TRAINING OF PHOTOVOLTAIC INSTALLERS

Definition of installers’ professional framework
and development of the training methodology

PVTRIN Training Methodology and Curriculum
(WP2 -D2.10)
PVTRIN: The PVTRIN project scope is the development of a training and certification scheme for technicians, according common accepted criteria and standards, focused on the installation and maintenance of small scale PV.

The expected results are: Accredited training courses and an operational certification scheme for PV installers in 6 participating countries; Practical training material/tools for installers and their trainers; Web portal with access to technical information on PV installation/integration; 8 pilot training courses implemented, a pool of skilled/certified PV installers; A roadmap for the adoption of the certification scheme across Europe.

Long term, PVTRIN will contribute to the PV/BIPV market growth in the participating countries, provide a supporting instrument for EU MS to meet their obligations for acknowledged certifications for RES installers till 31/12/2012 and enforce the MS efforts to achieve the mandatory target of a 20% share of energy from RES in overall Community energy consumption by 2020. The PVTRIN is co-financed by the Intelligent Energy - Europe (IEE) programme.

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1. Introduction

The aim of this task is to form the structure and curriculum of the training course, taking into account the knowledge areas described in the 2009/28/EC Directive. The theoretical and practical parts of the training are analysed and linked with the skills and competences required to be developed.

In this task, the course contents and length are described (including the process followed, the structure, methods, requirements and the developed syllabus). It contains also the analytical description of tasks and learning objectives that will be covered during the training course, as well as decisions on theoretical vs. practical training focus and duration. This analysis also proposes the training methods and tools that will be used during the training procedure. E-learning platforms, in combination with workshops, instructor-led and paper based training methods are also considered in order to develop a flexible and easy to replicate training course.

Furthermore, the criteria in order to select trainers and the process of evaluating their delivery are specified; also the key requirements of the training providers are defined taking into account that training provider has continuity, regional or national coverage and adequate technical facilities to provide practical training (further analysed to D5.3).

Finally, in addition to the basic training, shorter refresher courses on topical issues, to enable life-long learning in installations and keep the installers technical competence up-to-date will be examined and foreseen.
2. Training Methodology Development - Rationale

For the implementation and completion of this task, the following were taken into account:

- Criteria set by the 2009/28/EC Directive, relevant to this issue (Article 14 and Annex IV)
- Successful examples and relevant expertise in EU level; also outputs from initiatives and the most recent projects co-financed by EC, such as the Qualicert, Install+RES (IEE2), SOLTEC COMPENER - Leonardo Da Vinci, PV SUNRISE – 6th Framework Programme (DG TREN)
- The input and recommendations of the NCC’s members, the industry representative and other stakeholders
- The existing national legislative framework and the requirements of the certification scheme
- Successful training courses in EU level
- The PV Installers task analysis

The main concepts taken into account were:

- The TCs should provide educational and training experiences that lead to defined PV workplace knowledge, skills and competencies
- The TCs should appropriately address issues of safety, codes, and core competencies of a professionally-approved task analysis
- Training should be implemented in the appropriate environment (facilities, tools and safe practices)
- The training structure should be well defined; emphasis should be put on a practical part
- The trainee’s progress is being assessed
- Training should be implemented by a legal entity
- Training should be offered by an entity with administrative and managerial quality

As concerns the various phases of the TC:

(i) **Analysis of the needs** is done (D2.9)

(ii) During the **design phase** the following are developed

  - the course curriculum
  - the course outline showing the structure of the course (modules, topics, subtopics, learning objectives, learner activities)
  - the design of the training content (e.g. storyboards, audio scripts, video scripts, instructor and student manuals and presentations in the powerpoint format (*.ppt or...
*.pptx) for instructor-led or virtual classroom training, job aids like quick reference guides and checklists).

(iii) in the **development phase**, based on the outcomes of the two previous phases the actual training materials will be created - e.g. study guide/handbook, web-based course, audio and video recordings, quick reference guides, and final draft instructor and student guides – to be provided to the trainers and trainees. This phase will also encompass a pilot test of the developed training materials. In this test, a group of learners from the target audience follows the instructor-led training or virtual classroom training, or goes through the developed training materials. Based on the feedback from the learners final changes will be made to the training materials.

