Implementation of Renewable Energy Technologies – Opportunities and Barriers

Summary of Country Studies

Jyoti Prasad Painuly
Jørgen Villy Fenhann

UNEP Collaborating Centre on Energy and Environment
Risø National Laboratory
Denmark

Summary of Country Studies.
Published by: UNEP Collaborating Centre on Energy and Environment,
Risø National Laboratory, Denmark, 2002.

ISBN: 87-550-3013-0

Available on request from:

UNEP Collaborating Centre on Energy and Environment
Risø National Laboratory
P.O. Box 49
DK 4000 Roskilde
Denmark
Phone: +45 46 32 22 88
Fax: +45 46 32 19 99

Cover photo: NREA, Egypt and Wisdom Ahiataku Togobo, Ministry of Energy, Ghana
Photo: Jørgen Fenhann, Risø

Print: Pitney Bowes Management Services Denmark A/S, 2002

Contents

Preface

The project was initiated in 1999 jointly by UNEP and RISØ National Laboratory, and sponsored by DANIDA. The UNEP Centre, RISØ co-ordinated the project. The project was launched to identify barriers to the implementation of renewable energy technologies (RETs) and explore measures to overcome the identified barriers. It included three country case studies; Egypt, Ghana and Zimbabwe. The studies were carried out by national institutions in these countries. The New and Renewable Energy Authority (NREA) at the Ministry of Electricity and Energy in Egypt, the Kumasi Institute of Technology and Environment (KITE) in Ghana, and the Southern Centre For Energy and Environment (SCEE) in Zimbabwe were responsible for the country case studies.

In addition to the direct results of the national studies, the project also provided input to the preparatory process of the Commission for Sustainable Development (CSD) for its ninth session in 2001. The national studies were presented at the African High-Level Regional Meeting on Energy and Sustainable Development, held in Nairobi in January, 2001. The inputs from the meeting were provided to CSD9 through a ministerial declaration of African countries on strategies for action and ways of strengthening regional co-operation in the areas of energy and sustainable development.

The case studies have analysed the barriers to the implementation of potential RETs in the three countries and also identified measures to remove the barriers. The case studies have been published and are available at the Centre, as well as at it's web site (http://www.uccee.org/). This summary of the case studies brings forth the valuable lessons learnt in the three countries, and is expected to be useful in identifying barriers and removal measures to RETs in other countries also. This, it is hoped, will help successful implementation of these technologies.

Implementation of Renewable Energy Technologies (RETs) Project – Opportunities & Barriers; Egypt, Ghana and Zimbabwe country studies

Executive Summary

The project was launched to identify barriers to the implementation of renewable energy technologies (RETs) and explore measures to overcome the identified barriers. National institutions in Egypt, Ghana and Zimbabwe carried out the country studies based on the basic methodological framework provided by the UNEP Centre. The objectives of the project included strengthening institutional capacity for analysis and implementation of RET projects in the participating countries and bring out experiences on RETs barriers and removal measures for dissemination so that others can benefit from the knowledge so gained. An important highlight of the studies was involvement of stakeholders in the process of identification of barriers and measures to remove them.

A preliminary identification of relevant RETs for their countries was done by the country teams in the initial stage of the project. After that, national workshops involving various stakeholders were held between July and September 1999 to discuss the RETs and barriers to their implementation. Based on the discussions, a few important RETs were identified for more detailed study. PV systems for rural electrification, solar water heating systems and large-scale biogas system were identified and analysed for barriers in the Egypt country study. Economic, information and policy barriers were identified as major barriers for these technologies. Solar water pumps, biogas and small hydro were the focus of study in Ghana. In this case also, economic, information and policy barriers were found to be the important barriers for the selected technologies. In the case of Zimbabwe, focus was on identification of primary and secondary barriers to RETs dissemination. The primary barriers included lack of capacity to develop proposals, lack of information for policymaking and framework for information dissemination. The study concluded that the secondary barriers as seen and experienced by the stakeholders are due to primary barriers. Therefore, it is important to address primary barriers. Measures to remove the identified barriers were suggested by the stakeholders in all the three countries.

Final national workshops were held in June in Egypt and Ghana, and in August 2000 in Zimbabwe to discuss the study findings. The workshops were attended by a spectrum of stakeholders and generated a lot of interest and discussions on the findings of the studies in all the three countries. The feedback from the stakeholders has been included in the reports finalised during 2001. The lessons learnt from the studies included in this summary report point to the key concerns of the stakeholders on the RETs and their suggestions to promote these technologies.

1. Introduction

Economic development is closely linked with the energy development. Most of the world's commercial energy supplies are provided by fossil fuels, with the associated emissions causing local, regional and global environmental problems. Projections over the horizon to 2050 indicate that world energy demand may increase dramatically, with most of this increase taking place in developing countries. It is feared that not only these levels of energy production and use from current energy sources are difficult to achieve but also un-sustainable. Therefore, energy-use efficiency needs to be increased to moderate the growth of energy while contribution from clean energy sources needs to be increased to reduce adverse environmental impacts of energy usage.

Renewable energy is considered one of the potential measures to meet the challenges of ever increasing energy use and related environmental concerns. Renewable energy offers a promising alternative to traditional energy sources in developing countries, who may face several constraints in meeting their energy requirements in future. Most of the investment is still directed towards conventional energy technologies, even where commercially available energy efficient and renewable technologies are technically feasible and economically attractive. Several developing countries have tried to promote renewable energy but despite their efforts renewable energy contribution to the total energy use has not increased significantly. The fact that renewable energy accounts for only a modest proportion in meeting the world's (commercial) energy demand means that there is a missing link in their potential and their implementation - the barriers in their implementation. These barriers (either financial or non-financial) need to be identified and addressed in order to design innovative policy approaches for the international and domestic financing or RETs.

In Africa also, current pattern of energy use is environmentally damaging and unsustainable, and the existing environmental problems are closely linked to energy systems. Africa has substantial renewable energy sources that could be harnessed to meet energy needs of various sectors. Currently, a lack of consumer access to these sources means that Africa is faced with the paradox of experiencing a shortage of energy despite an abundance of energy sources.

Renewable energy can play an important role in helping to meet basic energy needs in peri-urban zones and in rural areas, through the use of modern technologies. These can help to provide alternative sources of energy for some specific needs, for example, hot water production using solar heaters, and small-scale agro-processing industries. However, before this can be done, several issues may have to be addressed. These may include financing schemes, technical appraisal and testing, technology transfer and job creation and product manufacturing etc.

The project was instituted with a view to use case studies of renewable energy implementation projects to analyse the reasons for success or failure of specific projects or technologies. In particular, the project's aim was to identify possibilities for "removing" the main barriers and thus promoting increased implementation of Renewable Energy Technologies (RETs). African region was the focus area of the project and three countries were selected for the case studies. These included Egypt, Ghana and Zimbabwe. The country selection criteria included existence of the RETs programmes in the countries, their interest and capacity in conducting the study, and possibilities to build on existing collaborative activities and experiences between the countries and the implementing/funding institutions. The case study countries were expected to provide sufficient understanding of the barriers to RETs and possible measures to overcome them. The experiences from the case studies can throw valuable lessons to promote the RETs in Africa. This report is an attempt in that direction. It seeks to generalise the experiences from the case studies for dissemination and promotion of RETs.

2. Objectives

The project had the following three main objectives:

1. to improve knowledge, skills, and confidence on the part of project partners so they can identify situations in which renewable energy technologies can contribute to national energy needs;

2. to strengthen institutional capacity for analysis and implementation of RET projects in the participating countries;

3. to generalise the experiences from the three participating countries and disseminate the findings internationally, so other groups can benefit from the knowledge gained.

Within these three broad objectives, specific objectives for each case study country were determined based on status of RETs implementation, work already carried out in the country in this direction through other programmes, ongoing projects in this area, and capacity of the project implementing national institution / agency in the country.

Thus, in case of Egypt, where there is significant experience with RETS, the more specific objectives included;

(a) identification of barriers and actions required to remove the barriers based on analysis of past experience,
(b) to apply the knowledge so gained to a detailed analysis of a few selected RETs with potential for implementation in Egypt, and
(c) identify specific RET projects for removal of identified barriers .

In case of Ghana, specific objectives included;
(a) studying merits of a few selected economic instruments such as subsidies, tax reductions and duty drawbacks etc. and assess the role of existing instruments in promoting or inhibiting RETs implementation in Ghana
(b) develop an approach to analyse barriers to diffusion of RETs based on the above study, and
(c) identify factors that have helped promotion of RETs in Ghana with a view to apply these to promote a few selected potential RETs.

In case of Zimbabwe, specific objectives included assessment of lessons learnt from the already implemented RETs and barriers they tried to address, and developing projects with the help of stakeholders to address the barriers that still remained. Thus, in all the three case studies, specific RETs projects were to be identified for application of barrier removal measures proposed in the studies. In case of Zimbabwe, this was one of the major components of the study.

3. Methodology

First step in the project was selection of countries and establishing national teams to work on the case studies. The criteria for country selection, besides interest and commitment of the potential partners in the project, included the following:

- stated national interest in sustainable energy development;
- existence of national plans and the capability to identify relevant RET projects;
- availability of sufficient experience with implementation of RET projects to allow the assessment of barriers encountered;
- diversity of the RET resource base (e.g., solar, bio-energy, micro hydro and wind) so that it is possible to gain experience from a range of projects;
- possibilities to build on existing collaborative activities and experiences between the countries and the implementing/funding institutions.

