IEA INTERNATIONAL ENERGY AGENCY

PV for Rural Electrification in Developing Countries - Programme Design, Planning and Implementation

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

Report IEA-PVPS T9-05:2003

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 – Programme Design, Planning and Implementation

September 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 (PV) 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.

Thirteen 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 provides an introduction to the project planning, implementation, and evaluation steps involved in the deployment of PV in developing and transitional economies. It is part of a series of Guides and other documents being published by the International Energy Agency's (IEA's) Photovoltaic Power Systems (PVPS) Task 9 Experts Group. Other guides in the series are

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

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

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

In addition to the guides of Task 9, IEA's Task 3 contributes important information for PV project planners. Two Task 3 documents are recommended to PV programme planners:

- Recommended Practices for Managing the Quality of Stand-alone Photovoltaic Systems.[2]
- Survey of PV Programmes and Applications in Developing Countries in 1996. IEA PVPS Report T3-03:1999

SCOPE AND OBJECTIVE

This document is intended as a guide for PV programme planners during the process of planning and implementing their projects to ensure that they continue on a sustained basis. The guide details four phases of PV programme planning: the preparation of PV programme, programme design, implementation and monitoring/evaluation. The guide should be used once the programme developer has a clear concept for a feasible programme. This guide should be useful to all the decision-makers in the process of developing a programme, be they bilateral and multilateral institutions, host governments in developing countries, PV programme developers and sponsors, PV producers and suppliers, entrepreneurs, or NGOs.

This guide details:

- Preparation for PV programmes, including needs assessment, stakeholder consultation, social context analysis, supply options, and national policy consideration;
- Design of PV programmes, including establishment of goals, delivery modes, timelines, logistics, and quality assurance;
- Implementation, and
- Monitoring and evaluation of PV programmes.

A number of methodologies have been developed over the years with the aim of improving programme design and implementation. This guide is intended to highlight the issues pertinent to a rural energy programmes in developing countries rather than providing an in-depth step by step methodology to standard programme design, planning and implementation.

Although the focus of this guide is on PV technologies, much of the discussion will apply to other rural decentralised energy systems.

KEYWORDS

Keywords: developing countries, PV, solar home systems, programme design, planning, implementation, deployment.

[2] To be Published, September 2003

ACKNOWLEDGEMENTS

The authors would like to thank the experts from the participating countries for their contribution to this report.

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 the authors, nor the IEA PVPS Programme 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

DAC	Development Assistance Committee of the OECD
GIS	Geographical Information System
GPS	Global Positioning System
IEA	International Energy Agency
IMS	Information Management System
kWh	Kilowatt hour
NGO	Non Governmental Organisation
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organisation Economic Co-operation and Development
PRA	Participatory Rural Appraisal
PV	Photovoltaic
PVMTI	Photovoltaic Market Transformation Initiative
PVPS	Photovoltaic Power Systems
SHS	Solar Home System: PV system of 20 to 100 Watt peak capacity, with a storage battery, charge controller.
W	Watt
Wp	Peak Watt

SUMMARY

Photovoltaic (PV) technology can supply reliable, relatively cost-effective electricity for basic needs in remote and developing areas. Photovoltaics can be used to better the lives of people in many ways, including supplying clean electricity to light homes or schools, running medical refrigerators, powering small businesses, and pumping or purifying water. Using the natural resource of sunlight, the lives of hundreds of thousands of people can be improved in ways that can range from local to regional in scale, depending on the size of the programme and the resources available to carry it out.

In order for a PV programme to be successful, it needs to be planned carefully. Many issues need to be considered before implementation can begin. As many programmes in the past were not entirely successful, it is useful to learn from past mistakes rather than repeat them.

The objective of this document is to provide input to those programme developers who are interested in implementing or improving support programmes for the deployment of solar photovoltaic energy systems for rural electrification. This guide will lead programme administrators through the process of planning and implementing a PV programme, broken down here into the following phases: (1) the preparation phase; (2) the programme design phase; (3) the implementation; and, (4) the monitoring and evaluation of the programme.

The preparation phase of PV programme planning consists of the consideration of the overall policy objectives, a needs assessment, stakeholder consultation, social context analysis, and analysis of technical supply options. Within this phase, the goal or goals of the potential programme are identified, as are the various stakeholder groups and key actors. National and regional policy objectives are taken into consideration, addressing the question whether the programme fits the overall goals and objectives of the state and the society. In addition, this phase includes consideration of the benefits and costs or consequences of the programme – both social and financial. Different technological options available to meet the energy needs must be assessed (e.g. PV, hydro power, etc.) and the best solution for the particular situation needs to be found and then adapted to the particular constraints of the environment.

The design phase includes detailed planning to carry out the programme successfully, to address the different costs and benefits identified in the first planning phase, and to inform and train stakeholders and make provision for the ongoing performance of the programme. This section highlights a number of issues related to programme design which have to be considered by programme administrators during the process of planning a renewable energy programme.

Once thorough programme planning is in place, with time lines, logistics, budgets, and team roles delineated, the programme is ready to be implemented. In the implementation phase, quality control and supervision are critical to ensure the desired outcome.

Monitoring and evaluation should already start during the programme preparation and extend through to post-implementation. Even a thorough needs assessment and stakeholder consultation may fail to identify potential negative effects or challenges of renewable energy development. Therefore planning for on-going monitoring is important. Re-assessing the programme after its completion can also allow for unforeseen or unintended consequences to be identified and addressed.

1 INTRODUCTION

Photovoltaic (PV) technology can supply reliable, relatively cost-effective electricity for basic needs in remote and developing areas. Photovoltaics can be used to better the lives of people in many ways, including supplying clean electricity to light homes or schools, running medical refrigerators, powering small businesses, and pumping or purifying water. Using the natural resource of sunlight, the lives of hundreds of thousands of people can be improved in ways that can range from local to regional in scale, depending on the size of the programme and the resources available to carry it out.

Poor design is often the root cause of unsuccessful programme or project implementation. In order for a PV programme to be successful, it needs to be planned carefully. However it is important to know that there can never be a blueprint for designing programmes.

In planning for PV programmes, decision-makers must carefully weigh the costs and potential social, personal, and national benefits that will accrue from different allocations of resources. In addition, they must put significant effort into assessing the needs to be addressed by a particular PV programme, consulting with stakeholders, analysing potential technological solutions, and then designing a solution that will yield the desired benefits at appropriate costs.

Planning for and developing a PV programme is a multi-phase challenge. This guide is designed to give input to those programme developers who are interested in implementing or improving support programmes for the deployment of PV for rural electrification. This Guide will lead programme administrators through the process of planning a PV programme, broken down here into the following phases: (1) the preparation phase; (2) the programme design phase (3) the implementation phase; and (4) the monitoring and evaluation of the programme.

Figure 1 gives an overview of the activities carried out in each of the different phases.

Preparation Phase

- National Policy Objectives
- Needs Assessment
- Stakeholder Consultation and Social Context Analysis
- Assessment of capacity requirements
- Identification of technical assistance requirements
- Technical Supply Options and Analysis

Design Phase

- Goals and Objectives
- Institutional and Policy Framework
- Schedule and Milestones
- Logistics
- Management and Project Team Functions
- Training/Capacity Building
- Financial Delivery Mechanisms
- Technical System Specification and Procurement
- Quality Assurance Aspects
- Information management System
- Provision for ongoing maintenance, replacements

Implementation Phase

- Quality Control, Management and Evaluation
- Information Management System
- Capacity building

Monitoring and Evaluation Phase

- Impact Assessment
- Project Evaluation

Figure 1: Activities during the different programme phases

2 PREPARATION PHASE

The preparation phase of PV programme planning consists of the consideration of the overall policy objectives, a needs assessment, stakeholder consultation, social context analysis, and analysis of technical supply options. Within this phase, the goal or goals of the potential programme are identified, as are the various stakeholder groups and key actors. National and regional policy objectives are taken into consideration, addressing the question whether the programme fits the overall goals and objectives of the state and the society. In addition, this phase includes consideration of the benefits and costs or consequences of the programme – both social and financial. Different technological options available to meet the energy needs must be assessed (e.g. PV, hydro power, etc.) and the best solution for the particular situation needs to be found and then adapted to the particular constraints of the environment. Photovoltaics may not be the best solution for all situations, and often the best solution will be a combination of different technologies.