(iv) **Quality Assurance**

At the end of every phase of the training development methodology the deliverables resulting from the phase will undergo an internal assessment. The NCC and EPIA members will assist to a quality check before they are handed to the trainees. After having received their feedback on the deliverables, changes may be occurred accordingly. Once the materials have been approved the training process will begin.
3. Training Course Design

3.1. Entry requirements - Profile of the trainees

The profile of the course attendees is in general practicing qualified electricians and other relevant specialties. They are expected to have relevant experience gained whilst working for a PV installation company, electrical installation company or a roofing company. The amount of experience required is likely to depend on the qualifications of the trainee. More details about the criteria and requirements for the PVTRIN trainees may found at D5.3.

3.2. Course structure

The PVTRIN TC covers 8 major areas:
1. Basics
2. Design principles
3. BAPV and BIPV
4. Installation-Safety
5. Maintenance and troubleshooting
6. Case studies-best practices
7. Example installation of a small scale PV in building
8. Quality management and customer care

The course structure and duration are presented in the following table.

<table>
<thead>
<tr>
<th>MODULE</th>
<th>CLASS</th>
<th>LAB</th>
<th>SELF STUDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. BASICS</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2. DESIGN PRINCIPLES</td>
<td>9</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>3. BAPV AND BIPV</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>4. INSTALLATION - SITEWORK</td>
<td>10</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>5. MAINTENANCE AND TROUBLESHOOTING</td>
<td>3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>6. CASE STUDIES – BEST PRACTICES</td>
<td>3</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>7. EXAMPLE INSTALLATION OF A SMALL SCALE PV ON BUILDING</td>
<td>4</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>8. QUALITY MANAGEMENT AND CUSTOMER CARE</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>
In general the course analysis is made of two parts. The first part describes the underpinning knowledge that is required to understand the theory behind PV systems, related regulations, safety requirements and installation and testing. The second unit is concerned with the application of practical skills in carrying out installation and testing.

The full duration of the TC -starting date to assessment completion- is estimated to be approximately 2 months. The examination/assessment procedures will follow 2 weeks after the end of the training.

3.3. Study guide contents

The following table presents an overview of the study guide contents:

<table>
<thead>
<tr>
<th>MODULE</th>
<th>PVTRIN STUDY GUIDE CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Solar Basics</td>
</tr>
<tr>
<td>1.1.</td>
<td><strong>Solar energy</strong></td>
</tr>
<tr>
<td>1.2.</td>
<td><strong>PV technologies</strong></td>
</tr>
<tr>
<td></td>
<td>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</td>
</tr>
<tr>
<td>1.3.</td>
<td><strong>PV system</strong></td>
</tr>
<tr>
<td></td>
<td>Cells, modules and other system components: inverters, batteries, controllers, cables and wires, distribution boxes, electricity meter, net-metering, etc.</td>
</tr>
<tr>
<td>1.4.</td>
<td><strong>Types of PV systems/applications</strong></td>
</tr>
<tr>
<td></td>
<td>grid connected, stand alone, hybrid – residential, industrial</td>
</tr>
<tr>
<td>1.5.</td>
<td><strong>Benefits of PV technology</strong></td>
</tr>
<tr>
<td></td>
<td>environmental, economic, grid efficiency, energy adequacy, employment etc</td>
</tr>
<tr>
<td>1.6.</td>
<td><strong>Exercises</strong></td>
</tr>
<tr>
<td>2.</td>
<td>Design Principles</td>
</tr>
<tr>
<td>2.1.</td>
<td><strong>Site Survey</strong></td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>2.2.</td>
<td><strong>System Sizing and Design</strong></td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>2.3.</td>
<td><strong>Simulation Software</strong></td>
</tr>
<tr>
<td></td>
<td>Description, examples, comparison, web based simulation solutions, supplementary software and data sources</td>
</tr>
<tr>
<td>2.4.</td>
<td><strong>Economics and Environmental Issues</strong></td>
</tr>
<tr>
<td></td>
<td>Economic Assessment (operating expenses, energy payback, IRR) Environmental impact (CO2 emissions, Recycling of PV components, battery management)</td>
</tr>
</tbody>
</table>
2.5. **Standards and regulations (EU /national)**  
Relevant EU and national laws, tariff structure, FIT, Subsidies, licensing and planning regulations, quality standards