Egypt, Ghana and Zimbabwe were selected for the case studies. In Egypt, National Renewable Energy Authority (NREA), the nodal agency responsible for RETs under the Ministry of Electricity and Energy was identified as the national institution. In Ghana, Kumasi Institute of Technology and Environment (KITE), an organisation working on several renewable energy and sustainable development initiatives was identified as the national institution, and in Zimbabwe, the Southern Centre for Energy and Environment, an independent research organisation working on various energy and environment issues was identified as the national institution.

3.1. The Framework

A broad methodological framework was developed and provided to the national institutions for the case studies. The basic approach included stakeholders' involvement in identification of barriers to RETs and measures to remove the barriers. This was with an aim to bring out concerns and views of the stakeholders on barriers and removal measures for the potential RETs in their countries. The basic framework provided flexibility to the national teams to tailor it to their needs of analysis. The basic framework consisted of the following steps;

A. Review of national energy plans and policies, evaluation of past RET projects and preliminary selection of RETs for analysis: This included the following**;**

(i) **Review of national energy policies and plans:** Review existing energy strategies and plans, and financial, institutional and legal mechanisms with reference to RETs. The aim was to identify shortcomings in the policies and mechanisms that hinder implementation of RETs.

(ii) **Literature survey**: Review of national studies and reports related to existing renewable energy projects, their evaluation, reasons for their success and failures (analysis of barriers), and lessons learnt.

(iii) **Preliminary selection of RETs for detailed analysis**: Based on the review of the national experiences and analysis, selecting a number of relevant RETs in the country for consideration and detailed analysis. Selection criteria included:

- adequate resource base for the RET (solar, bio-mass, hydro, etc);
- available technologies and their costs;
- commercial viability and financing (public, private, international);
- environmental impacts and benefits;
- socio-economic impacts, including job creation;
- coverage of both centralised and decentralised options.

The purpose of the preliminary selection was to focus the information collection and subsequently work on a limited number of relevant RETs. RETs were loosely defined to mean both a technology in a particular renewable type or scale of application.

(iv) **Feedback from Experts and Stakeholders:** This was done through structured questionnaires and interviews with relevant stakeholders to obtain specific information on current status of the RETs (technical and commercial issues), adequacies of policies and plans, institutional, financial and legal mechanisms, and other barriers. The national teams also formed Advisory Committees (one in each country) consisting of experts, practitioners, relevant governmental institutions / ministries including rural agencies and other stakeholders (manufacturers, users, NGOs, financiers etc.) to get feedback on their work from time to time.

(v) **Consultation with a broad spectrum of stakeholders:** Before finalising RETs for detailed study of barriers and removal measures, the national teams discussed these with a large cross section of the stakeholders through a national workshop in each case study country.

(vi) **Final selection of RETs for detailed analysis**: A synthesis of workshop discussions brought out stakeholders' perception of problems/barriers and solutions/actions. Based on the information gathered and feedback from the stakeholders, a limited number of RETs were selected for detailed analysis. Besides feedback from stakeholders, other criteria for selection included potential for application and availability of information on barriers and implementation conditions. The national teams also formed an informal interest group for each selected RET to act as resource persons for further work.

B. Analysis of barriers and barrier removal measures: The purpose was to identify the institutional, financial and policy conditions (and changes required) to implement the selected RET projects. The results of the analysis formed the basis for recommendations on specific actions to address the main barriers identified. This included the following;

(i) **Collection of additional information on selected RETs:** Additional information was collected based on the stakeholders' feedback during the workshop.

(ii) **Analysis of barriers:** Detailed analysis of barriers was carried out for the selected RETs. Various categories of barriers examined have been included in Table 3.1.

Table 3.1: Barriers analysed

Barrier type	Example
Institutional	Institutional capacity limitations (R & D, demonstration and implementation)
Market	Small size of the market, limited access to international markets for modern RETs, limited involvement of the private sector
Awareness / Information	Lack of awareness / access to information on RETs
Financial	Inadequate financing arrangements (local, national, international) for RET projects
Economic	Unfavourable costs, taxes (local and import), subsidies and energy prices
Technical	Lack of access to the technology, inadequate maintenance facilities, bad quality of product
Capacity	Lack of skilled manpower and training facilities
Social	Lack of social acceptance and local participation
Environmental	Visual pollution, lack of valuation of social and environmental benefits
Policy	Unfavourable energy sector policies and unwieldy regulatory mechanisms

(iii) **Identification of conditions for successes of the each (selected) RET:** The conditions for success of a RET are related to barriers it faces. Barrier removal may need actions on several fronts; policy changes, setting up institutional mechanisms for technology availability and upgrade, capacity building (making available skilled personnel), and financing, changes in laws or designing and implementing a regulatory framework etc. Each barrier was critically examined and actions identified for its removal. It is expected that it would be possible to implement the RET once the actions so identified are taken.

(iv) **Evaluate direct and indirect effects:** Implementation of a RET may lead to a variety of impacts. A qualitative assessment of direct and indirect effects (including environmental impacts) was made in one of the case study (the Egypt study). The direct impacts include environmental, social, and other effects, which follow from implementation and operation of RETs, while the indirect impacts are attributable to the barrier removal actions and the necessary assumptions. Such an analysis is important in order to ensure that eventual implementation the projects does not have undesirable side effects.

C. Identification of specific RET projects: After a set of actions had been identified to remove barriers, specific RETs projects were identified that are expected to lead to implementation of these actions and test their effectiveness. Provided that the actions and conditions for barrier removal identified are fulfilled, these projects would have a high chance of success. Implementation of the projects would test the effectiveness of the barrier removal actions.

The projects so identified included identification of specific sites and involved parties in some cases. The proposals may however need to be fully developed before projects can be funded.

D. Stakeholder feedback and dissemination: A Second National workshop was held in each country to present the results of the project and barrier analysis and the recommendations for action to promote increased implementation of RETs. The purpose was to get stakeholder feedback on the work and gain wider understanding of and agreement about changes that need to be made in order to make RET projects more favourable. Reports were submitted by each country team on the project.

E. Summary of findings: This report presents summary and analysis of experiences from the three case studies. The purpose is to expand understanding of the specific and generic aspects of barriers to RETs and the general validity of the national recommendations and actions.

3.2. Methodological Variation across the Case Studies

As mentioned earlier, the national teams had flexibility to tailor the methodology to their specific needs within the broad framework. The Egypt national team followed the methodology described above without any substantial change. An Advisory Committee consisting of experts, relevant governmental institutions / ministries including rural agencies, manufacturers, users, and other stakeholders (NGOs, financiers, etc.) was formed after preliminary selection of RETs. Feedback from the committee was obtained on the stakeholders' survey findings before the first workshop. This helped the workshop focus on important issues related to the selected RETs. Interaction with the committee was maintained at various stages of the project. The Ghana team conducted stakeholder interviews (step A(iv)) but did not use the structured questionnaire for this purpose. The responses received through the interviews were analysed and the findings presented to their Advisory Committee by the team. However additional information on selected RETs was collected through structured questionnaire. At this stage they visited some of the specific project sites to discuss various issues with the project operators and owners. Most of the information on barriers and options for their removal were collected through these interviews. Some questionnaires (mainly on biomass and solar technologies) were also administered. The barriers identified for each of the technologies were then analysed in detail using a framework that categorised barriers into three main groups – Socio-technical barriers; Economic Barriers; and Cross-Cutting Barriers. Socio-technical barriers covered resource-based, technological, environmental, and social barriers. Economics barriers included those related to the market, costs and benefits, and finance. Under crosscutting barriers, informational, institutional and policy barriers were considered. In the Second National workshop, the stakeholders were first asked to identify the key barriers to the three selected RETs (for which detailed analysis was being carried out), and then rank the barriers in order of their importance (extent to which they each inhibit the implementation of the selected RET), and finally recommend how best each of the barriers identified could be removed. The project proposals made by the national team were based on this stakeholders' feedback.

In case of Zimbabwe the team focused on desk study of RET projects and identification of barriers in the initial stages. Stakeholders were consulted during the

First Workshop and several barrier removal projects were also presented by various institutions and discussed during the workshop. Based on the stakeholder feedback on projects, four institutions were asked to develop a few selected projects further and present to the advisory committee. The projects so developed were circulated to various stakeholders for barrier identification, removal options and analysis. Several organisations responded with their comments on the projects. The Second Workshop was utilized to discuss the projects and comments from various stakeholders. The feedback from the workshop was utilized to modify the approach for barrier removal in the proposed projects. Thus the focus was on development of projects for barrier removal.

4. Findings from the Case Studies

4.1. Egypt Case Study

4.1.1. Energy Policy in Egypt

Fossil fuels, in addition to hydropower and non-commercial fuels such as firewood, agricultural wastes and dried dung, are considered as the main energy resources in Egypt. Petroleum fuels are the most important energy sources in the Egypt at present with production of oil and natural gas (NG) touching 55 metric tons of oil equivalent (MTOE) in 1998-99. These are likely to be main fuels in Egypt in foreseeable future. Hydropower contributes significantly to the electric generation in the Egypt; 15 terra watt hours (TWh) was generated in 1998-99, representing about 22.5% of the total electricity generated in that year. Although hydropower is renewable energy, it is not reflected in this category in Egyptian energy statistics. Commercial energy consumption increased at an average annual growth rate of 4.6% since early sixties. It reached 30 MTOE in 1998-99.

