IEA INTERNATIONAL ENERGY AGENCY

The Role of Quality Management, Hardware Certification and Accredited Training in PV Programmes in Developing Countries

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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International Energy Agency

Implementing Agreement on Photovoltaic Power Systems

Task 9

Deployment of Photovoltaic Technologies: Co-operation with Developing Countries

The Role of Quality Management, Hardware Certification and Accredited Training in PV Programmes in Developing Countries

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

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

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

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

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. This report has been prepared under the supervision of Task 9 by:

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The views expressed in this paper represent a consensus of opinion amongst the Task 9 experts. This document is one of a series being published by Task 9. The complete series of documents comprises:

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

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

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

KEYWORDS

Keywords: developing countries, photovoltaic, PV, renewable energy programmes, rural electrification, training, accreditation, certification, workforce development, quality assurance, quality management systems.

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ABBREVIATIONS AND ACRONYMS

ASTAE	Asia-Pacific Alternative Energy Unit of The World Bank
BOS	Balance of System
CENELEC	European Committee for Electro-technical Standardisation
DAC	Development Assistance Committee
DfID	Department for International Development
IEEE	Institute for Electrical & Electronics Engineers (USA)
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IECQ	International Electrotechnical Commission Quality Systems
ISO	International Standards Organisation
ISP	Institute for Sustainable Power, Inc.
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
PV GAP	Global Approval Program for Photovoltaics
PVPS	Photovoltaic Power Systems Programme
QMS	Quality Management System

SCOPE AND OBJECTIVES

This document provides an introduction to the issues of Quality Assurance, as they relate to what should be addressed during the planning and implementation stages of a large-scale photovoltaic (PV) implementation programme. Quality Assurance activities are important in ensuring that a long-term sustainable PV market is established.

This document covers issues relating to Quality Assurance in the following areas:

- The need for quality in PV and rural electrification
- Quality Management
- Hardware Quality: Certification of Products
- Training and Practitioner Quality: Accreditation and Certification

The objective of this document is to provide assistance to those project developers that are interested in implementing or improving support programmes for the deployment of PV systems for rural electrification, and to enable them to address and implement quality assurance measures throughout all aspects of a programme. It is aimed in particular at bilateral donor agencies and multi-lateral agencies, but also at other international, national, regional financing organisations, development agencies and project developers.

Whilst the emphasis of this is on management, technical and training issues, the authors fully recognise that these are not the only factors to be considered for the sustainable implementation of a rural electrification programme. It is important that quality, in its broadest sense, also addresses the socio-economic and the socio-technical aspects of a programme concept and that practitioners must be fully aware of these issues.

EXECUTIVE SUMMARY

With the increased emphasis on the role of electricity in rural development and poverty alleviation, it is very important that future PV-based rural electrification programmes are seen to bring real benefits to rural communities in developing countries. Many previous projects have not met with the degree of success they might have because of a lack of quality at some point in the delivery chain. This lack of quality has been seen at all levels in the implementation process – be it a lack of competent personnel within an implementing agency, a lack of well trained installation and maintenance technicians or poor hardware quality.

By imposing a quality remit on an implementation programme, the likelihood of a project's success can be substantially enhanced. It is generally acknowledged that recognised standards lead to increased quality of a given product. However, the issue of quality assurance goes beyond compliance with technical standards. In order for a PV implementation programme to be successful, it needs to be designed with quality assurance in mind throughout the implementation process, not just when hardware is procured. Quality assurance has important implications for, inter alia, programme design, selection of equipment and supplier, checking compliance of systems/components delivered, installation and commissioning, ongoing maintenance, and training of personnel at various levels.

For a PV implementation programme, or indeed any rural electrification programme, there are three important areas of quality control:

- quality management – which covers the operational procedures of the organisations involved – from PV system installers and hardware suppliers to technical consultants, financiers and service providers.
- technical standards – compliance with technical standards provides a degree of assurance that components and systems meet agreed performance criteria
- quality of training – ensures that system design, installation, commissioning and maintenance personnel have been trained to an agreed level of competence.

A requirement that recognised levels of quality are maintained in each of these three areas will help to ensure the success of a programme. Furthermore, the use of quality management systems, certified components and practitioners and accredited training programmes is of direct benefit to all the stakeholders in a rural electrification programme. The spin-offs of this improved reliability have repercussions throughout the length of the supply chain and impacts on every stakeholder within the programme, as well as within sectors that have yet to fully recognise the market potential that PV technology represents.

1 INTRODUCTION

In spite of good intentions, many programmes implementing photovoltaics (PV) in developing nations have failed in one way or another, and only a very few, if any, programmes can be regarded as all round success stories. A large number of failures can be attributed to lack of quality, both in terms of components and installation quality as well as in the organisation and management of implementation programmes.

It is generally acknowledged that recognised standards lead to increased quality of a given product. There is an array of national and international standards relating to the technical aspects of the various components of a PV system, which are summarised in a recent report of Task 3 of the IEA's PVPS Programme[2]. The standards have been developed mainly through the International Electrotechnical Committee and until recently have concentrated mainly on PV modules and measurement devices/procedures. Standards for other components are only becoming available slowly, and standards relating to systems as a whole are still in the early stages of development. In order to expedite this process, 'interim' or 'recommended' standards, practices and guidelines are being developed through other organisations such as PV GAP and IEA PVPS Task 3, although even these alternatives have not been as fast as envisaged.

The absence of recognised standards should not be used as a justification for cost saving on hardware through the selection of low-quality components – this is always a false economy. Life cycle cost analysis should be used in order to select components whenever possible and stakeholders should be encouraged to use this approach. Such an analysis must include all costs including hardware, installation, maintenance and replacement of components according to a realistic estimate of their lifetime.

However, the issue of quality assurance goes beyond compliance with technical standards. In order for a PV implementation programme to be successful, it needs to be designed with quality assurance in mind throughout the implementation process, not just when hardware is procured. It is also important to consider the socio-economic impacts of any programme and how full end-user participation can impact on the success of a programme.

The aim of any quality assurance system is to ensure that quality is consistent and of a certain defined level, thus ensuring that the end-user gets a functional PV system which has a reasonable life expectancy, and the funding agency gets value for money. The value of a quality assurance system is in improving the repeatability of an organisation's processes. The basis of any quality management system is a documentation trail; regular feedback from employees, customers, and suppliers; and, the recognition by customers, partners and clients of the value of the organisation's adherence to a set of recognised quality standards.