2.6. **Exercises**

### 3. BAPV and BIPV

#### 3.1. Mounting and building integrating options

#### 3.2. Roof basics  
Roofs -roofs tasks, shapes, basic constructions - On-roof / In-roof systems - Sloping/Flat roof

#### 3.3. Façade basics  
Facade types structures and construction methods, Fastening/Joints, Mounting modules on existing facades, Facades with integrated modules

#### 3.4. Glass roofs and others  
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. Typical examples in 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. Mechanical components installation  
Install equipment base, mounting system, PV modules

#### 4.5. Grid-connected PV Systems

#### 4.6. Stand-alone PV Systems

#### 4.7. Mounting systems and building integration

#### 4.8. Completing the PV installation  
Testing, Commissioning, Documentation to the customer

#### 4.9. Installation checklist

#### 4.10. 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

Exercise
7. Maintenance and Troubleshooting

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

7.2. Typical mistakes and failures
Corrective measures and troubleshooting

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

7.4. Documentation to the customer

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. Bibliography

10. Further Reading

11. Glossary of terms

ANNEXES

i. Abbreviations and acronyms
ii. International and EU standards with relevance to photovoltaics
iii. Wiring symbols characteristic I-V curves for modules
iv. Radiation maps
v. Etc...
vi. Useful links

3.4. Training methods

The training will include a mixed balance of classroom instruction (theory and practice) including presentation of case studies, practical exercises/practice on related software and also actual hands-on work with PV systems and equipment, with an overall goal of developing "system-knowledgeable" professionals

A combination of workshops, web and paper based training methods involving appropriate web tools will be considered in order to develop a flexible and easy-to-replicate training course:
• Lecture instructor-led class
• Demonstration – lab practice
• Case Studies analysis
• Simulations
• self-directed study through e-learning platform
• Projects
• Webinar
• Movies/videos/computer-based training
• On-the-job training

Following the TC, the participants will undergo an assessment, including a practical assessment (task 4.3).

3.5. Training tools – Supporting materials

• PVTRIN Handbook – Study Guide
• Worksheets (Exercise book and solutions book)
• Checklists, How to do guides
• Course handouts
• Recording lectures presented by the learner
• Relevant software and simulation tools
• E-learning platform
• Further reading resources (useful links, online publications, manufacturers’ manuals etc)

3.6. Evaluation of Knowledge

The trainees will be examined in theoretical and practical skills. The assessment criteria and procedures are defined under the WP5 (D5.4, D5.7).
## 4. Syllabus and Learning outcomes

### Module 1. Basics

<table>
<thead>
<tr>
<th>LEARNING UNITS</th>
<th>LEARNING OBJECTIVES</th>
<th>SKILLS</th>
<th>COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.1 Solar energy</strong></td>
<td>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.</td>
<td>- calculate the monthly and annual solar potential considering orientation and geography</td>
<td>- making the main calculations at advising customers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- being familiar with solar calculations</td>
</tr>
<tr>
<td><strong>1.2 PV technologies</strong></td>
<td>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</td>
<td>- understand the main aspects of the photovoltaic phenomenon, the available collector types</td>
<td>- being aware in brief of the way of the solar electricity production</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- suggesting the appropriate collector system to the customer</td>
</tr>
<tr>
<td><strong>1.3 PV system</strong></td>
<td>cells, modules and other system components: inverters, batteries, controllers, cables and wires, distribution boxes, electricity meter, net-metering, etc.</td>
<td>- understand the main aspects of the cells, inverters and the associated components</td>
<td>- being aware of the main components of the PV system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- selecting the optimum solution and suggesting it to the customer</td>
</tr>
<tr>
<td><strong>1.4 Types of PV systems/ applications</strong></td>
<td>grid connected, stand alone, hybrid - residential, industrial</td>
<td>- comprehend the main differences amongst the various types of PV systems, as concerns the connection and the scale</td>
<td>- being aware of the main type of PV systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- selecting the appropriate connection needs</td>
</tr>
<tr>
<td><strong>1.5 Benefits of PV technology</strong></td>
<td>environmental, economic, grid efficiency, energy adequacy, employment etc.</td>
<td>- understand the main benefits of the PV technology</td>
<td>- being aware of the main environmental, energy and economical benefits of the PV technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- promoting these benefits to the potential clients</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- creating positive professional clima</td>
</tr>
</tbody>
</table>
## MODULE 2. DESIGN PRINCIPLES