The Supreme Council of Energy (SCE) is responsible for formulation of energy policy in Egypt. It consists of the ministers of electricity and petroleum, and works in consu1tations with the parliamentary committee for industry and energy. The energy policy in Egypt focuses on the following:

- Enhancement of natural gas utilization.
- Adjustment of energy prices and removal of subsidies.
- Energy conservation and efficient energy use.
- Promotion of renewable energy utilization.

4.1.2. Renewable Energy Strategies

The government of Egypt recognised importance of renewable energy sources in early eighties and formulated a national strategy for the development of energy conservation measures and renewable energy applications in 1982 as an integral element of national energy planning. The New & Renewable Energy Authority (NREA) was established in 1986 to be the focal point for renewable energy activities in Egypt. The renewable energy strategy targets to supply 3% of the electricity production from renewable resources by the year 2010.

Although RETs implementation has made progress in Egypt, it has been limited to technology development, demonstrations and very little commercialisation. Effective market penetration of RETs has been below expectations. The total energy savings by renewable energy technologies is about 0.4 MTOE annually; and over 39% of it is from commercialisation of renewable energy applications such as solar water heating systems, industrial process heat systems, and electricity generation (solar and wind). In the past, renewable energy development in Egypt has been carried out through encouraging programmes for developing the renewable energy resources, setting up specialised bodies to implement national renewable energy plans, and promoting business opportunities for renewable energy projects. The current strategy for development of renewable energy focuses on technology development through research and transfer, technology demonstration, establishing testing and certification facilities, increasing awareness, and promotion from environmental considerations.

4.1.3. Status of RETs in Egypt

Mostly solar, wind and biomass technologies and applications have been tested and demonstrated in Egypt. Egypt has excellent solar energy availability with the annual global solar radiation between 900-2600 kWh/m^2. Therefore, solar thermal technologies were identified as one of thrust area for development. Solar water heating for domestic and commercial use, solar systems for industrial process heat and solar thermal electricity generation were three solar thermal technologies promoted by the government. Solar water heating systems are manufactured locally and 200,000 families are using these systems in Egypt. Over 65% of the total energy saving by renewable energies in the last decade was due to the commercialisation of solar thermal technologies, mainly domestic solar water heaters. The other two solar thermal technologies are still in demonstration / implementation stages.

Solar Photovoltaic (PV) Technology is one of the RETs actively being promoted in Egypt for use in rural and remote area. Electricity generation and groundwater pumping have been identified as two applications for PV technology in these areas. Other applications include remote services related to telecommunication, railroad and navigation, water treatment, and billboards. By 1995, total installed capacity of PV applications was estimated to around 1MWp. Several projects and plans totalling more than 10MWp are under preparation.

Egypt also has very good wind resources. Wind energy development through large-scale grid connected wind farms has been taken up with the help of donors. Wind power totalling about 63 MW has already been installed and connected to the grid and programs to increase it to 300 MW by 2004 and 600 MW by 2010 is in operation. A wind energy technology centre has been established in Egypt for testing of wind turbines, and to serve as a training centre for the Middle East and Africa.

Biomass also has significant potential in Egypt; estimated potential is about 40 million tons / year. The biomass resources contribute more than 3.6 MTOE / year (primary energy) in Egypt. Current focus of biomass usage is on small-scale biogas plants with a digester volume ranging between 5 and 50 m^3. Large scale systems are still in pilot stage. Traditionally, plant residues have been the most important fuel in the Egyptian rural area. Therefore, biomass laboratories of the NREA are also involved in converting ligneous plant residues into an alternative solid fuel using an advanced briquetting system.

4.1.4. Selection of RETs for Study of Barriers

The criteria described in the methodology (A-(iii)) were applied to select RETs for preliminary study. The selected RETs included solar water heating systems, PV systems for electrification of remote areas, PV systems for pumping of groundwater, and biomass applications. Various stakeholders including manufacturers, users, experts and policy makers were administered structured questionnaires to obtain their opinion on RETs implementation in Egypt, adequacy of policies and plans, and various barriers in implementation. The findings were presented in a workshop with a large cross section of stakeholders. Based on the feedback received from the stakeholders and considering the criteria that RET should have adequate potential for application, information on barriers and implementation conditions should be readily available, and technologies should be easily available, the following three RETs were selected for detailed study of barriers:

1. Solar water heating systems for domestic and commercial applications
2. PV systems for electrification of remote areas
3. Large scale biogas systems.

4.1.5. Barriers to RETs implementation in Egypt

Further information on barriers and barrier removal measures was collected on the three selected RETs. This was done through further literature review, questionnaires and interviews of the stakeholders including manufacturers, users and owners, and targeted users. Responses received through interviews / questionnaires were analysed, and the barriers were classified in the following categories:

- Economic & financial barriers,
- Awareness & information barriers
- Technical barriers
- Market barriers
- Social barriers
- Institutional & policy barriers

The barriers in case of the selected RETs are described below.

<u>Solar water heating systems (SWHS)</u>

Most of the SWHS installed in Egypt (about 85%) are small with a capacity of 150 litres/day and are simple individual systems. In case of big systems, problems related to faulty design were common; the systems could not support the load as per specifications. Problems such as malfunctioning pumps, leakage from tanks etc. were experienced and maintenance and repairing facilities were not to the required level. However, individual users in direct contact with manufacturing companies were generally satisfied. But this was true for only new systems. An encouraging response came from the potential users; 90% in the cities were willing to buy if it saved them energy. But current high prices of the system were a deterrent to them.

Although solar water heating systems are simple in construction, responses indicated that minor faults could lead to serious problems, especially if not detected early. It was found that many systems did not perform as expected due to reasons such as low level of awareness, technical problems and lack of maintenance. It was also revealed that due to unsatisfactory performance, credibility of SWHS was low and there was an urgent need to restore the confidence of both existing and potential users. SWHS are still not perceived as environmentally attractive and potentially economical means of providing hot water to targeted users. Therefore, serious efforts and corrective measures both from industry and government are needed for a sustained growth of SWHS market.

The following emerged as major barriers with the first three having no significant difference in their ranks (importance):

- About 26.5% of the key stakeholders (users, manufacturers and experts) indicated that the economic / financial barriers are the most important barriers for SWHS industry (rank 1). The SWHS were considered high priced compared to conventional water heating systems and subsidised electricity made it further unattractive for the "low bill" electricity consumers. A lack of credit facilities was another obstacle in this category. In case of new houses, low cost LPG and natural gas are fuel choices making the SWHS uncompetitive for this segment.

- Awareness / information barriers were ranked second with about 24% of stakeholder indicating these as most important. Presence of SWHS industry can hardly be noticed by consumers. Industry on the other hand offers very limited choices due to a lack of significant market.

- Technical barriers were ranked third with about 22% of the stakeholders indicating these as most important. However, some experts and users were of the opinion that technical barrier would have been ranked first if the SWHS were used more widely. SWHS manufacturers on the other hand argued that the lack of knowledge about the system design and operation, and a lack of maintenance were the root cause of the problem. The quality of the product has improved in the last three years.

- Institutional barriers were ranked as fourth, indicating the need for better institutional arrangement and co-ordination between the stakeholders.

Recommended actions to remove SWHS barriers

The Following measures were recommended by the stakeholders to remove the barriers.

- **Information and awareness**

- Development of effective public awareness and promotion programs that are prepared based on market surveys and studies. It was proposed that the programmes should concentrate on use of media especially TV and newspapers. The concept, the benefits and the required operating conditions for SWHS should be made clear to end-users through these media strategies.

- Promotion of SWHS could also be done through participation in various exhibitions held in syndicates, hotels, clubs etc. The demonstration systems can be set-up in places like city councils, clubs, big factories, conference halls, and stadiums etc. where the impact can be far reaching.

- Printed materials (such as leaflets, brochures) containing information on systems, selection criteria, maintenance requirements, and information about suppliers and their after sales services needs to be made available to the consumers.

- Other modes for awareness building could include seminars and presentation to targetted users in schools, universities and clubs, and awareness among students by setting up of laboratories in these places.

• **Economic and financial**

- Financial support from the governmental, private sectors and donor agencies to the SWHS needs to be put in place. Availability of credit facilities with low interest rates and reduction in SWHS prices to make it competitive with other alternatives is equally important.

- Soft loans could also be provided to entreprenuers market and maintain SWHS.

- Electricity and natural gas enjoy subsidy in Egypt, making SWHS an expensive alternative. Incentives corresponding to the subsidies given to electricity and natural gas consumers could be introduced for SWHS also. This could be in the form of subsidy to bring down initial cost or reduction in user taxes for SWHS users.

- Encouraging local manufacture of SWHS by reducing taxes and customs duties on solar water heating system components.

- Financial and technical support to research and development activities for product improvement should also be provided.

• **Technical**

- Current manufacturing standards and specifications should be revised to include quality control and assurance components and installation requirements.

- SWHS and their spare parts could be made available in shops and markets, especially outside Cairo. This should be accompanied with availability of maintenance centres within easy reach.

- A program or mechanism to address the problem of the systems already installed in the new cities needs to be prepared and implemented. Relevant government authorities, manufacturers and dealers of SWHS need to co-operate in this programme. The users of the system need to be made aware of the maintenance requirements of the SWHS through the programme.