As the market for PV systems grows, the availability of a quality framework for hardware systems, hardware components, the accreditation of training providers, and the certification of PV practitioners to objective quality standards is becoming increasingly important. A broadly recognised quality management system for PV which is independent of any particular PV programme will have a number of benefits. It will allow finance and donor organisations to more easily assess the risks in financing or funding projects; it will provide clients with a tool to evaluate potential systems, contractors, and training providers; it will provide companies with a metric for evaluating potential hardware for purchase and candidates for jobs; it will assist manufacturers in assessing their products against objective

[2] Survey of National and International Standards, Guidelines & QA Procedures for Stand-alone PV Systems - available on the Task 3 website (http://www.task3.pvps.iea.org)

standards; and it will assist training bodies in evaluating their programmes against objective standards.

There are three main aspects where compliance with agreed standards and norms can help to ensure the success of a PV-based rural electrification programme and re-assure the programme stakeholders that it will have the desired outcomes.

Firstly, the implementation of a recognised and documented quality management system can provide re-assurance to others (clients, customers, suppliers) outside the particular organisation. When the quality management system is certified to an acknowledged international standard, such as ISO 9001:2000, then that re-assurance is further strengthened.

Secondly, the requirement that components and systems meet internationally or nationally recognised standards or norms provides a degree of re-assurance as to the quality of those systems and components. This is particularly important in off-grid rural electrification programmes, as there are many different stakeholders from many different sectors, many of whom are not familiar with PV technology. However, it must be recognised that standards only stipulate minimum requirements for a component or a system. They can become out-dated by technology advances, particularly for high-tech electronic devices – this is further exacerbated by the lengthy approval process.

Thirdly, the requirement for trained and certified design, installation, commissioning and maintenance personnel will ensure that they are competent to undertake the tasks assigned to them in a professional and diligent manner. The control of training programmes that are offered, both under specific programmes and more generally, needs to be ensured through an independent accreditation process, such as that promoted by the World Bank[3].

[3] Quality Programme for Photovoltaics (Quap-PV) http://www.worldbank.org/astae/quappv/

2 WHO BENEFITS FROM QUALITY MANAGEMENT AND COMPLIANCE WITH STANDARDS?

The use of quality management systems, certified components and practitioners and accredited training programmes is of direct benefit to all the stakeholders in a rural electrification programme. This benefit primarily arises from the improved reliability and performance of the PV system and in particular the reduced maintenance requirements and costs, though there are additional benefits from the creation of local, sustainable jobs. The spin-offs of this improved reliability have repercussions throughout the length of the supply chain and impacts on every stakeholder within the programme. An outline of how these impacts are felt by the various stakeholders is given in the following sections.

2.1 Finance Sector

The finance community is understandably risk averse and seeks to minimise its exposure to high risk investments as much as possible. The fact that PV is perceived as a new, high risk technology means the finance sector starts from a position of caution when considering investments in the technology or in companies selling the technology. Furthermore, the target market for the technology is the rural poor in remote parts of developing countries who have little or no collateral to provide against a loan. These two facts mean that it is extremely difficult to raise finance for the purchase/supply of PV into this market.

However, the recent recognition that energy has a pivotal role to play in helping to meet the millennium development targets[4], will result in an expansion of renewable energy-based rural electrification. In the light of this, increasing pressure will come to bear on the financial sector to play its role in the provision of modern energy services.

In its turn, the finance sector will seek to protect itself from the perceived increased risks. Quality management systems are important in providing a basis for conventional risk analysis in evaluating loans and investment opportunities for PV equipment and PV implementation projects. The finance sector will look to the PV industry overall, or to national governments, to provide a qualifying framework, either through licensing or certification of hardware, training, and practitioners. Such a framework will allow them to evaluate the qualifications of organisations or individuals requesting funds, receiving funds, or installing the equipment and systems provided with the funds. The concern of the finance community is that, if the systems cease to function, the owners might refuse continued payment[5]. As the finance organisation does not want to repossess the equipment, it wants to ensure that the systems perform as expected at least until they are fully re-paid.

Typically, the finance professionals involved in making loans are not experienced in technical matters in general, and are certainly not experts in PV. They rely mainly on external consultants, but also on documentation on an individual's, an organisation's, or the equipment's qualifications in their assessments. Without such documentation, it is difficult for the financial professional to approve loans.

For development organisations providing financing and funding, there may be technical experts available as well as managerial, economic and social experts. However, even experienced professionals may not be able to accurately evaluate the capabilities of those individuals or organisations requesting support and funding or the quality of PV equipment

[4] *Energy for the Poor: Underpinning the Millennium Development Goals* published by DfID, August 2002.

[5] It should be noted that technical failures are not the only reason for non-payment of loan installments or service fees. However, if a system ceases to operate and is not repaired promptly, it is inevitable that any payments from the end-user will be very difficult to collect.

proposed. A qualifying certificate can help in the selection of a contractor but it is important to recognise that contractors should be assessed against a range of relevant criteria.

2.2 Government Ministries

In many countries, there are a number of government ministries involved with the planning and implementation of rural and remote energy installation and infrastructure programmes. These might include ministries with responsibilities for the following: energy, trade, finance, environment, education, employment, planning, military, economic and social affairs, education, and health. Either directly or indirectly, these ministries are responsible to those supplying the funding, and to the beneficiaries of the programme plans. In order to better ensure the success of programmes they manage, they should include requirements for certified hardware, accredited training organisations, and certified practitioners in the terms of reference for their programmes.

In order to ensure that these requirements can be met, it is important that an infrastructure for quality control is established and – when necessary – subsidies provided to lower the high up-front costs of establishing such an infrastructure. These subsidies may be required to assist small local manufacturing and installation companies to develop quality management systems, particularly if they are made a requirement for accessing donor funded programmes. Training on quality control issues and the promotion of approaches focussed on quality help to promote the sustainable implementation of rural electrification/development programmes.

This infrastructure not only provides greater assurances of the success of projects, but it provides a means to encourage local development and support the creation of sustainable local jobs within the context of the social requirements and needs of the local communities. Specifying the requirement of quality hardware, training, and practitioner systems as a project component provides longer-term local benefits.

2.3 Service Delivery Chain

While quality management systems for products and practitioners in the service delivery chain will inevitably represent an added cost, it must also be viewed as a source of benefit.

Using products of recognised quality and consistency from manufacturers using quality management systems can improve system reliability, reducing the frequency and expense of maintenance calls; it can assist in relations with the manufacturer, providing for a better working relationship and product/delivery quality based on experience; and it can improve customer satisfaction, providing reliable systems that perform as expected and encourage interest by a larger customer base.

In addition, using installation and maintenance practitioners that are certified to recognised knowledge and skills competency standards provides a number of clear benefits. One benefit is that a practitioner is more likely to properly and safely install the system, reducing the potential for system failures and improving customer satisfaction. In addition, as the direct interface with the customer, the certified practitioner will be better able to provide customer education on the uses and limitations of the system and the customer-dependent maintenance issues. The certified practitioner will also be able to most efficiently evaluate, troubleshoot, and provide maintenance on a wider range of potential systems failures.