**Training method (hours):** Class (9) - Lab(3) - elearning / self study (24)

<table>
<thead>
<tr>
<th>LEARNING UNITS</th>
<th>LEARNING OBJECTIVES</th>
<th>SKILLS</th>
<th>COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of...</td>
<td>on site survey and customer needs: local radiation, climate conditions, wind exposure, shading analysis, array orientation, angle definition; roof/wall structure, mounting methods, hazard assessment, energy expectations, profitability, critical loads, legal aspects, aesthetics etc.</td>
<td>- identify typical tools and equipment required for conducting site surveys for PV installations, and demonstrate proficiency in their use&lt;br&gt; - establish suitable location with proper orientation, sufficient area, adequate solar access taking account of present and future over-shading issues, and structural integrity for installing PV array&lt;br&gt; - establish suitable locations, minimizing cable runs, for installing inverters, control, batteries, and other balance-of-system components&lt;br&gt; - establish and illustrate possible layouts and locations for array and equipment, including existing building or site features&lt;br&gt; - obtain and interpret solar radiation and temperature data, as well as potential wind and snow loads, for site for purposes of establishing performance expectations and use in electrical system calculations&lt;br&gt; - identify opportunities for the use of energy efficient equipment/appliances, conservation and energy management practices</td>
<td>- quantifying the customer electrical load and energy use (e.g., through review of utility bills, meter readings, measurements, and/or customer interview)&lt;br&gt; - being competent at advising the clients according to their actual needs&lt;br&gt; - selecting the best system and way of implementation</td>
</tr>
</tbody>
</table>

### 2.1. Site Survey

- 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<br> DC system, PV array design, cable sizing, plug and socket connectors, junction box, string fuses, blocking diodes, DC switch<br> earthing, lightning and surge protection<br> AC system, AC cabling, switch-disconnector<br> performance calculations and electrical diagrams. | - estimate and/or measure the peak load demand and average daily energy use for all loads directly connected to inverter-battery systems for purposes of sizing equipment, as applicable<br> - determine requirements for installing additional subpanels and interfacing PV system with electrical supply network and/or other generation sources as applicable<br> - determine the design currents and voltages for any part of a PV system electrical circuit<br> - determine the capacity of system conductors, and select | - being able to make decisions on the size and design of the system<br> - being able to determine appropriate size, ratings, and locations for earthing, surge suppression, lightning protection and associated equipment<br> - being able to identify appropriate module/array layout, orientation, and mounting method for ease of installation, electrical configuration and maintenance |

### 2.2. System Sizing and Design
<table>
<thead>
<tr>
<th>2.3. Simulation Software</th>
<th>description, examples, comparison, web based simulation solutions, supplementary software and data sources</th>
<th>to calculate the main parameters for the sizing and the optimum operation of the PV system</th>
<th>making all necessary calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4. Economics and Environmental Issues</td>
<td>economic assessment (operating expenses, energy payback, IRR) environmental impact (CO2 emissions, recycling of PV components, battery management)</td>
<td>to assess the economic and environmental performance of the system</td>
<td>initiating projects according to the real needs, priorities and economics of the client</td>
</tr>
<tr>
<td>2.5. Standards and regulations (EU /national)</td>
<td>relevant EU and national laws, tariff structure, FIT, subsidies, licensing and planning regulations, quality standards</td>
<td>to know how to take into account the current legal and regulatory framework</td>
<td>presenting and communicating to the potential customers and legal bodies in the most appropriate and understandable way - reacting and solving potential problems - being aware of the importance of calculations and actions - developing the necessary self-efficiency on the issues of the module 2</td>
</tr>
</tbody>
</table>
## MODULE 3. BAPV AND BIPV

