REVIEW OF STANDARDS AND QUALITY ASSURANCE SCHEMES FOR PV SYSTEMS

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ABSTRACT: This paper describes work undertaken as part of Task III (Stand-alone and Island Applications of Photovoltaic Power Systems) of the International Energy Agency's Photovoltaic Power Systems Programme1. The long term objective of this work is to develop a series of recommendations which will be collated into a Recommended Practice Guide on Quality Assurance Schemes for stand alone PV and hybrid systems. The QA recommendations will be drawn up in consultation with the PV industry in each of the participating countries to encourage widespread acceptance. It is intended that the QA recommendations could be used for a further development (modification) of existing commissioning and acceptance tests as a draft for a new standard, possibly through PV-GAP. This paper describes the work to date on this programme and summarises the current status of international standards, guidelines and QA procedures for PV systems and components.
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1. INTRODUCTION

This paper reviews current international standards, guidelines and QA procedures in order to assess the areas which are not covered by the existing guidelines. It is intended to provide a starting point from which a means of providing Quality Assurance to the users of stand-alone PV systems can be implemented. It provides a useful overview of which organisations are working in this area, and summarises their progress to date.

The stand-alone market comprises about three quarters of the total world PV market. A large proportion of this market is in developing countries, but there is also a stand-alone PV market in industrialised countries. Typical developing country applications are solar home systems, applications in health care, and PV pumping. There is also a market for stand-alone PV systems to provide power for professional applications. This market mainly consists of niche applications for remote power supply, where it is more economic to use PV than any other form of power supply.

It is widely accepted that the continued development of markets for stand-alone PV systems is greatly hindered by the absence or limitations of national and international standards and QA procedures. This is illustrated by the fact that the quality of PV systems and components installed and sold to date varies considerably. As a result of the marketing of poor quality systems in the past, the markets of today are impeded.

The development of standards for stand-alone PV systems takes place primarily within IEC and CENELEC, with several international standards already published and many more under development. These standards cover both the individual components of stand-alone PV systems as well as the system as a whole.

Task III intends to contribute to the development of international standards governing quality assurance and performance guarantees for stand-alone PV systems. Systematic quality assurance procedures must include several steps: definition of component and system standards, definition of laboratory tests, testing of prototypes or product samples in accredited laboratories, and on-site quality control of systems.

The issue of performance guarantees for PV systems is extremely complex, not least because of the many different players involved in the design, supply, installation, operation and maintenance of a PV system. 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. Each stage in the life cycle of a PV system must be considered as a potential source of system failure; most of the maintenance and repair requirements result from failures in the specification, design, and installation processes.

2. INTERNATIONAL QA AND STANDARDS ORGANISATIONS

2.1 Status of standardisation for stand-alone PV

The development of Standards for Stand-Alone Systems takes place largely within the IEC and CENELEC, with several international standards published and many more under development. This reflects the global nature of the stand-alone market, a large part of which is in the developing world.

[1] The following countries are actively participating in the work of the Task: Australia, Canada, France, Germany, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom.

Most of the existing standards are from the IEC and cover only PV modules, and the measurement of their performance, as well as batteries and lights.

In June 1997, the IEC drafted its first standard on Stand-alone PV Systems. This document describes a remote home application, with a PV array rated up to 1kWp which is used to power lamps, radio, TV, refrigerator and telecommunication loads. The current draft, however, is in its early stages and a large amount of information is still lacking in the document. For example, no specifications on minimum requirements or recommendations for installation have yet been made.

Both CENELEC and the IEC working groups are also discussing two detailed documents, for charge regulators and lamps with electronic ballasts. These were proposed as standards by TÜV-Rheinland (Germany), the Fraunhofer Institut für Solarenergiesysteme (Germany) and the Energy Technology Laboratory of BPPT (Indonesia). A panel of experts from GENEC (France), CIEMAT (Spain) and JRC Ispra (EC) is contributing further to these drafts. The same panel is also developing test procedures for laboratory and field experiments on other system components, as well as for Solar Home Systems. These new drafts are expected to be reviewed early in 2001. Three further draft standards from CENELEC on PV modules, batteries and Solar Home Systems are still in early stages and will not be completed for some time.

