

# QUALITY MANAGEMENT OF STAND ALONE PV SYSTEMS: RECOMMENDED PRACTICES

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**ABSTRACT:** Task 3 of the International Energy Agency Photovoltaic Power Systems Programme focuses on stand alone PV and island systems. One of the main areas of work of Task 3 concerns the quality management of stand alone (and hybrid) PV systems. Task 3 Experts are currently preparing a document which sets out the minimum recommendations necessary to ensure the quality of a PV project. This paper summarises the recommendations.

**Keywords:** Stand alone PV systems, Quality, Implementation

## 1 INTRODUCTION

Task 3 of the International Energy Agency's (IEA) Implementing Agreement on Photovoltaic Power Systems deals with Stand-alone and Island Applications. Within this Task, Quality Assurance of PV systems is considered to be of special interest.

A strong emphasis on quality aspects is essential for the long term success of any PV project. However, stand-alone PV systems are frequently installed with little or no attention to quality issues. One of the main reasons for this is that the work required to implement quality procedures is perceived as being complicated and costly. Unfortunately, this perception gives rise to many project failures which are both costly and difficult to rectify.

A previous Task 3 study has shown that there are no QA guidelines specifically intended for managing stand alone PV projects [1]. Task 3 is therefore producing a set of QA guidelines for stand alone PV project managers. The document aims to provide simple but effective guidance in order to implement quality procedures within a realistic project timeframe. Implementing these procedures will be less expensive than solving the problems that result when quality issues are not properly addressed.

## 2 DEFINING ROLES AND RESPONSIBILITIES

### 2.1 The need for roles

An important aspect of quality management is to ensure that the roles and responsibilities of all participants in a project are clearly defined. The most common reason for an aspect of a project causing a problem is that all parties believed it to be someone else's responsibility. It is important to define each project role at the start of a project to ensure that all responsibilities are clearly allocated.

In general, the actors in a PV project can be placed into one of three categories: Financer, Implementer or User. For larger projects, an 'Expert Advisor' may also be needed to provide third party guidance to some or all of the actors.

The Implementer may consist of one organisation providing all of the services required. Frequently, however, it consists of a main contractor with subcontractors providing services such as installation or supply of equipment. In either case, the Implementer must fulfil the following roles: Project Manager, Logistics Manager, Project Engineer, Trainer, Supplier and Installer.

It is of utmost importance that a Project Manager is identified who will assume responsibility for the overall project design (technical and non-technical issues). This is necessary to ensure that somebody has an overview of the project as a whole and so can identify any omissions.

The Expert Advisor has a key role to play, which may often be overlooked. For example, it is possible for a client to go straight to a supplier without the need for a third party. However, as a supplier has an interest in selling their equipment, there is a need for a project to be checked by someone else in order to ensure quality.

An Expert Advisor is particularly important with programmes involving large numbers of systems, because various factors can be overlooked without an independent check and any mistakes will be duplicated many times. Independent external advice may also be required in other areas of the project, for instance to carry out quality control checks of installations, and to consider the non-technical aspects of the project.

Finally, there is frequently a need to provide suitable training for both installers and users. To ensure high quality training, it is recommended that all training bodies are accredited by an approved organisation. Further information on this aspect can be found in the literature [2].

Accredited bodies have a very important role to play in the assurance of quality. Their contribution may be required in the certification of training and testing. They must be able to provide documentation to demonstrate accreditation.

### 2.2 Defining system ownership

Different players can take on the ownership of a PV system, depending upon the type of project. However, for a PV project to succeed, it is essential that the system owners are given responsibility for the operation and maintenance of the system – this can then be sub-contracted out if necessary. This will help to ensure the long term sustainability of the project.

## 3 SUMMARY OF GUIDELINES

The guidelines define the main phases of a stand-alone PV project as well as the key players involved in each phase. Each project phase is described in terms of the documentation that should be provided and the quality issues that must be observed. In order to make the guidelines more generally applicable, a key has been used to separate 'compulsory' from 'recommended' guidelines. This paper highlights the importance of some of the key recommendations.

