IEA INTERNATIONAL ENERGY AGENCY

# PV for Rural Electrification in Developing Countries - A Guide to Capacity Building Requirements

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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**IEA PVPS**
International Energy Agency
Implementing Agreement on Photovoltaic Power Systems

**Task 9**

**Deployment of Photovoltaic Technologies: Co-operation with Developing Countries**

# PV for Rural Electrification in Developing Countries – A Guide to Capacity Building Requirements

**March 2003**

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## FOREWORD

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme is one of the collaborative R&D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. Currently activities are underway in five Tasks.

The 21 members of IEA PVPS are: Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), European Commission, Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), the United Kingdom (GBR), and the United States (USA).

The objective of Task 9, which started in late 1999, is to increase the overall rate of successful deployment of PV systems in developing countries, through increased co-operation and information exchange with developing countries and the bilateral and multilateral donors.

Twelve countries[1] participate in the work of Task 9, which is an international collaboration of experts appointed by national governments and also includes representatives of the World Bank and United Nations Development Programme. Developing country representatives are invited to participate.

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in co-operation with experts of the following countries: Canada, Denmark, Finland, France, Germany, Italy, Japan, Switzerland, and the United States of America. The views expressed in this paper represent a consensus of opinion amongst the Task 9 experts.

This document is one of a series being published by Task 9. The complete series of documents comprises:

- PV for Rural Electrification in Developing Countries – A Guide to Institutional and Infrastructure Frameworks.
- Summary of Models for the Implementation of Photovoltaic Solar Home Systems in Developing Countries.
- Financing Mechanisms for Solar Home Systems in Developing Countries: The Role of Financing in the Dissemination Process.
- The Role of Quality Management, Hardware Quality and Accredited Training in PV Programmes in Developing Countries.

[1] Australia, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom, the United States of America.

- PV for Rural Electrification in Developing Countries - Programme Design, Planning and Implementation.
- Sources of Financing for PV Based Rural Electrification in Developing Countries.

## KEYWORDS

Keywords: capacity building, training, developing countries, PV, renewable energy programmes, rural electrification, solar home systems

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Every effort has been made to ensure the accuracy of the information within this report. However, mistakes with regard to the contents cannot be precluded. Neither DTI, DfID, the authors, nor the IEA PVPS shall be liable for any claim, loss, or damage directly or indirectly resulting from the use of or reliance upon the information in this study, or directly or indirectly resulting from errors, inaccuracies or omissions in the information in this study.

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| $CO_2$ | Carbon Dioxide |
| ESCO | Energy Service Company |
| GEF | Global Environmental Facility |
| ICT | Information, communication and technology |
| IEA | International Energy Agency |
| kWh | kilowatt hour |
| kW | kilowatt |
| LPG | Liquid Petroleum Gas |
| NGO | Non Governmental Organisation |
| OECD | Organisation for Economic Co-operation and Development |
| PV | Photovoltaic |
| SHS | Solar Home System: PV system of ca. 20 Wp to 100 Wp capacity, with a storage battery, charge controller, compact fluorescent lamps. |
| SMEs | Small and Medium Enterprises |
| $SO_x$ | Sulphur oxides |
| UNDP | United Nations Development Programme |
| VAT/TVA | Value Added Tax |
| VCR | Video Cassette Recorder |
| Wp | Watt peak |

## SCOPE AND OBJECTIVES

This document identifies capacity building measures that should be undertaken as an integral component of a PV based rural electrification implementation programme. Many of the measures outlined could be adapted to any other off-grid or dispersed renewable energy technology. However, as the mandate of IEA PVPS Task 9 is to consider only photovoltaics, other technologies are not explicitly addressed.

The objective of this document is to provide guidance to those project developers who are interested in implementing or improving support programmes for the deployment of

photovoltaic systems for rural electrification. In particular it is targeted at bilateral donor agencies, at international, national and regional financing organisations, development agencies and project developers.

Many previous PV projects and programmes have failed because a lack of skilled personnel at all levels – from Government departments and implementing agencies, to installation and maintenance personnel. This lack of local capacity can be relatively easily addressed if appropriate measures are identified at an early stage in the project life-cycle.

This document provides an introduction to capacity building measures that should be addressed early during the planning and implementation stages of a PV programme to facilitate a sustainable market for PV to develop in a country. The capacity building activities should be prioritised and must be geared in a timely process to the progress of a given programme. Capacity building measures are equally important in countries without independent or strategic programmes if PV is to meet some of the energy needs of the country in a sustainable manner.

This document covers issues relating to capacity building within the following sectors and groups:

- Government Bodies (Ministries responsible for Agriculture, Education, Energy, Environment, Finance, Health, Industry, Public Works, Water).
- Utility Sector.
- Financial Community.
- NGOs.
- Service Delivery Chain.
- End-users.

This document identifies capacity building measures that could be implemented for government departments, utilities, the service delivery chain, the finance sector and for NGOs and end-users. The capacity building measures suggested in this document can be transferred to most relevant renewable (or cost effective non-renewable) technologies, not just PV.

# 1 INTRODUCTION TO CAPACITY BUILDING

Capacity building can be defined as the development of an organisation's or individual's core knowledge, skills and capabilities in order to build and enhance the organisation's effectiveness and sustainability. It is the process of assisting an individual or group to identify and address issues and gain the insights, knowledge and experience needed to perform effectively. Capacity building can also include the creation of an enabling environment with appropriate policy and legal frameworks, institutional development and human resources development and strengthening of managerial systems.

Capacity building is facilitated through the provision of technical support activities, training, specific technical assistance and resource networking. Capacity building is recognised as being a long-term, continuing process, in which all stakeholders participate.

Renewable energy technologies have wide ranging potential for providing basic domestic electricity services, as well as energy to the health, educational, agricultural and commercial sectors. This is often not well understood by the government ministries and experts in charge of (rural) development portfolios. Therefore, it is important that renewable energy and PV technology expertise is developed in those ministries addressing the rural population.

To achieve this, capacity building is required across many sectors, organisations and groups. The capacity building that is required is diverse and the actual requirements vary from country to country. The type of capacity building activities that could be required include developing the skills to undertake the following activities: awareness raising; evaluation and selection of technology options; preparation of business plans; resource assessments; investment promotion; financial analysis; project finance; technical advisory services, product development; establish community based utilities; set tariff structures and accounting procedures.

It is also important to recognise that the right capacity must be built in the right organisation. For instance, government ministries and departments should not generally be considered as suitable entities for the implementation of projects. Implementation should instead be undertaken by entities that have the necessary technical and managerial expertise, for example an electricity utility or suitably qualified NGO. The role of government should be to set policy and regulations and to enforce these regulations.

PV projects have been implemented in a number of countries, but capacity building activities have tended to be concentrated in only a few of the areas where it is needed: the success of many projects is often hampered by a lack of capacity in the other, related areas. Raising awareness in only one or two areas will help increase the dissemination of the technology, but raising awareness and skills more widely will, in general, contribute to the rapid and sustainable implementation of PV and assist in creating a sustainable market.

Even a large-scale PV programme is unlikely to cover all public sectors. Priority should be given to those sectors and groups applicable to a particular programme (i.e. capacity building is a lower priority in the health sector if a schools electrification programme is being planned). However, there are advantages to capacity building in many government ministries so that synergies between different sectors can be maximised. In all cases capacity should be built up in the ministry responsible for energy/rural electrification. For all programmes it is usually necessary to increase capacity within the service delivery chain, the financial community, the utility sector and the end-users.

It is also important to realise that many of the problems associated with rural electrification using off-grid renewable energy technologies is the 'stop start' nature of much development aid. This results in a limited amount of capacity building within specific sectors to be developed, but the lack of a sustainable approach means that this expertise is often dissipated after a project is completed. Rural electrification programmes should be

implemented taking into account the needs and priorities of all relevant sectors to maximise the synergies between them.

**Example 1. Capacity Building in South Africa**

Between 1998 and 2002 15 million EUR were allocated to a European Commission programme to supply 1000 schools with PV systems in South Africa. The Technical Assistance component, which comprised largely of capacity building activities, was spread over two years. Capacity building accounted for just 4 % of the total project cost or 670 EUR per kW installed.

The Technical Assistance Unit (TAU) was set up to advise the implementation agency (Eskom) and the supervisory Ministry (Department of Minerals and Energy, DME) on technical and project management issues. The TAU worked within the Department of Minerals and Energy.

During the first months of the TAU's existence, technical problems became apparent which resulted in the installation process being halted for some time to enable these issues to be addressed.