<table>
<thead>
<tr>
<th>LEARNING UNITS</th>
<th>LEARNING OBJECTIVES</th>
<th>SKILLS</th>
<th>COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knowledge of...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Mounting and building integrating options</td>
<td>definition of BAPV and BIPV, aspects of Building integration and aesthetics</td>
<td>- make the appropriate actions for the mounting, as well as integrating of the system in the building</td>
<td>- being able to mount and integrate the PV system in the building</td>
</tr>
<tr>
<td>3.2 Roof basics</td>
<td>roofs -roofs tasks, shapes, basic constructions- on-roof / in-roof systems -sloping/flat roof</td>
<td>- understand the main tasks for the building roof as concerns the PV integration</td>
<td>- being able to integrate in the roof the PV systems</td>
</tr>
<tr>
<td>3.3 Façade basics</td>
<td>facade types structures and construction methods, fastening/joints, mounting modules on existing facades, facades with integrated modules</td>
<td>- understand the main tasks for the building’s façade as concerns the PV integration possibility</td>
<td>- being able to integrate the PV system in the façade</td>
</tr>
<tr>
<td>3.4 Glass roofs and others</td>
<td>glass roofs, atria and canopies, shading systems</td>
<td>- understand the main tasks for the glass roofs and other typical building components for PV integration</td>
<td>- being able to integrate the PV taking into account the glass roof and other important building parameters for the integration</td>
</tr>
<tr>
<td>3.5 Design parameters and performance factors</td>
<td>tilt and orientation, shade structure (overshadowing, partial shading), connection concepts, temperature effect and ventilation etc</td>
<td>- understand the critical design parameters affecting the BIPV and BAPV</td>
<td>- being able to make the appropriate actions and decisions as concerns critical design parameters of the building</td>
</tr>
<tr>
<td>3.6 Examples in the residential sector</td>
<td>- see examples linked to the module 3</td>
<td>- developing the necessary self-efficiency on the issues of the module 3</td>
<td></td>
</tr>
</tbody>
</table>
### MODULE 4. INSTALLATION - SITEWORK

<table>
<thead>
<tr>
<th>LEARNING UNITS</th>
<th>LEARNING OBJECTIVES</th>
<th>SKILLS</th>
<th>COMPETENCES</th>
</tr>
</thead>
</table>
| **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 | - identify and assess any site-specific safety hazards or other issues associated with installation of system  
- maintain safe working practices  
- demonstrate safe and proper use of required tools and equipment  
- demonstrate safe and accepted practices for personnel protection  
- demonstrate awareness of safety hazards and how to avoid them (specific for the electrical installations)  
- identify and implement appropriate codes and standards concerning installation, operation, and maintenance of PV systems and equipment  
- identify and implement appropriate codes and standards concerning worker and public safety | - being responsible that the work is carried out according to the safety plans  
- making the working team follow the safety regulations |
| **4.2. Installation plan**    | work sequences, technical drawings, technical documentation, tools and equipment, safety plan | - utilise drawings, schematics, instructions and recommended procedures in installing equipment  
- implement all applicable personnel safety and environmental protection measures  
- visually inspect and quick-test PV modules  
- assemble modules, panels, and support structures as specified by module manufacturer or design/structural engineer.  
- select material, tools, suppliers and other technical resources | - taking responsibility for the planning of the involved working team  
- taking decisions concerning the procurement of materials/components and delivery  
- defining the proper working methods  
- being proactive in the required procedures |
| **4.3. Electrical components installation** | mitigate electrical hazards, install grounding system, conduit, electrical components, circuit conductors, system instrumentation, battery components, etc | - install module array interconnect wiring; implement measures to disable array during installation  
- label, install, and terminate electrical wiring; verify proper connections, voltages, and phase/polarity | - being competent at implementing all necessary electrical actions for PV installation |
| 4.4. Mechanical components installation | install equipment base, mounting system, PV modules | - use appropriate 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 | - complete final assembly, structural attachment, and weather sealing of array to building or other support mechanism | - being competent at implementing all necessary mechanical actions for PV installation |
| 4.5. Grid-connected PV Systems |  | - understand the critical parameters for the grid-connected PV systems | - being able to make the appropriate decisions and solutions for grid-connected systems |
| 4.6. Stand-alone PV Systems |  | - understand the critical parameters for the stand-alone PV systems | - being able to make the appropriate decisions and solutions for stand-alone systems |
| 4.7. Mounting systems and building integration |  | - understand the critical parameters for the mounting and integration of PV systems | - being able to make the appropriate decisions and solutions |
| 4.8. Completing the PV installation | testing, commissioning, documentation to the customer | - comprehend the last stages required on site and documented | - testing, commissioning and documenting the PV system  
- seeing the linkages in the system and think and act in a holistic way  
- working honesty and accuracy and to declare any mistakes and unexpected problems which can compromise  
- the functionality and efficiency of the system |
| 4.9. Installation checklist |  | - recognize, in brief, all parameters of the installed systems | - being able to check and to present all PV installation parameters |
## Module 5. Case Studies – Best Practices