Planning at a high level is beset by difficulties. It is difficult to collect reliable data, and equally difficult to know how to use the data once they are obtained. Interviews with stakeholders may or may not yield insight into how stakeholders will react to and benefit from renewable energy technologies. Potential problems or challenges may or may not be identified.[3] Planners must use the best data available, and to the extent that they are able, they must seek stakeholder input and involvement in the programme.

2.1 National Policy Objectives

A programme should be matched against the national policy objectives of the country in which it will be undertaken. National policy objectives might vary from emphasis on national infrastructure development to emphasis on hygiene projects, food production, rural electrification, or political needs. Where possible, local and regional programmes should fit into the national or regional policy objectives of the area in which they will be undertaken.

A variety of potential policy objectives are listed in Table 1, along with specific examples of renewable energy programmes that could help meet these policy objectives. This is by no means an inclusive list, and is meant to serve only as an illustration to programme administrators to allow them to better analyse the synergies between regional or local renewable energy programmes and the goals and objectives of the existing political forces.

Table 1: Contribution to policy objectives of renewable energy/PV programmes

Policy Objective	Specific Example
Full employment	Renewable energy training and workforce infrastructure development to provide employment opportunities; micro-enterprise
Increase in real income per capita	PV to provide electricity for small business and education opportunities
Provision of food & shelter	PV to provide water pumping for agriculture, clean drinking water to communities, or to run building equipment for the construction of shelters
Provision for health needs	PV to power medical refrigerators, health centre lighting

[3] Herschenbach, Dennis R. Davis, Cynthia. "Planning, Efficiency, and Equity: A Conceptual Framework." In Workforce Preparation: An International Perspective. Edited by Dennis R. Herschenbach and Clifton P. Campbell. (Ann Arbor, Michigan: Tech Directions Books) 2000.

Provision of education	PV to power schools or provide household lighting for study or running educational media (TV, computers, internet)
Improvement of general standard of living	PV to provide clean water, basic lighting, simple media for households
Achievement of economic equilibrium	Renewable energy training and infrastructure development to provide employment opportunities, empower the local development and expansion of small businesses, provision of sustainable electric or water pumping resource
Electrification of unelectrified areas	PV to provide electricity and lighting for rural households, etc.

Renewable energy plans can help meet national policy objectives in a variety of ways, of which those listed in the table above are just a few examples. However, renewable energy plans are only a piece of the policy puzzle. A government objective to achieve economic growth should also take into account fiscal measures to encourage and develop sustainable businesses, such as tax incentives, low-interest loans, development assistance, import quotas, export assistance, government investment, capital rationing, agriculture controls or assistance, transportation infrastructure development, communications infrastructure development, or a variety of other policy tools. As with any development planning, attention to the big picture is vital if a sustainable success is to be achieved.[4]

2.2 Needs Assessment

In order to ensure that the needs of the beneficiaries are being met, it is important to clearly identify and assess the needs of the target group. The needs assessment phase of programme planning must take into account not only why the programme should be undertaken, but who the beneficiaries and other stakeholders are and how they benefit from the programme.

First, programme planners should establish why the programme is being considered. What will the recipients gain by the completion of the programme, and how will those gains be measured? What justifies the input of the resources that will be required to undertake the programme?

Energy projects can bring a number of benefits to the target group, in particular PV technology can provide many potential macro-level benefits, including

- reduced dependency on fuel resource purchases or fuel gathering, resulting in both time and money savings;
- electricity generation in areas not otherwise served by electricity grids;
- increased reliability in areas where grid power is intermittent;
- limitation or mitigation of the environmental costs of conventional fuels;
- reduction in greenhouse gas emissions from the production of electricity or the burning of other fuels for lighting.[5]

The micro-level benefits might include

- water purification;
- health care;

[4] United Nations. Guidelines for Development Planning: Procedures, Methods and Techniques. (New York: UN) 1987. p36-37.

[5] Kozloff, Keith. "Electricity Sector Reform in Developing Countries: Implications for Renewable Energy." Renewable Energy Project Research Report. April 1998 (No. 2).

- education support;
- communications opportunities;
- home lighting; and
- small businesses opportunities.

Local consultation meeting in Gadora, India

A needs assessment should consider both the macro- and micro-level benefits that an energy project could bring to a population. In addition, a needs assessment should consider the final outcomes needed and expected from the programme. For example, a PV programme may have a micro-level benefit of providing electricity for basic lighting. How will that basic lighting be used and what benefits will it provide? Students might be able to study after dark, being able to do their farming work during daylight and still succeed in school, thus maintaining the family income while simultaneously achieving educational goals. Alternatively, basic lighting may allow a homeowner to take on small piece work and create a home business, increasing his or her standard of living. In addition, PV lighting might supplant oil or kerosene lights, improving indoor air quality. The actual benefits which accrue from a specific PV programme might be many and varied, depending on the ways in which the resource is used.

Assessing the micro-level needs of a community is essential in developing the best energy programme to match the population's needs. For example, determining that a specific society or region is in need of additional sources of income should lead policy makers to consider how those people currently spend their daylight hours, what their resource constraints are, and what their traditional modes of employment or income generation are. Once these variables are identified, policy planners will be better able to determine how basic electricity, water purification and pumping, or health and education technologies will serve this particular community, and how it will be most useful and best accepted and implemented. One community might benefit most from electricity geared towards small business or micro enterprise development, while a different community might benefit most from small household systems that will run lights and a radio. Another community might benefit most from electricity for a school or for a medical clinic. Needs assessment should directly inform the type of project or programme and the appropriate energy source.

Depending on the financial and other resources available for the programme, planners might be able to meet several basic community needs at once. In other circumstances, planners might need to prioritise what the most important electricity use for a particular community will be, given the wide range of needs present. The needs assessment phase allows planners to identify the various ways that electricity might serve a people or a community, and then prioritise which needs might be most important or which outcomes might be most beneficial over time. Electricity for lighting, for example, might not be as important to a particular village as providing clean water. If there is no money for students to attend school or buy books, or if there is no money for homeowners to invest in the raw materials for small work projects like sewing, providing evening lighting to houses may be less important. Allocating renewable energy resources elsewhere, for instance for the development of opportunities for small businesses or for medical applications, may be more appropriate. Needs analysis will take these details into account and help determine which benefits will be most useful to beneficiaries and under what priority, and therefore what direction an electricity project should take as part of the larger planning and development goals of a region. The following table provides examples of different target groups for a PV programme and the benefits and potential costs of a given programme for each group.

