of people and/or conducting a relatively small number of focus group discussions.

Participants are asked to respond to general questions and the interviewer or group moderator probes and explores the responses to identify and define respondents’ perceptions, opinions and feelings about the topic or about the ideas being discussed and to determine the degree of agreement that exists within the group. The quality of the findings from qualitative research is directly dependent upon the skills, experience and sensitive of the interviewer or group moderator.

Qualitative research techniques are used in this study because many of the explanations and understandings of programs cannot be obtained through quantitative means using predetermined response categories.

In general, qualitative research generates rich, detailed and valid (process) data that contributes to an in-depth understanding of the research context.

2.5.3 Target groups

The target groups used in the case study field surveys were the SHS users ranging in ages from 20 – 65 years in rural communities in which renewable energy projects are being, or have been, implemented. A portion of the householders interviewed (1% of the total sample) was from households that did not have SHS installed. These householders were interviewed to understand the reason why they are not using SHS. It was not logistically possible to interview a particular member of a household, such as the oldest male or the head of the household, as this would have required using either pre-arranged visit schedule or repeated visits. The householder interviewed was therefore the most responsible adult at the house at the time of the visit.
Non-householder program participants interviewed included representatives from the following groups:

- Government agencies with responsibility for energy policy and/or rural renewable electrification programs (e.g. Fiji Department of Energy),
- Local government bodies
- Agencies with responsibility for implementing SHS programs
- Third party service providers, Partner Organizations POs of IDCOL), Renewable energy Services Companies (RESCOs), SOPAC
- Electricity authorities (Bangladesh Power Development Board (BPDB), Rural Electrification Board (REB), Palli Biddut Samity (PBS))
- Fiji Electricity Authority,
- International funding agencies (The World Bank, German technical cooperation (GTZ), UNDP, JICA)

### 2.6 Data Collection and Analysis

#### 2.6.1 Interviews

The primary data collection method employed in the field studies was the interview. Structured interviews were conducted using a survey questionnaire. Notes were also taken during the course of the interviews. Unstructured open-ended interviews, semi-structured interviews and focus group interviews were conducted. All interviews were recorded with the permission of participants and later transcribed.

#### 2.6.1.1 Interview techniques

Interviewing is described by Kahn and Cannell as: "a conversation with a purpose" (Kahn & Cannell 1957, p.149). Marshall and Rossman state that a fundamental
assumption of qualitative research is: "the participant's perspective on the phenomenon of interest should unfold as the participant views it, not as the researcher views it" (Marshall & Rossman 1995, p.80).

The most important aspect of the interviewer's approach concerns conveying an attitude of acceptance - that the participant's information is valuable and useful. Interviewing, however, does have its weaknesses. Cooperation from interviewees may not be forthcoming if they are uncomfortable sharing all that the interviewer hopes to explore, or may be unaware of recurring patterns in their lives. The interviewer needs to have interviewing skills and expertise, including good listening skills, and a familiarity with the local language to ask questions that evoke long narratives from participants (Marshall & Rossman, 1995). The participants can be 'elite' interviewees that are influential or well-informed in respect of a particular area of expertise and are selected for their knowledge or experience. Elite interviewing has the advantage in that these elites are usually more familiar with the legal and financial intricacies of an organization and are more able to report on past policies and future plans from an experienced perspective. The disadvantage main disadvantage is their lack of accessibility due to time constraints or scheduling.

The interviews in this research study were unstructured to permit maximum flexibility in the free flow of dialogue. This enabled participants to express their own views and perceptions to the interviewer.

The levels of knowledge and experience of the respective participants varied considerably therefore, the researcher used experience and discretion in the order or sequence of questions.
Interviews were conducted with the target groups mentioned in section 3.5.3. In case of solar home system (SHS) users, personal (face to face) interviews were used using a semi structured survey questionnaire. Questionnaires and guide question for interview and focus group discussions (FGD) are attached in Annex 2.

Due to the relatively large number (16) of implementing agencies involved in the SHS project in Bangladesh, two FGD were used to interview the members of these agencies to obtain the maximum amount of information.

Those from donor organisations and policy making agencies, the maximum number of persons interviewed were eight. The number in the groups varied as it was determined by the availability of respondents. Personal face to face interviews were undertaken in this group. The information collected from each of the above groups is linked as shown in Figure 2.2 below:

![Figure 2.2: Linkage between the survey groups](image-url)
Chapter 2: Research Methodology

2.6.2 Data Analysis

Data analysis as defined by Huberman & Miles (1994) refers to data reduction, data display, and conclusion drawing and verification. Dey (1993) describes data analysis in a similar way in terms of identifying and linking analytic categories. Dey (1993) breaks it down into three related processes: describing, classifying, and connecting. Under this set of processes, the descriptions of an action, phenomenon or behaviour should be thorough and comprehensive. The data should then be classified in order to give meaning (assigning of data to themes and codes). Finally, the coded data can be analysed in terms of patterns or connections as they emerge. Tesch (1990) points out that there are many types of qualitative data analysis and that on the whole, analysis should be an inductive, data-led activity.

The computer software package SPSS (Version 15) was used for analysing the questionnaire interviews. The NVivo (version 8) software package was used for text analysis. The latter is a qualitative research software package that enables data from word files, spreadsheets or statistical files to be fed in (Richards 1999; Richards 2000) that can then be browsed and edited. In a second data base, the researcher can create ideas, concepts, categories for thinking about the data, and code all the relevant data into nodes. As the researcher develops ideas about the data, data documents or nodes can be linked in many ways. Once the data becomes more complex, the project can be shaped by managing ideas in trees of nodes which can be filtered, changed or examined as shapes develop. Ideas, theories and processes can be modelled and displayed. NVivo encourages the creation of documents as early as possible in the data collection process, coding occurring with the write and editing with the coding. The documents in NVivo can be edited as understanding grows progressively.
A node is the container used in the NVivo software program for categories and coding. Nodes can represent concepts, processes, people, distant ideas, places or any other categories in this project. Qualitative researchers normally link data and ideas in growing webs of understanding. NVivo offers three ways of linking to data outside the project, or between documents and nodes. NVivo is designed to support many modes of coding and to integrate them with other ways of viewing, dissecting, linking and gathering material. The software package enables the revision and refining of coded material to permit a sense and new meaning to emerge from the data. The software also aids comparison on the views expressed on different concepts that emerged from the interview by others and reported in the literature.

2.6.2.1 Transcription
Audio files were transcribed to a word processing file using listening software. Transcripts were produced as soon as the researcher returned from the interviews to facilitate or ensure accuracy of the coding and analysis process. Each interview was labelled with an identifier and each word file was saved as an NVivo source file. Soft copies of interviews were copied onto a CD and kept in a secured location.

2.6.2.2 Documentation
Apart from the audio files, other documents that formed a part of the research evidence, including printed materials on participants’ organizations, These included company brochures, annual reports, policy documents, government reports, statistical and bureau reports. These materials were useful in understanding the background of the implementing agencies and also helped in evaluating program success. These materials were scanned and saved as either an NVivo source or external file.
2.6.2.3 Coding

Coding begun with a transcript selected by the researcher, that encompassed a wide range of issue to emerge from the data.

Stage 1

Each of the interviews was coded under the following categories:

- Current Implementation mechanism
- Financial mechanism
- Social and environmental aspect
- Problem encountered by the program
- Policy and its effect on the program
- Views on the degree of success of the program

Each of the above nodes was described as a category and represented a fundamental class of data. A coding report was generated of each of the broad category to find all comments made by interviewees on each category.

Stage 2

The data in each category was then reviewed and coded to the next level. These nodes were described as ‘concept nodes’. For example, taking the first category node, ‘Current Implementation mechanism’, the concept nodes created under this node were:

- Institutional approach
- System size determination
- Maintenance and monitoring
• Technical performance of the installed system

• Training

These are parent nodes. Each node below a higher node is referred to as a child node.

A total of 6 major criteria were developed and 54 concept nodes were coded out of the whole survey.

Each of the nodes is then run to find the number of respondents that responded on that particular theme and their views. The searching tools in NVivo also allow the researcher to interrogate the result or her data at a particular level. This can, in turn, improve the rigour of the analysis process by validating (or not) some of the researcher’s own impressions of the data.

2.7 Problem Encountered in Field Work

Interviewing households in Fiji using the questionnaire was difficult due to the unfamiliarity of the interviewer with the Fijian language. A translator was therefore used to help facilitate the interviews and to summarise responses to the questionnaire.

Some interviews of representative from implementing agencies and other stakeholder organisations were initially very slow. Careful listening to and prompting of the participant was required to explain the research goals and questions and the importance of some of the questions.

Recorder failure on two occasions required the interviewer to apologise to the participant and for the interview to be restarted.

Scheduling was required to accommodate the busy routines of business people and government agencies.
Chapter 2: Research Methodology

Encouraging all participants in focus group discussions to take a part in the process was required as it was usual for one or two participants to express their views and for others to indicate agreement by nodding. A professional FGD guide was used in the FGDs in Bangladesh and good outcomes were achieved.

2.8 Summary

The research design was based on both qualitative and quantitative processes to evaluate the success of solar electrification programs by collecting information on the implementation mechanisms employed, project viability, social and environmental impacts, and barriers encountered by the implementing agencies. This method required interviewing all stakeholder groups associated with the program. Semi-structured and open-ended questions were developed. Semi-structured questionnaire were used for interviewing system users with to the aim of collecting data on system users’ household energy use, the impact of the system and information on the service offered by the program implementers. Open-ended questions were used to collect data from interviews with representatives from implementing agencies, donors, policy makers, and government organisations with responsibility for rural electrification of energy supply. Interviews between the researcher and participants represented the primary method used to collect data. Focus group discussions were used to interview representatives from policy making and implementation organisations to obtain the views of implementers and policy makers on their programs. The SPSS and NVivo software packages were used to analyse the questionnaires and the transcripts of interviews.
Chapter 3

Success and Sustainability Criteria for the SHS Program
Chapter 3 - Success and Sustainability Criteria for the SHS Program

3.1 Introduction

The conventional approach to electrification is that it occurs as a part of the process of economic development, which has been described as a “virtuous energy cycle”. According to this view, investment in energy supply capacity underpins economic development. The industrial and commercial activities that come as a result create employment and generate wealth. This stimulates the demand for better quality of life and higher standards of living and alleviates poverty. Development requires improved energy services and in urban areas these services are supplied via electricity or gas networks. This results in an increase in the demand for energy, and the further investment in energy supply capacity that further drives economic development, and so on (IEA, 2006). The World Summit on Sustainable Development (WSSD, 2000) effectively adopted this view when it explicitly identified access to electricity services as being essential for achieving the UN Millennium Development Goal of halving poverty by 2015 in the world’s poorest countries (Modi et al., 2006). This traditional approach to electrification, however, does not work in rural or remote areas where electricity grids do not exist. In these areas, access to electricity, and the alleviation of poverty that results from this, needs to be provided through the use of stand-alone electricity generation systems.

For over a decade, solar home systems (SHS) have been promoted by many as the best solution for providing access to electricity in rural areas of developing countries where supplying electricity from the grid is not a practical option (Williams, 2005). More recent experience in China, India and Bangladesh has verified that solar PV has in fact become the least cost and environmentally preferred option for increasing access to electricity for rural households and small enterprises (WB, 2007).
A number of solar rural electricity programs have been implemented to date, but the proportion of the total populations of those living in rural and remote areas that have been provided with access to electricity through this means has been relatively low and the number of SHS installed has not kept pace with population growth. Current programs therefore urgently need to be expanded and new programs need to be initiated (MNES, 2005). Many governments and policy makers, however, continue to lack confidence in the ability of SHS to provide reliable and affordable electricity. Although information on the successfulness of programs is often difficult to obtain, what evidence does exist suggests that many of the SHS programs undertaken to date have indeed met with limited success (Martinot, 2003). Improving the effectiveness of these programs will therefore be important for obtaining increased support for future programs (Goldblatt, 2005). Finding ways to achieve greater success of programs, however, requires a better understanding of the factors that contribute to the success of some programs and those factors that contribute to a relative lack of success of other programs. This is the sort of information that will be needed to inform the development and implementation of future programs.

Many studies and surveys have been undertaken to identify barriers to the widespread take-up of renewable energy systems and this information has been used to develop best practice guidelines for the implementation of programs (Beck and Martinot, 2004, Martinot, 2003). The limited success of many current programs, despite the development of these best practice guidelines, begs the question of the reasons for this continued lack of success of some program. One possible answer to this question is that these guidelines are incomplete and have not been developed on the basis of all of the important issues or factors that need to be considered in project planning, design and implementation (Martinot et.al., 2002, RERIC, 2005b).
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A comprehensive review of the literature on the renewable energy electrification programs undertaken in the Asia-Pacific region was used as the first step in identifying the issues that need to be considered in the implementation of solar PV electrification projects. The literature review included both published papers and unpublished reports. This chapter contains a summary of the results of the literature review and provides background information on SHS programs currently being implemented in the Asia-Pacific region. It showed the apparent or claimed benefits that SHS offer and the different types of delivery approaches and financial mechanisms used in implementing these solar programs. The main barriers that have been identified in implementing these programs are discussed as are the issues or factors that appear to be related to the success of solar electrification programs. From this information, an initial set of success criteria is developed and presented at the end of the chapter.

3.2 Status of electrification in Asia-Pacific region

Per capita consumption of electricity in developing countries varies enormously, both from country to country (Table 3.1) and within countries. More than two-thirds of the world’s population that does not have access to electricity is concentrated in 12 countries, 50% of which are in South and Southeast Asia. India alone accounts for more than 35% of the world’s population without access electricity, followed by Bangladesh with another 6.39% (GNESD, 2006, GNESD, 2004).

The IEA estimates that an investment of more than US$5.2 trillion will be needed to meet the projected combined demand for electricity in 2030 in all developing countries. Even if this huge investment is made, the total number of people in the world without access to electricity in 2030 will exceed 1.5 billion (IEA, 2003b). To reduce this figure below 1 billion, another US$202 billion in investment in electricity supply capacity will be necessary (GNESD, 2006).
Table 3.1: Countries with largest numbers of people without access to electricity in 2000 and per capita electricity consumption

<table>
<thead>
<tr>
<th>Country</th>
<th>Per capita electricity consumption (kWh)</th>
<th>Population without access to electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of the world</td>
<td>Million</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>102</td>
<td>6.39</td>
</tr>
<tr>
<td>DPR of Korea</td>
<td>1288</td>
<td>1.09</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>24</td>
<td>3.75</td>
</tr>
<tr>
<td>India</td>
<td>393</td>
<td>35.44</td>
</tr>
<tr>
<td>Indonesia</td>
<td>390</td>
<td>6.00</td>
</tr>
<tr>
<td>Kenya</td>
<td>107</td>
<td>1.70</td>
</tr>
<tr>
<td>Myanmar</td>
<td>74</td>
<td>2.77</td>
</tr>
<tr>
<td>Mozambique</td>
<td>47</td>
<td>1.00</td>
</tr>
<tr>
<td>Nepal</td>
<td>61</td>
<td>1.19</td>
</tr>
<tr>
<td>Nigeria</td>
<td>85</td>
<td>4.66</td>
</tr>
<tr>
<td>Pakistan</td>
<td>374</td>
<td>3.98</td>
</tr>
<tr>
<td>Tanzania</td>
<td>55</td>
<td>1.85</td>
</tr>
<tr>
<td>World Total</td>
<td>2343</td>
<td>100</td>
</tr>
</tbody>
</table>


The figures shown in Table 3.1 above, however, are unreliable and most likely significantly understate the actual proportions of the populations within these countries that do not have access to electricity as villages are often classified as being electrified even if the only building connected to the grid is a single government building (GNESD, 2004).

3.2.1 Access to Electricity in the Asia-Pacific Region

Of the 2.4 billion people in the world without access to electricity, more than two-thirds are located in 12 countries, 50% of which are located within the South Asian and Southeast Asian regions (IEA, 2004). India (35%) and Bangladesh (6.4%) together account for over 40% of the world’s population that does not yet have access to electricity (IEA, 2006). Across these regions as a whole, the average fraction of the population without access to electricity is approximately 40%. But the proportion of the population without access to electricity varies significantly between countries in the region. In countries like China, the Marshall islands and Thailand almost 90% of the population has access to electricity, while in Bhutan, Cambodia Myanmar, and the
Solomon Islands, less than 20% of the population has access to electricity (GNESD, 2004) as shown in Table 3.2.

Table 3.2: Access to electricity in Asia and the Pacific

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Level of Electrification (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>Bangladesh</td>
<td>32.5</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Nepal</td>
<td>15.4</td>
</tr>
<tr>
<td></td>
<td>Pakistan</td>
<td>52.9</td>
</tr>
<tr>
<td></td>
<td>Sri Lanka</td>
<td>62</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>Cambodia</td>
<td>15.8</td>
</tr>
<tr>
<td></td>
<td>Indonesia</td>
<td>53.4</td>
</tr>
<tr>
<td></td>
<td>Laos</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Malaysia</td>
<td>96.9</td>
</tr>
<tr>
<td></td>
<td>Myanmar</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>87.4</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>82.1</td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td>75.8</td>
</tr>
<tr>
<td>East Asia</td>
<td>China</td>
<td>98.6</td>
</tr>
<tr>
<td>Pacific</td>
<td>Fiji</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Kiribati</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Marshall Island</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Micronesia</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Papua New Guinea</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Samoa</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Solomon Islands</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Timor-Leste</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Tonga</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Vanuatu</td>
<td>26</td>
</tr>
</tbody>
</table>


In many rural and remote areas within the region, populations are dispersed and population densities are relatively low. In many cases, rural communities are separated by relatively large distances. It is therefore not possible to achieve economies of scale in local electricity generation, while connection to the grid is usually prohibitively costly. As a result, approximately 70% of those living in remote and rural areas in the region still lack access to electricity. In the case of the Pacific Island countries, furthermore, although they often have an abundance of renewable energy resources, most remain almost completely dependent on imported fossil fuels to meet their energy needs. Rising oil prices and growing trade deficits make this situation unsustainable. The
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statistics on the proportion of the populations that are supplied from stand alone systems as opposed to those that are supplied from the grid is even more limited here.

3.3 Status of Solar Electrification Program Asia-Pacific Countries

Providing access to electricity is a common national policy objective of most governments in the Asia-Pacific region, including increasing access to electricity for rural and remote populations, and most governments also have also made a commitment to increasing reliance on renewable energy (Marinot, 2003). These policies have translated into rural electrification programs using renewable energy in most countries. In the case of Bangladesh, although no renewable energy policy has been adopted, a “Draft Renewable Energy Policy” was prepared by the Power Cell of the Ministry of Power, Energy and Mineral Resources (MEMR) (Miyan et.al., 2005, LGED, 2006) and submitted to government in 2002. The draft policy is yet to be approved by the Government. Such a policy is required in order to foster the development of a range of renewable energy technologies. Despite the lack of policy, the solar home program in Bangladesh is often cited as a highly successful example of a market-oriented program (Cabraal et.al., 1996, Cabraal et.al., 1998, Urmee, 1999, Barton, 2001, Martinot et.al., 2001, Scheutzlich et.al., 2002, Martinot, 2003, Barua, 2005, Hossain and M. Tamim, 2006, GS, 2008, IDCOL, 2008, MARCEL, 2008). The total number of systems installed under the program to September 2008 was 240,381 (IDCOL, 2008).

Globally, over 270,000 solar home systems were installed in 2005, taking the world total number of systems installed at the time to around 2.4 million. This includes over 120,000 added in China (where a World Bank/GEF project had cumulatively installed 350,000 systems by 2005); more than 90,000 added in Thailand; more than 20,000 each added in India, Sri Lanka, and Bangladesh; and smaller numbers added in other countries. The limited information available on solar programs suggests that on average,
approximately 1% of households in developing countries that have access to electricity are supplied with solar home power systems (Nieuwenhout et al., 2001). This appears to be accurate for Bangladesh, while the proportion of households that use solar home systems is lower in countries such as India (0.06%) and Nepal (0.05%) (Nieuwenhout et al., 2001, WB., 2005, LGED, 2006).

In the case of China, under the China Township Electrification Program, which ended in 2005, solar PV, small hydro, and a small number of wind power systems were installed to supply electricity to approximately 200,000 rural households (approximately 1.3 million people). In 2006, China began planning its next program that aimed to electrify 10,000 villages and 3.5 million rural households by 2010 using renewable energy systems, including small hydro systems and up to 270 MW of solar PV (NREL, 2004).

The main renewable energy technologies used in Fiji are hydro-electric systems (4 kW to 80 MW capacity), biomass (from household scale up to 3 MW capacity industrial boilers), small wind (less than 100 kW), solar PV (less than 10 kW), biogas (individual farm demonstration units), and biofuel (small pilot projects) (Wade et al., 2005). The rural electrification programs based on solar PV systems were first implemented in the villages of Namara (Kadavu) and Vatulele (Koro), using 30-40 PV systems. Households paid F$25 upfront and $3-4 per month. A private company, the Renewable Energy Service Company (RESCO), was used to install and maintain the systems. The project in the village of Koro failed after the volunteer manager resigned. By mid-2004, nearly 400 solar PV systems had been installed under the program, producing in total about 40 MWh/year. This number had increased to 550 systems by August 2007 and the target was to install 700 systems by the end of 2007 (DoEF, 2007). It has been reported that the solar systems are considered by householders to be reliable, convenient and economically competitive with traditional energy sources such as kerosene, dry cell
batteries, and benzine. Although householders have been reported as being able and willing to pay for these systems, the program has not expanded significantly and the main reasons for this have been attributed to a lack of maintenance and monitoring, which in turn have been ascribed to insufficient program funding. No maintenance company was contracted to provide maintenance services for the 18 month period from January 2005 to July 2007 (Gonelevu, 2006).

Under India’s Integrated Rural Energy Program (IREP), renewable energy systems is 250 remote villages in seven states were electrified using renewable energy systems during 2005, while other projects were under implementation in over 800 villages and 700 hamlets in another 13 states and federal territories. The total number of solar home lighting systems installed was increased to 340,000, the number of solar lanterns 540,000, and the number of solar water pumps to 7,000 (MINES, 2007). Some of the programs, such as the solar program in Sagar Island, indicated that the main factors contributing to the success of the program were the harmonious tariff collection system used, the high level of community management, the resources provided to support the program, the competence of program implementers and the assertiveness of the West Bengal Renewable Energy Development Agency (WBREDA) (Shrank, 2008).

In Nepal, the National Planning Commission has recognised the important role that renewable energy technologies need to play in meeting the needs of rural people. The 10th Five Year Plan set a target of installing 52,000 solar PV home systems, 200,000 biogas plants, building 10 MW of pico and micro hydro plant to supply remote villages, and providing 250,000 improved cooking stoves throughout 45 districts (CRT, 2005). Under a separate policy, the Nepalese government is committed to subsidising an extensive uptake of renewable energy systems in rural and remote areas (CRT, 2005). The subsidies for solar PV systems is capped at 50% of the total cost of Solar Home
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Systems (SHS) and at 75% of the cost of community systems (Jivscate and Buakhiew, 2003).

In the Philippines, about 130 PV-powered drinking water systems and 120 telecommunications systems have been installed, with an average installed output capacity of about 1 kW per system. A 28 kW solar PV village power plant capable of providing electricity to 200 households has also been commissioned by the Philippines government. The Development Bank of the Philippines (DBP) used the BELSOLAR project to test a credit facility for development lending projects [Mendoza, 1996]. The implementing agency is a church-based co-operative, Saint Joseph’s Credit Union (SJCU), which was created to finance farm development projects for Belance-farmers. A steering committee oversees the project and a Project Manager appointed by SJCU manages the day-to-day operations. Only one type of system is offered through the program, which comprises 3 lamps, a battery, indoor cabling and switches. These are bought by the customer, while the PV panel, support frame, outdoor cabling, and battery control unit are financed by the project. Loans are available for only those installations that meet approved standards. In order achieve high recovery rates, the panels are removed if instalment payments are not made, which means that the householder has to take the battery to a recharging station to be recharged in order to continue to operate the lamps (Nieuwenhout et. al, 2000). The responsibilities of the end-users are spelled out in a contract and the maintenance service includes a standard service cost per visit. Servicemen are instructed by the SJCU to inspect the systems from time to time until the systems are completely owned by the end-user. It has been reported that none of the 100 systems was operational in 2000 (Mendoza, 2000) and from this it was concluded that the Rural Electric Co-operatives are not necessarily the suitable or appropriate implementation mechanisms for PV based electrification in the more remote areas. This led to a decision to try a different approach and, in the SHS program implemented in
Palawan, the systems were owned by the local government unit (Nieuwenhout et al., 2000).

The rural electrification program in Thailand is based on supporting the installation of solar home systems and aimed to provide access to electricity for 200,000 households by 2006 (Jivscate and Buakhiew, 2003).

In Sri Lanka, decentralised energy planning is at present non-existent as the energy authority has a strong commercial and a national focus, while provincial energy ministries do not have a mandate to consider alternatives to grid extension as a means of rural electrification (Martinot et al., 2000). During 2005, 900 households were provided with electricity from small hydro-electric systems and 20,000 from solar PV systems (IDEA, 2006). Solar PV programs in Sri Lanka are implemented mostly by rural organizations, such as rural cooperatives, or by grassroots NGOs, government agencies or private firms. These organizations offer access to credit, supply products and provide maintenance and support services. Credit shortages have been identified as a major constraint on increasing the uptake of solar PV systems in most programs. Where available, the loans carry high interest rates and/or short repayment periods, which limit the affordability of the systems. While government-sponsored programs offer subsidized credit, the funds made available for those programs are limited and cost recovery has been poor (Cabraal et al., 1996). Most of the programs have incorporated training and maintenance support components, but these are reported to have suffered from a number of weaknesses, including poor program design, defective components and irregular maintenance due to the limited number of systems installed, which have contributed to significant failure rates for the systems that were installed early in the program.
3.4 Identifying and Quantifying the Benefits and Impacts of Solar PV

Measuring the benefits of a SHS program is not straightforward. The costs and benefits of solar PV programs are sometimes assessed on a relative basis, that is, by comparing the situation where SHS have been installed with the situation that would prevail in absence of the project (ESMAP, 2002b). The benefits and costs of a project are measured by the difference between the two situations.

The World Bank’s (WB) previous estimates of the benefits of development programs relied heavily on demonstrated expenditures and cost savings calculated by using relative energy prices and associated outlays for the same level of energy service. This approach, however, cannot be applied to a solar program. The tariff charged is also used sometimes as a measure of the unit benefit of rural electrification programs. The use of tariff as a measure of program benefits, however, is misleading if the tariff is subsidized, in which case social benefits would depend arbitrarily on the degree of subsidization. The monetary benefits associated with an electricity project may also include reductions in expenditure on other forms of energy, such as kerosene. The monetary costs would also need to include all the costs associated with designing, installing, operating and maintaining the electricity project.

Furthermore, in most cases renewable energy electricity projects generate non-monetary costs and benefits that often make important contributions to the broader economic viability of a project. Ideally, these would need to be considered when conducting an economic analysis. A solar electrification project, for example, may result in reduced carbon dioxide emissions if the use of the solar systems displaces fossil fuel-based forms of energy. Several economic valuation techniques can be used to measure and quantify the economic value of non-market costs and benefits.
Energy services, such as lighting and household appliances, rather than energy per se yield benefits to energy users (ESMAP, 2002b). The types of benefits that these energy services provide are illustrated in Figure 3.1. For solar electricity programs, the benefits fall under the following categories:

**Improved Lighting:** This may be in terms of either better quality of lighting or greater reliability of lighting. For example, in the case of kerosene lamps, if the fuel is not available, the lamps cannot be operated.

**Education:** Improved quality of lighting enables children to study for longer hours, which may lead to long-term improved educational outcomes.

**Health:** Improved health may result from improved hygiene as a consequence of being able to store food safely for longer periods or in reduced indoor air pollution levels.

**Entertainment and Communication:** Electricity enables householders to use a range of entertainment equipment, such as radios, TVs, video players and mobile phones.

Figure 3.1: Benefits of Electricity

Source: (ESMAP, 2002b)
Improved Productivity Levels: Household members may be able to engage in productive activities for more hours each day (e.g. weaving handicrafts) as a result of better quality lighting or to saving time on domestic chores as a result of electrical appliance use.

Increased Savings: If the cost of the electricity produced from the solar system is lower than the cost of the alternative, such as kerosene and dry cell batteries, the solar systems can result in reduced household expenditure on energy.

Safety: Solar systems result in reduced fire risks associated with the use of kerosene lamps and fuel wood.

In order to assess how successful a program is, it needs to be based on an assessment of the impacts of the program on users from their perspective as well as the perspective of program designers and implementers. In this study, the following parameters are used to assess program outputs.

- Better quality of lighting or increased reliability of lighting
- More time for study
- Reduction in indoor pollution levels
- Communication and entertainment is accessible
- Productive use of energy
- Improved safety as a result of the reduced risk from fires
- Reduced expenditure on energy as a result of reduced expenditure on kerosene, candles, dry cell batteries, etc.
3.5 Delivery approaches and Financing Mechanisms of Solar PV Electrification Programs in Asia-Pacific

Several different approaches and delivery mechanisms have been used for the delivery of solar electrification programs in the Asia-Pacific region. These approaches, and the financial mechanisms that have been used, are discussed below.

3.5.1 Delivery approaches

The approach used to deliver a program can have a significant influence on the success of the programs. The two main broad types of approaches used to deliver solar PV rural electrification programs are:

- Donor aid/government funded programs and

- NGO or private sector programs that use a Market Oriented Approach (MOA)

A third type, ‘Public Private Partnership (PPP)’ approach, represents a hybrid between these two broad types of approaches. It has only recently started to be used for RE (Radka, 2005) and is currently used in only one program being implemented in the Asia-Pacific region.

Donor or Government subsidised programs rely on grants from donor organisations, such as the World Bank (WB), Global Environment Facility (GEF), Japan International Cooperation Agency (JICA), Australian Government Overseas Aid (AUSAID), Department for International Development (DFID) (UDDIN and Taplin, 2006). A requirement of donor funding has been that the funding be provided through the government, although this is now changing and NGOs and the private sector are increasingly able to access donor funding. The donor organisation that provides the funding, however, tends to specify the terms and conditions for the use of the funding. These terms and conditions can stipulate, for example, the sizes of the solar home...
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systems to be supplied, the financial mechanism that is to be used, and the target customer groups. Donor-funded programs are often designed to advantage low income groups, as the funding is used to lower the initial cost of the systems.

The success and popularity of this approach, however, has been reduced over time as a result of problems experienced (Liebental et al., 1994), such as a lack of commitment on the part of users to properly maintain their systems and lack of availability of spare parts or necessary maintenance kits (distilled water, replacement bulbs, fuses, etc.) (Nieuwenhout et al., 2001).

Those programs, delivered by either NGOs or by the private sector, on the other hand, rely primarily on their own sources of funding, although this is sometimes supplemented by government funding support. The funding is often obtained using soft (low interest) loans from banks. These programs are based on the market based or commercial approach. The NGOs and private companies have their own distribution infrastructure in the program areas, through which they provide after sales service and collect monthly repayments. Some companies contract local retailers or technicians and this creates new jobs within the local area (Barua, 2005, GNESD, 2006, GNESD, 2004).

These two broad types of programs are compared in Table 3.3 below in terms of demand analysis, equipment, system design, quality control, cost, warranty, and financing. One of the main differences between NGO (or private dealers) and donor funded programs is that the former tend to place a high emphasis on keeping the cost of the equipment down, while the latter place a high emphasis on the quality of the equipment. NGO programs tend also to use system designs based on the needs and the affordability of the systems for the users.
Donor or government funded programs also place a high importance on assessing the performance of the program, while less importance is placed on the costs of the systems. This is because donor organizations subsidise the costs of systems and the tariffs or system prices that the users pay therefore do not reflect the full costs of their systems. Most donor or government funded programs tend to be implemented as pilot programs and rely on imported systems that are very reliable, but which are also costly. An example of this type of program is the e8 funded wind PV hybrid system in Rote Island, Indonesia (e8, 2001). Obtaining replacement parts at the end of component life or when they become faulty can be difficult for these systems.

Table 3.3: Comparison of NGOs/private dealers and Donor driven programs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Market Oriented Program (MOA)</th>
<th>Donor/government aided program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand analysis</td>
<td>Those responsible for implementing the program undertake their own surveys in an area prior to commencement to determine the demand for the solar systems. Users are categorised in terms of their ability to pay.</td>
<td>Donor funded programs use a pre-feasibility study undertaken by the consultants. Based on the consultant reports and on discussions with government authorities, an area of operation is chosen.</td>
</tr>
<tr>
<td>System size and components</td>
<td>Users are offered variety of systems to choose and are able to select a system which suits their needs and affordability. Most of the system components are locally available (in nearest district or town at a minimum)</td>
<td>Not many options are available under this type of program. Users are supplied with a complete systems and appliances. Most of the components under this type of program are imported.</td>
</tr>
<tr>
<td>System design procedure</td>
<td>Most systems are designed by the program implementers. System design is based on rule of thumb rather than the use of software.</td>
<td>Designed by experts. Softwares are used in designing the system.</td>
</tr>
<tr>
<td>Quality control</td>
<td>There is no quality assurance as there is a willingness to compromise on quality in order to minimise system costs.</td>
<td>Quality is not compromised. This increases system costs. Most of the equipment and appliances are imported, making the program less sustainable.</td>
</tr>
<tr>
<td>System and component costs</td>
<td>Both low and high cost equipments are available. Market agents have an interest in selling equipment that represents the best value for money and minimize consumer complaints</td>
<td>System costs are high because only high cost equipment with certified component quality is used. The lack of competition also increases system costs.</td>
</tr>
<tr>
<td>After sales maintenance</td>
<td>Usually undertaken by system owners/users, although sometimes the implementer is responsible for the after sales maintenance</td>
<td>In most cases a dedicated organization with a limited mandate is set up to manage the after sales support. After sales support is not embedded in the program.</td>
</tr>
</tbody>
</table>
### Table 3.3 continued….

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Market Oriented Program</th>
<th>Donor/government aided program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warranty</td>
<td>Normal manufacturer warranties are given on components</td>
<td>Project implementing entity often provides warranties for the performance of the complete system, or sometimes differed to agreed dealers.</td>
</tr>
<tr>
<td>Training of end users</td>
<td>Normally provided by the implementer but it is not mandatory for implementers to do so. Users received a guide book containing DOS and DONTS.</td>
<td>This is a mandatory option for a project. The users receive training and also receive some written documents on how to use their systems.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Monitoring system are not used. If a system is faulty, the users make contact with the supplier and the supplier takes action.</td>
<td>Most projects have monitoring systems built in with the program as a component of the program.</td>
</tr>
<tr>
<td>Impact analysis</td>
<td>The impacts of project are not relevant to implementers as they do not receive any benefits themselves.</td>
<td>The impacts are an important issue for donor driven projects. Implementers are required to demonstrate the impact of the program and justify the donor investment.</td>
</tr>
<tr>
<td>Environmental impact analysis</td>
<td>Neither private dealers nor NGO undertake analyses before or after the program is undertaken.</td>
<td>Donors are provided with an impact report.</td>
</tr>
<tr>
<td>Technical institutional capacity</td>
<td>An extensive decentralised network of retailers, installer and technician exists, which is adapted to providing the low cost solution that people require. The larger the market, the greater the network and service provided.</td>
<td>Needs to be created; high end system require trained technicians as this technical capacity do not normally exist. Importers of equipment often create this capacity within their main offices.</td>
</tr>
<tr>
<td>Government Policy</td>
<td>In general government policy neither recognizes the usefulness of the actors nor the equipment that is being promoted. Levies or other duties are often levied on equipment and services.</td>
<td>Governments often provide exemptions on duties and taxes on imported equipment and services. Governments may also provide other financial assistance for project actors.</td>
</tr>
</tbody>
</table>

**Sources:** (Martinot and Reiche, 2000, Nieuwenhout et al., 2001, Srinivasan, 2005)

In the MOA approach, dealers purchase the systems or components from manufacturers and sell them directly to households, usually as installed systems. They are sometimes sold using credit. The householder owns, and is responsible for servicing, the system, although the dealer may provide service contracts or guarantees. The MOA approach is currently being employed in several countries, including Bangladesh, China, Indonesia, India, Sri Lanka and Vietnam (Marinot et al., 2001).

#### 3.5.2 Financing mechanisms

The high upfront cost of solar home systems is regarded by many to be the most significant or important barrier to renewable energy electrification programs. The use of
appropriate financing mechanisms is therefore regarded as being critical to program success (Vleuten et al., 2006). Four types of financing mechanism have been used in rural renewable electrification programs (Marinot, 2003, Nieuwenhout et al., 2001, RERIC, 2005b, Scheutzlich et al., 2002):

- a fee-for-service
- cash sales
- direct subsidies and
- consumer credit sales (hire purchase)

3.5.2.1 Fee-for-service
Under the fee-for-service mechanism, the renewable energy system is installed and owned by an energy-service-company (ESCO) (Anisuzzaman and Urmee, 2006). The ESCO, which can be an electric utility, a cooperative, a non-governmental organization or a private company, buys the PV systems in bulk, installs them and retains both ownership of the systems and the responsibility for maintaining and servicing the systems. Householders are charged a fixed monthly fee. This model represents the most affordable payment scheme and is capable of being used to achieve a larger program customer base than other types of credit delivery schemes (ESMAP, 2002a).

The ESCO is sometimes granted a monopoly concession to offer an exclusive services to those in a prescribed geographic area (as occurs in the cases of Argentina, Benin and Togo) or may compete with other ESCOs (as occurs in the cases of the Dominican Republic and India) (SELCO, 2006, Karekez and Kithyoma, 2002).

There are many variations of the fee-for-service model. In Sri Lanka, for example, private dealers and non-governmental organizations (NGOs) borrow from commercial financiers that are participants in the project (Cabral, 1996). In China, the World Bank
funded project provides funding to dealers with the aim of improving system quality (through cost-sharing of design, testing and certification), product marketing and after-sales services. The overall feedback from the projects that have used the ESCO model, such as the SELCO project in India, appears to be positive (SELCO, 2006).

