PVTRIN
INSTALLER CERTIFICATION

TRAINING OF PHOTOVOLTAIC INSTALLERS IN EUROPE

THE PVTRIN TRAINING AND CERTIFICATION SCHEME

FINAL REPORT

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www.pvtrin.eu

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A great deal of additional information on the PVTRIN project is available on the web at: www.pvtrin.eu

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EXECUTIVE SUMMARY

The photovoltaic market has shown a continuous growth during the last decades due to the EU supporting policies and the favorable national regulatory frameworks. More than 58,000 MW of capacity were added to the grid since 2008, reaching 68,600 MW at the end of 2012 (cumulated photovoltaic capacity in EU).

Although the European growth is affected by the global financial crisis, the EU PV market will continue to grow. According to the industry's forecasting scenarios, the total installed capacity may reach 130 GW (baseline scenario) to 200 GW (accelerated scenario) till 2020. In EU27, PV jobs may reach to 1 million in 2020; half of them directly or indirectly related to PV installation and maintenance.

The application of PV technologies, however, requires highly-qualified technicians for PV installation, repair and maintenance. Up to now, national markets have been growing at a faster rate than the qualified PV installers force can satisfy. Investors are aware that using a qualified installer means better system performance, less technical failures and reduced risks throughout the life of their installation. Obviously, the need for quality installations calls for skilled technicians; the shortage of competent workforce may result in a threat to the PV market.

Certification schemes can provide reassurance that the installer has the capacity (organisation, competence and equipment) to complete a PV installation safely and effectively. Across Europe the availability of certification schemes for PV installers varies greatly between countries. Many do not have certification schemes in place, although training courses for PV installers are often available. But where training courses are available, these may have different eligibility requirements and qualifications.

Along these lines, the recent EU Directive (2009/28/EC) is forcing the Member States (MS) for mutual acknowledged certification schemes. Furthermore, the interested parties (manufacturers, developers, investors) seek certified skills and quality assurance in all phases of a PV installation (design, installation and maintenance).

This is the scope of the European initiative PVTRIN which focuses on the development of an appropriate training and certification scheme for technicians who are active in the installation and maintenance of small scale PV systems. It fulfils the criteria set by the 2009/28/EC Directive and establishes the basis for the adoption of a mutually acknowledged certification scheme within EU MS.

The PVTRIN Scheme has been, initially, implemented in six (6) countries: Greece, Bulgaria, Croatia, Cyprus, Romania and Spain, incorporating the national legislation, the market's needs and the PV industry's requirements. In order to incorporate the real needs of the market, to achieve consensus and to assure the broadest possible support, the key stakeholder groups are involved to transfer the market's experience and needs, and to provide consultation.

The PVTRIN Training and Certification scheme offers to the installers:

- Appropriate, acknowledged training courses
- Practical training materials and tools (handbooks, checklists and tips, e-learning platform, practical guides, lists of useful resources)
- Advancement and continuous updating of their knowledge and technical skills
- Employability; recognition and professional competitive advantage due to their certification according acknowledged quality standards
- Mobility; the certification provides the "passport" to the EU job market.

To achieve certification, the PVTRIN trainee has to prove the required knowledge and skills by successfully completing the PVTRIN exams (written and practical part). Once the required areas of competencies are fulfilled and the assessment requirements are met the installer is eligible for the PVTRIN Certification. The certified installer is awarded the "Photovoltaics Certified Installer" certification mark which they can display publicly to demonstrate their proficiency.

As a result of the PVTRIN activities, **a pool of 185 qualified/certified PV installers** has been created in the 6 participating countries where an operational qualification and certification scheme for PV installers is currently in place. More than 40,000 technicians are aware of the PVTRIN scheme in EU level.

Creating a qualified installers workforce, PVTRIN supports the European Photovoltaic industry to confront the shortage of skilled technicians. By employing a qualified PV installer, customers gain confidence that the appropriate level of quality and performance is met and maintained for their PV system.

Long term, PVTRIN will contribute to the PV/BIPV market growth in the participating countries, provide a supporting instrument for the EU Member States to meet their obligations for acknowledged certifications for RES installers and enforce their efforts in achieving the mandatory target of a 20% share of energy from RES in overall Community energy consumption by 2020.

The PVTRIN project is co-financed by the Intelligent Energy Europe programme of the European Commission.

1 INTRODUCTION

The fast growth of photovoltaics (PV) has created a high demand for skilled installers. The application of PV technologies requires highly-qualified technicians for installation, repair and maintenance.

Choosing the right PV installer plays a significant role to the quality and the performance of the system. The installation is a complex task, not only from the technical point of view where installers must have knowledge about DC/AC electricity and safety, in parallel with roofing skills and understanding of designing rules, but also from the financial and legal aspects, as -in most countries- PV systems are subject to a number of administrative issues and diverse regulations. PV is considered as an expensive energy technology, thus the highest possible performance of a PV system is the main concern of the investors. Installers must not only perform technical tasks correctly and precisely, but also to provide customers with appropriate information about incentives, investment costs and other regulations critical to the installation of their PV system. Nowadays, investors seek skills certification and quality assurance in all phases of a PV installation process (design, installation and maintenance).

The PVTRIN initiative supports the European Photovoltaic industry to confront the shortage of skilled technicians by developing a training and certification scheme for technicians who are active in the installation and maintenance of small scale PV systems. This scheme incorporates the criteria set by the 2009/28/EC Directive (article 14, Annex IV) for qualification schemes and certified training courses in each Member State, taking into account the national legislation, as well as the national market's needs.

The PVTRIN Training and Certification Scheme provides the key components for the PV installer's qualification framework, an appropriate training methodology and a transparent and clearly defined accreditation route and set the base for the adoption of a mutually acknowledged certification scheme across Europe. It is, initially, implemented in six countries which represent a different level of market maturity and perspectives: Greece, Bulgaria, Croatia, Cyprus, Romania and Spain.

Choosing a PVTRIN Certified Installer means that the installer has been trained, assessed and is committed to install PV systems that meet the performance and reliability needs of their customer by incorporating quality craftsmanship and complying with all applicable codes and standards.

The PVTRIN activities resulted in:

- Acknowledged training courses and operational certification scheme for PV installers; certification scheme's documentation and guidelines for the replication of the action throughout Europe
- Eight (8) pilot training courses implemented in six (6) countries (Greece, Bulgaria, Croatia, Cyprus, Romania and Spain); a pool of 185 qualified PV installers
- Appropriate training "package" for PV installers and their trainers (handbooks, checklists and tips, e-learning platform, assessment forms; other training materials/tools); also for training providers, assessors and certification bodies, available in 6 languages
- Encouragement of a greater number of technicians to advance their professional skills; more than 40.000 technicians aware of the scheme in EU level
- Increased awareness for the benefits of engaging certified installers; more than 1.000.000 EU citizens informed
- Raised knowledge of good practices and "key-parameters" for effective PV/BIPV installation/integration
- All key stakeholder groups actively involved and supported the initiative in the 6 participating countries.

In the long term, the PVTRIN outcomes are expected to:

- encourage a greater number of technicians to advance their professional skills
- provide a supporting instrument, for EU MS to meet their obligations for acknowledged qualification/certification schemes for RES installers
- facilitate job mobility within Europe
- contribute to the PV market growth in the participating countries
- support the EU countries to achieve the mandatory target of a 20% share of energy from RES in the overall Community's energy consumption, by 2020.

The partners cooperating in the PVTRIN project are presented below.

Partner		Country	Website
	Technical University of Crete *Environmental Engineering School* *Renewable and Sustainable Energy Systems Lab* *PROJECT COORDINATOR*	Greece	www.tuc.gr
	Agency of Brasov for the Management of Energy and Environment	Romania	www.abmee.ro
	Building Research Establishment Ltd	UK	www.bre.co.uk
	Energy Institute Hrvoje Požar	Croatia	www.eihp.hr
	European Photovoltaic Industry Association	EU/ Belgium	www.epia.org
	Scientific and Technical Chamber of Cyprus	Cyprus	www.etek.org.cy
	Sofia Energy Centre	Bulgaria	www.sec.bg
	Tecnalia	Spain	www.tecnalia.com
	Technical Chamber of Greece *Branch of Western Crete*	Greece	www.teetdk.gr

Benefits of the PVTRIN Scheme

i) for the installers

- acknowledged training courses;
- practical training guides and flexible training opportunities through the e-learning platform;
- advancement and updating of their knowledge and technical skills;
- Independent confirmation of their competences;
- employability; recognition and professional competitive advantage;
- mobility; the certification provides the "passport" to the EU job market.

ii) for the training providers

- a training methodology and accreditation route, focused to PV installers to be adopted in their training courses;
- a well-structured training course and tools to correspond to an active need of the market and the society;
- training materials "package" for trainers and trainees in their national language;
- a defined professional framework to develop their courses.

iii) for the PV industry

- availability of efficient workforce;
- increased credibility and confidence to the technology by the potential investors (better system performance and reduced risks);
- satisfied customers (efficient installations, less technical failures, lower operational costs).

Apart from the directly involved parties, the entire society is to benefit. By increasing the PV technology penetration to the energy mix, greenhouse gas emissions will be reduced, improving the citizens' quality of life.

The PVTRIN Scheme, has been developed within the framework of the European project PVTRIN and co-financed by the Intelligent Energy Europe programme of the European Commission

More information on the PVTRIN project is available on the web at: www.pvtrin.eu.

2 THE PVTRIN SCHEME DEVELOPMENT

The PVTRIN scheme provides the key components for a mutually acknowledged qualification framework, an appropriate training methodology and a transparent and clearly defined accreditation route, incorporating the criteria set by the Directive 2009/28/EC for qualification schemes and certified training courses in each Member State, as well as the national framework and legislation and the national markets' needs. The scheme was, initially, implemented in six (6) countries: Greece, Bulgaria, Croatia, Cyprus, Romania and Spain.

2.1. The scope of the PVTRIN scheme

The scope of the PVTRIN training and certification scheme includes:

- Fulfilling the requirements of 2009/28/EC Directive Annex IV i.e. the certification scheme should:
  - be transparent; the scheme requirements are public, subject to review and approval by national bodies and widely available
  - include an accredited training course, including theory and practical examinations that leads to the certification of PV installers
  - include requirements for regular training updates as part of the certification maintenance requirements

- Meeting the legal requirements and be compatible with the institutional framework of each Member State
- Maintaining and enhancing the reputation of the PV industry by including a set of clear and robust requirements that:
  - Underpin the safety, quality and performance of PV installations
  - Minimise complaints and provide processes for dealing with these swiftly and effectively should they arise.

The PVTRIN's action plan foresaw the following steps (Figure 2.1):

i. Comparative analysis of the industry and market needs on PV installation and maintenance, as well as the national legislative and normative framework in six (6) countries
ii. Definition of the professional framework for PV installers and development of a suitable training methodology
iii. Development of proper training material for installers and trainers; also practical training tools and an e-learning platform for a flexible and adaptable training procedure
iv. Development of a transparent and clearly defined certification scheme, focused on small scale applications, in order to accredit the training course for installers and to provide mutually acknowledged quality standards within EU countries
v. Implementation of pilot training courses, resulting to a pool of skilled and certified PV installers in 6 countries
vi. Evaluation of developed methodologies, materials and tools, in order to ensure that the project's outcomes will match the pre-decided quality standards
vii. Development of a roadmap and concrete documentation to facilitate replication and exploitation of the project's deliverables throughout Europe.