### 3.1 Documentation

Documentation is an important aspect of any quality assurance system. It ensures that all aspects of the project are recorded appropriately and that the necessary information is available for anyone needing to carry out work on the system at a later stage.

### 3.2 Project planning

The project planning stage defines the way in which the project is implemented. It is therefore essential that correct quality procedures are put in place at this stage of the project, as it is difficult to implement them retrospectively.

At the outset of a PV project, care should be taken to define the contractual responsibilities of all organisations involved in the project. Appropriate mechanisms should also be in place such that each organisation is answerable for any problems or defects arising from their work.

It is important to plan the project schedule very carefully and to continually update it over the course of the project. The staff required for each task should be identified and involved in the project at the correct time. If this issue is not considered, the entire project is at risk of being poorly designed. In addition, the level of competence of the staff and users should be assessed in order to prepare training courses adapted to them.

The planning team must define at the outset how the system will be maintained after installation, and who will be responsible for this task. It is also necessary to allow sufficient time in the project schedule to enable testing of components and to carry out the system design approval.

The planning team must define who will be responsible for the project after installation and, if possible, involve this person at the planning stage or at least prior to commissioning. It is important to ensure that the person responsible for the system maintenance can demonstrate a long term commitment to the project.

### 3.3 Financing

A financial analysis over the project lifetime should be conducted. It should assess whether the energy bill will cover the cost of the energy and also bring in enough money for maintenance, replacement of the batteries and other ageing components. The planning team must assess how the users will pay for the energy, and whether they will be able to afford it.

Provision of sufficient funding for the project must be secured, including hardware and installation costs as well as any related costs such as project management, independent external advisers, testing and training, or user-related activities. The budget should include an allocation to cover the replacement of components, as well as public liability insurance, monitoring and insurance against theft and damage.

In order to ensure the long term sustainability of any project, it is essential to ensure that sufficient budget is allocated for regular system maintenance.

### 3.4 System design

At the design stage, the quality aspects of all other stages of the project should be considered – it is impossible to ensure a high quality installation if the system is poorly designed and difficult to install.

Comprehensive plant documentation with details of all the components used should be prepared in order to

facilitate repairs or modifications at a subsequent stage of the project. A list of spare parts for all critical components should also be drawn up so that they are readily available when the need arises.

All components should adhere to current national and international standards. System design is also very important; it should be noted that individually certified components do not necessarily work together in a system. Standards should be followed where possible and relevant.

Components that have already been used widely with success in the field should be selected – the use of prototypes is not advisable. The use of locally manufactured components (charge controllers, lamps, batteries) should be encouraged, but compliance with relevant standards is necessary.

Site access should also be considered; it must be possible to deliver all components to site and store them appropriately. Lastly, due consideration should be given to system security, because theft of PV system components has been a common problem.

### 3.5 Logistics

Poor management of logistics can seriously affect the quality of a project. If components are not delivered to schedule and to the appropriate place, then time is lost which has to be regained later in the project. This can mean that crucial aspects of subsequent project stages are omitted, for example during system installation.



**Figure 1:** Incorrect storage of batteries

It is important to ensure that the delivery of system components is made at the correct time, and that adequate storage is available to protect components once on site. All components should be visually inspected on delivery. This is particularly important for batteries, for which polarity should be checked and voltage measured to ensure the integrity of all internal connections. Figure 1 shows an example of incorrectly stored batteries, from a recent project in Africa.

### 3.6 Training

Training is one of the most important aspects of ensuring the success of a project, and one that is often neglected.

Training of installers is essential to ensure that high quality systems are installed. It is important that they receive training appropriate to their needs and that the training is provided by an accredited institute, if possible.

