



Over the past five years, the PV GAP quality label has grown from an idea to a sought-after industry standard. Four of the major PV manufacturers have now been awarded PV GAP status. **Markus Real, Pierre de Ruvo, Richard Kay and Peter F. Varadi** review experience gained in the process of certifying and approving the first products to carry the PV GAP label.

# Quality assured

## PV GAP global quality label based on IECCE certification

**S**olar photovoltaics is used around the world to provide clean and reliable distributed power for a variety of applications. And because PV is a global business, it needs global standards and specifications for manufacturing and testing, to ensure that components of suitable quality are combined into properly designed and maintained systems. This is critical to the industry's continued success: and with PV manufacturing and markets growing at rapid rates, standards and specifications become even more important. The quality and durability of installed PV systems can have a profound impact on customers' acceptance of the technology. (The importance of PV standards/specifications is covered in further detail in previous *Renewable Energy World* articles.<sup>1,2</sup>)

At present, there are few harmonized international

standards and specifications for PV products and systems. This means that many manufacturers, especially in developing countries, have practically no guidelines for producing a reliable product, installing it as part of a system, or servicing it. As there are only a limited number of accredited testing laboratories, it is also difficult for manufacturers to test their products.

To ensure the high quality of PV products and installations around the world, a PV quality assurance programme is essential. Products and systems that fulfil test criteria can then be labelled for easy identification. The Global Approval Program for Photovoltaics – PV GAP – was initiated to provide such a resource for quality assurance. The Program represents a unique opportunity for achieving a global quality seal for PV products and systems.

### THE PV GAP SYSTEM

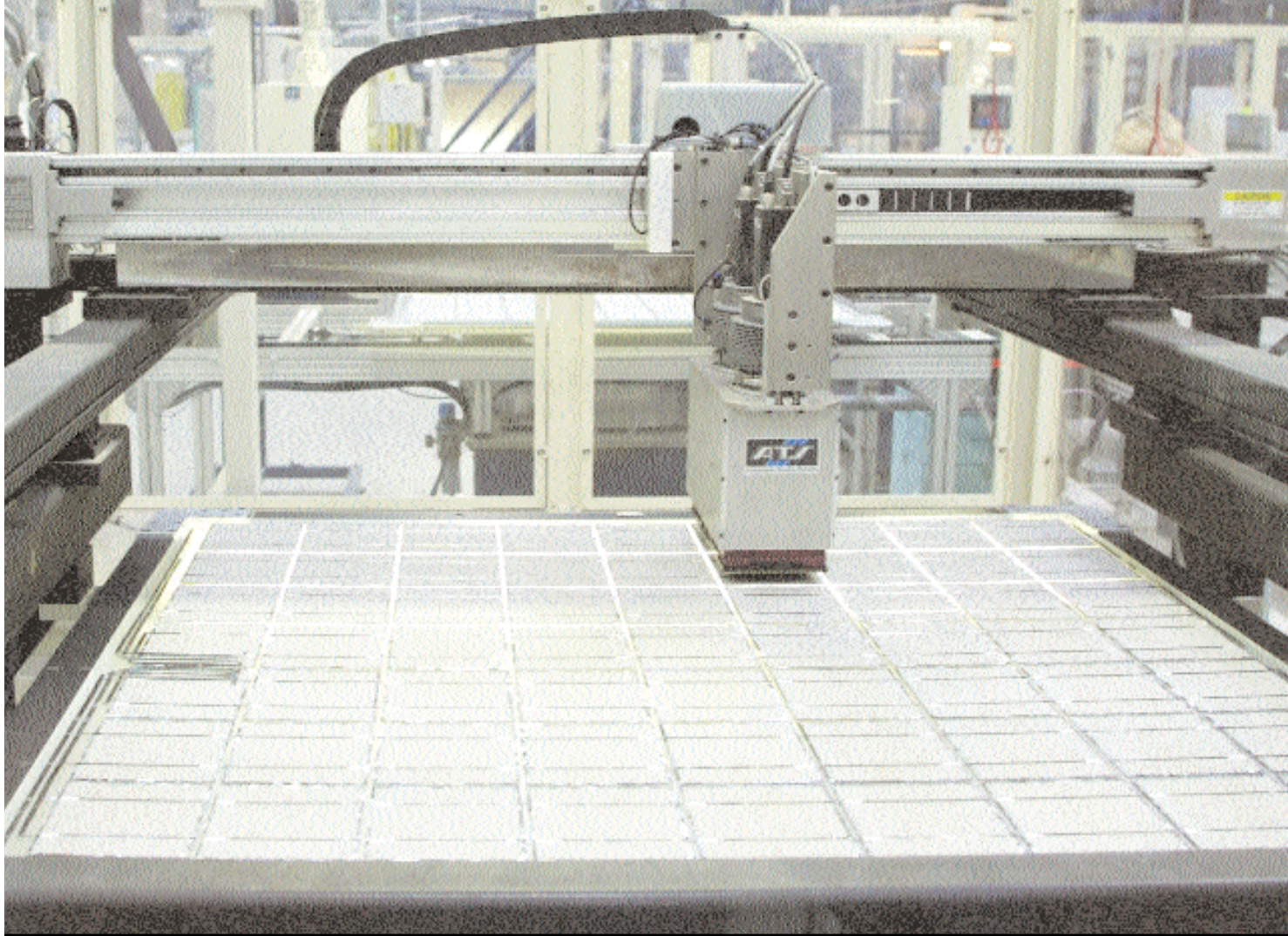
PV GAP, the Global Approval Program for Photovoltaics, accepts the certification of PV products by the International Electrotechnical Commission System for Conformity Testing and Certification of Electrical Equipment (IECEE). The IECEE operates the well known global Certification Bodies (CB) Scheme for Mutual Recognition of Test Certificates for Electrical Equipment, and the Full Certification Scheme (CB-FCS) that tests PV products for performance. Until the end of 2003, the IEC's designated certification scheme for PV was the Quality Assessment System for Electronic Components (IECQ).