2.2 International Electrotechnical Commission (IEC)

The IEC established a Technical Committee (IEC/TC82): Solar Photovoltaic Energy Systems, in 1981. Its purpose is to prepare international performance and safety standards for PV cells, modules, and systems. There has been a long period of international R&D which has led to IEC Standards for all aspects of silicon cells and modules and, more recently, PV systems and BOS components.

Within the IEC, Working Groups 3 and 6 of TC82 deal with standards for stand-alone PV Systems. WG3 deals with system aspects and WG6 with component aspects.

2.3 European Committee for Electrotechnical Standardisation (CENELEC)

In 1995 the EU mandated CENELEC to establish its own Technical Committee to prepare European PV standards. The first meeting of the new CENELEC Task Force BTTF-86-2 was held in Brussels in June 1996. There are five working groups:

- WG1 Solar Home Systems
- WG2a Inverters
- WG2b AC modules
- WG3 PV pumps
- WG4 PV in buildings

2.4 International Electrotechnical Commission Quality Assessment System for Electronic Components (IECQ)

The IECQ is a third-party certification system for the conformity of electronic components to specified quality requirements. Since its inception, IECQ has offered the only comprehensive world-wide programme in the electronics industry that provides relevant, ongoing quality assessment for customers and suppliers. Assessment of supplier quality management is an integral part of IECQ.

An approval under the IECQ system means that its recipient must have dual certification to defined IECQ requirements and an ISO 9000 standard. Similarly, approval of test laboratories includes dual certification to the requirements of IECQ and ISO / IEC Guide 25.

2.5 Global Approval Program for Photovoltaics (PVGAP)

The Global Approval Program for PV (PVGAP) has been established to promote high standards for the production, installation and servicing of PV systems. The need for PV GAP was identified at an industry meeting on system reliability at the European PV Conference in Nice in October 1995. Participants were concerned about PV getting a bad reputation due to the sale of unreliable systems. The founders met at the IEEE PV Specialists Conference in Washington DC in April 1996, when the World Bank, UNDP and the Rockerfeller Brothers Fund participated and endorsed the initiative. The formal founding meeting was held in the United States in June 1996. PV GAP was formally launched at the European PV conference in Barcelona in July 1997.

PV GAP is a Swiss-registered non-profit organisation that focuses on certifying the quality of PV systems. PV GAP also concentrates on the enforcement of international standards that promote the integration of quality. The organisation will work to get testing standards into the financing stream, such that finance for a project is conditional on PV-GAP approval. It will also establish international reciprocity of recognition of standards and testing laboratories.

PV GAP is intended to complement the work of IEC and will use standards published by IEC, but will prepare its own interim standards until IEC standards become available. Manufacturers, distributors and installers that are approved under PV GAP will be licensed to utilise and display a distinctive 'Quality Seal'. PV GAP differs significantly from the IEC in that it is market and industry driven.

The first draft version of the PV GAP Reference Manual was published in February 1998.

2.6 Other organisations with standards and guidelines relevant to stand-alone PV systems

Several other bodies issue standards, guidelines or codes of practice which are of interest or relevance to stand-alone PV. The following list is not exhaustive.

The ISO (International Organisation for Standardisation) issues international standards in areas other than electrical and electronic engineering. For example, ISO Standards relevant for PV have been issued for glazing materials for use in buildings.

Within Europe, CEN (Comité Européen de Normalisation) deals with standards in areas other than electrical and electronic engineering.

The Institute of Electrical and Electronic Engineers (IEEE), based in the US, also publishes standards on PV, which are widely accepted and may eventually be recognised as international standards.

In the US, Underwriters Laboratory (UL) issue safety regulations. These documents are generally not concerned with performance, only with safety. In the US, electrical inspectors often refuse to accept products which have not been tested to UL specifications.

NREL, the National Renewable Energy Laboratory of the US (formerly SERI), has developed a number of documents relevant to the performance and testing of stand-alone PV systems and components. These are often used as interim standards within the PV community.