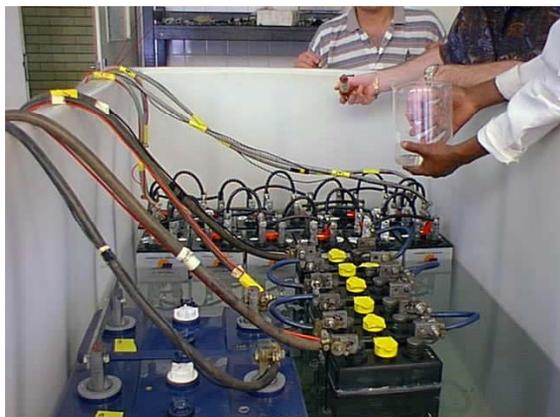
Training of users is necessary to avoid misuse of components, and to ensure that they get the best from their system. A key objective of this training is to reduce the energy demand of the loads. Where relevant, the users should be given guidance on how to finance their energy usage.

### 3.7 Quality Control

It is not possible to achieve a high quality system if it is based on low quality components. Fortunately, the quality of components is one of the easiest aspects of a project to control because there are a number of international standards that can be used to ensure this.

For small projects of one or two PV systems, all system components should be checked individually on delivery. For large projects (i.e. many similar systems), a check on around 5 % of system components selected at random should be made. The Quality Control procedures should be carried out by qualified staff, e.g. an accredited laboratory or individual trained by an accredited body.

When the PV systems are to be installed in large numbers and, in particular, when they are to be installed in remote locations, the components should be tested as per the system design. Acceptance testing of individual components should also be considered on large orders to ensure the equipment meets the specification. Figure 2 shows testing of batteries being conducted in Southern Africa.



**Figure 2:** Acceptance testing of batteries in Southern Africa

PV system tests should include the typical loads to be used on site. Consideration should be given to setting up a trial system for testing and troubleshooting of problems.

The PV module supplier may offer a performance guarantee which specifies how much power the modules will generate under local weather conditions. This can be a useful mechanism for ensuring the quality of the modules supplied.

### 3.8 Installation

The highest quality equipment and best system design will not function correctly if they are badly installed. It is important to define the contractual responsibilities for installation clearly, including warranty terms, in order to be able to identify the party responsible for any faults. The project manager should verify that the installation is carried out in accordance with the system specification, and that national and

international standards are followed. Figure 3 shows a poor quality installation observed in Morocco.



**Figure 3:** Poorly installed PV system

Competent and appropriately trained staff should carry out the installation work. A procedure should be written stating how the installation will be carried out, including attention to any necessary safety arrangements. This statement can be checked by an independent third party to ensure that the proposed procedures are appropriate.

### 3.9 Commissioning

Correct commissioning of a system is crucial to ensure that it is functioning correctly and that the installation team have fulfilled their obligations. The documentation of this stage is very important because it will be the first point to refer to if there are any problems with the operation of the system. Commissioning must be undertaken according to a pre-defined procedure and all checks, tests and measurements should be clearly recorded.

The person responsible for the commissioning of each aspect of the system should be suitably qualified, to a recognised standard if possible. A schedule of appropriate functional tests should be designed, which must be signed off by commissioning staff when all are completed satisfactorily.

Commissioning should be witnessed by an independent third party, and ideally it should be a PV expert. For larger projects, commissioning of a representative sample of installations should be witnessed. Random spot checks are also recommended to ensure consistent quality. Witnessing by the owner or user is also beneficial as it proves to them that the system is working properly. The system owner could be asked to sign in order to indicate acceptance of the finished system.

A diagram should be provided showing the system configuration and protection settings. This should also include contact details in case of faults with the system.

### 3.10 Operation and maintenance

Due consideration must be given to operation and maintenance. A system may be installed to the highest standards, but if it is not properly maintained there will be problems with its operation at a later stage. It is therefore important to ensure that sufficient budget is allocated for this purpose. The importance of regular system maintenance in order to ensure the medium to long-term sustainability of any project is often overlooked and cannot be stressed enough.