The TAU developed improved procedures for system installation and commissioning and trained Eskom's Commissioning Officers. The procedures were then implemented in co-operation with Eskom and ongoing liaison with Eskom staff and installation contractors. Further capacity building took place through training emerging contractors. This resulted in the second phase of installations going much smoother and increased the chances of long-term sustainability of the installations.

*Large Scale (1000 Schools) EU Funded PV Project in South Africa*

The justification for the costs of capacity building in PV has been demonstrated in a number of PV projects, where training has had a direct impact on the sustainability of a project and on future programmes. The costs for capacity building can be as little as a few percent of the project budget, but may determine whether the project is a success or not. However, it is important to prioritise effort to maximise the advantages from limited resources.

The private sector also has an important role to play and should be encouraged to provide capacity building and to support the local PV market. It is in the interests of the private sector/PV businesses to ensure that installers, technicians, programme designers and end-users are all better informed, so that there are less failures and the local PV market will develop more quickly.

## 2 ASSESSING THE NEED FOR CAPACITY BUILDING

The level of capacity between different countries, provinces, or even localities can vary considerably. It is a prerequisite that, before the implementation of any intervention in rural development, an assessment of the existing capacity within the country is undertaken in order to assess additional measures that need to be implemented. Furthermore, it is important that the additional measures identified are integrated with the local infrastructure as opposed to imposing a series of new and often unfamiliar measures onto the existing structures.

It must be recognised that through the life of a programme, or the development of a sustainable market, measures will be required that were not identified during an initial assessment phase, or that measures that were identified are not required to the level proposed. It is imperative that a flexible approach is taken to allow capacity building measures to adapt to the reality in the field – i.e., they need to be integrated into a programme rather than viewed as a separate project.

The following is a general sequence for assessing the type of capacity building measures that may be required in a particular ministry or organisation. This summary is not intended to be all encompassing:

- Understand the issue – It is necessary to understand the role that PV can play in helping to meet rural needs. For example, it would be useful for a health authority to know that it could meet the electricity needs of rural clinics from PV, rather than diesel generation, or for a rural entrepreneur to recognise the potential market for PV and so increase his business by expanding into PV.
- Assess existing knowledge - It is important to understand how widespread the knowledge of PV is. It may be that no one has heard of the opportunities from PV or that there is misleading information in the market. It is necessary that an organisation understands what PV is, how it works and how it may help meet the organisation's objectives. Similarly entrepreneurs or potential technicians need to know how to install PV correctly or how to train the end-user.
- Identify training needs – Following on from an evaluation of the existing knowledge and skill base, the next step is to identify where capacity needs to be built and knowledge increased within a given ministry or organisation.
- Define training measures – Once training needs have been identified, it is necessary to define what type of training is required. Varying training methods will suit different organisations. In some cases awareness raising through information packages will be sufficient. In other cases, seminars, workshops and manuals will be needed or an in-depth course required.
- Implementing capacity building activities – It is important to establish how these training needs be met. Are there training organisations or experts in-country that could fulfil the requirements? It may be possible to adapt exiting resources or international experience may be required to provide some of the training.

Although this sequence does not cover all the issues it gives an indication of the tasks to be undertaken prior to carrying out capacity building exercises. The capacity building measures identified in the following sections assume that there is no prior knowledge of PV.

# 3 GOVERNMENT BODIES

## 3.1 Introduction

In many countries there are government ministries, departments or authorities whose role it is to set policy which will affect the development of the renewable energy sector, particularly PV. This section looks at the typical government ministries (or departments) and how they can directly and indirectly affect the development of the PV sector and foster the creation of a sustainable market. Suggestions are provided on capacity building activities that can be implemented in order to achieve this goal.

Rural electrification and renewable energy sources as part of the development process should be viewed by the government from a cross-sectoral perspective rather than solely from an energy perspective. Therefore it is important that those agencies addressing the rural population should have, or have access to, renewable energy and PV technology expertise. Renewable energy expertise does not have to exist within *each* ministry although there should be an awareness of how renewable energy can contribute to the sector goals of the ministry. Each ministry should have easy access to PV expertise, whether it exists in another ministry or as a central resource. Although the remit of different ministries and agencies varies considerably between different countries, it is important that the capacity should be developed within the appropriate level of government. Furthermore, within some countries the responsibility for certain activities may be devolved to state or provincial level rather than being at national level.

The following sections provide a guide to the capacity required overall and the specific capacity required in various ministries.

## 3.2 Common Capacity Building Measures

There are a number of capacity building measures for PV that are common to most government ministries or public authorities, as well as specific capacity building that may be required within a particular ministry.

One of the main capacity building measures for all policy, planning and development staff in any government ministry is general awareness raising. Staff will require familiarising on the various applications of PV systems and where they can help in meeting sectoral priorities. For instance, this could be meeting the energy requirements for rural schools, health clinics, vaccine refrigeration, water pumping, agricultural needs, or energy for productive uses and business opportunities, as well as meeting the demand for household electricity.

The capacity building measures must also include raising awareness of the skills required for PV systems to be delivered through the private sector, the quantity and cost of maintenance required when in the field, and the limitations of PV when compared to other electricity sources such as the grid.

It is important that life cycle costs of a proposed project are also taken into account, as PV is often a cheaper option than diesel when costed on this basis. In many countries there is cost sharing between the national government, the provincial government and the community for any infrastructure project. Often the national government bears the investment costs, but not the operation costs and therefore their prime criteria is the initial investment cost. All parties should be aware of life cycle costing techniques which evaluate the project cost over its lifetime, rather than placing an undue emphasis on capital costs. This enables an accurate analysis of the real costs of a project to be undertaken and allows an informed decision to be made on the least cost option for energy supply.

Co-ordination should be encouraged between ministries with responsibility for health, education, telecommunications, agriculture and other ministries with a role in the provision of rural infrastructure. Synergies can often be found between ministries and any knowledge shared and programmes co-ordinated.

### *3.2.1 Energy Technology Expertise*

Although not a 'sector' in itself, provision of energy is an important element of many government activities, from providing electricity to health clinics to facilitate better services, to providing electricity in schools for lighting and access to modern ICTs. It is therefore important that each ministry active in rural development has access to energy technology expertise. This expertise need not be developed in each ministry but can be in any one ministry, in a number of ministries or as an independent agency. The key is that the expertise is accessible to all relevant ministries and is utilised.

The following skills, knowledge and expertise should be accessible to all government departments:

- Understanding of the role of energy across various sectors, particularly health, education and water provision.
- Understanding of the value of electricity services to rural populations, its role in communities and for income generating activities.
- Ability to carry out a survey of the current energy use of different facilities, businesses and households not connected to the grid and to determine the amount they currently spend on energy.
- Life cycle cost analysis of PV compared with grid extension and other renewable energy technologies.
- Socio-economic and environmental impact assessments of PV and other competing technologies.

- Comprehensive knowledge of the costs associated with PV and the various forms of financing available. This should include knowledge of import tariffs and duties on imported products and any in-country taxes.
- Understanding of the different modes for the deployment of PV in rural areas.
- Information on any PV programmes carried out in the country and knowledge of the local capacity in PV – from PV suppliers, rural enterprises, financing organisations and NGOs. Access to lessons learned from case studies of PV programmes particularly locally, but also abroad.
- Capacity to undertake promotional and educational activities to promote PV technology to the community. This could include development of information leaflets and/or booklets, local workshops and demonstrations.
- Knowledge of PV technology and associated components, how to design a system and its installation and maintenance requirements. Awareness of the life expectancy of the PV system components and the need for safe disposal and recycling.
- Understanding of the importance of the quality of PV system components, installation and after sales service.

This capacity could be developed through specific training activities, seminars and workshops for key staff. The training providers may be in-country specialists or international consultants. These capacity building measures will require financial assistance from central government and/or donor organisations.

### *3.2.2 Provision of Training for Government Ministries*

Building capacity within government ministries will require the knowledge, skills and expertise that already exist within the PV industry. This knowledge may be available locally if a well developed PV sector already exists locally. However, training is likely to be provided by mix of international consultants and local industry experts. It must be emphasised that all advice must be independent of any one company or product.

This knowledge, skills and expertise can be provided to government ministries through:

- Seminars aimed at raising the awareness of ministry staff about energy provision, PV and its applications.
- General information booklets and manuals.
- Specific workshops that relate to particular requirements outlined above.

In the following Section, capacity building measures which should be implemented for the various government ministries are identified.

## 3.3 Capacity Building for Government Ministries

### *3.3.1 Energy and Electricity*

In general, the role of the ministry with responsibility for energy is to set policy on the distribution of energy and to monitor and control energy pricing. This control of energy pricing may also involve the implementation of policies of cross-subsidisation in order to fix electricity prices or to generate funds for grid extension for rural electrification. Another aspect of an energy ministry is often to control the country's energy resources, both the available in-country resources and the import of energy resources.