In Kiribati, the Solar Energy Company (SEC) successfully converted its operations from supplying solar home systems for cash to providing electricity to rural customers. It has offices in local areas (districts) and offers a range of sizes of solar system (50 to 125 Wp), and the installed systems are serviced by SEC technicians. System users pay an installation fee of AUS$50 and a monthly fee of AUS$9-15, depending on system size. The monthly fees covers the actual cost of operation in the field and also includes battery replacement and system maintenance (Nieuwenhout et al., 2001). The cost of the maintenance is therefore included in the monthly fee paid by users. A recent survey, however, indicated that users are not happy paying the monthly fee because a significant proportion of installed systems were not working (Mala et al., 2007).

The PV-based, micro utility system used in rural Bangladesh is also a type of fee-for-service model. This approach, pioneered by the Center for Mass Education in Science (CMES), involves the installation of systems by PV companies in market places. Interested shop owners are offered connection and pay a monthly fee based on a monthly charge of US$2.50 per month per light. The system remains the property of the installing company and the service and maintenance is undertaken by local technicians who are provided with training prior to their appointment (Ibrahim et al., 2002). The technicians also collect the payments from the shop owners. One problem with this approach is the risk that the users will not take good care of the systems as they are not the owners of the systems. In order to reduce this risk, a security deposit of US$3 is charged before connection is provided and the CMES reserves the right to forfeit the
deposit if the agreement is violated. The CMES uses a management committee, comprising people from the local market, that is responsible for managing the security (theft or damage) of the systems (RERIC, 2005a). A second problem with this approach is the tendency for users to operate the systems for longer than the prescribed periods, which causes damage to the batteries.

The fee-for-service model provides the greatest affordability of systems and is designed to achieve a larger program customer base. The monthly fees cover the actual operation cost in the field and in some programs this also includes battery replacement and system maintenance. The main disadvantage of the program is the limited funding that is available. Since the capital cost of the systems is not incorporated in the fees, it is difficult to increase the program size. Secondly, users are not responsible for the system maintenance, and if proper maintenance of systems is not carried out, users quickly become increasingly reluctant to pay the monthly fees.

### 3.5.2.2 Cash sales

Distributors are often reluctant to provide credit to low income household customers themselves as their own cash flows are limited and the costs associated with collecting debts are high (Hankin, 2003). Distributors operating in countries where credit systems have not yet been created therefore tend to supply small (20 – 75 W) inexpensive, solar PV systems that customers are able to purchase for cash. Using this approach limits the sale of PV systems to those wealthier members of rural communities that can afford to purchase systems outright. This represents a serious limitation as, according to Grameen Shakti (GS), only 1% of its customers in Bangladesh use cash to purchase systems and of those using cash, 70% were institutional customers (GS, 2005). The cash sales approach therefore significantly restricts the number of potential customers, the range in participating income groups and the size of the systems installed.
Chapter 3: Success and Sustainability Criteria for the SHS Program

The cash sales approach, however, has been relatively well accepted in a number of Pacific Island countries. In Kiribati, the Solar Energy Company (SEC) started selling PV systems at commercial prices, with installation and technical back-up supported by USAID grants (Liebental et al., 1994). The SEC also provided service on demand for the systems. By 1989, however, the SEC was close to being bankrupted (Nieuwenhout et al., 2001).

A survey undertaken in 1992 revealed that less than 10% of the systems that had been installed were not operating. The main reasons for this high failure rate were reported to be (AEA-ETSU, 1999, Nieuwenhout et al., 2000):

- under-sizing of systems,
- unwillingness of customers to pay for professional installation,
- inability of customers to properly install the systems that they purchased although a good instruction manual was provided, and
- unwillingness of customers to pay the maintenance service fee and the common use of cheap replacements parts to save money

The main advantage of the cash sales system is that it represents an easy financing system with low transaction costs and provides flexibility of choice for customers. Its main disadvantage is that it targets the highest income groups as most rural people cannot afford to pay cash for a solar home system.

3.5.2.3 Direct subsidies

In order to provide the lowest income households with access to small PV home systems, some form of subsidy is required. A number of World Bank funded projects therefore incorporate per-system subsidies in order to make systems more affordable for users by reducing the initial and/or monthly payments that the householders are required
to make. Subsidies are used in various ways in different projects. In Sri Lanka, a microfinance organization provides consumer credit, and the monthly credit repayments are reduced by a share of a US$100 per-system subsidy. Some projects offer fixed grants, while others provide grant amounts that decline for installations made during later years of the project. In China, a fixed cash grant equal to US$1.50/Wp of installed capacity is paid directly to dealers (Martinot, 2003).

Subsidy schemes are designed by program planners and can be applied in ways that reduce their effectiveness (UNEP, 2006). Great care in the use of subsidies is therefore required. The use of subsidies to reduce the costs to users also needs to be combined with the creation a stable and sustainable industry. To cover the operating costs without such a plan grants or subsidies has been found to be dangerous as it can undermine the long-term sustainability of a PV electrification program (Martinot et.al., 2001).

3.5.2.4 Consumer credit sale

One of the important recent advancements in renewable rural electrification programs has been the development of consumer credit. This financing approach has emerged as a reaction to negative experiences with subsidised programs and in recognition of the need for better access to finance (Srinivasan, 2005). This approach was pioneered in Bangladesh in 1996 by Grameen Shakti in order to provide solar systems to low income households in rural areas that did not have collateral. The systems are purchased with a down payment of 15-50% and the outstanding amount repaid in instalments using a 12% interest rate. Grameen Shakti undertook the marketing, sales, service, credit provision, collections, and guarantees. Its credit terms and conditions, however, were different from the traditional Grameen Bank microfinance terms and conditions. Grameen Bank offers small, repeatable micro-enterprise loans, for income-generation purposes only, for terms up to one year, while Grameen Shakti offered larger, once-off
loans for purchasing solar home systems for terms up to three years (Barua, 2005, Barua et al., 2001, GS, 2005, Urmee, 1999). Grameen Shakti continues to use it in Bangladesh and this approach has since been deployed in a large number of successful programs in other places. In Indonesia, for example, in Sudimara village about 7,000 systems were sold over 2.5 years using a 4-year credit period and this high uptake has been attributed to the availability of a credit facility (Millar and Hope, 2000).

Another type of credit approach used in many countries is the Revolving Credit Fund (RCF). The fund is started using seed capital that is used to pay for the initial purchase of a number of systems. This allows a number of families to purchase solar home systems by taking loans from the RCF. The monthly repayments include interest and these repayments replenish the fund, enabling the program to be expanded by offering loans to additional families.

The sale of solar systems using credit has also been used in India since 1996. The level of credit approved is based on the ability to pay and a pre-program survey is used to assess the ability of householders to pay for SHS. Credit financing is provided by stores located in the local area and users make a 25% down payment, with the remainder paid in instalments over 6 to 24 months. The special feature of this mechanism is that members of the public service are able to purchase systems without the need to make any down payment and their repayments are deducted directly from their salaries by the Government Salary Service Bureau. Ownership of the system is transferred to the customer on completion of payment. About 70% of the solar home systems installed in India are reportedly sold through credit (IEA, 2003a).

Programs that use the customer credit approach need to operate as commercially viable businesses. The main advantages of this mechanism are that it provides customers with a strong incentive to look after their system and for program implementers to provide
reliable after sales service. The system costs include the installation and pre-instalment maintenance charges. Once the loan period has expired, users are required to pay local technicians for maintenance (IDEA, 2006, IEA PVPS, 2003 a, Marinot, 2002, Martinot and Reiche, 2000, Nieuwenhout et.al., 2001, Scheutzlich et.al., 2002). Low income households are assisted by offering longer micro-credit loan periods. This type of credit can also reduce the risk to the lender of not recovering the money (Urmee, 2000).

The disadvantages of this mechanism are that PV suppliers are often reluctant to offer credit to rural customers with little credit history and these programs therefore are often not available to the poorer groups. Implementers also sometimes face a risk of not recovering the money that they lend. Longer credit terms assist poorer consumer groups, but increase the risks to the financer. Also, in most of the developing countries in the region, government policies often do not permit implementers the flexibility to develop innovative financing schemes that could potentially make the systems more affordable for customers (Anisuzzaman and Urmee, 2006, Beck and Martinot, 2004, Marinot, 2002).

3.6 Barriers to Solar PV Electrification Program

The focus of much of the published literature on the subject of renewable rural electrification programs in developing countries is on the identification of the barriers to the uptake of renewable energy systems. In general, projects are designed to overcome barriers that have been identified to the accelerated uptake of SHS within a given situation. This has influenced the evolution of the design of SHS projects together with an understanding of what constitutes best practice in program implementation.

The two main barriers to the uptake of renewable systems used in rural electrification cited in the literature are the high upfront costs of the systems and the relatively low income of those living in these areas (Haanyika, 2006, Martinot and Reiche, 2000,
Hatano, 2006, GNESD, 2006). These two barriers are seen to give rise to many other issues and the limited access of households to finance significantly compounds these problems (Haanyika, 2006). These problems require the businesses providing SHS or related services to operate on low profit margins and this requires the ability to adopt flexible business models.

Some of the other barriers that have been found to influence the rate of uptake of renewable energy technologies (RETs) include (Martinot et.al., 2001):

- poor system specification
- poor installation and maintenance,
- lack of awareness of solar home systems in terms of how well they work and how reliable the systems are,
- over dependence of programs on funding from donor organisations.

Donor dependency is regarded by some to be a significant barrier as it can mislead users into assuming that their systems will be replaced with further funding from donor organisations when the need arises. Furthermore, the funding provided from donor organisations is a non-repayable grant and some commentators consider that this does not require adequate accountability from program implementers (Ranganathan, 1992). Inappropriate policy frameworks are also considered by many to represent a barrier to the increased use of renewable energy. Sri Lanka has been cited as a case where an inappropriate policy framework has limited the uptake of SHS (Cabral, 2000).

Yet another major barrier to rural electrification programs in Asia-Pacific regions is a common expectation, realistic or otherwise, that the grid may at some time be extended into the area. Decentralised electricity grids in many developing countries are being gradually extended and this creates an expectation that the grid might one day be
extended into the householder’s area. This expectation acts as a strong deterrent to investment in stand-alone energy systems (Urmee, 2000). Extension of the grid, for political rather than commercial reasons, significantly amplifies this problem. This has occurred for example, in Bangladesh, where solar electrification programs undertaken by the Government through the Rural Electrification Board (REB) in 1996 were subsequently abandoned due to an election commitment by the energy minister to extend the electricity grid into those areas (Urmee, 2000, IDEA, 2006).

Many other barriers to the uptake of PV solar systems are cited within the literature and these are commonly classified into one of three broad categories, which are then classified into subcategories (Beck and Marinot, 2004):

- Economic barriers
  - high initial capital cost of renewable energy technologies
  - common lack of subsidies provided to reduce these capital costs
  - failure to incorporate the risks of higher than projected fossil fuel prices
  - the high transaction costs associated with the purchase of small decentralized system
  - failure to take into account the real economic costs of environmental damage caused by the use of fossil fuels in electricity pricing policies

- Legal and regulatory barriers
  - inadequate legal frameworks to support investment in renewable energy generation systems
  - onerous requirements set by the utilities for the small power producers

- Financial and institutional barriers
  - lack of access to credit for both consumers and investors, and
• lack of sufficient technical, geographical, and/or commercial information for market participants to enable these players to make sound economic decisions

Credit shortages are commonly cited as one of the major constraints to a broader use of PV in most programs. Affordability was limited as loans, when available, carried high interest rates and/or short repayment periods. While government-sponsored programs offered subsidized credit, funds were limited and cost recovery was poor (Cabraal et al., 1998). Economic and policy barriers tend to be regarded in the literature as the most significant barriers (Vega, 2004) and the barriers in these two categories have received the greatest amount of attention in the development of the best practice guidelines.

Based on the information obtained through the literature review, a more comprehensive classification of the barriers to rural renewable energy programs in developing countries was developed for this study (Table 3.4).

Table 3.4: Classification of barriers to solar rural electrification derived from the literature review

<table>
<thead>
<tr>
<th>Category</th>
<th>Example of barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic and financial</td>
<td>High Capital cost</td>
</tr>
<tr>
<td></td>
<td>Lack of financing</td>
</tr>
<tr>
<td></td>
<td>Lack of access of credit for the consumer</td>
</tr>
<tr>
<td></td>
<td>No link with income generation</td>
</tr>
<tr>
<td>Policy, legal and regulatory</td>
<td>Lack of policy and legal framework</td>
</tr>
<tr>
<td></td>
<td>Improper use of subsidies</td>
</tr>
<tr>
<td></td>
<td>Donor dependency</td>
</tr>
<tr>
<td></td>
<td>Unrealistic political commitment</td>
</tr>
<tr>
<td>Institutional</td>
<td>Lack of institutional capacity</td>
</tr>
<tr>
<td></td>
<td>Training on system uses</td>
</tr>
<tr>
<td></td>
<td>Lack of technical knowledge</td>
</tr>
<tr>
<td>Technical</td>
<td>Lack of spare parts</td>
</tr>
<tr>
<td>General</td>
<td>Lack of awareness among the users of the technology</td>
</tr>
</tbody>
</table>

3.7 Solar PV Program Success Factors

The primary cause for lack of program success program or poor project implementation is commonly ascribed in the literature to poor program design. There is a strong view that in order for a PV program to be successful, it needs to be planned carefully. However, it is also commonly accepted that there can never be a blueprint for designing programs. In 2003, the IEA developed a guide for designing or improving a PV program (IEA, 2003). The process of planning a PV program contained in that guide, is broken down into the following phases:

- the preparation or planning phase
- the programme design phase
- the implementation phase and
- the monitoring and evaluation of the programme.

These phases are connected (Fig. 3.2) and the IEA stresses that the planning and design activities need to be done before implementing a PV program.
Many unpublished reports prepared by program implementers and others mention other important issues that need to be considered when designing and implementing renewable energy electrification programs in developing countries. These issues can be separated into those that are important from the perspective of the program implementer and those that are important from the perspective of the users. These have been incorporated into Figure 3.2. The most important from the perspective of the household or consumer are:

- **Suitability** - Whether the systems are designed to meet the real needs of users
• Affordability - If the systems affordable for the users

• Reliability - Quality of the system

• Financing - The availability of appropriate and flexible financing.

### 3.8 Summary and Conclusion

Based on the information obtained from the literature review, the following comprehensive list of the requirements for program success was developed (Table 3.5).

Rural electrification programs have been implemented in most countries in the Asia-Pacific Region using a range of delivery mechanisms and financial mechanisms. Most of these programs, however, are not managing to keep pace with population increases. The degree to which these programs expand in the future will depend to a large extent on how effective those programs currently being implemented are perceived to be. This is a cause for concern as there is some evidence that suggests that many programs are meeting with limited success. In order to ensure that future programs are effective, it will be necessary to understand the reasons behind the success of some programs and the more limited success of others.

Most studies undertaken to date that have aimed at finding ways to improve the effectiveness of programs have focused on identifying barriers to the uptake of renewable rural electrification programs. This research effort has been useful and has led to the development of best practice guidelines for the implementation of projects designed with the intention of addressing the important barriers. Despite the development of best practice guidelines, however, many programs continue to meet with limited success, clearly indicating that the development of these best practice guidelines, on its own, has been insufficient.
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Table 3.5: Comprehensive list of requirements summarises from literature for ensuring the success of renewable energy electrification programs

| Institutional and management skills of program implementers | An appropriate and accessible financing mechanism  
Sufficient revenues to recover program costs  
A reliable revenue collection system  
Market aggregation to increase effectiveness  
Reliance on appropriate technologies to provide the energy needs for customers  
A well designed maintenance and monitoring system |
|----------------------------------------------------------|
| Customers and community participation                     | Effective consumer education and communication programs that promote productive uses  
Involvement of locals committed to customer service |
| Product quality                                           | A recognized quality approval system  
The use of international standards (IEC and PVRS) and the harmonization of national standards  
Adequate component availability  
A warranty system that is honoured |
| Appropriate, timely and low cost maintenance               | Market delivery and maintenance support infrastructure located close to customers  
Established network of technicians in areas where the systems are installed. |
| Productive use of the electricity generated by the solar system | Education for users on how their systems should be used in the most productive ways  
Encouragement of users to utilise their systems to develop small businesses. |
| Supportive government policies                            | A policy framework that supports the objectives of the renewable energy electrification program, for example by reduced taxes on solar home system equipment  
Opportunities for public/private partnerships to participate at every level  
Support by other development activities, such as rural infrastructure development, road network, etc. |

One of the reasons for this appears to be that the literature focuses on barriers and largely ignores many other issues that need to be considered in planning and implementing programs. A comprehensive review of the literature, including unpublished reports, indicates that not only is the number of barriers substantial, but that many other issues are also regarded as having an important impact on the outcomes of programs. The degree to which these issues are considered in the development and implementation will determine the success and the sustainability of those programs.

What is therefore required is a set of criteria that can enable the success of the program to be measured. Also needed is a comprehensive list of issues that can be used as a checklist for program planners and implementers to refer to when developing their programs, in order to assess whether their programs are likely to be successful and sustainable. This study has used an extensive review of the published and unpublished...
literature to develop such a list. This list was used in email and field surveys to further refine it and to test its utility as a mechanism for improving the effectiveness of future program. The refine list of criteria can be used to measure the success of the program and also help implementers to make the program sustainable in future and to suggest changes that can be made to improve current program.
Chapter 4

Success Criteria for SHS Programs-Implementer’s View
Chapter 4 - Success Criteria for SHS Programs –Implementer’s View

4.1 Introduction

Providing and increasing access to electricity are major political and social goals in most developing countries. In areas where it is not feasible to do so by extending the electricity grids, programs based on installing solar PV home systems (SHS) have come to represent a common approach (Williams, 2005). While many such programs have been implemented in developing countries, a significant portion appear to have met with limited success (Cabral and Martinot, 2000, GNESD, 2006, Hankin, 2006, Martinot, 2003). An understanding of why some programs are more successful and others less successful is important as this is needed to inform policy makers, donor organisations and program implementers on how to improve future programs.

Understanding why some programs meet with limited success however, is not straightforward (Beck and Martinot, 2004). Most of the research effort that has attempted to do so has focused on identifying barriers to the take-up of renewable energy systems and this information has been used as input into the development of best practice guidelines for programs. Despite this research effort and the development of these best practice guidelines, however, many programs have continued to experience problems and this suggests that barriers, on their own, do not provide a complete explanation of the reasons for lack of success. The aim of this survey is examine the factors behind program success or lack of success by surveying those involved in the implementation of programs and their views on the reasons for, and the determinants of program success.
This chapter addresses the following questions using the results of the email survey:

- To what extent are current programs failing to be developed and implemented on the basis of the best practice guidelines?

- What are the approaches and mechanisms used in the existing renewable energy projects in remote areas?

A more comprehensive set of criteria that can be applied in the assessment of renewable based electrification programs is developed at the end of the chapter. These criteria were used to develop the questionnaire and guide questions for the detailed field survey and also used to check to what extent the programs met these criteria.

4.2 Target respondents

The respondents were the managers of SHS programs being implemented in the Asia-Pacific region. The email survey was sent to, and returned by the managers. As no information was provided by program managers that responded as to whether the responses had been made by themselves or by others within the agency, it was assumed that the responses were from program managers.

The number of agencies involved in the development and implementation of renewable energy electrification programs in the South Asia, Southeast Asia and the Pacific regions is relatively small. Using the websites of national energy departments in Bangladesh, India, Vietnam, Fiji, Nepal and Cambodia, and from the authors’ personal contacts in these countries, a list of agencies was compiled. Those that provided e-mail addresses on their websites were contacted and asked to complete a survey.
4.2.1 Respondent types

Twelve (44%) of the respondents worked for private organizations, 7 (26%) were employed by NGOs, and five (19%) by government agencies. The remaining three respondents (11%) were employed by government agencies that promoted renewable energy and had responsibility for undertaking and supporting renewable energy projects.

![Figure 4.1: Types of organizations providing responses to the survey](image)

4.3 Survey questionnaire

A structured questionnaire was developed for use in the study, which included questions on the following issues:

- Program objectives and target groups,

- The degree to which guidelines/best practice documents were followed prior to program implementation,
• The program implementation mechanisms employed,

• Program outputs achieved,

• Factors perceived to be essential for program success,

• Perceived barriers to program expansion, and

• Reasons for program success

Three types of questions were used. Multiple choice questions were used to obtain the views of implementers on the impacts of their programs and on the issues that they considered to be essential for program success. Rating and agreement scales from “not important” (1) to “most important” (5) were used to grade responses to these questions. Respondents were also invited to provide details or summaries of any particular success stories of their program, if any.

Numeric open ended and open text questions were used to determine the opinions of the implementing agencies on barriers and success factors.

4.3.1 Dissemination of survey questionnaire and survey response rate

The questionnaire was emailed to thirty-five organisations. Replies were received from twenty-seven organisations, with the highest response rate from those organisations that had been included on the list through personal contact.

The twenty-seven email responses were from organisations in Bangladesh, India, Sri Lanka, Nepal, Vietnam, Thailand, Cambodia and Fiji. Only one response was received from the three organisations to which the questionnaire was sent in the Pacific region. Some respondents provided multiple responses, and not all respondents provided
answers to every questioning the questionnaire, so that the total number of responses varied from one question to another.

4.3.2 Strengths and Weaknesses of the Email survey

With the growth of the Internet (and in particular the World Wide Web) and the expanded use of electronic mail for business communication, the electronic survey is becoming a more widely used survey method. But still there are some strengths and weaknesses of this dissemination method as shown in Table 1.

Table 4.1: Strength and Weakness of E-mail Survey

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced material cost</td>
<td>Lower response rate</td>
</tr>
<tr>
<td>Respondent may feel less inhibited if not responding in a group</td>
<td>Anonymity somewhat harder to guarantee</td>
</tr>
<tr>
<td>Time required for data entry and analysis is usually reduced</td>
<td>Technical ability is required to format the survey and related database</td>
</tr>
<tr>
<td>Faster results</td>
<td>Respondents may need additional instruction or orientation before they are able to complete the survey</td>
</tr>
<tr>
<td>Faster Transmission Time</td>
<td>Technology failures possible</td>
</tr>
<tr>
<td>More Candid Responses</td>
<td>Responses may be more difficult to modify</td>
</tr>
</tbody>
</table>

Source: (Evans and Mathur, 2005)

4.4 Results and Discussion

4.4.1 Program design and objectives

The two most commonly stated program objectives reported by respondents (Table 2) were

i. to provide electricity to those in rural areas through off-grid electrification, and

ii. to improve the standard of living of program users.

iii. to supply sustainable energy for household lighting, followed closely by increasing income generation opportunities for the users.
These responses of most implementing agencies regarding the primary objective of their programs relate to the social and economic benefits of rural electrification.

Although environmental objectives (reducing greenhouse gas emissions) were seen to be of less importance, the number of responses that mentioned reducing greenhouse gas emissions was very similar to the number of responses that mentioned increasing household incomes. The fact that there were 89 responses from 27 organisations indicated that most programs are considered to have multiple objectives.

Table 4.2: Program objectives reported by the program implementers

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective</th>
<th>Frequency of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>To provide off-grid electrification in remote areas where conventional electricity is not available</td>
<td>20</td>
</tr>
<tr>
<td>Socio-economical</td>
<td>Improve standard of living</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Enable income generation to be increased</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Supply sustainable energy for household illumination</td>
<td>17</td>
</tr>
<tr>
<td>Environmental</td>
<td>Reduce GHG emissions</td>
<td>14</td>
</tr>
<tr>
<td>Institutional</td>
<td>Awareness development on use of clean energy and energy efficiency</td>
<td>1</td>
</tr>
</tbody>
</table>

4.4.2 Reliance on best practice guidelines or experience gained from previous programs

Ninety-three percent of respondents stated that the design and implementation of their programs was not based on either best practice guidelines or the lessons or experience gained from previously implemented programs. Forty percent of respondents were unaware of the existence of any best practice guidelines and over half of the respondents (53%) stated that their programs were developed and implemented without reference to either best practice guidelines or experience gained from previous programs.
4.4.3 Program implementation mechanism employed

The types of financing mechanisms used in the programs included micro-credit schemes, interest rate buy-downs and fee-for-service mechanism which includes subsidies. Forty percent of the respondents used a micro-credit or consumer credit financial mechanism, 20 used a monthly tariff mechanism, 25% provided subsidies or donor funded subsidies, 5% used cash sales and 10% used an interest rate buy-down.

An interest rate buy-down approach is a mechanism not previously used in programs in this region and involves providing subsidies to partner financial institutions which are then able to offer loans to customers at discounted interest rates. One of the most attractive features of this approach is that it doesn't distort the market, either in terms of the capital cost (i.e. the ticket price) that the customer associates with a solar PV system, or the risk that a banker associates with a solar loan (UNEP, 2006).

The choice of financing mechanism used was related to organisation type. Most government organizations used a fee-for-service mechanism and these programs provided all equipment and maintenance costs, and the users pay a service fee only. Private organisations or NGOs tended to use a consumer credit, micro-credit or cash sale mechanism.

4.4.3.1 Maintenance and monitoring (M&M) of installed systems

Most implementing agencies valued the importance of maintenance and monitoring and put into a regular maintenance system in place. Only a minority of programs did not emphasize maintenance and monitoring. In 35% of cases, the responsibility for maintenance and monitoring rested with program implementers, while in 30% of cases this responsibility was shared between program implementers and users. In 29% of
cases, this responsibility had been outsourced to authorised technicians (20%) or equipment suppliers (9%). Where this responsibility had been vested with technicians or equipment suppliers, which were mainly government funded programs, dissatisfaction with the timeliness of the maintenance was frequently reported by program implementing agencies.

Almost 65% of the respondents reported that a 4-week maintenance schedule was used, 8% reported that an eight-week schedule was used and 12% reported that systems installed under their programs were monitored once a year (Figure 3.2). The remaining 15% of respondents indicated that neither monitoring nor maintenance was undertaken under their standard schedules.

![Figure 4.2: Maintenance schedule of the program implementers](image)

**4.4.3.2 Training**

Program implementers reported that they considered the training of users and technicians to be one of the most important factors for program success. Eighty three
percent of respondents indicated that training was provided and 40% indicated that written material explaining the “DOs” and “DON’Ts” of system use, was provided to users. Training was provided to users only in 85% of programs and to both technicians and to users in only 15% of programs.

4.4.3.3 System sizes

Two thirds of the programs offered provided systems of more than one size, with the sizes ranging from 37 Wp to 75 Wp (Fig. 3). The size of the system is determined on the basis of the needs of customers. Twenty-seven programs offered a single sized system only to all users, the size being either a 10, 40 or a 50 Wp system. These programs tended to be either government or donor funded in which the costs of the systems were subsidised in order to make them affordable for as many householders as possible.

Figure 4. 3: Solar Home System sizes offered through programs.
Program implementers stated that the reasons for offering either a single system size or a small number of systems sizes were to reduce the costs of the systems and to achieve administrative simplicity and reduce administrative costs.

### 4.4.3.4 System Cost

The unit cost of the systems offered in programs in different countries varied significantly, with programs in Bangladesh offering the lowest average installed system cost and a small range in costs (US$360-370 for a 50 Wp system) offered by different organisations throughout the country.

The average reported cost of a 50 Wp system in Sri Lanka was US$480, 30% higher than the average cost in Bangladesh. The full cost of a 50 Wp system in India was US$490-US$500, but the cost to users is lower as implementing agencies are able to claim a rebate from the Indian government once the system has been installed and the user has provided the agency with a satisfactory report. The cost of solar systems in Nepal is relatively high (approximate US$350 for a 30Wp system). In Vietnam and Cambodia, a 40Wp system costs up to US$500. In Fiji, only one system size (100 Wp) is offered and the installed cost to the user is approximately US$1,458.

Although it is usual to expect that the unit cost ($/Wp) will be lower for larger systems (because the cost of other components does not vary much within the range from 30-100Wp), the larger system has highest unit cost in the case of Fiji as shown in figure 4.4. The cost of the system per Wp (Fig. 4.4) not surprisingly tends to be higher for those programs undertaken in remote locations, such as in Fiji and Nepal. The reported reasons for this were the high reliance on imported system components and relative inaccessibility of the program areas. The unit costs of systems also tended to be higher
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(by an average of approximately 20%) for those programs implemented in Cambodia, Vietnam and Thailand, which are implemented by government agencies. No explanations for the higher costs in these programs were provided by respondents. The cost of systems was higher for those programs where the number of users was lower, suggesting an economy of scale effect that was expected.

![System Cost per Peak Watt](image)

Figure 4.4: System Cost per Peak Watt

4.4.4 Program outputs achieved

4.4.4.1 Numbers of users

Respondents were asked to provide information on the total number of users provided with systems to date. The results indicated that the number of users per program varied significantly from one program to another. Thirteen percent of respondents reported that the number of users under their program was less than 1,000, ten percent of respondents reported a number of program users between 1,000 and 2,000, twenty five percent reported a number of users between 10,000 and 50,000, and twenty percent of respondents reported that the number of program users was above 50,000. The number
of users per program varied and was depend on a number of factors, including whether government subsidies were provided, population density, average household income and the perceived likelihood of the grid being extended in the area. Also the implementation of some of the programs began only 1 or 2 years ago, while the implementation of other programs began up to 10 years. The duration of the programs, however does not provide a full explanation for the differences in numbers of users as some of the programs with low numbers of users had been operating for up to 5 years. The larger the number of users in a program, the lower the cost per system. The programs with largest number of system in this study are in Bangladesh and India and the system costs in these programs are lower as seen in Figure 4.4. Conversely, the program with the least no of users (Fiji) had the highest system costs. The number of users therefore, appears to play a strong role in determining the system, cost as was expected.

4.4.4.2 Benefits of SHS

Respondents were asked to rank the perceived benefits from a list. The list included:

i. increased quality of life,

ii. providing access to television and information,

iii. enabling users to increase their hours for study,

iv. enabling users to increase their hours of working after dusk,

v. increased users’ ability to generate income,

vi. greater mobility to work at night (due to an increase sense of security),

vii. increased employment opportunities,
viii. increased social activities,

ix. reducing the workload for women due to reduced needs for cleaning kerosene lamps, and

x. increased women’s opportunities to work at night and to thereby increased the contribution that they are able to make towards family earnings.

All respondents viewed their programs as having resulted in improvements in their quality of life and in gender equity (Fig. 4.5). There was also a strong level of support (93%) for the statement that the systems increased the opportunities for users to engage in social activities, and increased opportunities for entertainment (87%),

A majority of respondents disagreed, however, with the statements that the solar home systems increased employment opportunities (60%), and increased income (62%).

A majority agreed with the statement that the SHS increased working hours (65%), increased study hours (73%) and access to information (75%).
Figure 4.5: Impact of the programs

More than half of the respondents disagreed with the statement that their systems increased access to information. Twenty percent strongly agreed with this statement, ten percent were neutral and thirty percent disagreed. The greatest level of disagreement related to the questions of whether the installation of solar home systems increased the opportunities for employment (45% disagreed or strongly disagreed and a further 15% were neutral) and whether the systems increased users’ capacity to generate income (38% disagreed or strongly disagreed and a further 25% were neutral).

4.4.5 Factors perceived to be essential for program success

Program implementers were asked what factors they considered had a positive influence on success of their rural renewable energy program. Examples of factors were provided in the glossary for the questionnaire and included: institutional
arrangements, political support, financial support, administrative support, technological support, etc.

Respondents were asked to rank the listed factors in order of importance on the basis of the above explanations by selecting one of the following five options for responding to each statement from “Not Important” to “Most important”. The importance of each factor as reported by respondents is shown in Figure 4.6. The responses were grouped into categories according to whether the factors were social, technical, financial, and economic or policy in nature. The majority of respondents considered financing and policy factors to be most critical to program success.

The factors considered by respondents to be of least importance were those that were technical and social in nature. Only 25% of respondents indicated that they considered the involvement of local people in the design of the systems to be important, and only 40% of respondents thought that good in-house ‘technical know how’ was important. Just over half of the respondents (53.3%) thought that a well-designed maintenance and monitoring program was important. In terms of the importance of institutional factors, offering warranties, a simple warranty claiming process and ensuring quality control were seen to be more important than other institutional factors.

Most of the respondents considered government policy on financing to be very important. Some 33% of respondents, however, indicated that they did not consider attempting to influence policy through their work to be important. A majority (60%) of the respondent indicated that it was important for system supply and maintenance support infrastructures should be located close to customers and spare parts to be available at the local level.
Some of these responses were not readily understood. For example, only 40% of respondents thought that good in-house ‘technical know how’ was important, although it is unlikely that implementing agencies would have the capacity to develop a well-designed maintenance and monitoring program without having good in-house technical knowledge.

Figure 4.6: The importance of factors for program success by type of factor

### 4.4.6 Perceived barriers to program expansion

Open-ended questions were used to obtain responses on the question relating to barriers to the uptake of renewable energy systems. Barriers were defined and examples of different types of barriers were provided in the glossary to the
questionnaire. Respondents were asked to answer this question based on their experience. Not all respondents, however, answered this question and some respondents indicated that they considered more than one barrier to be important.

The lack of a suitable financing mechanism was regarded by respondents as the most significant barrier to the uptake of solar home systems (Fig. 4.7), and this was considered to be of more importance than technical and policy issues.

Program implementers tended to see a lack of financing and lack of sufficient funds to be of high importance. Lack of government policy, low education levels among users, and lack of availability of spare parts were also seen as important factors and were mentioned by 74% of respondents. Institutional and social issues were considered to be less important.

Figure 4.7: Barriers according to the respondents
4.4.7 Reasons for program success

In regard to the perceived reasons for program success, only 15% of respondents answered this question. The responses (Figure 4.8) indicate that financial support for purchasing systems, awareness creation about the technology among users, and the development of a soft credit mechanism were the factors that implementers most commonly reported as being important for the success of their programs.

Other issues that appeared to be of importance were the involvement of local people, strong management quality of the implementing organization, quality control, regular evaluation, the use of appropriate technology, the creation of local employment, and an efficient after-sales service.

Figure 4. 8: Reason for achievement according to the respondent
4.5 Summary and Discussion

Although the number of respondents to the email survey was relatively small, these respondents represented a significant proportion of those responsible for implementing renewable energy programs in the Asia and Pacific regions. In spite of the known limitations of email surveys (Kaplowitz et al., 2004), the survey provided a useful perspective on the thoughts and views of those implementing programs on what makes a Solar Home PV program successful.

Most of the programs were found to have relatively broad or high level objectives, which suggested that most programs were not using a Logical Framework methodology that linked program goals, objectives and outputs. These broad objectives have limited value in terms of being able to assess whether a program is successful or not as they provide only weak measures of real success. The use of Logical Framework analysis would provide more specific and more useful indicators of program success.

In terms of explaining why some programs are considered to be more successful than others and why some programs are perceived as meeting with limited success, the survey results provided some interesting insights. The most important of these was simply that few program implementers reported being even aware of the existence of any best practice guidelines. This suggests that many programs are being designed an implemented in isolation and the conclusion is obvious: program implementers need to be made aware of best practice guidelines. A more startling result was that many of those that were aware of the existence of best practice guidelines reported that they did not refer to these when designing and implementing their programs.
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The reasons for this conscious decision by many program implementers to ignore best practice guidelines needs to be understood if this problem is to be addressed. The finding that best practice guidelines are not being referred to is one clear explanation for the limited success of many programs. It points to a serious failure on the part of some agencies with overall responsibility for oversight of the programs or for providing funding for programs. Those agencies need to ensure that program implementers have the necessary background and understanding of programs and program management.

The survey results found that the financing mechanisms or models most commonly used in renewable energy programs in the region are subsidies, cash sales, consumer credit and fee-for-service. The inclusion of a new model, an ‘interest rates buy-down’ approach, was interesting. The use of this financing model indicates that some program implementers are open to trying new approaches.

Most respondents also indicated that they considered the availability of sufficient funding from government to be a critical determinant of program success, and yet a third of respondents did not consider that attempting to influence government decisions relating to the amount of funding provided by their government was important. This may indicate that many program implementers probably recognise that their program funding is inadequate, but do not consider that they have any capacity to influence government decisions or policies in this regard and therefore accept inadequate funding as \textit{fait accompli}. Governments therefore need to be made more aware of the risk of eventual program failure if sufficient funding is not made available.
To a significant degree, the views of those implementing SHS programs in the region on what factors contribute to program success were consistent with those in the literature. The barriers to the uptake of SHS considered by respondents to be important tended to be the same as those commonly cited by others, with the lack of access to finance considered to be the most important barrier in both this survey and in the literature (Beck and Martinot, 2004).

One important finding was that, while low incomes were regarded to be a barrier, the findings of this study suggest that low income is no longer perceived to be the primary, or even a major, barrier to the uptake of SHS. The explanation for this is likely to be that while program implementers continue to consider low income to be a barrier; this is now seen as a barrier that can be overcome with the availability of funding and the application of an appropriate financing mechanism.

In terms of identifying the reasons behind program achievement, two factors were regarded by respondents to be particularly important. By far the most important determinants of success were considered to be the availability of finance or an appropriate financing mechanism. This was not a surprising result as without the capacity to pay for a system, the number of users able to participate in the program will be limited. The availability of finance is commonly mentioned in the literature as being important, while the availability of an appropriate financing mechanism is less commonly cited in the literature and its inclusion as an important factor by many of the respondents in this survey probably reflects the practical experience gained by those program implementers.
According to the literature, program costs can be reduced if awareness about the systems can be developed among the users and if the maintenance and monitoring components of a program involve local communities or users (Beck and Martinot, 2004, Martinot, 2001, Martinot et al., 2001). Most (85%) of the organisations participating in this survey reported that they had monitoring and maintenance in place. Those organizations whose maintenance programs involved users also reported experiencing fewer maintenance calls and lower operating costs per installed system.

In some areas, however, the views expressed by those implementing programs in the area were at odds with those commonly expressed in the literature. No correlation was found to exist between the duration of a program and the number of systems installed under the program. Those programs that offered a larger range of system sizes, however, tended to also be larger programs in terms of the numbers of systems installed. Those organisations that offered users a larger range of system sizes stressed the importance of having the flexibility to meet the needs of users, while those organisations that offered a single system size stressed the need to minimise system and program administrative costs.