Table 2: Common Target Groups for a PV Programme

Stakeholder	Needs Met or Service Provided	Potential Costs or Considerations
Farmers	Water for irrigation, energy for farm implements and food processing, household lighting	Reduced work-hours leading to reduced employment; social system restructuring; environmental effects of changed farming or irrigation methods
Students	Lighting for studying	Social system restructuring; daylight hours use/schedule changes
Householders	Lighting for housework, home business; water pumping or purification; radios or television	Reduced household work-hours leading to social system restructuring; increased home business leading to market restructuring; media influence
Small business owners	Electricity for lighting, small business needs; water pumping or purification for business needs	Market restructuring; business outputs or opportunities resulting in social restructuring
Workers	Electricity or water for businesses; potential to remain in local community rather than travelling to large cities or out of the country for work	Work condition changes resulting in possible condition degradation or social system degradation; work force restructuring and possible displacement; possible worker-hour reductions; market disruption
Children & families	Electricity for healthcare, schools; retain family unit rather than having workers leave the community	Family structure disruption; social restructuring; consequences of longer life expectancies
Area, regional or national administrators	Street lighting to increase safety, work hours; increased grid reliability to aid businesses & town services; healthcare; education, electricity, water purification or pumping, workforce opportunities	Social restructuring; consequences of healthcare changes such as longer life expectancies; market restructuring; hourly labour changes; administrative infrastructure changes

Once basic needs have been assessed and some programme outcomes have been identified, the next step of the needs assessment phase is to consider the quantitative and qualitative characteristics of the potential energy programme. Quantitative analysis looks at the amount of energy needed over a given period of time to achieve the expected outcomes. This can then be matched against the expected output of different programme designs. Qualitative analysis looks at the demands for reliability and availability that will be placed on the energy programme.[6]

2.3 Stakeholder Consultation and Social Context Analysis

In order to determine what the potential costs and benefits of a programme will be in relation to the individual stakeholders affected by a programme, planners should contact and consult those stakeholders who will be most affected by the programme. Stakeholders are not limited to the target group, but might include local industry, small business owners, consumers of small business goods, non-government organisations, trainers, local

[6] DRE Specification, "From Energy Requirements to Electrification System." Section A1, page 3. Electricite de France, Research and Development Division (Clamart, France). 1997

government and state government. In some communities, the religious organisation will be a key player. Stakeholder groups will change depending on the scope, location, and goal of the programme – each situation will be unique and will have unique needs. Table 3 below provides examples of different stakeholder groups to consult with and the role each organisation could perform in a PV programme. Table 2 identified the potential target groups to be consulted with.

Table 3: Common Stakeholder Groups for a PV Programme

Stakeholder	**Possible role**
Local industry, Entrepreneurs and Small business owners	Opportunities to enter into a new market as suppliers, installers, provision of maintenance services etc.
Non-government and community based organisations	Representation of target groups, possibilities to form energy service companies, provision of financing services, programme facilitation, needs assessment etc.
Training organisation	Opportunity to provide training to local people in a new market area.
Financial organisations	Opportunity to enter new market, provision of financial services, loans etc.
Utility sector	Opportunity for the utility sector to enter a new market. It is important to consult with the utility sector to ensure that the objectives of the programme do not oppose any existing rural electrification policies.
Sectoral ministries	Any PV programme should fit within the institutional and policy objectives of the ministries for health, education, water, communication, agriculture and energy.
Area administrators	Opportunities to meet development targets and to increase economic activity in the area. Any PV programme should fit within the local institutional and policy framework.
Regional or national administrators	Opportunities to meet development targets and to increase economic activity in the area. Any PV programme should fit within the national institutional and policy framework.

The assumption that bringing renewable energy to people will only yield benefits is not necessarily correct. Whenever change is instituted in a society, there will be challenges and potential costs. Changing the status quo may benefit some stakeholders more than others, and may bring some unfortunate consequences along with the benefits. The preparation phase of programme planning needs to take potential costs, challenges, or negative reactions to the programme into account. Stakeholder consultation should seek to identify the economic, social, and cultural costs and benefits of a particular programme, in addition to the direct programme results.

There are many examples of technologies being implemented in developing-world communities in the hope of improving the quality of life, but where the end outcome was disappointing. One of the key factors that has been identified as contributing to the failure of technology "transfers" to developing communities is the lack of involvement of the end users in planning and carrying out the programme, thereby helping to identify potential failure points before the programmes is implemented.

For example[7], high-efficiency cook stoves were designed to reduce the amount of fuel needed to cook a family meal. While they operated admirably in the laboratory, they smoked and did not provide the efficiency savings in the field because the villagers didn't have access to the high-quality, uniform fire wood that was used to test the stoves. In either case, greater interaction between the villagers who were to receive the technology and the programme planners might have alerted planners to these potential problems earlier in the planning process, where provision might either have been made to resolve the problems, or where a different approach may have been taken.

In solar programmes, analogous technical problems include the unavailability or high cost (hence in-affordability) of quality storage batteries, specified wire or other equipment, or the lack of access to maintenance expertise. This is not an exhaustive list of the technical difficulties that may arise at the local level of programme implementation. There are potential social consequences as well. Introducing a new technology into any social context, even a highly-anticipated, generally accepted technology like running water or electricity, can have unexpected social consequences. For example, during the 1970s, running water was installed in houses in a small village of Ibieca, Spain. The goal was to eliminate the need for the villagers to go and fetch water from the village fountain. The unexpected side effect was the loss of social interaction at that same fountain. Innovators failed to recognise and mitigate the loss of that social interaction. Since the installation of indoor plumbing, the tight social bonds of the community have eroded.[8] In solar programmes, providing electricity to a village might disrupt social status, inspire markets for unexpected loads (such as extra electrical appliances), elongate the working hours, increase hours spent watching television or listening to radio, or otherwise change the social fabric of the village in subtle or less-subtle ways.

Consultation with stakeholders is perhaps the only way to identify these hidden social costs in advance, though it is not failsafe. Sometimes neither stakeholders themselves nor experienced programme planners can foresee the costs, implications, and social upheavals that might follow an otherwise well-planned programme. Involving stakeholders is key to successful planning in the development of local infrastructure to support a PV programme. The use of appropriate methods for stakeholder consultation should be considered, for instance Participatory Rural Appraisal (PRA)[9], which comprises a set of techniques aimed at shared learning between local people and outsiders.

Stakeholder consultation is a costly and time-consuming process, but it should be included in the planning for any PV programme. Considering the stakeholder comments and opinions, and determining how and where renewable energy programmes will benefit different stakeholder groups while identifying potential social disruptions and resultant challenges or costs, will help ensure the final success of a given programme. Ignoring stakeholders and not involving them will often ensure the quick failure of the programme, as uninvolved stakeholders will not have an incentive to overcome barriers that might arise preventing them from understanding or enjoying the benefits of the programme.

Involving stakeholders in the programme planning phase through stakeholder consultation is one way of not only identifying but potentially alleviating stakeholder resistance or rejection of PV technology due to misunderstanding, poor planning, or non-involvement. This involvement also provides an avenue for local ownership of the ideas and outcomes.

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[7] Dudley, Eric. The Critical Villager: Beyond Community Participation (London: Routledge Press) 1993

8 Sclove, Richard E. Democracy and Technology. (New York: Guilford Press) 1995. p3.

The anecdote refers to Harding 1984: Remaking Ibieca: Rural Life in Aragon under Franco. Published by the University of North Carolina Press.

[9] Information on PRA can be found at http://www.fao.org/lead/aaa-%20old%20-%20todelete/toolbox/refer/pral.htm and http://www.ids.ac.uk/ids/particip/information/index.html#introart

Stakeholder consultation, India

An important accompaniment to stakeholder consultation and involvement is social context analysis. Social context analysis looks at family relationships, living conditions, working patterns, village and social interactions, purchasing patterns, and social values. Some societies, for example, place a higher value on domestic cleanliness than others. Similarly, the value of interpersonal relationships and co-operation varies among different societies. These priorities may affect how stakeholders will respond to or value a PV programme. Relative gender roles and assigned power roles within the community or society should also be considered. Will the renewable energy programme alter these patterns? If so, how? Will the stakeholder groups affected consider the changes a benefit or a threat? How will they respond to perceived threats or lifestyle alterations caused by the renewable energy programme?

In some cases, social context analysis may suggest the redirection of efforts in order to suit better the perceived needs and fears of the stakeholder groups that will be affected by the programme.

Once stakeholder groups affected by a potential programme have been identified, a variety of methods can be used to query them about their reactions to programmes and involve them in the development of the programme. Survey methods will be affected by funding and time available, but in rural and remote situations, surveys should involve some amount of personal field surveys. Planners need to consult programme beneficiaries as well as experts from the region. Town meetings, news articles, or other outreach methods might be appropriate depending on the culture and media outlets in a given area. Educating stakeholders about the benefits as well as the maintenance aspects of a PV programme builds local infrastructure that can be key to the long-term reliability of the PV programme. The inclusion of the programme in the fabric and responsibilities of the society or household that will receive it are important planning considerations.