It is common for this ministry to have overall responsibility for rural electrification and this has traditionally been pursued through extending the electricity distribution network.

Increasing costs associated with continued grid extension, coupled with low population density and low energy consumption in rural areas have made grid extension less viable

from both an economic, as well as an environmental point of view. However, because of this background, the expertise within ministries responsible for energy is frequently oriented towards grid extension for rural electrification, rather than through off-grid, renewable energy technologies. This perspective often results in a lack of understanding of the technical, economic and social issues that are specific to the use of renewable energy technologies for rural electrification.

There is increasing private sector participation in the electricity sector in many countries. Reforms of power sector utilities and privatisation under various guises is a major restructuring trend. In the restructuring (privatisation) of the power sector, it is important for the government to consider how areas without access to energy services should be addressed. Rural electrification requires high level planning. The energy requirements of the rural population should be identified and governments should develop a strategy outlining suitable technologies to meet the electricity needs of the rural population. Programmes can be seriously delayed or even been cancelled due to a lack of clarity and commitment to rural electrification by utilities and government ministries. It is important that a coherent rural electrification strategy is put in place which addresses both on-grid and off-grid rural electrification. There should be a published policy that clarifies the mandates, goals, interventions and promotions of government and the scope of the private sector.

The ministry of energy policy on PV and renewable energy should promote fair competition for the installation of PV through ensuring a 'level playing field' for PV and other competing technologies. This is particularly important when fossil fuels receive direct or indirect subsidies for social reasons. PV and other technologies should also benefit from financial support of pilot projects and awareness raising. An open and competitive market should also be encouraged to ensure costs are driven down, although quality standards with regard to system and component, installation and after sales services must not be compromised.

In addition to those measures identified in Section 3.2. specific capacity building measures for the ministry of energy should include:

- Development of an active renewable energy policy to encourage the use of off-grid renewable energy systems, where cost effective.
- Understanding the energy implications of other government strategies, particularly those of rural development, agriculture, health, water and education.
- Training in the use of life cycle cost analysis for rural electrification to enable comparison between PV, other renewable energy technologies, diesel and grid extension.
- Knowledge of the extent of current electrical grid system and how to determine the number of villages and people who are not currently connected to the grid.
- Training on how to develop a policy on rural electrification, defining areas that will be supplied by grid extension and those to be electrified by off-grid or mini-grid systems.
- How to monitor and evaluate performance of systems after they are installed.
- Encouraging promotional and educational activities to promote PV technology to the community. These could include development of information leaflets and/or booklets, local workshops and demonstrations.

The above activities will help increase awareness about PV technologies as well as build local knowledge of the energy needs of rural communities and the potential market for PV technology. The capacity building measures could be carried out by national or international organisations but, once the skills exist in the ministry, it will be possible for internal ongoing training.

### 3.3.2 Development

Many countries have a ministry whose role is to oversee the planning of national strategic development initiatives in order to facilitate economic growth, efficiency, stability, eradication of poverty and enhancement of overall development. This ministry may have a greater appreciation of cross-sectoral linkages than other ministries as its role implies that national socio-economic development requirements are fully identified across all relevant sectors. Appropriate capacity building measures can help the ministry ensure the needs and priorities of the relevant sectors are well balanced and integrated at all levels.

In addition to the capacity building measures in Section 3.2, the following measures should also be addressed:

- Raising awareness of the role of energy provision can play in meeting development needs and in helping meet sector goals in the ministries of health, education and water amongst others.

The ministry could also be instrumental in providing co-ordination between different sectors of government and ensuring that national, regional and sector policies on energy provision converge. Further activities could be the provision of information and support services (statistics, data processing, etc.) to executing agencies in both the public and private sectors to facilitate realistic planning, rational decision making and effective evaluation.

### 3.3.3 Water and Natural Resources

In general, the role of the ministry of water is to set policy to provide clean water as a direct means of improving peoples' lives and health as well as an essential requirement for agricultural, commercial and industrial development. The availability of clean drinking water is a basic human need and in many countries the government will be responsible for the investment and operation of rural water supplies for the foreseeable future.

Electricity can play an important role in meeting the energy needs of water supply, both in terms of delivery and purification. In some situations mechanised water systems, such as hand-pumps or wind-pumps, provide a number of benefits including an improved service and greater quantities of water available to the end-users. In addition it can save transport time as water can be pumped into an elevated storage tank with an electrical pump and then distributed by pipeline.

*A PV powered water pumping system for a community in Mali.*

Existing water pumping systems in remote rural areas are often powered by diesel generators, which can be expensive and difficult to maintain. PV can provide an alternative to diesel generation where it is the least cost option. The World Bank and the European Commission have implemented a number of programmes that have demonstrated the technical and economic viability of the technology.

**Example 2. Capacity Building for Local Installers**

The Regional Solar Programme (RSP) laid particular emphasis on support for the development of local know-how through built-in training programmes and by adopting an integrated Quality Control Approach (QCA). This covered training of local installers and assessment of performance 5 years after installation. The cost of this training and quality control was very low compared to the PV system cost, although this amount was specifically identified.

- Definition of the QCA: 0.14 Euro.$W_p^{-1}$ (0.72% of system cost)
- Laboratory test for the QCA: 0.25 Euro.$W_p^{-1}$ (1.3% of system cost)

By carrying out the training as well as adopting the quality approach, the RSP improved the reliability of the PV systems: 5 to 10 years after installation more than 95% of the systems were still providing water and mean time between failure averaged 6 years.

*Lessons from the Regional Solar Programme (RSP) in the Sahelian Countries*

In addition to the common capacity building activities identified in Section 3.2, the following measures can be implemented for the ministry of water:

- Awareness raising on the various applications of PV in water pumping systems and where they can help to meet current water policy objectives. Information on how PV compares to diesel generation in terms of reliability, service, capital and operating costs and maintenance requirements.
- Training in assessing different renewable energy sources and selection of PV systems, where cost effective.
- Enabling water policy to be considered in conjunction with energy/electricity policy. Subsequently producing a policy on water supply that identifies whether supply will be from a central system or from alternative stand alone sources and the corresponding power requirement.
- Awareness of the different financial schemes available for water supply such as a 'user pays' system or community ownership (e.g. see Example 3).

**Example 3. Community Ownership and the "User Pays" System for Water Supply**

Between 1991 and 1997 the EC funded Regional Solar Programme (RSP) installed 626 PV water pumping systems and 644 PV community systems, for health centres and schools, in the 9 countries of the CILSS (Comité Inter-Etat de Lutte contre la Sécheresse au Sahel). Villagers were organised into village water committees that took responsibility for tasks such as:

- Daily care-taking, maintenance;
- Collection of water payments;
- Management of payments.

The villagers agreed, when they were well informed, that the price of water should be sufficient to cover operation, maintenance and renewal costs. This understanding was only possible through strong involvement of the end-users and building a sense of ownership (one way to achieve this was through a compulsory down payment before starting of works).

In-depth analysis has shown that recovery levels depend on the efficiency of the local based management organisation, rather than the ability to pay of the villagers. The villagers will be more likely to accept paying for a service and will feel more responsible for its maintenance, if they receive information and some basic training.

*Lessons from the Regional Solar Programme (RSP) in the Sahel Countries*

### 3.3.4 Public Works

In general, the role of the ministry of public works is to plan and implement infrastructure projects. This can include the provision of roads, ports, railways and buildings (e.g. hospitals and schools) although on completion of a project, operational responsibility is often handed over to the respective government ministry. Problems often arise if the ministry responsible for public works only looks at capital costs of a project and seeks to minimise these without considering operational costs which are frequently the responsibility of other ministries (and therefore different budget lines).

Therefore a number of capacity building measures are particularly important for the ministry responsible for public works. It is very important that the ministry consults with those ministries responsible for the ongoing maintenance costs of a project, so that the whole life-cycle cost are taken into account.

In addition to the those measures identified in Section 3.2, the following measures should be considered for the ministry of public works:

- Awareness raising on the various applications of PV and other renewable energy systems and how they could meet the electricity requirements of a given application.
- Ability to carry out life cycle cost comparisons of the alternative energy options available for a given application.
- Allowing consideration of PV whenever there is a power need remote from the electricity grid.

### 3.3.5 Health

In general, the role of the ministry of health is to improve the health of the population by setting policy on the provision of adequate heath services. This is generally through the provision of health clinics and suitably trained personnel who can provide these services. In rural areas, these clinics are frequently in areas without grid electricity.