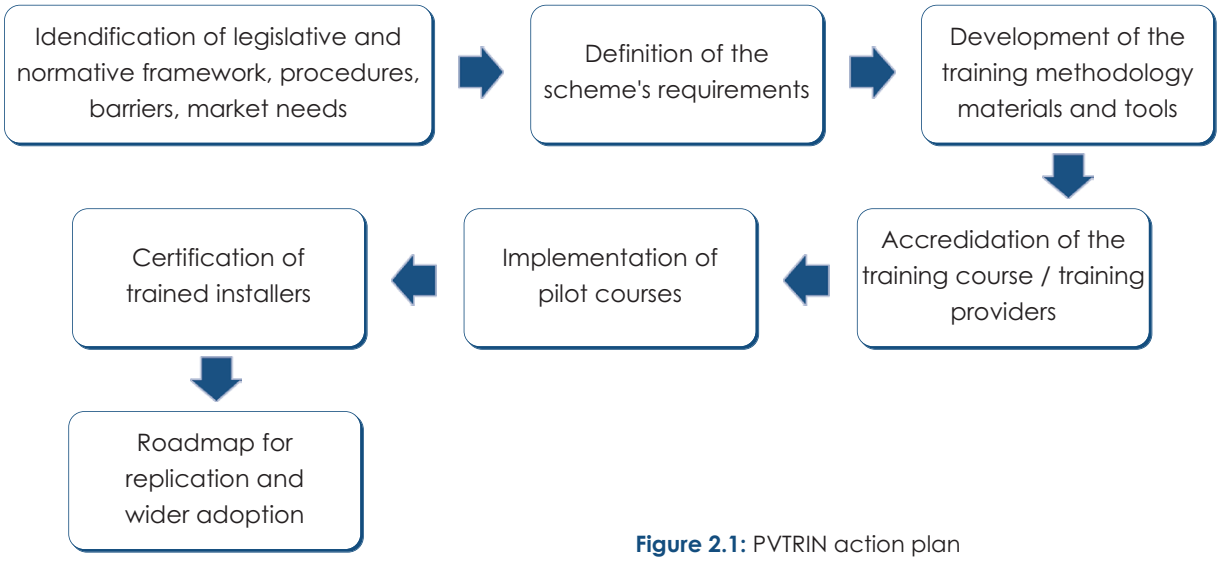

Figure 2.1: PVTRIN action plan

2.2. The development process

Initially, the national legislative and normative framework regarding professional training, qualifications and certification was identified. The competent bodies (national authorities, accreditation bodies and involved associations) in the six (6) participating countries were contacted. The procedures for the acknowledgment of the PVTRIN scheme were identified; in addition potential synergies and barriers were evaluated.

A fieldwork research was conducted in the PVTRIN countries, in order to record the attitudes, perceptions and considerations of the PV industry actors regarding the training and certification of PV installers. A second survey measured the satisfaction level of PV investors as concerns the quality of the installation process of their system. PV industry and investors have noted that the lack of qualified installers is resulting to considerable technical failures.

In order to incorporate the genuine market needs and to assure the broadest possible support, the key stakeholder groups were involved to transfer the market's experience and to provide consultation.

Moreover, relevant initiatives and existing certification schemes for PV/RES installers -in Europe and internationally- were reviewed in order to exploit existing knowledge and expertise; also to create links and synergies with relevant initiatives.

Through the above methodology, the PVTRIN scheme integrates the national legislation, the market's needs and the PV industry's requirements. The interaction with the stakeholder groups has revealed significant issues to be taken into account for the scheme's development. Also, the cross-national analysis of the field surveys' results shows the different markets' needs, industry's considerations and investors' opinion and perceptions.

Furthermore, the scheme incorporates the criteria set by the RES Directive with regard to the requirements for certified training courses and training providers, thus providing a supporting instrument for EU Member States to meet their obligations for acknowledged certifications for RES installers.

Procedures for the maintenance of the certification through reassessment procedures are defined. The transferability and replication of the scheme in the PVTRIN countries, as well as in other EU MS, were also taken into account.

2.2.1. Market survey in the PVTRIN countries

196 responders (distributors, authorized dealers, wholesalers, engineers, technicians and building constructors, professional associations, chambers and other market actors engaged with the PV installation) participated in the field research conducted in the 6 PVTRIN countries; 8 out of 10 admitted that the certified professional skills -according to internationally acknowledged quality standards- will improve the competitiveness and will contribute to the industry's healthy development.

Indicatively, findings of the cross-national analysis, reveal that:

- 12% evaluate the quality of existing PV installations as non satisfactory, whereas 41% consider it to be just tolerable.
- 60% admit that operational problems, due to technical failures, may occur during the installations; 20% of them consider this fact frequent; in Spain, where a large number of installations exists, this percentage reaches to 32%; in Romania 43% and in Greece 16% - highlighting the importance of training and assessment of the installers' skills.
- Regarding their opinion for the current installers workforce skills, the PV industry/market actors believe that their qualifications are rather satisfactory as concerns sizing, electrical/ mechanical design; however when it comes to the compliance with safety rules, the integration in buildings and the proper maintenance of the systems, they rate them as rather inadequate (Figure 2.2).
- Responders highlight the lack of existing courses, the importance of targeted training for PV installers in their country (Figure 2.3) and the adoption of quality standards, regarding PV installations. 75% of them recognised that the adoption of a mutually acknowledged EU certification scheme for PV installers is important for the healthy PV market development (Figure 2.4).

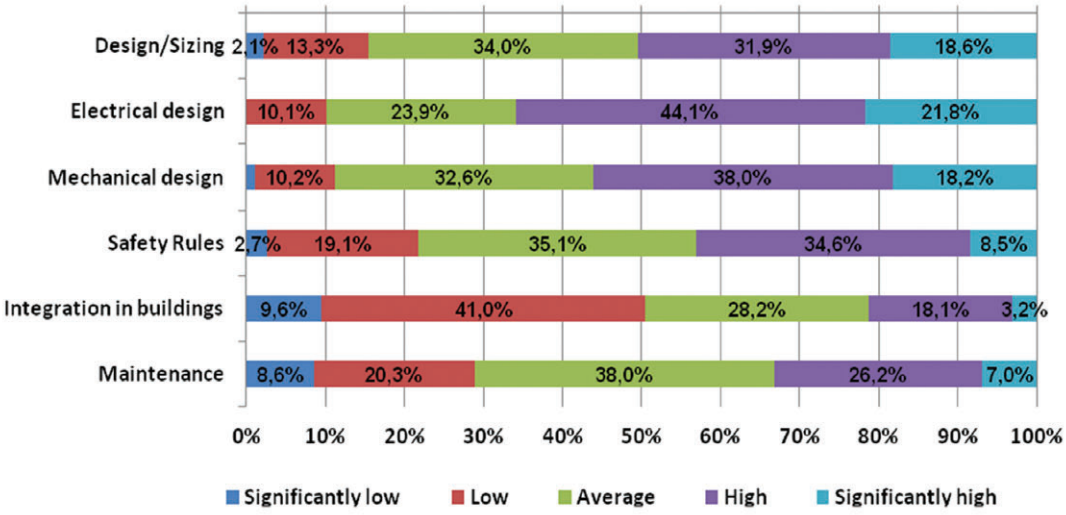

Figure 2.2: Rating of the current installers' workforce skills based on the PV industry/market actors' opinion

The most important measures in order to improve the quality and performance of the PV installations, according to the opinion of the PV industry/market actors are illustrated in Table 2.1.

Table 2.1: Most important measures to improve the quality of PV installations, according to the market actors' opinion

	1st	2nd	3rd
Spain	Equipment certification	Systems certification	Certified training of installers
Romania	Certified training for installers	Technical training for installers by companies	Systems certification
Greece	Systems certification	Technical training by companies	Certified training of installers
Cyprus	Technical training by companies	Certified training of installers	Methods to confirm the installer's skills and adequacy
Croatia	Technical training by companies	Certified training of installers	Identified qualifications framework
Bulgaria	Equipment certification	Systems certification	Technical training by companies

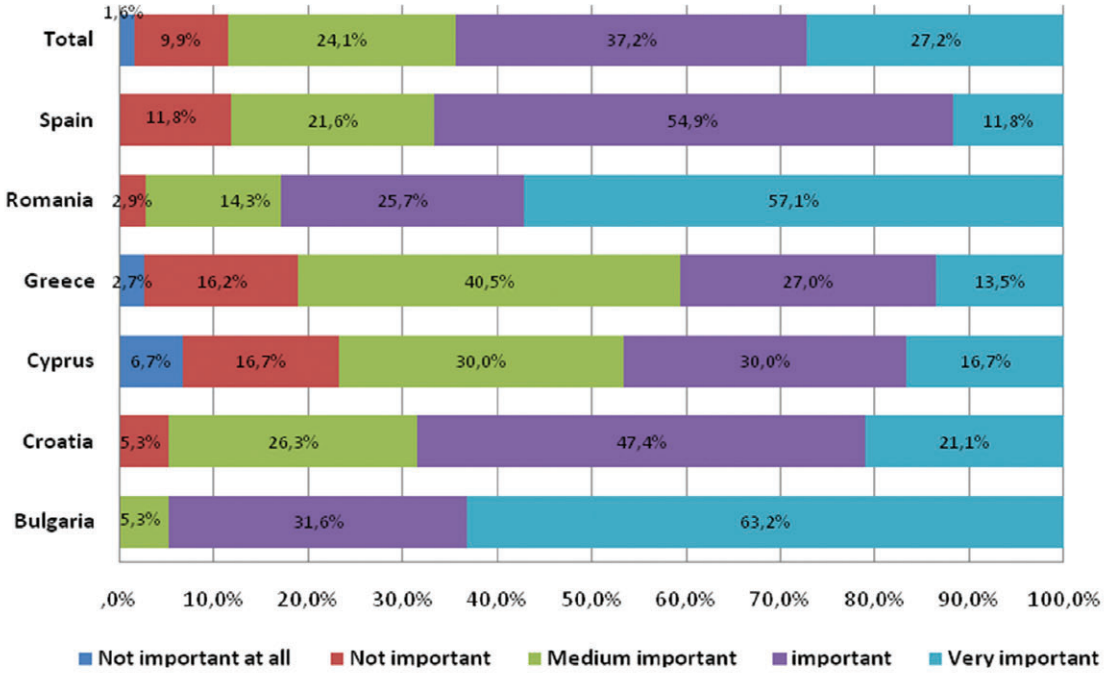

Figure 2.3: Importance of appropriate training for the PV market growth

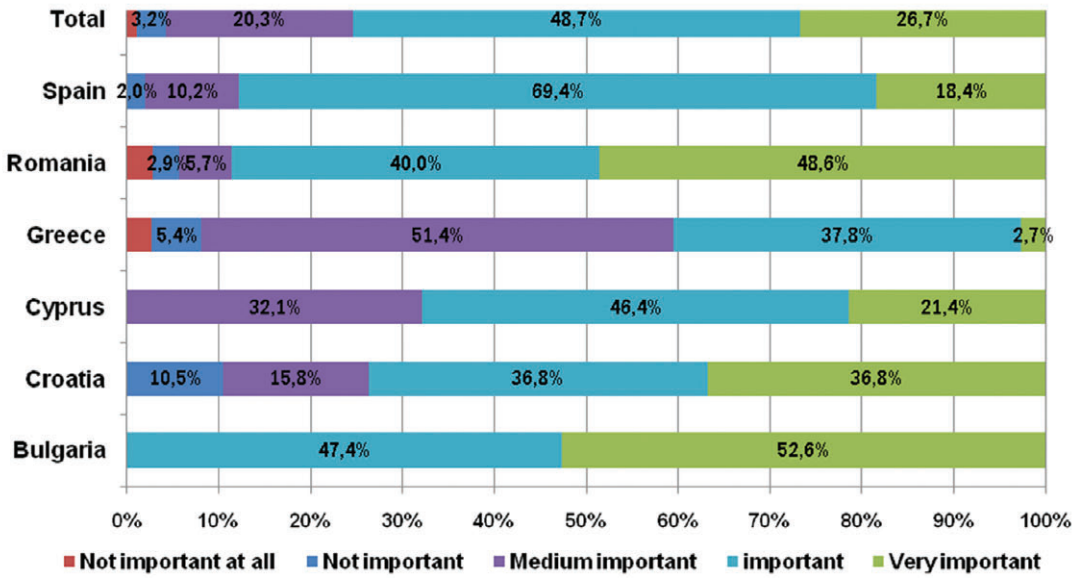

Figure 2.4: PV market actors' opinion on the importance of adopting an EU acknowledged certification scheme

A second survey estimated the satisfaction level of PV investors (128 responders) as concerns the quality of the installation process:

- The basic motive to invest was to make profit, whereas saving money from reduced electricity consumption followed.
- 91% declared themselves as being satisfied or very satisfied from their PV installation. However, 42% reported technical failures (Figure 2.5).
- Inverters (40%) and fuses (20%) are the parts that malfunctions occur more often. According to their perception the most probable reasons for these malfunctions are the "PV system components failure". However it is important to mention that 25% believe that these failures are due to failures in electrical installation, technicians' inexperience or improper design.
- 30% consider the technical skills of the existing PV installers, in relation to their own needs, as non-satisfactory.
- 74% admit that they would be more confident if their system was installed by a certified installer and 52% are willing to pay more to have their system installed by certified staff.