<table>
<thead>
<tr>
<th>LEARNING UNITS</th>
<th>LEARNING OBJECTIVES</th>
<th>SKILLS</th>
<th>COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1. Case studies – Best Practices</td>
<td>Knowledge of.....</td>
<td>-see examples linked to the modules 1-5</td>
<td>- developing the necessary self-efficiency on the issues of the modules 1-5</td>
</tr>
</tbody>
</table>

## Module 6. Example Installation of a Small Scale PV on Building

<table>
<thead>
<tr>
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<th>LEARNING OBJECTIVES</th>
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<th>COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1. Step by step practical guide</td>
<td>development of a PV project supported by appropriate software: design, performance analysis, installation project planning, safety plan of a small scale PV installation</td>
<td>- use the proper techniques to install all the equipment according to the state-of-the-art - be able to choose and use the personal safety equipment and methods to prevent and minimize risks - assess the efficiency and test the system</td>
<td>- working accuracy and declaring any mistakes and unexpected problems, which can compromise the functionality and efficiency of the system - being in charge for the own physical and psychological conditions for undertaking the practical execution - maintaining a high quality and helping colleagues to meet the required standards</td>
</tr>
</tbody>
</table>
# Module 7. Maintenance and Troubleshooting

<table>
<thead>
<tr>
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<th>COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knowledge of...</td>
<td>To be able to...</td>
<td>To be competent at...</td>
</tr>
<tr>
<td><strong>7.1. Maintenance plan</strong></td>
<td>periodical inspection, array maintenance, battery/inverter and charge controller maintenance, maintenance tools and equipment, dirt accumulation, electrical connections check, other damages.</td>
<td>analyze the technical documentation/manuals of PV installations, determining actions and resources required for the maintenance process</td>
<td>taking responsibility for the planning</td>
</tr>
<tr>
<td></td>
<td><strong>7.2. Typical mistakes and failures</strong></td>
<td>analyze the past production report and – potential – fault reports</td>
<td>identifying tools and equipment required for maintaining and troubleshooting PV systems; demonstrate proficiency in their use</td>
</tr>
<tr>
<td></td>
<td>corrective measures and troubleshooting</td>
<td>design a typical periodical maintenance plan for this type of plant and select the appropriate required tools</td>
<td>identifying maintenance needs and implement service procedures for modules, arrays, batteries, power conditioning equipment, safety systems, structural and weather sealing systems, and balance of systems equipment</td>
</tr>
<tr>
<td></td>
<td>visual inspection procedures, analysis of the monitoring system data, performance monitoring</td>
<td>apply techniques of the PV system</td>
<td>having a “problem solving- attitude”</td>
</tr>
<tr>
<td></td>
<td><strong>7.2. Diagnostic procedures</strong></td>
<td>use the proper measurement techniques</td>
<td>identifying performance and safety issues, and implement corrective measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>make the tests of the performance of the PV system</td>
<td>verifying and demonstrating complete functionality and performance of system, including start-up, shut-down, normal operation, and emergency/bypass operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>analyse the performance and define the problems of the PV-system</td>
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<td></td>
<td></td>
<td>visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship particularly mounting systems, ventilation, cable runs and connections/junction boxes</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>check system mechanical installation for structural integrity and weather sealing</td>
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<tr>
<td></td>
<td></td>
<td>check electrical installation for proper wiring practice, polarity, earthing, and integrity of terminations according to appropriate regulations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>performing diagnostic procedures and interpret results</td>
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</tbody>
</table>
- Activate system and verify overall system functionality and performance; compare with expectations
- Demonstrate procedures for connecting and disconnecting the system and equipment from all sources

7.3. Documentation to the customer
- Understand the documentation and technical standards
- Identify what documentation is required to be provided to the PV system owner/operator by the installer.
- Be able to write an O&M manual according to the minimum requirements
- Be able to document the work performance
- Be able to make suggestions and recommendations for the further optimum management of the system
- Compiling and maintaining records of system operation, performance, and maintenance
- Having the ability to focus the important points for the manual
- Working honesty and accuracy in the documentation process
- Taking the responsibility to give all the necessary information to manage and maintain the plant in a good way