- Formulation and enforcement of appropriate quality checks at the factory level, product quality and performance guarantee and mechanism for their enforceability , and setting up maintenance cum marketing centres for SWHS are other measures to increase their penetration.

- **Institutional**

- A federation, union or society, which can bring representatives of users, companies, financing sources, policy makers and researches on one platform can be very useful to co-ordinate efforts in this area.

PV systems for electrification of remote areas

There was a consensus that economic and financial barriers are the most important barriers and should be addressed first. This was followed by policy barriers, indicating need for a governmental mechanism to promote PV technology. Market barriers were considered next in importance, indicating small size of the market and limited access to international market. Private sector involvement was limited due to small size of the market. Some PV manufacturers even suggested the need for obligatory laws for rural electrification using PVs. While experts and users considered technical problems and availability of maintenance as an important barrier, PV manufacturers did not consider this as a barrier. Important barriers within these categories were as follows:

- **Lack of information**

In spite of the efforts in recent years, the awareness on the applications of solar PV systems is very low. PV is still considered an exceptional solution in rural programmes for potable water supply.

- **High dissemination costs**

The target group for rural solar electrification lives in dispersed rural dwellings, and proportion of wealthy households is also low in these areas. Dwellings are far apart, and therefore the transaction costs for commercial dissemination, installation and after-sales services are very high. These costs are estimated to be about 30% of the total costs of PV systems.

- **Unfavourable tariff system**

The tariff charged by utilities does not reflect the real cost of rural electrification. Tariffs for electricity are identical in rural and urban areas, although the cost of supplying electricity is much higher in the countryside. On the other hand, consumers with low consumption of electricity pay lower tariffs. This makes PV system uncompetitive with the grid electricity. PV system is also not able to offer the range of services that a grid can offer, making it further uncompetitive.

The electricity tariffs do not include external costs (environmental costs) due to use of fossil fuels in electricity generation. If these costs are considered in tariff setting, PV systems could be competitive with traditional electricity sources.

- **Taxes and duties**

As in many other developing countries, PV system is considered a luxury product and charged very high import duty in Egypt. Sometimes, tax exemptions may be available for equipment imports for a public or NGO project. But this inhibits commercialization. Further, the components that are produced locally (such as charge regulators, and batteries), attract high duties to protect the market for local manufacturers. This can cause problems if technology with the local manufacturer is not reliable. Import of equipment and materials is also a problem due to foreign exchange constraints.

- **High capital costs of the PV system and a lack of financing mechanism**

The capital cost of PV systems is very high and people in the remote (rural) areas are not able to afford it. Most of the people in these areas are poor and cannot pay for these systems. At the same time there is no suitable financing mechanism to support them.

- **Subsidized PV programmes**

An interesting barrier pointed out in Egypt is " Negative effects of subsidised dissemination on commercialization". The stakeholders were of the view that a number of PV programmes, characterised by different approaches and different levels of subsidies, and supported by donors kill the commercialisation drive of the private sector.

Actions to overcome the PV rural electrification barriers

The solar PV systems still have opportunities and potential for contribution to the rural development programs. These include the following:

- Small villages with no access to the grid (high potential area).
- The government policy and plans to electrify all small villages and attachments provides an opportunity.
- Solar radiation is high in Egypt, making solar PV system operation quite reliable and attractive.
- Technical and technological experiences are available.

The actions to overcome the barriers include the following;

- Awareness campaigns need to be launched on regular basis to bring out the potential merits of PV systems and applications.
- Financial schemes need to be designed to support buyers.
- Manufacturers, suppliers, and agents should have their representatives and centres near the consumers.
- Since the PV programme is in initial stage, government supported market incentives needs to be designed to encourage commercial development and deployment.
- PV rural electrification projects can be integrated with other development programs.
- Integration of various PV rural electrification projects can help sharing of experiences in barrier removal.

Large Biogas Plants (LBP)

The barriers identified in the case of LBP are:

- **Information and awareness barriers**
- A lack of awareness on LBP's positive economic and environmental impacts
- Absence of governmental support for development, awareness and dissemination of the technology, necessary in the early stages of such programmes
- **Institutional barriers**
- Lack of co-operation and communication between the involved institutions, organisations and other stakeholders.
- Absence of NGOs role
- **Economic and financial barriers**
- Competing petroleum products and electricity are subsidised and easily available in the countryside.
- High capital costs of LBP compared to other organic waste treatment systems.
- There is no economic evaluation for the positive environmental impact of the LBP.
- Unavailability of land within the targeted sites.
- **Technical barriers**
- Quality problems with raw material.
- Absence of national programmes for developing, adapting and manufacturing LBP to suit the local conditions.
- Non availability of local technical expertize for design and construction. This applies to maintenance also.
- There are no training facilities.
- **Policy barriers**
- A lack of application of environmental laws

Actions to overcome the LBP barriers

Since the LBP programme is in initial stages, most of the action needed relates to formulation of a proper plan and setting up implementing agencies, and ensuring co-operation between various agencies involved in the programme. The actions may include;

- Awareness programmes bringing out benefits of LBP as a source of clean energy and provider of environmental benefits through waste treatment.
- Reforming energy pricing policy to encourage and make RETs competitive with petroleum fuels and electricity.
- Setting up financing mechanisms to provide financing at reasonable rates of interest.
- Carrying out market potential study.
- Setting up a co-ordinating committee for planning and implementing the national action plan as suggested above for LBP.
- Strengthening the co-operation between the concerned ministries, institutions and organisations involved in the programme.
- Encouraging NGOs role in promoting LBP technology.

- Instituting a national action program for LBP implementation within a defined period. The plan should address information / awareness barriers, economic / financial barriers and technical barriers. Pilot projects need to be set up for this purpose.

4.1.6. Direct and Indirect Impacts

Social and environmental impacts of SWHS

SWHS share of total energy saved by renewable energy technologies was estimated to be about 65% in Egypt. This is about 80 thousand TOE annually. Estimated annual reduction in CO_2 emissions is 190 thousand tons. Since the manufacturing is de-centralised and relatively labour intensive (at present, compared to alternatives; oil and electric heating), it is expected to have provided social benefit through increased employment. Unlike oil and gas, it does not need fuel processing, and hence air and water pollution associated with processing of these fuels is reduced. The technology is safer to use compared to other alternatives (gas, electricity). Installation of systems may however need careful planning to avoid disturbing landscape and building attractiveness.

Impacts of PV systems

Rural electrification positively impacts the living conditions of consumers and their provide productive or income generating activities. This is through irrigation of agricultural and grazing lands (using PV pumping technology), crop drying and providing energy for small scale projects. Availability of electricity for lighting, TV and radio sets, social centers, clinics, roads and schools improves the quality of life in rural areas. As a source of clean energy, it reduces pollution inside the homes. It also promises to be a sustainable energy source and provides global benefits through reduction of CO_2 emissions from the conventional electricity generation.

Impacts of LBPs

LBPs have potential to reduce GHG emissions from waste and replacing reducing fossil fuels usage. The organic fertilizer produced by LBPs can substitute a part of chemical fertilizer usage, reducing GHG emissions (emitted from energy used in producing the fertiliser) and soil pollution from chemicals. LBPs can also be expected to have positive social impacts through increased employment and income generating activities.

4.1.7. Conclusions of the Egypt Study

The case study revealed that for the SWHS the main barriers are economic and financial barriers, followed by awareness / information barriers, technical barriers and institutional barriers in that order. For the solar PV electrification of (rural) remote areas, the important barriers are economic and financial barriers, awareness / information barriers, followed by technical barriers. For the large-scale biogas systems, the important barriers include institutional, capacity, economic and financial, policy and awareness / information barriers.

The actions that could be taken to overcome the barriers and use the opportunities provided by the RETs are summarised below.

A. Economic / Financial Barriers

- Creation of financial schemes (for purchasing RETs equipment and systems.)
- Reduction in taxes and duties on the components and / or materials needed for renewable energy (RE) systems.
- Government-supported market incentives to encourage commercial development and deployment of RE technologies.

B. Technical Barriers

- Setting rules and legislation for quality assurance, standardisation, and certification of all the RE components and systems.
- Manufacturers, suppliers, and agents should have their representatives and centres near the consumers.

C. Information and Awareness Barriers

Development of effective public awareness and promotion programs such as demonstrations of systems, brochures, training courses, and workshops for targeted users.

D. Donor's Support

To overcome the barriers / implement barrier removal measures.

4.1.8. Proposal for Follow-up RETs Projects in Egypt

Following projects were proposed to remove the identified barriers to RETs in Egypt;

(a) Creation of a financial and technical support mechanism for SWHS dissemination in Egypt

Objectives of the project are to remove the financial and technical barriers, two major barriers to widespread dissemination of SWHS in Egypt. The project will help increased penetration of RETs through increased production and installation rates of SWHS in Egypt, and also help increase public awareness on RETs use in general and SWHS in particular. Credit facilities from banks for SWHS, quality control and life time guarantee for system performance do not exist as of now. The project seeks to achieve this through creation of a mechanism to co-ordinate between users, bank, consultant and manufactures of the SWHS.