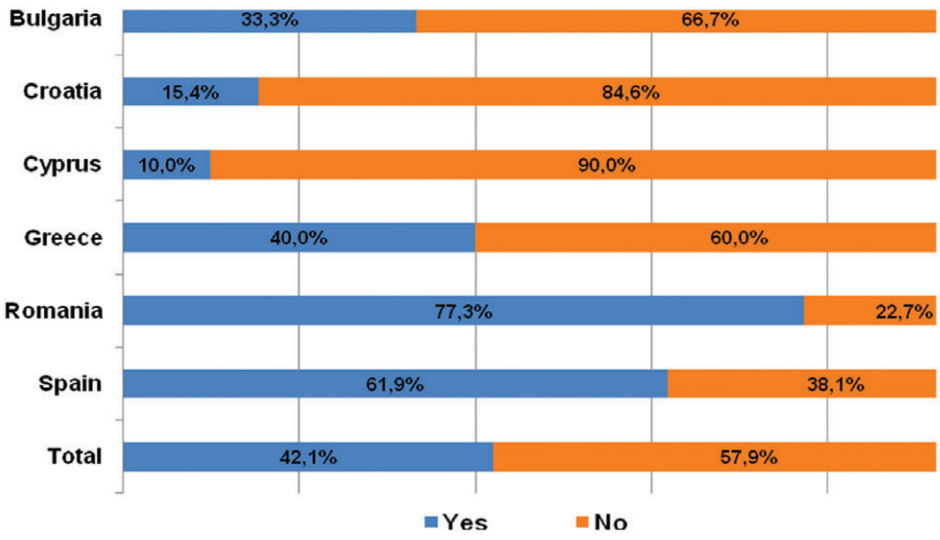

Figure 2.5: Did any technical malfunctions occur during your system's operation?

2.2.2. National Consultation Committees

Active National Consultation Committees (NCCs) were constituted in the 6 PVTRIN countries, involving the competent national authorities, key market actors, the national PV industry and professional associations, accreditation bodies and vocational training organisations.

45 organizations (i.e. PV/RES industry associations, professional unions and installers associations, the competent national authorities, vocational training organizations, accreditation/certification bodies, chambers of commerce and investors associations) have been involved as members of the NCCs (Figure 2.6) in order to:

- transfer the national market's experience and status
- assist in the identification of the gaps in the qualifications of the current workforce and of specific needs/priorities for training
- gain consensus about the skills expected from PV installers
- formulate the PV installers' task analysis as a basis for the PVTRIN course curriculum
- provide consultation for the PVTRIN scheme development
- promote the training and reinforce the recognition of the certification scheme
- maintain the scheme after the project's end.

The stakeholder groups declared that the establishment of certification schemes may well improve the market function and will contribute to more efficient installations. However, they emphasized that decisions regarding the certification requirements and criteria should avoid additional bureaucratic barriers to the market or costs to the investors. They admitted that some technicians may not have the competences expected to efficiently install PVs, others are not aware of basic safety and sizing principles; which means high risk of accidents and technical failures. Experts highlight the importance of practical training in PV (training in the industry and/or lab courses where practical experience can be obtained).

NCC members formed the Technical Committee of the Certification Scheme, where required by the National Accreditation Bodies, and committed to monitor, update and maintain the PVTRIN Scheme after the project's end.

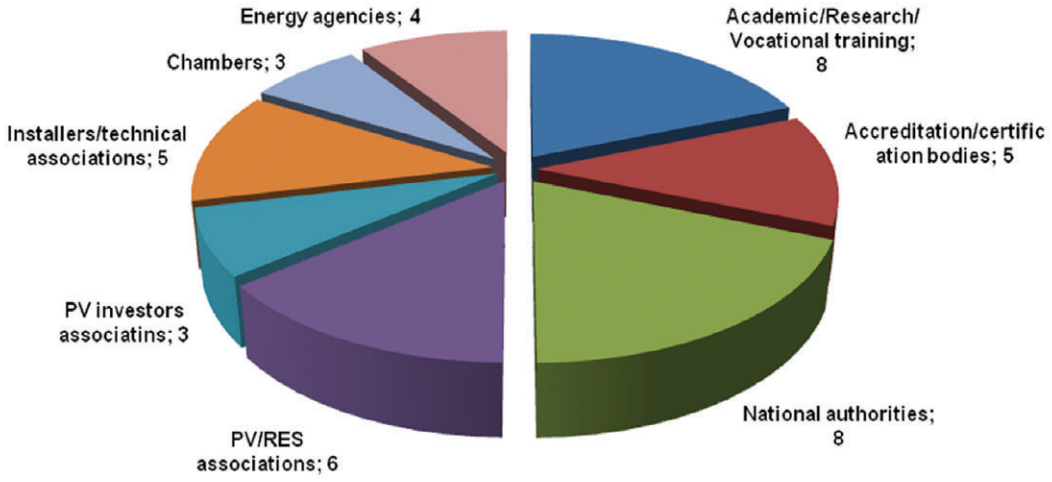

Figure 2.6: Synthesis of the PVTRIN National Consultation Committees

The organizations engaged to the National Consultation Committees are listed in Annex 2.

2.2.3. PV Installers' task analysis

During the Scheme's development, the potential qualifications and skills expected for any qualified PV installer to be able to properly install and maintain PV systems were identified, through a consultation process with the NCC members. The PV installer task analysis helped to:

- define the requirements for the assessment and credentialing of practitioners
- establish the requirements for the accreditation of training programs
- develop the PVTRIN curriculum.

Table 2.2 presents the key tasks and skills of a small scale PV installer:

Table 2.2: PV Installer key tasks and skills

i. Working Safely with Photovoltaic Systems
- Maintain safe work habits - Demonstrate safe and proper use of required tools and equipment - Demonstrate safe practices for personnel protection - Prove awareness of safety hazards and knowledge how to avoid them - Understand and apply appropriate codes and standards
ii. Conduct a Site Assessment
- Identify tools and equipment required for conducting site surveys for PV installations - Determine suitable location with proper orientation, sufficient area, adequate solar access - Determine suitable locations for installing all PV system's components - Illustrate possible layouts and locations for array and equipment - Identify and assess any site-specific safety hazards associated with the installation of the system - Obtain and interpret solar radiation and temperature data
iii. Select and size a PV system
- Estimate and/or measure the peak load demand and average daily energy use for loads - Determine the design currents and voltages for any part of a PV system electrical circuit - Determine the capacity of system conductors, and select correct sizes - Determine appropriate size, ratings, and locations for earthing and lightning protection - Identify array layout, orientation and mounting method for ease of installation - Select major PV system's components - Estimate annual energy performance of proposed system
iv. Installation of the system in the field
- Install module array interconnecting wiring; implement measures to disable array during installation - Label, install, and terminate electrical wiring - Use proper and correctly labelled DC junction boxes and isolation switches - Verify continuity and measure impedance of earthing system - Program, adjust, and/or configure inverters-controls for desired set points and operating modes - Utilise drawings, schematics, instructions and recommended procedures in installing equipment - Assemble modules, panels, and support structures as specified by design - Inspect entire installation, identifying and resolving any deficiencies in materials or workmanship - Activate system and verify overall system functionality and performance - Explain safety issues associated with the operation and maintenance of the system

Table 2.2 (continued): PV Installer key tasks and skills

v. Maintaining and Troubleshooting
- Analyse the manuals of PV installations, determining actions required for the maintenance - Design a typical periodical maintenance plan and select the appropriate tools - Analyse the past production report and -potential- fault reports - Identify typical installation mistakes/failures - Inspect entire installation, check mounting systems, ventilation, cable runs and connections - Check system mechanical installation for structural integrity and weather sealing - Check electrical installation for proper wiring practice, polarity, earthing etc. - Compile and maintain records of system operation, performance, and maintenance
vi. Quality management and customer care
- Understand all quality parameters regarding quality management, efficiency and functional controls - Recognize and understand EU standards associated with the system components and processes - Understand and apply all necessary customer care activities.

3 THE PVTRIN TRAINING PROGRAMME

3.1. PVTRIN training course overview

The PVTRIN course consists of two parts, the theoretical and practical training; the first part describes the underpinning knowledge that is required to understand essential theory behind PV systems, related regulations, applicable standards, safety requirements, installation and testing procedures. The second part concerns the application of practical skills in carrying out installation and testing.

It is a 10-day course including class lectures, exercises and hands-on training in demonstration facilities and laboratories. Participants are enabled to study online, to self-evaluate their progress and to get further training through the PVTRIN e-learning platform. It covers the design, installation and maintenance principles of small scale PV installations. Participants develop their skills and understanding of basic solar theory, system components, design, installation, commissioning and handover of a small scale PV system, including maintenance and troubleshooting. After the completion of the training course, the trainees have to undertake an assessment, that includes a practical assessment.

The PVTRIN training courses are currently offered in Greece, Bulgaria, Croatia, Cyprus, Romania and Spain in the national languages, by acknowledged training providers.

3.1.1. Training course's target group

The PVTRIN training courses are addressed to qualified electricians, with relevant working experience, who wish to activate in PV installation and maintenance. The applicants are expected to have received training on DC systems, to hold license to practice in electrical installations of at least 10 kW and to have gained relevant experience whilst working for an electrical installation company or a PV installation company. The level of field experience required is likely to depend on the qualifications of the trainee.

3.1.2. Training course's syllabus

The training course's syllabus and the training approach took into account:

- The criteria and requirements set by the 2009/28/EC Directive, regarding the qualifications and training of the small scale PV installers
- The existing national legislative framework
- The PV Installer task analysis
- The input and recommendations of the NCC members and other stakeholders, and the identified requirements of the Certification Scheme
- Successful examples and relevant expertise in EU level.

The PVTRIN course's training modules are introduced in Table 3.1.

Table 3.1: PVTRIN course overview

Training module	Knowledge area
1. Solar Basics	1.1 Solar photovoltaic (PV) 1.2 PV system 1.3 PV technologies 1.4 Benefits of PV technology
2. Design Principles	2.1. On site visit 2.2. System sizing and design 2.3. Simulation software 2.4. Economics and environmental Issues 2.5. Standards and regulations
3. BAPV and BIPV	3.1 Mounting and building integration options 3.2 BIPV and BAPV on roofs 3.3 PV on façades 3.4 Glass roofs, shading systems and other applications 3.5 Design parameters and performance factors
4. Installation - Site work	4.1. Working safely with PV 4.2. Installation plan 4.3. Electrical components installation 4.4. Mechanical components Installation 4.5. Grid-connected PV Systems 4.6. Stand-alone PV System 4.7. Mounting system and building installation 4.8. Completing the PV installation 4.9. Installation checklist
7. Maintenance and troubleshooting	7.1. Maintenance plan 7.2. Common mistakes and failures 7.3. Diagnostic procedures-Documentation to the customer 7.4. Customer documentation 7.5. Maintenance checklist
8. Quality Management and Customer care	8.1. Quality principles 8.2. EU standards for PV 8.3. Customer care

3.1.3. Training approach

The training includes a balanced mixture of classroom instruction (lectures, case studies analysis, group discussions, exercises), hands-on work with PV systems and equipment (lab practice, demonstration, simulations using appropriate software), and also self-study through the PVTRIN e-learning platform (monitored by an assigned trainer).