*PV provides electricity for lighting in this health clinic in Africa.*

The provision of electricity can have the potential to improve the quality of service at health centres and clinics in the rural areas that tend to be far from the electricity grid. The level of impact of electricity provision is dependent on the associated services and access to water. In general electricity needs and use can be categorised into the following groups*:* lighting for emergency and in-patients; medical appliances; vaccine storage, water supply and purification; staff housing amenities, and tele-medicine and ICTs, and communication facilities.

Capacity building measures within the ministry of health should aim to raise the awareness of staff of the opportunities afforded by PV in the health sector and how it can

**Example 4. Building Long-term Capacity for Health Centres**

A grant funded government programme to electrify approximately 250 rural health facilities in Mozambique has been underway since 1997. Capacity building measures have been an important part of the project and have been focused on health centre staff, as they were to use and maintain the PV systems on a daily basis. However, the quality of the instruction given to the health centre staff was difficult to assess. There is evidence to suggest that constant re-training of the staff with regards to operation and maintenance will be important during the first two or three years in order to ensure the best possible use of the PV systems. In the case of Mozambique, it is the Ministry of Health, through its organisation at the provincial and district level, which must assume the responsibility for training and re-training of clinic staff.

*Solar Energy for Health Improvement in Mozambique*

contribute to meeting sector priorities. Activities which can be implemented, in addition to the common capacity building measures identified in Section 3.2, for the ministry of health should include:

- Awareness raising on the various applications of PV systems and other renewable energy systems and how they could meet the sectoral goals of the health sector.
- Awareness of the need for ongoing maintenance of PV systems and the need for local technicians to provide this service.
- Ability to determine the economic benefits of PV compared to kerosene other alternatives.
- Increase understanding of the services at health facilities that are dependent on access to electricity, how services could be improved with electricity and what new services may become possible.
- Identify the number of clinics that are not connected to the grid and do not have access to reliable electricity services. During this study determine the typical energy requirements and investigate the distance of the clinics to the nearest grid.
- Develop a policy on the electrification of clinics by extension of the grid or by alternative sources.

### 3.3.6 Education

The ministry responsible for education is responsible for the provision of education to the whole population, from primary schools through to training institutions and universities. The education sector has two main areas that will impact on the renewable energy sector: firstly in the provision of basic (primary and secondary) education to people in rural communities; secondly in ensuring there are sufficient skilled and competent personnel to meet the needs of the industry. The second of these issues is dealt with in Section 9.

*In South Africa, off-grid PV has been provided to schools*

PV can play an important role in improving the provision of education services to the rural areas. Better access to electricity and to information, communication and technology (ICT) can facilitate expansion of the course curricula, facilitate distance learning, extend teaching hours and promote adult education programmes, as well as encouraging teachers to remain in rural areas rather than migrating to urban areas where conditions are often better. In general, the role of electricity consists of: providing lighting for evening classes, extra-curricular activities and residences on premises and providing access to better communication, information technology and the media through television and video, telephones, fax machines and computers. In addition, community uses of schools can be encouraged: for example, provision of entertainment, meeting facilities etc. Furthermore, good quality lighting, such as that provided by compact fluorescent lamps, permits home study in the evening.

In addition to the measures identified in Section 3.2, capacity building activities that can be implemented for the ministry of education, include:

- Awareness raising on the various applications of PV systems and the improvements they can provide to education.

- Training in assessing all renewable energy sources and selection of PV systems, where cost effective.
- Awareness of the need for ongoing maintenance of PV systems and the need for local technicians to provide this service.
- Ability to determine the economic benefits of PV compared to other alternatives.
- Increased understanding of the services for education that are dependent on access to electricity, how services could be improved with electricity and what new services may become possible.
- Identify the number of schools not connected to the grid and which do not have access to reliable electricity services. During this study determine the typical energy requirements and investigate the distance of the schools to the nearest grid.
- Develop a policy on the electrification of schools by extension of the grid or by alternative sources.
- Ensuring co-operation with other departments.

### *3.3.7 Finance*

The role of the ministry of finance is normally to manage and control public finances in a prudent and sustainable manner. The ministry of finance is responsible for the regulation, formulation and monitoring of fiscal policies. The ministry is accountable for matters related to public, domestic and external credit and debt, for the budget regime and for the policy, collection and control of national and customs taxes. The ministry often has strong links with international financial and economic organisations. In addition it can be responsible for the regulation, organisation and the control of banking policy, for the registration, inspection and supervision of savings banks and control of the capital markets. In some cases the ministry of finance is also responsible for the privatisation and public accountability of assets owned, controlled or acquired by the government.

**Example 5. An Initiative in the Philippines**

The Windows III (Special Credit Facility) programme of the Development Bank of the Philippines (DBP) offers loans for renewable energy and energy efficiency measures on 'developmental' terms.

In recognition of the need for innovative financing programmes to stimulate commercial use of renewable energy resources in the Philippines, the UNDP is providing technical assistance (TA) to the DBP. This assistance will enable DBP staff to develop and strengthen their capability in identifying, formulating, appraising, generating and managing a pipeline / portfolio of renewable energy projects.

A major component of the TA is capacity building of the DBP's new and renewable energy team.

*Characterisation of the Photovoltaic Market in the Philippines: Opportunities and Requirements for Large-scale Application*

Through its policies the ministry can have a large influence on the development of the market. This could be through its taxation policies – both direct and indirect (VAT and income tax); through import duties; through tariff setting and buyback obligations and through subsidies. In addition the ministry of finance can have an impact through discussions with the banking sector to make renewable energy and energy efficiency eligible for "developmental" credit lines, which often have privileged "soft" conditions in terms of interest rates and reimbursement periods.

To ensure that the market operates on a level playing field with the energy market it is important that the ministry of finance understands the role of PV in contributing to economic growth and in meeting the development needs of the country, and in turn recognising the impact of its fiscal policies on this market. The capacity building activities needed within the ministry of finance are, in addition to the common measures (see Section 3.2) listed below:

- Awareness of the PV industry and the potential impacts of how preferential loans, taxes and import duties and fair regulation policies.
- Awareness of life cycle cost analysis of PV for rural electrification compared with grid extension and diesel generation to ensure that, when allocating budgets, all options are considered according to their relative merits.
- Assessment of the distorting role of subsidies for competing technologies to PV, such as kerosene, diesel, grid extensions etc.
- Assessment of the role of taxation and import subsidies for competing technologies to PV, such as kerosene, diesel, grid extensions etc.

### *3.3.8 Trade and Industry*

Renewable energy products frequently have to compete against subsidised electricity or other fuels such as kerosene or diesel. These subsidies can act as a disincentive to the use of renewable energy technologies. Whilst it is often not politically possible to remove these subsidies for social reasons it is important that any negative effects on renewable energy technologies are identified and mitigated. Some countries have in fact introduced policies relating to the prevention of anti-competitive practices within industry and have departments or authorities, whose role is to ensure that individuals, products or companies are not disadvantaged by unfair pricing or policies. It is important that staff within the ministry understand the technologies and are made aware of schemes or policies that may penalise the use of renewable energy technologies.

*PV laminator at SolarLab in Vietnam*

Power sector reform and privatisation is increasingly common. Implicit within the privatisation process is the need for fair competition between the incumbent utilities and new market entrants, and between different energy sources to ensure fair energy pricing. Therefore there is a need for a supportive, transparent regulatory framework. Often the expertise required for a regulatory body is not available locally and will need to be developed.

The ministry for trade and industry may also provide support for the set up of new companies. This is dealt with in the section for Small and Medium Enterprises below.

In addition to those measures outlined in Section 3.2, capacity building measures for the ministry for trade and industry should include:

- Identification of unfair practices and awareness of barriers to new market entrants, particularly in PV.
- Training staff on regulatory skills and frameworks to set up an independent regulatory body.
- Establishing a national quality scheme comprising standards, quality control and a national supervisory authority.

### 3.3.9 Small Businesses

The sustainable implementation of PV technology throughout the rural areas of developing countries will require the successful operation of renewable energy businesses. Much of the business activity will be through small and medium enterprises (SMEs) making commercial sales or through energy service companies (ESCOs). In either situation the operators of those companies must have the necessary business skills to survive in what is a very difficult market environment.

*A small shop in Lhasa, Tibet selling Solar Home Systems.*

One of the factors that has slowed the growth in PV implementation is the fact that many of the companies that have entered the industry are not commercially viable or are on the borderline of viability. One of the main impacts of this is customers frequently have little or no after sales support.

**Example 6. Improving the Commercial Capabilities of Small PV Companies**

A major impact of the PV component of the China Renewable Energy Development Project was the significant improvement of the commercial capabilities of local PV companies. Most of the companies were small-scale businesses lacking commercial capabilities, which made it very difficult for them to secure loans from commercial banks. Most of the PV companies also lacked the necessary skills for business plan development.