(b) Rural electrification using PV systems

The main objective of the project is to set up a demonstration project in a rural area to increase public awareness of the PV systems and their benefits. Other objectives include local capacity building on operation and maintenance of PV systems and demonstrate suitability of the system for various end uses in rural areas. The project seeks to achieve this by establishing an independent PV solar systems for supplying electricity to five small rural communities in Egypt that are far from the utility grid, and not included in future plans for electrification from the grid. The end uses to be demonstrated include PV electricity for lighting, TV sets, telecommunication, refrigerators for foods and vaccines, water pumping and desalination.

(c) A pilot large-scale (centralized) biogas plant (LBP)

The main objective of the project is to create the favourable conditions by removing barriers against successful implementation of biogas projects. Other objective include improving knowledge, skills, and confidence of interest groups, to strengthen institutional capacity, to upgrade the Egyptian experience in the design, construction, starting up, operation, maintenance of such systems, and to increase the public awareness. The project seeks to achieve these objectives through installation of a pilot project. It is believed that once a successful Large-scale Biogas plants (LBP) is introduced and its advantages are recognized in Egypt the dissemination and adoption of this technology will take place by itself.

4.2. Ghana Case Study

4.2.1. Renewable Energy in Ghana

Ghana is endowed with several renewable energy resources like solar radiation, small hydro, biomass, and wind. Technologies to harness most of these resources except small hydro and wind have been demonstrated in Ghana. Ghana receives good amounts of solar energy (particularly in its northern regions) with an average annual solar radiation of 16-29 MJ/m^2. Conditions are therefore ideal throughout the country for the exploitation of solar energy. Technologies demonstrated to harness the solar energy resources in Ghana include solar water heaters (SWHS), solar crop dryers (SCD), solar water pumps (SWP), solar refrigeration and solar lighting. Wind speeds in Ghana are low and therefore scope for development of wind energy is limited with current technology.

Biomass is the dominant source of energy with about 69% of the total national energy consumption being accounted for by biomass in either direct or processed form [National Energy Statistics, 1998]. It is used in the domestic sector for cooking and many other applications such as water heating. Biomass is also used in many commercial and educational establishments throughout the country. Wood-fuel is the dominant biomass form used in Ghana. The biomass technologies demonstrated in Ghana include pyrolysis, improved cook-stoves, biomass fired dryers, sawdust briquette, improved charcoal production, biogas and cogeneration. The forest resources in Ghana include open zone (savanna) covering an estimated area of 9.6 million hectares, and closed zone (high forest). The closed forest zone covers a little more than a third of the country's total land area and has a size of about 8.2 million ha, 20% of which is demarcated either as forest reserves or fuelwood plantations. Crop residues production in Ghana was estimated about 1.1 million tons in 1990.

Hydropower has been the main source of electric power in Ghana. Until early 1998, virtually all of Ghana's electricity was produced from two hydro dams at Akosombo and Kpong, which have a combined installed capacity of 1,072 MW. It is estimated that Ghana may have the potential for additional 2,000 MW of hydropower. About 1,205 MW of this total is expected to be produced from proven large hydro sources while the rest will come from medium to small hydro plants.[1] About 70 Small Hydro Power sites have been identified in Ghana.

Overall, small hydro potential in Ghana has been estimated between 1.2 MW to 14 MW installed capacity under different scenarios. Thus, it is expected to have only a marginal effect on the overall fuel and energy balance of Ghana (ACRES International,1991)[2]. However, SHP technology could play an important role in widening the implementation of rural electrification programmes in Ghana. None of the SHP projects have been developed in Ghana so far.

[1] Akuffo, F. O. (1998). 'Options for Meeting Ghana's Future Power Needs'. Renewable Energy Sources'

[2] ACRES. (1991). "National Electrification Planning Study", Ministry of Energy.

4.2.2. Energy Policies in Ghana

Exploitation of Ghana's renewable energy resources has been carried out under two main policy regimes – PNDC Law 62 (1983) and the Energy Sector Development Programme (ESDP). The PNDC law established the National Energy Board (NEB) and mandated the NEB to direct the development and demonstration of renewable energy projects throughout Ghana. The NEB initiated a number of projects in the areas of renewable, electricity, petroleum, energy conservation and demand management; and policy analysis, planning and institutional management. The NEB was abolished in March 1991 and its function taken over by the Ministry of Energy. Some four years later, an Energy Sector Development Programme (ESDP) was instituted by the Ministry of Mine and Energy (MME) in 1996. The ESDP is the overall energy policy framework that has been guiding the development of RETs also since 1996. The Renewable Energy Development Programme (REDP) under ESDP includes evaluation, support and demonstration of potential RETs, promotion of renewable energy industries and development of information data base on renewable energy sources, technologies, end use patterns etc. The REDP has supported a number of biomass and solar energy projects in Ghana. ESDP has come to an end and a new National Renewable Energy Strategy (NRES) is being formulated under the Renewable Energy Component (REC) of the DANIDA Energy Sector Programme Support (ESPS).[3]

As a part of the institutional reforms programme, an Energy Commission (EC) and a Public Utilities Regulatory Commission (PURC) was set up in Ghana in 1997. This also had provision for establishment of an Energy Fund under the Energy Commission. One of the end uses of the Fund money was to promote RETs. But the allocation for promotion of renewable from the fund has been insufficient. PURC on the other hand has been engaged in rationalising electricity tariffs as a part of its mandate, a measure that may help promote RETs also. Other significant policy measure was include reduction of import duty on solar panels in 1999.

Thus, several measures and instruments have been employed to implement renewable energy policies in Ghana. Some economic instruments, such as subsidies, taxes, and duty waiver/reduction have also been used been used to a limited extent. However, existing renewable energy policy framework is not potent enough to ensure the commercialisation and widespread utilisation of RETs. This is because the policy framework relies heavily on government budgetary allocation and donor funding which is not likely to be sustainable. The policy framework also does not provide for development of small hydropower in Ghana.

4.2.3. RETs selected for Barrier analysis

Some biomass and solar technologies and small hydro were selected for preliminary analysis of barriers in Ghana. In the biomass category, barriers to use of biomass fired dryers, sawdust briquetting, sawdust stoves and biogas were studied and based on the findings biogas was analysed in detail. In case of solar, barriers to solar crop dryers

[3] In 1996, the governments of Denmark and Ghana agreed that the energy sector would be one of the priority areas for future Danish-Ghana development co-operation assistance. Pursuant to this agreement, the Danish government is funding the ESPS. REC is a component under ESPS supporting the development and management of Ghana's renewable energy.

(SCD), solar water heaters (SWHS) and solar water pumps (SWP) were studied and finally SWP was subjected to detailed barrier analysis.

Potential for small hydropower development has been identified in Ghana but no project has been commissioned so far. Therefore, barriers for this technology were also explored in the study. The selection of these technologies was based on their potential contribution to socio-economic development, potential for application, and availability of information on barriers, environmental impacts and benefits.

The choice of biogas for detailed barrier analysis was mainly because a lot of efforts have already been put into developing projects employing this technology and biogas is still receiving significant attention from both government bodies and the private sector. It is perceived to have huge environmental/sanitation and agricultural benefits. SWP technology was selected for detailed barrier analysis because among the solar energy technologies studied, this had least number of barriers. It was also considered most promising of the three solar technologies on account of its potential to address rural drinking water needs. Small hydro power was also selected for detailed barrier analysis due to its uniqueness; potential exists and technology is well known, yet it has failed to penetrate.

Information on barriers and how to remove barriers was solicited from local experts and institutions, manufacturers, installers and users/consumers of the products through questionnaires and interviews. Site visits were also made in some cases. As part of the barrier analysis process, participants at the Second Workshop of the project were given the opportunity to rank the barriers identified earlier through questionnaires and interviews

4.2.4. Barriers to RETs Implementation in Ghana

The effective development, implementation and dissemination of all the RETs studied was found to have been hampered by several barriers, which have been grouped into three main categories – socio-technical barriers, economic barriers and crosscutting barriers. Socio-technical barriers refer to resource-based, technological, environmental, and social barriers. Economics barriers constitute those related to the market, costs and benefits, and finance. Under crosscutting barriers, informational, institutional and policy barriers were considered.

Barriers to solar water pumping technology

For the three solar energy technologies considered in the case study, SWP had least number of barriers. The most important barrier identified for SWP was high initial cost with often un-quantified long-term benefits and a general lack of information. With the given costs, it is not competitive with other alternatives such as electric grid, and diesel pumps. Further, there are no financing schemes for the SWP. Weak and small market was also one of the barriers but it was suggested that market for such RETs should be considered at regional level and not at national level.

Recommendations to remove barriers to SWP

Stakeholders and experts were of the view that the most effective way of removing these barriers is to start by addressing the information barrier. It was pointed out that information is needed to convince policy makers as well as decision-makers in other sectors of the economy. It was felt very strongly that the way forward is to integrate the promotion of SWP and other solar energy technologies more closely with national programmes that span across areas like infrastructure and youth development. In order to do this effectively, the right information will need to be fed to the relevant programme developers and managers. Other measures needed are financial incentives like tax waivers and subsidies, and necessary legislation for this purpose.

Barriers to biogas technology

The most important barrier to biogas in Ghana is resource availability. Seasonal dung and water shortages were experienced in some plants. This was followed by absence of favourable promotion policies, absence of right financing schemes, high cost, and a lack of market and information. Experts considered the technology most needed by poor but their inability to share cost was found to be a major barrier. Unwillingness of people to use biogas for cooking was also identified as a barrier.