The course structure is presented in Table 3.2.

Table 3.2: PVTRIN Training Course Structure

MODULE	CLASS	LAB/ON-SITE	SELF STUDY
		hours	
1. BASICS	4		6
2. DESIGN PRINCIPLES	9	3	24
3. BAPV AND BIPV	4		8
4. INSTALLATION – SITEWORK	10	2	30
5. MAINTENANCE AND TROUBLESHOOTING	3	2	8
6. CASE STUDIES – BEST PRACTICES	3		14
7. EXAMPLE INSTALLATION OF A SMALL SCALE PV ON BUILDING	4	7	12
8. QUALITY MANAGEMENT AND CUSTOMER CARE	3		6
	40	**14**	**108**

Classroom Lectures

The lecture part of the training is conducted based on the Trainee's Study Guide (PVTRIN Solar Installer Handbook), which contains several figures, diagrams, existing examples and good practices, photos and demonstration videos to facilitate better understanding. Also, a great number of resources are recommended in order to help trainees to expand their knowledge and advance the level of understanding on specific topics.

Hands-on training

The hands-on training deepens the participant's knowledge and understanding on the points covered during the lecture. The practical training should be better carried out in small groups, with 3-4 persons per group. Data sheets for hands-on training need to be prepared in advance and to be provided to each participant.

Self study

The self-study process, using the flexible and resourceful PVTRIN e-learning platform, is further supporting the learning experience and enhances the better understanding of the training

modules. With this approach, the repetition of the theory and the learning experience becomes more efficient and more attractive for both trainers and trainees.

Trainees' practice and performance assessment during the training course

The trainees practice through online assessment activities, in-class exercises and trainer's assignment, before the final exams.

- Theory Assessment (multiple choice, short answers, essay questions)
- Design assignment where the trainee designs a rooftop PV system, including:
  - definition of customer's requirements
  - calculations for matching the inverter power rating with the array rating, location assessment, performance of the system
  - approximate costing of materials
  - safety issues/concerns and how to minimise the risk
  - greenhouse gas emissions avoided by installing the solar system
  - complete installation checklist
- Practical lab exercises: the trainee practices the following tasks:
  - Solar pathfinder & shading activity
  - Site assessment activity
  - Simulation of the installation & activity sheet
  - Assembling the main components of the PV systems
  - Commissioning activity
  - Fault-finding activity.

3.2. PVTRIN Training materials and tools

Practical training material and tools have been developed in 6 languages (English, Greek, Croatian, Bulgarian, Romanian and Spanish) to support the PVTRIN trainees and trainers during the PVTRIN courses (Table 3.3, Figures 3.1-3.4).

Table 3.3: List of the PVTRIN training materials and tools

PVTRIN TRAINING MATERIALS	
For Trainees	**For Trainers and Training Providers**
• PVTRIN Installer Handbook - Study Guide	• PVTRIN Trainers Guide
• Worksheets - Exercises on theory	• Course Syllabus and Delivery plan
• Checklists - Practical tips on PV/BIPV installation	• Course Notes
• Troubleshooting Guide for PV installers	• Worksheets (Exercises and Solutions workbook)
• List of common failures and improper practices in PV installation and maintenance	• Assessment forms
	• Guide for PVTRIN training providers
• Practical aspects of Installing Photovoltaics	• E-learning platform – Trainers area, Users Manual for Tutors/Supervisors
• E-learning platform - Users Manual	
• Further resources - Bibliography	• Further resources (suggested books, online publications, webinars etc.), Useful links

PVTRIN Handbook for PV Installer - Study Guide

The PVTRIN handbook contains the theoretical content of the PVTRIN course, as well as comprehensive exercises and other useful resources i.e. further reading references (suggested books, online publications, etc), appropriate software and simulation tools, useful links to EU and national legislation, online libraries for applicable codes and quality standards, glossary and references. It is used along with a number of selective resources which supplement the curriculum, as the main theory supporting document. The PVTRIN handbook contents are presented in Annex 3.

Worksheets (Activities, Exercises and Solutions book)

The Worksheets provide a set of exercises developed to help trainees to self-evaluate their progress and prepare for the final assessment. The Worksheets also provide the solutions of the exercises included in the PVTRIN Handbook, as well as the solutions of the exercises of the PVTRIN e-learning platform.

E-learning platform

The PVTRIN e-learning platform is a self-study tool which enables trainees to review classroom lectures, to access additional information, to carry out activities and exercises, to communicate with the tutor, to self evaluate their advancement and to acquire further knowledge. At the same time, it enables trainers to monitor the progress of their trainees, to communicate with them in order to make suggestions about areas for improvement or new activities for better preparation for the final assessment.

The PVTRIN e-learning platform has been developed in 6 languages and is a limited access area where all the training materials are uploaded in order to facilitate the training procedure.

Relevant software and simulation tools

Appropriate software packages and simulation tools for sizing and simulating the performance of grid-connected and stand-alone PV systems are explained. Trainees practice during the lessons on existing installation cases as best examples.

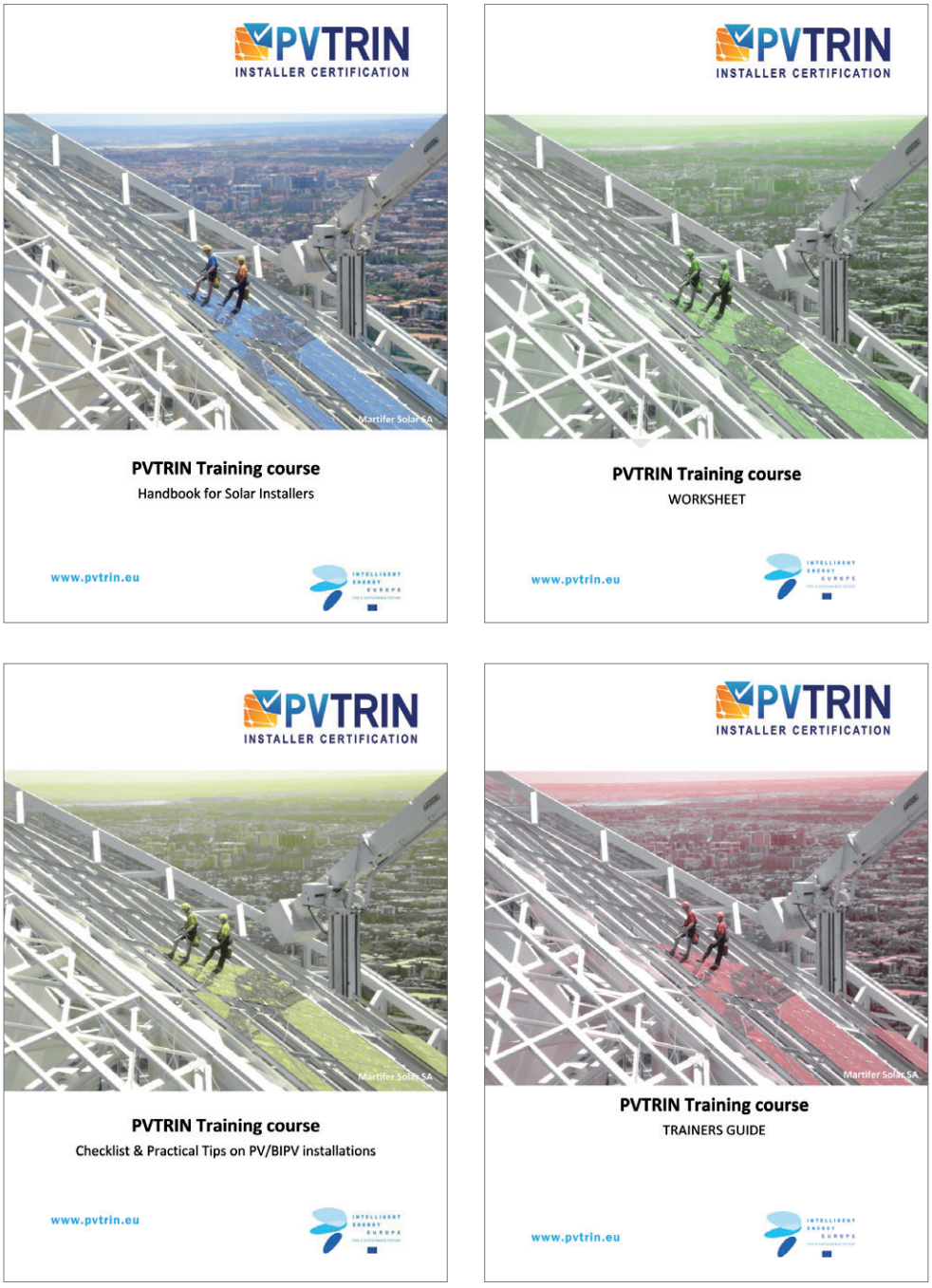

Figure 3.1: The PVTRIN training material for trainees

Demonstration Videos

Demonstration videos presenting step by step important parts of the installation process may be used during the training.

PVTRIN Trainers Guide

The trainers guide includes the PVTRIN course curriculum, guides for the course delivery, an indicative delivery plan, the training material/tools and the suggested lab infrastructure, the certification process and requirements, the trainees' assessment criteria and procedures. Also, for further information about the PVTRIN Training, the following documents are provided as part of the trainer's training:

- Training Methodology - PVTRIN course curriculum
- PV installers task analysis and professional framework

PVTRIN trainers may get support for the training and monitoring of the trainees through the PVTRIN e-learning platform. To learn how to use this tool they may refer to the PVTRIN e-platform Users Manual for Tutors/Supervisors.

Trainers' handouts

Trainers' handouts, in accordance with the contents of the PVTRIN Installer Handbook focusing to the most essential parts of each chapter, have been developed to support trainers during the lectures.

Further resources

The trainees and trainers are also provided with a number of further resources including references, online libraries and links about: national regulations and legislation, applicable quality standards and codes, relevant webinars, books, technical manuals, databases and appropriate simulation software.