2.4 Assessment of Capacity Building Requirements

It is important to identify the skills required within the stakeholder groups to ensure that the programme will continue, post intervention, on a sustainable basis. A number of new skills, both technical and business skills, will be required when electricity is brought to a new area. The capacity building that is required will be diverse and the actual requirements vary from country to country. 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 each stakeholder organisation.

Needs should be assessed, inter alia, in the following stakeholder organisations:

- Relevant Government ministries
- Implementing agency

- Financial sector
- Installation contractors
- Local industry, small businesses
- End-users

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; installation, operation and maintenance; financial analysis; project finance; product development; establishment of community based utilities; setting tariff structures and accounting procedures[10].

2.5 Identification of Technical Assistance Requirements

The assessment of the capacity building requirements will also help identify any needs for technical assistance. Should technical assistance be required it is important to include it as early as possible within the preparation and planning process to ensure there is a common understanding regarding the objectives and goals of the programme. Many projects and programmes supported by the bilateral agencies and multilateral agencies include technical assistance as an integral part of the work. Where there is co-operation with an international agency, the individual agency will have its own particular criteria for the recruitment of technical assistance.

As a minimum when selecting technical assistance it is very important that the consultant or organisation has the correct expertise and is suitably qualified for the job. The organisation should demonstrate past experience in similar / related work and demonstrate an ability to deal with local conditions. In particular the key staff to work on the programme should have the right expertise and past experience of similar work.

To ensure the most suitable organisation carries out the technical assistance at a reasonable cost the work should be competitively tendered against clear Terms of Reference (ToR). The Terms of Reference are key to ensuring that the technical assistance fulfils the expected requirements of the programme planner.

2.6 Technical Supply Options and Analysis

Decisions about the best technology and about technical details will be dependent on the needs assessment, stakeholder consultation, and other planning variables given above, in particular the quantitative and qualitative assessment and the determination of priority outcomes and the social context analysis.

The resource for different technologies will have to be considered for the site or sites of the programme. The demand (e.g. small home systems or much larger systems for small industry) and the load density (e.g. mini-grid or dispersed systems) have to be taken into account. For example, a small solar home system will typically yield enough electricity to run a few compact fluorescent lights for a few hours each night and a small radio - no more. If a refrigerator is needed, or if a TV will be plugged into the circuit, a larger system will be needed.

Will the programme outcome be affected if the solar resource is only intermittently available? Will a back-up power source be needed? For a medical refrigerator, for example, reliability of the power source, and power storage for overnight and for cloudy days, is imperative. Will

10 IEA PVPS Report T9-03:2002 'PV for Rural Electrification in Developing Countries – A Guide to Capacity Building Requirements.'

down time be acceptable for a small solar home system used to power compact fluorescent lights? Will down time be acceptable for a PV-powered school media system? Or, for a cell-phone battery charging station? PV systems (or indeed solutions using other technologies) will need to be designed according to the quantitative and qualitative needs of a specific programme.

Details about the size of the system, type of system components (battery, inverter, modules), availability of alternative power sources and backup power will be decided during the design phase. However, the analysis of different technology options should occur at this stage of programme planning. In order to make the most of limited resources, it is important that the technology chosen is the one best suited for the circumstances.

2.7 Programme Budgets

The most critical element of any programme is the cost and it is important that realistic and sufficient allowance is made for all those costs that may not appear obvious at first glance. The costs of a PV development project can be broadly broken down as follows:

1) planning and project development, including stakeholder assessment and organisation of participation;
2) capacity building and training;
3) capital costs (hardware and equipment);
4) transportation and installation;
5) operating and maintenance, replacement component costs (e.g., batteries) and,
6) monitoring and evaluation costs.

Planners should keep each of these categories in mind when developing a budget and proposing financing for a programme. It is also important to define how these costs will be met and more importantly who will meet them. This is particularly important when third party financing is being considered – for example, it is important that end-users are consulted if they are going to be expected to meet the costs of O&M. Effective planning of financing should take into consideration the costs end-users can realistically be expected to bear, and which costs should be absorbed in the broader funding package.

2.7.1 System Costs

A PV system is a high capital cost technology and it is important that cost estimates are based on realistic figures. Typical capital costs of various system types are summarised in Figure 2.

These costs can only be used for rough planning. Each project may have a final cost per system that is significantly higher than or even lower than the above estimates. The actual costs of a programme vary widely, depending on the size and number of components, the number of systems purchased (volume discount), the level of competition in the local market, duties and taxes, subsidies available in the installation market, project planning and marketing needs, and financing costs such as interest and fees.

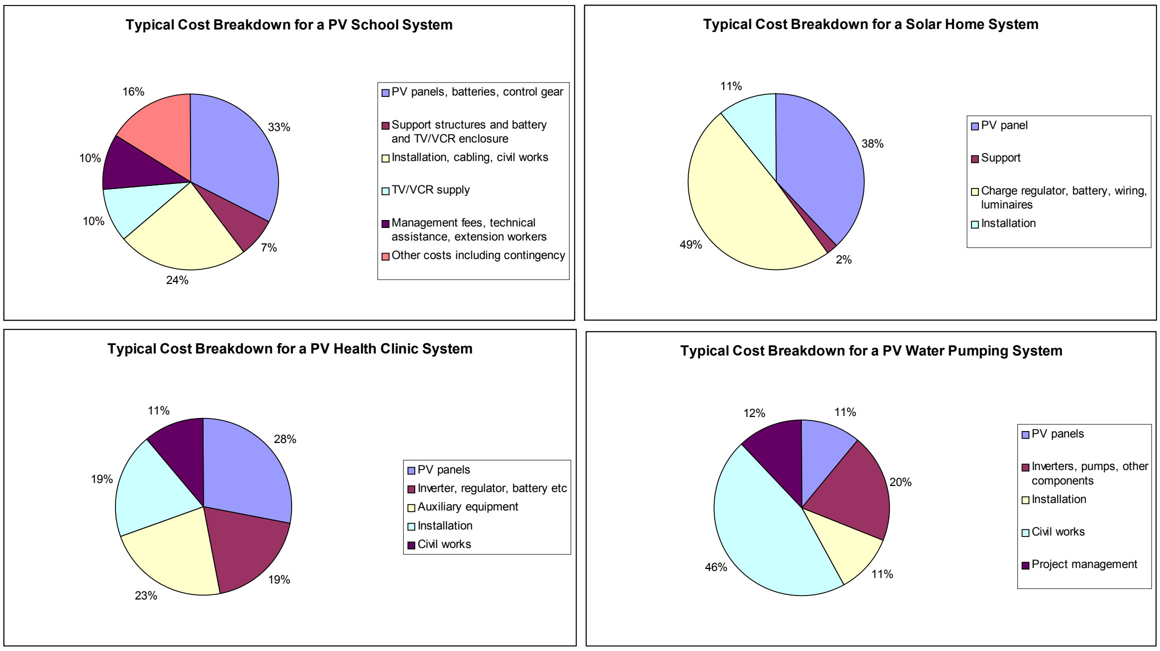

Figure 2: Typical cost breakdowns for various applications of PV

2.7.2 Life Cycle Cost Analysis

When comparing technology options, it important that decisions are made on the basis of a Life Cycle Cost Analysis (LCCA) rather than on the basis of capital costs alone. This cost analysis should also consider issues relating to sustainability, as well as the provision of infrastructure services (health, education, communications, etc) with high added value. A life cycle cost analysis should include hidden subsidies for grid extension or diesel generators as well as maintenance costs in order to provide a fair basis for comparison. Consideration should also be given to the added value of the implementation of renewables.