For the employer in the service delivery chain, having access to certified hardware allows for an equitable means to evaluate purchases and to plan and budget for the terms of any maintenance or warranty work. And, when considering potential employees, having a certification available provides a means to evaluate the skills of the candidates in a more objective manner and, by pre-qualifying employees, may reduce the need for companies to provide extensive and expensive training.

Finally, companies in the service delivery chain have a commercial advantage in the market if they are able to demonstrate their adherence to quality management systems and their use of certified equipment and personnel. Large programme sponsors, government agencies, and organisations such as utilities are likely to appreciate and understand the value of quality management systems when considering procurements.

2.4 Customers

Ultimately, the customer is the one most directly affected by the use of quality management systems, or the lack of them, and is the least able to access alternative means of assessing hardware quality or practitioner competency. If the customer's system fails, it does not matter whether it was due to incorrect operation, poor quality hardware or poor design, installation, and maintenance; all the customer knows is that the system does not work. If the system fails, the customer may lose the investment made in the system or may cease to make instalment payments. Without some means to qualify the hardware or practitioners, customers are left to decide based on the best marketing or the lowest price, neither of which is a good way to ensure a reliable and cost-effective system. With a quality management systems framework in place, though, manufacturers are encouraged to improve the quality of their products, and practitioners are encouraged to improve the quality of their work, just to compete in a market where the customers have the tools available to make informed decisions.

3 QUALITY MANAGEMENT

3.1 An Overview of Quality Management Systems

While quality management systems and continuous quality improvement are often associated with large organisations that have substantial resources, they are just as important for small businesses with few employees. Quality management systems often simply document and formalise the work processes which are already in place in an organisation. The implementation of a quality management system can be a daunting task and small companies will need assistance to do this – both in terms of resources and expertise. It is also not an instant process – to implement such a system can take a number of years and this may be a significant handicap in the implementation of quality management systems within development aid projects.

The development of a formal quality management system requires the participation of all employees involved in the aspects of the business that affect the ultimate quality of the products and services. They must feel ownership in the process if it is to succeed. In addition, it requires a commitment on the part of the senior management—not just a hollow dictate to create a document that has no use or relevance. Without the mandate and full support of the senior management for the implementation of a quality management system, the work in developing the system will be a wasted exercise.

For a quality management system to succeed, it must extend beyond the immediate scope of the organisation and include its customers as well as its subcontractors and suppliers. A quality management system that is certified to the ISO 9001:2000 standard imposes the requirement for using pre-approved contractors and suppliers in order to extend the quality obligation one step further down the supply chain. The quality management system should include communication with customers in order to identify their requirements with regards to the product/service, delivery and maintenance/service needs. For suppliers and subcontractors, it is important to assess the quality of the products and services they supply as well as their quality management systems, to ensure accountability for the quality of their products and services.

The implementation of a recognised quality management system, along with using product standards and best practices taken from the industry, will lead to increased national and international business opportunities. A recognised quality management system can provide an entree to new customers, along with the potential for new financing options. Perhaps most important, though, it improves the efficiency of the business and the reliability of the products and services, leading to increased profits and additional opportunities.

<u>What is a Quality Management System?</u>

A quality management system provides a framework within which an organisation operates and against which its performance can be assessed. A quality management system provides an organisation with important tools to assist it in improving its internal systems for manufacturing products or providing services.

By providing a mechanism for continual assessment, processes within an organisation, be it a manufacturing process or an installation process, can be checked for consistency, quality of results, and success of continual improvement procedures. Furthermore, the quality management system ensures that the documentation necessary to evaluate any portion of the process is available and, more importantly, auditable.

In general a quality management system involves:

- a documented way of working within an organisation that is understood by everyone involved, from the most senior manager to the newest employee;
- a system of documenting development efforts, work procedures, work performed, testing, modifications, customer feedback, etc.;
- regular reviews and evaluation of critical aspects of the organisation and the quality management system itself;
- using results of reviews and customer feedback to improve the quality of the organisation's work.

Benefits of a Quality Management System

Working to a quality management system has a number of benefits for the organisation, its clients and suppliers. A documented quality management system, meeting recognised standards:

- demonstrates an organisation's commitment to quality;
- helps to have a better focus on business objectives and customer expectations;
- leads to better quality products and services;
- indicates consistency and efficiency of work processes;
- provides a solid foundation for continuous improvement;
- improves the performance of the organisation and hence leads to a more competitive business;
- encourages customer confidence in the quality of the products and services provided by the organisation;
- encourages investor and financier confidence;
- potentially opens up access to more markets.

Implementing a quality management system provides a level of rigour and discipline necessary for continual improvement and validation. It provides an organisation with the opportunity to identify system inefficiencies, track and correct deficiencies, and continually improve the manufacturing, delivery, training, service, and maintenance processes, all with the potential to reduce the organisation's costs and significantly improve its profits and product/service quality. Apart from improving business practices, implementation of a quality management system can also provide a competitive advantage through the recognition by customers of the advantages of doing business with an organisation that has implemented such a system.

What a Quality Management System does not do

While a quality management system provides many benefits, it is not a quick solution to all problems and does not, in the first instance, guarantee high quality products.

It is only a means and a tool and cannot take the place of good management and planning. It is important to be aware of the following:

- A quality management system, by itself, will not automatically lead to improvements or high quality products or services;
- Quality management system standards should not be confused with product standards;

- Implementing a formal quality management system may result in a greater administrative burden – it is important not to let his happen;
- A quality management system is a tool that should build on the systems and procedures that are already in place in an organisation.

Commitment to Quality

A clear commitment to quality is essential for an organisation to maximise the benefits of implementing a quality management system. A formal, written quality policy should have the backing of the most senior management. The quality policy should:

- Confirm the organisation's commitment to quality;
- Identify what the quality objectives are; and
- Establish how the objectives relate to the customers' expectations.

To be most effective, there should be a single manager responsible for the quality management system, reporting directly to senior management. This manager must have the seniority, authority and responsibility to develop, implement, and maintain the quality management system and its documentation. This manager is also responsible for ensuring that all employees are familiar with the quality policies and their implementation.