The survey results suggest that system costs would be reduced if the number of systems installed was increased, and that this would also reduce operation and maintenance costs per system. A high number of users could indicate that the systems installed under the program are working well and that the systems are therefore technically sound. It could also indicate the degree of faith that potential program users have in the program.
In many cases, the responses of those implementing SHS in the region not only contradicted the literature, but in some cases the responses contradicted other responses. Some 60% of respondents reported that they did not consider technical know-how within the program to be important, while 54% reported that they considered technical know-how to be important in order for the maintenance and monitoring components of their program to be well designed. The fact that over half of respondents considered technical know-how within a program to be unimportant and only half of respondents considered it to be important for developing monitoring and maintenance components is of concern as it is difficult to know how a program could incorporate a good monitoring and maintenance service component without having good technical know-how.

Another contradictory finding was that many respondents cited the involvement of local people as being important for overall program success. This result was at odds with another finding that only 25% of respondents considered the involvement of local people in the design of the systems to be important. This contradictory result probably indicates that while those that have had successful programs see the involvement of local people to be important, many of those currently implementing programs in the region may not have gained sufficient experience to be able to gauge the importance of elements such as this. If this is the case, it indicates that some of the programs currently being implemented in the region are likely to meet with limited success.

The results of the survey also revealed that some of the determinants of program success perceived by implementers as being important are not generally mentioned in either the literature or in best practice guidelines. Offering warranties and having a
simple warranty claim process, and ensuring quality control, were seen to be important factors of program success, although these are not mentioned in the best practice guidelines. The local availability of systems and spare parts and the existence of local maintenance infrastructure were also seen as important factors by most (60%) respondents. The reasons given for success of programs, by those that considered their programs to be successful included:

i. strong management quality of the implementing organization,

ii. quality control

iii. routine evaluation

iv. the use of appropriate technology

v. creation of local employment and

vi. efficient after-sales service.

Not all programs, however, appeared to incorporate these as a part of their regular practice as only 15% of the respondents answered the question on their views on which factors they attributed the success of their programs. In some cases, program managers or implementers reported that they did not consider their programs to be successful, although the approaches and mechanisms that had been adopted in these programs had followed the same approaches and mechanisms that had been used in previously successful programs. It was not possible to explain this, but it suggests that local and cultural factors can be very important in determining program success.

The survey results pointed to many other areas where there was a gap between an awareness of what was required for a program to be successful and what actually occurred on the ground. Capacity building of local communities in terms of installing,
operating and managing the systems, is widely cited in the literature to be an important component of program success. Some of the program implementers surveyed reported that they were aware of the importance of this, but that they were not able to provide training for local people on maintenance and monitoring due to lack of program funding. The fact that most respondents failed to respond to the question of the primary reasons for program success is curious, but does hint that many program implementers may be more focused on the implementation process than they are on the outcomes.

Figure 4.9: Program success factors and their indicators
From the above discussion, a list of critical success factors was formed and categorised according to six broad categories (Fig. 4.9). Each of the factors has been associated with a set of indicators, from which program success can be judged, while recognising that the final choice of indicators needs to reflect the local context and the objectives of the project. All factors relate strongly to the sustainability of renewable energy rural electrification program, but their relative importance should reflect the particular project nature. These indicators were tested in chapter five and six to assess program success.

4.6 Conclusions

In terms of the original questions of why many programs continue to meet with limited success, a number of conclusions can be drawn from this small survey. It appears that the aims and objectives of most programs are specified in very broad terms, such as providing access to electricity to rural people, rather than in more specific outcomes, such increasing users’ capacities to generate income or increasing users’ opportunities for studying. The objectives set for the programs are not formulated in terms of the outcomes for users but in terms of administrative criteria and the needs of the implementing organization. To make a successful program the objectives should be set based on the needs of the users and the benefits to users. A lack of government policies that support project expansion appears to be another significant explanation for the limited success of some programs and this type of issue is not addressed in the best practice guidelines. Similarly, the fact that many respondents cited inadequate management capacity as an important barrier is also revealing and suggests that adherence to best practice guidelines is a necessary, but insufficient condition for success and that the weaknesses of some programs have more fundamental origins.
than failure to adhere to best practice guidelines, or to barriers. That is, the lack of program success of some programs may not be attributable to technical or financial barriers, but to:

- the way the programs are designed, developed and administered
- whether government policies support or constrain programs aimed at providing access to electricity using renewable energy systems
- the experience and training of those administering the programs, and
- the adequacy of program funding

In summary, it seems that the best practice guidelines are not being followed. In addition, some fundamental problems lie at the heart of the limited success of many programs. However, despite these problems and despite the failure to follow best practice guidelines, some programs are meeting with success. This indicates that the reasons for success or lack of success of programs need to be further investigated and this will be presented in next chapters.
Chapter 5

Solar PV Program Analysis: Fiji Case Study
Chapter 5 – Solar PV Program Analysis: Fiji Case Study

This and the next chapter are used to present the categories described in chapter two and to illustrate these with data from interview transcripts along with results from quantitative data analysis.

The Fijian solar home program was selected as a case study for this research for two reasons. Firstly, it represents a government subsidised program with a limited focus on the development of markets or other mechanisms to make the program self-sustaining. Secondly, this program is one that has been identified as having met significant issues related to maintenance of systems and the number of systems not operating and lack of revenue collection (Gonelevu, 2006). The approaches used in the implementation of the Fijian program are similar to those adopted for programs being implemented in other countries in the region. The reported lack of success of the Fijian program therefore cannot be readily attributed to substantive differences from other programs in terms of the approach being used. The Fijian program therefore represents an appropriate case study as it fits toward one end of the spectrum in terms of success and also in terms of the degree to which it reflects and ‘old paradigm’ style of program.

This chapter is presented in three parts. The first part provides background information on the Fiji’s geography, climate and demography and on the energy situation of Fiji, including the rural electrification program and the solar PV component of the program. The second part provides an overview of the current SHS program. The third part presents the results of a survey undertaken as a part of this research project in 2007. The results of the quantitative research are presented using graphs, charts and numbers. The qualitative findings are presented firstly as a diagram showing the criteria concept.
and issues derived from the transcript of the interviewee followed by the researchers’ comments. Quotes in italics, from the transcripts are used to allow respondents to ‘speak for themselves’ in illustrating the issues (Whiteley, 2002). Where direct quotes from the respondents are used, they are bounded by “//…//” symbols. In some instances, the quotes from the interviews with respondents have been slightly modified in order to ensure clarity of meaning, such as by removing redundant or duplicate words or by making grammatical correction, but without altering the meaning of their responses.

The results are used to discuss the weaknesses and strengths of Fijian SHS program, the extent to which it has been successful or unsuccessful, the primary reasons behind this success or lack of success and the factors that constrain its potential to expand and to become sustainable.

5.1 Background information on Fiji

The Fiji Islands (Fig. 5.1) are located between 177° E and 178° W longitude and 12° to 22° S latitude. The average mean temperature of the country is 26°C and the annual rainfall ranges from 1,800 to 2,600 mm. It is one of the largest of the Pacific island nations, comprising over 330 islands, only about one third of which are inhabited.

Almost three quarters (74.5%) of the country’s population lives on one of these islands, the largest island, Viti Levu (Great Island), which makes up 57% of Fiji’s total land area of 18,333 km². Another 25% percent of the population lives on the second largest island, Vanua Levu (Sandlewood Island), which makes up another 30% of the nation’s land area. The other 10% of the population lives on over 100 of the smaller islands (Johnston, Vos, & Wade, 2004).
5.1.1 Demographic Information

The most recent census was undertaken in 2007 (Fiji Islands Bureau of Statistics, 2007), when the population was estimated to be 827,900, a 6.8% increase on the 1996 census estimate and representing an average population growth rate of 0.62% per year. The number of households increased from 144,617 to 174,460 in the same period, an increase of 20% or an average of 1.87% per year. At the time that the census was taken, just over half (51%) of households were Fijian, 43% Indo-Fijian, and 4% were from other ethnic backgrounds (mainly Chinese and European). Slightly more than 60% of the total population lived in rural areas, but urban growth has been accelerating in recent years (Sauturaga, et al., 2004). A sharp disparity in income exists between urban and rural areas, with much of the rural population participating in a semi-subistence/barter economy that is weakly connected with the monetized economy through modest cash flows.
5.1.2 The Energy situation in Fiji

Approximately 60% of Fijian households and businesses, and 87% of urban households and businesses, are supplied with electricity from a grid that is owned and operated by the Fiji Electricity Authority (FEA). FEA supplies electricity to the most part of costal inhabited areas and some inland regions on Viti Levu as well as the main towns on Vanua Levu and on Ovalau (Fig. 5.2). Approximately 15% of those that have access to the grid remain unconnected. Ninety three percent of the houses that are grid-connected are on Viti Levu. The proportion of the Fijian population supplied with electricity from the grid increased by 6% over the period 1990 to 2006 (FDoE, 2004).

Figure 5.2: Electricity Distribution Areas in Fiji. (Source: Vega, 2007)
More than 70% of Fiji’s stationary energy requirements are met from indigenous energy resources and the Monosavu hydroelectric scheme on Vitu Levu supplies more than 50% of total electricity generated (FEA, 2008). Grid-connected biomass, wind and solar (PV) generators are also used to generate electricity on Vitu Levu. The FEA has several grid extension and capacity reinforcement plans, based primarily on the construction of new hydropower plants.

The situation on Vanua Levu differs significantly from that on Viti Levu. Due to the lack of hydroelectric resources, the high costs of generating electricity from diesel and bagasse, and the lower population densities (i.e. higher supply cost per customer) the FEA grids on Vanua Levu are more limited. The grids therefore supply only urban and peri-urban areas, representing 5.5% of all grid-connected customers in Fiji. The grid supplying Labasa, the main town on Vanua Levu, represents 4.5% of the national grid in terms of total network length (km), and that supplying the second largest town on the Island, Savusavu represents 1% of the national grid (L Vega, 2007).

Uniform electricity tariffs are used and set at levels that are lower than cost recovery rate, and electricity customers on Vanua Levu are therefore heavily subsidised. As a result, the FEA is not planning to extend the grid in Vanua Levu, at least in the short or medium term. This makes the rural electrification program particularly important at Vanua Levu.

5.1.3 Rural electrification

The Department of Energy, Fiji (DoEF), with assistance from the Public Works Department (PWD), has responsibility for rural electrification in areas that are not supplied with electricity via a grid. Approximately 25% of the total population
(200,000), representing approximately half (51%) of rural households, have no access to electricity.

The DoEF and PWD have installed several hundred diesel generators in the inland and mountainous areas of Viti Levu and on the other islands. They are relatively active on Vanua Levu and have built a number of mini-grids supplied from diesel generators. However, the electrification rate in rural areas of Vanua Levu remains quite low overall.

5.1.3.1 Rural electrification policy background

The Rural Electrification Policy, which was revised and endorsed by the Fijian cabinet in 1993, entitles rural villages to request Government assistance for electrification. A Rural Electrification Unit (REU) with a manager and small number of staff members, was set up in 1993 within the DoEF to facilitate the implementation of the Policy (Johnston, 2008).

Since 1993, about 900 communities have applied to DoEF for rural electrification and over 250 diesel generation mini-grid systems have been commissioned, serving around 7,500 households. As the rate of household growth in of rural HH is of the same approximate order, the current rural electrification program is not able to achieve an overall long-term reduction in the number of households without access to electricity.

Under the Rural Electrification Policy, which is a part of the National Energy Policy published by DoEF in November 2006, rural villages are offered the following options for gaining access to electricity (DoEF, 2006a):

- An extension of an FEA rural grid;
• A mini-grid system supplied by a Government-owned stand-alone diesel generator; or

• A renewable energy system, which in practice is limited to either solar photovoltaics or small hydro, but which can in principle include wind or bio-fuel.

Under the terms of the revised Policy, villages (applicants) are required to pay 10% of the total capital costs for the installation, while the Government pays for the remaining 90% (DoEF, 2006b). If the option chosen is to gain access via an extension of the grid, the households connected to the network are required to pay the standard national tariff. Grid extension schemes, both from the FEA grid and the small Government Station grids operated by PWD, provide continuous electricity service at the FEA tariff, although actual cost of power delivery to these rural areas is much higher than the national standard tariff.

If the option chosen is a stand-alone mini-grid system, the DoEF bears the responsibility and costs for maintaining and operating the system for the first three years. A village committee is typically established and is vested with ownership of the system and the responsibility for setting and collecting the service fees and for paying for the operation and maintenance costs after the three year warranty period lapses. The diesel generators used to supply rural mini-grids are generally operated for approximately 4.5 hours per day during the evening. The monthly fee for householders is typically set between A$1.3 and A$3.45, which is well below the amount required to cover actual operating and maintenance costs and barely covers fuel costs (Sauturaga, 2007). The DoEF has estimated the cost of supplying electricity for the 15 villages electrified since 1993 to be AS$2.70/kWh, including transmission costs, meaning that the government subsidy represents on average about 60% of total cost of the service (DoEF, 2004).
It is not unusual for diesel mini-grid systems to be off-line for weeks, or even months, as repairs are delayed due to lack of funds or to problems of obtaining the necessary repair services or parts. When a large maintenance or repair cost is incurred, the committee either instigates a fundraising program or requests a once-off high payment from users to cover the cost. No information is available on the number of diesel generator systems that are not operating either as a result of breakdown due to poor management, poor operation and maintenance, or due to high fuel costs.

The effectiveness of the Rural Electrification Office established under the Rural Electrification Policy has been limited to date due to lack of adequate funding and staffing and compounded by a failure to set electricity prices at a level that covers operation and maintenance costs of the systems installed. In order to accelerate rural electrification, the DoEF has developed a process that combines the strengths of the public and the private sectors for renewable-based electrification. The approach, in concept, is that the public sector provides the capitalization and regulation, while the private sector has responsibility for the installation, operation and maintenance of the electricity systems using a Renewable Energy Service Company (RESCO) structure. The RESCO model, however, has not as yet been set up on a legal basis and this may have retarded the development of this approach.

5.2 The Fijian SHS Program

The Fiji government’s Solar Home System (SHS) Program has been restricted to date to a small number of rural communities on Vanua Levu that are not connected to the electricity grid. According to the DoEF, about 2,000 households (about 10,000 people) on this island do not have access to electricity.
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The potential to provide solar home systems is thought to be considerably higher in Vanua Levu than it is in Viti Levu (pers. comm., Mr. Kishan Raj, Manager of RES Ltd., August, 2007) because of the large percentage of the population of Viti Levu that is connected to the grid and because household density in most of the rural regions of Vanua Levu is fairly low. Box 1 shows the demographic, economic and geographical information for Vanua Levu.

Box 1: Demographic, Geographic and Socio-economic Information of Vanua Levu
(Source: [http://www.economicexpert.com/a/Vanua:Levu.html](http://www.economicexpert.com/a/Vanua:Levu.html))

- **Location:** Located 70 km to the north of the main island, Vanua Levu.
- **Population:** 130,000;
- **Land area:** 5,500 km$^2$;
- **Main occupation:** Farming
- **Crops:** Sugar, copra, rice; citrus fruits
- **Other industries:** Tourism; gold mining

Note: There are differences between the above information on population and that provided in section 5.1. The reasons for these differences cannot be explained, but are likely to be due to the inherent unreliability of statistical data available.

The Program is implemented by the Department of Energy (DoEF) and has been developed to provide electricity for lighting for remote households located in rural areas where supplying electricity via the grid is not an economic option.

To date, only one tenth of the households that do not have electricity access, applied to the DoEF to participate in the solar electrification program. Approximately 700 SHS
systems have been installed and a company, RES Ltd., manages those systems from its head office in Lambasa on Vanua Levu. Users pay a monthly fee of F$14 (A$9.70) at the local post office and receive a code that is used to activate the charge controller for 1 month.

DoEF started to work on developing a ‘Vanua Levu RESCO’ pilot project in the 90s with the help of the Pacific International Center for High Technology Research (PICHTR). Prior to this project, several trials with the Operation and Maintenance (O&M) scheme supported by local cooperatives, village communities or the DoEF itself were implemented in Namara (1983 to present) and Naroï (1999 to present). These first solar projects have similarities to the present RESCO approach.

In 1996 the residents of Vunivau settlement on Western Vanua Levu expressed interest in installation of solar PV systems in each household in the area. This request prompted DoEF to conduct a survey of the settlement to determine the feasibility of SHS for the households. Results from the study revealed that Vunivau settlement qualified as a candidate for a PV project. After getting funds from foreign aid, project implementation began in August 2000.

This pilot SHS project was carried out with the assistance of the PICHTR and led to first trial SHS installations in 2000 (Sauturaga, Vega, Vos, Johnston, & Wade, 2004). Twelve local technicians who were trained by DoE and PICHTR were recruited for the installation phase of the project and supervised by DoEF staff. A local PV technician was also engaged by PICHTR for the installation of the systems. The installation of 58 systems took 30 days with two more systems installed at a later date, for a total of 60 installed systems (Wade, 2003).
In Vunivau, each family of farmers lives in a home on or near to its farm. The homes are widely separated and household loads are low, making supply via a grid much more costly than through the use of stand alone PV systems.

Under this initial solar PV Program householders were provided with two solar PV modules mounted on a wooden pole next to the house (Fig 5.3), battery, change controller and lamps (Box 2).

![Two 50 Watt Solar PV module](image)

Figure 5.3 : Two 50 W solar panels installed under the Fijian SHS program

A total of 60 systems were installed in the first phase of the program in 2000. Ninety-six additional systems were subsequently purchased using funding provided by the Government of Japan and from the Fijian Government for installation during 2002. Eighty four of those systems were installed in Vunivau in July, 2002, and another twelve were installed in Nasuva in the Bua province, which is far from the main road as shown in Annex 5-I.
Box 2: Solar System Components used in the Fijian SHS Program in 2000

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel:</strong></td>
<td>2 Shell Solar RSM 50S polycrystalline panels (US$490)</td>
</tr>
<tr>
<td><strong>Battery:</strong></td>
<td>1 Pacific Battery (Fiji) open cell, 110Ah at C_{20} model SSDL-100-12. 3mm plate automotive type battery (US$79)</td>
</tr>
<tr>
<td><strong>Charge Controller:</strong></td>
<td>1 CONLOG microprocessor controller and pre-payment card reader. (US$98)</td>
</tr>
<tr>
<td><strong>Lamps:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three 11 watt STECA Solsum CFL lights (US$39.90)</td>
</tr>
<tr>
<td></td>
<td>One 7 watt STECA Solsum CFL light (US$13.30)</td>
</tr>
<tr>
<td></td>
<td>One 0.25 watt STECA LED night light (US$5.15)</td>
</tr>
</tbody>
</table>

In January 2002, the Government of Japan provided PICHTR with funding for another ninety solar home systems, with a funding contribution from the DoEF contribution. Forty-four of these were installed in Na suva, and fifty two in settlements in the Cakaudrove province. All of the installations were managed by the DoEF and maintained by a private contractor using a modified form of the RESCO approach. By early 2003, a total of about 252 SHSs had therefore been installed in Western Vuna Levu. The systems are owned and managed by the Fiji Government and have been maintained through a RESCO type of energy services contract.

Since 2003, almost 100 SHS have been installed per year, following similar investment and management schemes with the financial and technical assistance of PICHTR, the Japan Government and the DoEF, so that by mid-2006 the total number of systems installed was 493 solar systems, with another 150 planned for installation in 2007. The SHS are spread among a dozen Fijian Villages and Indian settlements, mostly based in the eastern and western part of the Island.

The technical design of the systems was improved as a result of the technical monitoring undertaken by the DoEF and PICHTR, and the involvement of the RESCO
(RES Ltd) increased. The most recent systems that have been installed consist of two 55Wp Shell solar panels, a 100 Ah open cell lead acid plate automotive type battery, an Enercash controller with prepayment meter, STECA Solsum CFLs, a LED night light designed by RES limited, and a DC plug for radio.

The Conlog prepayment meters/controllers used previously are no longer manufactured and Enercash units (Fig. 5.4) that are used in their stead are considered to be more reliable as no technical problems have been encountered in the one year that they have been in operation (Per comm., Raj, K., 2007). Figure 5.5 shows a the code in the meter being inserted to activate a system.

Figure 5.4: Enercash meter used as charge controller and meter in the SHS in Fiji

Figure 5.5: Entering the code into the meter to activate the system
5.3 Survey and survey results

In this section, the results of the users’ survey and survey on stakeholders undertaken in August 2007 are presented and discussed. The user survey was undertaken using a questionnaire to gain the following information:

- techno-socio-economic information,
- entho-cultural backgrounds of the users,
- technical condition of systems and
- users’ perceived impacts of their solar home system on their quality of life.

The interviews with the users and village headman provided information on the impacts of the program. The focus group discussion was used to gain the perspective on the whole program, its benefits, its problems and its future prospects.

5.3.1 Survey of householders with SHS

The survey involved undertaking interviews in 4 of the villages (Vusasivu, Korokandi, Drikiniwi and Driti as shown in Annex 5-I ) on the island of Vanua Levu in which the Fijian Solar PV Program is being implemented. The numbers of systems installed in these villages at the time of interviews were 51, 26, 48 and 24 respectively. Of the total of 149 systems, 100 system users (67.1%) were surveyed. Summaries of the personal interviews and focus group discussions conducted in the four villages surveyed are provided below.

Vusasivu Village

Fifty one systems had been installed in Phase I of the program. Of these, one had been removed (by the DoEF) as the owner of the house had connected the system to an inverter and was using it to operate a TV. Another system had been damaged by
Hurricane Ami in 2003. Two systems had faulty batteries and the battery in another system was completely flat. The service company had topped up the batteries with distilled water at the end of July 2007 and expected the batteries to operate well (Per comm., Raj. K, 2007).

Twenty houses were surveyed in this village and only one controller was found to be not working. Thirty-two lamps had blown and were in need of replacing. Twenty systems were found not to be working due to low battery water levels over a period of several days.

It is difficult for the people from Vusasivu to contact the service company and advise of any problems they may have with their solar home systems because it takes almost 5 to 6 hours to reach to the local office.

**Korokandi**

The distance between the village and the nearest RES office is 100 km. Twenty-six systems had been installed, ten of which were found to be faulty at the time of the interview and three of these households had stopped paying the fees as their system had not been working for the last 6 months. The batteries of seven systems had no water in any of the cells and were completely flat. Nineteen lamps had blown.

**Drikiniwi**

The distance between the village and the nearest RES office is 140 km. Most of the houses in this village had only one or two rooms. The main occupation of the villagers was farming, mainly rice and other crops such as water melon. The villagers have their own vegetable gardens and domestic animals (goats, cows, chickens and ducks). Forty-eight systems had been installed in the village and the maintenance company visits the village once every two months. Most households reported being very happy with their
system. The problems reported by the owners of the solar home systems were that it took two months to replace any components, that five systems were not working and that the maintenance company had not replaced the faulty parts, and that some of the batteries had been sent to be recharged but when they had been returned to the households they did not work as well as they had done before being sent away.

**Driti Village**

Driti is a native Fijian village 120 km from the RES office. Five out of twenty four systems that had been installed were not working at all and the village headman mentioned that his own system had not been working since June 2007 and that he had complained to DoEF but that the parts had not been replaced. He also pointed out that the batteries had not been checked and refilled for six months and that many of the batteries had no water. The main comment made by the villagers was that they wanted the systems serviced more regularly. Some households were happy with the small systems as they had only one or two rooms, while others wanted larger systems and were prepared to pay a larger fee for this. Some householders said that the security light remained on from dawn to dusk which resulted in overuse of the systems during the rainy season. These security lights use a 7 watt lamp that could be replaced by a LED light.

The main cause of faults was a lack of maintenance. Water loss from batteries occurs rapidly due to the hot and humid climate, and most batteries had not been checked or refilled for the last six to eight months. Most of the batteries were found to be low on water and many were flat. Many of the charge controllers were also malfunctioning and would not allow these systems to operate with any load, although the lights on these controllers were green. The prepayment system requires a fixed upfront payment for a 30-day period and these costs are incurred whether the systems operate for the
full period or not. These problems meant that some users were therefore paying for a service although their systems were not working.

5.3.2 Socio-economic Survey

5.3.2.1 Household pattern

According to some people and village chiefs of the native Fijian village interviewed, living in the rural and remote places of the Fiji islands is most of the time a personal and cultural preference rather than a necessity. Almost all the children receive a school education, and health care appeared to be good overall.

In Vanua Levu most houses are built with durable materials (Fig. 5.6). Most of the houses surveyed were clad with iron sheeting and houses with concrete walls also had iron sheeting roofing. The houses surveyed were well equipped and maintained and there are few signs of significant poverty.

Figure 5.6: Construction material observed in surveyed houses

About one quarter (27%) of the houses in the survey area had only one large room and although these required only two lights, they had three lights as this was the standard
package. Another quarter (24%) of houses surveyed had three rooms and less than 18% households had more than four rooms as shown in Figure 5.7.

![Figure 5.7: House size (number of rooms)](image1)

Household size ranged from one to more than nine persons with an average household size of 5 (Fig. 5.8).

![Figure 5.8: Average household size](image2)
The distance of the house from the nearest market ranged from two to over ten km, with around eighteen percent (18%) of the houses being within 2 to 3 km and 88% being within 7 km (Fig. 5.9).

![Figure 5.9: Distance of Nearest Market from HH](image)

In summary the people in these villages lived in relatively simple and low cost housing made of galvanized iron sheet, bamboo and other low cost materials. The houses tend to be small, most houses having one to three rooms. Typical household size is five persons, and over 75% of households have between three and six persons. Most households having SHS are within 6 km from the closest market (i.e. distance required for purchasing kerosene for lighting), with an even spread in the proportion of households within the two to six kilometre range. Small proportions (12%) are over 6 kilometres from the closest market.

### 5.3.2.2 Income and Expenditure of the surveyed householders:

Average household income (Fig. 5.10) was A$380/month and median household income A$240 a month, as a relatively high proportion of households (68%) had
incomes of less than A$300/month and only a small number of households had relatively high incomes.

Approximately half of the households surveyed reported that they also had significant remittance income (i.e. money sent from relatives working in urban areas). The 11% of the households that included a member that earned a regular salary tended to have higher incomes than did other households.

![Figure 5.10: Income of the households](image)

The items of major household expenditure were food, clothing, tobacco, school fees, church and community donations and energy (fuel, solar and batteries). The monthly amounts paid for these items varied widely among households with the proportion of household expenditure spent on food (rice, tea/coffee and tinned foods) and energy being low and the proportion of household expenditure on tobacco being high for those households with low income levels (i.e. those households involved in the subsistence economy). The proportion of household expenditure spent on clothing varied widely and was determined by both household income and access to second hand clothing via
sellers that provided serviceable clothing for as little as A$0.50 per item. School fees ranged from A$20 per year for primary students to over A$100 per year for secondary students, with the cost increasing if the student has to board at the school.

![Figure 5.11: Itemized Monthly Household Expenditure in the surveyed Areas](image)

All households surveyed had solar home systems, but some of these houses also continued to use kerosene lamps. Average household expenditure on kerosene per month was A$17.63 and the median amount was A$13.04, with a relatively small number of households having significantly higher use.

Most households reported that household income fluctuated significantly over the year, with two-thirds of households reporting significant month to month fluctuations. About half of the households selling garden product, reported little income in some periods, and the other half reporting a low income over most of the year with high income during some months who are sugar cane and rice farmers (Fig. 5.12). Only one-third of households (those with a member with a regular salary) surveyed reported having a fairly even income stream. Households with variable income patterns,
particularly those with high incomes in a small number of months and low incomes over most months, find it hard to consistently make scheduled, fixed payments to RESCOs for electricity services.

Figure 5.12: Income patterns of the PV users

In summary, most households’ surveyed earned relatively low income, the main source of the income for most (87%) households surveyed coming from the sale of agriculture products or fish. Expenditure on energy represented an increasing proportion of total household expenditure as household income decreases. For the lowest income households expenditure on energy represents approximately 30% of total household expenditure.

### 5.3.2.3 Impact of the SHS programs

The program impacts are the specific changes in householders’ attitudes towards the systems and the changes in their social and economical well-being as a result of their participation in the program (REEEP, 2006). If an audit of the program had been undertaken and this included an assessment of the impacts on the users of the SHS, as recommended by the IEA, in its guidelines on PV programs for rural electrification, then the impacts of the SHS would have been found to be (IEA, 2003):
• A reduction in kerosene/benzine use for lighting;

• A reduction or change in householder expenditure on lighting;

• Users’ satisfaction with lighting systems;

• A positive impact on quality of life;

• Increased use of information;

• An increase in study hours;

• An increase in working hours, productivity and income generated; and

• Greater gender equality through improved indoor air quality and quality of lighting and a reduction in the difference in total work loads undertaken by women and men.

The impact assessment of the program depends on the needs and priority of the users, stakeholders and implementers, specific project area, and type and size of the renewable technology. In this study the impacts of the program on the SHS users were measured using the variables and indicators developed from the literature review and the email survey in Chapter 3 and 4 respectively and summarise in Table 5.1.
Table 5.1: Solar Home System Output and impact indicators for households

<table>
<thead>
<tr>
<th>Variables</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy access and uses</td>
<td>Access to more lumens and cleaner light</td>
</tr>
<tr>
<td></td>
<td>Reduction in use of traditional fuels</td>
</tr>
<tr>
<td>Social Impact</td>
<td>Quality of life increase by using modern technology</td>
</tr>
<tr>
<td></td>
<td>Increased number of hours for relaxation</td>
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<tr>
<td></td>
<td>Increased in listening radio/watching TV</td>
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<tr>
<td></td>
<td>Access to information increase and easy</td>
</tr>
<tr>
<td></td>
<td>Increased social status</td>
</tr>
<tr>
<td></td>
<td>Increased social activities hours</td>
</tr>
<tr>
<td>Economical Impact</td>
<td>Monthly payment on energy decreases</td>
</tr>
<tr>
<td></td>
<td>Changed economic well being of the users</td>
</tr>
<tr>
<td></td>
<td>Repayment is a burden</td>
</tr>
<tr>
<td></td>
<td>New employment opportunities</td>
</tr>
<tr>
<td></td>
<td>Working and study hour increase</td>
</tr>
<tr>
<td>Management and ownership</td>
<td>System maintained by the users</td>
</tr>
<tr>
<td></td>
<td>Easy to operate</td>
</tr>
<tr>
<td></td>
<td>Received training on maintenance and monitoring</td>
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<tr>
<td></td>
<td>Distance to local service centres</td>
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<td></td>
<td>Costs of maintenance</td>
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<td></td>
<td>Spare parts availability</td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>Battery recycling available</td>
</tr>
<tr>
<td></td>
<td>Reduced interior pollution</td>
</tr>
<tr>
<td>Impact on gender equity</td>
<td>Women get more free time</td>
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<tr>
<td></td>
<td>Women’s work load reduced</td>
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<tr>
<td></td>
<td>Familiarity with new technology</td>
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<tr>
<td></td>
<td>Men and women are able to undertake income generating activities after dusk</td>
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</tbody>
</table>

Most respondents (71%) reported strong preference for solar lighting as it is cleaner and more convenient than lighting from kerosene or benzine (White oil or naphtha) (Fig. 5.13).

Figure 5.13: Energy access and uses
Almost all respondents indicated that they were happy switching from these traditional lighting fuels to SHS.

The majority (84%) of respondents reported that their participation in the program had resulted in an increase in their quality of life (Fig. 5.14). About seventy percent of respondents reported that their SHS had increased their time spent in relaxation (Fig. 5.14). Only one fifth of respondents agreed with the statement their SHS has resulted in increased access to information and the majority of respondents (70%) disagreed with this statement.

Figure 5.14: Social impact due to use of SHS

TVs are not included in the system design as there is no TV reception available in these areas. Survey response reflects the fact that TV reception was unavailable in the survey area as TV represents the main means of gaining access to information. But some SHS users (10%) use cassette player to listen music (Fig.5.14). Regarding increasing social status, ninety percent of the respondents disagreed as shown in figure 5.14. There was very strong support (88%) for the statement that the installation of the
SHS had increased their opportunities for engagement in social activities. In Church they now spend quality time under clean light and have their community meetings.

Although the tariff was designed based on what householders spent on kerosene or benzine, most respondents reported that their monthly expenditure on lighting had increased as a result of their participation in the SHS program. It was also reported by the respondents that this increase in expenditure had not been compensated for by increased income (91% disagreed and a further 9% were neutral) or increased employment opportunities (70% disagreed or strongly disagreed and a further 30% were neutral as shown in figure 5.15). It was not clear from these responses whether actual lighting costs for householders had increased or not, but if they had increased, householders appeared to consider that the improvements in the quality of their life and in their social engagement had offset any such cost increases. Forty percent respondents indicated that the system had increased study and working hours after dusk (Fig. 5.15).

![Economical Impact](image)

Figure 5.15: Economical benefit for using SHS
In response to the statements about whether their SHS had affected the quality of life for women, the results clearly indicated the improvement of quality of life for woman. (Figure 5.16).

The main benefit of the SHS for women was a reduction in the time spent for cleaning and refuelling kerosene lamps. Most female respondents (96%) also agreed that the installation of their SHS had resulted in reduced work loads. The handicraft industry in Fiji is not well developed and the main income of the rural people is from farming. These situations therefore did not encourage income generating activities after dusk, although some women do sewing or mat making at night for their own family.

Figure 5.16: Impact on gender issues

In summary, the results show that program participants valued increased quality of life and social engagement over increased opportunities for income or employment. This finding that the people in these communities do not use their SHS to increase income or employment is very important. It suggests that either they are quite happy with their
lives and do not want to spend hours in the evening to increase income. This has implications for the funding mechanisms. It is difficult to use credit to fund the SHS if they are not increasing income as a result.

5.3.3 Stakeholder survey

The Fijian solar PV program is based on earlier experience with the Kiribati RESCO program. A RESCO solar PV electrification scheme is a renewable energy program in which the solar PV and other equipment are owned and serviced by either a government agency and/or a private company. The users are charged an amount that is intended to cover the operating, maintenance and administrative costs and to provide a profit margin. This type of RESCO scheme has been applied in countries such as Kiribati and was first considered by Fijian authorities when the DoEF started to work on developing the pilot program in Vunivau. The RESCO pilot program started in 2000 with sixty SHS with plans to reach up to 700 systems by 2007.

The survey results were analysed by using qualitative software NVivo. The use of NVivo to undertake data coding was described in Chapter 4. The six broad criteria were coded into sub –criteria and further coded into concepts (Table 5.2). This was done to aid an understanding and evaluation of the Fijian SHS program. Each criterion is illustrated by a model imported from NVivo (Richard 1999; NVivo, 2008).
### Table 5.2: Criteria and concepts

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Concepts</th>
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<tbody>
<tr>
<td><strong>Implementation mechanism</strong></td>
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<td><strong>Institutional approach</strong></td>
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<td>Objective of the program</td>
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<td>Institutional framework</td>
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<td>Supply Chain</td>
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<td>Market demand assessment</td>
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<td>Range of system offered</td>
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<td>System size determination</td>
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<td>Program Actor Selection</td>
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<td>Awareness development to users</td>
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<td><strong>Technical performance and training</strong></td>
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<td>Users training</td>
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<td>Technician training</td>
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<td>Technical performance evaluation</td>
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<td>Training manual</td>
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<td><strong>Maintenance &amp; Monitoring</strong></td>
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<td>Reliable customer service</td>
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<td>Component selection process</td>
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<td>Regular monitoring</td>
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<td><strong>Financial</strong></td>
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<td><strong>Funding</strong></td>
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<td>Criteria for funding</td>
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<td>Funding Sources</td>
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<td>Financing through bank</td>
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<td><strong>Cost Recovery</strong></td>
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<td>Loan repayment</td>
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<td>Monthly Fee</td>
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<td>Revenue Collection</td>
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<td>Tariff</td>
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<td><strong>Economical perspective</strong></td>
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<td>Affordability of the users</td>
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<td>System price</td>
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<td>Income generation</td>
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<td>Affordability of the users</td>
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</tbody>
</table>
Table 5. 2 Continued

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>User's Behaviour</td>
<td>Cultural difference</td>
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<tr>
<td></td>
<td></td>
<td>Attitude towards system</td>
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<td></td>
<td>Satisfaction level</td>
<td>Customer satisfaction</td>
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<td>Social impact</td>
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<td>Decision making</td>
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<td>Relationships with service providers</td>
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<td>Requirements</td>
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<td></td>
<td>Gender issues</td>
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<tr>
<td>Policy</td>
<td>Lack of policy</td>
<td>Lack of policy</td>
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<td></td>
<td></td>
<td>Implementation of policy</td>
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<td>Rural electrification policy</td>
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<td>Government requirement</td>
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<td>RE Policy</td>
<td>Government Policy</td>
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<td>Country specific need</td>
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<td>Conflict between grid and RE</td>
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<td>Future plan for electricity access</td>
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<td>Policy advocacy</td>
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<td>Bureaucracy</td>
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<td>Lack of human resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main problem encountered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Major barriers to success</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cultural difference</td>
<td></td>
</tr>
<tr>
<td>Measurement of Program Success</td>
<td>Limiting factors</td>
<td>Factor limit the viability</td>
</tr>
<tr>
<td></td>
<td>Program Success</td>
<td>Sustainability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Factors contributing to program viability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strength of successful implementers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Measurement of program success</td>
</tr>
</tbody>
</table>

The findings are presented firstly as a diagram that is used to show the criteria and sub-criteria. The issues are then illustrated by using the transcripts from the interviews with the stakeholders undertaken to analyse the program delivery mechanism. The analysis is focused on the implementation mechanism, technical status of SHS, financial mechanism, social and environmental aspects of the program, barriers to program success and adaptation of SHS, policy and views on the degree of success or failure of the program.
5.3.3.1 Implementation mechanism

The program implementation criteria relate to the institutional approach, technical performance and training and maintenance and monitoring of the systems (Fig. 5.17). Each of the sub-categories is subdivided into concepts noted from the transcripts of the stakeholders’ interviews. The comments from the respondents are shown in Annex 5-II.