2.7.3 Positive Externalities of PV Systems

In addition to frequently being the most cost effective option for energy supply, the technology has further advantages over other energy delivery systems which should be considered. These “positive externalities” are not taken into account when doing a least cost analysis, but have their importance in a wider economic analysis. Some of these factors are:

- local job creation (sales and service networks in rural areas, local maintenance). Several case studies have shown that dealer networks are important to reach potential customers in rural areas. The network serves in initiating sales, in the fee-collection process, as well as in after-sales servicing and problem solving. Local jobs are created at the start up of the PV programme, if it is successful then an increasing number of jobs will be generated as systems sales increase. In cases of larger systems for social needs, e.g. a pump system for drinking water, a local person is placed in charge of the maintenance and care of the system and is remunerated by the community.
- higher reliability of PV, when compared to the procurement and transportation of diesel and propane or the security of grid lines. Reliability of energy supply is essential for applications such as vaccine refrigeration, hospital lighting and other medical applications;
- time saved on travel to get fuel supplies, which can then be used for other purposes, e.g. for income generating activities. Often families travel a considerable distance to collect fuel or to charge car batteries. With a PV system the energy is available at their doorstep.
- avoidance of environmental degradation. Many traditional fuel sources, including diesel, propane and wood, create environmental hazards ranging from noise and smoke to caustic fumes and carcinogens. SHS can improve the indoor environment on a local scale and improve indoor air quality and helping to reduce respiratory illnesses often associated with the indoor burning of firewood for cooking.

Considering 'positive externalities' like these when planning a programme presents a truer understanding of the real costs than merely making a decision on a capital cost basis. In the end, the cost of the project must be covered through funding mechanisms and pay-back plans, but taking into account these externalities can provide some justification for larger or more aggressive programmes even when the costs alone are borderline improvements over other energy sources.

2.7.4 Planning for Long-term Sustainability

When PV projects were first undertaken in developing countries, there was often little or no element of cost recovery built into them and donor and grant funding was used to cover operational costs. This led to abandonment of the equipment once funds run out and/or the components broke, since there were no cumulative funds to replace components in the long term. This situation can be avoided by planning a programme such that it generates revenue to pay back loans and cover the on-going costs.

Long-term sustainability of projects is ensured by planning an element of cost recovery into the project from the start[11]. Grants or donations should never be used to cover operating costs and should only contribute to alleviating the initial high cost of purchasing equipment. The financing should be set up in such a way that it creates revenue that will at a minimum cover the cost of operation and maintenance of the PV systems. Careful consideration should be given to how this money is saved and allocated for purchasing replacement components.

[11] Best Practices for Photovoltaic Household Electrification Programs , World Bank Technical Paper no.324, 1996

3 DESIGN PHASE

The second programme planning phase is the design phase, coming logically after the preparation phase, in which the needs driving the programme and initial goals and constraints have been identified. The design phase includes detailed planning to carry out the programme successfully, to address the different costs and benefits identified in the first planning phase, and to inform and train stakeholders and make provision for the ongoing performance of the programme. This section highlights a number of issues related to programme design which have to be considered by programme administrators during the process of planning a renewable energy project.

During the design phase, one of the most important task is to incorporate quality assurance measures into the overall programme design. In order to achieve a project which is successful in the longer term, quality assurance must penetrate all aspects of its implementation. Appropriate procedures need to be put in place that ensure that quality is maintained at all stages of the programme.

At this stage, detailed technical specifications should be developed by technical experts, taking into consideration the results of the needs assessment and stakeholder analysis. This should include details about the size of the system, requirements for system components (battery, inverter, modules), availability of quality equipment, availability of alternative power methods and backup power. In addition, constraints such as climate and solar resource need to be taken into account. Detailed procedures need to be drawn up, covering functionality testing of systems, acceptance testing of components, system installation and system commissioning. Quality assurance requirements should be taken into consideration when these procedures are developed.

Programme planners should work closely with technical experts to ensure that the technical experts understand both the constraints on the programme and the desired outcomes. Technical experts need to remember at this point that models and designs that have worked in other countries will need to be adapted to the specific constraints of the new programme. What has worked in an industrialised country may not work the same way in a developing country because of different social, economic, resource, and accessibility variables.

Working with technical experts the programme planners will fully understand the implementation demands of the programme. Technical experts can advise what degree of training system owners or operators will be needed. The advice of technical experts should be sought regarding incorporating necessary quality assurance measures into the programme design. Technical experts can advise about possible system shortfalls and failures, and suggest remedies. Finally, technical experts must advise on on-going maintenance needs and assess the availability and quality of locally manufactured or locally available components, and the skills of local personnel.

3.1 Goals and Objectives

Determining the programme goals has its root in the initial needs assessment undertaken in the preparation phase. Besides consideration of the needs of the stakeholders and the benefits that will accrue to them (as well as any costs), and beyond aligning the programme with the national or regional policy goals, the planners will need to develop a framework to guide programme deployment, implementation, and ongoing sustainability. The programme design and strategy should be transparent to all the stakeholders.

Specific goals and objectives should define the number of people affected directly by the programme, the amount of electricity or water (or other service) that will be produced, and the indicators that will be used to measure the success of the programme. For example, in an electricity programme, the outcome indicating success may be the success of income generating activities due to evening illumination of a number of village houses, allowing residents to sew or study in the evening hours. Improved exam results for local children and increased sewing income for local families will be part of the programme objectives, and will allow programme administrators to judge the success of the programme.

When defining programme goals, some thought should be given to medium and longer term aspects of a programme. Some of the questions which should be considered are how long the PV systems are expected to last; what actions are required to ensure that systems continue to be operational throughout their expected life time; and what will happen once they have reached the end of their useful life. In most cases, programme initiators will wish the systems to have a reasonably long life, which should be clearly defined as a programme objective. In order to achieve this, indicators used to assess a programme and define its success must include some form of assessment of system lifetimes and hence programme sustainability. The biggest factors affecting the expected lifetimes of PV systems are probably the quality of design, components and installation work, and how well systems are maintained. These issues need to be addressed during programme design.

3.2 Institutional and Policy Framework

In addition to defining basic programme goals, this phase of planning needs to take into account the institutional and policy framework in which the programme will be undertaken. Depending on the level at which PV programme administrators work, various institutions may inherently be involved in the programme already. However, some institutions or institutional processes may have escaped inclusion. Institutions to be considered during the programme design include:

- Government departments and ministries at national level;
- Government at provincial, regional and local level;
- Central, sectoral, regional, and local planning agencies;
- Ministry of finance and financial organisations;
- Private sector industry.

Planning should incorporate continued stakeholder participation and should garner popular support for the programme. This can be done through continued public participation in town meetings or training and installation activities. Flyers and newspaper articles or radio announcements might also be useful, depending on the culture and resources. In addition, carefully designed economic incentives and a description of expected benefits of a PV programme can be powerful means to obtain and foster positive public opinion.[12]

Finally, planning should also consider means by which co-operation between multinational technical and development organisations and local efforts could be encouraged. For example, a United Nations report suggested that a prevailing practice in multinational co-operation is the arrangement of free trade for specific projects. This might include the elimination of tariffs and trade barriers for products included in a specific development plan.[13] The potential need for protection of local industry should however also be considered.

[12] United Nations. Guidelines for Development Planning: Procedures, Methods and Techniques. (New York: UN) 1987.

[13] ibid

3.3 Programme Activities, Schedule and Milestones

The programme activities are the inputs required to meet the programme goals and objectives identified. Each individual PV programme will have unique deliverables and milestones that should be mapped out in advance to ensure the timely and sustainable continuation of the programme and final achievement of programme goals. Some typical activities and milestones in a PV programme are:

- Completion of programme planning;
- Engagement of staff;
- Completion of training of personnel;
- Consultation and involvement of end-users;
- Definition and/or testing of qualified and quality hardware;
- Procurement of hardware;
- Inventory of hardware;
- Transportation of hardware to site or sites;
- Training of installers;
- Physical commencement of installation work;
- Installation completion;
- Training of end-users for operation and maintenance of systems;
- Follow-up;
- Programme evaluation and reports.