The project offered tailored business training workshops to all the companies and provided individual business tutor services including advice on financing, accounting and business development plans to companies that were facing specific problems.

As a result, some companies have been offered bank loans from local commercial banks and many companies have seen their Solar Home System (SHS) business grow on a yearly basis.

*GEF / World Bank Assisted China Renewable Energy Development Project – PV Component*

In some countries there is an office of small business, frequently a department within the ministry of trade and industry, which actively supports the activities of small businesses. The remit of such an office is generally to provide support SMEs, often in the form of seminars, information booklets and training courses to improve the business skills of SMEs. Support for the creation of new businesses and companies in urban and rural areas has to be recognised as an initiative that leads to sustainable sources of income within the country.

In addition to offering information services to potential businesses entering the PV industry the office for small business can also offer information to potential rural businesses to on the opportunities to be gained from the provision of electricity and how PV could be used to supply that electricity.

These offices need to be made aware of the PV industry and its requirements so that they can actively support the development of relevant skills. A survey of the PV industry (if it exists) should be carried out regarding the current and future business training requirements.

In addition to the common capacity building measures (see Section 3.2) capacity building activities that could be implemented for the office of small business, include:

- Awareness raising on the various applications of PV systems and the business opportunities they offer and the skills that these businesses require.
- Awareness raising about what international resources are available to support new PV businesses in developing countries and support in assisting the establishment of joint ventures with international suppliers.

- Training on how to access finance, business plan development and business skills.

The office of small business can play a key role as a supporter of start-up companies. However it is important that any strategy considers the long-term perspective so that the companies are sustainable and any subsidies or training received is reduced as the companies become established.

The initial training may be from national or international experts in seminars and workshops and through manuals. Once the capacity is established it will be possible for the office for small business to offer relevant support to entrepreneurs and businesses.

### 3.3.10 Agriculture

The ministry responsible for agriculture generally has a mandate to support and promote the efficient utilisation of resources and the production of crops, livestock and fisheries so as to ensure high quality and quantity of agricultural produce and products for domestic consumption and export. PV can meet some of the electricity needs for agriculture, in particular the pumping for irrigation, drainage and stock watering.

*PV for irrigation in Baguineda , Mali*

**Example 7. Capacity Building for PV Water Pumps**

In the PV Pumping programme implemented by GTZ in co-operation with national and water authorities in Argentina, Brazil, Indonesia, Jordan, the Philippines, Tunisia and Zimbabwe, the transfer of expertise to national counterparts and of experience to industry was crucial for the success of the programme.

Capacity building activities included:

- Adaptation of country-specific planning procedures;
- Promotion of technology and knowledge transfer by involving national companies in the supply and maintenance process;
- Training of water utilities' technical staff, planners and decision – makers;
- Dissemination of project results and public relations work.

*Drinking Water Supply with Photovoltaic Water Pumps*

The capacity building required in the agricultural sector is similar to that required in the water sector – an understanding of the role that PV could play in improving agriculture and how it compares to competing technologies, such as diesel generation.

### 3.3.11 Environment

The main function of the ministry responsible for the environment is to promote, ensure and sustain good environmental practices and management. Environmental policy objectives are geared towards ensuring continued economic, social and cultural progress and the enhancement of the quality of life of the population, through environmentally sound and sustainable development.

Ministries can carry this out with varying strategies, including pollution control and prevention, conservation of resources and the integration of environmental factors into development planning. The ministry often also promotes environmental education and awareness; controls standards and licensing; provides standards for environmental impact assessments; compiles environmental data, and co-ordinates the implementation of various national and international environmental conventions. In these roles the ministry advises both the government and the private sector.

The use of energy from traditional sources (biomass and kerosene) and electricity generation from fossil fuels has a large impact on the general environment through its $CO_2$ and $SO_x$ emissions and on the local environment and the health of the population. Therefore any clean alternative that can provide modern energy services is an advantage.

*Firewood collection in Indonesia*

The ministry of the environment can play an important role in providing information campaigns and awareness on environmental issues and the role of renewable energy to the general public. The ministry can also help the private sector and other government ministries to carry out integrated decision making for development projects. To help them fulfil this role, capacity building for the ministry of the environment staff should include:

- Training in the role that PV can play in development and in reducing emissions. This should include how PV could be included within the Clean Development Mechanism and the environmental differences between competing technologies.
- Training to carry out environmental impact assessments for rural electrification projects.
- Training in environmental analysis of PV projects and competing technologies.
- Training in integrated decision-making to incorporate environmental issues.

## 4 UTILITY SECTOR

In general, a public utility or service company administers the electricity grid within a country and is responsible for electricity distribution and sometimes generation and transmission of electricity. This is changing and deregulation and privatisation of the electricity sector is occurring in many countries. However, electricity and the supply of energy are still generally viewed by the consumers as a “community service” and the rural electrification policies of the government are often implemented by the utilities.

*Electricity grid extension to a school*

The utilities responsible for rural electrification should consider adopting a strategy that would bring power to the most people at the least cost. The least cost solution could be through grid extension or mini-grids but must also address how power is to be brought to those who are not going to be connected to the grid in the foreseeable future. Therefore it is important to have a detailed knowledge of the status of electrification in the country and that any rural electrification strategies are made available. This enables organisations interested in providing electricity to rural areas to do so in the knowledge that there are no plans to extend the grid to that area in the near future.

In order for the deployment of PV technologies to be sustainable in the long term it is critical that off-grid rural electrification programmes are integrated and co-ordinated with existing plans for grid extension (including isolated grid systems). This should eliminate potential conflicts developing between the electrification strategies and also help in managing the

expectations of end-users who, given the choice, tend to prefer 'grid electricity' to 'off-grid electricity'.

As part of the planning process a thorough cost analysis of all energy supply options should be undertaken. In spite of the high capital costs of PV and other renewable energy technologies, they are often competitive with grid extension in rural, sparsely populated areas if costed on a life cycle basis, e.g. over 20 years, and if subsidies for other forms of fuel are taken into account. A life cycle cost analysis should also consider issues relating to sustainability, as well as the provision of infrastructure services (health, education, communications, etc.) which have high added value. This life cycle cost analysis should include hidden subsidies for grid extension or diesel generators as well as operation and maintenance costs in order to provide a fair basis for comparison.

It is important that new technologies, like PV, are accepted as a potential source for meeting rural energy needs. However, in order for this to happen, the technology must be understood and accepted by the utilities. Often engineers and managers from the utilities are asked to advise on or recommend new projects. If the utilities do not understand that PV is a viable technology that can meet rural energy needs, then the utilities can potentially undermine any initiative that might be raised to introduce PV based systems into rural areas. Even when the utility has no long term plans to extend the grid to that area, their lack of support can hinder the introduction of PV projects.

Capacity building activities that can be implemented for the utility sector, include:

- Awareness raising through seminars on the various applications of PV systems and how PV can be used as an alternative to grid extension. This may lead to an unbiased outlook within the utility when designing and implementing rural electrification projects.
- Technical training courses for engineers and technicians so they can undertake design and maintenance of systems and therefore appreciate the potential and limitations of PV.
- Encourage staff to undertake true life cycle costing of all the alternatives when planning the supply of electricity to rural communities.
- Ensuring staff understand the energy expenditure of rural people so that comparisons are made with those costs, rather than with the cost of grid electricity in another location.
- Training in socio-economic and environmental impact assessments.
- Encourage the investigation by the utility into supplying PV systems to remote communities either as a commercial business section of the utility, via a 'fee for service' structure or via a whole new business structure. If this approach was adopted, then the staff involved will require business and possibly sales and marketing training.
- Awareness of where energy provision fits in with overall government strategy on rural development and the sectoral priorities in health, education, water and agriculture.

This training might be carried out by local or international consultants on the technical issues of off-grid rural electrification and by the government on cross-sectoral polices of development and poverty alleviation.

## 5 FINANCIAL COMMUNITY

The financial community has a very important role in helping the introduction of new technology into a country, and particularly into the rural areas within a developing country. All levels of the financial community, from large banks to small rural credit programmes, should be aware of PV and its applications and in particular how they can be supportive of its use by providing:

- credit facilities for end-users to buy the systems.

- savings facilities for rural populations.
- finance through business loans for new businesses (e.g. suppliers and installers) to enter the industry.
- finance for entrepreneurs to introduce new rural electrification projects based on PV technology.

The specific capacity building measures are dependent on the type of financial institutions that can provide the finance and the customer who requires this finance.