For more information, see [www.pvgap.org](http://www.pvgap.org)

### BENEFITS OF QUALITY

The quality label on a PV product has two advantages. Firstly, it allows customers to identify quality products easily. Secondly, it means that PV manufacturers and system installers – as well as the customers – can distinguish their products from those of unknown quality. PV GAP has two quality labels for PV products. One is for components themselves, and the other is for entire systems, respectively the PV Quality Mark and a PV Quality Seal (as seen in Figure 1). These labels are awarded if the product fulfils PV GAP's requirements and is certified by an independent, third-party global certification process.

The rapid growth of the PV industry is taking place at a time when the electricity market is shifting from utility monopoly to deregulated service. Worldwide, PV module production may soon pass 1 GW of capacity each year, and these modules are installed in a vast range of decentralized



Stringer for PV cells at Photowatt's Bourgoin Jallieu plant, France, where the company produces PV GAP-certified products PHOTOWATT

systems for independent customers. In this environment, visible labelling provides vital customer protection, assuring them of enhanced product quality.

Customer satisfaction is, after all, a key indicator of quality (though not the only one). For PV systems, customer satisfaction will be shaped by perceptions about price, performance, warranty, safety, labelling and information, as well as environmental impact. In developing countries, customers will also be interested in perceived improvements to their living conditions and to their income.

What will also have a bearing on quality is the system's overall effectiveness, which is of concern both to customers and to manufacturers. PV systems are designed to provide energy services, and a poor-quality product may result in premature failure, requiring replacement of a component or system. In the case of a solar home system (SHS), component quality and system configuration will also affect battery life-cycle. Poor-quality components, or system designs that do not correctly balance module power, battery size and charge controller behaviour, may mean batteries have to be discharged on a regular basis, dramatically shortening their life and necessitating frequent replacements. This not only has a significant effect on customer satisfaction, but also has a direct influence on the life-cycle value of the battery and its environmental impact. An increase of just one year in a battery's lifetime, combined with a good

quality system, can reduce lead flux waste by the same quantity as if recycling were enhanced by 40%.<sup>3</sup>

### THIRD-PARTY CERTIFICATION - IECEE

The use of a global, third-party certification system for PV GAP, the IECEE,<sup>4</sup> offers benefits all round. The IECEE gives users confidence in the safety, performance and quality of PV components and systems, which in turn facilitates international trade in such products for the range of applications.

IECEE certification depends on Certification Regulations, which were established to implement the Rules of Procedures drawn up by the Certification Bodies Full Certification Scheme (CB-FCS).<sup>5</sup> The Scheme operates with the mutual recognition of Conformity Assessment Certificates (CACs) issued by members of the FCS, as the basis for the certifying electrical products at the national and international level. Bodies that hold the right to use CACs must commit themselves to adhering to the Certification Regulations.