Figure 3.2: The PVTRIN e-learning platform

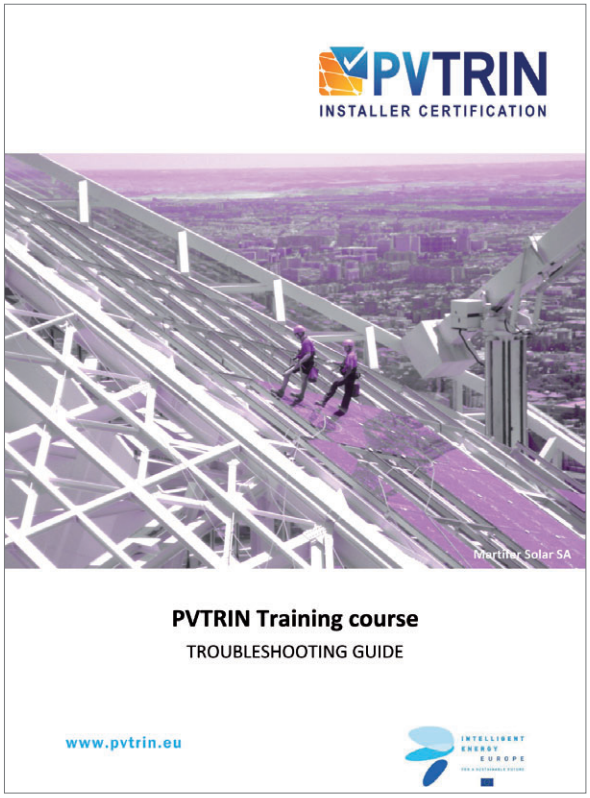

Figure 3.3: The PVTRIN trainers guide

PHOTOVOLTAIC INSTALLER SYLLABUS				
CATEGORY	LEARNING AREA	REF	KNOWLEDGE / SKILL / COMPETENCE	K / S / C
1. Basic	1.1 Solar energy	1.1.1	the role of the sun as an energy source; solar radiation; direct and diffuse radiation; solar altitude and spectrum; ground reflection; measurement of the solar radiation; solar potential.	K
		1.1.2	calculate the monthly and annual solar potential considering orientation and geography	S
		1.1.3	making the main calculations at advising customers	C
		1.1.4	being familiar with solar calculations	C
	1.2 PV technologies	1.2.1	the photovoltaic effect and how solar cells work; crystalline silicon, amorphous silicon, thin-film, CdTe, CIS; concentrating systems; 3rd generation; comparison of solar cell types and trends	K
		1.2.2	understand the main aspects of the photovoltaic phenomenon, the available collector types	S
		1.2.3	compare the available solar cell types	S
		1.2.4	being aware in brief of the way of the solar electricity production	C
		1.2.5	suggesting the appropriate collector system to the customer	C
	1.3 PV system	1.3.1	cells, modules and other system components: inverters, batteries, controllers, cables and wires, distribution boxes, electricity meter, net-metering, etc.	K
		1.3.2	understand the main aspects of the cells, inverters and the associated components	S
		1.3.3	comprehend the role of the various components in the PV system	S
		1.3.4	being aware of the main components of the PV system	C
		1.3.5	selecting the optimum solution and suggesting it to the customer.	C
	1.4 Types of PV systems/ applications	1.4.1	grid connected, stand alone, hybrid – residential, industrial	K
		1.4.2	comprehend the main differences amongst the various types of PV systems, as concerns the connection and the scale	S
		1.4.3	being aware of the main type of PV systems	C
		1.4.4	selecting the appropriate connection needs	C
	1.5 Benefits of PV technology	1.5.1	environmental, economic, grid efficiency, energy adequacy, employment etc.	K
		1.5.2	understand the main benefits of the PV technology	S

Figure 3.4: Sample page of the PVTRIN Syllabus

3.3. Training Facilities and infrastructure

Practical training (hands-on) on example installations is required to comply with the PVTRIN training course; one practice example for ground mount system and one for roof system are suggested. In the hands-on training, data sheets, measuring instruments and tools are required, and also a PV training kit could be helpful in case of indoor training. Both theory and practice of the following topics can be studied using an appropriate solar power laboratory:

- Measurements with the solar power circuit
- Identifying the IV characteristic and the MPP
- The battery as the energy accumulator in the PV off-grid technology
- Electric circuits possible with the PV off-grid technology
- Separate inverters
- Develop a back-up power supply for safety lighting
- Design, construct and test solar power of the on-grid and off-grid PV system.

Indicative facilities are:

- Complete grid-connected PV system package(s)
- Assorted types, sizes and models of flat-plate PV modules and BIPV products, battery subsystems of various sizes, voltages and types
- Assorted cables, wiring, connectors, terminal blocks, junction boxes, disconnectors and over-current devices
- Mounting structures and kits, roof mockups, mechanical hardware and weather sealing materials
- Site survey equipment, including lines, levels, tapes, markers, inclinometers, sun path calculators
- Basic electrical meters and diagnostic equipment, including volt/ohm/ammeters, clamp on
- Typical construction, electrician power and hand tools required for PV system installations
- Safety equipment.

3.4. PVTRIN national contact points

The PVTRIN training course is operating in Greece, Bulgaria, Croatia, Cyprus, Romania and Spain in the national languages, by acknowledged training providers. More information is provided by the National Contact Points (Table 3.4). Organisations interested to replicate the PVTRIN Scheme in their countries may contact the project coordinator.

Table 3.4: PVTRIN National Contact Points

COUNTRY	ORGANISATION	WEBSITE
Greece	Renewable and Sustainable Energy Systems Lab, Environmental Engineering School, Technical University of Crete	www.resel.tuc.gr
Croatia	Energy Institute Hrvoje Požar	www.eihp.hr
Bulgaria	Sofia Energy Centre	www.sec.bg
Cyprus	Scientific and Technical Chamber of Cyprus	www.etek.org.cy
Romania	Agency of Brasov for the Management of Energy and Environment	www.abmee.ro
Spain	Tecnalia Research & Innovation	ww.tecnalia.com

4 THE PVTRIN CERTIFICATION SCHEME

The PVTRIN Certification is an independent certification scheme for PV installers in line with the requirements of the 2009/28/EC Directive and incorporates:

- Accredited or nationally recognized training leading to the certification of PV installers; training includes both theoretical and practical parts and ends with an examination which includes practical assessment
- Defined and published requirements (fully transparent process, transferable requirements)
- Best practice from existing schemes and compliance with national requirements
- Performance monitoring
- Requirements for the certification maintenance (annual surveillance, refresher events, certification renewal).

The Scheme's requirements include applicable regulations and directives, installation and maintenance requirements, site specific issues, system performance, quality management and customer care.

The PVTRIN certification is time restricted. A refresher seminar or event is necessary for continued certification.

The developed documentation provides guidance to training providers, assessors and certification bodies:

- Guide for training providers and certification bodies
- Guide for assessors
- Written and practical exam assessment forms.

4.1. Certification Procedure

The following schematic diagram (Figure 4.1) outlines the PVTRIN certification process.

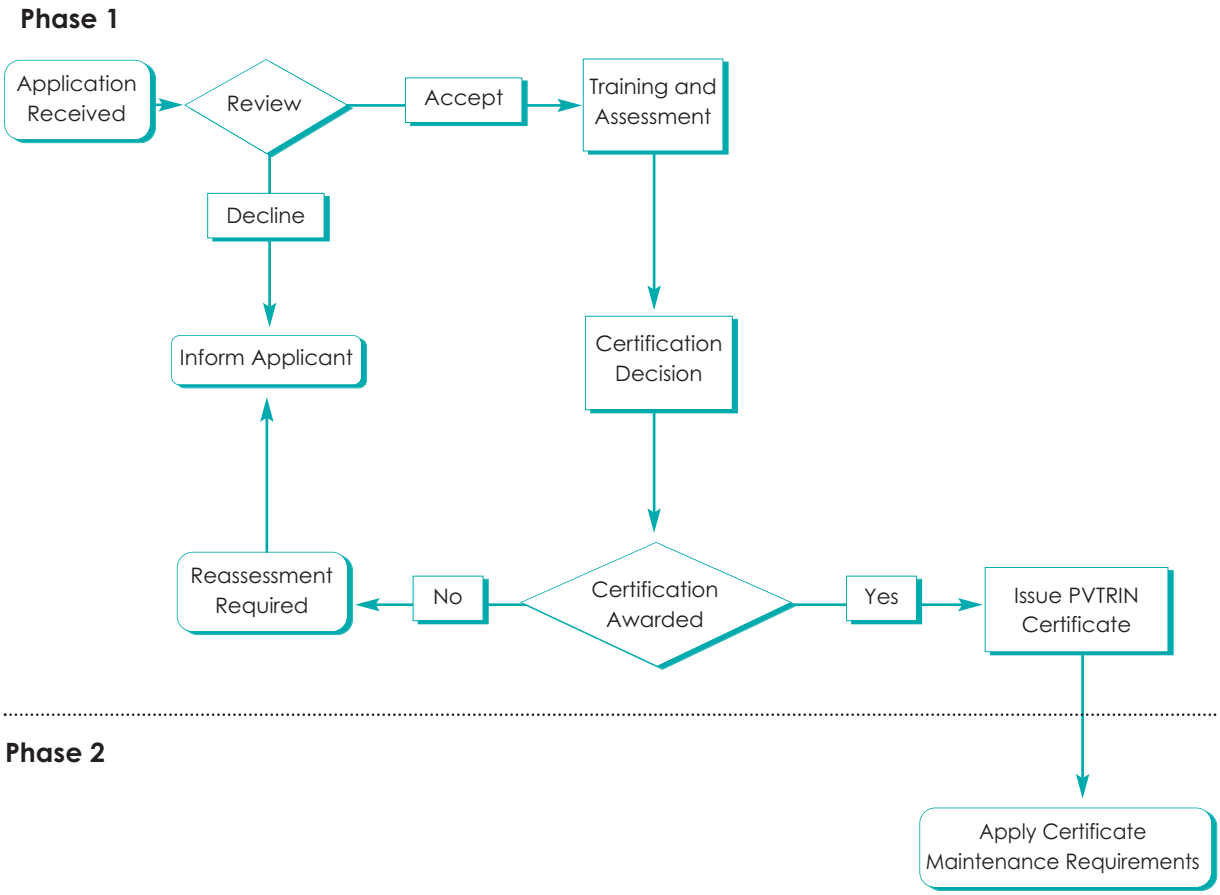

Figure 4.1: Schematic diagram outlining the PVTRIN certification process

Phase 1 involves the training of PV installers and the subsequent assessment of their knowledge, understanding and application of the requirements of the PVTRIN Certification Scheme. Theoretical and practical training is provided by a PVTRIN training organisation. The knowledge and practical competency of trainees is then assessed through written and practical examinations by a PVTRIN training / certification body. Successful candidates are awarded the PVTRIN certification and granted the "Photovoltaics Certified Installer" certification mark which represents independent confirmation of the competency of the certificate holder.

Certification of PVTRIN installers is time limited and **Phase 2** involves PVTRIN certificated installers fulfilling the requirement of Directive 2009/28/EC that, a refresher event such as a seminar or workshop is attended to ensure that they are up to date with industry knowledge and best practice. The successful completion of the refresher event will enable the PVTRIN installer to maintain their certification.

4.2. Roles within the PVTRIN Scheme

Trainers

Trainers are required to deliver the PVTRIN training course and ensure that trainees understand the content. This includes presenting course material (both theoretical and practical), providing feedback on course work and assessments and answering questions from trainees.

PVTRIN trainers should possess an appropriate training or assessment qualification from a recognised national authority. They should also have verifiable experience and knowledge of PV systems and their installation. This may include qualifications relevant to the PV installation industry awarded by a recognised organisation.

PVTRIN trainers for the training course's practical part should have relevant experience of installing PV systems. This may have been gained through previous work as a PV installer or through being responsible for supervising and/or approving the installation of PV systems.

Training Provider

Training providers have access to all resources needed to deliver the PVTRIN training course, written and practical examinations. This includes the availability of suitably qualified and experienced trainers and assessors. In addition, training providers must have proper policies and procedures in place to ensure that, training is available to all suitably qualified applicants, the quality of learning is maintained and trainees' progress is appropriately monitored and evaluated.

The training provider should be compliant with the requirements of ISO/IEC 17024 and preferably will have the PVTRIN Certification Scheme document included in its scope of accreditation. If the training provider is not accredited with the ISO/IEC 17024 for the certification of PV installers, the training provider and/or the PVTRIN training course could be officially recognised by the National Authority responsible for the certification of vocational training institutions.

Assessor

The primary role of assessors is to assess trainees' knowledge of PV systems and/or their PV system installation skills against the requirements of the PVTRIN Certification Scheme. This will include assessing written exam papers using an approved marking regime provided by the training centre/certification body. An assessor, who may be different from the assessor of the written examination, should also observe performance during the practical examination and point out to the trainee any errors made during the PV installation exercise.