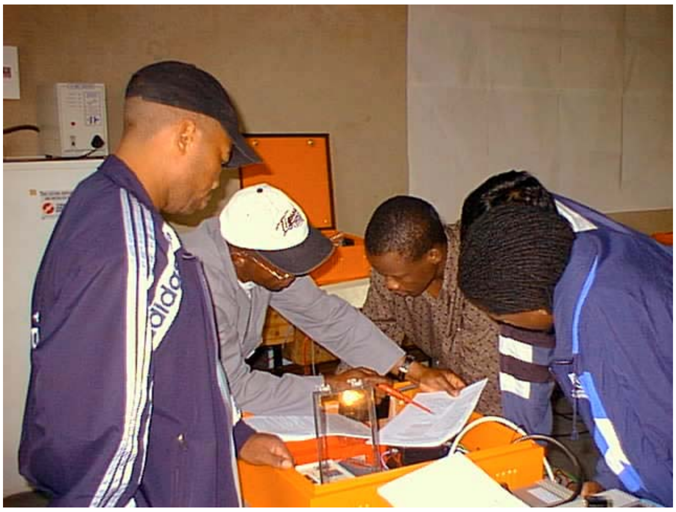
Documentation

The core of a quality management system is the Quality Manual, which details the procedures and practices and against which the company's activities must be measured. Regular internal audits are necessary to ensure that the practice and the spirit of the quality management system are maintained.

It is important that the organisation documents every aspect of its activities and the feedback and comments from its customers and clients. The Quality Manual should be reviewed and updated on a regular basis, and this process should be documented. All aspects of personnel activity and management should also be documented, included hiring of personnel and services, training, skills, experience, and any employee actions or sanctions.

Continual Quality Improvement

To ensure that the work of the company is current and of the desired quality, it is necessary to perform internal audits and regularly solicit customer/client feedback. With information gained from these, the procedures and practices of the organisation should be reviewed and adapted, where necessary. The organisation's management should be kept informed and involved in this process.



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All staff must be involved in, and committed to, any quality management system.

Staff Training

An important aspect of a quality management system is ensuring that the staff within an organisation are competent to undertake the tasks assigned to them. This can be achieved through an on-going system of regular assessment of training needs, management commitment to provide necessary training for staff, and documenting training activities undertaken by staff.

Certification

Organisations may have their quality management system certified in order to add credibility. This means that an independent auditor will carry out an audit on an organisation's quality management system, including its Quality Manual, quality procedures, internal reviews, etc.

The elements outlined above reflect the essentials of the ISO 9001:2000 standard.

3.2 Quality Management Systems Development

Implementation of a Quality Management System

The development of an approved quality management system involves a feed-back process of continual assessment, documentation, validation, and revision. The development process may fall into three broad areas:

- Review, assess, and document the organisation's practices and operations;
- Develop and implement the quality management system;
- Evaluate and continually improve the quality management system.

The key to developing a successful quality process programme is to involve all employees in the development activities. These are the people who do the work on a daily basis; they are the people who are most familiar with what works and what doesn't; and, they are the people who will be responsible for carrying out any new policies, procedures, and documentation practices.

Preparation for Implementing a Quality Management System

Before pursuing a full quality programme, it is prudent to analyse the requirements of implementing a quality management system (i.e. staff time, consultant time, cost of auditing, etc.) and weigh them against the potential benefits (e.g. easier access to credit, easier access to tenders/solicitations, reduced costs of manufacture/training, reduced costs of service/maintenance/warranty, greater product/service quality/reliability, greater control of business activities, etc.). If the benefits sufficiently outweigh the costs, then proceeding with the implementation of a quality management system follows a number of steps that will vary in relation to the overall complexity of the business.

Review of Current Practices

First, it is best to review and document the purpose of the organisation, its products and services, and the processes currently in place to develop and deliver those products and services. From this initial assessment may come a sense of the importance of instituting a formal quality management system, an understanding of how much of such a system is already in place (formally or informally), and how much effort it might take to develop and implement such a system.

Determination of Resources and Expertise Required

The next step could be the choice of how to approach the development and implementation of such a system. An organisation might well choose to develop a quality management system with in-house resources. In this case, it would be a good idea to identify training courses, seminars, and computer software packages that could be helpful in developing the appropriate expertise. Another option would be to bring in a consultant experienced in the development of quality management systems. Either way, the bulk of the development work will (and should) be the responsibility of the staff of the organisation, as they will ultimately have to implement and work with the system.

Development

If not already in place, it is critical that the organisation identifies a management representative with the appropriate skills and level of authority to take responsibility for the development and implementation of the quality management system.

Any existing documentation which is relevant to a functioning quality system has to be identified and collected. This includes job descriptions (not idealised descriptions often used in job adverts, but descriptions from the employees describing their job activities); equipment inventories; any operational procedures used, and operations manuals; maintenance records; training programme materials; training records; forms (tracking, purchasing, contract, inventory, safety, etc.); warranty documents; warranty/service histories; etc.

The assembled material can then be assessed to determine what exists and what needs to be developed. It is important to involve employees at all levels of the business operation that have an impact on the quality of the company's products and services, and will be affected by the implementation of the quality management system. Finally, it is important to work with the organisation's customers to identify any additional requirements that they might have.

Requirements for a Quality Manual

To establish a quality management system requires that the organisation develops a Quality Manual, which either includes the organisation's quality management system procedures or identifies where they are located. This requires that the organisation establishes a quality management system, write down what the organisation/employee does in each step of the production/testing/training process, and makes sure that that documentation is kept up to date.

The requirements for the contents of an organisation's Quality Manual, as part of its Quality management system, include the following:

- A Quality Policy Statement, signed by the most senior manager or executive;
- A brief description of the legal status of the organisation, including the names of the owners, if applicable, and if different, the names of the persons who control it;
- The names, qualifications, experience, and terms of reference of the senior executive and other key personnel influencing the quality of the administrative functions;
- An organisation chart, showing lines of authority, responsibility, and allocation of functions stemming from the senior executive;
- A description of the organisation, including details of the management (committee, group, or person), its constitution, terms of reference, and rules of procedure;
- The policy and procedures for conducting management reviews;

- Administrative procedures, including document control;
- The operational and functional duties and services pertaining to quality, so that the extent and limits of each person's responsibility are known to all concerned;
- The policy and procedures for the recruitment and training of personnel and the monitoring of their performance;
- A list of subcontractors with an impact on the organisation's quality management systems, and details of the procedures for assessing, recording, and monitoring their competence;
- The policy and procedures for administering the work and quality processes;
- The policy and procedures for dealing with appeals, complaints, and disputes; and,
- The procedures for conducting internal audits (based on the provisions of ISO 10011-1 or other relevant documents)

3.3 Certification of a Quality Management System

In order to obtain certification of a quality management system to ISO 9001:2000, an external audit of the organisation's quality management system must be undertaken by a qualified auditor. The audit will assess the different aspects of the organisation's quality management system, and whether the organisation complies with the requirements of ISO 9001:2000. Following certification, an annual surveillance audit is required.