Members of the CB-FCS recognize the Manufacturer's Quality Management System (such as ISO 9001:2000), including the surveillance methods at the factories producing the certified products. The CB-FCS member issuing the CAC will also establish a follow-up programme: this ensures consistency of design and construction, as well as

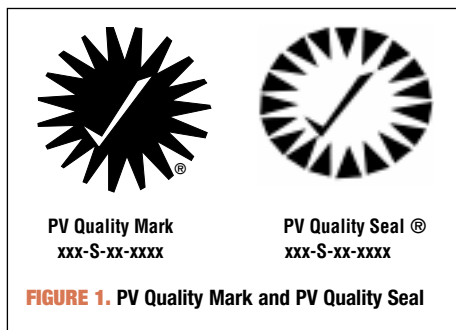


FIGURE 1. PV Quality Mark and PV Quality Seal



ABOVE RWE Schott's ASIOPAK-30-SG modules in use in a roof-integrated application  
ABOVE RIGHT Certification for the ASIOPAK-30-SG product RWE SCHOTT SOLAR



satisfying the requirements of the CB-FCS member receiving the documentation for national certification.<sup>6</sup>

### THE CERTIFICATION PROCESS IN PRACTICE

There are four main criteria for manufacturers seeking the PV GAP label.

- First, the manufacturer must have current certification for the manufacturing site, with relevant scope. This will be to a Quality Management System (QMS) standard such as ISO 9001:2000. Manufacturers will have to show evidence of current registration/certification to ISO 9001:2000, or will have to be assessed by the National Certification Body (NCB) of the IECCE. In the latter case, the NCB ascertains that all information provided in the QMS Application Questionnaire is correct, and that the QMS is effectively implemented.

- Second, products need a valid IECCE Conformity Assessment Report (CAR), and related CAC as issued by an NCB and its Testing Laboratory (CBTL). The product must be tested according to an IEC Standard, or an IEC Publicly Available Specification or a PV GAP Recommended Specification (PVRs).
- Third, the standardized and publicly available requirements for periodic re-testing and also for re-testing for declared changes to the product are published. These requirements are part of the NCB certification programme.
- Finally, auditing and factory inspection should be carried out according to a harmonized Factory Audit Procedure (FAP) and/or the NCB FAP. If a manufacturer already has an appropriate ISO 9001:2000 certificate from an accredited registrar, this is accepted as part of their QMS.

### Step-by-step

The certification procedure (see Figure 2) begins when a company applies to the NCB with a new product for certification. A quotation for the cost of certification is submitted to the company. Once this is agreed, the company is asked to confirm its acceptance of the conditions as presented in the offer and associated certification documents. Following this confirmation, the following stages occur:

- *Registration* - the certification application is analysed and checked with the applicant; the technical file is reviewed according to applicable specification requirements.
- *Licensing/certification contract* - a contractual agreement is signed by the applicant and the relevant certification body, including provisions concerning:
  - use and control of the CAC
  - use and control of the NCB's mark
  - adherence to the applicable parts of the present certification regulations.
- *Pre-licence inspection* - a pre-licence inspection is organized at the factory to audit the manufacturing process, from the incoming goods to the assembly, including routine and random tests and associated QMS implementation. A pre-licence inspection report is completed and signed by the NCB's auditor and the company's designated management representative,

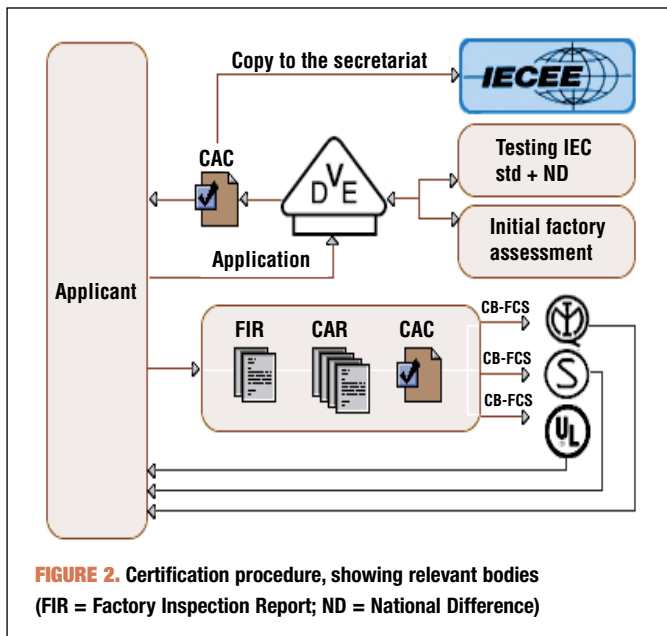


FIGURE 2. Certification procedure, showing relevant bodies (FIR = Factory Inspection Report; ND = National Difference)