Institutional approach

Although the approach used in the Fiji SHS program is commonly referred to as a RESCO program, both within the literature and officially, this is not an accurate descriptor of the program. An ESCO or RESCO sells energy services, but retains ownership of the system. That is, the hardware is neither sold nor leased. This type of program supports the formation of a local company that could supply energy services (Karekez & Kithyoma, 2002).

The program was initially designed on the basis of the RESCO approach and a private company has been established to take on the responsibility for maintaining the systems. Currently, however, all responsibility for monitoring and maintenance remains with the Department.
This is reflected in the comments made by some respondents. The respondents stated that DoEF is looking after the program and did not delegate any responsibility on the service company. Respondents also feel that there is a need to set up a genuine RESCO operation. There is lack of skilled people and company which makes difficult to choosing a RESCO for the program. Government was reluctant to handed over the responsibility of the program to a private company until it was sure whether the company had sufficient technical, financial and managerial experience.

On the other hand private companies have different views. They are not willing to enter this area of business as they perceive there to be very high risks involved in this business and they are not sure on the return on investment. There is no incentive for the companies from the government for implementing these RESCO program. Also
Government wants overall control on the program, which conflicts with the RESCO approach.

The stakeholders of the program think that the approach of the program is not a true RESCO and there is a need to make the program include other stakeholders. Initial program objective was to determine whether or not a SHS program could be made to work in Fiji and, if so, to use a SHS to provide electric lighting to households in remote parts of the country. The first objective was realised. It is questionable whether the second objective has been fully achieved as almost thirty percent of systems are not working now for a variety of reasons.

The range of system sizes offered though the program has influence on the program. Only one size SHS is provided through the program - 100 Watt system with three fluorescent lights and one radio point. This is because the program implementers themselves perceive the value of offering a range of system sizes suited to users’ needs, but that they are reluctant to do so to avoid overstretching their resources, increasing their work loads or creating problematical system quality compliance issues. Another reason is a part of the Fijian culture is to offer uniform service for all rather than to differentiate on the basis of household income.

**Maintenance and monitoring**

The comments from the stakeholders on maintenance reflect the difficulty and dilemma for government in attempting to encourage private company partners to develop capacity to participate in the program. According to the respondent, the number of solar systems is very low still which makes hard to make any profit from the maintenance job for a company. The more the number of system increases the more cost effective it will be. At the moment they are not really concern about the cost
effectiveness of the program. DoEF did not have any field offices or outlet in the remote areas where the system exists. The time required to reach at the program areas from DoEF office are minimum two days.

Government wanted to hand over the program to a private company too, but was faced with the problem that no company able to effectively take on this responsibility actually existed. The government, therefore, first had to facilitate the development of such companies. Very few companies in Fiji are capable of taking on responsibility for maintaining SHS and it was not until July 2007 that a company, RES Ltd, was offered a three years contact from the government to provide SHS maintenance support.

**Technical performance of the installed system**

The batteries of most of the systems installed in the households that were surveyed had been topped up with distilled water and a small amount of maintenance had been undertaken on the systems. Eighty percent of the systems were found to be operating well. A report compiled by the maintenance company, however, on the condition of solar home systems after taking over responsibility for maintaining the solar home systems in late July 2007 indicated that approximately 30% of the systems at the time were faulty in most of the villages and that in some cases (Vusasivu phase I, Nabunabu, Lea and Korokadi East) over 50% of systems were faulty. Those villages with a higher proportion of faulty systems tended to be located furthest from a maintenance company’s office and some of these villages had not been visited by the company’s maintenance technicians for between 8 and 12 months.
Figure 5.18: System status in Fiji as of August 2007

Source: RESCO limited (2007)

In the case of one village, Nadua, the systems had been installed by a company that had no experience in PV installation. None of the 15 systems installed were working during the company’s survey. According to the manager of the RES limited, excessively long wiring that had been which reduced the power output, and the panels had not been installed with the correct orientation or tilt.

Most of the faults that were found in the installed systems were aroused due to lack of maintenance. There is a need to pour water in the battery at least every three months for the climatic condition like Fiji. If this was not done the battery gets dry and can be burst. During the survey one battery was bursts in one house but no one was at home that time. Also the battery terminals were not cleaned and many battery problems are caused by dirty and loose connections. Another problem of replacing the faulty items is that the maintenance company need to wait for decision from DoEF to replace battery or light or to perform any types of maintenance works. This makes the process of maintenance lengthy and expensive.
Training

No ongoing training for users has been provided under the current program structure and users had not received any training on how to use and maintain their systems from either the supplier or the DoEF. DoEF does not want the users to do any maintenance work. Since the users do not have any training or instruction on how to use the system, system failed due to overuse or not having any regular maintenance. Major weakness of the program has been system failure and lack of maintenance.

Training and maintenance are at the heart of the solar program and it is apparent from interviews that most system faults occurred due to a lack of training of system users. The interviews also highlighted a need to train locals in order to provide maintenance support. Providing training or user’s manual showing the Do’s and Don’ts would help to minimize maintenance cost and would increased the sense of ownership of users and hence there willingness to take on responsibility for system maintenance. Program implementer recognises that training to the users and potential technicians is very important but claimed that they have not been given the budget for that.

5.3.3.2 Financial mechanism

The program in Fiji is financed by the government. Ninety percent of the capital cost of rural electrification is borne by the government and only 10% by the villagers. An initial survey prior to program implementation was undertaken to determine the affordability of systems for users, but the costs of kerosene and benzine have increased significantly since the pre-program survey and users are now paying more for these and so could afford to pay higher monthly fees for their SHS. Figure 5.19 shows the concepts of the financial mechanism that found from the transcripts.
Figure 5.19: Stakeholders’ views on the issues and factors that need to be considered in selecting a suitable financial mechanism for SHS programs in Fiji

**Funding**

The availability of funding has been publicized as a major problem for the renewable energy electrification program. The upfront cost of the systems is very high. Major funding source for Fiji program is JICA. Some of the systems are from French grant. UNDP provided technical training to the DoEF personnel. Initially the program was started with donor fund. Later on the government allocated fund for rural electrification. The fund contributes for providing the cost of the equipment, implementation, and operation cost of the program.

Government did not have knowledge on design such programs, but realising the importance of the solar program, they started the program with association from PITCHR.
Cost recovery

The current monthly fees are A$11 out of which A$0.40 is taken by the post office as a fee and the rest is used for maintenance purpose. The fees were determined based on the affordability of the users and not on recovery or replacement costs. Current tariff only support operation and maintenance cost and some portion of the spare parts cost. If the fees were to reflect the actual cost it would be almost double to current monthly fees. Respondents said that the level of subsidization of the renewable energy electrification program was generally set by a political rather than by an economic agenda. Some respondents indicated that they believe that this has had an impact on program success.

Also the recovery is not regular because some people didn’t buy the card. The number of users that have paid for a code is collected from the report sent by the post office to the DoEF. It is difficult to locate the customers who did not buy the card for that month as there is a lagging of three months to receive the data by the DoEF. In theory, if a household fails to purchase a card for three consecutive months then the household is disconnected from the system. However, it is difficult for the DoEF to implement the rules as the information is not received by the DoEF in a timely manner. This has an impact on the DoEF’s maintenance budget.

The Fijian culture makes it difficult to collect monthly charges from individual households. In the case of the SHS program, it is made more difficult by the fact that people go to other people’s houses so that they can use the electric lighting for study or work. That is, SHS are treated as communal property rather than as private property. It is also difficult for some people to pay an amount for the SHS that is greater than they paid for kerosene before they had as solar system.
In a few cases where, the post offices are distant form the village, the DoEF appoints the Village headman to collect the money and to sell the codes to the users. This approach, however, is not always one hundred percent successful. There is no memorandum of understanding signed between the village headman and DoEF on how the money will be collected later on or other terms and condition for selling the code to the villagers. As there is no memorandum of understanding (MOU) it is sometimes difficult for DoEF to collect the money timely way. According to the village headman DoEF personnel did not come to take the money within last one year, and he had to keep the money in a butter box.

**Economical perspective**

Before the program was implemented, the DoEF undertook a survey of rural communities to determine the type and amount of fuel being used in these communities, and the amount of money spent on kerosene and other fuels. Based on this information, the DoEF calculated the amount of kerosene that a SHS would displace, how much the household would save on kerosene and then used this information to calculate what monthly charge would make the SHS competitive with kerosene. However, many now recognise that this approach was inadequate.

The reason is that the consequences of not having light relate to comfort in this life, but this is less important than ensuring what happens to them in after life. Regarding income generation activities, there are no income generation activities available. People like to leave comfort life. They do not want to work hard as they are happy whatever they have in their life. This makes difficult to build a program based on credit where the users become owners of the system.
Social and environmental aspect

The SHS is well accepted by the users and user satisfaction is high. The monthly fee of A$9.7 does not appear to be a great burden on the majority of the surveyed households. This is confirmed by the manager of the company, RES Ltd., who is directly concerned by customer complaints. The notion of service is largely accepted and the package provided by DoEF (high quality equipment) and the RES (good maintenance service) is assumed to be consistent with the monthly financial contribution. Figure 5.20 shows the social concepts from the transcripts.

Figure 5. 20: Stakeholders’ views on the primary issues that influence the social outcomes of the SHS program in Fiji

User’s behaviour

The solar electric service is now considered as reliable, comfortable and economically competitive with traditional energy sources (kerosene, dry cell batteries or portable petrol gensets). According to the users this program not only offers lighting but also lots of benefits like changing in-house environment, children can study at home with clean light etc.
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The main complaints concerned the inflexibility of the service and the necessity to go to a post office to purchase an activation code. A significant portion of customers claimed to be prepared to pay higher fee for having a larger system.

Some villages that are especially isolated complain about difficulties in going regularly to the post office, which can take a full day and increase the cost of the system by adding a substantial transportation cost. The respondents of the survey have the following view on the impact of the program.

In summary, it was found that most users are happy with the system. Some are even prepared to pay higher monthly fees for a bigger system. In general, the people in the Pacific did not have to work hard and they prefer an easy life. They even complaint about the distance of the post office for buying the activation code.

**Satisfaction levels**

The objective of the current rural PV program in Fiji was to provide electricity to communities and PV systems are not the only means of doing so. The usual fuel used to get better light was white benzene, which is no longer as readily available and has increased significantly in price due to high production cost. White benzine is commonly used for lighting in the Pacific countries only. Rural households have no other choice but to use kerosene lamp instead.

People are happy to have the systems. According to them now they can gather for a social discussion in the community centre and enjoy the light, drink and discuss their issues and problems. Solar lighting makes it easy for the people to stay longer time than before. They did not have any complaints about the system as the people of Fiji are very peaceful. Children have better light for studying at night and people can do
their activities when the lights are on that they couldn’t do with kerosene or benzene lamp.

### 5.3.3.3 Policy and its effect on the program

Interviewees were asked about their opinion on the current policy and its effect on the program. Respondents recognised that energy policy does include clear statements about renewable energy and explicit energy targets, as well as short, middle and long-term tasks which will change as a result of the lessons learned from current program. Figure 5.21 shows the criteria and concepts extracted from the transcripts of the policy.

![Figure 5.21: Stakeholders’ views on the primary issues and factors influencing rural electrification and renewable energy policies in Fiji](image)

**Rural electrification policy**

The two key elements of the current rural policy are uniform tariff and the subsidization policy. Regardless of the actual cost of electricity production, all customers are charged the same rate, 22 cents per kWh, which is the same tariff charged on the main grid on Vanua Levu. The government also has a policy that...
irrespective of the type of electricity generation system used, the government provides 90% of the capital cost of the system and the community provides the other 10%. The Government, however, has only limited funds available for rural electrification and this subsidy limits the number of villages that the Government is able to assist in this way. There is no specific renewable electrification policy in Fiji. A draft policy was prepared but has not been approved.

Lack of actual policies on renewable energy or rural electrification implies that government is in a dilemma on rural electrification. The old policy has some parts on rural electrification, but the stakeholders feel that the policies need to be changed and that is why they submitted a new draft policy.

There is a rule that rural electrification will be placed where the power utility never goes. Government in a way tries to put a sort of plan and policies. But still there is no specific policy so far. Demarcation between the grid and the renewable energy promotion helps the implementers to achieve their goals. This also helps in planning for future and makes the program sustainable. The FEA is committed to spend certain amount for rural electrification each year. But if fuel price goes up, then they are not able to do it. But sometimes if they do not have enough profit then they apply to government to wave this amount to be deposit to government rural electrification fund.

The Government wanted to electrify all the areas with any sorts of power in future similar with rural electrification program in the USA and Australia. But the policy for getting the electricity is same for diesel, solar, hydro, grid extension. Also government does not have funds for this and so FEA needs to allocate some fund for rural electrification every year. Another area where respondents believe policy need to be focused is on country’s specific needs. In Fiji people need basic lighting in the
evening and community lighting is much preferable. They have different culture and needs. Therefore, system design needed to be customised by considering the cultural issues and willingness to pay of the users.

In summary, policy plays a major role in designing the rural electrification program specially using renewable energy technologies. Depending on the priority of the users and government policy rural electrification using solar PV/wind/hydro technologies is needed to be designed.

**Lack of Policy**

The rural electrification program in Fiji suffered due to lack of Government policy. Specific policy on rural electrification is another issue which needs to be addressed while developing RE electrification program. Government feel that it is not possible to reach each household by conventional electricity and so this project considered being a good option to provide electricity to remotest areas. To do so, there is a need of a specific policy because each technology is different and the capital and operational costs are different from one on other.

According to the respondents rural electrification policies in Fiji did not mention anything specifically on renewable energy technologies. Sometime policies are there, but there is a need to follow up the policy and implement it. Policy also needs to be revised and improve every two years which is not happening in Fiji.

Policy is important but implementation of the policy is much more important. There is a need to revised and improve the policy in regular manner. Government also need to be aware about their commitment while designing the tariff. Political interference is setting the tariffs; therefore, tariff did not reflect the cost of the program or based on the affordability of the users.
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**Political Situation**

Like most developing countries, Fiji has experienced political unrest and instability. This affects all development programs as prove by the statements of the respondents (Annex 5-I).

Policies are changed with changing the government. Before the current political situation, the previous government announced the 100% duty waiver for the solar systems to encourage the utility for using solar. But that was stopped after the current government take over the charge. This is also very common in other developing countries. Policies created by one government can change with a change in the government.

**Bureaucracy**

Excessive bureaucracy can make the program unstable. If the government changes the policy frequently, it affects the program implementation. The Fiji program has been affected by the bureaucracy system. It make difficult to engage a private company because it the company has to deal with a lot of processes with the Government and the process is also not fast. Therefore, private companies are not keen to take charge of the program.

DoEF itself is also facing problems while providing contracts for maintenance to private companies as the whole process was taking 1 to 2 years. But again if from the beginning of the program everything was decided and if there was a suitable timeframe submitted to the government, these types of problem can be resolved.

**5.3.3.4 Reasons for slow uptake of the program**

The main problem the program implementer has encountered is maintenance and monitoring (M&M). There was no regular maintenance service for the last two years
(2005-2007) although the implementer recognises the importance of M&M. Figure 5.22 shows the criteria used by the respondent as the reason for slow uptake of the program. The respondents were asked about the barriers they encountered during design, implementation and post operation stages.

Some respondent articulated data management as a barrier as this enable revenue to be increased. The amount of the households not buying the card is as high as 30% in some villages. Since there is no monthly report on how much revenue is collected and how many households are not purchasing the card, it is hard for the DoEF to get a clear picture. The revenue collected is used to pay the maintenance companies fees and purchase the spare parts. The DoEF also realises the problem.

The political situation and bureaucracy are other barriers for these types of programs as mentioned earlier. Changing the policy frequently causes problems for long term planning.

In summary, the major problem encountered by the Fijian program is due to lack of M&M. The reason for this is partially policy and partially lack of resources. It is hard
to get a company who are capable of doing the work within the budget proposed by the DoEF. They tariff that was set while designing the program does not reflect the actual maintenance and replacement cost which create problems to appoint an M&M company.

5.3.3.5 Views on the degree of success of the program

The question was asked to the policy makers, implementers (DoEF), and the maintenance provider on their opinion on the successfulness of the program. Figure 5.23 shows the criteria program success and the concepts derived from the transcripts.

![Program Success Diagram](image)

Figure 5.23: Stakeholders’ views on the issues and factors influencing program success in the Fiji SHS program.

There is self learning by DoEF from the mistake that had been done during the past installation. There is no users training built in the program design. The users training are very important. Because, the people did not know why their light is not working? They only appreciate that the light should there all the time.

In Fiji if the money is collected regularly, it would be able to cover the cost of operation, maintenance and replacement of battery, light and charge controllers. The
previous fees were F$18. But now the fees are F$14. So, more users are needed to make a sustainable maintenance program. Also there is no scheduled maintenance and monitoring system or near-by offices that could looks after system. These make the program unstable.

Limiting factors
In response to the question on limiting factors, it comes out that people consider that they know the things that are wrong with this program. The implementers understand that there is a need for regular contact with the users. The people should be well informed on what the system is able to provide and what not. Regular contact with them and telling them what is happening is very important.

Specific policy is needed for this kind of program. There should be a clear implementation rules and regulation

In summary, program success depends on the regular maintenance and monitoring support, regular revenue collection, creating customer awareness on system use, regular contact with the users and informing them about the situation on replacement parts, and last but not least, specific policy and its implementation.

5.3.3.6 SWOT Analysis on planning Solar Program in Fiji
From the focus group discussion with the implementers the strength, weakness, opportunities, threats (SWOT) and the probable actions on the program implementation and planning were developed (Fig. 5.24).
Table 5.3 indicates that the problem arises during the program implementation can be solved by taking the probable actions. This table was summerised based on the discussion with the program implementers. The stakeholder whom could play a role of taking the actions was not clear as the project is conducted by the Government.
Table 5.3: Probable actions against the weakness and threats of Fiji SHS program

<table>
<thead>
<tr>
<th>Problems</th>
<th>Probable Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of Finance</td>
<td>• Budget all activities well Look for loans and grants</td>
</tr>
<tr>
<td></td>
<td>• List responsibilities and make action plan. Coordinator of the program is responsible to make the plan</td>
</tr>
<tr>
<td></td>
<td>• Look for loans and grants to develop projects</td>
</tr>
<tr>
<td></td>
<td>• Approach funding agencies with new plan</td>
</tr>
<tr>
<td>No management skills</td>
<td>• Develop managerial skill within the program implementers</td>
</tr>
<tr>
<td></td>
<td>• Arrange training to develop skill</td>
</tr>
<tr>
<td></td>
<td>• Develop proper system maintenance through a plan for a new MIS software</td>
</tr>
<tr>
<td></td>
<td>• Active participation from all stakeholders to find the best way of providing SHS</td>
</tr>
<tr>
<td>Government policy for rural electrification</td>
<td>• Plan for local offices</td>
</tr>
<tr>
<td></td>
<td>• Revised policy regularly</td>
</tr>
<tr>
<td></td>
<td>• Develop policy for local entrepreneurship development</td>
</tr>
<tr>
<td>Irregular maintenance and monitoring program</td>
<td>• Develop local technicians</td>
</tr>
<tr>
<td></td>
<td>• Develop training program on M&amp;M for both users and technicians</td>
</tr>
<tr>
<td></td>
<td>• Design regular maintenance scheme within the program</td>
</tr>
<tr>
<td></td>
<td>• Look for funds for capacity development</td>
</tr>
</tbody>
</table>

The strengths of the program are that there is an ongoing fund for this program from the government now and also people are willing to pay for the system. They can plan all activities based on the budget available. They also can plan for a MIS system to manage the program finance.

The weaknesses of the program were insufficient finance, inadequate management skills, no MIS system available and also lack of technical skills. This can be addressed by looking for new grants or loans for the SHS components, and capacity development.

There are opportunities to develop new local manufacturers which will help to reduce the cost of the system. But at the same time this may create threats for the program if the components are not reliable.
5.4 Discussion

The criteria of successfulness of a solar electrification program have been analysed in two parts in the above sections. The first part analysed the impact of the program on the users and on the user’s attitude towards the way in which the program implemented. The second part analysed the program was implementation approach, financial approach, policy and problems faced in the program implementation.

5.4.1 Program Impacts Analysis

The users of four villages were interviewed to find the impacts of the program. The impact were analysed on energy access and uses, social impact, economical impact, management and ownership, environmental impact and gender impact. Table 5.5 shows the outcome of the survey on level of the issues.

These results show the impacts of the program on social issues are positive. Women also get benefit from the system. Most of the respondents regarded their programs as having increased their quality of life. They also agreed that their SHS has increased opportunities for engagement in social activities and in an increase in relaxation hours for men and women. Fifty eight percent agreed that their SHS has increased working and study hours as they did not work after dusk.

Most users did not agree that SHS helped their economic activities. Before the system was installed, the average household expenditure on kerosene per month was A$17.63, and the median amount was A$13.04, with a relatively small number of households having significantly higher use. After getting the SHS the amount spent on electricity was A$9.50, which is lower than the median.
### Table 5.4: Survey outcome based on success indicators

<table>
<thead>
<tr>
<th>Variables</th>
<th>Indicators</th>
<th>Survey outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy access and uses</td>
<td>- Access to better and clean light</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Switching from traditional fuels</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Access to information becoming easier</td>
<td>- Not agreed</td>
</tr>
<tr>
<td></td>
<td>- Working and study hours increase</td>
<td>- Not agreed</td>
</tr>
<tr>
<td>Social Impact</td>
<td>- Quality of life increase</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Increase number of hours for relaxation</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Increase in listening radio/ watching TV</td>
<td>- Not agreed</td>
</tr>
<tr>
<td></td>
<td>- Increase status</td>
<td>- Not agreed</td>
</tr>
<tr>
<td></td>
<td>- Increase social activities</td>
<td>- Agreed</td>
</tr>
<tr>
<td>Economical Impact</td>
<td>- Monthly expenditure on energy decrease</td>
<td>- Not agreed</td>
</tr>
<tr>
<td></td>
<td>- Changes financial status of the users</td>
<td>- Not agreed</td>
</tr>
<tr>
<td></td>
<td>- Repayment amount is a burden</td>
<td>- N/A</td>
</tr>
<tr>
<td></td>
<td>- New employment opportunities</td>
<td>- Not agreed</td>
</tr>
<tr>
<td>Management and ownership of the</td>
<td>- System maintain by the users</td>
<td>- Not agreed</td>
</tr>
<tr>
<td>program</td>
<td>- Easy to operate</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Receive training on maintenance and monitoring</td>
<td>- Not agreed</td>
</tr>
<tr>
<td></td>
<td>- Distance to closet local service centre</td>
<td>- too far</td>
</tr>
<tr>
<td></td>
<td>- Costs of maintenance</td>
<td>- N/A</td>
</tr>
<tr>
<td></td>
<td>- Spare parts availability</td>
<td>- N/A</td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>- Battery recycling available</td>
<td>- yes</td>
</tr>
<tr>
<td>Impact on quality of life for</td>
<td>- Women get more free time</td>
<td>- Agreed</td>
</tr>
<tr>
<td>women</td>
<td>- Women’s work load is reduced</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Familiar with new technology</td>
<td>- Agreed</td>
</tr>
<tr>
<td></td>
<td>- Can do income generation activities after dusk</td>
<td>- Not agreed</td>
</tr>
</tbody>
</table>
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The users still think their expenses are increased. The reason for this is, before if there was shortage of money for spending on energy, people wouldn’t buy kerosene for that day. But now, they have to spend a fixed amount of money to buy the card every month.

The user did not receive any training on how to use the system or how to maintain the system. So there is a lack of ownership of the program by the users. Users always think the system is given by the Government and, if any problem occurred the government would take care of that. This impression among the users makes the program vulnerable in the long run.

5.4.2 Program Design Analysis: Is it a RESCO approach?

The concept of RESCO did not support the Fiji program. The program also relies on donor-supplied capital equipment to get started and therefore is not commercially replicable. Another criterion of the energy service company model is module, controller and battery are owned by the company; other components are owned by the customer, but in Fiji case it is all owned by the Government.

The system size was determined based on the survey done before implementing the program. There is no choice for the users, even if they need less or more light and even if they can afford it. The implementer at this stage is not ready to provide different types of systems.

Current maintenance and monitoring is the weakest part of the program. Maintenance is an important part of the SHS program. It is important to assure the maintenance service to establish long-term credibility of the technology. The quality of panels and PV-related hardware has been more or less well-established, though the reliability of locally produced hardware, such as charge controllers, may have to
be established. Even where reliability has been established, it is strongly influenced by maintenance, hence the need to focus on reliable service as a goal to establish long-term credibility (Martinot, Cabraal, & Mathur, 2001).

Training is an important part of the SHS program. Inadequate education and training of households led to technical failures and declining use subsequent to each new program (Martinot, 2002). The literature also supports the needs for training the users and local people. User’s satisfaction with solar home systems also depends on the user education provided by program administrators, technicians, and suppliers (Cosgrove-Davies & Cabraal, 2000). The education program should cover routine maintenance procedures such as watering batteries (including how to collect clean rainwater if distilled water is not readily available), interpreting control panel information, managing loads, solar access, and replacing fuses and bulbs. User’s education should also make clear the capabilities and limitations of the particular solar home system.

The financing for the program is provided by the Government through a service agreement. Users pay monthly fees to the Government through purchasing a meter code from the post office. The payment goes for the maintenance and monitoring service, and administration cost of some staff. Capital cost and spare parts cost are not covered by the monthly fees.

Collecting revenue is a very important part for the program to be sustainable. From the above discussion in section 4.2.2, it is clear that revenue collection is a problem in the Fiji Program. To provide the maintenance support it is necessary to keep the revenue money flow. DoEF admits that the funds collected from the users’ fees are not sufficient to provide maintenance contracts and component replacement, despite a fee
collection rate above 85%. The rate of collection of fees strongly correlates with system reliability, customer service and the disconnect policy for non-payment. There does not appear to be a correlation between the rate of fee collection and the method used to collect fees.

So basically, Solar Home Systems (SHS) are one way of providing electricity to non-electrified and under-electrified rural households to contribute to the overall goal of improving quality of life. From the Fiji program the following benefits have observed:

- better quality of life, for example, health benefit, such as clean kitchen lighting, better quality of light for reading and studying
- providing electricity in an environmentally benign manner in a world increasingly alarmed by global climate change.
- providing safety with the space lighting which provided lights from dusk to dawn.

Renewable energy, especially PV electricity, is still expensive for the very poor. One of the limitations of the current program is does not have a long term view. The batteries need to be replaced after 4 years and the battery cost is F$240. But there is no allocation of the money to replace the battery for each system after 4 years. In Fiji, they have to import all the equipment from abroad and duty waived on solar systems could save on the cost of purchasing the equipment.

Funding is another major problem for the SHS program. In Fiji the government decided that for any kind of the rural electrification system to give a subsidy of 90% and community will pay 10%. But the Government has shortage of funds, so very few
villages have got this opportunity. The Fiji Electricity Authority (FEA) is committed to spend certain amount for rural electrification each year.

Policy and its implementation is also requires attention. In Fiji, the Government does not have any specific renewable energy policy. The rural electrification policy is a part of national energy policy.

According to the literature some of the key barriers are given below. Some of the key barriers usually addressed through off-grid solar PV programs (E. Martinot, 2003; REIN, 2006; Renewable Energy Information Network, 2006; Luis Vega, 2004; Wallace, 2004) are:

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

But in the Fiji case, the main barrier is to provide the maintenance and monitoring. The second barrier is lack of political commitment and lack of implementation of the policy. Other barriers are same as mentioned in the literature, lack of experience of regulating and implementing the program. The barriers found in the Fiji case could be removed without increasing program costs.
It is very difficult to find the factors that contribute the program success because all the factors are mutually connected. In the Pacific region, the most successful programs are in Kiribati. Literature mentioned (Johnston, Vos, & Wade, 2004) that in Kiribati the policy for RE is remained its place for long time. The government own Solar Energy Company and is committed and enthusiastic and so they work very hard to make the system work. This makes the program successful. They also make the charge controllers by themselves. So it is sustainable in the sense that there is enough money to cover the system operation and other costs except the solar panel cost.

So, based on the above findings the following could be selected as the factors for a successful project:

- Develop awareness on the SHS among the community and willingness to pay for the this service
- Design the tariff based on the monthly expenditure for operation and maintenance. So the tariff should cover the maintenance cost
- Arrange sufficient training for people for operation, maintenance, and management of the program including financial management for the systems
- Set up a mechanism to ensure the availability of the spare parts like lights controllers, batteries at local areas
- Also there should be proper monitoring systems available under the program mechanism. Ensure the quality service and good technical systems.

There is a need of local expertise to develop some components. For example, in Kiribati they make their own controllers. So, it need to be noted while designing the
system that the specification of the system should comply with country’s needs and resources. The component should be standardized and easily available.

Most of the above mentioned findings are supported by the literature also. Chung (2004) mentioned that the critical success factors of rural electrification are stable system operation and maintenance, a strong sense of ownership, a self-reliant tariff scheme, equitable access and encouragement of productive activities.

### 5.5 Summary and conclusions

Fiji SHS program started in the year 2000 and around 700 systems were installed up to August 2007. The impacts of the program on social issues are positive. Most problems that have arisen in the Solar Home Program in Fiji appear to be attributable to institutional rather than to technical issues. Furthermore, most of the technical problems that have occurred have been caused by lack of system maintenance. The following are the summary of the above analysis.

- The company with the current contract to provide maintenance services for the solar home program, RES Ltd, is effectively a monopoly service provider as no other companies are interested in undertaking this type of work. As an officer from the Department of Energy explained, “Fiji’s experience with solar home systems began in 2000 and so far only two companies are able to install the systems. The private sector does not have the capability that we require yet”.

- Both of two companies that currently offer to provide this service lack the resources required to provide the technical support required by customers. Neither company has a portable battery charger in either remote sites or in their local offices. One of the companies has a battery charger in its head office but this charger is capable of charging only two batteries at a time. Having their
batteries recharged can therefore take customers several days as they need to take their batteries to the company’s head office, leave them to be charged and then return with the charged batteries to their houses or businesses. The companies do not have site offices nearby to customers’ homes and even to pour the battery water customers have to go to and from the head office. This makes the task of maintaining the systems onerous and time consuming for both customer and RES.

- Another major problem is the lack of availability of spare parts. The RESCO does not even stock spare batteries at its head office. If maintenance technicians find equipment is faulty when they are visiting a site, they return to the head office and send a list to SUVA office of the Department of Energy. The Department then sends out the equipment. The length of time between finding the fault being found and the equipment being replaced often takes 2 to 3 days, but can take up to a month if the DoEF does not have the equipment in stock and has to call for tenders for the supply of the parts. During this period, the customer is required to pay the monthly fees for the system regardless of its condition.

- The maintenance company offers low salaries to the technicians which imply that they cannot afford to employ qualified technicians, while the short term contracts mean that it is also unable to offer permanent positions to staff.

- Due to the relatively low numbers of customers, the cost of providing quality service per customer is high. The maintenance service fee that customers are charged is too low to cover the costs of both maintenance and spare parts.

- Most of the qualified people go to work in the city and doesn’t stay in the village. So it is a very difficult job to create local technicians to handed over the
maintenance job. There often is a high turnover of field technicians and a continuing recruitment and training program is necessary where there is large scale implementation of SHS. Also better incentives are need to make the job attractive.

- A significant proportion of systems (5% from the survey sample) have suffered from misuse of the batteries. This misuse of systems is caused by a number of factors, one of the primary ones being that because the systems are owned by the government, users tend not to regard the systems as their own and this increases the incidence of misuse. This is amplified by the lack of a system monitoring program. As systems fail, this is not detected quickly, and this reduces customer satisfaction. As system misuse is correlated with customer dissatisfaction, this further exacerbates the problem.

- The government provides customers with new lamps when their lamps burn out. Under a service type of mechanism, lamps would be the property of the customer rather than property of the service providers, as is the case with grid connected systems. The DoEF also needs to purchase new batteries every three to five years, depending on the status of the battery. Because the DoEF needs to source funds to purchase new systems as well as provide new parts for existing systems, this puts strain on its resources and makes the program vulnerable.

- Another factor impacting on the success of the program is the frequency of the fee collection. This strongly correlates with system reliability, customer service and the disconnect policy for non-payment. The use of prepayment meters for solar implementation has not resulted in high rates of collection. According to the RES manager, this has increased initial cost, lowered system reliability and increased maintenance costs. Locally manufactured electronic components
(lights, controllers and DC/DC converters) can provide high reliability service if the design is attuned to local conditions and quality control is maintained. Many users did not refill their cards and there was a lack of information on how many systems were in use. In some cases, although no one had lived in the house for a long period and the DoEF had not been collecting fees for those systems, the system had not been removed. This indicated the lack of an effective disconnect policy. Furthermore, fees were not reviewed and adjusted frequently to take account of the increasing costs or changing conditions. This area need to be scrutinized for the success of current program.

- External supervision of local technicians is necessary for quality maintenance, and DoEF has been trying to do that by sending people from Suva. This is very time consuming and there is no monitoring of these people, whether they are doing their job or not. There appears to be a direct correlation between long term program success and the level of input of the private sector in operation and maintenance of SHS.

In summary, the solar program in Fiji suffers from lack of planning and policy. The problems occur due to lack of maintenance support and policy. It is not a full RESCO program as the program is totally run by the Government and there is no service company who is responsible for the program. Government has not been generally successful in providing quality after sales support of the PV rural electrification program. DoEF is trying to develop the local companies. But there are shortages of qualified companies and people also.

Overall, the program concept was good but it needs proper planning and implementation to make this program successful. There is a need to develop proper monitoring systems under the program mechanism and ensuring quality service,
quality components and implementation of the policy. Policies are ineffective unless supported by suitable institutional mechanisms and unless the resources for enforcing the policies are in place.

In fact solar systems could be maintained by the users if proper training could be provided. There is a need for local expertise to develop some components locally and overall need to develop and placed policy on renewable energy systems.
Chapter 6

Solar PV Program Analysis – Bangladesh Case Studies
Chapter 6 – Solar PV Program Analysis – Bangladesh Case Study

6.1 Introduction

In this chapter is the results of the survey used for the second case study of a Solar PV Program, the Bangladeshi program are presented. The field survey was undertaken over the period October 2007 to December 2007. As with the previous case study, the purpose of the survey was to obtain a better understanding of the political and institutional framework within which the program is implemented, the approach used and the outcomes of the program in terms of the benefits for users.

Bangladesh was chosen as a case study because the literature review revealed that the Solar Home System (SHS) program being implemented in Bangladesh is probably considered to be a highly successful program. This view is supported by the international awards that have recognised role that the program has played in providing large numbers of rural people in Bangladesh with electricity for lighting and other purposes. These include the Eurosolar Prize in 2003, the Ashden Award in 2006, the Right Livelihood Award (Alternative Nobel Prize) in 2007, and the Ashden Award again in 2007.

The Bangladeshi program is large in terms of the number of people that participate, the number of organisations involved in the implementation of the program and in term of geographical coverage. These factors indicated that using Bangladesh as a case study would be difficult as the number of participants and organisations surveyed would need to be large and the need for travel within Bangladesh high. It was possible to include Bangladesh as a case study, however, because the researcher is a Bangladeshi national who has worked on Solar Home System programs in the country. This removed any difficulties that would have been otherwise caused by a
lack of knowledge of the culture, the geography or knowledge of the agencies administering renewable energy programs in Bangladesh.

As with the Fiji case study, this chapter is presented in three parts. Section 6.1 provides background information on the geography, climate, demography and the energy situation of Bangladesh. Section 6.2 provides a summary overview of the current SHS program. The results of the survey undertaken in 2007 as a part of the research are presented in section 6.3. A similar approach to that used in Chapter 5 is then used to explain the results of the survey in section 6.4.

### 6.2 Background information on Bangladesh

Bangladesh is located between $23^\circ 34'\text{N}$ and $26^\circ 38'\text{N}$ latitudes and $88^\circ 01'\text{E}$ and $92^\circ 41'\text{E}$ longitudes (WorldAtlas, 2008). Bangladesh is surrounded by India on west, north and north-east and Myanmar on the south-east and the Bay of Bengal on the south. The total area of the country is 144,000 Sq.km (WorldAtlas, 2008). Figure 6.1 shows the map of the country.

Bangladesh has a sub-tropical monsoon climate. Winter temperatures range from a minimum of 7.22 - 12.77º C to maximum of 23.88 - 31.11º C. The maximum summer temperature recorded range from 36.66 to 40.55º C (SNDBD, 2008).

The country is divided into 6 divisions (regions): Dhaka, Chittagong, Rajshahi, Barisal, Sylhet and Khulna (Fig. 6.1). Each division is further split into districts (Zila), which are then further sub-divided into thana, unions and villages. There are 64 districts 490 thanas, 4,451 unions and 59,990 villages. Most of the houses in the rural areas are dispersed and are not readily accessible.
6.2.1 Demographic information

According to the most recent census, the population of Bangladesh was estimated to be 138.1 million in 2004. The population density at the time, 959 people/km², made it the most densely populated country in the world (BBS, 2007). The vast majority of the population (80.2%) live in rural areas (BBS, 2007), and the rural population is relatively evenly distributed throughout the 64 districts, with the eastern districts

having slightly higher population densities than the western ones and the three Hill Tracts districts in Chittagong being less densely populated. The average population of a district is 1.8 million, a thana 230,000, a union 25,000 and a village 2,000. The total number of rural households is approximately 20 million and the average household size is 5 persons.

6.2.2 Economic information

The country’s economy relies on mainly agriculture, forestry, fishing, mining and manufacturing. In 2004-2005, the per capita GDP of the country at current market prices was approximately 27061 BDT or US$ 440 (1 US$= 61.39 BDT) (BBS, 2007). Average annual growth in GDP over the last 5 years was over 5% during. In the financial year 2003–04, GDP grew at an average rate of 5.5%, an increase of 20% over the previous year (WB, 2007).