3.4 Encouraging the Adoption of a Quality Management System

It is of no doubt that implementing a QMS in an organisation has a quantifiable cost, and that many small companies in developing countries will not have the expertise or inclination to adopt such a system. It is all the more difficult to justify the cost of implementing such a system when the benefits are less easy to quantify. No small or medium-sized company will install such a system voluntarily when there is no obvious guarantee the investment will be re-paid.

However, should companies be required to operate a documented QMS in order to participate in tenders, or should they gain preferential scoring in tender evaluations, the situation will change. Furthermore, in order to encourage implementation of a QMS, donor agencies should consider supporting capacity building activities in this area.

4 HARDWARE QUALITY: CERTIFICATION OF PRODUCTS

4.1 The Benefits of Product Certification

Photovoltaic technology is commonly regarded as being technically mature and operationally reliable. However, this is only really true for applications in industrialised countries with high quality products and efficient after-sales service in place. Implementation of PV (both Solar Home Systems and other applications) in developing countries often lacks reliability in certain components, mainly batteries, lamps and charge controllers, and especially so if these are locally manufactured. Malfunctioning systems, however, lead to higher operational costs, reduce the confidence of end-users in PV technology and ultimately their willingness to pay. It is important that project designers realise that the lowest initial investment costs may be a more expensive option in the long run. It should also be recognised that many difficulties encountered with PV technology in developing countries result from problems of a non-technical, or social, nature. It is important that both the technical and non-technical problems are addressed together and not in isolation.

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Solar simulator for flash testing of PV modules

Furthermore, by minimising technical and social risks, the commercial risks for both suppliers and end-users can be reduced. The use of high quality components coupled with well trained system designers and installers can substantially reduce commercial risk, as quality installations are likely to afford greater end-user satisfaction. The use of warrantees/guarantees and service and/or maintenance contracts can also provide further protection to the end-user[6].

One of the most effective ways of reducing technical risk is through the use of nationally or internationally recognised standards. Although the use of PV modules certified to international standards IEC 61215/61646 is becoming increasingly commonplace, the lack of international standards on balance-of-system components makes their specification and selection more problematic. There are a number of activities underway to address this absence – IEC Technical Committee 82 is currently developing a number of standards relating to PV components and systems, as is the Global Approval Programme for PV (PV GAP).

In the absence of a comprehensive suite of IEC standards, a number of organisations are developing a series of 'interim standards' which are designed to either be recognised by the IEC or superseded by IEC standards when these have been agreed, and a number of national programmes are developing national or regional standards.

[6] More direct protection against commercial risk is essentially a function of the deployment model used – cash sales, credit/leasing, service provision etc, as well as the details of the delivery/supply chain. A number of programmes have considered ways to minimise the commercial risks inherent in delivery of PV technology in rural areas of developing countries.

4.2 Standards, Guidelines and Recommended Practices

An in-depth survey of standards and guidelines relating to stand-alone PV systems was undertaken by Task 3 of the IEA PVPS programme[7] and is available from the IEA PVPS website.

Standards are widely recognised and utilised throughout the world, primarily as a means of ensuring that products are independently tested and certified to agreed norms. This process provides a level of assurance that a certified product will perform according to these norms. Within PV technologies, many standards have been developed under the auspices of International Electrotechnical Commission (IEC), although a number of national standards bodies have been very active in this area.

Within the IEC, Technical Committee 82 (TC82) generally develops standards related to PV. However the vast majority of these standards are concerned with PV module technology, safety and labelling, and performance measurements. There is only one published standard relating to other system components, which is concerned with efficiency measurements for the efficiency of power conditioners for stand-alone and grid-connected PV systems. TC82 is beginning to address components such as charge controllers, inverters, water pumps etc, but the process of developing international standards is lengthy and it will be some time before these are published. Unfortunately there are, as yet, no IEC standards relating to system design or installation procedures, or socio-technical or socio-economic issues.

The IEC has published a Publicly Available Specification (PAS) on renewable energy used in rural electrification, which includes some references to PV[8]. It should be noted that this document is not an IEC standard, but an industry specification.

There are a number of national standards relating to stand-alone PV system design published by the Japanese Industrial Standards Committee. Two Australian standards provide guidelines for the installation, maintenance and safety of remote power systems, and include PV systems.

There are numerous IEC standards dealing with batteries in general and are relevant to PV. These cover general requirements, test methods, dimensions and safety aspects for lead acid batteries. However, only one of the available standards deals specifically with batteries for PV systems. This document is a general standard covering basic functions, (i.e. capacity, cycle and mechanical endurance) and methods of testing. It does not cover battery sizing for PV systems, or methods of battery charging. The battery is still weakest component in a PV system and it is important that an internationally accepted standard is developed for battery qualification[9].

There are however a number of national standards and recommended practices (Japan, IEEE France, Australia, Canada) relating specifically to batteries in stand-alone PV systems.

In the absence of a comprehensive suite of internationally recognised standards, many countries have developed their own national guidelines, recommended practices and specifications. A number of guidelines and Best Practice documents relevant to PV systems are summarised in the Task 3 document mentioned above. Task 3 is also addressing issues

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[7] IEA PVPS Task 3 Report T3-07:2000: Survey of National and International Standards, Guidelines & QA Procedures for Stand-alone PV Systems. Available from the IEA PVPS website: http://www.iea-pvps.org

[8] IEC/PAS 62111 Ed. 1.0 Specifications for the use of renewable energies in rural decentralised electrification

[9] IEA PVPS Task 3 Report T3-11:2002: Testing of batteries used in Stand Alone PV Power Supply Systems. Available from the IEA PVPS website: http://www.iea-pvps.org). The report highlights the fact that the main quality characteristic of a battery, the cycle lifetime, is very dependent on the test method. Another difficulty for quality testing of batteries is the very long test period of up to two years, which makes a testing during the implementation phase of a project very difficult if not impossible. Furthermore, the performance of any battery is very dependent on the user's behaviour in the operation and maintenance of the system.

relating to quality management of stand-alone PV systems as well as developing guidelines on the selection of batteries and charge controllers and also identifying common problems with appliances[10].

4.3 Technical Specifications and Tender Documentation

In the absence of nationally and internationally accepted standards, it is particularly important that the supply PV system hardware is correctly specified within technical specifications and tender documentation. Furthermore, acceptance testing of components against the specification should be undertaken at an independent test facility *before* the goods are accepted. This is particularly important for large procurements. There are a number of publicly available documents offering guidance[11] on this but many donor agencies will sub-contract this activity to specialist consultants. It is critical that the consultants that are appointed to undertake this work are technically competent.

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Testing of inverters at Department of Electronic Engineering of University of Witwatersrand, South Africa.