3.4 Programme Logistics and Budget

Detailed planning is required to co-ordinate the various different aspects of a programme. The following are some of the questions which need to be considered: What personnel and equipment will be required to transport materials to site, manage the work on site, and install the system or systems? What personnel, equipment and other resources will be needed to provide training, and who needs to be trained? Who will oversee and manage the programme? Who will provide security for equipment and materials left otherwise unattended on site overnight while installation is in process? Do personnel need to be housed and fed? If the programme will entail a disruption of users' lives for a given period of time, how will they be housed or compensated? Finally, how will programme maintenance and follow-up be provided, and what emergency plans will be in place to deal with natural or social catastrophes?

Each PV programme will entail different logistical considerations, depending on the location, scope, resource constraints, involvement of stakeholders and local conditions. In general, programme planners should develop logistical plans for categories outlined in Table 2.

Table 2: Summary of logistical plans

Management employees	Hiring, training, transportation, housing, food, equipment
Tools and equipment	Transportation, storage, security
PV materials	Transportation, storage, security
Installation employees	Hiring, training, transportation, housing, food, job equipment
Communications	How; language and dialects; literate or non-literate
Security	Where and by whom

Users	Training, inclusion, alleviation of disruptions
Management systems	Data acquisition, trouble-shooting
Emergency & contingency plans	
Programme budget	

Programme budgeting is an important part of this planning phase and should not be overlooked. Programme expenditures should be estimated and tied to programme milestones to ensure that funding will cover the length of the entire programme. There should be accounts for materials and equipment provision, transportation, personnel wages and benefits, training costs, installation costs, communication and administration, public outreach, and programme evaluation and adjustment, among others. A detailed budget combined with detailed accounting over the duration of the programme will alert programme administrators if expenditures in certain areas exceed the allocated budget. The budget should be reviewed on a regular basis throughout the programme. Necessary revisions and adjustments should be made, to take account of cost categories that were either significantly under or overestimated. Budgeting will then help keep the programme on track.

Logistical planning takes the time plan and schedules and adds the detail that will be needed to ensure that the job gets done correctly. Detailed planning, budgeting, and planning for security and contingencies is essential. However, flexibility is also important. Plans should be made to allow for re-assessment and corrections as unforeseen circumstances may require certain logistics to be reworked, or some steps to be repeated. Logistical planning takes into account "what if" scenarios and then does what it can to eliminate potential setbacks. But logistical planning also leaves room for reconsideration when setbacks arise.

3.5 Programme Management and Programme Team Functions

During the design phase, personnel requirements, hiring, and training should be considered, but further consideration than mere head-counting needs to be given to the personnel aspect. It needs to be determined which job functions and associated skills are required in order to successfully implement the programme. There will be the programme planners themselves at the head. Beneath them may be a project manager, technical experts, installation staff, procurement personnel, and transportation and security personnel, to name a few potential categories. The management structure of the team needs to be mapped out, including reporting and feedback roles. This will ensure that any problems with the running of the programme are highlighted early and can be remedied. Delineation of who is responsible for which parts of the programme implementation, and training for team members to understand the expectations placed on them, is a part of this step. If technical assistance is required as part of the programme, the terms of reference for the work should be clear by this point in the programme process.

Mapping team functions and inter-relationships prepares the way for the actual identification of team members. Personnel should be chosen through a predictable, transparent process that takes into account the skills and experience of each team member in the task or job area they will be asked to fulfil.

3.6 Training / Capacity Building

Capacity building should be integrated into any programme, rather than seen as an additional activity. Following the assessment of capacity requirements in the preparation phase and the programme team identification, the training needs should be met within the design phase of the programme and continue throughout as necessary. Varying training methods will suit different organisations and personnel. 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. Capacity building can include the training of local practitioners.

Training practitioners in South Africa

It is equally important to establish how these training needs be met and that the training is carried out to a suitable standard. Are there training organisations or experts in-country that could fulfil the requirements? Should the practitioner training be accredited? It may be possible to adapt existing resources or international experience may be required to provide some of the training.

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 the 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. Further information about capacity building and the accreditation of training is included in other Task 9 publications[14].

3.7 Financial Delivery Mechanisms

Financing is the greatest limiting factor of many development projects. Financing options and sources of finance, as well as payment models, are treated more completely in other Task 9 resource guides:

- PV for Rural Electrification in Developing Countries – A Guide to Institutional and Infrastructure Frameworks.
- Financing Mechanisms for Solar Home Systems in Developing Countries: The Role of Financing in the Dissemination Process.
- Sources of Financing for PV Based Rural Electrification in Developing Countries.

PV programmes might contain some mix of end-user payment along with government or international development support. End-users might cover the cost of the programme over time with a low-interest loan, or they might contribute some portion of the initial capital needed. The first option is the more feasible one, as in most developing and transition economies, relatively few people have the capital reserves to pay the full costs of a PV

[14] IEA PVPS Report T9-03:2002 'PV for Rural Electrification in Developing Countries – A Guide to Capacity Building Requirements" and IEA PVPS Report T9-04:2003 'The Role of Quality Management, Hardware Quality and Accredited Training in PV Programmes in Developing Countries'.

system up-front. However, when cost savings of other sources of energy such as dry cell batteries or kerosene are considered, many end-users can contribute some percentage of the cost of a PV system over time. The additional income to small businesses as a result of using PV electricity may also lead to users being able to contribute to the cost of a PV system over a longer period of time. As a minimum the on-going operation and maintenance costs of the programme must be met.

Decisions regarding financing mechanisms should take into account the following:

- Traditional energy usage costs and prices;
- Accessibility of financing services to the stakeholders;
- Levels of capital savings available at end-user, stakeholder, and regional or national levels;
- Means of generating and tapping domestic savings; and
- Means of tapping international and donor funding.

The implications of different financing mechanisms should also be considered. Some local participation in meeting the cost of PV systems encourages a sense of local responsibility and ownership of the equipment. But depending on the uses of the PV and its actual intended ownership, this might or might not be a good thing. Stakeholder reactions to, or costs of, incurring debt should also be considered. National costs of incurring international debt cannot be ignored either, along with the economic and political implications of such burdens.[15]

Regular maintenance is absolutely vital for the medium to long-term sustainability of a programme. If maintenance is neglected, systems are likely to break down and become effectively useless within a couple of years or less. Therefore, in order to enable the long-term success of a programme, any programme must include provisions for the funding of ongoing maintenance.

3.8 Technical System Specification and Procurement

During the design phase, attention needs to be given to technical specification and system design aspects. A number of questions need to be considered in detail. What are the technical requirements which the system or systems has to fulfil? How will the equipment be chosen? Who will be responsible for the system design and system integration? What procedures need to be developed, for instance for testing or commissioning?

Performance requirements should be defined at the beginning of the programme, and should form the basis for the technical system specification. Often equipment will be selected through a tender process, in order to obtain good value for money. If this is the case, a clear tender specification is essential. When comparing bids from different suppliers, it must be ensured that each supplier meets the specifications, and there should be penalties for a failure to meet the specifications and deliverables once the programme is awarded. It is not sufficient to base the decision on price alone, without a thorough assessment of the technical aspects of each bid. The detailed system design will usually depend on the equipment chosen. The easiest approach is to obtain turnkey systems from a supplier, but buying equipment from different suppliers is also possible.

Procedures need to be developed for certain project tasks. Procedures may be required for component or system testing, for installation or for commissioning. Procedures should be appropriate for the staff who have to use them. Depending on their experience and training,

[15] United Nations. Energy Planning in Developing Countries. Authored by the Division of Natural Resources and Energy, Technical Co-operation for Development. (Oxford, England: Oxford University Press) 1984. p.69

procedures may have to be quite detailed. Pro-formas may be required for recording the actions undertaken and the results of any tests.