Recommendations to remove barriers to biogas technology

- Enforcement of already existing environmental laws that requires proper disposal of any kind of waste can create a favourable environment for adoption of biogas technology.
- Workshops intended to disseminate information on biogas technology to policy makers and other stakeholders was also seen a way to sensitise them to the benefits of the technology.
- Incentives in the form of tax holidays, tax/import duty waivers, tied-in-tariffs etc. for programmes utilising biogas and other renewable technologies should also be proposed to the policy makers by the stakeholders. This will help bring private sector on board.
- Putting up plants only at the sites where the resource supply/availability is proven, and where the focus is more on solving an environmental problem rather than an energy problem. Specific sites mentioned included abattoirs, public bathhouses and latrines, and institutions such as schools and hospitals. For large plants, dumping sites for liquid domestic waste close to cities and towns were suggested.
- It was also suggested to package the projects to international standards and explore funding from mechanisms such as Global Environment Facility (GEF), Clean Development Mechanism (CDM) and the African Rural Energy Enterprise Development (AREED).
- Finally, “best practice” suggests that biogas should be packaged more as sanitation or agricultural project with energy as spin-off.

Barriers to hydropower technology

For small hydropower (SHP), even though over seventy (70) sites have been identified, none has been developed so far. The only pilot project commenced was never completed and abandoned in 1983. Absence of a policy framework for the development of SHP has been found to be the most important barrier to harnessing the SHP resources. Other important barriers identified include a lack of information on SHP opportunities to private investors, a lack of financing mechanism to promote SHP development, absence of any specific institutional structure to take up SHP projects, and low electricity tariff.

Recommendations to remove barriers to small hydro power

The stakeholders emphasised the need for adequate information on potential, cost and benefits of the SHP and recommended this be generated and made available to various stakeholders including the Government. It was recommended that once the Government accepts the role of SHP based on this information, clear-cut small hydro policies need to be formulated spelling out the Government's strategy for the development of SHP. This could be followed by developing a couple of sites as a pilot or demonstration project to prove the viability and feasibility of the technology. Funds for such demonstration project(s) could be sourced from the Energy Fund or from the donor community.

The stakeholders were also of the view that the "Self-Help Electrification Programme" (SHEP) currently being implemented by the government should be expanded to include community built, owned and managed SHP plants. They recommended it to be made an integral part of the SHEP.

Some specific policy instruments and measures recommended by the stakeholders included upward adjustment of existing tariffs to economic levels so as to encourage private investors to enter into the development of SHP plants. Alternatively, a premium price may have to be paid for power generated by SHP plants. Cataloguing information on the potential benefit of SHP, and educating various stakeholders including government agencies and policy makers, local communities, financial institutions, local communities, District Chief Executives etc on the potential benefits of SHP were other recommended measures.

Thus, a general lack of information on the potential benefits of RETs was found to be a major barrier with regard to the government and end-users alike. Energy policy analysts in Ghana will therefore need to remove these barriers by generating the necessary information and disseminating it as widely as possible using various techniques ranging from lobbying parliamentarians to advertising in the mass media.

4.2.5. Opportunities for Promotion of RETs and General Recommendations

Notwithstanding the barriers identified, there are some opportunities for the dissemination and wide-scale adoption of RETs in Ghana. These are the government's National Electrification Scheme (NES) for rural electrification, ongoing power sector reform programme, and the establishment of the Energy Fund and National

Electrification Funds. It is expected that if these opportunities are capitalised on, the "frontier" of RETs will be pushed forward. The recommendations are:

- It suggested that since Ghana's renewable energy policies have been found to be inadequate in ensuring widespread utilisation of RETs, a new policy framework, that would help remove identified barriers, is required. It was recommended that the new National Renewable Energy Strategy (NRES) should contain the necessary measures and instruments to promote RETs. Before any community is connected to grid electricity, various supply options including renewable should be considered.
- There is need for the Government to set targets for the renewable (the national institution KITE recommended 20%) and design ways of achieving these targets.
- In general low electricity tariffs have made renewable un-competitive and also served as a deterrent to private investors. The Public Utilities Regulatory Commission (PURC) should therefore institute an upward review of tariffs or a premium price for renewably generated electricity.
- To ensure private sector participation in the renewable energy industry, there is a need for a level playing field. Because conventional energy is subsidised, either these should be eliminated or similar subsidies should be provided for the renewable.
- Plans and programmes for the extension of grid electricity should be made available to the public to reduce uncertainty about when the grid will reach a particular location. This will enable private investors to identify potential markets.
- On the institutional front it was recommended that the Renewable Energy Unit of the MME should be hived-off into a full-fledged NGO using the "Energy Foundation"[4] model. This will guarantee autonomy for the unit in pursuit of its objectives.
- It was also proposed that a Clean Development Mechanism (CDM) office should be set up by the government and the proposed renewable energy NGO should work with other interested parties to assess and package renewable energy projects as CDM projects.
- In view of the fact that RETs are expensive but clean technologies compared with conventional energy, donor support will be crucial for widespread utilisation of renewable in the rural areas where ability to pay is low.

Specific recommendations for the solar. biomass and hydro power technologies are as follows:

[4] The Energy Foundation is a Non-Governmental Organisation, which was established in November 1997 to, among other things, take over the MME's Energy Efficiency and conservation Programme.

Solar technologies:

- Key barrier for the solar technologies has been identified to be the high start-up cost associated with the acquisition of the technology. To overcome this barrier, new and innovative financing mechanisms need to be devised. It was suggested to set up a fund in a financial institution to administer soft loans, grants and flexible financing schemes to dealers and end-users. Such a fund could be fed by disbursements from the Energy Fund. Duty waiver could also be considered to reduce costs.
- To help expand the market for solar PVs, rural electrification projects aimed at meeting the basic lighting needs of rural communities should consider the use of solar lighting. Similarly, PV systems could be integrated into urban housing and building schemes in areas yet to be serviced with grid electricity. A beginning could be made with the Government funded building projects incorporating PV systems.
- For awareness raising and widespread dissemination of information, educational and training programmes and workshops should be organised.

Biomass technologies:

- Existing environmental standards governing urban waste disposal should be reviewed and enforced.
- Incentive schemes for promotion of biogas technologies should be introduced.
- Awareness raising and training programmes should be initiated for various technologies.

Small Hydro Power

- Review, update and dissemination of the assessment of the SHP potential of Ghana needs to be done.
- A pilot project should be taken up.

4.2.6. Proposal for Follow-Up RETs Projects in Ghana

(a) Biogas project

It is proposed to install a community biogas plant in a hospital or a school with waste disposal problem. It has been realised that biogas technology in Ghana is useful as a sanitation project or solution to a environmental problem. The energy and fertilizer can be treated as spin-off from the project. The project could also be installed at an abattoir site, that also face environmental problem related to waste disposal.

(b) Solar water pumping project

A pilot project to remove identified barriers can be set up for the SWP technology. Such a project can have three dimensions: data collection, data analysis and then dissemination of this data and analysis. The first two dimensions would constitute a study aimed at determining costs and benefits of SWP as well as the competing technologies in both the domestic and agricultural sectors. The third dimension will involve dynamic interactions with policy makers, including sessions with parliamentarians and decision makers in the relevant public and private sectors.

(c) Hydro power project

A study to update potential and estimated cost profile of SHPs, and bring out technological and technical difficulties peculiar to SHP in Ghana is need to be initiated to provide a sufficient basis for investment decisions. A demonstration project involving development of one small hydro site is proposed to address the barriers. The proposed site for such a demonstration project is the Likpe-Kukurantumi site. This site has been chosen because there is some civil work already in place and the generating plant imported for the original project is still available and in good condition.

4.3. Zimbabwe Case Study

4.3.1. Energy policy in Zimbabwe

Several types of energy are in use in Zimbabwe. Biomass accounts for 50% of the energy used, while coal and electricity account for 13 and 12% respectively. Fuelwood is the most important domestic fuel in the country. It is the major source of energy for cooking, lighting and heating for over 80% of the population mainly in the rural and peri-urban areas. But fuelwood is legally not a commercial fuel as the collection and sale of fuelwood requires a license form the government. The emphasis here is on controlling the supply side. Coal is the most abundant source of primary energy found in Zimbabwe apart from fuelwood.

The energy supply options for Zimbabwe have a mixture of hydroelectricity coal and renewable. After the development and refurbishment of some coal fired thermal power plants in the past years the thrust is now on developing hydroelectric power plants as well. The country has several interconnectors for importing power from South Africa, DRC and Zambia.

To-date, only 20% of Zimbabwean households have access to electricity. Nevertheless the grid is well developed with efforts after 1980 having extended supplies to rural business and government administrative centers. Access to financial and technical resources, that could enable the communities to utilize the electricity, has been lacking.

Alternative energy sources were recognized as a viable solution for the energy needs of the poor. This included the introduction of efficient cook stoves to save energy, trials with various new and renewable sources of energy including solar PVs, biogas digesters, crop waste briquetting and community wood lots development.

As on date, three major policy indications for expanded access have been put in place:

- Rural Electrification Master Plan
- Alternative Energy Strategy Document
- National Biomass Strategy Document

The rural electrification initiative of the government requires beneficiary to share 50% of the cost of grid extension, opening up the opportunity for alternative energy supplies where the cost of supply would be lower than a grid hook-up. The government in consultation with all stakeholders formulated the Alternative Energy Strategy Document and the National Biomass Strategy Document. These two documents set out technology evaluation guidelines, the intervention strategy and the institutional arrangements of all stakeholders in the dissemination of RETs. However, success of the dissemination of RETs has been very rudimentary due to the high capital cost and in some cases equipment failure.