containing a summary of the assessment that was carried out, and the auditor's conclusions. It may also refer to non-conformity sheets, and corrective actions planned to ensure conformity. The NCB notifies the applicant of the testing laboratory that will carry out the testing, as well as the person to be contacted, the number of samples, and any additional information needed to complete testing.

- *Product-type testing* – a CBTL, accepted to operate within the CB-FCS, will carry out the relevant type testing under the auspices of the associated NCB.

Optionally, the testing may be carried out according to:

- the TMP (Testing at Manufacturer's Premises) procedure, carried out by the CBTL personnel
- the WMT (Witnessed Manufacturer's Testing) procedure, where the CBTL personnel witness tests performed by the manufacturer's staff at the manufacturer's lab
- the SMT (Supervised Manufacturer's Testing) procedure, where the CBTL personnel supervise the quality system and the testing processes at the manufacturer's premises, witnessing some of tests.

A test report needs to be issued for any tested samples.

**Conformity Assessment Report**

The Conformity Assessment Report (CAR) is a complete package of product and factory information developed by an NCB in one country ('A'). The CAR can be made available by the applicant to an NCB in another country which will accept it ('B'). The CAR includes the following conformity assessment details, to demonstrate that the product or components and the factory quality system have been fully evaluated and meet all applicable requirements:

- for the product
  - information including product description, product test results, observations and national differences
  - any additional information required by NCB 'Bs' (if applicable and requested by the applicant)
- for the factory
  - Initial or Surveillance Factory Audit Report as applicable.
  - description of the arrangements made by NCB 'A' to ensure ongoing compliance of the product with the requirements (such as a copy of the licence).

The CAR compiles all the information for evaluating an organization's conformity and assessing product performance to the relevant specification. What it does is demonstrate that the factory quality system and the product have been fully evaluated, and meet the applicable requirements. It contains:

- for the factory quality system:
  - evidence of an operating quality system for the specific product

- accuracy of the manufacturing quality plan for product control
- for the product:
  - technical documentation
  - method for evaluating product construction, if it is not described in the relevant standard or CB Bulletin, or covered by the IECCE Committee of Testing Laboratories (CTL) decisions
  - a product description report
  - identification of the applied standards and specifications, and requirements
  - test methods, data, results and conclusions
  - interpretation of requirements
  - general conclusion.

**Product conformity assessment certificate**

A CAC is issued by the NCB, once the CAR shows that the factory and product performance have conformed to requirements.

**The CB Full Certification Scheme**

**Advantages**

The benefits of using the FCS include:

- acceleration of product acceptance
- more rapid testing and certification
- greater universal product recognition
- expanded markets
- faster movement of products from plant to market.

**Peer assessment of NCBs and CBTLs**

The CB Scheme is globally administered by the IECCE Secretariat in Geneva, using a registered pool of assessors and technical assessors. Peer assessment allows experts employed by IECCE member organizations to ensure that candidates seeking membership are capable of processing and carrying out the overall conformity assessment procedures. These procedures cover the quality system, and the testing and certifying of the third-party certification process. An Assessment Advisory Group analyses whether or not a candidate NCB or CBTL has the same capabilities as the rest of the group; if they do, the candidate is accepted into the group.

Experience shows that, as well as promoting confidence among the members of the CB Scheme, peer assessment is accepted by authorities and clients of testing and certification bodies as having the same value as accreditation, in terms of verifying competence and building confidence.

**Committee of Testing Laboratories**

The CTL is the technical branch of the IECCE, comprising experts employed by testing laboratories. CTL decisions must be used in IECCE schemes, together with the relevant IEC standards, or if the latter



Manufacturing PV at Isofoton plant ISOFOTON



### **RWE SCHOTT SOLAR**

RWE Schott Solar opted mainly for in-house testing of its framed thin-film modules, ASI-F 2/12 to 10/12, to IEC 61646. This testing was performed in agreement with the VDE (Verband Deutscher Elektroingenieure) Testing and Certification Institute. VDE arranged for specialized tests, such as UV and hail testing, to be conducted in an accredited external laboratory. Testing was performed according to the requirements of IEC 61646, and successfully completed at the end of 2002.