## 5.1 Finance for End-users

Many studies over the last few years have found that many rural households spend up to 20 USD per month on energy. This money is spent on dry cell batteries for portable radios and stereos, kerosene for lighting and/or recharging second hand car batteries. In spite of this relatively high expenditure on energy, the overwhelming majority of rural households do not have the available cash to pay for the up-front capital costs of a PV system in a lump sum. However, they are frequently able to afford the ongoing operation and maintenance costs, (some 5 USD to 10 USD per month for a SHS) as well as making contribution to the capital costs if these are spread over a long enough period – perhaps 10 years.

Unfortunately the larger banks usually do not usually have the local knowledge or facilities to be involved in micro-credit - lending money of less than 1 000 USD for periods of up to 10 years. The smaller regional banks or rural co-operatives that are involved in lending money to the rural communities are in a position to lend to this market and in some countries these are very well established. However these entities tend to lend money for agricultural or cottage industries, both of which are directly income generating. Lending to individuals for the purpose of making a down-payment on a PV system is perceived as high risk, both through uncertainty as to the likelihood of debt recovery and a lack of confidence in the technology. Furthermore, the credit structures tend to very rigid and loans are only made to those with sufficient collateral or with a previous good credit history.

It is important to establish whether these agricultural banks or rural co-operative lenders exist in the country. If not, identifying banks and co-operatives that would be willing and able to work in this sector is important. Once potential financial institutions have been identified then the following capacity building measures should be initiated:

- Education of the financial institutions about the market, or potential market, that exists for lending money for the purchase of PV systems. This education will include raising awareness of how PV systems can improve the quality of life for the end-users.
- Training in the financial institutions on the opportunities for providing savings facilities for the rural population, using local or international examples.
- Providing case studies of successful similar operations in other countries.
- An understanding of the country's energy policy and the opportunities for PV.
- Seminars on the life cycle costs of off-grid power supply systems, including the infrastructure required for proper operation and maintenance.
- Information on risk mitigation - the structure of rural loans and the influence of the quality of the PV system on loan repayments.
- Information on the various implementation models for PV in rural areas.
- Training staff on how to best structure the repayments based on existing energy expenditure and income.
- Encouraging the financial institutions to make loans for PV systems a specific product they have available for customers.

- Identifying where PV loans can be tied with other lending products they already offer their rural based customers.
- Understanding how a PV system can offset some of the end-users' costs, such as reduced kerosene and battery purchasing. It is important to be aware when undertaking the financial analysis and determining repayment levels that not all the use of kerosene, candles or dry cell batteries will be displaced by a PV system.

The above activities can be achieved through targeted seminars, workshops and training. Financial institutions are generally conservative and only lend money when the perceived risk is minimal and/or they have a product that they can repossess for re-sale if the lender defaults on the loan. Discussions need to be held with the financial institutions regarding the use of the PV module as collateral against a loan. The re-sale value of a PV module to a lender is likely to be less than it is to an end-user or company so the lender may require additional collateral or an arrangement with a PV dealer/supplier may be of benefit.

Successful capacity building in the financial sector may require working closely with industry so that the risk to the financial institutions is minimised. One possible way of achieving this would be to convince the PV businesses to buy the PV module back in the event of a loan default.

### 5.2 Finance for SMEs

In general, banks will lend money to businesses based on the ability of the business to make loan repayments and/or the business has assets that will be used as collateral. SMEs entering the PV market will usually not have sufficient start-up capital or assets to be used as collateral and therefore they will need to present a realistic business plan to show how the business will meet its loan commitments. This area of capacity building for SMEs is covered in Section 5.2.

An SME will find it easier when approaching financial institutions if the institutions already have an understanding of the PV market. Otherwise the financial institutions will perceive it as a high risk industry and be reluctant to support PV businesses.

Capacity building activities that can be implemented for financial institutions and their staff include:

- Educating the banks on the PV industry, in particular the market PV businesses serve, how these businesses operate and the likely capital demands and cash flows they will generate.
- Demonstrating profitable PV business models from other countries with similar financial environments.
- Information on programmes of off-grid power supply systems implemented by the national government and/or international donors.

These activities can be undertaken through workshops, seminars, targeted training courses and through general information sheets. Training can be carried out by government bodies (e.g. office of small business) or independent consultancies and could, in the first instance, be financed by national government.

### 5.3 Finance for Large Projects

Grid extension and new power station projects are generally well understood by the banks and other large financial institutions. Money is loaned for this type of project based on a sound project plan where the risks are known and often the borrower is a well established utility or project developer. However large PV projects such as 15 000 Solar Home Systems' or a large scale solar water pumping programme are less common and the projects are seen

as high risk by the financial institutions. To overcome this perceived problem the following capacity building activities can be undertaken:

- Educating the institutions on potential PV projects and comparing these to other energy projects, showing how they can be cost effective, viable projects.
- Information on risk mitigation and loan structures relevant to large PV projects.
- Training staff on how to assess proposals for PV projects.

The capacity building should be provided by government bodies or independent consultancies and could, in the first instance, be financed by the national government.

## 6 NON GOVERNMENTAL ORGANISATIONS

Non Government Organisations (NGOs) are often very active on a local level in the villages and communities. They often work closely with them and are often very knowledgeable of the real needs of the community. NGOs can also play a very important role on the implementation and dissemination of new technologies like renewable energy.

NGOs can represent the views of the communities to potential service providers as well as disseminating information on the benefits of renewable energy systems to these communities. In addition, NGOs can also support, co-ordinate or help fund the installation of renewable energy technologies, e.g. water pumps and vaccine refrigeration, if this meets the needs of the local communities.

In cases where the NGO is a local co-operative, the co-operative can act as a rural financing body, assessing micro-credit loans and taking responsibility for payment collection. The co-operative deals directly with the financing institution. The capacity building measures for this are dealt with in Section 5.

Capacity building activities that can be implemented for NGO staff include:

- Training on how to identify the energy needs of the local population, whether it is at the community or household level.
- Awareness raising on the various applications of PV systems.
- Understanding how PV can be used to help with income generation activities within a community.
- Technical training courses for engineers and technicians who might work for NGOs, so they can design and plan projects for the communities in which they are working.
- Understanding the operation and maintenance requirements for PV and training end-users on the limitations of their systems and basic maintenance requirements.
- Providing material and training NGO staff to enable them to give seminars in the communities on the potential of PV in meeting some of the community needs.

## 7 SERVICE DELIVERY CHAIN

### 7.1 Actors in the Service Delivery Chain

One of the main reasons that many previous PV rural electrification programmes have failed is because of the lack of a sustainable service delivery chain. Previous programmes have had a tendency to supply only the hardware with no means of ensuring adequate provision for system maintenance, supply of spare components etc. The continued maintenance of PV systems must be assured. This does not necessarily mean an open-ended commitment from bilateral and multilateral agencies, but help to ensure that an infrastructure or service delivery chain is in place to continue system maintenance.

Very often aid is made available to support the manufacturers of a donor country, which may not be able to provide the most suitable equipment for the application. Furthermore, many rural electrification programmes have tended to be small and to consist of only a few thousand systems. It is doubtful whether this level of penetration is sufficient to maintain a local industry[2].

The creation of a service delivery chain is a key feature in ensuring that a rural electrification programme is sustainable in the long-term. It can be viewed as an investment in infrastructure development and, as such, could be stimulated through government assistance – particularly through government investment in PV for healthcare, education, information, communication and technology (ICT) etc, which could then be serviced by the private sector. Such an approach would help to create a critical mass that would support a local infrastructure thereby facilitating the deployment of PV into rural homes as well. It should also be emphasised that the private sector has a role in supporting the local infrastructure and providing support for capacity building activities.

For PV systems to be deployed the following roles need to be established:

- Manufacturers/assemblers of equipment and/or companies importing the required products.
- Engineers/technicians who can design systems based on equipment that is easy to obtain locally and which meet international or national standards.
- Sales staff that can explain the systems to potential end-users.
- Technicians who can install and maintain systems.
- Entrepreneurs that can create new businesses to service this market and who have the skills to ensure the business is viable and sustainable.

How this service delivery chain evolves can be varied and may result in a number of different structures, but it is critical that the majority of sales staff and technicians are based close to the villages where the end-user (the market) is located. These in-field sales people and technicians could be operating their own businesses, sourcing material from a central supplier in the main town and thereby acting as agents. Alternatively, they could be employed by a larger company which has staff located in the field. There is a significant problem in the latter structure: most large international PV companies are interested in selling modules / systems, but are seldom interested in taking direct responsibility for the installation, let alone for the operation over a long time period.

Various deployment models can and do work but to succeed there must be a real market, that is, a sufficient number of potential end-users with the financial capability to buy systems, for cash or on credit.