The International Telecommunication Union (ITU) is an international organisation within which governments and the private sector co-ordinate global telecom networks and services. Its headquarters are in Geneva, Switzerland. The ITU is the leading publisher of telecommunication technology, regulatory and standards information. The ITU-T Recommendations developed by the Telecommunication Standardisation Sector (formerly CCITT) constitute the basis for international telecommunication standards. These are final results of studies on technical, operating and tariff issues with the objective of standardising telecommunications on a world-wide basis, including interconnection of radio systems in public telecommunication networks and on the performance required for these interconnections. ETSI, the European Telecommunications Standards Institution, deals with telecommunications standards on a European level.

The International Commission on Illumination, or CIE, publishes information on all aspects of lighting.

3 INTERNATIONAL QA PROCEDURES AND BEST PRACTICE PROGRAMMES

3.1 PV GAP and IECQ

PV GAP is working with the IECQ (the International Electrotechnical Commission Quality Assurance Scheme) with the support of the World Bank, the United Nations and the industry associations of Europe, Japan and the USA on QA for PV systems. Interim standards have been developed and are included in the PV GAP handbook. These will be withdrawn once suitable IEC standards have been approved.

PV GAP Recommended Standard PVRS 1 is an interim 'recommended standard' which is to be used until IEC standards are completed. The document gives test specifications for PV modules, charge controllers, batteries and fluorescent lamps. Test procedures for system approval, verification of sizing, and performance rating are also given.

3.2 World Bank ASTAE Quality Management in Photovoltaics (QuaP-PV)

The ASTAE Unit of the World Bank has recently financed the development of four QA manuals and associated training programmes, with funding provided by the Dutch Government:

- Quality Management in Photovoltaics: Manufacturers Quality Control Training Manual;
- Manual for design and modification of solar home system components;
- Training Manual for Quality Improvement of Photovoltaic Testing Laboratories in Developing Countries;
- PV Installation and Maintenance Practitioner Certification Infrastructure: Development Procedures.

These documents are basically training manuals to enable manufacturers of PV components, testing laboratories and organisations responsible for the training of installation personnel to gain a basic understanding of quality issues.

3.3 World Bank ASTAE Best Practices for Photovoltaic Household Electrification Programmes

The document, published by the World Bank ASTAE Unit in 1996, documents best practices for rural electrification programmes based on experiences in Indonesia, Sri Lanka, the Dominican Republic and the Philippines.

3.4 Institute for Sustainable Power (ISP) Training Accreditation and Certification

In 1997 the ISP, a US organisation, launched an international programme to provide accreditation and certification to centres which conduct training in PV systems installation. The goal of this programme is a globally recognised standard for the accreditation of training programmes and the certification of the participants of the training programmes. This accreditation will give funding organisations a third party assurance of professional skills and capabilities.

3.5 Universal Technical Standard for Solar Home Systems

The Instituto de Energia Solar (Spain) has drawn up a proposed standard for SHS, in conjunction with JRC Ispra (EC), GENEC (France) and WIP (Germany) within the framework of the European THERMIE B programme (SUP-995-96). This document intends to provide the basis for technical QA procedures and makes use of standards and guidelines from around 20 countries.

4 NATIONAL QA PROCEDURES AND BEST PRACTICES

The French utility, Electricite de France (EDF), published its 'Specifications for the use of renewable energies in rural decentralised electrification' in 1997. This document includes outline QA procedures for project life-cycle assessment.

In Germany, GTZ published a set of guidelines called Basic Electrification for Rural Households in 1995. In addition, GTZ is currently completing work on the very useful document 'Quality Standards for Solar Home Systems and Rural Health Power Supply', which provides an overview of standards and QA issues for stand-alone PV systems in developing countries.

In addition, a number of countries have their own standards and QA and testing specifications. For example India, South Africa (NRS-052) and China have all developed useful documentation which is being reviewed as part of the Task III study.

CONCLUSIONS

In the stand-alone PV systems sector, R&D on draft standards for systems and components should be given the highest priority. As another matter of high priority, Task III would emphasise the development of international standards which govern certification and accreditation procedures. The development of a standard covering installation aspects of stand-alone PV systems is also of high priority, as poor installation can lead to system malfunctioning. This can have a significant impact, as the quality of installations can affect the success or failure of a large PV rural electrification programme.

FURTHER WORK

The authors would welcome communication from any individuals or organisations working on or with standards and QA procedures which would complement this study.