4.4 Quality Marks and other Quality Control Measures

4.4.1 Industry Quality Marks, Standards and Certification

When considering the use of a Quality Mark, acceptance of international or other national standards and certification, it is important to consider their general applicability within a particular country. It should also be recognised that the purpose of industry quality marks and standards etc. is to provide protection and assurance to the end-user and not to allow large manufacturers to dominate particular markets. It is also necessary to ensure that the products and services of small local companies are not excluded by the expense of having their products certified, as this will also encourage the domination of the market by a few international companies.

In general, issues that should be considered include:

- The use of Quality Marks in other business sectors – are customers and the commercial sector familiar with them?

[10] Documents will be available from the IEA PVPS website: http://www.iea-pvps.org

[11] GTZ reports: "Quality standards for solar home systems and rural health power supply" and "Proposal for Tender Documents for the Procurement of Photovoltaic Pumping-Systems (PVP)"

- Impact of requirement that components meet National and/or International Standards on future potential for local manufacture of BOS components. Assessment of quality of existing imported components.
- Feasibility of national organisation for standards and certification applying for Membership or Associate Membership of the IEC (many countries now have Associated Membership of the IEC) or other similar organisations. The costs and additional capacity requirements for this must be explored.
- Identification of possible institution(s) or testing facilities to enforce technical specifications if required.
- Identification of possible avenues for training of system designers, installers, maintenance personnel and end-users.
- Identification of existing training organisations which could be accredited for training of PV designers, installers, O&M personnel.

An example of an industry initiative is the Global Approval Programme for Photovoltaics (PV GAP). PV GAP aims to promote and maintain a set of quality standards and approval procedures for the performance of PV products and systems, to ensure high quality, durability and reliability. PV GAP has introduced a Quality Mark (for PV components) and Seal (for PV systems). Further information can be found on the PV GAP web-site[12].

4.4.2 Performance Guarantees and Warranties

Performance guarantees and warranties are a common way of providing protection for both businesses and consumers in the industrialised world. However, a warranty or guarantee is worthless if it is not enforceable. Furthermore, warranties need to be provided along the full length of the service delivery chain, in addition to being enforceable. A dealer will not provide a performance guarantee for a PV module unless the manufacturer provides a ‘back-to-back’ guarantee. Access to spare components must be available locally as returning a faulty component such as a charge regulator/controller to an overseas manufacturer/supplier is often more expensive than simply replacing it with a new one. Furthermore, end-users must be fully aware of their rights. System installers (often the only contact person for the end-user) are often unsympathetic to warranty claims. If a system is malfunctioning, many installers will try to blame the end-user for incorrect system operation, overuse or poor maintenance. In the light of this, information must be provided to end-users by the financing institution/donor agency independently of the supplier wherever possible.

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Outdoor testing of PV modules can assist in determining whether they meet the required specification.

In order to assess the potential efficacy of performance guarantees the following should be considered:

12 http://www.pvgap.org

- The use of performance guarantees or warranties in other business sectors – are customers and the commercial sector familiar with them? What precedents are there and how are they enforced, if at all? What is the recourse for failure?
- The modus operandi of the existing service delivery chain and how a guarantee could be enforced from the end-user or retailer back to the hardware manufacturer. What kind of performance guarantee would be appropriate, e.g. lifetime or energy based? How will components such as batteries be dealt with?
- The feasibility of back-to-back guarantees from foreign supplier and local dealer, and between local dealer and retailer, to dealer/retailer and on to final customers.
- Appropriateness and applicability of other possible mechanisms, for example enforceable service contracts with penalties.

In the absence of accepted standards and certified products, performance guarantees and warranties are the only legal option for end-users and financing institutions to enforce their right for a functioning, high quality PV-system. The terms of these warranties and guarantees, for both components and for entire systems, should be stipulated in tender specifications and also in supply contracts.

4.5 Certification of Components

While a quality management system can ensure the consistency of the products manufactured, it will not ensure that the output products perform as required or meet measurable standards. To ensure that a given product meets performance or prescriptive standards set by objective recognised third-party bodies (e.g., European Committee for Electro-technical Standardisation (CENELEC), ISO/IEC, IECQ, Underwriters Laboratories (UL), IEEE, ASTM, etc.), it is critical to have a system where products are tested by qualified and approved laboratories (e.g. those recognised by the Supervisory Inspectorates (SIs) of the IECQ, or accredited under the guidelines of the ISO Guide 25) against the standards.

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Testing of batteries at the South African Bureau of Standards

The testing must be not only for selected products supplied by the manufacturer but on randomly selected products to make sure that the supplied samples represent the general production quality. Finally, even if one product passes the laboratory testing, this does not automatically qualify all of the company's other product lines. Each different product must be approved and/or certified separately, and any product where the design is changed after approval must be re-tested and re-approved.

However the process is still expensive and with the limited market volumes and small manufacturing companies, the question is how to refinance these costs in the light of the small production volumes. In order to support local companies (and thereby helping create a sustainable market, and indigenous employment) donor agencies should consider assisting these companies in gaining certification for their products through technical development aid or through a dedicated budget line within an implementation programme.

5 TRAINING AND PRACTITIONER QUALITY: ACCREDITATION AND CERTIFICATION

5.1 The Benefits of Accreditation of Training and Certification of Installers

Sustainable energy technologies in general, and PV specifically, are particularly effective when implemented at the remote home or rural community level. This results in the installation of many small systems, and requires a dispersed resource of installation and maintenance technicians and businesses to serve this decentralised market.

Funding organisations and government agencies are very interested in accelerating the market development of sustainable technologies, but they often find that there is not an adequate infrastructure in place to successfully market, install, and service the technical solutions that they wish to support. Quality training and practitioner certification are critical components for successful market development.

Since the 1970s, PV practitioner training has been implemented around the world, in some fashion, by a disparate group of individuals and organisations. The main problem with this approach in developing countries was that the different development organisations, often financed by bilateral development, did not co-ordinate their activities. Furthermore, development organisations were sometimes required to work with government organisations and were not allowed to train personnel in the private sector. However, the government staff were often high ranking officials and not those involved in installation work. This problem was often exacerbated if training programmes were held overseas.

While important and useful, this training has often lacked follow-up and linkages with sustainable jobs, and was not based on qualifying participants to clearly defined competencies. Without clear practitioner knowledge and skills competency targets, the effectiveness of the training could not be properly evaluated. Programmes have also not built on one another, and isolated training activities have been undertaken in one country, often "reinventing the wheel" in terms of content, lab and field activity, method and logistics. Furthermore, the trainers themselves were often not suitably qualified or experienced.

A worldwide acceleration in market development for these decentralised technologies will be seriously impeded unless the accreditation of training programmes and certification of practitioners emerge to help focus efforts and scarce resources. This will allow funding organisations as well as businesses to concentrate on developing programmes and products in the context of accepted standards for participant performance at the end of their training. As the market for PV installations increases it is important that practitioner training is fully integrated into existing training infrastructures so the technology is not treated differently from ‘standard’ electrical training.