By testing in-house, the manufacturer gathers first-hand experience from the tests, and may feel that there is room for improvement in a revised version of the standard. IEC Technical Committee 82, which deals with solar PV energy systems, is already working on this for IEC 61215.

RWE Schott Solar reported in the press that, with the concept of structural similarity, and the definition (in the Detail Specification) of the limited tests needed for specific module changes, savings can be made equivalent to at least a third of the testing costs. RWE Schott Solar also tested its ASI OPAK and ASI THRU frameless thin-film modules for facades and roof-integrated systems.

RWE Schott Solar's IECQ product certification was announced during the Electronica event in Munich, November 2002. (IECEE has since taken over the IECQ approval).

are not yet available, with PVRS. The CTL's objective is to achieve reproducibility of test results, and to promote close collaboration between testing laboratories.

### **Completing the Blank Detail Specification (BDS)**

Every module family has to conform to the relevant standards for crystalline modules or thin-film modules (IEC 61215 and IEC 61646 respectively). In addition to this, the IECEE will, through the accepted member National Certification Bodies (NCBs), use existing blank detail specifications (BDS). Manufacturers must fill these in prior to testing and certification (see 'Raising the standard'<sup>2</sup>), integrating their data sheet information into the BDS, and accepting the certification conditions it lays down. The BDS conditions cover PV GAP/IECEE qualification approval procedure, quality conformity inspection (including periodic tests and acceptance criteria), modifications likely to require re-testing (and those which do not), marking, structural similarity rules (e.g. testing a representative module instead of all modules in the same structural family) and documentation. (IECEE is considering replacing the BDS with a Manufacturer's Declaration Form in future, which are presently under development within the CTL Expert Task Force 9 [ETF9] on PV.)

The resulting Detail Specifications are then agreed with the NCB, which carries out the IECEE FCS certification process on the basis of published IEC standards. In the absence of the latter, PV GAP Recommended Specifications (PVRSs) can be used, provided this is agreed with the IECEE-CMC, as PVRSs are approved as IECEE provisional specifications.

### **Obtaining the PV Quality Mark/Seal**

On the basis of the CAC issued for a PV product by the NCB,

the manufacturer will be licensed by PV GAP to display the PV Quality Mark on that component, or the PV Quality Seal on systems. When the PV manufacturer receives its first CAC, they are eligible to sign a licensing agreement authorizing them to use the PV GAP Mark/Seal on a certified product. The licensing agreement will come from PV GAP's Central Office in Geneva, Switzerland, or from the competent PV Industry Association, which holds a master licence for sub-licensing manufacturers on its territory. After the agreement has been signed by the manufacturer, PV GAP issues a certificate of approval, listing the approved products. If the manufacturer receives a CAC for other products, they will receive additional certificates of approval without needing to sign a new licence agreement. The manufacturer and approved products will be listed on the PV GAP website. The procedure for this is shown in Figure 3.

At present, the competent PV industry associations are the European Photovoltaic Industry (EPIA), and the Solar Energy Industries Association (SEIA). EPIA has sub-licensed RWE Schott Solar, Photowatt International and

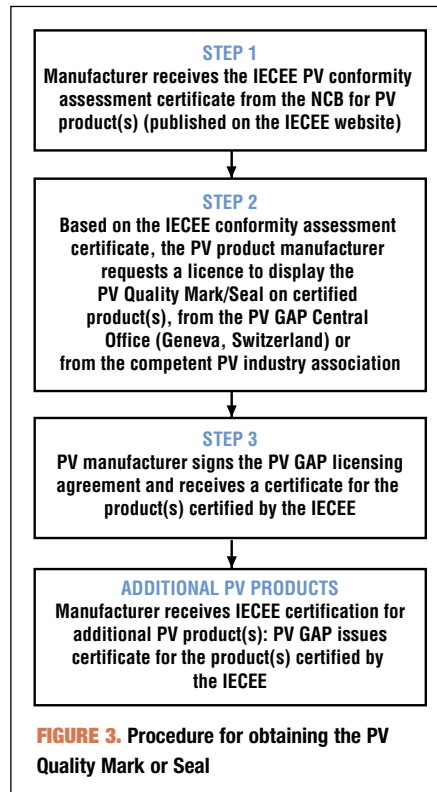
periodic testing - such as repetition of the hail test when no changes to the glass on a module had been made - were

Isofoton to use the PV Quality Mark on their approved products, and SEIA has sub-licensed BP Solar. Manufacturers outside Europe and the US will be licensed directly from PV GAP headquarters in Geneva, until the relevant regional PV association has registered as a PV GAP member. The 'PV Quality Mark' seen in Figure 1 is already in use on Photowatt International PW 1250 and PW 1650 module labels.