Awarding / Certification Body

When a training centre is not accredited for the certification of PV installers, a certification body may assess evidences of an individual's knowledge/skills/competences in order to make certification decisions. The assessment and validation procedure includes written and practical examination results as well as other evidence, e.g. qualifications, that an installer meets the requirements of the PVTRIN Certification Scheme.

4.3. Trainees' assessment

To achieve certification, the PVTRIN trainee has to prove the required knowledge and skills by successfully completing the PVTRIN exams. Once the required areas of competencies are fulfilled and the assessment requirements are met, the installer is eligible for the PVTRIN Certification.

Upon completion of the PVTRIN training course, the knowledge and skills of the candidates - required to install the relevant PV equipment and systems to meet the PVTRIN Scheme's requirements and the performance and reliability needs of the customer - are examined. This includes supervised written and practical examinations and candidates are required to pass both in order to be certified. Pass criteria are established and agreed with the Scheme's Technical Committee. Sample assessment forms for the written and practical examinations are available.

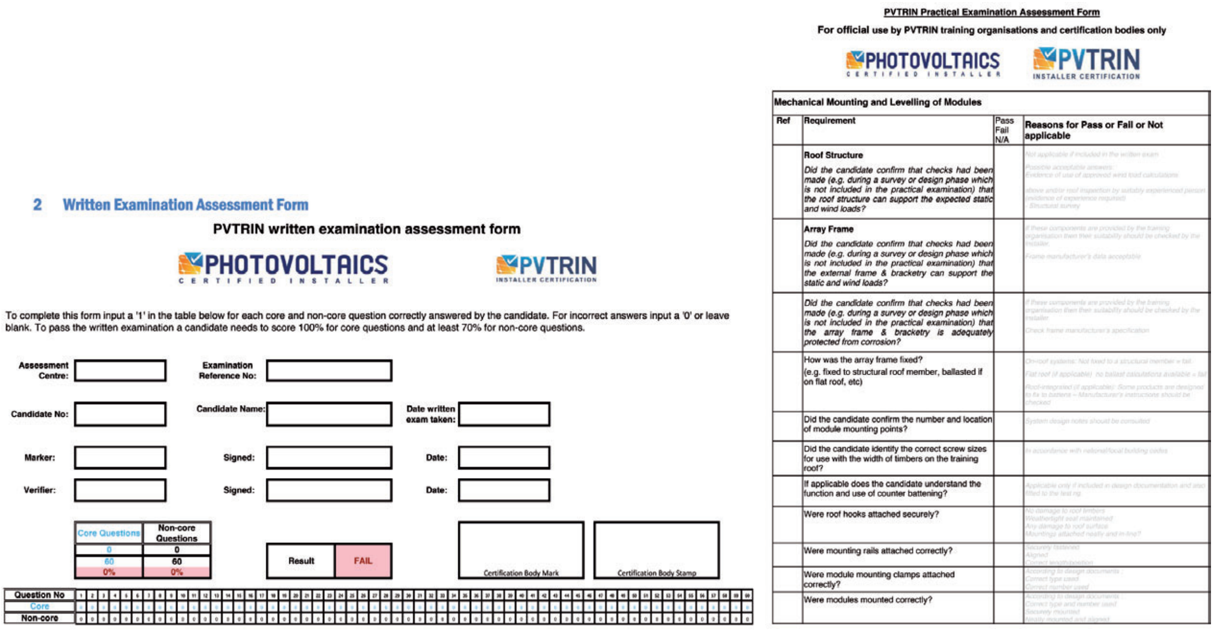

Figure 4.2: Sample assessment forms

During the assessment the installer should demonstrate the following key competencies:

- the ability to work safely using the required tools and equipment and implementing safety codes and standards and the ability to identify electrical and other hazards associated with solar installations;
- the ability to identify systems and their components specific to active and passive systems, including the mechanical design, and determine the components' location and system layout and configuration;
- the ability to determine the required installation area, orientation and tilt, taking into account shading, solar access, structural integrity, the appropriateness of the installation for the building or the climate and the ability to identify different installation methods suitable for roof types and the balance of system equipment required for the installation; and
- the ability to adapt the electrical design, including determining design currents, selecting correct conductor types and ratings for each electrical circuit, determining appropriate size, ratings and locations for all associated equipment and subsystems and selecting an appropriate interconnection point.

4.3.1. Preparation of examination paper

Appropriate written exam questions and practical examination tasks are prepared to enable the candidate to demonstrate the essential skills and knowledge required to install PV systems safely, efficiently and robustly. These should:

- fully reflect the requirements of the PVTRIN Certification Scheme
- cover each subject included in the PVTRIN training syllabus
- require trainees to demonstrate an appropriate and consistent level of knowledge/skills.

Training organisations should have access to a sufficient number of written exam questions to enable them to vary the content of the written examination from course to course. This is to reduce the ability of trainees to gain prior knowledge of examination questions.

4.3.2. Evaluation and grading of trainees' performance

After the examination, assessors mark the examination papers. Marking of the examinations is subjected to appropriate quality control procedures which should include an independent verification of the mark awarded. After marking, the scoring percentage is calculated so that this can be compared with the relevant pass criteria.

Written examination

Candidates undergo written examinations based on the material included in the PVTRIN training course. Certain questions included in these examinations are categorised as "core" according to the subject area of the question. Failure to answer correctly the "core" questions results in the written exam failure.

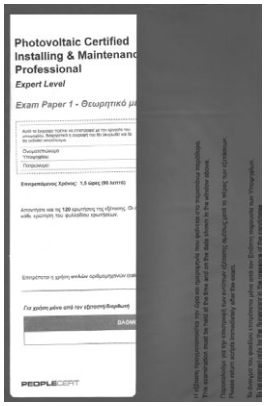

Figure 4.3: Written exams in Crete

Examination papers are sealed till the exams time and opened by the certification body's invigilator

The outcomes from the written exam are:

All pass criteria met: Pass awarded; Feedback given to the candidate regarding any knowledge gaps.

Pass criteria not met: Candidate should re-sit the entire examination.

Practical examination

Candidates should also undergo a practical examination of their competency to install, test, commission and troubleshoot PV systems according to the requirements of the PVTRIN Scheme. It is essential that an appropriate risk assessment is conducted by the trainer/assessor and appropriate actions are taken to eliminate or reduce risks to an acceptable level before the practical examination commences. For an assessment "pass", all tasks included in the practical examination must be successfully completed. In order to pass, the candidate is allowed no more than 3 second attempts over the whole practical assessment.

The activities included in the practical examination are included in the PVTRIN Certification Handbook and those that should specifically be assessed are included in the PVTRIN Practical Examination Assessment Form.

4.4. Certification award

The decision to award a certificate (the certification decision) must only be taken in accordance with national regulations and requirements. Often this means certificates may be issued only by an appropriately accredited certification body to either:

- EN ISO/IEC 17024 Conformity assessment – General requirements for bodies operating individuals' certification schemes, or
- EN 45011 (ISO/IEC Guide 65) – General requirements for bodies operating product certification systems
- In addition, the scope of accreditation should include the training and/or certification of PVTRIN installers.

Training organisations appropriately accredited to EN ISO/IEC 17024 may award their own certificates directly to installers who successfully complete the PVTRIN training course.

4.4.1. Certification Mark – PVTRIN Certificate

The PVTRIN trainees that have met the requirements of the PVTRIN Certification Scheme and have successfully completed both written and practical examinations, may be awarded the PVTRIN certification mark "Photovoltaics Certified Installer" (Figure 4.4), which they can display publicly to demonstrate their proficiency. For the maintenance of the PVTRIN certificate an annual surveillance, refresher seminars and a re-certification process have been foreseen.

Figure 4.4: PVTRIN certification mark

Upon achieving PVTRIN certification, the PVTRIN "Photovoltaics Certified Installer" shall receive:

- A PVTRIN Certificate (Figure 4.5)
- Electronic versions of the PVTRIN certification mark, e.g. for use in business documentation, including guidelines about the terms and conditions of use
- Listing on the PVTRIN website (www.pvtrin.eu). The training organisation/certification body may also list certificated installers on their own website.

The Certification Body maintains a PVTRIN installer registry including the following data: Full name, Certificate level and number, Syllabus, Certificate issue date, Surveillance date.

Figure 4.5: PVTRIN Certificate sample (Greek)

4.4.2. Compliance with the relevant Code of Conduct

Certified professionals need to demonstrate compliance with the relevant Code of Conduct. Certification bodies issuing PVTRIN certificates retain the right to withdraw the certificate of professionals who do not comply with the certification criteria or act against the Photovoltaic Installers Code of Conduct and/or in instances of serious or sustained non conformities.

4.5. Certification maintenance

PVTRIN certification is time restricted in accordance with Annex IV of Directive 2009/28/EC and in order to maintain it, certification installers are required to prove practical experience and to attend refresher events held by PVTRIN training organisations before the expiry of their certification.

4.5.1. Annual surveillance

Certified Installers are required to demonstrate the ongoing use of their certification level's competence and knowledge and continuous professional development by means of an annual surveillance process. This surveillance process involves the submission of documentation at the end of each year from the date of certification.

4.5.2. Refresher events

The certified installer should attend refresher events, such as a seminars or workshops, to keep up to date with the PV technology evolution and best practices. The identity of PVTRIN installers attending refresher events should be confirmed, in the same way attendance at the initial training course was confirmed, i.e. there should be a formal registration process and photographic proof of identity should be required. The refresher event may conclude with written and practical examinations as appropriate to confirm continued competence of the certificated installer.

4.5.3. Installer Monitoring

Certificate issuers should monitor and investigate all complaints made against their PVTRIN certificated installers. Consideration should be given to how efficiently and effectively an installer resolves complaints.

If the quality of the installer's work is found to fall below that required by the PVTRIN Certification Scheme then the certificate issuer should consider suspending the PVTRIN certification of the liable installer until the installer has implemented corrective actions to improve the quality of their work to an acceptable level.

Re-assessment or re-training of the installer should also be considered. Withdrawal of certification should be considered if the suspended installer fails to implement satisfactory corrective action within an agreed time scale.

5 PILOT TRAINING COURSES IN THE PVTRIN COUNTRIES

Eight (8) pilot courses were implemented in the six (6) PVTRIN countries. 185 PV installers were trained according to the PVTRIN requirements; 145 were certified after successfully completing the assessment process (both theoretical and practical exams).

For the pilot courses implementation, the following steps were carried out:

- identification of the appropriate training providers and provisions for the infrastructure required for the implementation of the practical part of the course (and the practical assessment), according to the PVTRIN Scheme criteria and requirements
- selection of appropriate trainers and the development of guidelines and course notes
- call for applicants for the PVTRIN pilot training course announced through the PVTRIN website (www.pvtrin.eu) and through the professional associations and the media
- evaluation of the candidates' application and the enrolment of trainees
- implementation of the courses, lectures and practical training on PV demo installation
- assessment of the trainees (theory and practical exams) after the training courses' end; trainees who successfully passed the assessment requirements were awarded the PVTRIN certification. The list of certified installers is available online, on the PVTRIN website, www.pvtrin.eu.

Upon completion, the pilot training courses were evaluated by trainers and trainees with the use of structured questionnaires.

An overview of the pilot courses at the PVTRIN countries is presented below:

Bulgaria

- 19 PVTRIN certified trainees
- PVTRIN course meets the national recognition requirements
- Training provider acknowledged for training of RES installers by the national authority.

Croatia

- 1 pilot course was implemented in Rijeka, Croatia
- 64 potential trainees applied to attend PVTRIN course
- 25 trainees enrolled in the course
- 23 certified PV installers
- The Certification Scheme is compliant to the RED directive and PVTRIN requirements; Certification body accredited against ISO/IEC 17024.
- The Certification Scheme will be maintained and further developed by the Technical Committee of the PVTRIN Scheme.
- PVTRIN served as the basis for the Regulation on certification of RES installers, issued by the Ministry of Construction and Spatial Planning in June 2013.