6.2.3 The energy situation in Bangladesh

Commercial energy sources account for about 60% of the total primary energy supply in the country (NEP, 2006). The predominant commercial fuel used is natural gas (around 66%), followed by oil, hydropower and coal (Alam et al., 2004). The recoverable proven and probable reserves of natural gas are estimated to be 20.51 trillion cubic feet (TCF) and cumulative production up to June, 2004 was 5.90 TCF(BBS, 2007). The total gas consumption in 1999-00 and 2004-05 was 8780 MMCF and 12922 MMCF respectively (BBS, 2007, p. 251). Gas consumption has increased over the last six years at an average annual rate of 7.86%. With without any discovery of new gas fields and at this average growth in consumption, current estimated reserves of natural gas could not meet demand beyond the year 2020 (BBS, 2007, p. 244, 246, 251).
Non-commercial energy sources, such as wood, animal wastes, and crop residues, are estimated to account for over half of the country’s energy use. Biomass accounts for about 40% of the total primary energy use (NEP, 2006).

The total installed electricity generation capacity in Bangladesh is 5,245 MW (BPDB, 2008). The country is currently experiencing a critical shortage of installed electricity generation capacity shortages, with 572 MW against load shedding required to meet a peak load of 3,548 MW on as on June 2007. Natural gas is the main source of primary energy in electricity generation followed by furnace oil. Figure 6.2 and 6.3 shows the installed capacity of electricity generation by type of fuel and plant type respectively.

Figure 6.2: Fuel mix in electricity generation in Bangladesh

Source: http://www.bpdb.gov.bd/
Per capita energy consumption in Bangladesh remains one of the lowest in the world. It increases steadily from 10 kWh in 1971 to approximately 40 kWh in 1990 and then quite sharply to 150 kWh in 2005 (Fig. 6.3).  

\[ \text{Per capita electricity consumption decreased in 1989-90 due to massive flooding in 1988 and tornado in 1990.} \]
6.2.4 Available RE resources for electrification

Bangladesh has good solar radiation resources (Fig. 6.4), with daily average solar radiation ranging from 4 to 6.5 kWh/m². Most locations have solar radiation levels between 5.5 and 6 kWh/m²/day. Solar radiation levels reach a maximum during March-April and drop to a minimum during December-January. Even during the monsoon season, due to the long daylight hours, daily solar radiation is close to the annual average.

The combination of fertile soils, high rainfall and high solar radiation means that significant amounts of biomass are produced and biomass is used as a fuel for a wide variety of purposes.

Wind speed data are sparse, although an early study of wind energy potential was undertaken in the 1980s [Hussain et. al 1986] and the Bangladesh Meteorological Department has wind speed measuring stations in most of the towns and cities. Data from earlier measurements indicated that the average wind speed in most areas in Bangladesh is less than 7 m/s, which is too low to make grid connected wind commercially viable [GEF 2001]. The coastal regions of the country, however, have been found to be suitable for the installation of small wind turbines and a number of small wind-PV hybrid systems (two 10 kW systems, three 1.5 kW systems and a number of 1 kW systems) have been installed along the coastal belt. Studies have indicated limited potential for hydro-electric development in the hilly areas of Bangladesh, although the utilisation of wind turbines in these areas is difficult for political reasons.

There are many waterways of various forms with a range of current speeds that provide significant potential for wave and hydro-electric generation.
6.3 Rural Electrification

The Bangladesh Power Development Board (BPDB), the publicly-owned vertically integrated utility, had a monopoly on the generation, transmission and distribution of electricity in Bangladesh until 1977. For economic and operational reasons, the BPDB focused its activities in urban and sub-urban peripheries with the result that it was not an effective vehicle for increasing access to electricity for those in rural areas (BBS, 2006).

A rural electricity program based on cooperatives, or Palli Biddult Samity (PBS), supplying electricity to rural areas was therefore developed. The PBS function under the umbrella of an apex organization, the Rural Electrification Board (REB), which functions both as a quasi-regulator and a program financial manager. It also provides...
a wide range of technical and institutional support to the PBSs and has an excellent track record of project implementation.

6.3.1 Rural electrification policy background

The REB applies an ‘area coverage’ criterion when selecting rural areas for grid extension projects. While this network extension approach has been successful in the past, its efficacy is now being constrained by:

- The higher costs of grid extension in areas with lower load densities;
- Constrained electricity generation capacity which limits the BPDB’s ability to supply electricity to further rural areas; and
- The declining financial sustainability of PBSs as a result of declining availability of subsidies;

While these constraints are being addressed and nearly 400,000 new rural consumers are connected to the grid each year, it has become clear to the REB that alternatives to the grid will be required if the Government’s goal of universal access to electricity by 2020 is to be achieved.

To address the three above constraints, the Government is rationalizing distribution networks by handing over BPDB-operated power systems in secondary towns to the REB in an attempt to increase the efficiency of supply and to reduce the overall costs of electrification. The REB is also applying stricter planning criteria for new lines and is revisiting the revenue and cost assumptions that have governed the area coverage program to date. As a result, off-grid electrification options are now being increasingly promoted.

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3 The general area coverage criterion is 5-10 thanas within a geographical area between 1500 and 2000 km².
To address the constraints on generation capacity, the REB and the Government have adopted a policy of promoting localized power generation based on small, privately owned and operated generation plants that supply directly to PBSs. A number of measures have been introduced to increase the financial viability of PBSs. These include:

- revenue enhancing measures, such as actions to transfer pocket areas and critical load centres from BPDB;
- debt restructuring in the form of increased grace periods or adjustment of debt against grants;
- selective investments that could enhance revenue and performance profiles; and
- encouraging productive uses of electricity in order to increase electricity demand and thereby increase the financial viability of the electrification projects.

In 1996, the Government also adopted a Private Power Generation Policy to encourage private sector participation in the electricity generation sector to compete with the BPDB. Several Independent Power Producers (IPPs) are now supplying electricity into the national grid. A Small Power Generation Policy (SPGP), was also introduced in 1998 to encourage investment in small (up to 10 MW) electricity generation plant by the private sector throughout the country.

Government policies and strategies have promoted off-grid options in areas that are unsuitable for grid expansion. The import duty on solar home systems, for example, was eliminated in April 2000. The Government’s strategy also recognises the pivotal role that rural organizations play in promoting off-grid options and the strengths of the PBSs, non-government organizations (NGOs) and microfinance institutions (MFIs).
The weakness of the current government policy framework is that its rural electrification policy has not been formalized or articulated and it does not actively promote the use of renewable energy systems. No framework for the implementation of SHS through the PBSs has yet been developed and no framework currently exists to permit the electricity generated from wind and hydro-electric systems to be sold either directly to customers or to the utility.

The only Renewable Energy Policy is contained in the National Energy Policy (NEP) 1996, which sets the following objectives for development of the renewable energy sectors (NEP, 2004):

i. to harness the potential of modern renewable energy, especially for hard-to-reach populations and the rural poor;

ii. to enable investment in renewable energy whenever it is an economic alternative to conventional supplies;

iii. to develop sustainable energy supplies that can substitute for indigenous non-renewable energy supplies as they are being depleted; and

iv. to scale up contributions of renewable energy to electricity production.


Despite not having any final renewable energy policies or strategies in place, the existing energy and environmental policy frameworks in Bangladesh do advocate and support renewable energy programs to a degree. In 1998, the Government lifted import duty and Value Added Tax (VAT) from solar photovoltaic and wind turbines.
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The Solar PV programs of different government bodies (BPDB, LGED, REB) are basically subsidy driven. At present, under the Biogas Pilot Plant project, the Government of Bangladesh (GOB) provides an A$110 (BDT. 5,000) subsidy for a family-size biogas plant that can be used for cooking and lighting purposes.

To date, most of the policy initiatives for the advancement of renewable energy have been supported via the provision of development assistance from industrialized nations and/or international organizations, rather than being fully driven by the Bangladesh government. As a consequence, they have seldom involved all stakeholders, such as end users in the community (Timilsina et al., 2001).

6.3.2 The Solar PV Program in Bangladesh

The first solar photovoltaic systems installed in Bangladesh, which were installed by the Bangladesh Power Development Board (BPDB) in 1981, were used to power signal lighting systems. Fifty-five solar powered signalling lights were installed on eleven towers of the East-West Power Inter-connector in Aricha. Those systems are still operating.

In 1983, the Bangladesh Inland Water Transport Authority (BIWTA) installed 125 solar-powered beacon lights throughout the country to identify marine routes at night. In 1988, the Bangladesh Atomic Energy Commission (BAEC) undertook a Solar Photovoltaic Pilot project at Sandwip Island, where a solar-powered system was installed on top of a watch tower to supply electricity for refrigerators in a veterinary hospital, and lights and a PV system in the local mosque. All of these systems were destroyed in a cyclone in 1991. Two solar-powered pumps, one at Moulovibazar in the Sylhet division and the other one at Savar district in the Dhaka

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4 The thana of Aricha Ghat, which means ‘Ferry Pier’, is situated on the river Jamuna (Brahmaputra) and is an important business place as it is connected by road to the capital, Dhaka, and other cities of Goalundo and Nagar Bari by river.
division, are used by the BAEC to supply water for irrigation. As no storage batteries are used in these systems, the pumps turn off automatically at sunset.

The REB undertook the Narshingdi Solar Electrification Pilot Project in 1995 in which about 900 households within a 29 km² riverine island area were supplied with electricity from three solar charging stations and stand-alone systems. The Narshingdi experience provided the REB and the PBSs with their initial experience in implementing SHS projects. The project demonstrated the technological suitability of SHS and the potential to use a fee-for-service approach. As the program was predominantly a grant-based program, financed from a 6.4 million French Franc (US$1.1 million) grant from the Government of France and a local currency (GOB) of 27 million Taka (A$ 7.7 million), it did not provide confirmation of the project’s financial viability or operational sustainability. The program was more or less directly implemented by the REB and the PBS involved (Narsingdi) had little say in the design or implementation. When the grid was extended into the project area in 1998, it damaged the reputation of the solar PV project as many wanted access to the electricity grid as it provided electricity at all times rather than for just a few hours after sunset. Limited solar electrification of a number of cyclone shelters has also been carried out by the local government engineering department, as well as by government defence and telecommunications departments.

In June 1996, Grameen Shakti (GS), a subsidiary of the Grameen Bank, was created as a renewable energy company. The main program offered by GS was the Solar Photovoltaic Program. Under this program, the GS sold SHS using a combination of credit and cash. This revolutionised the solar photovoltaic program in Bangladesh.

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5 The term used by the locals for electricity supplied from the grid is ‘big electricity’ and for electricity supplied from SHS is ‘small electricity’.
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Based on a survey of user affordability, it found that electrification using solar home systems represented a more promising and cost effective option than did supplying electricity from the centralised electricity grid (LGED, 2006, UDDIN and Taplin, 2006).

A large number of organisations were involved in the establishment of the Solar PV program. These included the Red Crescent, Bangladesh Protibondhi Foundation, Nijera Kori, Centre for Mass Education in Science (CMES), the Fuel Research Institute of Bangladesh Council of Scientific and Industrial Research (BCSIR), the Energy Park of the Renewable Energy Research Centre (RERC)(of the Department of Applied Physics and Electronics at Dhaka University), the Atomic Energy Centre, the Rotary Club of Dhaka, Rahimafrooz Battery, Bangladesh Solar, Bangladesh Centre for Advanced Studies, Swanirvar, Solar Energy System, Ananda, First Bangladesh Technologies, Prakaushali Sangsad, Grameen Shakti (GS), Bangladesh Rural Advancement Committee (BRAC) and the Rural Electrification Board (REB). These organisations played various roles as users, educators and sellers and the number of organisations actively involved in the program has continued to grow.

A number of NGOs proved to be quite successful at selling SHS on a commercial basis. Examples are Grameen Shakti, BRAC and Thengamara Mohila Songsad Somity (TMSS). However, only 1,450 systems had been installed by the end of 1999 (GS, 1999).

6.3.2.1 Affordability of the users

A market assessment of the potential for solar photovoltaic energy undertaken in 2000 indicated the potential market for solar home systems (SHS) in Bangladesh to be nearly two million systems (WB, 2000). According to the survey, undertaken by the Prakaushali Sangsod Limited (PSL) (Khan and Huque, 1998), the average
monthly household expenditure on kerosene used for lighting in rural areas was US$1.5 – US$2. Rural households typically did not have sufficient income to purchase a solar home system using cash, but the use of credit or other forms of extended payment would expand the potential market significantly.

The economic, technological and environmental advantages of photovoltaics, biogas and solar cookers have been well proven in Bangladesh. To date, there are over 150,000 installed stand-alone PV systems, generating over 6 megawatts of power. Grameen Shakti installed over 90,000 of these systems and BRAC, 31,000. A typical 50-watt solar home system comes with three 8-watt fluorescent lights, a deep cycle battery, and a charge controller. The cost, around Taka 20,000 (about $300), includes installation and warranty. The solar module comes with a warranty of 20 years, and the battery, 5 years (with an expected life of 8-10 years and recycling options). Such a system can save around Taka 400 per month spent on kerosene. Still, the upfront payment can be high for many, so micro-credit financing helps in making the systems affordable.

6.3.2.2 IDCOL solar program

The evidence that a solar program rooted in private and community based initiatives could be more successful is recent (LGED, 2007). In 2001, when the IDCOL was planning to develop a Solar PV program, the non-government sector, the Grameen Shakti, a subsidiary of the Grameen Bank, had already been involved in financing SHSs since 1998 and had installed nearly 5,000 systems. The BRAC, the largest national NGO, has also recently embarked on a SHS financing program for its beneficiaries, and is planning to extend its activities. As well as these organisations, other organizations, including a private sector dealer, have also been involved in a limited manner in solar energy programs. With assistance from the IFC and the GEF,
Grameen Shakti has evolved another program for the sale of SHS, but has reached only a small segment of the total potential market because of institutional, policy and financial barriers. To reduce these barriers and to provide a sound and sustainable implementation framework to tap into the total solar energy potential of Bangladesh, the IDCOL promotes SHSs under the Rural Electrification and Renewable Energy Development Project (REREDP).

The REREDP has been jointly financed by the IDA, the Global Environment Facility (GEF), Kreditanstalt für Wiederaufbau (KfW), German Technical Cooperation (GTZ) from 2002 to 2009. The IDCOL’s initial target was to finance 50,000 SHSs with financial assistance from the World Bank and the GEF by the end of June 2008. The target was achieved in September 2005, three years ahead of schedule and at US$2.0 million below estimated project cost. The IDCOL has revised its target to 200,000 SHSs by year 2009, with additional assistance from the World Bank, the KfW and the GTZ, making the IDCOL’s Solar Energy Programme the fastest growing renewable energy program in the world. The program covers almost all rural and remote areas in Bangladesh (Annex 6-I).

Over 240,000 households were incorporated in the Infrastructure Development Company Ltd (IDCOL)'s Solar Program. The total number of systems installed by January 2003 was around 8,500. After the IDCOL program had been initiated, 256,114 SHS were installed by November 2008 (IDCOL, 2008) (Fig 6.6). The rate increased due to the initial initiative of micro credit programs of Grameen Shaki and the recent initiatives of the Infrastructure Development Company Limited (IDCOL) to promote SHS under the Rural Electrification and Renewable Energy Development Project (REREDP) using financing provided from the World Bank, GTZ, KfW etc. (Uddin and Taplin, 2006).
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The total number of SHS that had been installed by January 2003 was around 8,500. Under the IDCOL program, 256,114 SHS had been installed by November 2008 (IDCOL, 2008) (Fig 6.6). The rapid increase was directly attributable to the adoption of the micro credit approach adopted by Grameen Shaki and the recent initiatives of the Infrastructure Development Company Limited (IDCOL) to promote SHS under the Rural Electrification and Renewable Energy Development Project (REREDP) (Uddin and Taplin, 2006).

A total of 15 Partner Organizations (POs) are now disseminating solar home systems in the remote rural areas of Bangladesh under the IDCOL’s renewable energy programme. The system sizes available under this program are given in Table 6.1 and the technical specifications are provided in Annex 6-II.
Table 6.1: System sizes available under the IDCOL program

<table>
<thead>
<tr>
<th>System Size</th>
<th>Load</th>
<th>System Price including installation (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Wp</td>
<td>CFL (5 watt)- 01, 36 LED lamp - 01 &amp; 24 LED lamp – 01</td>
<td>110.00</td>
</tr>
<tr>
<td>16 Wp</td>
<td>CFL (5 Watt) - 01, 36 LED lamp - 01, 18 LED lamp - 01 &amp; LED Lantern – 01</td>
<td>111.00</td>
</tr>
<tr>
<td>20 Wp</td>
<td>CFL (7 watt) - 01, 36 LED lamp - 01, 24 LED lamp - 01 &amp; 18 LED lamp – 01</td>
<td>179.00</td>
</tr>
<tr>
<td>30 Wp</td>
<td>2 Light</td>
<td>222.00</td>
</tr>
<tr>
<td>30 Wp</td>
<td>2 CFL (7 watt)</td>
<td>243.00</td>
</tr>
<tr>
<td>40 Wp</td>
<td>2 Light &amp;1 no 14” B/W TV Point</td>
<td>285.00</td>
</tr>
<tr>
<td>40 Wp</td>
<td>3 Light &amp;1 no 14” B/W TV Point</td>
<td>299.00</td>
</tr>
<tr>
<td>50 Wp</td>
<td>4 Light &amp;1 no 14” B/W TV Point</td>
<td>360.00</td>
</tr>
<tr>
<td>50 Wp</td>
<td>4CFL (7 watt) &amp;1 no 14” B/W TV Point</td>
<td>368.00</td>
</tr>
<tr>
<td>60 Wp</td>
<td>5 Light &amp;1 no 14” B/W TV Point</td>
<td>410.00</td>
</tr>
<tr>
<td>65 Wp</td>
<td>5 Light &amp;1 no 17” B/W TV Point</td>
<td>422.00</td>
</tr>
<tr>
<td>75 Wp</td>
<td>6 Light &amp;1 no 17” B/W TV Point</td>
<td>499.00</td>
</tr>
<tr>
<td>85 Wp</td>
<td>7 Light &amp;1 no 17” B/W TV Point</td>
<td>532.00</td>
</tr>
<tr>
<td>120 Wp</td>
<td>10 Light &amp;1 no 17”-20” B/W TV Point</td>
<td>821.00</td>
</tr>
</tbody>
</table>

The Solar Home Systems (SHSs) are sold by the POs to households and businesses mainly through micro-credit. The IDCOL provides a refinancing facility to the POs and channels grants to reduce the SHS costs, and also supports the institutional development of the POs. In addition, the IDCOL provides technical, logistical, promotional and training assistance to the POs (Fig. 6.7).
6.4 Survey results

Around 500 users of SHS were surveyed in order to obtain the techno-socio-economic information of the SHS users in Bangladesh. A questionnaire survey was used to obtain information on the impacts of the program on users’ quality of life.

6.4.1 Socio-economic survey

The interviews were undertaken in the three divisions of Dhaka, Khulna and Sylhet (Fig. 6.1). These areas were selected to ensure that the income levels of those interviewed covered the full range. Those interviewed in the Sylhet division tended to have high to medium incomes, while those interviewed in the Dhaka and Khulna divisions tended to have medium to low incomes. The sizes of the systems installed in these areas ranged from 35 Wp to 75 Wp. The numbers of systems installed in each of the three areas at the time of interview were 23,639, 38,987 and 36,867.
respectively. More than half (55.4%) of the survey participants were aged between 30 to 50.

6.4.1.1 Household pattern

The houses in rural agricultural communities are typically grouped in homesteads consisting of a group of houses belonging to an extended family. The houses of the survey participants were constructed using a range of materials, bamboo, mud and wood being the most widely used local building materials (Fig. 6.8). The materials used varied according to regional availability. Non-traditional materials, such as corrugated iron sheet (CI), concrete pillars and bricks are increasingly replacing local materials in rural areas.

![Pie chart showing construction material in surveyed households in Bangladesh]

Figure 6.8: Construction material observed in surveyed households in Bangladesh

The houses of most of those surveyed tended to be well maintained, and only a small proportions were found to be otherwise and to display signs of neglect. These participants tended to be from the lowest income group. Most of the houses were detached, had between two and four rooms, and the number of persons in the
household ranged from one to ten, with most households having three to six household members (Fig. 6.9).

![Chart showing average household size in Bangladesh](image)

Figure 6. 9: Average household size in Bangladesh

The distances of the survey households from the main electricity grid ranged from less than one kilometre to over twenty kilometres, with around 19% of the houses being within 3 kilometre, 49% being within 5 kilometre, 77% being within 10 kilometre, and 23% over 10 kilometre (Fig. 6.10).

![Chart showing distances of survey households from main electricity grid](image)

The distances of the survey households from the main electricity grid ranged from less than one kilometre to over twenty kilometres, with around 19% of the houses being within 3 kilometre, 49% being within 5 kilometre, 77% being within 10 kilometre, and 23% over 10 kilometre (Fig. 6.10).
Access to the houses of most of those interviewed was via an unpaved road (73%). Access to a small proportion of remote houses (9%) was via either river or by walking track (Fig. 6.11).

In summary, the people living in these areas live in relatively simple houses made of semi-brick, corrugated iron sheeting, bamboo and other low cost materials. The houses tended to be detached and to be relatively large, with two to four separate rooms. Approximately 70% of the households had between three and six persons. Most of the households with SHS were over three kilometres from the grid and the nearest market (i.e. for purchasing kerosene for lighting). There was an even spread in proportion of households within the two to six kilometre range. A small proportion of households (12%) were over 6 kilometres from the closest market.
6.4.1.2 Income and Expenditure of the surveyed householders:
The annual income of the surveyed households varied from A$500 to A$8,000. Most respondent (46 %) had an annual income between A$1,000-AU$3,000 (Fig.6.12). About a quarter of the households (28.3%) earned their income from providing services, a few households (13.9 %) had remittance income from relatives (i.e. money sent from relatives working in urban areas or overseas), 48% earned an income from business (fishing, farming, trading, retailing, etc.), 5.6% earned their income from renting houses or shops and the remainder (4.2%) earned their income from farming.

Most of the households surveyed (87%) that derived their incomes from farming, fishing, service, or other activities also produced their own food, which was not included as income. The major household expenditure items were food, education, medicine, clothes and energy. There was significant variation in the monthly amount paid for these items. The annual expenditure of most households was in the range A$1,500 to A$2,500.
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Figure 6.12: Yearly income of the surveyed households

All respondents used SHS. Ninety seven percent of the respondents acquired their SHS using a combination of a down payment and monthly credit. The down payment varied from A$20 to A$150. Nearly half of the respondents (41.5%) paid around A$50-A$75 in down payment, 30.7% paid more than A$100, 19.2% paid from A$75-A$100 and 8.6% paid less than A$50 (Fig 6.13).

Monthly expenditure on lighting varied from A$1 to A$25 (Fig. 6.14). About two third of respondents (75.1%) spent around A$6 to A$10 on energy, 19.6% spent A$15-25 and 2.7% spent more than A$ 25. A small group (2.7%) spent less than A$5 on energy.
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Figure 6.13: Down payment paid by the households for purchasing the SHS

Figure 6.14: Expenditure on lighting per month of the households

Over one third (35.5%) of the households that used kerosene for lighting spent A$1-A$5 per month on kerosene, 25% spent around A$10 per month and remainder (9.5%) spent more than A$10 per month (Fig. 6.15).
In summary, the average household income per month of most respondents was around A$250, monthly expenditure on food, clothes and energy was approximately A$125 to A$208. Expenditure on lighting was only 2 to 4% of total household expenditure. Of the 35.5% of respondents that spent less than A$6 per month on lighting, only 2.7% had a SHS.

6.4.1.3 Impact of the SHS program

The impact measures for the survey were described in Chapter 5, Section 5.5.3. Table 5.1 shows the impact indicators used for the Bangladesh survey. The SHS of most (70%) of the households surveyed, had been installed for between one and two years. The SHS had been installed for between 2 and 3 years in almost a quarter of the households (22%), and in only 8% of the systems had been installed for more than 3 years. The SHS were used for operating appliances as well as for lighting, including B&W TVs, cassette players, mobile phone chargers and security lighting.
Over one third (37%) used their systems to operate lights and a TV, 4.5% used their systems to operate lights and to charge mobile phones, and only 0.8% used their systems to operate lights only (Fig 6.16).

Most respondents (89%) agreed that the SHS provided cleaner and brighter lighting than did the kerosene lamps that they had previously used, and also agreed that the electric lighting was more convenient. Almost all respondents (98%) agreed that they were happy with the SHS that they had bought (Fig 6.17).
Almost all respondents agreed that using SHS had resulted in an increase in their quality of life. All respondents agreed that SHS increased time spent in relaxation and that they are able to get together at night and enjoy the white and clear light. The majority of the respondents (92%) reported that their systems had enabled them to use lights whenever they wanted to and to watch TV programs without being interrupted by power failures and that they did not have to worry about charging their batteries in order to watch TV. They agreed that by watching TV or listening to the radio they had greater access to information and were more informed about weather (tornados, cyclones) and other natural disasters. Ninety five percent of respondents agreed that their access to information through mobile phone or TV or radio had been improved by their SHS. They reported that they were able to charge their phones at home whenever they needed to use them. Most respondents (82%) also agreed that their SHS has increased their social status. They reported that neighbours and relatives from other villages visited their houses more often and
enjoyed the clean lighting. They also claimed that their SHS had increased the amount of time that they engaged in social activities (Fig. 6.18).

Figure 6.18: Social Impact on the users due to SHS uses

Half of the households interviewed (51%) agreed that their monthly payment on energy had decreased (Fig. 6.19). The reason that the other half reported that their expenditure on lighting had increased was that before they owned a SHS, they did not buy kerosene for lighting unless they had the cash to do so. But as the SHS repayment is on a monthly basis, they have spare cash until they need to make the repayment. All householders surveyed agreed that after the loan for the SHS had been paid off, they would be able to enjoy free lighting for the life of the system.
Half of the respondents (52%) reported that they maintained their system themselves, while 45% reported that as they were paying for the system and that it was still under warranty, they did feel obliged to maintain their systems. Almost all respondents (97%) agreed that the system was easy to operate and 86% reported that they had received training on monitoring and maintenance of the system (Fig. 6.20).

Most respondents reported that their systems were serviced whenever they required servicing. However, the 10% of respondents who had already repaid their loans disagreed that their systems were serviced when they needed serving. Almost all respondents agreed (97%) that spare parts were readily available and most disagreed (86%) that the cost of maintenance was high (Fig. 6.20).
Women were seen to benefit most from SHS. The primary benefit to women was reported to be reduced in-door air pollution and greater security. Most women also reported having more free time (92%) and reduced work loads (89%) (Fig. 6.21). Seventy two percent of respondents agreed that women were familiar with the new technology and that the electric lighting allowed both men and women to work in the evenings and to increase household income by undertaking activities such as sewing, basket making, handicrafts making, and by renting lights to neighbours.
In summary, the respondents reported that their SHS helped them to generate increased income through different activities. The survey analysis showed that people valued their quality of life changes and also changes in economic condition made possible by the purchase of their SHS. Respondents reported satisfaction with the availability of spare parts, the maintenance and monitoring support, and the training on maintenance and monitoring provided by the program implementers. They tend to express satisfaction with the support that they are able to obtain from the implementers and the access to program implementers if there are any problems.

6.4.2 Stakeholder Survey

The Solar PV Program being implemented in Bangladesh is one of 61 projects being undertaken in 34 countries that are supported by the World Bank Group. The Bangladesh program is regarded as the model that the “that the World Bank hopes to duplicate in Africa, where many energy access projects now have a renewable
energy component,” (WB, 2007). Under the Bangladesh SHS program, the systems are sold to the customers who are provided with access to credit facilities from program implementers or system suppliers. Using this credit system increases the affordability of a SHS and therefore extends the program to a larger proportion of those living in rural areas.

In Chapter 5, section 5.3.2, the criteria and concepts used to analysed the survey were described, and the use of the NVivo software package to analysed the survey results was described in section 5.3.2. The comments from the interviews are shown in Annex 6 -III

6.4.2.1 Implementation mechanism

The criteria and the concepts that stakeholders consider to be related to the implementation mechanism, as determined using the NVivo software, are shown in Figure 6.22. The comments of the interviewee on the program issues and factors are selected and grouped as Maintenance and monitoring, Implementation approach, Technical performance and training under implementation mechanism. The numbers inside each issue and factors represent how many participants were mentioned this issue.
Institutional Approach

The Bangladeshi program has adopted a market-based approach. The objectives of the program are seen as demonstrating that there is a viable alternative to extending the grid to provide access to electricity and to improve the living condition of the rural people living in remote areas. The objectives of the program were seen to be:

- to demonstrate that there is a viable alternative to extending the grid as a means of providing access to electricity, and
- to improve the living conditions of the rural people living in remote areas.
The program objectives were seen by some to be disseminating SHS in a way that is commercial and to show that SHS can be used as an alternative means of providing access to electricity.

Some program implementers also saw the objective to be learning by doing. The purpose of the program was seen to discover the issues that are important and considered to have been met as evidenced by the expansion of the program. Some regard the creation of business opportunities to be important. There should be a service delivery mechanism developed by the implementers. Creation of local entrepreneurs also needs to make the program sustain. Area selection is seen as an important parameter in order to implement the program successfully. It is seen as being critical and is based on the factors such as the community's desire for electricity, lack of access to grid services, householders' ability to pay, and the opportunities to create new business or increase income generation activities, all of which play key roles in project implementation.

The supply chain is seen to be important as it is for any kind of business. To run a SHS program as a business, the supply chains need to be maintained in order to run the program efficiently. While it was also recognised that the program creates opportunities for new business, it was also recognised that these are new businesses and this can cause problems.

There is acceptance of a need for systems of different sizes to be offered through the program in order to expand the program. The program implementers are helping the users to choose appropriate systems to reduce the cost of the system. There are around fifteen types of systems under this program. Program implementers and system suppliers know that people will buy a system that meets their own particular
needs and that is priced according to their ability to pay. Offering a range of systems increases consumers’ interest in purchasing a SHS.

In terms of program sustainability, there is recognition among program implementers of a need to create an optimal market size that will help to sustain the future market. The Bangladesh program shows that it is possible to create a market and to explore potential markets by providing proper training and by using proper institutional set up.

Developing awareness about a new technology is also seen as important. Awareness development was regarded by those involved in the program as a critically important factor for SHS programs. This was seen to help program implementers to expand the program area. In the case of the Bangladesh program, there is presence of market forces that will allow the demand to be created to be strengthened by proper awareness development among the users.

The most important criteria for SHS program is institutional framework development. The establishment of an appropriate institutional framework was considered to help the program to be organized and to develop the program as a business.

The IDCOL supports implementing organizations (according to IDCOL ‘Partner Organizations (POs) by providing them with long-term loans (10 years) and a grace period (2 years). The IDCOL also meets with the POs every month to discuss the program. This process helps implementers to monitor and re-check their program and to make changes that will make their programs more sustainable.

**Maintenance and monitoring**

Each implementing agency is responsible for maintaining the SHS within the loan period without cost. After the loan period, they are required to provide a service at a
minimum service cost. The comments from the stakeholders on the maintenance of systems reflected the perceived importance of this feature of their programs and the critical connection between the development of a maintenance and monitoring program and the success of their SHS program. Maintenance and monitoring consists of regular monitoring, providing system warranty, a careful component selection process and regular customer service. Implementing agencies provide maintenance support whenever the customer requires this. It also provides a check and balance system for the program.

Component selection and warranty was also regarded as being an important aspect in running the program successfully. In this program, the systems are sold to the people. The need for good quality products and the use of system warranties was recognised. Customer service was seen as another important issue for the success of the SHS program.

Using a market-based approach means that customers have to willingly buy the SHS. A proper customer service was seen as necessary in order to ensure the viability of the project. It was recognised that if the systems do not operate well, customers would lose faith in the systems and would not recommend to others that they should buy such a system.

**Technical performance and training**

Most of the systems visited were still under warranty with the loan period and were working well. A very small proportion (2%) of the systems surveyed had been fully paid for. No complaints were reported about system performance other than some controllers and lamps. These faulty components are also replaced as soon as they are reported by users to the unit office.
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Spare parts availability helps the program to run smoothly. The main objective of the SHS program is to provide electricity services and if the parts are not available locally, people will not get the electricity unless the parts are replaced. By operating through unit offices within a few kilometres of the project area, the program runs smoothly. There are 16 partner organizations under the program and it has been found that the organizations that have more unit offices do better.

Training both technicians and users was also seen as important by program implementers for running the program successfully. But at the same time it was recognised that it represents a cost to the implementers. Some implementers saw training as the part of their business strategy to reduce the maintenance cost. Almost all implementers agreed that providing training to the users and technician helps to make the programs more sustainable. Development of a training manual was seen to be another important aspect of a program. In the Bangladesh program, a training manual for technicians was developed by the government through the IDCOL. Some implementers have produced their own manuals. Informative and pictorial information was seen by some as easy for customers to understand and to be more effective than printed material.

Proper system size was another major aspect of a market based approach. It was accepted that in order to sell systems, different options need to be available in the market so that customers can choose, based on their needs and affordability. It was not clear from the survey how system sizes were determined. There are some rules and guidelines but sometime implementers offer more lights with a pre-designed package system. Although they claim that customers follow the instruction and they do not receive many calls regarding maintenance, from personal communication with customers it was found that some systems are used for more
than the prescribed time and that the batteries of those systems are not working well. It was also mentioned by some participants that there is a need to develop low consumption lights to make the program more successful.

In summary, technical performance and training are seen as of great importance for running a program smoothly. By providing proper training and technical services, it is possible to keep the maintenance cost low. There is also seen to be a need to have spare parts available in the local area. Customers feel happy and have faith in the technology as well as in the program if they can get the services and the spare parts locally.

6.4.2.2 Financial mechanism

The diagram in Figure 6.23 shows issues and factors related to financial mechanism that is found in the Bangladesh program. The figure was created from the transcripts of the interviews conducted for the research using the NVivo software. Figure 6.23 shows the issues and factors related to financial mechanism raised by the interviewee. As mentioned before the number represents the number of interviewee mentioned about the issues.

Funding

Funding was seen to be of critical importance to the success of a SHS program. In Bangladesh, a new type of funding is used for the program. This funding mechanism allows householders or businesses to acquire a system without having collateral. The program is based on Grameen Bank's experience and involves creating a financial package based on instalment payments that reduce the upfront costs and help the program to achieve an economy of scale.
Funding criteria depend on many things. In this program, the Government finances the program through the IDCOL. Implementing agencies (POs) borrow money from the IDCOL to purchase their systems. The POs provide financial services to the people to enable them to acquire a SHS.

There is no subsidy for the SHS. The major funding source for the Bangladesh program is the Government, which receives soft loans and grants from donors and disburses these through the IDCOL, among the Pos, as loans. POs receive the loan amount as refunds after they have sold systems to customers and get customers to sign a contract with the POs. Customers receive no direct subsidies.
Cost recovery

Cost recovery was considered to be a major issue for making a project sustainable by the stakeholders. If the POs cannot get the money back from the customers in the form of monthly repayments, they do not have the money to buy new systems and thus cannot expand their businesses. So, it was recognised that it is important to recover the money from the customer to roll over the program. The POs receive only the amount that they spend on the SHS program as reimbursement and they have to pay back the money after two years. They can invest in new systems only if the collection of money is regular. Social benefit of the program is also recognised to be an important factor by some of the interviewee.

Economic perspective

A survey was undertaken on the affordability of the program before it started. The program also involves the actors/POs like Grameen Shakti, BRAC, etc., who have been working in this business for long time. It was found in the survey that there is a demand for SHS and that people are willing to pay for them. The only problem was the upfront cost of the systems and using micro-finance eliminates this problem for most. There are not many people who can buy the system in cash.

Program implementers reported that householders like the SHS technology and accept that there is a need for these as grid electricity will not be available in the near future. The main problem of SHS was seen to be the high upfront cost, which created the need to provide soft (low interest, long-term and without collateral) finance to the people to buy the system. It is also well accepted by the program implementers that in order to buy the system and in order to pay the monthly instalments it is necessary for householders and businesses to use their SHS productively. Program
implementers considered that income generation opportunities were increased as a result of SHS installation. The can work at night to earn extra.

Some customers install the system at their own premises and share the load with some of their neighbours. Owners of the system are responsible for making instalment payments to us, more than 50% of which is recovered by the rents collected from the other users of the system.

According to those involved in the program, businesses such as rice/saw mills, grocery /tailoring shops, restaurants, market places had increased their income by extending working hours after dusk. Women were also seen to benefit by being able to enjoying hazardless and uninterrupted free lighting systems in their daily life as well as getting opportunities to earn extra income by utilizing their time after dusk by sewing, poultry farming or setting up other home-based industries.

The above discussions on financial criteria show that there is a need to develop financial mechanisms to expand the program. It is difficult for the rural people, especially the very poorest, to afford a SHS. This program developed an innovative financial approach that works for many rural people living in Bangladesh. Implementing agencies (POs) provide customers with loans to enable them to acquire a system without having any collateral. Customers pay a 10% down payment and pay off the loan on the rest using monthly instalments over a 2 or 3 year period. Either the government or a development bank needs to provide assistance. If private commercial banks do not offer the necessary financing, it is difficult for private enterprise to run the business. There is also a need to encourage the private sector by opening up the RE energy sector and providing fair subsidies from the Government. These are attractions for the private sector to become more involved and reduce the risks of the business.
The monthly repayment amount varies from A$3 to A$25 (Fig. 6.15). The concept revolves around the customer using the electricity that is generated by the SHS to undertake new income generation activities or to increase existing income activities, and to use the additional income to meet the monthly repayments. In this way, the SHS program is used to facilitate the creation of new opportunities for employment and income generation, such as electronic repair shops and mobile phone shops, and this further assists the program to become sustainable.

Transaction costs are often very high, so much so that they can affect the viability of the program. Addressing this often requires a subsidy in one form or another.

Different approaches to financing renewable energy-based rural electrification schemes can coexist. The participants in the Bangladeshi program have come to the conclusion that the use of different approaches is not a bad thing and that it is actually desirable to have flexibility in order to address the issues that arise out of different contexts in which the programs are being implemented.