As can be seen from Figure 1, the Mark/Seal is always to be accompanied by its licence number. This number provides traceability, allowing the manufacturer to be identified.

### HOW HAS CERTIFICATION WORKED IN PRACTICE?

During the first few certifications, manufacturers were not familiar with the product certification procedure, so the PV GAP Secretariat provided guidance to help complete the BDSs. What was also discovered in the certification process was that some of the requirements for



**FIGURE 3.** Procedure for obtaining the PV Quality Mark or Seal



### PHOTOWATT INTERNATIONAL

The path taken by Photowatt International, which wished to obtain the PV Quality Mark for its PW 1250 – PW 1650 crystalline silicon modules, was different from that for RWE Schott (see text box, p. 50).

Specifically, Photowatt had recently obtained complete IEC 61215 (including UV) test reports from the Joint Research Council's European Solar Test Installation (JRC ESTI) at Ispra, Italy. As ESTI is accredited by the Comité français d'accréditation (COFRAC) for IEC 61215 testing, the test reports were accepted by LCIE/SNQ (Laboratoire Central des Industries Electricques/Service national de

qualité), and no further type approval testing was necessary. For the lot-by-lot and periodic testing, Photowatt International and LCIE/SNQ will consider whether and to what extent the testing will be conducted in-house under supervision, or in an external laboratory. Photowatt International's IECQ product certification was completed in March 2003 (and has since been transferred to the IECEE).

### ISOFOTON

Isoton followed the same path as Photowatt International to receive certification for its products.

unrealistic, and should therefore be removed, or at least relaxed. The PV GAP Technical Committee, which originally authored the BDS, considered the matter, amended the BDS accordingly and had it approved by the Board, transmitting it to the certification body in time for the completion of the work. The Detail Specifications generated for RWE Schott Solar and Photowatt International modules certification were IEC 61646 DE 0001 and IEC 61215 FR 0001 respectively,<sup>7,8</sup> both of which are publicly available on the IECEE and PV GAP websites.

#### **Certification by IECEE, and PV GAP approval for Mark and Seal**

When testing and factory audit have been successfully completed, the NCB issues the IECEE PV CAC and the CAR. The IECEE publishes the CACs that have been issued on its website, under

the relevant PV section, and these are available for consultation by PV members. (See box on opposite page on BP Solar.)

It is important to note that, under the IECEE, everything concerning certification is formally prescribed in publicly available documents, which are referenced in the IECEE Detail Specification. This tells the manufacturers precisely what they have to do to achieve approval, ensuring user confidence in the PV GAP approval process.

#### **SOME IMPORTANT CONCLUSIONS FROM APPROVAL EXPERIENCE**

This initial experience of the certification process leads to several important conclusions.



Photowatt are presented with certificate; Ibrahim Samak, President of EPIA, is shown left, and Photowatt CEO Mr Eric Laborde is on the right PHOTOWATT

The manufacturer should have an operating QMS in place that complies with ISO 9001:2000, covers their PV component manufacture, and includes their testing facilities, if appropriate. On this basis, it is possible for the manufacturer to fulfil its ongoing responsibilities regarding product certification, such as customer satisfaction, continuous improvement, and use of any in-house testing capabilities. The manufacturer should also be free to use any PV testing laboratory accredited to ISO/IEC 17025, and to make some or all tests in-house under NCB supervision. It should not require any onerous formal approval procedure in the manufacturer's laboratory.

The experience also demonstrates that a published BDS, acceptable to the PV industry and completed by the manufacturer, is a transparent and convenient means of making full use of the manufacturer's data sheet. In addition, it defines all of the immediate and ongoing certification requirements pertaining to the relevant IEC standard. Clear interest is being demonstrated in PV GAP's international 'PV Quality Mark' as well. The licensing of this must be on terms acceptable to the PV industry and beneficial to PV consumers.