For a training accreditation and practitioner certification programme to succeed, it must:

- have the support of the industry it represents;
- be credible to funding, government, and member groups;
- provide a benefit to its users and stakeholders that outweighs its costs;

- be based on valid standards of knowledge and skills competency and on auditable metrics of capability and process;
- have a chain of responsibility that extends from the national and/or international standards and oversight group to the participating organisations and individuals.

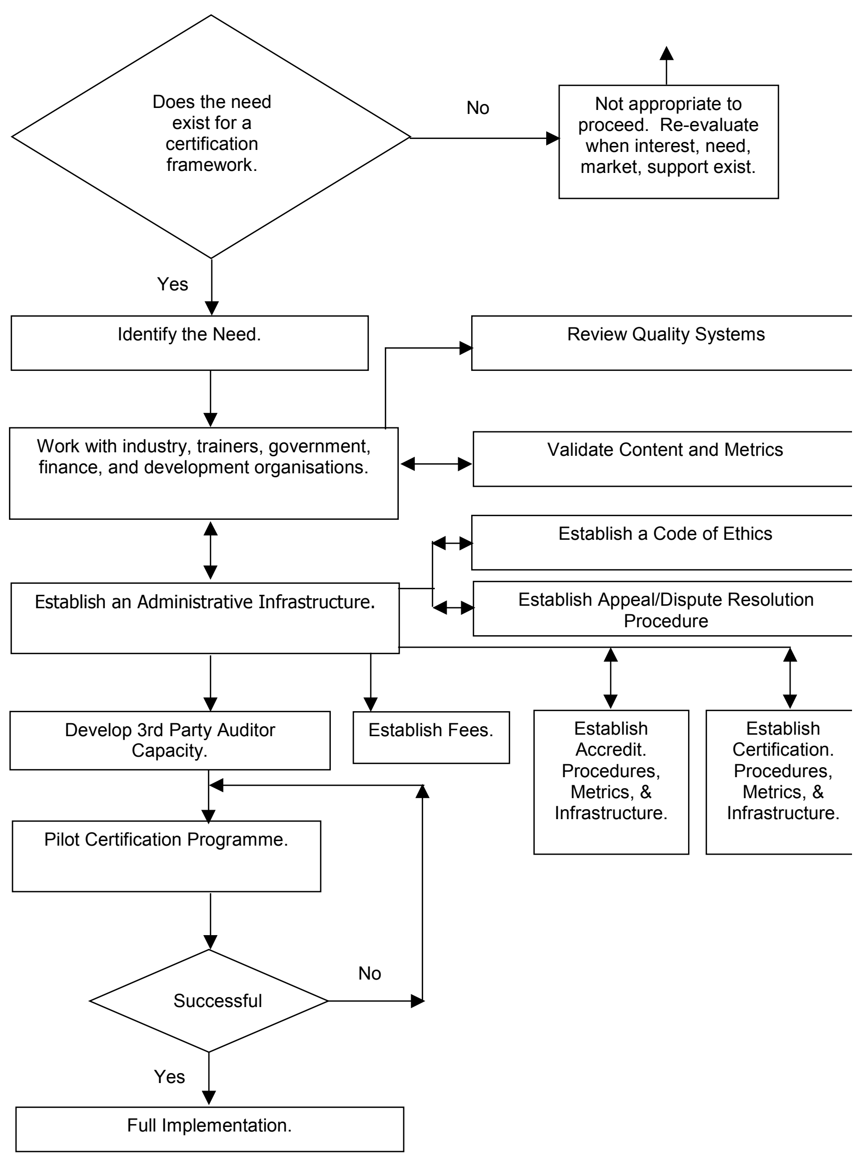

Figure 1: Flowchart for the implementation of a quality certification programme.

A consistent and broadly recognised quality system for accreditation and certification is important for training institutions, the practitioners certified through this workforce competency framework, customers/clients, and other relevant stakeholders and actors. Figure 1 shows schematically a general framework for implementing a quality certification programme[13].

Without both the reality and perception of quality, the training organisations and the candidates for certification will suffer in the market because of reduced access to customers and financing.

For a training organisation's quality system to succeed, the management of that organisation must ensure that procedures and services are consistent and that the processes involved are documented and reviewed regularly against the stated standards. In addition, the quality system must extend beyond the immediate scope of the training organisation. It must also include input from students and employers. Communication with these stakeholders is important and necessary to identify their needs and insights and to address these within the training programme.

With a recognised quality system, along with recommended Best Practice taken from the PV and training industries, even a small training organisation or individual practitioner can participate in national and international business opportunities.

[13] Source: Quality Program for Photovoltaics (QuaP-PV) 'Certification for the PV Installation and Maintenance Practitioner: Manual for Implementing Qualified Certification Programs' Institute for Sustainable Power.


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Poorly installed Solar Home Systems will not perform according to expectations and damage confidence in the technology.

For a training accreditation and practitioner certification programme to ultimately prove sustainable, there must be a market within which the certified practitioners can work. Companies and individuals will only invest the absolute minimum in the qualification of their personnel if there is not a long term market opportunity.

5.2 Training Accreditation

To understand the requirements and demands of establishing a quality system for training, it is important to review the relevant international and national quality standards for training and certification, to evaluate them in the context of the local market, and to assess the impacts of implementing a quality system.

Review International Quality Training Accreditation and Certification Standards

In making the decision to move ahead with the development of the PV training accreditation framework, it is important to understand the level of rigour and discipline required of an internationally recognised quality system. ISO's draft standard ISO 17024, *General Requirements for Bodies Operating Certification Systems of Persons*, provides guidance on the components and level of effort required in implementing and maintaining a quality certification system. Understanding these requirements is important because they can be daunting, because it is good to understand from the outset the level of effort required to ensure quality, and because adherence to the standard is necessary to instil confidence in the capabilities and responsibility of the organisation.

Evaluate the Requirements Based on Local Needs

Simply reading the text of these quality standards will not provide the appropriate level of understanding of the challenge taken on. It is important to evaluate the standards in the context of the identified market. While the intent and level of discipline cannot be compromised, it is also true that they must be adapted to the local conditions to make them relevant.