Participants agreed that sustainable financing is the main constraint and is often the most challenging aspect of rural electrification programs. There was agreement that financing mechanisms need to be developed that facilitate access by lenders to long-term loans and rates on a commercial loan basis. The terms and conditions of rural electrification projects, however, are often not suited to commercial loans. They need to be distinguished project financing that uses corporate or private financing. In the case of renewable energy rural electrification projects, a loan recovery time of 7 to 8 years would be too long, the consumers have no collateral, no guarantors and the risks are high due to natural disasters. Commercial banks are therefore not convinced that renewable energy rural electrification programs represent good business.
Government was considered by the participants interviewed to be the key player with the renewable energy electricity regulator. The successful financing of renewable energy electrification schemes and projects was regarded by participants as primarily a question of good and appropriate public policy. They regard the appropriate subsidization process and mechanism to be crucial, but agreed that direct subsidies do not work. Public policy was therefore considered by the participants to be the main factor determining success of a program.

6.4.2.3 Social and environmental aspect
The SHS program in Bangladesh is highly supported by users and the number of customers has been increasing rapidly every year over the past five years and it is the fastest growing program in the world. The social changes that have been derived from this program are considered to be many. The number of interviewee and the factors that stakeholders considered important as the social outcomes of the program are shown in Figure 6.24.

![Figure 6.24: Stakeholders’ views on the primary issues that influence the social outcomes of the SHS program in Bangladesh](image)

User's behaviour
SHSs were considered by those interviewed to have become increasingly popular among customers because they present an attractive alternative to conventional electricity supply options, including high reliability, no monthly bills (once the systems have been paid off), no fuel costs, low maintenance and repair requirements, low costs, and ease of instalment. Due to this program total status of the villages has changed. A link has been developed between the urban and the rural and also between the family members living in rural and urban areas. Rural people were seen to be obtaining benefits from their systems. The environment within households changed, as is people's way of thinking. Culturally, people do not like to take the risk of buying a new product without asking the village leader for his opinion. There is a need for a catalyst in every area to boost the sale of the SHS.

**Satisfaction levels**

The main stated objective of the PV program in Bangladesh was to provide electricity to rural people so as to improve their lifestyles. Without such a program, the people in most rural areas are forced to rely on kerosene lamps for lighting. Those that are connected to the grid face the problems associated with lack of reliability as most rural areas do not have power for between 6 and 10 hours a day due to generation capacity shortages. Customers are satisfied in spite of a few occasional of failures, caused mainly by weather. Children are more studious due to the availability of bright light at night.

The users’ survey supported these comments by program implementers, as 90% of the customers responded that SHS had had a positive impact on the livelihoods of those living in that area. Customer opinion during the project development stage was seen to be very important and most POs working worked closely with potential
customers. The project follows a bottom up approach. Motivation and community involvement become a part of our marketing system.

Users’ satisfaction is seen to depend on not only having reliable components but also the service that is provided by the implementing agencies. This program has brought significant improvements in the standard of living – better light for children’s’ education and household activities for women, reduced in-door air pollution, and increased security.

The service provided through this program has a direct impact on the minds of the people. Now people are sending their children to school and the children can study at home with clean light. Users are getting numerous social benefits. The program also has positive environmental impacts as the use of kerosene is reduced and used batteries are recycled.

### 6.4.2.4 Policy and its effect on the program

Current government energy policy does not specifically address renewable energy, but a policy supporting new and renewable energy developed and submitted to the government in 2003, was approved in November 2008 but is not yet implemented. Interviewees were asked their views on the adequacy of current policy and the impacts on the program. The issues that program participants considered as important in influencing policy and the number of participants mentioned about the issues and factors are shown in Figure 6.26.
Rural electrification policy

Policy was regarded as necessary for the formulation of program objectives, to muster support for intervention or to focus attention on a particular objective. Having a policy, however, was not seen as meaning that the policy would be implemented. A specific rural electrification policy is seen as necessary as is an advocate on renewable energy policy issues.

There is a concern among the stakeholders about the monetary benefit that received by the customers. Rural people are not getting benefits from the system installed directly. Program implementers argue that the government should consider providing some sort of subsidy to SHS buyers as the electricity supplied from the grid is subsidised, while those purchasing SHS to gain access to electricity are not
subsidised. They also argued that the import tax duty on solar panels should be removed.

Government intervention was seen to be needed to address a financial requirement of the program. The policy needs to be revised within a certain timeframe. Program implementers realize that there is a need for policy advocacy for doing sustainable business.

**Lack of Policy**

Program implementers saw the lack of a policy that specially addresses the needs of the renewable energy program to be a weakness in this program. There was seen to be a need to have a policy on renewable energy electrification that would help to define the program and run it efficiently. Some stakeholders felt that having no policy is a barrier to program success, while others thought that having a policy would not help much and were not a necessary requirement for program success. There was agreement that if a policy was developed, it would need to be implemented properly.
Chapter 6: Solar PV Program Analysis – Bangladesh Case Studies

**Political situation**

Political situation change is also regarded as having a negative impact on program success. Political change and policy instability based on commitment made by political leaders are seen to act as a significant barrier to program success. Due to political commitments, the grid is to be expanding in some areas that were not included in the plan before and creates problem for SHS program. No coordination between the planning processes of expansion of grid electricity. Once a commitment is made for the electricity grid to be extended into an area, those living in the area lose interest in buying a SHS and the sustainability of the program is weakened. Recently a duty on importing solar panel has been imposed which increase the cost of the SHS.

**Bureaucracy**

The government bureaucracy was seen to play a negative role in the implementation of the SHS programs. Bureaucracy works as a counter force for not implementing the program. It was seen to be a significant problem, although most implementing agencies consider themselves to be able to run the program. One respondent pointed out that the bureaucracy could be tackled by developing awareness among those in government responsible for developing policies in this area.

In summary, the Bangladesh Government has a national policy, but this policy is focused primarily on stationary energy sector reforms policy and does not cover rural electrification or renewable energy issues. The current initiatives in Bangladesh are nonetheless supported by the Government. Despite the lack of policy and the high involvement of the bureaucracy, and although the program is not considered as a part of the national rural electrification policy, the program nonetheless works relatively well. All of the actors felt that policy has a major influence on program success and
agreed that there is a need to develop a policy specifically on renewable energy electrification. They also believe that by developing awareness among the people and government it would be possible to run these programs more successfully.

6.4.2.5 Barriers to the program

Figure 6.26 indicates the views of the stakeholders on the factors behind the difficulties experienced in implementing the SHS program in Bangladesh. Three participants among 26 mentioned about the main problem that they encountered in the program. Five participants comments on the major barriers to success and three participants mentioned about the lacking of human resources.

![Diagram showing difficulties and barriers](image)

Figure 6.26: Stakeholders’ views on the factors behind the difficulties experienced in implementing SHS programs in Bangladesh

The SHS program was seen to face many problems and there have been attempts to overcome some of these problems during the course of the program. A major problem that was recognised early in the program, for example, was the high cost of the systems. This led to the 15% import duty on solar panel and accessories being removed after lobbying by the implementing agencies.

Although the program is running well there is a need to be addressed. There was seen to be a need to develop awareness among the people about the benefits of using
renewable energy. Funds are needed to conduct the awareness activities for the implementing organizations. The cost of the system components and the availability of some components, such as solar panels, are still seen to be acting as barriers for the program. This is because the panels are imported and the end cost of the panel depends on the current exchange rate. The import duty and tax on the imported items further increases the cost of the systems. This makes it difficult to design systems suitable for the poorest people as they cannot afford the down payment or monthly repayment for the larger systems. There is seen to be a need for policy advocacy to remove the duty on solar panels in order to reduce the costs of the systems and to make them available for the members of the rural communities.

The process of component selection and approval is also in need of being simplified. There was seen to be a need for continuous improvement in quality control of the components. Information sharing on the availability of components in the national and international markets among implementers is also necessary. The rapid growth of the program over recent years has created a shortage of skilled people technically trained, as well as those with good managerial capacity needed to run the program successfully. Providing training for those working in the implementation of the program is very important and this is something that is missing in this program. The barriers discussed above are institutional, policy, financing, technical, information, and human resource in nature or classification.

6.4.2.6 Views on the degree of success of the program

The degree of program success depends on various factors and issues that vary from program to program based on the objectives of the program and how the program has been designed. Figure 6.27 shows the issues and the factors that are considered by
stakeholders to influence the success of the Bangladesh program. The participants mentioned about the policy issues and factors are also shown in the figure.

**Program Success**

The success of a program was assessed primarily by the degree to which the objectives of the program are met. This is influenced by socio-cultural factors, by the financial steadiness in the program area and also by sustainability issues that lead the program towards success. From stakeholders views continuous monitoring is needed to make a program successful. It is also important to develop awareness, provide training to the users of the system, and keep in touch with the customers. The larger implementing agencies are doing well in this business whose strengths are good management and skilled people.

They have their own technical people who can address field problems very quickly. After installation service is also a very important success element. Ownership development also plays an important role in program success, as this helps the users to realize that the system is, in the end, their own asset.
Limiting Factors

The factors seen by stakeholders to limit program success were also mentioned by the participants. The market for SHS has already been developed. Now the challenge is to handle the market and to develop a sustainable way of doing this business. The implementing agencies have good technical perspective, but they don't have managerial capacity. Managerial capacity needs to be developed among the employee to provide best service in this market. The repayment or money collection should be up to date to make the program sustain. There is a need for Government intervention to keep the system price within the range of poor people. Tax holiday could be a better option mentioned by the implementing agencies. There is a need for policy advocacy as Government rules changes time to time.

In summary, to ensure program success stakeholders considered that the following factors need to be fulfilled:

- creation of demand
- affordability for the users
- ensuring supply chain maintenance
- enforcement of proper standards
- ensuring adequate financing and recovery
- favourable government policy and government leadership on policy issues related to the RE program

If the above are ensured, then success is considered by stakeholders to be likely criteria and the program may be sustainable, and that missing any one of the above, could threaten the sustainability of the program.
6.4.3 SWOT Analysis

From the above focus group discussions with the implementing agencies, the strengths, weaknesses, opportunities and threats of the program were developed (Fig 6.28).

**Strengths**
- Good relations with customers
- Provide reasonable service
- Get reasonably cheap component price
- Monthly meeting with government entity
- Micro finance mechanism available
- Huge market demand
- Good field networks

**Weaknesses**
- Lack of human resources
- Lack of managerial strength and commitment among employees
- System reliability hampered and increase maintenance cost
- Transport cost increased
- Risk of loan recovery from field
- Cannot supply system in time
- Increase operational costs

**Opportunities**
- Dealing with few external supplier
- Reduce total system price
- Rising international price of oil
- Government policy and program to promote RE
- Training of users and technicians
- Government’s/Donor support

**Threat**
- Number of suppliers reduces and price could be increased without prior notice
- Poor quality components from local supplier
- Currency devaluation
- Government Policy change
- Lack of investment in building capacity of staff and users
- Natural Disaster

Figure 6.28: SWOT test on SHS electrification program in Bangladesh
Respondents also discussed the probable role of different stakeholders in the threats and weaknesses of the program, which is summarised in Table 6.2. The problems are categorised as technical, financial, institutional and uncertainties.

Table 6.2: Actions against the weakness and the threats of Bangladesh program and role of different stakeholders to resolve it

<table>
<thead>
<tr>
<th>Problems</th>
<th>Probable Solution</th>
<th>Role of stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical</strong></td>
<td><strong>Supplier shortage and price increase in the world market</strong></td>
<td>POs can influence local/international suppliers</td>
</tr>
<tr>
<td></td>
<td><strong>No reliable supplier of charge controller and lamp. Technical problem arises due to bad quality product</strong></td>
<td>Provide training to local people which can create local employment</td>
</tr>
<tr>
<td></td>
<td><strong>Battery price increases 19.5% within last year (2006-2007). 85.7% in last four years (2003-2007).</strong></td>
<td>New entrepreneur development</td>
</tr>
<tr>
<td></td>
<td><strong>Find new suppliers and advocacy to the government to reduce/remove tax duty on panel</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Create new entrepreneurs, develop good technical knowledge, further development of product</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Further development of product and battery recycling for recovering the lead</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Financial</strong></td>
<td><strong>Currency devolution</strong></td>
<td>Bank can provide finance to create local entrepreneurs to help/support the POs.</td>
</tr>
<tr>
<td></td>
<td><strong>Duty on panel</strong></td>
<td>Government can take initiative</td>
</tr>
<tr>
<td></td>
<td><strong>Price of raw material increases</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Soft loan provided by the financial institutions</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Advocacy with government to remove tax</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Negotiation with the suppliers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Policy</strong></td>
<td><strong>Tax holding for RE</strong></td>
<td>Create association for policy intervention for clean technology</td>
</tr>
<tr>
<td></td>
<td><strong>POs can play role for policy advocacy</strong></td>
<td>International donors involvement for making the policy</td>
</tr>
<tr>
<td><strong>Institutional</strong></td>
<td><strong>Lack of skilled personnel</strong></td>
<td>Develop training institutes/universities</td>
</tr>
<tr>
<td></td>
<td><strong>Lack of coordination among the market actors</strong></td>
<td>Donor funding can be used for training</td>
</tr>
<tr>
<td></td>
<td><strong>Lack of advocacy for Renewable Energy Policy by the implementers</strong></td>
<td>Awareness development on climate change among all the stakeholders</td>
</tr>
<tr>
<td></td>
<td><strong>Awareness development on SHS uses</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Capacity development on technical and managerial issues</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Capacity building to create program manager</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Make available of soft loan from financial institution</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Create Renewable Energy Associations</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Provide training to all customers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Uncertainties</strong></td>
<td><strong>Insurance on system</strong></td>
<td>Donor agencies and government can play role</td>
</tr>
<tr>
<td><strong>Natural Disaster</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above table indicates that the problems that arise during program implementation can be resolved by coordinating with the stakeholders involved in the program. By selecting the problem the actors required for solving the problem can be identified and advocacy could be done.
6.5 Discussion and Summary

The Bangladesh SHS program has been analysed in two parts: the impact of the program on the users and the implementation mechanism, the financial mechanism, the policy environment and framework, barriers and the reasons behind the success of the program. The aim of the analysis was to develop an understanding on the program activities and the factors influencing program success.

6.5.1 Impact of the program

The impacts of the program were analysed based on the information obtained from a user survey. Almost all respondents agreed that using their SHS had resulted in an increase in their quality of life and in the time that they spent relaxing. The primary reason for purchasing a SHS was to be provided with clean and bright lighting by replacing kerosene lamps. They appreciated their electric lighting systems as they are reliable and can be operated when the user likes.

The users of SHS also reported increasing their access to information, increased ability to watch TV, to listen to the radio for news and warnings for tornadoes or hurricanes that are common in Bangladesh. They reported being able to charge their mobile phones with their SHS and this helps them to communicate with their relatives, business partners, friends living in another city or town or abroad. Mobile phones also keep farmers and businessmen updated on market prices of crops and products.

The capacity to increase income generation using SHS was also seen to be a major benefit of this program. Acquiring a SHS creates an opportunity to start up small businesses of various sorts. Many of those in rural areas did not consider it to be possible to open up businesses that stayed open late until after the introduction of
solar home systems. Today, most of the businesses stay open after dusk in order to gain access to late evening shoppers.

The SHS program, in this way has helped to reduce poverty by creating opportunities for new income earning activities, such as mobile phone charging shops, providing neon light traps for attracting and destroying insects, and operating social TV halls. The survey analyses also showed that people valued their quality of life changes and the changes in their economical situations brought about as a result of using their SHS.

Table 5.1 was used to list the variables and indicators to measure the impact of a SHS program. The outcomes of the user survey are summarised in Table 6.3 using the same indicators as used in Table 5.1.

Table 6.3: Survey outcomes of Bangladesh program based on success indicators

<table>
<thead>
<tr>
<th>Variables</th>
<th>Indicators</th>
<th>Survey outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy access and uses</td>
<td>Access to better and clean light</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Switching from traditional fuel</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Access to information becoming easier</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Working and study hours increase</td>
<td>Agreed</td>
</tr>
<tr>
<td>Social Impact</td>
<td>Quality of life increase</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increase number of hours for relaxation</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increase in listening radio/ watching TV</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increase status</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increase social activities</td>
<td>Agreed</td>
</tr>
<tr>
<td>Economica Impact</td>
<td>Monthly payment on energy decrease</td>
<td>Not agreed</td>
</tr>
<tr>
<td></td>
<td>Changes economic level of the users</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Repayment amount is a burden</td>
<td>Not agreed</td>
</tr>
<tr>
<td></td>
<td>New employment opportunities</td>
<td>Agreed</td>
</tr>
<tr>
<td>Management and ownership of the program</td>
<td>System maintained by the users</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Easy to operate</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Receive training on maintenance and monitoring</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Distance to closet local service centre</td>
<td>Near to program area</td>
</tr>
<tr>
<td></td>
<td>Costs of maintenance</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Spare parts availability</td>
<td>Available</td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>Battery recycling available</td>
<td>Yes</td>
</tr>
<tr>
<td>Impact on Gender</td>
<td>Women get more free time</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Women’s work load reduced</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Familiar with new technology</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Can do income generation activities after dusk</td>
<td>Agreed</td>
</tr>
</tbody>
</table>

The outcome of the survey shows that most respondents answered in the affirmative for most program indicators. As the overall quality of life of users was increased due
to the use of the SHS, the program has had a positive impact and can be demonstrated as a successful program. This supports the view within the literature that this program is a successful one.

6.5.2 Market based program approach

The program is a market-based approach and is not a Governments subsidised program. People buy the system by taking a loan from the service providers and become the owner of the system after the loan period.

In January 2003, with the support from IDA and GEF, this program started with the aim of providing loan for 50,000 SHSs in off-grid areas within five and half years i.e. by June 2008. The target was achieved in August 2005, almost 3 years ahead schedule and US$ 2 m below the estimated cost. Following this success, the World Bank, GTZ and KfW have extended support and IDCOL has revised its target to 1 million SHS by 2012. So far 256,114 SHS had been installed by November 2008. Sixteen partner organizations work under the IDCOL umbrella. These POs are responsible for sales, installation, after sales service and monitoring of the system. They also provide training to the users and technicians to create awareness among the users of SHS. The program implementers mainly target those areas, which have no access to conventional electricity and little chance of getting connected to the grid within 5 to 10 years. Area selection criteria are based on factors such as the community's desire for electricity, lack of access to grid services, householders' ability to pay, and the opportunities for business or income generation activities, which play a key role in project implementation.

Awareness development is an important factor for SHS programs. This helps the program implementers to expand the program area. In the Bangladesh program there is a presence of market forces which will allow demand to be created and demand
could be strengthened by awareness development among the users. There is a need to provide different size systems to make the customers happy and to expand the program. People will buy the system according to their needs and ability to pay. Therefore, if there are many options to choose from they feel comfortable.

The availability of spare parts, maintenance and monitoring support and training on maintenance and monitoring provided by the implementers have a good impact on the users as well as on the program sustainability. If the system did not work well the customer will lose faith in the system and will not recommend anyone to buy the system. Since this is a market based approach and customers are willingly buying the SHS, a proper customer service is required to ensure the viability of the project. Spare parts availability helps the program to run smoothly. The main objective of the SHS program is to provide electricity services and if the parts are not available locally, people will not get the electricity until the parts are replaced. By operating through unit offices within a few kilometres of the project area, the program runs efficiently.

Training is important but at the same time it is costly to implement. Some implementers see training as the part of their business strategy to reduce the maintenance cost. In the Bangladeshi SHS program almost all the implementers agreed that providing training to the users and technicians helps the programs to be sustainable. A training manual for technicians was developed by IDCOL on SHS. Some of the implementers have their own manuals.

It is not certain how the optional system size is determined under this program. There are some rules and guidelines but sometimes the implementers offer more lights with a pre-designed package system than it is designed for. Though they claimed that customers follow the instructions and they do not receive any
maintenance. From the field experience of the author and personal communication with the customers it was found that some systems are used more than the prescribed time and the batteries of those systems are not working well (Per comm. Tania November, 2007). It is also mentioned by the participants that there is a need to develop low consumption lights to make the program more successful.

Financing is a major constraint of the program. The main funding source for the SHS program is IDCOL, a Government entity which receives soft loans and grants from donors and disburses them among the POs as loans. POs receive the loan amount as a refund after they sell the system to the customer and submit their signed contract to IDCOL. The considerable upfront investment by the POs of this program is twenty percent of the hardware cost and the rest of the cost is borrowed as a loan from IDCOL. Lack of credit from the development banks also limits the scale of operation of the POs. Therefore, there is limited potential to scale up the number of installations and to commercialize the business for small POs. Scaling up of the solar program is limited to the larger micro-finance organizations.

The government or development banks also need to step in to provide assistance. If commercial banks do not provide greater access to financing, private enterprise should be encouraged by opening up the RE energy sector and providing fair subsidies. These are attraction factors for the private sector to be more involved and reduce the risks of the business.

Cost recovery is a big concern for this program. If the POs cannot get the money back from the customers as monthly repayments, they cannot buy new systems and thus cannot expand their business. Therefore, it is important to recover the money from the customer to roll over the program. The POs only receive the amount they spend in the SHS program as reimbursement and they have to pay back the money
after two years. They can only invest in new systems if the collection of money is regular.

The successful financing of RE electrification schemes and projects is primarily a question of good and appropriate public policy. Public policy is considered the main factor in the research by the respondents. Large scale power production has received much priority due to the overall shortage of power generation in Bangladesh and it affects the economic development. Therefore, large scale production has received a higher priority in the national agenda by the policy makers than renewable energy. For example, until last year there was no duty on the import of solar modules, but this has been set to 5% from this year. This has resulted in an increase in the price of the systems. In addition, worldwide increase in price of lead and copper has nearly doubled the price of batteries and cables, which is making even the subsidised projects unprofitable for the small operators, even though there is a significant demand for SHS in the country.

In the absence of any renewable energy policy in the country, this sector will not get any privileged retreat by the banks or other authorities like the mainstream power providers. There is a lack of awareness among the banks about the demand for solar equipment, so it is difficult to get any loan for doing business in this field. In contrast, in neighbouring countries like India, special incentives and provisions are made for similar projects through the taxation system (MARCEL, 2008). So, due to a lack of public incentives, there is very little private investment in solar energy applications in Bangladesh.

SHS programs in Bangladesh faced lots of problems and POs have tried to overcome some of them during the course of the program. The cost of the system components and availability of some components like panels are still acting as barriers for the
program. Because the panels are imported, the end cost of the panel depends on the current exchange rate. The import duty and tax on the imported items, as discussed above, also increases the cost of the system. This makes it difficult to design system for the poor people as they cannot afford the down payment or monthly repayment for the larger system. There is a need for policy advocacy to remove the duty on solar panels and to develop ensure a specific policy for the RE electrification program.

The process of component selection and approval also needs to be simplified. There is a need for continuous effort to improve the quality control of the components. Information sharing on the availability of components in national and international markets among the implementers is also necessary. As the market is growing very fast, it is a necessity to train skilled people who are technically sound and have good managerial capacity in order to run the program successfully. Training the people who are working in implementation is very important and that is something which is missing in this program at present.

The degree of success depends on various factors and issues and can be vary from program to program based on the objectives and design of the program. From the survey analysis, it is clear that to make a program successful, the program needs:

- continuous monitoring and technical support
- training program available for the users and local young people to develop awareness
- trained the users on use of system
- regular after installation service
- ownership on the system as the users think it is their asset
• Suitable financial mechanism - used in this program makes the program unique. This mechanism helps the rural poor people to acquire the system and enjoy the clean light as well as increases the number of users of the program but still is a need of money flow for the implementers to expand their program. The strength of the program like:

• good customer relationship,

• provide good service to the customer, micro-finance

• extensive field network

• monthly meeting with Government and field workers etc.

• The above strengths established by the program implementers’ show the key success factors of the program. The development opportunities that arose from the program also help to enhance the program’s success. The weaknesses of the programs are:

• lack of skilled and committed employees

• system price increases

• increased transport costs which slow down the after sales service,

• risks of loan recovery etc.

The stakeholders need to address the above to run the program successfully. Some threats like natural disaster, currency devaluation etc cannot be addressed without proper government policy. Other threats: Government policy change, poor quality components from local supplier, lack of investment in capacity building of the employees can be solved by taking proper initiatives and measures.
As mentioned in Table 6.2 to resolve most of the weakness and threats all stakeholders can play a role. Implementing agencies can work out most of the technical problems arising from the program. Government can play a major role by involving local banks for financing support. Government also can create a specific RE policy and international donor agencies, implementers, suppliers etc. can help to finalise the policy.

For developing institutional strength, both the government and implementing agencies can participate. Training institutions or universities can offer courses on it and implementing agencies can help them to formulate the course based on their needs and send their employees to participants. Implementing agencies and the government can jointly apply to the donor agencies to provide support for users and technician training and awareness development programs. The uncertainties like natural calamities can be addressed by the Government and donor agencies.

6.6 Summary of Findings

There has been a spectacular change in the SHS program in Bangladesh which brings electricity to the rural areas where grid electricity will not reach. From very limited demonstration and institutional uses of a decade ago, solar PV is now being taken directly to rural people most of whom earn US$ 3 to 8 per day. Much success has been achieved in making the system popular, user-friendly and affordable. This program has brought a new paradigm in the rural electrification in the country, offering a quick, feasible, and sustainable alternative to grid extension.

The most important factor in bringing about this change is the social entrepreneurship approach of some dedicated non-profit organizations. Users feel comfortable with the fact that they can get support from the implementers and they
can easily access them to resolve the problems. Component selection and warranty is also important to run the program successfully.

Maintenance and monitoring is one of the key success factors of any SHS program. This program consists of regular monitoring, system warranty and component selection process and regular customer service. There is a need of spare parts availability in the local area. Customers feel comforted and have faith in the technology as well as on the program if they can get the service and spare parts locally when they require them. Technical performance and training is important to run the program smoothly. By providing proper training and technical service it is possible to keep the maintenance cost low.

Sustainable financing is often the most challenging aspect of RE electrification. Financing is the main constraint as pointed out by all the stakeholders. Many different approaches for financing RE based rural electrification schemes can coexist. Differences in approach are bad, because it is desirable to have flexibility to address different contexts and issues to make the program successful.

There should be a mechanism put forth to facilitate access by lenders to long term loans and rates on a commercial loan basis. The terms and conditions of rural electrification projects are often not suited to commercial loans. In the case of RE rural electrification projects, the recovery time is too long (7 to 8 years), there is no collateral, no guarantor and risks exist due to natural disaster. Commercial banks are not convinced that RE rural electrification is good business.

A very important topic of concern is the lack of political commitment to renewable energy in general in the government. All the stakeholders who participated in the survey do feel that policy plays a major role for successfulness of the program. They
agree with the idea that there is a need to develop a policy specifically on renewable energy electrification.

Though the programs are running well, there are still lots of problems that need to be addressed. The barriers are classified as: institutional, policy, financing technical, information and human resource barriers. These barriers may be removed by working closely with all the stakeholders in the program and with the help of Government policy, in favour of the RE program.

Despite the lack of policy and the higher level of bureaucracy, and the program is not being followed by the national rural electricity policy, somehow this program works well. Therefore, a conclusion can be drawn that in order to make a SHS program successful and sustainable, the program should:

- Consider local and cultural factors in program design
- Design the system based on the users’ need
- Offer ownership development among the users
- Provide awareness development on SHS uses and benefits
- Develop quality control system
- Provide efficient after sales service
- Offer a simple warranty claiming procedure
- Have a routine monitoring and evaluation schedule built in the program
- Utilize good in-house technical knowhow
- Use locally available spare parts
- Provide users and technician training system available
• Offer an appropriate financing mechanism for users to acquire the system

• Use a regular revenue collection system

• Develop a mechanism to measure program impact regularly

If all these things are ensured then success can be achieved and the program can be sustainable. Missing only one thing might threaten the sustainability of the program.
Chapter 7

Summary of Major Findings
Chapter 7 - Summary of Major Findings

This study set out to explain why some renewable energy rural electrification programs based on solar home systems (SHS) work well and why others do not work so well. To do so it was considered necessary to understand these programs: what their primary objectives are; how and why they are designed and implemented in the ways that they are; and how successful they are in achieving those objectives. In order to gain such an understanding, information was required from multiple sources. This included surveys to obtain information from as many as possible of those involved in these programs, their views on how successful the programs are, what factors have been important in determining whether the programs have been successful or not, and how they could be improved. The aim was then to use this information to identify a set of factors that contribute to the success of programs and to develop a process that incorporated these success factors and that could be followed to improve program success. Because information was collected from number of sources, the purpose of this Chapter is to bring that information together to summarise the main findings.

7.1 Success Criteria

The literature shows that most SHS programs implemented in the Asia-Pacific Region use a range of delivery mechanisms and financial mechanisms. Most of these programs, however, are not managing to keep pace with population increases. The degree to which these programs are expanded in the future will depend to a large extent on how effective those programs currently being implemented are perceived to be.

Despite the development of best practice guidelines, many programs continue to meet with limited success, clearly indicating that the development of these best practice guidelines, on their own, has been insufficient. One of the reasons for this appears to
be that the literature focuses on barriers and largely ignores many other issues that need to be considered in planning and implementing programs. A comprehensive review of the literature, including unpublished reports, indicates that not only is the number of barriers substantial, but that many other issues are also regarded as having an important impact on the outcomes of SHS programs. The degree to which these issues are considered in the development and implementation will determine the success and the sustainability of those programs.

A set of criteria for measuring program success was developed from the extensive review of published and unpublished documents. These criteria were used in developing the questionnaire for the e-mail and field survey.

The email survey of those with responsibility for implementing programs in the Asia-Pacific region revealed much information that was useful in explaining why programs are more successful or less successful from the perspective of program implementers. First, it was found that the objectives of most programs are couched in relatively broad or high level terms, which leads to a problem as these broad objectives have limited value in terms of assessing whether a program is successful or not. Whether or not a program has met very broad, unspecific objectives provides only a weak measure of real program success. The fact that most respondents failed to respond to the question of the primary reasons for program success further suggests that many program implementers may be more focused on the implementation process than they are on the outcomes and that the objective becomes the delivery of the program itself rather than to use the program to achieve other objectives.

A second major finding of the email survey that contributed significantly to explaining why many programs may be less successful was the small proportion of program implementers that are aware of the existence of best practice guidelines and therefore
do not rely on these when designing and implementing their own programs. Even more surprising was the finding that many of those that are aware of best practice guidelines do not refer to these when designing and implementing their programs. The reasons for this need to be further explained.

Most program implementers consider the inclusion of an appropriate financing mechanism and the availability of funding as the most important determinants of program success. The former was not surprising as the availability of finance is commonly cited within the literature as being of critical importance. The latter, however, is not commonly cited in the literature as a determinant of program success and the fact that program implementers see this as an important factor perhaps reflects new practical experience gained that is not yet commonly recognised within the literature.

It was clear that program implementers have internally inconsistent views on what is important and what is not important. The fact that many do not rate a need for technical knowledge as important, while identifying a need for a built in monitoring and maintenance component suggests that some do not understand the close connection between the two. It would be difficult to incorporate a good monitoring and maintenance service component without having good technical know-how.

From the email survey a list of critical success factors was developed using six broad categories:

i. institutional mechanism

ii. financing mechanism

iii. program design

iv. monitoring and evaluation scheme
v. community involvement and

vi. capacity building

While each of these factors related strongly to the success and sustainability of renewable energy rural electrification program, their relative importance would depend on the particular situation in which a program is implemented.

These success factors were then linked to a set of indicators, which could be used to gauge program success. The impact assessment questionnaire and the guide questions for interviews with the stake holders were based on these success factors.

7.2 Program development issues and output

The study included two field surveys, one based on a donor/government funded program (Fiji) and the other based on a market-based approach (Bangladesh). The aim was, to assess the success of these programs and to understand the issues behind the success or relative lack of success. The impacts of the program were analysed using the set of success factors that were developed from the email survey (Chapter 4).

7.2.1 Fiji SHS program

The results of survey of Fiji SHS users indicated that the program has been successful in providing positive social outcomes. Most of those participating in the program considered their quality of life to have been improved as a result of their participation in the program, although many also considered that their expenditure on energy had increased. In most instances actual expenditure on energy had not increased but the need to purchase a SHS appears to have frequently led to a perception of increased expenditure.

The Fijian SHS program was found to have a number of fundamental weaknesses, one of which was the lack of choice over system size or costs. The reasons for this appear
to be twofold: program implementers consider that increasing the choice of system sizes would increase the costs of the program, which is already critically under under-funded and under-resourced. Another problem is the ownership model that is used. In order to reduce the costs of the program participants, the government retains ownership of the solar systems. This tends to result in those using the systems to assume no responsibility for maintaining the systems, which leads to maintenance and reliability issues and leaves the program vulnerable in the long run. This problem is compounded by a second fundamental weakness of the Fijian program, the lack of training of those using the systems on correct use and proper maintenance of the system.

The program is significantly underwritten by the Fijian Government. The revenue raised through the monthly fee for a metered usage code is used to cover the costs of the maintenance and monitoring service and a portion of the administration costs. It does not, however, cover the initial capital cost or the cost of spare parts. This means that the sustainability of the program is dependent on the government continuing to subsidise the program. Again, this problem or vulnerability to the sustainability of the program is compounded by the inefficiency of the revenue collection system which results the revenue from the program being significantly lower then it potentially could be.

There is a clear gulf between the intended and the actual program design and implementation. While initially designed on a RESCO approach with private businesses providing the maintenance on a fee for service basis, the monitoring and maintenance is fully funded and run by the Government, which contracts a private company to provide this service but with the Government agency having responsibility for the costs and the provision of spare components. The root cause for this gap between intended and actual policy is the lack of capacity within the private sector to
undertake the intended RESCO role and the lack of trained or skilled technicians that those companies could employ. This points to the need for programs to include capacity development, but provides a clear understanding of the problems faced by some program implementers who are constrained and do not have the latitude to follow a fixed process set out in best practice guidelines.

Most of the problems being experienced in the Fiji program are attributable to institutional rather than to technical causes. The technical problems that do occurred caused not by the technical performance of the equipment but by the flaws in the maintenance strategy and the system used for supplying spare parts when required. The program’s planning and implementation has several major weaknesses. The lack of on-ground support in areas where the systems are installed, the limited role of private businesses in providing maintenance, the poor after sales service that is provided and the lack of training of system users. These problems all stem from the top-down approach that is used in the planning and design of the program and the low level of involvement of those that use the solar home systems.

There is, however, scope for making several changes that would be likely to significantly improve the outcomes. The development of a proper monitoring system and the provision of a higher quality service, improved supply of higher quality components are possible without the need for a significant increase in funding from government. However, these changes will require changes to the institutional mechanisms and a willingness to provide sufficient resource for the policies to be implemented. There is a need to increase the tariff to cover the costs of maintenance, monitoring and replacement of the SHS components. The solar systems could be maintained, for example, by training users and the supply of spare components could
be improved and the cost reduced by focusing resources on developing local expertise and capacity.

7.2.2 Bangladesh SHS Program

The SHS program in Bangladesh represents a fundamental shift in the way that programs are implemented. In the case of the Bangladesh program, the results have been quite spectacular and the program now reaches large numbers of rural households with incomes as low as AU$1000/year. Much of the success is attributable to the effort that has gone into making the solar home systems popular, user-friendly and affordable. The program is now widely recognised as offering a feasible and sustainable alternative to the grid-extension option.

The program consists of regular monitoring, system warranties and component selection processes and regular customer service. Training of users is built into the program, which helps to keep maintenance costs low. Sustainable financing is often the most challenging aspect of RE electrification programs and the financial mechanism used in this program is what made the program unique. It enables low income rural households to acquire a solar system while allowing the number of households participating in the program to be steadily increased. Recovering the loan payments from those that borrow to purchase a system is therefore critical to program success as a failure to get the money back from the customers in the form of monthly repayments means that the POs are unable to purchase new systems and therefore cannot expand their businesses.

Although the program is highly successful, a number of issues need to be addressed. These problems fall into the categories of institutional, policy, financing, technical, information and human resource constraints. To resolve these issues it will be necessary for all the stakeholders involved in the program to collaborate, including
working together to achieve changes in Government policy to make these more favourable to the program.

The Bangladesh program has provided multiple benefits and has numerous strengths. The program has resulted in an increase in the quality of life of participants, many of whom reported spending more time relaxing, such as watching TV. The primary reasons for purchasing a SHS, however, was to replace kerosene lamps with a cleaner and brighter source of lighting to increase access to information, such as listening to the radio for news and weather alert warnings. They were also able to charge mobile phones so that they can communicate with relatives, business partners, friends living outside of the area and to keep updated on the market prices of crops and products.

The program uses a market-based approach and is not subsidised by government. The systems are purchased by taking out a loan from service providers, paying off the loans and becoming the owner of the system once the loan has been repaid. The program is large, with over a quarter of a million systems being installed by November 2008, and with sixteen partner organizations (POs) working under the IDCOL umbrella to implement the program.

The program has several strengths that make it efficient. The POs are responsible for sales, installation, after sales service and monitoring of the system as well as the training of local technicians and customers. Spare parts and services are provided through this network of partner organizations. The program is also designed around the needs of the system users and a number of system sizes are available under this program, although it was not possible to ascertain how the system size options have been determined. Awareness development is considered to be an important factor and the criteria for selecting an area for inclusion of the program include the community's desire for electricity, lack of access to grid services, householders' ability to pay, and
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the opportunities for business or income generation activities to be fostered by a SHS program.

The most important factor behind the success of the program is the social entrepreneurship approach used by some of the dedicated non-profit organizations. Despite a lack of supporting government policy, and the fact that the program is not supported through the national rural electricity policy, the program nonetheless works well.

The program, however, has a number of weaknesses and there are a number of potential threats that could reduce the program’s future growth and effectiveness. Training of those working on the implementation of the program is very important and that is something that is currently missing in this program. One of the constraints on future growth of the program is a lack of skilled and committed employees.

An increase in the price of the systems could reduce the ability of the lower income households to participate. The development of local components, such as low energy consumption lights, will help to manage the risk of price increases and to make the program more successful.

Finance is an issue. A lack of awareness among the banks about the demand for solar equipment makes it difficult for POs to obtain loans to fund their business activities. The inability of POs to obtain credit from the development banks limits the scale of POs operations and any scaling-up of the solar program will need to rely on the larger micro-finance organizations. The greatest immediate risk faced by the POs, however, is a failure to recover loans to program participants.