The following descriptions are broken down according to function. These functions could be carried out by the same organisation or by two or more organisations.

**Manufacturers/assemblers of equipment or companies importing products.**

The PV market is a global one and many PV components are manufactured in the IEA member countries. In 2001, 319 MWp of PV were manufactured in the IEA member countries[3], representing nearly 85 % of global production. It is very unlikely that manufacturing facilities will be established in every country, with regional production being the norm. However, there is considerable scope for local manufacture and assembly of components such as charge controllers, batteries, lamps and cables. Therefore capacity

[2] Data from Solar Energy Company (SEC) in Kiribati

[3] Trends in Photovoltaic Applications in selected IEA countries between 1992 and 2001, Report IEA-PVPS T1-11:2002.

building is required within the local industry to ensure that it is capable of assembly and manufacture of components to a suitable quality.

PV projects and programmes can have considerable impact on local markets and suppliers, and it must be realised that if designed for the benefit of any particular supplier, the impacts can be devastating on existing dealers or distributors. For this reason, any funded PV project or programme must ensure one supplier is not favoured over another. International suppliers must demonstrate a long term commitment to a market.

**Example 8. A Long Term Commitment**

In order to discourage the use of bilateral and multi-lateral aid money to support donor industry, a PV manufacturer should demonstrate a long term commitment to a market before being awarded major supply contracts. This is also vital to facilitate access to replacement components. A recent programme in South Africa to electrify 1 000 schools with PV systems saw a large order placed with a manufacturer in October 1999: one of the conditions of the procurement contract was that the company had local representation. The company eventually opened a local office in September 2000. The programme ended in March 2002 and company closed down their local offices in May 2002. The availability of spare parts is now in question for the whole programme.

### Sales and installers

A sales network is required for the supply of high quality systems at the point of demand, i.e., with outlets in the rural areas rather only in a provincial capital. Suppliers can import systems or assemble PV modules locally and source local components, and then establish their own sales network or provide systems to independent sales outlets, markets, installers and rural businesses.

Consumer organisations also have a role to play in advising customers and raising awareness the quality and price of PV systems and components in the market as well as on energy efficient appliances. They can also provide information on the possibilities of PV purchasing and leasing.

The installation of the systems can be carried out by the supplier, by subcontracted installers or by energy service companies. Training is required to ensure that the installation is to a high standard; systems not installed correctly are likely to operate unsatisfactorily, leading to dissatisfied end-users, a lack of confidence and reduced demand for future systems. The installers should also be in a position to be able to train the end-users on the use as well a ‘front-line operation and maintenance of their system if appropriate.

### After-sales service

Although PV systems have relatively low maintenance requirements, they are not maintenance free. Accessible after-sales service is important to the success of the deployment of PV. After sales service includes regular maintenance, troubleshooting as well as easy access to spare parts. The density of systems in an area is likely to influence the provision of services in that area. However it is very important that technicians are available within a short period of time in order to repair faulty systems quickly.

The provision of after-sales service can be carried out by a number of organisations including the supplier, local electricians or other rural businesses. In rural markets, local organisations are generally best equipped to install, service and collect payments. Community organisations, NGOs and locally based private companies know the local people and understand local traditions, customs and constraints and can react to problems and enquiries much quicker. In each case the organisation will need some training to understand the importance of after-sales service and how to ensure it is undertaken efficiently and cost effectively.

Spare parts must be available at reasonable costs and relatively quickly. PV equipment that needs to be available includes modules, batteries, wiring, regulators and lights. These are best kept by the service technicians as well as being stocked by local dealers and businesses.

To increase revenues for the local technicians it may be possible to combine service contracts for PV equipment with non-energy equipment and services, for example with community clean water supply and telecommunications. The number of technicians required in an area will depend on the number of systems, their accessibility and the quality of the installation.

Another important element of the service infrastructure is the provision of financial support and the collection of payments for the system. Training is needed so that the framework ensures ease of payment for the end-user, and minimum costs for the credit agency.

**Entrepreneurs**

There are opportunities for entrepreneurs in all aspects of the PV service delivery chain. There is the possibility to create new businesses to service this market or to expand from an existing core business already based in rural areas, for example agricultural equipment.

To ensure economic viability sufficient revenues are required at every level of the infrastructure to cover costs and profit/reinvestment needs, particularly since there is often a considerable time between purchase and sales. Interest and stock keeping costs must also be covered. In addition marketing costs, high import duties, VAT and other costs are incurred, resulting in considerable differences between the factory outlet and consumer price.

## 7.2 Quality Assurance for the PV Systems and Installers.

The quality assurance recommendations for PV systems, installers and companies are included in a separate document: *The Role of Quality Management, Hardware Quality and Accredited Training in PV Programmes in Developing Countries* also published by Task 9 and available from the IEA-PVPS website (www.iea-pvps.org).

## 7.3 Capacity Building in the Service Delivery Chain

To ensure the sustainability of the PV market the capacity building activities that are required for all areas of the service delivery chain include:

- Awareness raising for potential businesses, technicians and all potential staff about PV technology and how the industry is structured.
- Awareness raising of the business opportunities available within the PV industry.

Once awareness has been raised and people are interested in being involved in the industry, then training is the key capacity building requirement. Training is required in all the following areas:

- Manufacturing or assembly of suitable products if relevant.
- Sourcing the key components and establishing supply contracts.
- Quality assurance.
- Managing supply stores and how to transport products within the country.
- How to sell and provide customer service.
- How to operate a successful business, develop business plans and understand the financial aspects of operating a business, e.g. cash flows.

- How to access finance.
- How to operate an energy service company (ESCO) and raise finance to supply PV systems on a 'fee for service' basis.
- How to design PV systems.
- How to train end-users.
- Introducing continued internal training within the business.
- Installation and maintenance of systems.

The first five items will have similarities with many other existing industries within the country. Therefore this type of training may already be available in existing training schools or business schools and will only require small changes to adapt to the PV industry.

ESCO training will also require more specialised courses on all aspects of this type of business.

The technical training might not be available locally and therefore a structure will need to be developed to offer this training. Ideally this would be through the addition of courses in the existing technical training schools.

The critical issue with training is that it must be ongoing. One-off training does not lead to a viable sustainable industry. The government could provide initial training, either through an office for small business or ministry of education. However once a training infrastructure is established ongoing training should be paid for by the industry.

**Example 9. The Importance of Training Local Technicians**

In a pilot PV project in Zimbabwe it was found that the technicians were not installing PV to a high quality – the technicians were not careful when installing the PV systems and were not using appropriate tools. The wiring work was of poor quality, they often damaged the roof and wall and did not set the azimuth or angle for the PV module correctly. Therefore a training facility for local engineers and technicians was established to upgrade the level of maintenance and installation.

*JICA PV Project – Zimbabwe case study*

Another capacity building activity that can lead to a viable industry within a country (or region) is the development of an industry association. This association can be instrumental in delivering the capacity building activities in all sectors as well as providing a co-ordinated lobbying group representing the broader interests of the industry.

## 8 END-USERS

In order for a PV implementation programme to be sustainable in the long term, it is important that the technology is seen to be of benefit by the end-users – it must meet their needs. It is important that people are made aware of the benefits that can accrue from the provision of electricity services. These benefits relate not only to provision of domestic lighting and entertainment, but also to vaccine refrigeration and lighting provision in health clinics, provision of modern information and communications technology and access to improved education provision, as well as possibilities for income generating purposes.

*PV training for engineers in Sudan*

It is also important to appreciate that the majority of users would prefer to be connected to the grid and have power readily available like the urban population. All awareness raising activities must take this factor into account.

In an increasing number of countries there is an increasing emphasis on decentralisation , with ownership of aspects of rural infrastructure being gradually transferred to the equivalent of a village municipality. This is already the case for drinking water in rural India where the village councils (Panchayats) are free to set the water tariffs. In the rural electrification programme in Morocco, the "Communes" have to decide whether the villages and families on their territory opt for grid extension (which may imply waiting for a long time), or PV which implies getting a limited service now, and maybe forfeiting the grid altogether. The end-users in both examples have greater decision making power in their development priorities.