Assess the Impacts of Implementing the Quality Management System

Implementing a quality system for the accreditation of PV training programmes is important and necessary for recognition of the organisation's capability in the international markets and for objective evaluation. However, it is necessary to recognise that simply implementing a quality system does not guarantee success, and it does not guarantee local industry acceptance. There will certainly be criticism from organisations that are of marginal quality, which feel that the criteria and standards will be used to exclude them from the market; there will be criticism from those who feel that implementing standards will add costs to their programmes that outweigh the potential benefits; and, some will criticise it as an attempt by large international interests to take unfair advantage of smaller competitors in local markets. There may also be criticism that the training accreditation framework is simply being set up and dominated by insiders with political or commercial advantage. Any and all of these concerns must be weighed and addressed if the framework is to achieve broad local support and acceptance. It is important therefore that the accreditation of training organisations should be steered by a nationally accepted, independent, non-profit organisation.

On the positive side, though, it is important to note that implementing an internationally recognised quality framework for accreditation could well open new avenues to development and financing, as well as improve the quality of installations and maintenance schemes in the local markets. Outcomes from this include improving access to electricity, improving the quality of life for those using the systems, expanding the market for sustainable local jobs, and improving the economic and enterprise potential of the communities through improved reliability and confidence in the products and the practitioners.

The quality system requirements of the aforementioned ISO 17024 standard provide well-established, internationally recognised processes for establishing and maintaining a quality system. While not a requirement for establishing a quality PV accreditation and certification framework, following the framework this document lays out will help to ensure and document the quality of the administrative and certification systems.

It is to the benefit of the wider electrical industry, as well as the PV installations industry, that the responsibility for the training of installation practitioners is undertaken within the general education framework through the development of recognised apprenticeship programmes for which governments are ultimately responsible. This does not preclude specialist ‘product related’ training which is the remit of suppliers and product manufacturers.

5.3 Practitioner Certification

The validation of any certification is based on the perception of the quality of that certification in the marketplace. A consistent, documented quality programme; the development and validation of appropriate competency standards and examinations by qualified technical committees; and, appropriate arbitration and dispute resolution procedures should result in a legitimate certification credential. They will ensure that the level of knowledge and skills represented by the credential is consistent regardless of the source of the original training and that the credential retains its value in the market.

Standards Bodies

To ensure continuity, portability, and reciprocity, it is important that knowledge and skills competency standards for certification are based on validated standards either developed by national stakeholder and expert groups or based on international competency standards adopted for national use. Even if a country adopts existing international standards, it is important that the country has a committee of experts and stakeholders to ensure that those standards are relevant to the needs of the country's markets and to provide feedback to the standards body on the standards integration at the national level.

For PV systems, a task analysis competency standards committee would include installation professionals, representatives of product manufacturers, PV trainers, representatives of apprenticeship programmes, electricians, qualified government and financial professionals, Non-Governmental Organisations, and standards experts. With this diversity of experience and interest, the acceptance or adaptation of standards would have greater local validity.

6 CONCLUSIONS

The control of quality in a rural electrification programme, in particular one that involves the use of a relatively new technology such as PV, is of paramount importance in order to ensure the success of the programme. The roles of three key areas of quality control have been discussed and the key aspects of each defined.

If adequate quality control is maintained in each of these areas, the chances of an implementation programme having a successful outcome are greatly enhanced. Furthermore, the requirement for such a quality programme will provide a strong foundation for the development of a sustainable market in the medium term. Many external organisations, particularly in the finance sector, will look for independently audited and controlled quality mechanisms as a way of risk mitigation when investing in the PV market.

ANNEX 1: GLOSSARY

accreditation: procedure by which an objective, authoritative body gives formal recognition that a body is competent to carry out specific tasks.

audit: a systematic and independent examination to determine whether or not quality activities and related results comply with planned arrangements and whether or not these arrangements are implemented effectively and are suitable to achieve defined objectives.

auditor: individual tasked with performing audits.

certification: procedure by which an objective, authoritative body gives written assurance that a product, process, service, or individual conforms to specified requirements.

component: a constituent part of a product.

conformity evaluation: systematic examination of the extent to which a product, process, service, or individual fulfils specified requirements.

continual improvement: a process by which an organisation or a process is regularly reviewed against its actual and expected functioning or results in an attempt to improve its functioning.

contract: agreed requirements between a supplier and customer transmitted by any means.

customer: an individual or organisation that purchases or contracts for a commodity or service.

deficiency: sub-standard, non-conforming, or non-complying, relative to objective standards.

documentation: furnishing or authenticating with documents; evidence of a process; conformity to historical or objective facts or standards.

IEC: International Electrotechnical Commission.

IECQ: IEC Quality Assessment System for Electronic Components.

ISO 9001:2000: a family of standards, under the International Standards Organisation (ISO), which specify requirements for quality management systems and which provide guidance to aid in the interpretation and implementation of the quality management system.

ISP: Institute for Sustainable Power, Inc.; a world-wide organisation for developing, maintaining, implementing, and promoting international consensus standards for the qualification of renewable energy, energy efficiency, and distributed generation training and workforce development.

inspection: conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing, or gauging.

management representative: the organisation's representative who shall have the defined authority for ensuring that a quality management system is established, implemented, and maintained in accordance with the standard, and reporting on the performance of the quality management system to management for review and as a basis for improvement of the quality management system.

manager: the person who is exercising authority, taking responsibilities, making decisions, and fulfilling similar managerial functions on behalf of the business.

non-conformity: any instance of failure to meet a specified requirement.

objective evidence: information that can be proved true, based on facts obtained through observation, measurement, test, or other means.

photovoltaic: solid-state, semiconductor-based solar electric technology that directly converts light energy into electricity.

procedure: description that details by whom, with what, when, where, and how processes are carried out.

process: a series of actions or activities directed to a planned or specific result or product.

product: result of activities or processes.

PV GAP: Global Approval Programme for Photovoltaics: a world-wide organisation for promoting satisfactory photovoltaic products and systems.

quality manager: management representative with responsibility for the quality management system, its implementation, and its maintenance.

quality manual: the document in which is compiled the organisation's procedures and documentation for quality, quality maintenance, and quality improvement programmes.

quality management system: process by which an organisation's processes are carried out, writing down how things are done and recording the results to show how things were done.

quality team: an organisation's team of management and staff responsible for developing and reviewing the organisation's quality management systems.

registrar: independent, third-party body that audits organisations for accreditation and registers those qualified organisations.

review: the broad overview of the activities relevant to the situation under study. Here, used in three situations: management review, contract review, and design review.

service: the non-tangible result of a process or effort (e.g., testing, installation, maintenance, repair, consulting, etc.).

subcontractor: any organisation from which a business purchases products or services, or both.

supplier: in this manual, this term refers to the Company or Laboratory providing the product or service.

tender: offer made by a supplier in response to an invitation to satisfy a contract award to provide a product or service.

terms of reference: document outlining clients requirements and scope of work.

training: process to introduce, expand, and/or improve the knowledge and skills of individuals and teams in a systematic way.

vendor: outside provider or a product or service.

IEA INTERNATIONAL ENERGY AGENCY