In the mid eighties, however, policy redirection was engendered based on improving the fuel efficiency of wood stoves and the introduction of family and community wood lots.

4.3.2. Renewable Energy Potential in Zimbabwe

Renewable energy technologies available in Zimbabwe are solar photovoltaics and water heating, biomass technologies emphasizing on digesters, cogeneration, briquetting and gasification, mini-hydro, wind power and hybrid systems. Although renewable are already in use in the country, their potential remains largely unexploited. Table 4.1 indicates the status of renewable in Zimbabwe.

Table 4.1: Technical potential for Renewable Energy (MW) in Zimbabwe

Technology	Installed Capacity(MW)	Technical Potential (MW)
Solar PV	0.8	>300
Solar WH	10 000 units	1 million
Mini Hydro	1.7	20
Micro Hydro	1	15
Biogas	250 units	5000 units
Wind		
Bagasse based cogeneration	45	150
Power generation from sawmill waste	0	250

Solar photovoltaics (PVs) installed in the country are mainly in rural areas at service centres like schools and hospitals as well individual homes. In rural areas PV is used for lighting, radio and television. PVs have a lot of potential given the country's annual insolation of over 2000-2200kWh/m^2 and the fact that, of Zimbabwe's over 2 million households only 23% are electrified. Zimbabwe hosted the large UNDP GEF PV project, which installed about 9000 units. This project created a lot of experience, and disseminated a lot of information about PVs to the population in the country. The main barrier to the dissemination of this technology is the lack of capital by the majority of Zimbabweans to acquire the Solar Home systems. Solar PV market still remains open especially in very remote areas, which are not likely to be electrified both in the short and long run.

Solar water heaters are mainly afforded by the middle to high-income groups in the country due to high capital costs of over US$1000. There is a significant private sector activity in solar water heating for hotels and commercial buildings. The greatest market potential for these units however exists in low-income households who however do not have the capital to acquire such units. There is a need for strengthening of standards for PV systems and solar water-heating systems.

The main problem in case of biogas is lack of technology appreciation. Until today the effort to disseminate biogas technology have concentrated on household units. To date more than 250 units have been installed. They have been constructed with underground reactors and a typical digestor intake is about 20 kg of manure a day. The biogas unit supplies the household with energy for lighting, cooking and water heating. A number of biogas construction tradesmen have been educated by the Silveira House, an agency who has also installed several biogas plants. A major barrier is the lack of a maintenance infrastructure. All the major cities in the country treat their sewage anaerobically producing biogas. This biogas could be collected.

To reduce the petroleum imports, Zimbabwe established an ethanol-from-sugar plant with a capacity of 40 million litres of ethanol per year. Car owners can only blend, which is a mixture of gasoline with up to 13% alcohol.

The average annual wind speeds in Zimbabwe is in the rage 2-4 m/s. This is not enough for larger electricity generating wind turbines, only for smaller electricity producing turbines and for water pumping windmills. It is estimated that 600 locally manufactured wind pumps were installed. A local company has recently started to produce 1-3 kW turbine; one of this has been erected in Temaruru in the Eastern Highlands at a battery charging station. There is a large demand for this service since about 20% of rural households use vehicle batteries to power radios and TVs.

Zimbabwe thus has a long history with renewable energy. The pressure to reduce the import bill for petroleum fuels and the need to provide for the energy needs of the rural poor was the major driver in the early eighties. Studies had shown that fuel wood sources were rapidly being depleted with major environmental consequences. It was therefore a priority by government to find alternative energy sources that would not negatively affect the balance of payment. Fuel wood stocks were meant to be depleted by the late 1990's according to studies by the Beijer Institute[5]. These early assumptions drove government to implement several projects in support of adoption of renewable energy.

4.3.3. Barriers to RETs Implementation in Zimbabwe

It was brought out in an earlier UNDP-GEF study on industrial energy efficiency that there are primary and secondary barriers. The primary barriers are the actual reason why technologies are not implemented and the secondary barriers are often the apparent reason as seen from the stakeholders' perspective. Table 4.2 illustrates some of the primary and secondary barriers that are often quoted.

After identification of the primary and secondary barriers it is then important to identify the least cost intervention for successful barrier removal. It is important that on removing the current barrier no new barriers arise from the removal process.

Economic barriers

Renewable energy investment costs are normally higher than the comparable conventional energy option. The cost is mainly due to the limited scale of units that are bought for similar applications in the country. At the same time, renewable energy projects may fail to beat the competition from the conventional sources of electricity especially when environment benefits are not accounted for.

The question of investment cost is ambiguous because for the same cost the project would be viable if energy prices were higher. However the ruling criteria for most investment in small-scale energy technology is ability to pay and local perception of benefits. If the social benefits were seen as much more than the investment cost then the investor would set the acquisition of the technology as a high priority.

[5] Beijer Institute, 1998. 'Energy for Rural development in Zimbabwe'.

Table 4.2: Barrier Analysis

Primary Barrier	Secondary Barrier	Barrier effects
Inability to Develop and Present Project Proposals	Failure to secure investment support	Investor diversion to other areas. Poor volume of RETs trade Continued demand for grant funding
Inability to assess benefits and lobby government for policy improvement	Poor policy on RETs Subsidized fossil fuels Unfavorable taxation Poor baseline information	Continued view of RETs as a welfare good. Continued view of RETs as a small energy source.
Ignorance of government policy	No government incentive Inaction by government Inability to connect with relevant government bodies	No policy evaluation and feedback. Failure to benefit from existing policy.
Poor Fiscal/macroeconomic policy	No local technology base for RETs Poor institutional framework Poor infrastructure	Exclusion of RETs in energy planning. Exclusion of RETs from main stream industry. Lack of co-ordination of RETs programs. RETs disadvantaged by energy pricing. High initial investment cost. Limited skills base. Market ingress of sub-standard technologies.
Threat of natural disaster e.g. droughts and storms	Consistent food security problems Persistent water shortages and crop failure	Diversion of investment focus to basic needs.
Absence if curricular support in Schools	Poor academic consideration of RETs	Limited skills base.

O&M costs

RETs have been viewed as the energy supply option for the remote and rural poor in Zimbabwe. Some potential clients for renewable energy technologies may be prevented from adopting them due to the fear for technology failure in the absence of technical support.

Financial barriers

Finance for renewable energy investment is difficult to access. Off shore financing comes with more favourable interest rates and repayment conditions but faces a major barrier in exchange loss cover where the local administrator for the funds is forced to collect a large premium to protect for exchange variations. Micro financing has not been successful in promoting RETs.

Technology Barriers

Access to technology is often seen as a barrier to its use. This maybe true but in most cases access is restricted by other factors, which on their own stand as barriers to adoption of the technology. Given the improved trade and communication ties between countries it is no-longer material that technology be available from local sources. The real need is for localizing technology know-how to allow for local screening in favour of renewable energy. Successful localization of technology know-how requires demonstration of performance, transfer of technology assessment skills, transfer of technical knowledge and building of a local technology assessment matrix that includes financial, technical and social criteria for technology acceptance.

Social Barriers

Poor matching of individual and national development objectives. Most renewable energy projects implemented in Zimbabwe have been based on the assumption that rural communities need alternative energy to displace fuel wood. A further assumption is that they could do well with renewable energy sources because they are cleaner and help protect the environment. This assumption has been found to be a barrier to adoption of alternative energy.

Institutional Barriers

A key factor influencing the implementation and promotion of RETs in the country is the existing institutional infrastructure. A strategically set up and conducive institutional framework has in most cases shown to be a requirement for successful technology dissemination.

Barriers identified by stakeholders

Several barriers were identified at the second project workshop. These were :

- Poor institutional framework and infrastructure;
- Inadequate RETs planning policies;
- Lack of co-ordination and linkage in RETs programs;
- Pricing distortions, which have placed renewable energy at a permanent disadvantage to other conventional fossil fuels.
- High initial investment costs coupled with absence of supporting financial instruments;
- Weak dissemination strategies and excessive emphasis on the service and welfare functions, rather than production and entrepreneurial-based approaches;
- Lack of requisite skilled manpower;
- Poor baseline information;
- Inadequate technological bases necessary for the large-scale manufacture and distribution of RETs;
- Weak maintenance service and infrastructure
- Technology failure, inappropriate technologies, not matching with rural user needs
- Lack of liaison with rural development units;
- Natural barriers such as water shortages, poor wind speeds and other natural causes
- No serious official follow-up to the all ready implemented projects.
- Lack of curricular support in RETs in schools and institutions of higher learning.
- No official co-ordination from Donors. Donors end up funding the same project over and over again without any follow-ups. This depresses local initiatives.

- Unfavorable macro-economic policies. Sector affected by the state of the economy.
- Lack of a level playing field for all sources. Some energy sources are heavily subsidized at the expense of other technologies thereby creating an uneven playing field.
- No strategic view and planning on the future of RETs. Project sustainability not taken seriously.
- Lack of transparency on project allocation by the government and the donors.