During the design phase attention should also be given to the likely environmental impact of the programme. For PV projects the largest environmental impact is likely to be from the disposal of the system hardware when it reaches the end of its lifetime. Procedures should be put in place to ensure that the hardware, and in particular the battery, is not 'dumped' indiscriminately. These could include a battery recycling scheme, which is beneficial to the users.

A further issue to consider is theft and vandalism. In some countries, theft and vandalism are a very big problem, and have the potential to bring about the complete failure of a programme. In this case, security aspects are of paramount importance. PV systems are expensive and the PV modules, in particular, have a high re-sale value. This means they are often stolen, vandalised or damaged during an attempted theft. It is impossible to make a PV system completely 'theft-proof', but there are simple measures that can be taken to reduce the incidence of theft and vandalism. Social as well as technical solutions need to be considered to alleviate this problem. For larger systems, such measures could include:

- Use of 'tamper proof' fixings and the welding of bolts on the support structure of a ground mounted array;
- Use of security fencing;
- Employment of a night-watchman;
- Have someone living on site (ideally benefiting from the PV system);
- Careful design of battery/control gear enclosures to deter thieves (e.g., internal hinges, protection covers for padlocks locks);
- Consideration of non-standard modules to lower their re-sale value (e.g., colour coding, 24 V modules);
- Maximising community involvement and access to ensure benefit from the system are spread across the community as much as possible.

Security at Mecuburi, Mozambique

For smaller systems, the measures outlined above are not practical, but simple steps can be taken, such as mounting the PV module in a location which is difficult to access or the use of barbed or razor wire. The use of micro-chips to allow a PV module to communicate with only one charge-controller has been used, although the effectiveness of this is not confirmed[16].

Generally, the higher the perceived value of the PV system to the community, the more effort the community is likely to put in to protect the system. Demonstrating the value of the PV system to the community may therefore be a good way to improve its protection.

[16] Shell/ESKOM RSA concession

3.9 Quality Assurance

Many PV programmes carried out in the past have to be considered as failures due to the fact that quality assurance aspects had not been given sufficient consideration. In order to achieve installations of the highest quality, and therefore a greater chance of medium- to long-term success of a programme, quality assurance measures must be implemented in all phases of implementation: the system design must be verified; it must be ensured that all components used are of sufficient quality; the workmanship of the installation work must be checked; and regular ongoing maintenance must be sufficient to ensure a long working life of the systems.

Quality assurance aspects need to be worked through in detail at the planning stage of a programme. If they are implemented as an afterthought, there are likely to be deficiencies in areas which are too far progressed to allow rectification, and the programme may therefore be stuck with a design or equipment of inferior quality. Also, the project will be more costly overall, as any problems and deficiencies found will have to be rectified, probably necessitating additional site visits and possibly also new or additional equipment.

In order to maximise the benefits, quality assurance aspects need to be designed into the overall implementation process. Quality assurance for a PV programme should broadly follow the same principles as, for instance, quality management systems in manufacturing industries. All processes should be documented in detailed procedures. As procedures are followed, all activities should be documented and the results of any tests performed should be recorded. An independent auditor should check the records periodically and verify that procedures are being followed correctly. The following example illustrates this in the context of a PV programme. For instance, it may be decided that a percentage of each major item of equipment should undergo testing prior to installation in the field. A test procedure should describe exactly what tests should be performed. All test results should be recorded, together with the serial number of the item tested. This will allow verification of the test by an auditor at a later stage.

Procedures should allow for rectification of anything which was not 'right the first time'. In a practical project, it is normal that things go wrong from time to time. It is important that any shortcomings and deficiencies are noticed and documented, and that there are mechanisms in place for them to be rectified at some stage in the project. Where appropriate, responsibilities can be split, for instance for installation and commissioning, which means that a second person verifies the quality of the work carried out by the first. For example, a subcontractor may carry out the installation. Once installation is complete, the contractor's representative carries out a number of commissioning checks and system tests, recording the results. Any problems are noted in a snag or punch list, and the installer then goes to the site again and rectifies the problems.

Lastly, it is usually essential to have some form of independent audit to ensure that procedures are followed correctly. This is vital, as people are likely to 'cut corners' for a number of reasons, such as pressures to finish on schedule, cost savings, adverse weather conditions (e.g. heat, rain), or just laziness. Audits should ideally take place during implementation, in order to improve processes where necessary, as well as after completion of all installations, to ensure that quality is consistent throughout the programme.

Quality assurance in PV programmes is dealt with in more detail in the other documents published by the PVPS Programme[17].

[17] IEA PVPS Report T9-04:2003 'The Role of Quality Management, Hardware Quality and Accredited Training in PV Programmes in Developing Countries' and the forthcoming IEA PVPS Task 3: 'Recommended Practices for Managing the Quality of Stand-alone Photovoltaic Systems.'

3.10 Information Management Systems

The use of computers, databases, and data storage techniques, combined with communication tools such as satellite phones and the internet, allow for better overview of a programme and better control during implementation. During the programme implementation phase, the regular collection of various data about costs, personnel hours, training needs, and time requirements can be tracked in a database to facilitate the smooth implementation of the programme. Information systems, however, must be workable in the region or area where the programme is implemented. There may be limitations on electricity supply and phones may not be available. Information systems must take these constraints into consideration. Satellite phones might be needed if conventional land lines are not available or are unreliable. Computer-based tracking may be unfeasible. In the case of each programme, administrators will have to plan for how best to communicate, and how best to collect and store data.

For most programmes, the use of an information management system (IMS) will be invaluable. What form this IMS should take depends on the nature and structure of the programme. For instance, a programme with a large number of systems implemented by one organisation will require a sophisticated IMS containing a considerable amount of detail, such as site data including contact details, details on the status of each installation, records of any 'snags' outstanding, etc. An organisation simply overseeing a programme where a number of installers act more or less independently is likely to require less detail.

It is advisable to design the IMS at an early stage of a programme. This will allow pre-implementation data, for instance from the needs assessment, to be incorporated. The IMS should be updated continually as information becomes available. It can serve as a useful tool for tracking aspects relating to quality control, especially for programmes with a large number of different sites. The option to expand an IMS should be kept open, in case it becomes apparent that the inclusion of further data would be of benefit. For programmes where the maintenance of PV systems is managed centrally, an IMS could provide a very valuable tool to manage ongoing maintenance, capture data from maintenance visits, and providing the complete history of each installation.

Global Positioning System (GPS) co-ordinates should be included in the IMS to help find remote sites. A GPS system will be of help in remote areas where maps are non-existent or inaccurate. The incorporation of an IMS into a geographical information system (GIS) should also be considered. There may be other relevant data available which would be useful for the PV programme. Examples include the location of the electricity grid when planning the geographical area of the PV programme, or other infrastructure available which may be necessary or useful during implementation or for maintenance (e.g. access roads, petrol stations which sell distilled water).

3.11 Provision for ongoing maintenance and replacements

Even the most carefully designed and installed PV system will need periodic inspection and maintenance and may be subject to breakdowns that will require service and equipment replacement. It is imperative that the programme design phase takes these service issues into consideration and takes them seriously. The questions which need to be considered are who will conduct on-going maintenance and who will conduct on-going monitoring and programme evaluation? If system components fail, how easily and how quickly can they be replaced? Are the parts manufactured and available locally, and is the quality acceptable? What financial provisions need to be made to allow for efficient and adequate maintenance and replacements?

Programme administrators should determine who will monitor the equipment and should plan to provide the appropriate training and tools. When possible, on-going maintenance and monitoring should be the responsibility of local personnel who will have a natural interest in the proper performance and maintenance of the equipment. Training local personnel to take care of the renewable energy equipment can create local jobs and develop an infrastructure that will support further renewable energy and social development.

4 IMPLEMENTATION PHASE

Once thorough programme planning is in place, with time lines, logistics, budgets, and team roles delineated, the programme is ready to be implemented. In the implementation phase, quality control and supervision are critical to ensure the desired outcome.