Responsibilities for operation and maintenance must be clearly defined. The system user or operator should be issued with comprehensive system documentation in the appropriate language. This should include a circuit diagram in an easily understood format, information on how to operate the system and basic maintenance procedures.

The users must be instructed in their training sessions on the basic operation of the system and on how to remedy minor faults. They should also be told how to get in touch with the maintenance staff and under what circumstances they should do this.

Users should preferably be involved in system operation, e.g. by checking battery voltage or water level, as this improves their understanding and care of the system. They should be instructed on how to recognise when components need to be replaced. This is particularly important for the battery. Instruction should also be given on how to dispose of the battery and battery acid. Depending upon the circumstances, it is usually advisable for battery replacement to be undertaken by a trained technician.

An operational plan and system performance analysis should be conducted for at least two years after installation in order to identify and rectify any initial problems. A log book of maintenance schedule, maintenance completed and components replaced should be made and updated regularly.

### 3.11 Warranties

A system would not be considered to be high quality unless the owner or user were offered a warranty, both for the components and for the installation.

The planning team must consider the necessary warranties for the system components and identify who will be responsible for these warranties. Installation warranties are also recommended. One specific problem with component warranties is that they usually cover the cost of a replacement part, but not the cost of labour for a technician to fit the part. This should be allowed for in the project budget.

The procedure for reporting component failure and making use of warranties should be clearly defined. If the user does not have the means to make claims, any warranty is effectively useless. Therefore, the user's ability to report faults should be considered and suitable mechanisms for reporting should be devised. A performance guarantee should also be provided, if possible.

### 3.12 Safety

Safety regulations are country specific and the project manager should always ensure familiarity with the regulations applicable in the project country. Procedures should be put in place to ensure that throughout the project all members of the team conform with safety regulations and show due regard for the health and safety of all other staff and the public.

### 3.13 Post project evaluation and monitoring

Continuous improvement and learning from past projects is an important part of any quality system. It is therefore recommended that a system evaluation is carried out after a substantial operational period when it is possible to make a realistic assessment of whether the system meets the user's requirements.

An essential element of the post project evaluation is an assessment of the performance of the PV system. The overall system quality and long term performance can only be assessed by carrying out monitoring [3].

It is also useful to carry out a post project evaluation of the financial aspects of the project. This enables the project designers to assess the financial sustainability of the project.

Lastly, an assessment should be made of system utilisation and load growth. This provides useful experience for the design of future projects.

## 4 CASE STUDIES

The second part of the guidelines presents a selection of case studies from the participating Task 3 countries. The case studies show how the QA aspects of a variety of different stand-alone PV projects have been managed. In particular, they highlight the lessons that have been learned from the implementation of these projects.

## 5 CONCLUSIONS

The Task 3 QA guidelines will provide a useful resource for project managers and engineers working on stand alone PV projects. Implementing the guidelines will greatly improve the quality and success of installed projects.

A Quality Assurance approach allows control of the quality of a project by systematically implementing such actions as required for prevention, verification, validation and traceability. It also enables evidence of all actions to be provided to system owners and users.

To guarantee the quality level of an installed system each party must have a contractual responsibility: from the identification of energy-service requirements, through to installation, operation and maintenance activities. In addition it is important that the owner or operator of a stand-alone PV system has a vested interest in the project, in order to ensure the correct planning and continued maintenance of the system.

Finally, the importance of education and training in the assurance of quality must be emphasised. The user must be educated regarding technology options, limitations and capabilities, as well as understanding basic maintenance requirements.

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[1] 'Survey of national and international standards, guidelines and QA procedures for stand-alone PV systems' IEA Task 3, [www.task3.pvps.iea.org](http://www.task3.pvps.iea.org)

[2] ISP Global Training Accreditation and Certification, [www.ispq.org](http://www.ispq.org)

[3] 'Guidelines for monitoring equipment and protocols for SAPV systems', Task 3, to be published end 2003