Fast-track procedures for preparing and amending any specifications further to (or whilst waiting for) standards from IEC TC 82 have proved to be necessary. The PV GAP Technical Committee has so far played an essential part in this process by writing the BDSs; membership is open to all experts and is not limited to countries within the IEC family.

The certification and labelling structure is now well defined. There are still some standards missing, but with PVRs being available, this situation will soon be improved. PV GAP

### BP SOLAR

BP Solar obtained IECEE PV conformity assessment certificates from Underwriters Laboratories Inc, an NCB, during the first half of 2004. These CACs were for the crystalline silicon modules BP3140, BP3150 and BP 3160, as well as for the modules BP7185, -7180, -7175, -7170, -7160, -790 and -785. Based on the CACs, BP Solar received the licence to display the PV Quality Seal on these modules.



Soldering on: PV module matrix is soldered at a BP Solar plant BP SOLAR

already has a significant impact on the PV industry, as it is ultimately quality that will make PV more cost-effective.

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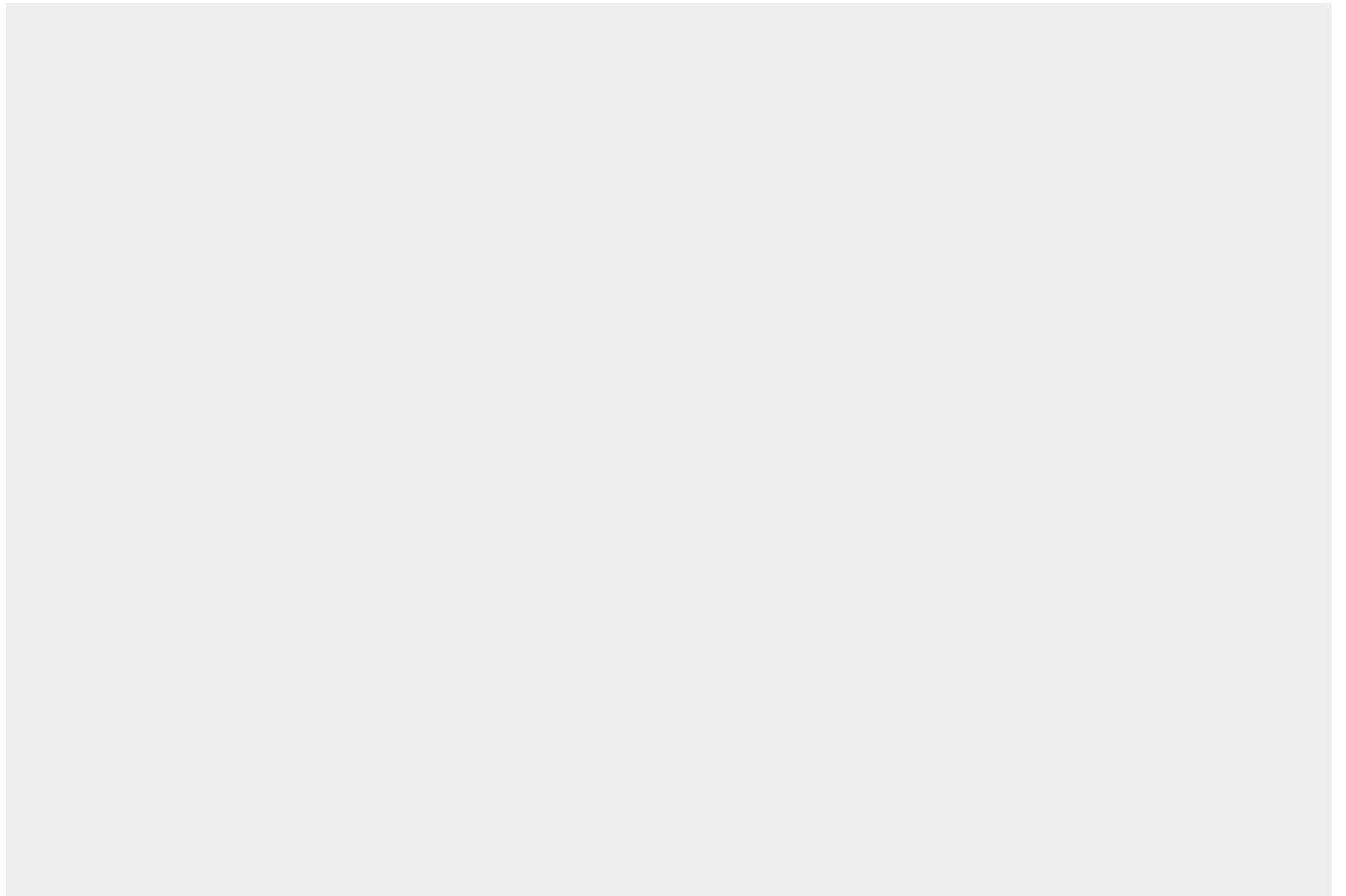
## ACKNOWLEDGEMENTS