One of the biggest weaknesses of the program is the lack of dedicated government policy on RE electrification. Appropriate public policy was seen by many program
implementers as the main factor that will determine the future success of the program. The program currently operates outside of any government policy framework. The successful financing of RE electrification schemes and projects relies critically on good and appropriate public policy. There is, therefore, seen to be a need to advocate for changes in policies, such as for the removal of the duty on solar panels, and a need to develop a specific policy to support the RE electrification program. The government and development banks also need to become more involved in the program by providing increased access to finance and by assisting to increase the level of private involvement in the program.

7.3 Proposed Roadmap for Solar Electrification Program Design

The degree of success or failure of a solar electrification program depends on multiple factors. The importance of these factors varies from program to program and depends on the programs’ objectives and design. From the analysis of the survey results it is clear that in order to make a program successful, the program needs the following:

- Continuous monitoring and technical support;

- Training program available for the users and local young people to develop awareness of SHS;

- Good and reliable after installation service agreement;

- Ownership development of the systems by the users;

- Suitable financial mechanism for repaying the loans;

- Good customer relationships;

- System design reflect users’ need;

- Establish extensive field offices;
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- Consider local and cultural factors in program design;

- Develop quality control system;

- Offer a simple warranty claiming procedure;

- Have a routine monitoring and evaluation schedule built in the program;

- Utilize good in-house technical knowhow;

- Spare parts available locally;

- Regular revenue collection system; and

- Mechanism to measure program impact regularly.

If all of the above are incorporated into a program, there would be a high likelihood that the program would be successful and sustainable. However, the omission of any one of these could undermine the sustainability of the program. These success factors and roles of the different stakeholders can be used to develop a sustainability roadmap for either a donor/government funded or a market based SHS program. The roadmaps developed from the results of this study are shown in Figure 7.1 and 7.2 respectively. These indicate the stakeholders, program stages and issues that need to be addressed in order to make the program successful. There are four stages (planning, design, implementation and post-implementation stage). Issues at each stage are more or less similar for either type of program, although some of the issues vary, based on the program types. In both types of SHS programs, the common stakeholders are the Government, the community, donor agencies and implementing organizations.
Figure 7.1: Roadmap for RESCO Approach
Figure 7.2: Roadmap for Market Oriented Approach.
7.4 Conclusions

To measure the program success during the post-implementation stage, the following criteria can be used as key success indicators:

- Positive social, environmental and economical impact
- Systems performed well
- Energy access increased
- Customer satisfied
- High tariff collection/recovery rate

A program that meets all of the above criteria is likely to be successful and sustainable. If, however, not all of the criteria are met indicates a need to review the respective stages to determine whether the issues are addressed properly. For example, if the program does not have a positive impact, it points to a need to assess whether all the issues in the planning stage were addressed. Similarly, if customers are not satisfied it points to a need to review the design and implementation stages of the program.
Chapter 8

Conclusions and Recommendations
Chapter 8 - Conclusions and Recommendations

This chapter presents the conclusion, recommendations and suggestions for further studies.

8.1 Research Questions

This study was based on three research questions

1. The first and overarching research question being why some rural electrification program based on the installation of solar home systems (SHSs) undertaken in developing countries are more successful and some less successful. This has been the fundamental question that has been behind much of the research undertaken in this field. The argument or hypothesis that was put forward was that attempting to find the answer to this question is neither simple nor straightforward as the number of issues involved is large. Most of the previous attempts at answering this question have not been based on a complete understanding of these programs or how they are planned, designed and implemented. More importantly, the argument that was put forward was that these previous studies did not assess the benefits and the problems associated with the programs from the perspective of all participants and stakeholders and that as a result, the answers that these previous studies have provided have been equivocal.

2. The second research question that steered this study was that of why some programs continue to fail or meet with limited success even though best practice guidelines and recommended practice guidelines have been developed to guide the planning, design and implementation of these programs. The argument or hypothesis that was forward to explain this was that the adoption of best practice guidelines is a necessary but insufficient condition for program success. The
reason this is that these best practice guidelines are complex and cover a large number of issues. But that they have been developed on the findings of those studies that have focused narrowly on barriers to the uptake to the renewable energy systems.

iii. The third and final research question behind this study was that of why some programs continue to be implemented on the basis of the ‘old paradigm’ or government/donor subsidy model when this is unlikely to result in program sustainability and or program success. The argument or hypothesis that was advanced put to explain this was that the reasons for adopting a government/donor model approach are political and institutional in nature and that such programs could be successful, but that a pre-condition of program success is a well-coordinated political and institutional framework at the national level.

In order to test the explanations or hypotheses above, this study set out to undertake a comprehensive study of renewable energy rural electrification programs using a literature review, an e-mail survey of program implementers and two field studies. The aim was to obtain a more complete understanding of these programs, of the impacts and benefits and of the issues associated with their planning and implementation from the perspective of all stakeholders involved.

The question that now needs to be asked is to what extent these aims were achieved and to what extent the research questions have been answered and the explanations or hypotheses that were put forward supported.
8.2 Reason for the Limited Success of Some SHS programs in the Asia-Pacific Region

The first of the research questions was why some programs are more successful than others and how those less successful programs can be changed to make them more successful. One of the main reasons for the limited success of many of the solar home system (SHS) programs being undertaken in the Asia-Pacific region was found to be a lack of monitoring and maintenance. This reason is also commonly identified in the literature too. Many program implementers continue to fail to recognise the need for maintenance and monitoring to be integrated into the design, planning, implementation and post-implementation stages of their programs.

The field studies provided further explanations of why some programs continue to meet with limited success. These included:

- **A lack of stakeholder consultation and use of a top down approach.** Many program implementers do not recognise the need for community involvement or input from program or potential program participants and to design the technical specifications of the systems and the program to meet the needs of participants.

- **Lack of information on willingness to pay** for the system by the users. The capability of paying for the service repayment of the system is important. If subsidies are required, they can be designed in smart ways to cover maintenance, monitoring and replacement costs.

- **Poor money collection rate** – it was found that the monthly expenditure for operation and maintenance does not cover the fees received from the participants because of the low rate of collection. Also, the money collected from the monthly fees does not always go towards the operation and maintenance of the systems.
Chapter 8: Conclusions and Recommendations

- **Lack of training**- this is an important part of the programs. The limited success of some programs is linked to a failure to build a training element into the program design.

- **Lack of spare parts availability**- if it is difficult for the users to get spare parts within program areas, they do not have electric lighting until the parts become available. This leads to dissatisfaction and loss of faith in the SHS system and program.

- **Local expertise development**- the development of local expertise minimises maintenance cost. Training of local people also help educate the users on the SHS system and reduces the incidence of misuse of the systems.

The second part of the research question is why some programs are considered to be more successful than others and why some programs are perceived as meeting with limited success. The survey results from the program implementers provided some useful insights. The reasons given for success of programs by those program implementers that considered their programs to be successful included:

- strong management quality of the implementing organization,

- quality control

- routine evaluation

- the use of appropriate technology

- creation of local employment and development of local expertise

- efficient after-sales service and spare parts availability

Not all programs incorporated these as a part of their regular practice which may be the reason why some programs have limited success. The above factors were obtained
from a more comprehensive survey with all stakeholders involved in the program and not only looking at the barriers and success stories.

8.3 Use of Best Practice Guidelines

The research efforts undertaken so far have aimed at identifying barriers to the uptake of renewable rural electrification programs and development of best practice guidelines for the implementation of projects designed with the intention of addressing the important barriers. However, many programs continue to meet with limited success, clearly indicating that the development of these best practice guidelines, on its own, has been insufficient.

The survey of the SHS program implementers in the Asia-Pacific region on their views of SHS program implementation shows:

- Forty percent of respondents were unaware of the existence of any best practice guidelines; and

- Over half of the respondents (53%) stated that their programs were developed and implemented without reference to either best practice guidelines or experience gained from previous programs.

- A more startling result was that many of those that were aware of the existence of best practice guidelines reported that they did not refer to these when designing and implementing their programs.

The results of the program implementers’ survey shows that most program implementers design and implement their program without best practice guidelines and without studying the lessons or experience gained from previously implemented programs. This suggests that many programs are being designed and implemented in
isolation and the conclusion is obvious: program implementers need to be made aware of best practice guidelines and previous experience.

The reasons for this conscious decision by many program implementers to ignore best practice guidelines are:

- A lack of awareness of best practice guidelines
- The failure of the best practice guidelines to describe the stages, issues and the stakeholders and their role in the design a SHS program
- A lack of understanding of the program design and management guidelines

The finding that best practice guidelines are not being referred to is one obvious explanation for the limited success of many programs. It points to a serious failure on the part of some agencies with overall responsibility for oversight of the programs or for providing funding for programs.

This provides a better explanation of why some programs continue to fail despite the development of best practice guidelines. The guidelines are based on a limited understanding of programs from the previous studies. They mainly concentrate on how the program can be designed, and how to address the barriers, rather than a complete process that includes the role of stakeholders and their activities in terms of program design, implementation and post implementation.

**8.4 Reasons why some program did not follow the new paradigm approach**

8.4.1 Fiji Program

One of the purposes of the field surveys was to assess the extent to which these programs have succeeded as successful according to the program success criteria. The Fiji SHS program was developed on the basis of a RESCO approach and being heavily
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reliant on subsidies from the Government. The findings from the field survey suggested that this program is not a full RESCO program as the program is totally run by the Government and the service company do not have responsibility for the program. The Government has generally not been successful in providing quality after sales support of the PV rural electrification program. The DoEF is attempting to develop the capacity of local companies, so that they can play a greater role but in doing so confronts a shortage of both qualified companies and people. The solar program in Fiji suffers from lack of planning and policy. Problems occur due to lack of maintenance support and policy framework.

Overall, the program concept behind the Fiji program was good, but is in need of a better planning and an implementation mechanism to make this program successful. Development of local expertise to make some components locally and to implement the policy on renewable energy systems is also essential in order to make the program successful.

8.4.2 Bangladesh Program

In Bangladesh, it was observed that there has been a spectacular change in the SHS program. From very limited demonstration and institutional uses of a decade ago, solar PV is now being taken directly to rural people most of whose income is around AU$ 3.5 to AU$ 8.5 per day. The systems are sold to the rural people with a credit options ranging from 1 to 4 years of lending period. Much success has been achieved in making the systems popular, user-friendly and affordable. This program has brought a new paradigm in the rural electrification to the country, offering a quick, feasible, and sustainable alternative to grid extension.

The program consists of regular monitoring, system warranty and a component selection process and regular customer service. Training of users is a built in
component of the program and this has helped to keep the maintenance cost down. Sustainable financing is often the most challenging aspect of RE electrification. The financial mechanism used in this program makes it unique. This mechanism helps the rural poor people to acquire the system and to enjoy clean lighting as well as increasing the number of users of the program. There is still a need of money flow for the implementers to expand their program.

Although the program is running well, a number of problems are needed to be addressed in order to improve the program. Cost recovery remains a major concern for this program. If the POs can not recover the money from the customers as monthly repayments, they are then unable to buy new systems and thus unable to expand their business. The problems are classified as: institutional, policy, financing, technical, information and human resource barriers. These barriers may be removed by working closely with all the stakeholders involved in the program and with the help of Government policy, which is favourable to the RE program.

8.4.3 General Observations

The reasons that many programs are still implemented in old way are not very obvious. Some of the reasons that were identified from the survey include

- **Lack of government policy**- Governments have the same policy for all types of rural electrification e.g. diesel generator, solar, micro-hydro.

- **Cultural issues**- Fijian people are not seeking to increase their working hours in order to do not want to work after hours and so the system cannot be used for income generation

- **Government policy**- not to decentralise the rural electrification program and lack of long term policy. Policy also affected due to political disturbances.
• **Lack of human resources** – Not many companies are interested in working in this program as they do not have staffs that have training on this technology. Also, they perceive the financial benefits as being low compared to other businesses.

• **Lack of finance for SHS system** - as a new technology, some financial institutions do not want to take a risk of providing finance for their systems.

The reason that some programs are continues to be based on the old paradigm have to do with cultural and political reasons present in that program location. Institutional issues are also sometimes accountable for this decision. These programs could nonetheless be more successful if there was a coordinated national approach based on a well documented policy framework.

### 8.5 Criteria for measuring the success of rural electrification programs

One objective of the study was to develop success criteria and refining them using the email survey to inform the field survey. That is to help formulate the survey questions and guide the unstructured surveys. The email survey was used to refine the set of success criteria.

The research began with the hypothesis that despite of availability of best practice guidelines, many programs have continued to experience problems. This suggests that barriers, on their own, do not provide a complete explanation of the reasons for lack of success. A comprehensive review of the literature, including unpublished reports, indicates that not only is the number of barriers substantial, but that many other issues are also regarded as having an important impact on the outcomes of programs. The degree to which these issues are considered in the development and implementation will determine the success and the sustainability of those programs.
A list of issues that can be used as a checklist or set of criteria was developed from an extensive review of the published and unpublished literature to measure the success of SHS programs in developing countries. These criteria are used to assess whether their programs are likely to be successful and sustainable. This checklist is used to develop the email and field questionnaires. A number of conclusions can be drawn from the and these include:

- The aims and objectives of most programs are specified in very broad terms, such as, providing access to electricity to rural people, rather than in terms of more specific outcomes,

- The objectives set for the programs are often not formulated in terms of the outcomes for users but in terms of administrative criteria and the needs of the implementing organization. To make a successful program the objectives should be based on the needs of the users and the benefits to users.

- The lack of success of some programs may not be attributable to technical or financial barriers, but to the way the programs are designed, developed and administered

- A lack of policy support – the Government does not provide a policy framework for the program

- A lack of experience and training of those administering the programs, and

- An inadequacy of program funding – limited funding can lead to essential features such as monitoring and maintenance being deleted

The results of the program evaluation are summarised in Table 8.1. These results show the outcomes from the survey measured using the success indicators (Table 8.1).
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A set of roadmaps was developed from the comprehensive success criteria that shows the stages (design, planning, implementation and post-implementation) of a program, its activities in detail, the probable stakeholders in the program and their respective roles in different stages (Fig. 7.1 and 7.2). If this roadmap is followed from the start, it would be possible to achieve success and sustainability for that program.

Table 8.1: Program impact evaluation based on the program criteria and success indicators

<table>
<thead>
<tr>
<th>Variables</th>
<th>Indicators</th>
<th>Survey outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Access to better and clean light</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Switching from traditional fuels</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Access to information becoming easier</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Working and study hours increase</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td></td>
</tr>
<tr>
<td>Social Impact</td>
<td>Quality of life increase</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increased number of hours for relaxation</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increased in listening radio/ watching TV</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increased status</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Increased social activities</td>
<td>Not agreed</td>
</tr>
<tr>
<td></td>
<td>Fiji</td>
<td></td>
</tr>
<tr>
<td>Economical Impact</td>
<td>Monthly expenditure on energy decreased</td>
<td>Not agreed</td>
</tr>
<tr>
<td></td>
<td>Changed financial status of the users</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Repayment amount is a burden</td>
<td>Not agreed</td>
</tr>
<tr>
<td></td>
<td>New employment opportunities</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td></td>
</tr>
<tr>
<td>Management and ownership of the program</td>
<td>System maintained by the users</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Easy to operate</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Received training on maintenance and monitoring</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Distance to closest local service centre</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Costs of maintenance</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td></td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>Battery recycling available</td>
<td>Yes</td>
</tr>
<tr>
<td>Impact on quality of life for women</td>
<td>Women get more free time</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Women’s work load is reduced</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Familiar with new technology</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Can do income generation activities after dusk</td>
<td>Agreed</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td></td>
</tr>
</tbody>
</table>

8.6 Suggested for Future research

Considering the above problems, the following future research is suggested:

i. How to create awareness among the stakeholders on the use of success indicators as a means of measuring the successfulness for an on-going program
ii. Effective training program for stakeholders on designing a successful program and to what extent the training affects the success and sustainability of a program

iii. Use the roadmap and measure its effectiveness

iv. The role of subsidies in creating a market oriented approach of delivering SHS programs

v. Applying the success criteria to more programs in order to refine these and to improve their use for program evaluation

vi. Ways of transforming a subsidy base program to a market oriented program

There is also a need to determine what lessons can be learned and applied to the development of a more effective training program to increase the success of a SHS program.

8.7 Concluding Remarks

Success criteria were developed in this study and used to evaluate the SHS programs in two countries in terms of financing mechanism, program design, monitoring and evaluation, community involvement, capacity building and program impact. The outcomes of this exercise can be used to determine whether the program is successful or not.

The roadmap that was developed in this study will help the planners, donors, governments and implementers to develop sustainable SHS programs. This roadmap can also be used as a checklist to determine if there is any scope for improving the existing program design.

There are still some uncertainties about whether this roadmap should be used by the program designer, donor, policy makers and the implementers. There is still a need for
Chapter 8: Conclusions and Recommendations

a policy framework to create awareness among all the stakeholders on the roadmap. The success indicators, on the other hand, can be used as a regular measure for a successful program.

If good policies can be developed and if awareness can be created about the use of success indicators and roadmaps, SHS can be used effectively to electrify the remote rural areas where extending the grid is not a viable option.
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References


References


References


References

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Annexure

- Annex 2: Survey questionnaires
- Annex 5-I: Map of Vanua Levu
- Annex 5-II: Comments from the survey Respondents in Fiji
- Annex 6-I: Map of Bangladesh
- Annex 6-II: Technical Standards for Solar Home System in Bangladesh
- Annex 6-III: Comments from the Survey Respondents in Bangladesh
Annex 2

Questionnaire for Users

This survey is a part of a Ph.D. research project that aims to use a holistic approach to the development of a best practice model for the design and implementation of rural renewable energy electrification projects in developing countries. Its purpose is to assist in understanding the factors that determine the effectiveness of rural renewable energy initiatives implemented in developing countries, including policy initiatives, institutional arrangements, delivery mechanisms, financial mechanisms and products and services.

This questionnaire will help to assess the impacts of Solar Home Systems in rural areas in Bangladesh. The results from these surveys will provide information about users’ attitudes towards their systems, their monthly expenditure on lighting, the role of the implementing agencies, any financial problems encountered and the solutions used to assist users acquire their Solar Home Systems, and a measure of the benefits and impacts of a solar home system on living standards. This information will be used to assist in the design of new projects and to assist policy makers to refine policies that support the uptake of solar home systems.

The questionnaire has three sections:

- Personal information;
- Energy use information; and
- Information about service providers.

In the first section, the questions relate to information on the household, household income and expenditure, etc. This information is required in order to better understand the views of householders and the impacts of Solar Home Systems on householders in different economic groups. The information collected will be aggregated and will not be used to identify any individuals or households. The second section is used to collect information on energy use patterns, expenditures and attitudes of the users towards Solar Home System (SHS). The last section seeks information and views on the services provided by the implementing agencies.

**All information collected in this survey will be treated as strictly confidential.**

If you are willing to assist in this study by participating in this survey, please complete the declaration below.

**Declaration by Survey Participant**

I (the participant) have read the above information. Any questions that I may have had regarding the survey have been answered to my satisfaction. I agree to take part in this activity, but I am aware that I am free to change my mind and to withdraw at any stage. I understand that all the information provided will be treated as strictly confidential and that no information that could identify individual respondents will be released by the investigator unless required to do so.
by law. I agree that research data gathered for this study may be published provided that my name or other information that might identify me is not used.

Participant/Authorised Representative: _____________________________  Date: 

Investigator's Name & sign: __________________________________________
<table>
<thead>
<tr>
<th>Person ID (used for computer analysis)</th>
<th>Name</th>
<th>Relation with head of the households (HH)</th>
<th>Age</th>
<th>Gender</th>
<th>Marital status</th>
<th>Occupation</th>
<th>Can read and write</th>
<th>No. of years of education completed</th>
<th>Presently enrolled in school</th>
<th>Hours spent at home reading or studying last 24 hours</th>
<th>Of which hours reading or studying at night</th>
</tr>
</thead>
</table>

**Relationship Codes:**

- (0) = Head of the HH
- (1) = Father
- (2) = Mother
- (3) = Husband
- (4) = Wife
- (5) = Brother
- (6) = Sister
- (7) = Son
- (8) = Daughter
- (9) = Father-in-law
- (10) = Mother-in-law
- (11) = Brother-in-law
- (12) = Sister-in-law
- (13) = Son-in-law
- (14) = Daughter-in-law

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(15)=Uncle  (16)=Aunt  
(17)= Cousin  (18)=Nephew  (19)=Niece  (20)=Grandfather  (21)=Grandmother  
(22)=Others (please specify)
### Cash Income

INC 0. What is your cash income over the past 12 months?

<table>
<thead>
<tr>
<th>INC 1.1 Income from service</th>
<th>INC 1.2 Income from other sources</th>
<th>INC 1.3 Remittances from relatives</th>
<th>INC 1.4 Income from business</th>
<th>INC 1.5 Income from rental properties</th>
<th>INC 1.6 Income from agriculture</th>
<th>INC 1.7 Total Income (sum 1 to 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>__________________________</td>
<td>__________________________</td>
<td>__________________________</td>
<td>__________________________</td>
<td>__________________________</td>
<td>__________________________</td>
<td>__________________________</td>
</tr>
</tbody>
</table>

### Agricultural Land

LA 2.0 Please describe your land that was under cultivation last year (in Acres). Total area under cultivation __________________ LA2.0

### Livestock holdings

LI 3.0 Please describe the number livestock currently raised by your households

<table>
<thead>
<tr>
<th>LI 3.1 Cattle/Buffalo</th>
<th>LI 3.2 Hen/Duck</th>
<th>LI 3.3 Other (Pl. Specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____________________</td>
<td>_______________</td>
<td>_______________</td>
</tr>
</tbody>
</table>

### Expenditures

EX 4.0 Please provide the information about your estimated yearly expenditure except for lighting

<table>
<thead>
<tr>
<th>EX 4.1 Food and food stuff (taka)</th>
<th>EX 4.2 Medical (taka)</th>
<th>EX 4.3 Education (taka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____________________</td>
<td>_____________________</td>
<td>_______________________</td>
</tr>
</tbody>
</table>
Housing Unit Information

HU5.1 Type of house

**Codes:**
(1) = Brick construction
(2) = Wooden construction
(3) = Mud construction
(4) = Semi brick house
(5) = Other, Specify

HU 5.2 Roof

**Codes:**
(1) = Straw, (2) = Concrete, (3) = Tiles

(4) = other, specify

HU 5.3 Is any part of your house used for business activities or commercial purposes?

**Codes:**
(1) = No, If no go to HU 5.6
(2) = Yes

HU 5.4 Please indicate the business type

**Codes:**
(1) = Crop Processing, (2) = Food shop, (3) = Grocery shop, (4) = Food and beverage
(5) = Tailoring shop, (6) = Handicraft, (7) = Basket making, (8) = Barber shop, (9) = Laundry,
(10) = Other, Specify

HU 5.5 Who is the operator of the above business?

Enter person identification number from personal information

HU 5.6 Do you own or rent the house?

(1) = Own,
(2) = Rent

Access to social Infrastructure

INF 1. Distance from the electricity grid line in km

INF 2. Distance from nearest school/college in km

INF 3. Distance from source of drinking water in km

INF 4. Source of household water supply in km

INF 5. Distance from the nearest health centre in km
Annexure

INF6. Main access to your home ____________ INF6
Codes:
(1) = Paved road/street, (2) = Unpaved road/street, (3) = Path to walk, (4) = River/canal/sea
(5) = Other, specify

Part 2: Information on Energy

Information on Fuel sources

E1 During last 30 days has your household used ________________ C1
Code:
(1) = Kerosene, (2) = Candles, (3) = Diesel, (4) = LPG, (5) = Dry cell battery, (6) = Car battery
(7) = Others, specify -

Candles
C1. During past 30 days how often have you used Candles? ____________ C2
Codes:
(1) = Do not use candles, go to question next section
(2) = Used sometimes (3) = Always
C2. How many candles do you purchase in the last 30 days ____________ C3
C3. On an average how much do you spend for candles each month? ____________ C4
C4. Does anyone of the household use candles for the following purposes?
C5a. Reading/writing/studying (1) Yes (2) No C5a
C5b Area lighting (1) Yes (2) No C5b
C5c. How many hours per evening do you use candles for lighting C5c

Kerosene Lamp
K1. During past 30 days how often you used kerosene? _______________ K1
Codes:
(0) = Do not use kerosene, (2) = Used sometimes, (3) = Always
K2. How many litres kerosene did you purchase in the last 30 days _______ K2
K3. On an average how much do you spend for kerosene each month? ________ K3
Annexure

K4. What is the average price of kerosene (Tk./Lit) you paid ________ last month?

K5. Does anyone in the household use kerosene lamp/kupi for the following purposes?

K5a. Reading/writing/studying  (1) Yes  (2) No  K5a

K5b Area lighting  (1) Yes  (2) No  K5b

K5c. How many hours per evening you use kerosene for lighting ________ K5c

K6. How many lamps/lantern do you use _______________ K6

K7. What is the one way distance you travel to collect the fuel (km) _______________ K7

Battery

B1. During past 30 days how often did you use a battery? _______________ B1

Codes:  
(1) = Did not use battery, (2)=used sometimes (3)=Always

B2. What are your reasons for using the battery? _______________ B2

B3. What is the rating of the battery (amp-hour) _______________ B3

B5. What is the one way distance (km) you travel to charge the battery? _______________ B5

B6. How often you charge your battery? _______________ B6

Solar Home system

PV1 How long have you used solar home system? _______________ PV1

PV2. What is the size (Watt-peak) of the solar panel? _______________ PV2

PV3. What is the rating of the battery (Amp-hour)? _______________ PV3

PV4. On average, how many **hours per day** do you use your PV system _______________ PV4

PV5. Do you use SHS to operate any of the following devices?

<table>
<thead>
<tr>
<th>Item</th>
<th>(1) = No</th>
<th>Av. No. of hours used</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV5a. Black &amp; White TV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV5b. Color TV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Annexure

PV5c. Radio
PV5d. Lamp
PV5e. Security light
PV5f. Others, specify………..

PV6. How did you acquire your SHS?  

**Codes:**
(1) = Loan  (2) =Cash Payment,  (3) = Rent,  (4) = Through project
(5) = Other, specify

PV7. If acquired through rent:
PV 7a. How much was your initial down payment?  
PV7b.  What is your monthly fees?  
PV7c. Are you able to pay every month?  
PV7d. Does it save the cost you spend for lighting before?

---

**Attitudes/perceptions**

The following statements concern electricity use and other issues. Please tell me if you strongly agree, agree, indifferent, disagree or strongly disagree with the statements.

**Use the following codes:**
(1) = Strongly agree,  (2) = Agree,  (3) Indifferent/neutral
(4) = Disagree  (5) = Disagree

ATT1 Having electricity is importance for children’s education
ATT2 Because of clear light children study more at night
ATT3 It is easy to work after dusk after having the system
ATT4 Reading/working is easier with a SHS than with candles/kupi/lantern
ATT5 Presently news and information become easier to get
ATT6 My family is happy with the SHS
ATT7 Using kerosene can causes health problems
ATT8 Now we often socialize with friends/ relatives, neighbours at our home in the evening
ATT9 Compare to before SHS installed life is easier now
ATT10 Taking a SHS a priority for household
ATT11 I feel safer in my house in the evening because of SHS
ATT12 I feel safer outside my house in the evening because of SHS
ATT13 Watching TV provides my family with great entertainment
ATT14 Monthly expenditure for lighting is now lower
ATT15 Repayment for the SHS become burden on my family
ATT16 If grid electricity are become available, I will go for that option
ATT17 I am happy with the service of the implementing agency
### Annexure

| ATT18 | I am proud of being owner of a SHS lighting system |
| ATT19 | SHS reduce health problems                        |
| ATT20 | Using SHS is safe for my house                    |

#### Part 3: Information on service provider

<table>
<thead>
<tr>
<th>Service provided by the implementing agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>This section concerns the service provided by the implementing agencies to the users.</td>
</tr>
</tbody>
</table>

**SP1. How frequent the service provider visits**

**Codes:**

- (1) = Once 1 months
- (2) = Once 3 months
- (3) = Once 6 months
- (4) = Once 1 year
- (5) = Once Never

**SP2. How long does it take to go to the nearby service center (hour)?**

**SP3. After reporting any fault, how long does the implementing agency took to solve the problem?**

**Codes:**

- (1) = they come in same day
- (2) = Following day
- (3) = One week
- (4) = Two weeks
- (5) = One month
- (6) = Other, specify

**SP4. Do they charge for maintenance?**

**Codes:**

- (1) = No
- (2) = Yes

**SP5. If yes, how much?**

**SP6. Are they providing any training on the use of system?**

**Codes:**

- (1) = No
- (2) = Yes

**SP7. If yes, do they provide any training material?**

**Codes:**

- (1) = No
- (2) = Yes

**SP8. Is the training useful for system operation and maintenance?**

**Codes:**

- (1) = No
- (2) = Yes

**SP9. Are they providing any subsidy for buying the system?**

**Codes:**

- (1) = No
- (2) = Yes

**SP10. Are you happy with the service provided by them?**

**Codes:**

- (1) = No
- (2) = Yes
Sample Questions for Focus Group Discussion

Meeting time: 2-3 hours

1. What is your opinion about the current implementation process?
   
   Probes

   Do you think it can be improved?

   Did you face any problem with the implementation under this mechanism?

2. What are your views about the current financing mechanism used?
   
   Probes

   Is the current financing mechanism working well?

   Would you suggest any better options?

   What are the problems that you are facing in using this financing mechanism?

3. What is your opinion about the IDCOL’s supervisions and assistance?
   
   Probes

   Is the money that the IDCOL provides as grant or loan is sufficient?

   How does the IDCOL provide training assistance?

   Any other assistance provided by IDCOL?

4. What is your opinion about the training support provided by the IDCOL?
   
   Probes

   Could there have been more training and discussion
Do you think that the level of supports needs to be increased?

What are the other components that you think should be included in the training program?

What are your priority training needs that IDCOI should address?

5. How sustainable is this program according to your opinion?

Probes

What is needed to make the program sustainable?

Is there any policy/rule that acts as a barrier for sustaining the program?

Is there any catalyst that helps to make the program more sustainable?

6. Do you think current energy policies help to extend or sustain the program?

Probes

How do the policies help to implement the program?

Have you faced any problem due to current policies?

7. In your opinion, what should the government do to help increase the access of rural people to electrification?

Probes

Should the government change/amendment their current policy?

Should the government implement more renewable energy program?

Should REB help to implement this kind of program?

8. What is your opinion about the viability of the program you are implementing?

Probes
Will the program be sustained after the IDCOL support is withdrawn?

What is your thinking about this business?

Can this part of your business be run successfully like the other parts of your business?
Guide questions for policy makers

Theme: Current policy objectives, Global warming, Renewable energy policy current, Solar Home System (SHS) program, Government role on the current program

Q1. Access to electricity is important for improving standards of living. In some areas, electricity access can be provided by extending grid. What are the present policies or plans in terms of extending the grid in future?

Q2. Has this policy been amended recently? When and how was it amended?

Q3. In many areas and especially in remote rural areas, grid extension is not a practical option. What are the government’s policies for electrifying those areas?

Q4. Does the government provide any financial support to the households in areas without the grid for lighting purpose? If yes, what kind of support and how it is provided?

Q5. Are any government policies in place to reduce current global warming emissions? If yes, how do these policies relate to electricity access in rural areas?

Q6. Does the government considered to use renewable energy, the best option for electrification in such areas?

Q7. Is there any policy or program to increase the uptake of renewable energy systems?

Q8. What is the government’s role in current solar home system program? Is there any coordination between the government and the implementing agencies?

Q9. To what extent do you think that these programs are benefiting the people in rural areas?

Q10. Does the government see any conflict, or potential conflict between its policies relating to renewable energy and grid extension policies?
Guide questions for Donor Agency

**Theme:** Criteria for funding, Selection process for funding, Best practice guidelines, Roles of policy makers, The political situation

Q1. What criteria are used to select a renewable energy electrification program for funding support? Are there any specific guidelines in place? What are the requirements to meet the criteria?

Q2. Once your organization has selected a program for funding, does the bureaucracy assist or hinder to implement the program?

Q3. Is there any requirement for national or local government policies to support or to be consistent with, the goals of the RE program before funding is making available?

Q4. Can problems occur if government policies do not support or are inconsistent with the goals of the program?

Q5. What role does your organization play in the implementation of a program?

Q6. Is there any requirement for the program to have the goal of continuing beyond the donor funding period? If so, how does the donor organization obtain confidence that the program will be sustainable beyond the donor funding period?

Q7. After the program is implemented, what mechanisms are used to measure the success? Do you have any concerns about the success of programs being implemented?

Q8. Has the organization reviewed past programs to assess their successfulness? If yes, what are the factors your organization think is required for success?

Q9. To what extent has this information been used to ensure that new program will be successful?

Q10. In your opinion, how does the political situation in this country impact on the achievement of the program? Do the current policies assist or hinder the program? In what way?