Barrier Removal Actions

It may appear easier to attack the primary barrier in barrier removal but the effects of barriers in some cases become a barrier. Barrier removal programs therefore need to include measures to overcome the secondary barriers as well as the effects of barriers before the system can gather sufficient momentum to run on market forces alone. An example is the need to improve the quality of proposals for RETs projects where seed money and entrepreneur development would be needed to make the barrier removal action effective. The following table details the actions recommended by the final workshop and also those recommended by the research team.

Table 4.3: Identified primary barriers and removal options

Primary Barrier	Removal Action	Responsible Parties
Inability to develop and present project proposals	Set-up finance schemes; Develop guidelines for proposals	DOE, Development Agencies
Inability to assess benefits and lobby government for policy improvement	Technology specific stakeholder meetings. Capacity building within DOE and Industry	RETs Industries DOE External Development Agencies
Ignorance of Government Policy	Regular meeting between DOE and stakeholders.	DOE, RETs Industries
Poor Fiscal/macroeconomic support for RETs	Capacity building within DOE, Industry Promote technology information exchange. Information programs for legislators	DOE, Industry External Development Agencies
Absence of curricular support in schools	Development of RETs curricular in schools Information programs for schools	Universities, DOE Industry External development agencies

The final workshop of the project recommended the following general barrier redress mechanisms

- Technology specific stakeholder meetings
- Communicating with development programs / projects
- Internal DOE capacity commitment and mandate to consider renewable energy
- Linkage with other stakeholders for implementing policy
- Regular meetings with DOE
- DOE newsletter as a communication tool with stakeholders
- Human resources audit in the Department of Energy
- Private sector should present recommendations to government
- Information programs for parliamentarians
- Web-sites for Zimbabwe alternative energy strategies
- Fiscal policy to promote renewable energy
- Research and development to reduce imports
- Promoting technology information exchange
- Screening of equipment for quality
- Development of the curricular on renewable energy in schools and colleges
- Information publicity and dissemination through competitions in the rural areas, schools and colleges on renewable energy
- Set up local finance- micro finance schemes for the implementation and promotion of RETs

4.3.4. Proposal for RETs Follow-up projects in Zimbabwe

In Zimbabwe the Advisory Committee members formulated a number of follow-up projects. Barriers for each of these projects were identified and recommendations for successful implementation were pointed out.

a) Country strategy on renewable energy technologies
This project aims at carrying out a survey study of the renewable energy market in Zimbabwe with the main objectives of identifying its strengths and weaknesses in the manufacturing, distribution and maintenance sectors of the market. The overall objective of the study is to come up with a guideline or strategy to be followed when it comes to the selection of a particular renewable energy technology to be implemented in a new project which would ensure that the most appropriate technology is chosen, implemented and can be practically maintained and sustained.

b) Entrepreneur business and technical skills development in renewable energy
Zimbabwe has emerging small and medium scale industries in renewable energy, which need an immediate support on both the technical and business areas in order to remain as a viable industry in the present harsh economic environment. This project aims to capacity build both the business and the technical skills of selected small and medium scale industries in solar, solar thermal, biomass and mini-micro hydro industries through the provision of structured practical training courses and the transfer of appropriate technologies.

c) Development of house-based solar power generation scheme

This project aims at developing of a 3 to 5 kW solar power generation scheme, which is synchronized with the power grid. The scheme will operate in parallel with the electrical system to meet the house need from energy and to export the excess energy back to the supply when it is not utilized. Energy bill will be based on the difference between energy import and export to and from the supply.

d) Development of affordable solar cookers for both rural and urban users

The aim is to develop affordable solar cookers with different cooking capacities and performances for both rural and urban users. The designs will be built using locally available materials and tested to show its cooking capabilities and its temperature profiles. Different designs are to be developed to give solar cookers with varied cooking capacity and costs to suit users varied financial capabilities and needs.

e) African windpower

This project is a proposal from the Zimbabwean wind turbine producer Powervision". The project aims to install 10 owner-operated income generating wind-charging systems around Zimbabwe. Suitable sites will be surveyed and if suitable a wind charger system will be installed. The owners will use the systems, to operate a commercial battery charging system, to sell limited Ac power to small business tenants and to provide power for lights and entertainment for owner's use.

f) Identification of desirable stove characteristics and development of prototype stoves for field-testing

The project will be community based and the key stakeholders are rural women, small rural enterprises and NGO's. The Biomass Users Network will execute the project. Women making food for hospitalized family members will test the stove. The proposed approach is to identify user modifications to the open fire and to existing "improved stoves." The next step is to develop a set of prototype designs of stoves based on the findings and then field-test a selection of potentially suitable stoves developed. The results are expected to be used by small-scale rural enterprises to produce and market the stoves.

5. Lessons Learned from the Case Studies

The country teams used the basic framework developed at the UNEP Centre, but tailored it to their needs of analysis. The basic approach included stakeholders' involvement in identification of barriers to RETs and measures to remove the barriers. The results of the case studies therefore indicate the specific concerns of the stakeholders on RETs.

In the Egypt case study, the focus was on PV systems for rural electrification, solar water heaters and large-scale biogas system. High capital costs of the system due to high tariffs and taxes were one of the major barriers for PV system. Lack of information and subsidized electricity were other important barriers. High cost, lack of information about technology, technical problems in usage and a lack of institutional structure to promote and support SWHS were identified as main barriers in that order for SWHS. In case of large-scale biogas plants, the barriers in order of importance were; a lack of institutional structure to promote the technology, skills, size of market, cost of technology and awareness. The measures to overcome the barriers recommended by the stakeholders to improve economic viability of these RETs included setting up of new financial schemes, reduction in taxes and duties on imports of RET equipment and components and better designed incentive schemes. Standardization and certification requirements through legislative measures and easy consumer access to the equipment suppliers for fault rectification were recommended measures to address technical barriers. Awareness and promotion campaigns, training courses and seminars for targeted users and educational institutions were recommended to disseminate information on the RETs.

In the Ghana case study, three solar energy technologies (solar water heaters, solar crop drying and solar water pumps), biogas and small hydro were studied. Of the three solar energy technologies, solar water pump was identified as a promising technology with least barriers. High initial costs and a lack of information on technology and its benefits were major barriers to SWP. Although biogas was identified as one of the RETs with promise, resource constraints (for example, minimum dung needed for a household biogas plant) was found to be a major barrier on detailed scrutiny of its potential for large-scale application. An interesting finding was the suggestion of the stakeholders to promote biogas projects in Ghana as a sanitation or agricultural project (with fertilizer as output) with energy as a spin-off. In case of small hydro, no development has taken place in Ghana despite some potential. Absence of a coherent energy policy framework was identified the reason for this.

In general, existing renewable energy policy framework in Ghana was found to be inadequate to promote RETs and harness their full potential. The RETs promotion relies heavily on governmental budgetary allocations and donors funding which are inadequate and unsustainable. The stakeholders identified need for clearly defined targets, investment plans and financing mechanisms in the national framework for renewable energy. Specifically, need for a role for renewable energy in the governmental "National Electrification Scheme" was recommended. Similarly, it was suggested that Rural Electrification and Self Help Electrification scheme of the government should shift focus from grid-extension to renewable, that are viable options for some applications. Need for a review of the existing low electricity tariff in urban areas was also stressed. Donors also have a role to play in cases where renewable energy is expensive.

The Zimbabwe case study focussed on RETs barrier analysis on a conceptual level. Participants in the workshop said that they were happy that all the stakeholders for the first time had a chance to discuss the barriers together. They also mentioned that clear targets for the numbers of RETs installed in the country in future are needed. The barriers were categorised as primary and secondary barriers, the latter's (secondary) existence being due to primary barrier. The stakeholders may see and experience only secondary barriers arising out of the presence of primary barriers. It is important to identify and remove primary barriers but it is equally important to remove "lingering effects" produced by secondary barriers. For example, banks have been reluctant to fund RETs due to poorly developed proposals and rated RETs as poor investment. Therefore, banks may be reluctant to fund RETs even when convincing proposals are made. The barrier effects were co-related with barrier effects indicating impacts of the barriers on RETs dissemination. Inability to develop and present sound project proposals, lack of capacity to assess cost and benefits, ineffective lobbying with the government, lack of information with the government for policy making, poor fiscal support to RETs and a lack of information dissemination on RETs from school level were identified as primary barriers. Developing guidelines for project proposals, setting up financing schemes, capacity building on technology assessment within government and industry, regular stakeholders' interaction with the government, setting up a technology information exchange on RETs, and development of curricular and information programs on RETs for schools were recommended as the measures to overcome the barriers.

In general, economic and information / awareness barriers were the most important barriers across the countries and RETs. This points to the low level of awareness and information on RETs among the potential users. Therefore, better ways to raise awareness are required. The economic barrier indicated high cost of the RETs (possibly except for a few selected applications), pointing to the need to bring down the cost of technology. Small size of market, unfavourable policies, and subsidy to competing conventional fuels were other reasons that affected the economics of RETs further. Lack of access to financing also contributed to lack of access to RETs. Problems related to product quality and maintenance indicated need for capacity building in this area. Finally, a lack of institutional structure to promote RETs was also noted as an important barrier by stakeholders for various technologies. Most of the barrier removal measures pointed out by the stakeholders indicated the need for policy intervention by the government to create a favourable environment for RETs to take off. Thus, need for a favourable policy regime to address these issues was a clear message given by the stakeholders.