The authors acknowledge the pioneering steps that were taken by IECQ in certifying the first three manufacturers' products, and the important work of updating and adopting the relevant rules and procedures being carried out by IECEE's ETF9 CTL, which will ensure smooth transition from successful IECQ approval to IECEE certification.

Many organizations and donor agencies have been instrumental in setting up the PV GAP structure, and support the goal of a quality label to ease trade, make PV more cost-competitive, protect consumer interests, and enhance quality of PV products and systems.

## NOTES

1. Varadi, P. F. and Bergmann, A. 'The cost of quality: establishing PV quality systems'. In *Renewable Energy World*, September–October 2002. James and James (Science Publishers).





2. Azzam, M. Jacquemart, C, Kay, R. Ossenbrink, H. Perujo, A. and Varadi, P. F. 'Raising the standard – global PV standardization and specification'. In *Renewable Energy World*, July–August 2004. James and James (Science Publishers).
3. Real, M. Bader, H. P. and Scheidegger, R. 'Minimizing the environmental impact of large-scale rural PV'. In *Renewable Energy World*, Jan–Feb 2001. James and James (Science Publishers).
4. IEC System for Conformity Testing and Certification of Electrical Equipment (IECEE).
5. The CB Scheme is the IECEE scheme for mutual recognition of electrical equipment test certificates by the scheme members; the CB-Full Certification Scheme is an extension of the CB Scheme to include Quality System assessment and periodic factory inspection, in addition to product testing.
6. General information about CB-FCS is available at [www.iecee.org](http://www.iecee.org)
7. IEC 61215: 1993, 'Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and Type Approval'.
8. IEC 61646 DE 0001: 2002, 'Detail specification for thin-film terrestrial PV modules of assessed quality'.

### FURTHER READING

- Kay, R. and Bergmann, A. 'Module International certification and marking, first experience'. Presented at 3rd World Conference on Photovoltaic Energy Conversion, Osaka, Japan. 2003.
- ISO 9001:2000, 'Quality management systems – Requirements'.
- IEC 61215 FR 0001: 2003, 'Detail specification for crystalline silicon terrestrial PV modules of assessed quality'.
- ISO/IEC 17025: 1999, 'General requirements for the competence of testing and calibration laboratories'.

### GLOSSARY OF ACRONYMS

- *BDS* – Blank Detail Specification
- *CAC* – Conformity Assessment Certificate
- *CAR* – Conformity Assessment Report
- *CB* – Scheme Certification Bodies Scheme of the IECEE
- *CB-FCS* – CB-Full Certification Scheme
- *CBTL* – CB Testing Laboratory
- *COFRAC* – Comité français d'accréditation
- *CTL* – Committee of Testing Laboratories of the IECEE
- *ETF9 CTL* – Expert Task Force 9, Photovoltaics
- *FAP* – Factory Audit Procedure
- *FIR* – Factory Inspection Report
- *IEC* – International Electrotechnical Commission [www.iec.ch](http://www.iec.ch)
- *IECEE* – IEC System for Conformity Testing and Certification of Electrical Equipment ([www.iecee.org](http://www.iecee.org))
- *IECQ* – IEC Quality Assessment System for Electronic Components (now IECQ-CECC); [www.iecq-cecc.org](http://www.iecq-cecc.org)
- *JRC ESTI* – European Commission Joint Research Centre, European Solar Test Installation, Ispra, Italy
- *NCB* – National Certification Body of the IECEE
- *PVRS* – PV GAP Recommended Specification
- *QMS* – Quality Management System
- *SI* – Supervising Inspectorate of the IECQ-CECC
- *SMT* – Supervised Manufacturer's Testing
- *TMP* – Testing at Manufacturer's Premises
- *WMT* – Witnessed Manufacturer's Testing