4.1 Quality control, management and evaluation

Even the best plans will be subject to contingencies and laxity. Shortfalls in production or quality, programme delays, or budget over-runs must be watched for and corrected regularly as the programme is carried out. During the team designation phase, some person or persons should have been identified as responsible for this. Specific time and budget control must be exercised by a recognised project authority. In addition, on-site monitoring of installation quality by persons with technical expertise is important. Programme administrators might plan a technical inspection by an expert at various key phases of installation.

Troubleshooting should be an integral part of the programme management. Where shortfalls or problems are found, the PV programme administrators should have a clear policy, known to all personnel involved in the project, for correcting the situation. This might be that all installation work that does not meet quality guidelines, when discovered in a regular inspection, will be re-done. Those responsible for the low quality work will be reprimanded in some way and remedial training or increased supervision will be provided. Enforcement of programme time plans, milestones, budgets, and quality guidelines should carry clear consequences. Personnel need to know in advance what is expected of them, and then need to know that they will be held to that expectation.

Continual programme evaluation should be used to identify areas where expectations may not have been in line with reality, and steps should be taken to adjust the plan. For example, if installer competence is found to be less than expected, remedial training may need to be written into a revised plan. Or if it is discovered that time expectations for the installation itself were too short, a revised time plan giving more accurate installation timing requirements will need to be developed. Regular reports, which may be required by financing or national authorities, can capture the progress of and make adjustments to the PV programme as required.

As with any plan, there will be numerous constraints in how flexible programme administrators can be in meeting contingencies and shortfalls. Creativity in adjusting timing considerations, dealing with budget shortfalls, or reacting to quality concerns may be necessary to juggle constraints in time and money available for the programme. Detailed programme planning in the design phase will help eliminate any major deviations from the programme plan during the implementation phase. Regular supervision and evaluation will help ensure quality and will prevent the programme from straying too far from its objectives.

4.2 Information Management System

If an IMS has been developed, it should be used to its full extent in order to maximise the benefits from it. Relevant information should be captured and entered into the IMS with minimum delay, to ensure that information is always as up-to-date as possible. Reporting functions should be incorporated into the IMS, and should be used for the logistics of the programme. An example would be to generate a report of all sites in a given district which require a visit by installation personnel, either for installation or for rectifying problems. These sites can then all be visited during the same trip, thus making the process more efficient.

4.3 Training / Capacity Building

In addition to training carried out during the design phase it is important that training should be on-going throughout the implementation and post-implementation phases. Personnel within the programme and stakeholder groups will change and needs not previously identified may be highlighted. An on-going training programme will ensure that the stakeholders continue to have the necessary skills and that the PV programme is sustainable in the long term.

5 MONITORING AND EVALUATION

This section deals with the programme monitoring and evaluation. Monitoring and evaluation should already start during the programme preparation and extend through to post-implementation. Even a thorough needs assessment and stakeholder consultation may fail to identify potential negative effects or challenges of renewable energy development. Therefore planning for on-going monitoring is important. Re-assessing the programme after its completion can also allow for unforeseen or unintended consequences to be identified and addressed. For some programmes, the post-implementation evaluation may be appropriate soon after completion of implementation; for others, the evaluation may be most appropriate after a period of a few years after installation.

5.1 Social, Economic and Environmental Impact Assessment

During implementation and after completion, an analysis of the impact of the programme on the target group is critical. Have users and other stakeholders reacted as early programme planning indicated? Is the PV technology creating the benefits anticipated? Have anticipated costs and challenges been accounted for?

Social and economic impact assessment involves follow-up with the programme results over time in order to perceive results that may occur as the stakeholders adjust to the new technology. The programme should be revisited, not just to evaluate its performance and quality, but also to look at how it has affected the lives of the stakeholders, over a time frame of at least a year following its implementation. The factors of social context analysis that occurred in the first phase of planning the programme (needs assessment, stakeholder consultation, and social context analysis) should be considered: Social status and interrelation systems, economic systems, family relationships, living conditions, working patterns, village and social interactions, purchasing patterns, and social values. Has the PV programme changed these variables? If so, how is the society responding? Does follow-up training or remediation need to be made?

Similarly, the environmental impact of the programme should be measured during implementation and post-implementation. For example has there been an improvement in the end-users environment? is the battery recycling scheme being used? or have there been any adverse environmental impacts that were not envisaged during the programme design?

5.2 Programme Evaluation

The programme should be evaluated against its projected targets and milestones as the project proceeds. Once implementation is complete the programme goals and objectives should be considered against the programme outcomes. At the beginning of the programme, metrics for the success of the programme should be developed using the goals and objectives of the programme. For example, the PV programme was undertaken with specific micro-level outcomes in mind. Solar Home Systems might improve family health by eliminating oil or kerosene lighting smoke, and increase people's quality of life by reducing the amount of money spent on traditional fuels. Or, basic lighting might allow students to study after dark, contributing more time to farming during daylight, thus increasing family income while simultaneously achieving educational goals. Or, basic lighting may allow a homeowner to take on small piece work and create a home business, increasing his or her standard of living.

Given the specific desired outcomes from the PV programme, the evaluation determines how and to what extent those goals are being realised. Measurements of community small business increases, income increases, agricultural output increases, educational opportunities, health improvement, or payment for services/repayment of loans can be made, depending on the specific outcomes desired, to demonstrate the success of the programme. Statistical surveys may need to be undertaken to assess the degree to which the PV programme has achieved desired micro-level benefits.

If technical problems are experienced a technical evaluation may be required. This would require technical experts to thoroughly inspect systems or inspect at least a sample of all systems installed, in order to assess technical failures or shortcomings, which might be due to poor system design, poor quality of components, poor workmanship during installation, or the use of inappropriate loads by the user.

Where the programme has not succeeded as expected, or where a programme has had unanticipated consequences, programme evaluation allows for the development of remediation plans that will improve these outcomes. For this reason, evaluation should occur as the programme is being implemented, and then over a given period of time beyond the completion of the programme installation. For example, evaluation measures can be taken six and twelve months after programme completion in order to verify and validate the programme results.

Programme evaluation will give a historical perspective on the results of the programme that will not only benefit the specific stakeholders of the programme, but also will aid administrators in planning future programmes. Consistent common planning failures, like over-ambitious goals or failure to take into account implementation constraints, can lead to public disaffection with PV technology. Inadequate programme preparation can be identified and improved planning can be implemented in future programmes.

Final evaluation should take into account the financial efficiency of the programme, the energy output of the programme, and the social performance of the programme. In addition, final evaluation should make judgements on programme significance and efficiency.[18] Assessing significance involves determining if the impact on the stakeholders was sufficient to merit the costs and effort involved in implementing the programme. Significance should be measured against the society's values and priorities in achieving economic growth and social development. Efficiency assessment relates to the relationship between the costs of the programme and the final significance of the programme's outcome. Could more significant results have been achieved through another approach? Or could a lower cost have been incurred through some adjustments?

[18] United Nations. Guidelines for Development Planning: Procedures, Methods and Techniques. (New York: UN) 1987. p94-95.

6 CONCLUSIONS AND RECOMMENDATIONS

The planning of a PV implementation programme is a fairly complex process. A large number of issues have to be taken into consideration, and many individual tasks are necessary. Neglect of some of these tasks may result in problems later on or, in the worst case, to failure of the programme.

This document lists issues to be considered which are typical for most PV programmes or projects. However, each programme is different, and special circumstances will require special consideration. Therefore it is necessary to assess the requirements of each programme individually.

During the preparation phase of a programme, it is essential to determine whether a programme fits into overall national goals and objectives. Needs assessment and stakeholder analysis should be carried out.

During the design phase, the programme is planned in detail. This includes financial, logistic, personnel and technical planning. During this phase, it is important that quality assurance aspects are incorporated into the programme design. Ongoing maintenance must also be considered.

During implementation, it is important to check progress, and to take corrective action if anything goes wrong. Programme evaluation should also take place, looking at the social and technical performance of a programme, measuring the results against the original objectives.