Figure 5.1: Practical and in-class training in Croatia

Figure 5.2: PVTRIN Certification award ceremony in Croatia

Cyprus

- 1 pilot course was implemented, in Nicosia Cyprus by the training provider, the Cyprus Productivity Centre
- 60 potential trainees applied to attend the PVTRIN course
- 25 trainees enrolled
- 24 certified PV installers
- Certification Scheme applied, compliant to the EN 45011, taking also into account the ISO 17024 requirements; the Cyprus Certification Company awarded the Certificates to the trainees who fulfilled the assessment requirements.
- The PVTRIN Scheme's technical committee consists of all key stakeholders of the PV market in Cyprus, including the Cyprus Association of RES companies, the Federation of Electrical Contractors Associations, the Association of PV installers, the Cyprus Organization for Standardization, who will continue to support the operation of the Scheme in the future.

Figure 5.3: Practical and in-class training in Cyprus

Figure 5.4: PVTRIN Certification award ceremony in Cyprus

Greece

- 2 pilot courses were implemented, in Chania and Athens
- 140 applications from technicians interested to attend the PVTRIN course; 50 trainees were enrolled
- 36 certified PV installers up to now
- Training providers acknowledged by the national competent authority for providing vocational training
- Certification Scheme applied; compliant to the ISO 17024, national legislation and RED requirements
- Certification body accredited by ISO 17024.
- The PVTRIN Scheme's technical committee, consisting of all key stakeholders of the PV market in Greece, including the National Association of PV companies, the Federation of Electrical Contractors Associations, the Association of PV installers, the Hellenic Association of Accreditation and Certification Bodies, will continue to support the operation of the Scheme in the future.
- The PVTRIN Scheme is available to all Certification bodies acknowledged for Personnel Certification and operating under ISO 17024. The Hellenic Association of Accredited Certification and Inspection Bodies (HellasCert) maintains the certification scheme after the end of the PVTRIN project.

Figure 5.5: Practical and in-class training in Greece

Figure 5.6: The PVTRIN trainees in Greece, 1st pilot training course in Chania

Romania

- 2 training courses implemented in parallel
- 112 potential trainees applied for the PVTRIN training
- 46 trainees attended the 2 PVTRIN pilot training courses
- 44 installers have been awarded a certificate issued by the Romanian National Authority for Qualifications (ANC) and signed by the Ministry of Labour, Family, Social Protection and Elderly and the Ministry of National Education
- PVTRIN is the first PV training course in Romania, authorized by the Romanian National Authority for Qualifications
- 1 authorized specialization scheme for the PV Installer occupation, was developed due to the PVTRIN activities.

Figure 5.7: Study visit during the PVTRIN training in Romania

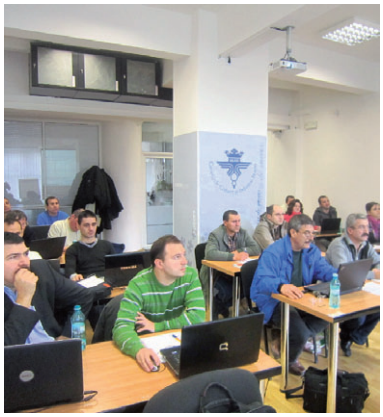

Figure 5.8: Class training in Romania

Spain

- 1 PVTRIN training course was implemented
- 35 have applied to attend the PVTRIN pilot course
- 20 technicians were enrolled as PVTRIN trainees
- 18 trained installers have successfully concluded the exam according to the PVTRIN criteria
- National Consultation Committee formed by UNEF, IDAE, AENOR, FENIE, TKNIKA, CS-COAVN.

Figure 5.9: Practical training in Spain

Figure 5.10: Award of the proof of attendance to the PVTRIN course's trainees in Spain

6 TOWARDS A QUALIFIED WORKFORCE FOR PV INSTALLATION IN EUROPE. CONCLUSIONS

The European Energy and Climate Change policies, as well as the supporting EU Member States' legislations have resulted in high market growth for photovoltaics. Moreover, PV technologies have changed radically in the past decades; most of the equipment has been significantly improved in terms of quality and safety, while testing requirements are better defined and the testing processes are becoming more and more standardised. Nowadays, in order to reduce failures during a PV installation, the focus has shifted away from the reliability and performance of the components and moved towards the quality of the planning, design and physical installation of the system.

Investing in a PV system is costly, and, what's more, the return of investment depends largely on the quality of the design and installation process and the compliance with the best practices in the field. Given the huge varieties and modularity of PV systems, it is obvious that a number of technical failures may occur in case of insufficient training of the installers. Most common failures are not caused by bad practices in one specific step alone, but they are rather a combination or accumulation of suboptimal actions in different stages or, simply, the result of wrong or inadequate communication between the designer and the installer.

Obviously, applying PV technologies requires highly-qualified technicians to install, repair and maintain them. Investors are aware that choosing a qualified PV installer is critical for the quality and performance of their investment. Nowadays, they seek for skills certification and quality assurance in all phases of their PV installation (design, installation and maintenance).

Certification can provide reassurance that an installer possesses the knowledge, skills and competence to complete a PV installation safely and effectively. Certification is about raising standards and promoting confidence. By employing a certified installer, customers ensure greater peace of mind for better system performance, less technical failures and reduced investment risks for their PV installation.

The European Initiative PVTRIN, co-financed by the Intelligent Energy Europe programme of the European Commission, addresses the market needs by developing a training and certification scheme for technicians who are active in the field of installation and maintenance of small scale PV systems.

The PVTRIN Training and Certification Scheme provides the key components for a common qualification framework, an appropriate training methodology and a transparent and clearly defined accreditation route, incorporating the criteria set by the 2009/28/EC Directive for qualification schemes and certified training courses in each Member State, as well as the national framework and legislation and the national markets' needs.

Choosing a PVTRIN Certified Installer means that the installer has been trained, assessed and has agreed to comply with all applicable codes and standards. This guarantees the safety and best performance of PV installations, lowering risks or technical failures during the system's installation and life cycle.

«MYTHS» ABOUT TRAINING AND CERTIFICATION OF PV INSTALLERS AND TECHNICAL PROFESSIONS

MYTH 1: "There are Paneuropean qualification schemes for RES installers ready to be applied and adopted horizontally"

REALITY: Indeed, there some qualification/certification schemes in place, and some competent certifying companies, which could be further adjusted to facilitate installers' mobility within EU MS. However, the major differences in legal aspects, as well as the diversity of building and PV requirements amongst countries, make it difficult to horizontally harmonise a very detailed scheme; qualification schemes for installers have to take into account the national markets' different aspects and the national legislative framework. Therefore, a set of common requirements have to be verified by competent bodies and acknowledged by the market at national level to become operational. In order to facilitate mobility, training providers and/or certification bodies operating/accredited by ISO 17024 could be involved.

MYTH 2: "The technicians are not interested in classroom lessons and the theory behind PV; they are only interested in training which is provided for free or supported by state's financial schemes"

REALITY: Technicians exhibit high interest to learn/understand the basic theory for PV installations design, performance, monitoring. Most of them have practical experience but because they lack a theoretic background, they may perform simple faults which could be easily avoided. They strongly believe that it is critical to advance their skills, thus becoming more competitive and improving their profession's image. Their associations confirm that if the training is of real value, even the low income technicians could pay a reasonable cost for obtaining the certification; however they could not cover the total cost for developing and operating an appropriate scheme; this should be financed by state or other sources.

MYTH 3: "Installers' associations may object to efforts of establishing qualification/certification schemes for their members"

REALITY: Installers' associations are highly concerned about the future of their members' employability and prosperity. They are concerned about the profession's protection from unqualified staff and black labour, also from discreditable performance of work. They are convinced that acquiring qualifications and updating skills is of high priority; they could be a supporting force for the acknowledgment of schemes. This belief is so strong, that in some cases associations are willing to ask the state for obligatory, not mandatory schemes.

MYTH 4: "There are a lot of training material and tools proper to lead an installer's qualification and training scheme"

REALITY: There are a number of good materials, practical and comprehensive (in most cases available in English). However the appropriate materials for a qualification / certification scheme have to address predefined sets of Knowledge-Skills-Competences to be acquired during the training. For this reason, the training material has to be adjusted to the specific training curriculum as defined from the scheme's requirements -adapted to national regulation and specific requirements, and from the certification scheme's regulation/documentation. In addition, training materials should be updated to include the most recent technology evolutions and good installation practices. Furthermore, it is critical that training materials are developed in the national language.

The PVTRIN Training and Certification scheme provides benefits for the installers, the PV industry and the society:

- Creating a qualified installers workforce, the PVTRIN certification supports the EU PV Industry to address the need for skilled technicians. The increased confidence of PV investors will support the sustainable market growth.
- The certified installers gain professional competitive advantage, improving their technical skills and knowledge; the certification provides the "passport" to the EU job market.
- Developers and engineers will profit by the existence of skilled installers. Involving them in their PV projects means efficient installations, less technical failures and satisfied customers.
- PV investors gain confidence that the appropriate level of quality and performance is met and maintained for their PV system by employing a qualified PV installer
- National authorities will find a supporting instrument to meet their obligations for acknowledged certifications for RES installers.
- The entire society is to benefit; the higher PV penetration to the energy mix will reduce the greenhouse gas emissions improving citizens' quality of life.

The PVTRIN Certification offers:

To installers	To PV investors	To PV industry
• Proficiency	• Confidence	• Efficient workforce
• Independent confirmation of competence	• Quality and Safety	• Satisfied customers
• Recognition	• Better system performance	• Isolation of "Cowboys"
• Mobility	• Reduced risks	• Underpin reputation
• Aspirations		
• Employability		

The PVTRIN Scheme has been, initially, implemented in six (6) countries: Greece, Bulgaria, Croatia, Cyprus, Romania and Spain. A pool of local technicians, competent at installing PV systems, according to multinational quality standards, has been established in the participating countries, as a result of PVTRIN's activities.

The PVTRIN Scheme provides a supporting instrument, for EU Member States, to meet their obligations for acknowledged certifications for RES installers according to the RED Directive. It could be an example for the development and implementation of certification schemes for solar thermal installers, small scale biomass stoves and boilers installers and heat pump installers, as requested in Directive 2009/28/EC.

In the long term, PVTRIN will contribute to the PV market growth, will facilitate job mobility of installers within Europe, and will enforce the EU MS to achieve the mandatory target of a 20% share of energy from RES in overall Community energy consumption by 2020.

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ABBREVIATIONS

AC	Alternating current
BAPV	Building Applied Photovoltaics
BIPV	Building Integrated Photovoltaics
DC	Direct Current
EA	European Co-operation for Accreditation
EC	European Commission
EPBD	Directive on the Energy Performance of Buildings
EU	European Union
FIT	Feed in tariff
IAF	International Accreditation Forum - Multilateral Recognition Agreement
MS	Member State
MPP	Maximum Power Point
NCC	National Consultation Committees
PV	Photovoltaic
PVTRIN	Training & Certification Scheme of PV Installers
RES	Renewable Energy Sources
TC	Training Course

TERMINOLOGY

Accreditation of an education or training programme

A process of quality assurance through which accredited status is granted to a programme of education or training, showing it has been approved by the relevant legislative or professional authorities by having met predetermined standards.

Accreditation of an education or training provider

A process of quality assurance through which accredited status is granted to an education or training provider, showing it has been approved by the relevant legislative or professional authorities by having met predetermined standards.

Accreditation of individual

Confirmation of competence to carry out specific conformity assessment (e.g. certification) tasks assessment (e.g. certification) tasks.

Assessment of learning outcomes

The process of appraising knowledge, know-how, skills and/or competences of an individual against predefined criteria (learning expectations, measurement of learning outcomes). Assessment is typically followed by validation and certification.

Assessment criteria

Criteria used to collect evidence of competence or of meeting certification requirements.