7.4. Maintenance checklist
- Identify and verify all required markings and labels for the system and equipment
- Being able to check and to present all PV maintenance parameters

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**MODULE 8. QUALITY MANAGEMENT AND CUSTOMER CARE**

Training method (hours): Class (3), e-learning /self study (6)

<table>
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<td>Knowledge of.....</td>
<td>To be able to...</td>
<td>To be competent at.....</td>
</tr>
<tr>
<td>8.1. Quality principles</td>
<td>quality management principles, efficiency and functional controls, quality assurance and in the construction of PV systems</td>
<td>understand all quality parameters of the installed system</td>
<td>implementing all necessary actions according to quality standards</td>
</tr>
<tr>
<td>8.2. EU standards for PV</td>
<td>recognize and understand all EU standards associated to the system</td>
<td>implementing all necessary actions according to the EU standards</td>
<td></td>
</tr>
<tr>
<td>8.3. Customer care</td>
<td>pre-sales activities, contracts, completing the work: delivery/final testing/handover, after sales: warranties/service and repairs/complaints handling.</td>
<td>understand the content and the way of all necessary customer care activities</td>
<td>implementing all necessary actions to keep the proper customer care</td>
</tr>
</tbody>
</table>
5. Trainers and Training providers

5.1. Trainers Profile

Trainers shall meet the requirements of the training program; in order to ensure that the training process is carried out effectively and uniformly, the competence requirements for personnel involved in the entire process shall be approved by the Steering committee of the PVTRIN project.

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 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 overseeing and/or approving the installation of PV systems.

In general the trainers should match the following criteria as pre-requisite:

- To have appropriate professional experience in the photovoltaics (theoretical and practical), at least five (5) years
- To be familiar with the PVTRIN training syllabus and curriculum
- To have a thorough knowledge of the relevant training methods
- To be able to communicate effectively both in writing and orally

More details about the requirements for the training providers may found in D5.3

5.2. Training providers

The training provider should be compliant with the requirements of ISO/IEC 17024 will be assessed by the relevant national accreditation body. Shall operate a documented management system that ensures the requirements of ISO/IEC 17024 are applied correctly. Internal audits shall also be conducted to ensure that the management system is being implemented correctly and to identify areas for continual improvement or those requiring corrective or preventative actions.

In addition to having sufficient numbers of appropriately qualified and experienced trainers and assessors the accredited training centre certificating successful candidates shall have policies and procedures that ensure that candidates are treated fairly and equitably. Policies will also ensure that the training centre manages the certification of trainees appropriately, including suspending and withdrawing certification when considered necessary. The training centre shall also ensure that in delivering training courses it remains within the scope of its accreditation. Policies and procedures for the resolution of complaints and certification decision appeals are also required. More details about the requirements for the training providers may found in D5.3.
5.3. Facilities, Hardware and Materials

Indicative facilities are:

- Complete grid-connected PV system package(s), including modules, mounting hardware, inverter, components and documentation.
- 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, disconnects and over-current devices (fuses and circuit breakers)
- Mounting structures and kits, roof mockups, mechanical hardware and weather sealing materials.
- Site survey equipment, including lines, levels, tapes, markers, inclinometers, sun path calculators and checklists.
- Basic electrical meters and diagnostic equipment, including volt/ohm/ammeters, clamp on
- DC ammeters, power analyzers, conventional and electronic watt/watt-hour meters, contact and IR temperature probes, solar irradiance meters, high voltage tester and ground resistance testers.
- Typical construction and electrician power and hand tools required for PV system installations.
- Safety equipment, including warning signs, eye protection and washes, gloves and aprons, first aid kits, lifting equipment, hard hats, safety harnesses and life lines, fire suppression equipment and electrolyte neutralizer.
6. 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.

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. ‘evaluation’ is more frequently used to describe appraisal of education and training methods or providers.

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.

e-learning: Learning supported by information and communication technologies (ICT).
*e-learning is not limited to ‘digital literacy’ (acquiring ICT skills). It may encompass multiple formats and hybrid methods: using software, Internet, CD-ROM, online learning or any other electronic or interactive media; e-learning can be used as a tool for distance education and training but also to support face-to-face learning.*
**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.

**Qualification system:** 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.

**Recognition 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.

**Skill:** The ability to perform tasks and solve problems.

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