The capacity building activities that are required involve:

- General awareness raising on the role that electricity can play in meeting rural needs and introduction to PV.
- Familiarising potential end-users on how PV systems can meet their requirements for lighting and small appliances. The education must include explaining the limitations of PV systems in comparison to the grid. An honest appraisal of when, or if, the grid will ever reach their village should be made and if not, the community informed.
- Realistic calculation of current energy expenditure and how this will change with the introduction of PV.
- Increased awareness of the importance of high quality PV products and installation and maintenance. Education on the existence of any quality certifications to ensure that the end-user is less likely to be disappointed and to be a more informed customer.
- Educating the end-users about energy management and energy efficient appliances.
- Educating end-users about the ongoing costs associated with a PV system. It is important for them to realise that, though the energy from the sun is free, there are ongoing costs, such as the replacement of batteries and other components.
- Training end-users on the operation of their systems and what maintenance they can undertake to ensure the system continues to operate satisfactorily. This will include such things as topping up the batteries with water, replacing fuses, ensuring electrical connections are still tight.
- Clear definitions of the ownership of the system and the responsibilities for the system and the different components, especially in hire purchase/leasing agreements and ESCOs. Clear explanations are required on the contracts, on the rights and obligations of the users and service providers respectively.

**Example 10. End-user Training – A Factor in Service Satisfaction**

In 1998 a survey was carried out to assess the end-users' satisfaction with their Solar Home Systems (SHS) in Namibia. Most stated that they were satisfied with the technical performance of the system and the after sales service provided by the local technicians. However many were not satisfied with the power delivery of the system. They had not been informed about the limitations of SHS electricity compared with grid electricity. End-user training could increase service satisfaction and contribute to a better image for PV technology.

*Need, policy, market development – PV Dissemination in Namibia*

The awareness raising activities could be carried out by village level associations, NGOs, government or through the service delivery chain. It can be undertaken through demonstrations of PV systems, in road shows, workshops and seminars throughout the community and through advertisements in the media. These should be accompanied by informative leaflets/booklets that include photos and diagrams and detail the limitations of electricity from PV in comparison to a grid connection. Many of the end-users may not be literate so pictorial training materials are preferred.

The training of the end-users should be undertaken by the installation and maintenance companies in the end-user's home or by the system supplier, if it is to be installed by the user. The cost of this training should be covered by these companies because benefits of end-user training accrue directly to them. These companies are likely to require initial support in developing effective training manuals and log books for the end-user to follow, as detailed in Section 7.

**Example 11. Awareness Raising in Swaziland**

In 1997 a leasing system for solar home systems was established in Swaziland. Information on PV was spread through a range of actions including:

- Road shows with a drama group;
- Video shows and demonstrations at rural schools and community meetings;
- Demonstration stand at trade fair;
- Demonstrations during gatherings of potential customer groups (teachers, nurses, police, etc.);
- Radio advertisements;
- Educational talks on the radio;
- Documentary on television;
- Editorials in newspapers;
- Leaflet drop from aeroplanes;
- Solar displays at rural hardware shops (inclusive training of sales personnel);
- Workshop for rural NGOs with a view to spread the solar message;
- House-to-house sales;
- Brochures, leaflets at strategic places (television distributors, LPG distributors, rural grocery shops).

The indirect effect of all these measures is difficult to assess. Based on the direct responses of the people, the radio and newspaper adverts combined with professional advice seemed to be the most effective in generating sales.
A working demonstration also had a large effect. However, the demonstration actions may have been useful for awareness raising but it is not always clear how effective they were for generation of sales.

*Power supply through Solar Home Systems in Swaziland*

## 9 TRAINING ORGANISATIONS

One of the main difficulties in trying to facilitate the development of a 'new industry' is the lack of skilled and competent personnel. With respect to the PV industry, this skills deficit ranges from planners and those responsible for rural development/electrification strategy, to dealers and suppliers of hardware, to electrical installation and maintenance personnel. Within the OECD countries, courses on PV and other renewable energy technologies have generally been provided by private organisations and have only recently been introduced to "main stream" centres for education such as universities and technical colleges.

*Training of field workers in South Africa on battery maintenance*

Each profession will have different requirements in terms of skills provision and each will need to be individually addressed. An important role of the ministry of education is to ensure that there are suitable technical and university resources to ensure there is a skilled workforce

available for the industry. Ensuring the ministry of education is aware of the PV industry and its needs is an important requirement in any country.

Initially, the capabilities of the existing training organisations need to be assessed. . Particular issues to consider are: the availability of any accredited electrician courses that could be expanded for PV? Who pays for them at the moment? Could PV suppliers provide training? What capacity is there in the universities and vocational colleges?

There are two categories of training: training of technicians and businesses within the service delivery chain and training and awareness raising of all other stakeholders. It is likely that this second category can be publicly funded through internal training sessions within government, via government publicity campaigns and at public universities and technical colleges.

Within the first category (the service delivery chain) the training courses can only be sustainable if training leads to employment. This allows the course to charge its participants but also means that the training courses must have the support of the industry that they serve.

The provision of training offers additional income opportunities to existing training organisations and opportunities for the establishment of new organisations. In many cases it is in the interests of the private sector and PV businesses to provide some support.

Specific capacity building measures for the education and skills sector include:

- Training to undertake a survey of the current and future training requirements for the PV industry (if it exists) within that country.
- Training to carry out a study on what teaching resources (staff and equipment) are required so that the needs of the industry can be met.
- Information on the skills requirements for the PV industry to develop training programmes for technical personnel within the industry.
- Benefits of independent accreditation of training providers and training courses.

To ensure that any of the above activities are carried out it is important that funds are made available for adequate teaching resources. This will build the capacity within the country to provide the necessary trained personnel to help the industry grow.

It is recommended that training of technicians should be undertaken by a nationally or internationally accredited institution that has been audited by a third party. This not only ensures that technicians are trained to a high standard by a qualified institute, but helps to ensure that systems are installed to a high standard. The use of certified installers can also help in credibility in applying for financing and registering for any possible grants. However, the benefits of any training accreditation or certification programme must outweigh the additional associated costs. Accreditation of training institutions and certification of installation personnel is covered further in the document: *The Role of Quality Management, Hardware Quality and Accredited Training in PV Programmes in Developing Countries*, also published by IEA PVPS Task 9 and available on the website (www.iea-pvps.org).

## 10 CONCLUSIONS

The importance of appropriate capacity building measures cannot be over emphasised. Many PV based programmes have not met with the success they ought to have done because these issues have not been addressed adequately, if at all. Unfortunately the project by project nature of many agencies mean that local skills and capacity are not developed in a strategic manner so that after a project has been completed, the skills gained tend to dissipate, meaning the process has to start again when the next project is initiated.

In order to overcome this problem, it is important that a more co-ordinated and programmatic approach is taken – this is the only way to build a sustainable market which has significant, but not exclusive, private sector engagement.

Although there is inevitably a cost associated with the implementation of effective capacity building measures, the fact that their implementation can significantly impact on the sustainability of an intervention, can justify this additional cost. The effectiveness of a number of specific measures have been highlighted through the various examples given in the document.

It is important that policy makers and programme developers identify capacity building requirements during the initiation, planning and implementation stages of a PV programme. It is equally important to prioritise the capacity building activities and to ensure that the capacity building develops in a timely process in line with the development of a sustainable PV market.

This document has highlighted the type of capacity building that is relevant to the following groups:

- Government bodies (Ministries responsible for energy, water, public works, education, health, agriculture, finance, environment, industry and small businesses)
- Utility sector
- Financial sector
- NGOs
- Service Delivery Chain
- End-users

The capacity building requirements of these groups is diverse and will vary between countries. . However, a number of core measures have been identified and should be considered or adapted where appropriate. These activities are summarised in Table 1.

**Table 1: Summary of capacity building measures for the main target groups.**

| | Rural electrification policy development and contribution of energy to sector | Fiscal policy impacts | Awareness raising, promotional and educational activities | Evaluation and choice of technology options | Resource assessments | Technical advisory services | Financial and least cost analysis | Co-ordination | Impact assessments | Business plan development | Development of quality standards. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ministry of Energy | X | X | X | X | X | X | X | X | X | | |
| Ministry of Education | X | | X | X | | | X | X | | | |
| Ministry of Health | X | | X | X | | | X | X | | | |
| Ministry of Water/Agriculture | X | | X | X | | | X | X | | | |
| Ministry of (Rural) Development | X | | X | | | | X | X | | | |
| Ministry of Public works | | | X | X | | | X | X | | | |
| Ministry of Environment | X | | X | | X | | X | X | X | | |
| Ministry of Trade and Industry | X | X | X | X | | | | | | X | X |
| Office for Small Business | | | X | X | | | | | | X | X |
| Ministry of Finance | X | X | X | | | | | | | | |
| Financiers & Lending Institutions | | | X | | | | X | | | X | X |
| Training Organisations | | | X | | | | | | | | X |
| NGOs | | | X | | | | | | | X | |
| Utilities | X | | X | X | X | X | X | | | X | |
| Service Delivery Chain | | | X | X | X | X | X | | | X | |