Q11. Has the organization implemented similar programs in other countries? If yes, how successful are those? Is there any difference between the programs?
ANNEX 5-I

Map of Vanua Levu
Annexure

Annex 5-II

Comments from the Survey Respondent in Fiji

Institutional Approach

//.. there is no RESCO as the government is looking after the program. Department of Energy has extended its works. There is no demarcation between RESCO and Government; it’s a sort of mixed program.//

//.. the system in Fiji is partially RESCO. The main reason is that Government wanted to control everything. The RESCO operator can’t do anything because they do not have the authority to do the program but they are responsible for the program.//

//.. the RESCO operator can’t do anything because it is responsible for the program but does not have the authority to do the program. So, there is a need to set up a genuine RESCO operation. Not the partially RESCO controlled by the govt.//

//.. the DoEF are taking the dual roles or most of the responsibilities of the program. We are in a sense to acclimatize a company to the RESCO and provide the company training on installation and maintenance. But still we cannot transfer the whole program to them due to lack of some policies.//

//.. It is not possible to work with DoEF because government want the service company to submit all the financial documents to see how much profit they will get from the maintenance work and also other works done by the company. As the maintenance work is not my only business why should I give my accounts and transaction details to DoEF.//

//.. DoEF has a separate unit and has assigned people to work on it. There is a lack of staff and a lack of resources too. Also, there is no company in Fiji that could be trusted to operate the program in full swing. They are trying stabilizing the whole program before handed over the program on a private company. The DoEF believe Government should have the control on equipment selection and also the price.//

//.. Main for the reluctances of private sector from this program is because the government does not have any policy. There are lacks of skill people in Fiji. The migration rate is very high. Specially if you want to work in rural areas. You do not have trained people. //

//.. there are very high risk in this business and not sure there in return on investment. Also lots of capital cost intensive involve with it. There is no incentive for the companies from the government for implementing these RESCO program.//

//.. Not many companies are really suitable for the work and we are not happy with their work. We found that they are not really ready for the work.//

//.. We wanted to give the program to the private company but also we need to keep in mind that they do not have expertise to be able to do the job. These are very small companies we are talking about. They even do not have any business plan. So, this is very challenging.//

//.. The main objective of the program was to provide light to remote rural areas where grid electricity is not feasible. //

//.. According to program objective we meet the objectives. People enjoy lights which they never had before. This I think can be regarded as success.//

//.. Objective of the program were clear and that is to provide light. Another objective was to see whether the system works or not. From the pilot program we found that this type of system works well and so we go for it. //

//.. we cannot provide different size because this is the only service that the government can provide for the time being. This is for our culture. Whatever the community receives from the government needs to be same for all.//

//.. we feel that there is a need for TV option with the system. But some remote communities don’t have access to a TV channel reception.//

//.. now we are trying to find out what are the other things we can provide like a TV or a mobile phone charger. We are looking for developing a system that can provide power for a TV also.://
Annexure

//... if there are too many different systems we cannot control the market as well as the quality. We
do not have the manpower to do that...//

Maintenance and monitoring
//.. Maintenance and monitoring is a major problem in this program. We need to inspect the
systems regularly...//
//.. One of the reasons that we asked the Govt. to give three years contract to the company was so
that we can assess its work. Before we only gave contract for 3 months or 6 months, which was
difficult to judge their work...//
//... The number of solar systems is very low still and this make tough there is not enough
household who have solar system and this makes hard to make any profit from the maintenance
job...//
//... If the number of systems increases to 2000 maintenance work could be done profitably...//
//... there are some other companies now in Fiji. But the Government asked for lots of papers work
including the financial breakdown of the company, which is difficult to provide. As the amount of
money for this job is very little we did not show any interest to get the job...//
//... another problem is DoEF did not decentralised the job which means that for each and every
decision (no matter how small the matter is) we have to take permission from them. This makes
the process hard for working in the areas...//
//... the design for RESCO Fiji, was after DoEF has started the private company will look after the
systems by themselves. But now at the moment we are taking the dual roles or most of the
responsibilities. This is because there is no company available which can take the job due to lack
of expertise. We are in a sense to acclimatize a company to the RESCO. We also provide the
company training on installation and maintenance...//
//... DoEF did not have any field office or outlet in the remote areas where the system exists. The
time required to reach at the program areas from DoEF office are minimum two days...//

Technical performance of the installed system
//... Its true 40% of the batteries are dead. Most of the batteries do not have water and we pour
water last two months. We need to change 30% of the battery and 10% we can recharge and could
bring back in previous condition...//
//... there were no maintenance last two years and we did not disconnect any system in last two
years...//
//... the maintenance company worked in the field need to wait for decision from DoEF to change
battery or light or any types of maintenance works. This makes the process of maintenance lengthy
and expensive...//

Training
//.. Maintenance and monitoring, users’ education and training are at the heart of this type of
program. There should be continuous training facilities for both the users and technicians.
Awareness development is also important. These parts are missing from our program...//
//... there is no certain training for the users. I think this is a good idea to train the users on what to
do with the system. The people will then become more careful and will never abuse the system...//
//... The DoEF trained the company on how to do the installations and maintenance services. But no
training program for the users. We also don’t want the users to do anything except enjoying the
light and input the code for use every month...//
//... we do not have a training program for the users. We actually have do budget for that. But we
do feel the importance of the users training. We can reduce the maintenance work if we trained the
users from the very beginning of the program...//
//... one of the mistakes we had done in past is not make a contact with the installation company to
provide training to the users on how to use the system. This helps a lot to minimise the misuse of
the system...//
//... we need to make a manual for the users, which can simply shows what to do and what not to
do. But we still haven’t got any thing...//

Funding
Annexure

//..Government is putting the fund for rural electrification and also DoEF received some fund for equipment from the donors.//.. the amount of funds for equipment has decreased. We also are receiving grant money from donor agencies like JICA, UNDP, GEF etc. So, the govt has seen the importance of having such a program and so start funding.//.. the villagers has to bear 10% of the cost of the system which is harder for some community to arrange.//.. the issues are community expectations and ability to arrange 10% fund.//.. We sort of put together the program and in assisted with PITCHR (Non-profit organization). They assisted in implementing the program.//..Initially when we have started with Donor fund and as the program progress Government is allocating rural electrification fund.//..We are receiving grant money from donor agency. So, the govt have seen the importance of having such a program and so start funding. It has now contributing for providing the cost of equipment, implementation, and operation cost of the program.//

Cost recovery
// its very difficult for long term planning to be done in a framework where the tariff is set by the politically rather than economically.//.. The money we are getting F$14, and out of this F$0.50 is taking by the post office as fee. And rest is used for maintenance purpose.//.. The users could buy the code from the village Post Office. Each users required to purchase a “charged” card from the Post Office at a cost of F$14.50, $0.50 of which went to the Post Office as a collection fee. When inserted into the card reader, the card was supposed to allow the system to operate for 30 days. The fees that are collected, less the Post Office collection charge, are kept in Fiji.//..there will be massive replacement cost after 4 years and we are not able to provide replacement unless we get any funds.//..Financially, the fees are based on the amount that each household is able to pay fees. Even some household can pay more but they gave same system to all to reduce the operation cost. The calculated tariff DoEFs not account the equipment cost. It only considers the maintenance and monitoring cost. It also did not take into account the replacement cost.//..The money we have received is not the same amount sometimes as it was hard to find how many people hasn’t buy that month. This is because the monthly record is coming after three months. The other thing is the money we should have received is not same because some people didn’t buy the card. The post office has cut the commission and sends the rest to department of energy.//..to reflect the actual cost, we have to look for F$22 per month instead of F$14 per month.//..One of the important factors that we consider while designing the financial part of the program is the implication of the prepayment system. This helps to collect the money regularly because if the don’t buy card they wouldn’t get light.//..last two years there were no maintenance contact. This was a problem and many users didn’t pay. We also didn’t disconnect any system during last two years.//..it is quite a hassle to link all the financial report together because we do not use any customize software.//..the money collection system needs to be improved.//..we appointed the village headman to collect the money. But we haven’t got any money from the headman as every time we visit, the Headman was out of the village. There is even no telephone connection there.//..the DoEF personnel never come to take the money within last one year. I kept the money in a butter box.//..calculating the fee on the basis of the user’s ability was incorrect as it failed to consider the maintenance cost. //
Annexure

//.. the community is willing to pay for the fund raising for church or Friday night party, but they do not want to pay for the service they receive for electricity. They do not lighting as an important need.../

Social and Environmental Aspect

User's behavior

//..This program not only offers lighting but also lots of benefits. The in-house environment is changing. The children can study at home with clean light. So, the users are getting lots of social benefit.../

//.. I worked for three years in South Asia. The main thing in South Asia is people have to work so hard to get food. But in Pacific life is much easier. In the pacific they do not have any handicraft or any productive uses. Basically most of the system here are to provide the basic lighting needs. And they do not have much necessity to do those works.../

Satisfaction levels

//..but what we want this to provide the clean electricity to the people. In rural areas the SHS is used only to provide light. In providing the light we can say it improve the way of light.../

//..There is a survey to find the need and based on that the program has been implemented. From the survey it was found that the cost that they are paying is not as much as they would be now paying for kerosene and benzine as the price of kerosene and benzene has increased over the past few years.../

//..We no longer have to buy the kerosene from the far away market. The SHS saves our time.../

//.. We can now gather for a social discussion in the community centre and we enjoy the light, drink and discuss our issues and problems there. Solar lighting makes it easy for the people to stay longer time than before.../

//..If you visit the field you can found that most of the people are happy to get the electricity. The service DoEFs improve their quality of life. Simply only access to electricity also gives them a good feelings.../

Policy and its effect on the program

Rural electrification policy

//.. We have a policy that we still are using which was established in 1993. Current plan is to look back at that policy and then amend it.../

//.. we have submitted a draft policy, but that is still under review.../

//.. The electrification has a big budget, but not for rural electrification. It looks as if the Fiji government wants to do it but that they are sort of stuck in the ritual assessment stage. They are not sure what they should use, whether it is micro hydro or wind.../

//.. Rural electrification will be placed where the power utility never goes. Government in a way tries to put a sort of plan and policies. But still there is no specific policy so far.../

//.. Officially, FEA is 100% owned by the government and does not account for rural electrification. It’s an entity by its own but government is responsible for all the policy issues. The utility is responsible for its day to day job.../

//.. we know the demarcation. We only put the stand alone system where the grid will not reach soon within 15-20 years. We did have regular contact with FEA when it comes to grid extension. But in case of planning there were no consultation. FEA is doing its works without asking us. There is one recommendation from the foreign consultant from UNDP to have a committee at national level to sort of look at the big project which have big implication on the community. At the moment we do not have any committee as such yet.../

//..There is no conflict or potential conflict between grid electrification and remote area electrification in Fiji. This is because of the geographical nature of the country.../

//..need for each country, culture is different. In Fiji the needs are to get clean light for community. There is no need to earn extra money and people are very happy whatever they have. They never complain for anything.../

//..Policy depends on what the communities preferred to be the benefits of having access to electricity. Those who do not want a PV system but get it by default will not be sustaining in
Annexure

future. Whether, it will do well if we only provide the lighting options and not even the TV
option.//
//..It all depends on Community access. There are not very really isolated places. Everywhere there
have accesses of road.//

Lack of Policy

//..providing grid electricity is now impossible as there are more than 400 remote areas and island.
Therefore we feel the needs and Government also feel that it is not possible to reach each
household by conventional electricity.
//..need for off-grid electrification is important and that’s why we feel that this project may be the
good option to provide electricity to remotest areas.//
//..Sometime policies are there, but there is a need to follow up the policy and implement it.////
//..There are lots of policies. Some of them are not policies but strategies but they are calling it
policy.//
//..The problem with short term contact was when once the contact has finished it was not possible
to extend with same company due to the government policy and the saddest part was some
companies are not experienced enough to provide the job.///
//..There are two policies. One is the rural electrification policy and the other is the national energy
policy and action plan. The national energy action plan has been finalized and published. The rural
electrification policy is done in 1993 and reviewed by 2003 by SOPAC and ESCAPE.///
//..During that review process we try to workout the actual rate for tariff. But before it was like a
political problem as the minister say to the villagers ok, you can pay 5 $ per month which does not
reflect not even maintenance cost.//
//.. There are two issues in the current policy: one is in any remote areas whatever the cost of
electricity production but the charge will be same as 22 cents per kWh as the national tariff rate…and
second is government decided that for any kind of system government is subsidized 90% and
community will pay 10%. But the Government has very low fund so, very few villages have got
this.///
//..even the policy is there but there is no activation or implementation of the policy. Policy needs
to be revised and improve every two years which is not happening.///
//..There are many sectors where we have the best policies but since the implementation is lacking
so it does not make any difference.///

Political Situation

//..just before the current political situation, the previous government announced the 100% duty
wave for the solar systems. They are working with the power utility to encourage using solar. But
that was stopped after the current government take over the charge.///
//.. As in Fiji there are lots of islands so extending grid is not a viable option. Government has a
policy on providing electricity in those areas but it was not mentioned in the policy what would be
the technologies for supplying electricity in those areas.///

Bureaucracy

//..It is very difficult to make the government understand something new.///
//..Main problem of the reluctances of private sector from this program is because the government
not have any specific policy on renewable energy and private power producers.///
//..It is difficult to engage a private company because it is not just a very fast process. We have to
really deal a lot of processes within the Government itself. When we have finished the processing
work everything by that time already 1 or 2 years have gone.///

Reasons for slow uptake of the program

//..We have faced some problem during last two-three years because there were no private
companies for providing the maintenance support. Therefore, many systems had broken down
(number could not mention). Also there are problem to collect the money from the village head as
we couldn’t met him during our visit.///
Annexure

One of the problems that we are facing is trying to link the financial structure with the current infrastructure. We have staff members who are trying to work on this but we do not have the proper database software at this moment.

Views on the degree of success of the program
Some comments on the successfulness of the PV program in Fiji are given below:

The first important things come is the development of awareness end users should be trained. Programs needs continuous monitoring and after installation service which is very important to realize the users that the system is taken care of by the Government or implementing agencies.

in Fiji if the money is collected regularly, it would be able to cover the cost of operation, maintenance and replacement of battery, light and charge controllers. The previous fees were F$18. But now the fees are F$14. So they need more users. Also there is no scheduled maintenance and monitoring system. No nearby offices that could looks after system. These makes the program unstable.

At the moment during implementation we actually tender out the installation. One of the mistakes that we had make in the past was not make a contact with the installation company on give training to the users on how to use the system.

I believe if we provided good maintenance support this is a very good approach.

At this moment the program is not sustainable, but if the maintenance and monitoring improved it seems to be. If we have a community then that community will take care. But in stand alone system we need to look at to the income generation activities also.

The users training is very important. Because, the people did not know why their light is not working? They only appreciate that the light should there all the time. They do not care about the problem.

Limiting factors
we will follow the same approach as we are doing now, but we will give more emphasize on maintenance and monitoring service and customer awareness.

regular contact with the users is also very important. The people should well inform on what the system is able to provide and what not. Regular contact with them and telling them this is what happening. So a company coming in regularly and telling them what is happening is very important.

Specific policy is needed for this kind of program. There should be a clear implementation rules and regulation.
Annex 6-I
Map of Bangladesh

ACTIVITIES AREA OF
Rural Services Foundation

Legend

Operation areas of RSF, one of the PO of IDCOL program
Source: (RSF, 2008)
Solar Home System Hardware Description

- The Solar Home System (SHS) is intended to provide the user with a convenient means of supplying power for small electrical loads such as lights, radio/cassette players or TV. A typical SHS operates at a rated voltage of 12 V DC and provides power for fluorescent luminaries, radio/cassette players, small black and white TV or similar low-power appliance for about three to five hours a day. Additionally, other types of luminaries, 12 V DC or lower voltage DC/DC converter outlets or a DC/AC inverter may be supplied as options. Each SHS consists of one or more photovoltaic (PV) modules, each having minimum output of 30 Wp charging a 12 V DC lead-acid battery along with luminaries, related electronic and electrical components and mounting hardware.

- The system should be designed to have at least three days autonomy (i.e. can run for three consecutive days without charging from the panel).

- The SHS is packaged to provide convenient installation at a remote customer home site by a qualified technician. The system is constructed such that a user can perform routine maintenance such as adding battery water and replacing light bulbs and fuses, and a technician can easily perform system diagnostics or replace components.

Certification Requirements

- 2.1. Products to be financed under the World Bank's and GEF PDF-B Project must have a type-test certificate from an accredited testing and certification organization like TUEV, Joint Research Centre, Factory Mutual, UL 1703, ISO 9001, ISO 14001, IEC 61215, CE marking, etc. For local products, a certification from a reputed institution like Bangladesh University of Engineering & Technology, Dhaka, is acceptable.

- 2.2. The supplier provides the most appropriate system integration, components, assembly and packaging that meet all the component specifications - Solar Home System Component Specifications' and the 'Recommended Practices' in Section 3.

Recommended Practices
This section provides a minimum set of requirements that shall be followed in the design, specification and installation of the qualified SHS. They form a set of “Recommended Practices” which when followed will ensure adequate levels of safety, performance, reliability and system lifetime.

PV Module Installation
a). If more than one module is used, identical models shall be used and they shall be connected in parallel.
b). For SHS installed permanently on a structure (in contrast with portable units):

i. The modules must ensure water proof sealing for the solar cells.
ii. Modules must be framed in such a way as to allow secure connection to the module mounting structure.

iii. The array mounting structure will hold the photovoltaic module(s). The module(s) must be mounted on a support structure made of corrosion resistant material that assures stable and secure attachment.

iv. The PV array and support structure must be able to withstand wind gusts up to 160 km/hour without damage.

v. The structure must be mounted at a fixed angle and oriented to maximize the useful energy supplied to the user over the year (for Bangladesh, the elevation should be around 23°S with the panel facing south).

vi. The structure will incorporate corrosion resistant hardware for all external connections.

vii. The modules can be roof or ground-mounted: In case of roof-mounted modules, minimum clearance between the PV array and the roofing material must be at least 20 cm above the roofing material. It is recommended that the module mounting structure be supported on top of a pole of at least 50 cm length. Anchoring of the mounting structure must be to the building and not to the roofing material. For ground-mounted modules, a metal, concrete or treated wood pole must be used with the modules attached at the top of the pole. The modules must be at least 4 meters off the ground. The pole must be anchored in concrete or tightly packed soil at least one meter deep in the ground. The pole and mounting structure must be sufficiently rigid to prevent twisting in the wind or if large birds alight on the array.

viii. The panel should be mounted clear of vegetation, trees and structure so as to assure that they are free of shadow throughout day light hours during each season of the year. Furthermore, if more than one panel is mounted on a support structure the panels should not be mounted such that one panel will not shade the other panel(s).

**Circuit Protection and Charge Controls**

a). Systems must include a means to protect users and system components from the following:

i. Battery overcharge and excessive water loss.

ii. Battery undercharge and excessive discharge.

iii. Circuit protection against short circuit of any load.

iv. Circuit protection against reverse polarity of module or battery.

v. Circuit protection against internal shorts in charge controller, inverter or other devices.
Annexure

vi. Circuit protection against damage by the high PV open circuit voltage when it is connected to the controller without battery.

vii. Night time discharge of the battery due to reverse current through the array.

b). Systems will provided appropriate protection by a charge controller incorporating a high voltage disconnect (HVD), low voltage disconnect (LVD) and circuit protection.

System Monitoring

a). A display to indicate when the battery is in the charging mode must be provided.

b). This device must, at a minimum, indicate when the battery condition is:
   − Suitable to operate loads
   − Energy conservation required

c). The chosen device must come appropriately labeled such that the user does not have to refer to a manual to understand the existing battery condition.

Batteries

a). Batteries should be selected to offer at least five years of useful life.
   b) The minimum size of the battery should be 50Ah@10 hours.
   c). The batteries can be supplied in a dry-charged condition and all chemicals and electrolyte must be supplied in accordance with battery supplier specifications. The battery and associated containers should be packaged to handle transport down rough roads.

Equipment Enclosure

− The batteries and charge controller should be kept in properly designed protective enclosures.
− The batteries must be housed in a vented compartment. All parts of the compartment subject to battery acid contact must be acid resistant. This compartment must be built strong enough to accommodate the weight of the battery. This compartment must adequately support and vent wet lead-acid batteries. Access to the battery compartment by children must be prevented.
− The remainder of the system components (electronics, switches, etc.) must be housed in a separate compartment or enclosures which prevents the system components being affected by battery acid spills or fumes. The compartment or enclosure design must allow the internal electronic equipment to operate within acceptable operating temperature limits.
− The enclosure must be constructed of a durable material.
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Wiring

a) Stranded and flexible insulated copper wiring must be used.
b) Notwithstanding the above minimum wire size requirements, all wiring must be sized to keep line voltage losses to less than 3% in each sub-circuit and to allow the circuit to operate within the ampere rating of the wire.
c) For SHS permanently installed on a structure, all exposed wiring (with the possible exception of the module interconnects) must be in conduits or be firmly fastened to the building structure. Wiring through roofing, walls and other structures must be protected through the use of bushings. Wiring through roofing must form a water-proof seal.
d) Field-installed wiring must be joined using terminal strips or screw connectors. Soldering or crimping in the field must be avoided if at all possible. Wire nuts are not allowed. The rated current carrying capacity of the joint must not be less than the circuit current rating. All connections must be made in junction boxes. Fittings for lights, switches, and socket outlets may be used as junction boxes where practical.
Design specifications for Solar Home Systems used

There are four pre-qualified SHS for the solar program. The design parameters of these systems are given here.

**System Design for SHS-1:**

<table>
<thead>
<tr>
<th>Design Criterion</th>
<th>Design Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Load option 1:</strong> 8W FTL6- 3 nos. OR</td>
<td>Battery Size Selection: 60 Ah No of Parallel Batteries: 1no. Panel Size Selection: 40Wp No of Parallel Panels: 1no. Controller: 6 Amp</td>
</tr>
<tr>
<td><strong>Load option 2:</strong> 7W CFL7-1 nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Days of Autonomy: 3 days Total operating hours: 4 hrs daily</td>
</tr>
<tr>
<td><strong>Load option 2:</strong> 7W CFL7-1 nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Days of Autonomy: 3 days Total operating hours: 4 hrs daily</td>
</tr>
<tr>
<td><strong>Load option 3:</strong> 7W CFL-3 nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Days of Autonomy: 3 days Total operating hours: 4 hrs daily</td>
</tr>
</tbody>
</table>

**System Design for SHS-2:**

<table>
<thead>
<tr>
<th>Design Criterion</th>
<th>Design Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Load option 1:</strong> 8W FTL- 4 nos. OR</td>
<td>Battery Size Selection: 70 Ah No of Parallel Batteries: 1no. Panel Size Selection: 50Wp No of Parallel Panels: 1no. Controller: 6Amp</td>
</tr>
<tr>
<td><strong>Load option 2:</strong> 8W FTL-2 nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Days of Autonomy: 3 days Total operating hours: 4 hrs daily</td>
</tr>
<tr>
<td><strong>Load option 3:</strong> 7W CFL-3 nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Days of Autonomy: 3 days Total operating hours: 4 hrs daily</td>
</tr>
</tbody>
</table>

**System Design for SHS-3:**

<table>
<thead>
<tr>
<th>Design Criterion</th>
<th>Design Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Load option 1:</strong> 8W FTL-1 nos. 10W FTL-2 nos. Black &amp; White TV-1no. (must be rated less than 15W) OR <strong>Load option 2:</strong> 7W CFL-4nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Battery Size Selection: 100 Ah No of Parallel Batteries: 1no. Panel Size Selection: 75Wp No of Parallel Panels: 1no. or Panel Size Selection: 40Wp No of Parallel Panels: 2nos. Controller: 8Amp</td>
</tr>
<tr>
<td><strong>Load option 2:</strong> 7W CFL-4nos. Black &amp; White TV-1no. (must be rated less than 15W)</td>
<td>Days of Autonomy: 3 days Total operating hours: 4 hrs daily</td>
</tr>
</tbody>
</table>
## Annexure

### System Design for SHS-4:

<table>
<thead>
<tr>
<th>Design Criterion</th>
<th>Design Selection</th>
</tr>
</thead>
</table>
| **Load option 1**: 8W FTL-2 nos. 10W FTL-2 no. Black & White TV-1 no. (must be rated less than 15W) **OR** | **Battery Size Selection**: 120 Ah  
**No of Parallel Batteries**: 1no.  
**Panel Size Selection**: 85Wp  
**No of Parallel Panels**: 1no.  
**Controller**: 10 Amp |
| **Load option 2**: 7W CFL-5 nos. Black & White TV-1 no. (must be rated less than 15W) **Days of Autonomy**: 3 days **Total operating hours**: 4 hrs daily | **Panel Size Selection**: 50Wp  
**No of Parallel Panels**: 2nos. |


Annexure

Annex 6-III
Comments from the Survey Respondent in Bangladesh

Institutional Approach

///...Given the geographic characteristics of the country, the grid will not be extended to most places. To introduce another alternative to conventional grid, to break the barriers on information, to show SHS can be used as an alternative and that was the objective of our program...///
///...The main objective was to promote RET. What are the issues related to implement a RET program, what should be the service delivery mechanism and how often they need the service...///
///...There are businesses opportunities come out and some local entrepreneurs are created. But the business is not so straight forward...///
///...Many small entrepreneurs like SHS electronics suppliers, ballast and charge controller manufacturers and suppliers, cable suppliers, new battery manufacturers were developed in these five years...///
///...Before choosing an area, we undertake a survey on that area and acquire information on the financial conditions, the number of school-aged children, the business opportunities in that area, etc...///
///...This is a tough job. In some areas we can sell the system very easily but in other areas it is tough. We try to select the areas where access is easier. We also look at the distance of the area from the grid...///
///...There should be a good, proper supply chain and oversight to ensure that bad systems need to be checked from the system...///
///...There is a problem of supplying reliable components used in the system. This need to be improved...///
///...There is a need to match the demand with supply. There are not many reliable suppliers available since it is a new technology...///
///...based on the needs of the customer, the systems are designed and also customized...///
///...We try to help customers by helping them to choose an appropriate system and to reduce their costs...///
///...In this program, around 15 types of systems are offered. We are now trying to provide small systems which will replace only one lamp. This targets the poorest people whose income is below A$3 per day...///

Awareness development

///...When the program was initially developed the concept was, there is a demand of SHS and people also feel comfort using it. If there is no demand it can’t be sustained. Also, whether the demand is backed by the supply. So, being able to create a mechanism where the demand could be met by proper supply can ensure sustainability...///
///...the DCOL also provide lots of support, like making billboards, providing motorbikes to the NGOs, providing promotional items, battery chargers, etc. All these things they are doing for market development...///
///...In Grameen Shakti we started the program in 1996 and there was no market at that time. It was very hard to sell even 10 systems per month in the first year. When we started the business, we went to rural areas from Dhaka and installed systems. Then we tried to increase awareness of our program and our engineers went door to door to promote the SHS program. Now the situation has changed a lot. People come to our office to buy a system...///
///...there is a market demand, with proper training, proper support, and proper finance and proper institutional set up this can be used as a model of electrification...///
Annexure

There is a need for the donor to enhance the awareness among the rural people on climate change and the problem. Then people will become alert to the problems of using kerosene lamps. //

First they will think about their own survival and then environment. So we need to show them the benefit of using SHS and to also develop an awareness of health issues to make them aware of the benefits of the SHS. //

We provide technical assistance, finance, awareness creation, arrange seminar etc…//

Awareness among the people on the benefit of solar home system use is a key success factors in Bangladesh program. //

IDCOL helped to develop a framework on how the program will run. They have developed certain rules to get the soft loans after selling the system. //

NGOs need to provide reports after installing the systems every month to IDCOL. //

We did campaign on our products in the program areas to create demand among the potential users. We also use door to door visits to explain how the system works, what its benefits are, etc. This helps to develop the market. //

We need to set up branch offices before starting the program. This is a mandatory criteria to enrol in the IDCOL program. //

This program tends to develop the ownership model. The people own the system. So, I would say it is the best in this region. //

Maintenance and Monitoring

We have to provide maintenance and monitoring support as a part of the contract with the customer. //

Regular maintenance is a core pillar of this program. We visit each customer’s house that acquire a system by loan every month, until the end of the loan period, and every three months in the first three years who acquire the system in cash. //

Customers will not pay if their systems do not work properly. //

Evaluation and monitoring are conducted by the IDCOL every three months to check the system status once we have supplied the total number of systems installed. The IDCOL has its own monitoring mechanism. //

we provide maintenance service free of cost during the loan period. After that we sign a yearly contract with the customer at an amount of Tk. 300 (A$7) to provide the maintenance service. //

Nowadays, the UNDP has introduced a result based monitoring system. This helps to monitor ourselves whether we can attend the result within the time frame of the program. //

There is a stake holder meeting every month in the IDCOL. They ask for feedback from suppliers and the POs. And also they visit to the field to check the quality of the components. //

The components, such as charge controller, lights, converters, etc. are made locally and therefore there is a need to check the quality of the components. //

All suppliers provide a warranty for their components. We pass on the warranty directly to the customer. So we are not worried if something goes wrong. The faulty parts can be replaced very soon and we claim the new component from the supplier. //

we provide regular customer service. If there is any fault in the system and we do not address the problem, we cannot sell systems in the nearby community. In Bangladesh it is a culture that people always listen to the opinion of others. //

in providing customer service, we make a good relation with the customer and also ensure system stability. //

Technical performance and training

We have a very good field network through the unit offices. Customers get services whenever they need them. Users also can buy lamps and fuses in the unit offices. They do not have to go to city. //
The main reason of expanding the number of unit offices is to provide an increased level of services to customers. We also try to make sure that all spare parts are available in local office. We try to keep at least two batteries per 100 households to provide services... We understand that we need to train local youth so that they can help in maintaining the systems. In some areas, we select the young people from among the customers and train them as technicians. This reduces the maintenance cost and the systems works well... We are doing our own training to reduce maintenance cost. It costs for us to arrange the training for few people. But the organizations that are doing business on a larger scale are doing better... We offer both customer and technician training. Customers know only how to operate the system and a bit about maintenance. On the other hand, technicians learn how to do the maintenance... To me, it is important to train the people through the suppliers as they can give hands-on training and they know about their products... Training is a must in our program. After completing every 20-30 installations we arrange a training session for the customers. When the number of customers in one village reaches more than 200, we arrange technician training in that area. We have started this part of the program with the support of funding from the Swedish International Development Agency (SIDA) that we got through the Asian Institute of Technology and the United States AID (USAID) and we are now running this as a compulsory component of the program... the training provided to users and technician makes the customer aware about the system use, limitations of the system and maintenance needed for the system... If the customers are not happy with the system we cannot sell the system. So we provide training to the users to let them understand about the system... training manual is prepared by the IDCOL for technicians only. We needed to prepare something for the users as well... Grameen Shakti (GS) has both users and technician manuals. It is a very big organization and can afford the cost of preparing its own training material... We printed some pictorial leaflets that show the DOs and DONTs and gave these to customers. We suggested that they hang the leaflet below the charge controller or in a place where they can always look... while selling the system we try to customise it depends on the demand of the customer as close as possible. Some time we provide more lights than the system usually designed if the customers agree to maintain the time of operation. We have to do this to keep the sale target... The problem is that the systems are designed by different experts and the IDCOL uses software for its design. The IDCOL provides specifications, but we have to find the suppliers for the lights and charge controllers. There is a need to develop good LED lamps that are very costly but have low power consumption. With this light we can provide more lighting options with smaller solar systems...

Financing Mechanism

The criteria differ from place to place and from program to program. The main criteria we looked for is the objective of the program. We then try to match how we can support the program through our technical knowledge. The next thing we see is the benefit of the users from the program. Does the program help to improve the quality of life of the poor people, and so on... The project is funded by the Government and Government is free to implement the project through private entrepreneurs. This project is also funded though the Government (IDCOL).
We select NGOs that have good networks in rural areas in Bangladesh. They should provide micro-credit to the poor people, and be willing to build up local technology and human resources.

Grant money is coming from the IDF, GEF, kfW and the WB to government. Government is financed the program through the IDCOL.

the IDCOL provides soft loans to the POs. But there is a need of other financing institutions also.

There are demands for SHS, but for this demand to be met there are financing constraints. So financing has to be ensured.

Cost recovery

Collecting money is a hassle. We need to visit the houses every month to collect the repayments.

Cost recovery is an important factor for making a project sustainable. But sometimes we have to do the project for social benefits.

It is difficult for some people to pay the repayment amount if it is more than they paid before for kerosene. But they try to do some income generating activities to pay back the loan. A few customers default on the loans.

But it is still a risk free because we have the systems. If a customer refuses to give the repayment money, we can bring back the system.

people will give instalments while the system is ok. If anything goes wrong we cannot get the instalments and thus recovery rates goes down.

Economical perspective

there is still lack of affordability of the users. The main barrier of this business is to circulate money and to provide micro-credit. There are not many people who can buy the system in cash. Those people that can afford a system have already bought a system.

Here microfinance is different. It is not for the real poor group. Its for a higher income groups.

Micro-finance helps people to get a new technology through this financing system. Otherwise it becomes hard for rural average income people to buy a system like this and they have to use kerosene for their whole lives.

now people can work at night, they can sew, or make baskets at night.

SHSs are used at shops, in fishing boats, etc. They can also be used to charge mobile phones. Some SHS customers provide phone services to others using their mobile phones.

There are some very poor consumers who cannot afford a complete solar home system. Some customers install the system at their own premises and share the load with some of their neighbours. Owners of the system are responsible for making instalment payments to us, more than 50% of which is recovered by the rents collected from the other users of the system.

one of our customers owns a saw mill and has increased his business turnover because of extended business hours.

one of our women customer is running a successful handicraft industry with the help of her SHS. Before she could not think about working at night, but now with the SHS she can work after dusk. Other women also come to her house to work and help her in her business as well as earn some money.

Social and environmental aspect

User’s Behaviour

this program has brought lighting facilities and related advantages such as mobile phones, computers, internet connection to remote, isolated areas, including islands.

The social status of the people has changed. A link has been developed between the urban and the rural and also between the family members living in rural and urban areas.
Annexure

// rural people always value the words from a local champion and leader. If the local leader
recognises the benefits of a SHS and buys a system, it becomes easier to sell the system in that
area. //

// people are used to going to a neighbours house, to gossip in the evenings and to get
together at local leader’s place. A SHS gives them opportunities to roam around and to enjoy the
night time. //

Satisfaction levels

// we can see a lots of change when we visit the villages now. If we compare this with five
years back, things have changed a lot and the solar program is the cause of that change in many
cases.

// customers are satisfied in spite of a few occasional of failures, caused mainly by weather,
and none would think about an alternative other than the grid electricity. //

// most of our customers see their SHS as a change in their livelihood. Children are more
studious due to the availability of bright light at night. //

// we values customers’ desires. Before installing a system we ask the customers where they
want their appliances, where they want the battery to be placed and where the want the solar panel
to be placed. //

// customers can buy customised system. We listen to their needs and other issues related to
buying a SHS. //

// Motivation and community involvement are a part of our marketing system. We believe
in using a bottom up approach rather than a top down approach. //

// our engineers work as social engineers and maintain good relations with customers. //

// while going to customers’ houses to collect the repayment, we asked them how they are
doing, whether they have started any new business or work, how their children are doing at school,
etc. So that they feel that we are not just a service provider but also their friend. //

// SHS provide the opportunity for increasing social and environmental awareness by
providing access to educational and entertainment programming through TV and radio. Our
contract with customers includes taking back their used batteries after their useful life time and
recycle them. Customers receive A$8.5 for their old battery. //

// Many small industries are developed making charge controllers, lamps, cables,
structures, etc. Before the program there was only one battery company, but three more companies
are now producing batteries for the program. So the program creates a lot of employment
opportunities across the community. //

// women are enjoying hazardlss and hassle free lighting systems in their daily life. //

Policy

Rural Electrification Policy

// We proposed that a renewable energy body be established under the Government in the
draft renewable energy policy, but it is still a draft. //

// We do need to develop an association that can negotiate with the Government and policy
makers. We really feel that there is a strong need for that. //

// there is no policy setting out how rural electrification by conventional grid extension
approach and by renewable energy programs fit together. //

// Rural people are not getting any benefits from buying a solar home system. Power
generation from PV is 80 to 90 taka per kWh, whereas per kWh generation cost of grid electricity
is only 4 to 5 taka. So there should be a carbon tax imposed by the government on those using
electricity from the grid in urban areas so that the government can cross subsidize the rural people
Government. The government also imposed a tax duty on solar panels recently. //

// We need to influence policy to get a proper policy. Government, for example, could
instruct local banks to lend money to the implementing agencies for this business. //

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///.. The policy needs to be revised and improved every two years...//
Lack of Policy
///.. Even if the policy is there, there is no activation or implementation of the policy...//
///.. Even with the present electricity problems, the government does not see the RET as a viable alternative and so the government is not really focused on the RET...//
///.. We need to get approval from the Government to start the business under this program and the process of getting permission is very complicated and time consuming...//
///.. Although we do not have any specific policy on renewable energy electrification in Bangladesh, the SHS program is working very well. This is because of the hard work of some of the implementers. But because some people work well, it does not mean that a policy would make it work well for all...//
///.. A policy framework would help but is not absolutely necessary because we have seen that policies are developed and are not then implemented at all...//

Political Commitment
///.. The government imposed an import tax on solar panel which increases the cost of a system. Before this government, we did not have an import tax on solar panels...//
///.. Due to political commitments, the grid is to be expanding in some areas that were not included in the plan before. This creates a problem for SHS program in these areas as people will now want to wait for the grid to be extended to gain access to electricity...//
///.. SHS business are hampered due to the commitments made by political leaders. They commit to expanding the grid electricity and people start waiting for the grid to come to their area. It is not sure when the electricity grid will come, but this creates problems for SHS businesses...//
///.. there is no coordination between which areas will be provided by grid expansion area and which areas by SHS programs. The government always changes its plans and commit to things that it had not committed to before...//

Bureaucracy
///.. We really have problem with bureaucracy. It works as a counter force for not implementing the program. Its a barrier...//
///.. You see, the bureaucracy problem is always there. We need a process that is leak proof. But how you work through such a process is the main question...//
///.. I think that the bureaucracy is a problem in Bangladesh as its acts as a huge barrier. There is a need to create a lot of awareness within the Government sector...//

Barriers of the program
///.. The main objective should be awareness development and to proof that SHS can be used as an alternative to supplying electricity from the grid electricity. And we help the implementing agencies to do that...//
///.. Recently for the supply of solar panels has become a problem. There is now only one supplier that gives us panels at a good rate. Other companies can't offer competitive prices, even if we buy in bulk quantities. This is a big threat to the program. If the current panel manufacturer increases the rate or cannot supply sufficient panels to meet our demand, we will be in trouble because there is no second supplier...//
///.. Another problem is the battery warranty. The warranty period is lower for small systems. This makes it difficult to promote small systems...//
///.. Battery costs have increased and we therefore need to increase the system costs. But this will affect the customers' ability to buy the systems and the sales will go down.
/// Natural disasters are also a threat to this program. In the case of the Sidor tornado, we could not get the repayments from the field...//
///.. Taking the approval of system components from the committee is another problem. The technical committee sits only once in three months. So we have to wait a long time if we want to purchase new components from different suppliers...//
Annexure

///...there is still lack of affordability of the users. The main barrier of this business is to
circulate money and provide micro-credit. There are not many people who can buy the system
using cash.///

///... Government imposed duty on solar panel recently. We are in big problem now as we
cannot increase system price but paying 5% extra while buying panel. Through the IDCOL we are
asking the Government to remove the duty.///

///...The solar market is increasing very fast. Sales are almost double what they were last year.
But there is a lack of skilled people in all areas. No capacity building is happening. We give a
short training and then send them to the village to sell the systems. This will create a problem in
the future.///

///...Providing training to the people that are working in the implementation is very important.
We need to develop an institute that can help to train the people that we can directly recruit in our
program.///

///...There is a need to create human resources for this industry. We do not have any middle
group managers or technical persons. The engineers whom we recruited are good at providing a
technical service, but they don't have managerial capacity to operate the program. Capacity needs
to be developed at the managerial level.///

6.3.2.6 Views on the degree of success of the program

Program Success

///...we need to consider the social and cultural development of those buying and using the
SHS.///

///...This project has a target of 50,000 SHS within 5 years and we thought that if we could do
that by 5 years, it would be a good start. But that target was met within two and half years. So the
government decided to disburse more fund for loans in the program. To date, 150,000 systems
have been installed.///

///...The project uses clear indicators of its successfulness. Some are quantitative and some
are qualitative. These are: the number of users so far connected and using SHS; the degree to
which after sales services are honoured by the implementing agencies; the increase in the number
of actors/implementing agencies/private sectors that are involve in the business.///

///...we used a Logical Framework Matrix (LFM) before implementing the program and that
includes sets of indicators and measures of indicators. We just follow the monitoring system based
on those indicators to measure the program success. So far this program has met all the criteria and
measures of the indicators.///

///...The program has been refinanced by the IDCOL. Eighty percent of the total system cost
is refinanced by the IDCOL as loan. This loan has a two years grace period and a ten year tenure
period. Partner organizations can revolve their money to invest for new systems and expand their
business.///

///...we are trying to minimise the cost by reducing the maintenance costs, recycling, reducing
travel costs, etc. This helps to reduce the overall program cost.///

///...The larger implementing agencies that are doing well in this business started their
programs with good management and skilled people. They have their own technical people who
can address field problems very quickly.///

///...The stakeholder’s role in the program is clear. So I believe that the program is not only
sustainable, but also a model for other countries.///

///...The maintenance service provided is very important. People do not know why their light
is not working. They only appreciate it when they can turn on the light when it is needed. They do
not care about the problem.///

///...Regular contact with users is very important. People should be well informed on what the
system is able to provide and what it cannot provide. Regular contact with users and telling them
this is what happening will make them think they are also part of the program.///

///...We do monitoring on regular basis. This I think is also a pillar for our success.///
Annexure

///..Success depends on the project target, project indicator, project goal. But one thing that we can measure is the impact on the users. This may give a an indicator or flavour of whether the program is running well or not.///
///..If someone can be assured of the money flow, this business will be a sustainable one.///
///..we feel that there needs to be a bonding with the customer which will reduce the system abuse and make system program run well.///
///..institutional management policy is important for the program to be successful.///
///..We trained all of our users and also the local people so they can look after their SHS. Providing training to customers and local technicians is important for program success. This help to reduce maintenance costs.///
///.. We try to explain to the customer that this is their system and that they will be owner of the system after they repay the whole amount. This helps to develop a sense of ownership among the users and make the program more sustainable.///

Limiting Factor

///..this business needs money flow for a three to four year period. We took a commercial loan from bank and are paying this back with high interest. If we can borrow money with low interest and over a long period, we can sell more systems.///
///..the engineers whom we recruited are good for technical perspective, but they don't have managerial capacity. Managerial capacity needs to be developed among the employee to provide best service in this market.///
///..there is a market that has already been developed. Now the challenge is to handle the market and to develop a sustainable way of doing this business.///
///..we need to find out what the strength are that we will need in future.///
///..one thing we need to make sure that the repayment or money collection should be up to date. Otherwise the program will not be sustained.///
///.. a tax holiday for companies working in this sector is important too. Renewable energy companies are paying 40% tax, but in most other countries renewable energy is subsidised. So we can have the benefit of tax holiday which we may pass to the users directly. There is a need of Government intervention to reduce the price of the system and make the system affordable to rural poor people.///
///..Government rules and regulations change alwa ys. We need to develop an association that can negotiate with the Government and policy makers.