Assessor

Person performing the assessment, e.g. for the purposes of certification.

Awarding body

A body issuing qualifications (certificates, diplomas or titles) formally recognising the learning outcomes (knowledge, skills and/or competences) of an individual, following a assessment and validation procedure.

Certificate

An official document, issued by an awarding body, which records the achievements of an individual following an assessment and validation against a predefined standard.

Certification decision

Decision to award, or refuse, certification.

Competence

The ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development). *Competence is not limited to cognitive elements (involving the use of theory, concepts or tacit knowledge); it also encompasses functional aspects (involving technical skills) as well as interpersonal attributes (e.g. social or organisational skills) and ethical values.*

Curriculum

The inventory of activities implemented to design, organize and plan an education or training action, including the definition of learning objectives, content, methods (including assessment) and material, as well as arrangements for training teachers and trainers.

European qualification framework for lifelong learning (EQF)

A reference tool for the description and comparison of qualification levels in qualifications systems developed at national, international or sectoral level. The EQF's main components are a set of 8 reference levels described in terms of learning outcomes (a combination of knowledge, skills and/or competences) and mechanisms and principles for voluntary cooperation. The eight levels cover the entire span of qualifications from those recognising basic knowledge, skills and competences to those awarded at the highest level of academic and professional and vocational education and training. EQF is a translation device for qualification systems.

Knowledge

The outcome of the assimilation of information through learning. *Knowledge is the body of facts, principles, theories and practices that is related to a field of study or work.*

Know-how

Practical knowledge or expertise.

Learning content

The topics and activities which make up what is learned by an individual or group of learners during a learning process.

Learning outcomes

The set of knowledge, skills and/or competences an individual has acquired and/or is able to demonstrate after completion of a learning process, either formal, non-formal or informal.

National accreditation body

Body recognised by government to assess, against internationally agreed standards, organisations that provide certification, testing, inspection and calibration services.

Non-conformance

Non-fulfilment of a certification requirement.

Qualification scheme

All activities related to the recognition of learning outcomes and other mechanisms that link education and training to the labour market and civil society. These activities include:

– definition of qualification policy, training design and implementation, institutional arrangements, funding, quality assurance;
– assessment, validation and certification of learning outcomes.

Qualification

The term qualification covers different aspects:
(a) formal qualification: the formal outcome (certificate, diploma or title) of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards and/or possesses the necessary competence to do a job in a specific area of work. A qualification confers official recognition of the value of learning outcomes in the labour market and in education and training. A qualification can be a legal entitlement to practice a trade (OECD);
(b) job requirements: the knowledge, aptitudes and skills required to perform the specific tasks attached to a particular work position (ILO).

Qualification framework

An instrument for the development and classification of qualifications (e.g. at national or sectoral level) according
to a set of criteria (e.g. using descriptors) applicable to specified levels of learning outcomes.

Recognition/assessment of learning outcomes:

(a) Formal recognition: the process of granting official status to skills and competences either through the:
– award of qualifications (certificates, diploma or titles); or
– grant of equivalence, credit units or waivers, validation of gained skills and/or competences; and/or
(b) Social recognition: the acknowledgement of the value of skills and/or competences by economic and social stakeholders.

Requirement

Criteria to be fulfilled in order to demonstrate compliance, e.g. with a standard.

Skills

The ability to perform tasks and solve problems.

Verifier

Person checking and confirming the quality of the activities of an assessor.

***Source**: CEDEFOP, 2008, Official Publications of the European Communities.*

ANNEXES

Annex 1: National Accreditation Bodies

Annex 2: List of PVTRIN NCC members

Annex 3: PVTIN Study Guide Contents

ANNEX 1: Accreditation bodies at the PVTRIN countries

COUNTRY	ORGANISATION	WEBSITE
BULGARIA	Bulgarian Accreditation Service (BAS)	www.nab-bas.bg
CROATIA	Croatian Accreditation Agency (HAA)	www.akreditacija.hr
CYPRUS	The Cyprus Organization for the Promotion of Quality (CYS-CYSAB)	www.cys.mcit.gov.cy
GREECE	Hellenic Accreditation System S.A. (ESYD)	www.esyd.gr
ROMANIA	Romanian Accreditation Association (RENAR)	www.renar.ro
SPAIN	Entidad Nacional de Acreditacion (ENAC)	www.enac.es

ANNEX 2: List of PVTRIN NCC members

The following organizations constitute the NCC members at the PVTRIN countries: Bulgaria, Croatia, Cyprus, Greece, Romania and Spain.

Bulgaria

- Energy Efficiency Agency
- Manager of Association of Producers of Ecological Energy
- Bulgarian Photovoltaic Association
- Free University of Varna
- Central Laboratory of Solar Energy and New Energy Sources (CLSENES) of Bulgarian Academy of Sciences

Croatia

- Croatian Professional Association for Solar Energy
- Technical School Sisak
- Regional Energy Agency Kvarner
- Croatian Chamber of Trades and Crafts
- Agency for Adult Education
- Croatian Accreditation Agency

Cyprus

- Cyprus Organisation for Standardisation
- Cyprus Association for the Promotion of Renewable Energy Sources
- University of Cyprus
- Electricity Authority of Cyprus
- Cyprus Energy Agency
- Department of Electrical Engineering Frederick University
- Electrical Contractors Federation of Cyprus
- Cyprus Productivity Center
- Human Resources Development Authority

Greece

- Hellenic Association of Photovoltaic Companies
- Association of Energy Producers from PV
- Panhellenic Association of PV investors
- Panhellenic Federation of Electrical Contractors Associations
- Union of Hellenic Chambers of Commerce and Industry
- Technical Chamber of Greece – Standardisation Dpt.
- National Accreditation Centre for Continuing Vocational Training
- Hellenic Association of Accredited Certification and Inspection Bodies
- Greek Regulatory Authority for energy
- Steering Committee of Technical Instructions for the integration of RES on buildings-Technical Chamber of Greece

Romania

- Ministry of Economy, Trade and Business Environment
- National Regulator Authority for Energy
- Regional Development and Tourism Ministry
- Industry Association – New Energy Sources
- "Ion Mincu" Architecture and Urbanism University, Bucharest
- Romanian Standards Association
- "Valahia" University, Targoviste
- "Transilvania" University, Brasov
- "URBAN-INCERC" National Institute for Research-Development in Construction, Urbanism and Sustainable Territorial Development – INCD
- National Authority for Qualifications - ANC

Spain

- Spanish PV Industry Association – ASIF: Actually Spanish Photovoltaic Union (UNEF) a merge of
  - Spanish PV Industry Association (ASIF)
  - Renewable Energy Productors Association- Photovoltaic Section (APPA-PV)
  - Photovoltaic Business Association (AEF)
  - Renewable Energy Productors and Investors National Association (ANPER)
- Spanish Association for Standardisation and Certification - AENOR
- Spanish Federation of Electrical & Telecommunication Contractors - FENIE
- Spanish Institute for Energy Diversification and Saving of Energy - IDAE
- Centre for Innovation in Basque Vocational Training - TKNIKA
- Basque Architect Association - Sustainability Commission (Bizkaia)- CS-CAVN

Annex 3: PVTIN Study Guide Contents

1. Solar Basics

1.1. Solar energy

The sun as an energy source. Solar radiation. Direct and diffuse radiation. Angle definition. Solar altitude and spectrum. Ground reflection. Measurement of the solar radiation. Solar potential.

1.2. PV system

Cells, modules and other system components: inverters, batteries, controllers, cables and wires, distribution boxes, electricity meter, net-metering ,etc.

1.3. PV technologies

The photovoltaic effect and how solar cells work

Crystalline silicon, Amorphous silicon, Thin-film, CdTe, CIS, Concentrating systems, 3rd generation, Comparison of solar cell types and trends

1.4. Types of PV systems/applications

Grid-connected, stand-alone, hybrid – residential, industrial

1.5. Benefits of PV technology

Environmental, economic, grid efficiency, energy adequacy, employment etc

1.6. Exercises

2. Design Principles

2.1. On Site Survey

On site survey and customer needs: local radiation, climate conditions, wind exposure, shading analysis, array orientation, roof/wall structure, mounting methods, hazard assessment, energy expectations, profitability, critical loads, legal aspects, aesthetics etc.

2.2. System Sizing and Design

Decision on system components, sizing the PV array, the electrical installation and storage, dimensioning of backup systems, sizing the PV generator, inverter, wiring and power connection, DC system, PV array design, cable sizing, plug and socket connectors, junction box, string fuses, blocking diodes, DC switch, Earthing, lightning and surge protection, AC system, AC cabling, switch-disconnector. Performance calculations and electrical diagrams.

2.3. Simulation Software

Description, examples, comparison, web based simulation solutions, supplementary software and data sources

2.4. Economics and Environmental Issues

Economic Assessment (operating expenses, energy payback, IRR)

Environmental impact (C02 emissions, Recycling of PV components, battery management)

2.5. Standards and regulations (EU /national)

Relevant EU and national laws, tariff structure, FIT, Subsidies, licensing and planning regulations, quality standards

2.6. Databases

2.7. Exercises

3. BAPV and BIPV

3.1. Mounting and building integrating options

3.2. BIPV and BAPV on roofs

Roofs -roofs tasks, shapes, basic constructions- On-roof / In-roof systems –Sloping/Flat roof

3.3. PV on Façades

Facade types structures and construction methods, Fastening/Joints, Mounting modules on existing facades, Facades with integrated modules

3.4. Glass roofs, shading systems and other applications

Glass roofs, Atria and canopies, Shading systems

3.5. Design parameters and performance factors

Tilt and orientation, shade structure (overshadowing, partial shading), connection concepts, temperature effect and ventilation etc.

3.6. Common examples from the residential sector

3.7. Exercises

4. Installation – Sitework

4.1. Working safely with PV

Safe working practices, potential hazards, safety with electrical installations (DC voltage), security provisions for works at height (roof and façades), safety equipment, fire protection

4.2. Installation plan

Work sequences, technical drawings, technical documentation, tools and equipment, safety plan

4.3. Electrical components installation

Mitigate electrical hazards, install grounding system, conduit, electrical components, circuit conductors, system instrumentation, battery components, etc

4.4. Equipment installation

4.5. Mechanical components installation

Install equipment base, mounting system, PV modules

4.6. Grid-connected PV Systems

4.7. Stand-alone PV Systems

4.8. Mounting systems and building integration

4.9. Completing the PV installation

Testing, Commissioning, Documentation to the customer

4.10. Installation checklist

4.11. Exercises

5. Case studies – Best Practices

6. Example installation of a small scale PV on building

Step by step practical guide (Development of a PV project supported by appropriate software: Design, performance analysis, installation project planning, safety plan of a small scale PV installation).

7. Maintenance and Troubleshooting

7.1. Maintenance plan

Periodical inspection, array maintenance, battery/ inverter and charge controller maintenance, maintenance tools and equipment, dirt accumulation, electrical connections check, other damages.

7.2. Common mistakes and failures

Corrective measures and troubleshooting

7.3. Diagnostic procedures

Visual inspection procedures, Analysis of the monitoring system data, performance monitoring.

7.4. Customer documentation

7.5. Maintenance checklist

7.6. Exercises

8. Quality Management and Customer Care

8.1. Quality principles

Quality management principles, efficiency and functional controls, quality assurance and in the construction of PV systems

8.2. EU standards for PV

8.3. Customer care

Pre-sales activities, contracts, completing the work: delivery/final testing/ handover, after sales: warranties/service and repairs/ complaints handling.

8.4. Exercises

9. Glossary of terms

10. Further Reading

11. References

ANNEXES

i. Abbreviations and acronyms
ii. Symbols and Units
iii. International and EU standards with relevance to PV
iv. National Standardisation organisations
v. Graphical symbols
vi. Characteristic I-V curves for modules
vii. Radiation maps
viii. Useful links

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