National Unit specification: general information

Unit title: PhotoVoltaic (PV) Arrays

Unit code: FF2P 12

Superclass: XJ

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Source: Scottish Qualifications Authority

Version: 01

Summary

This Unit has been designed to provide candidates with the necessary knowledge and understanding of the provision of PhotoVoltaic Arrays. The Unit will introduce candidates to the basic design principles, systems components and characteristics of PhotoVoltaic Arrays. The Unit will also introduce candidates to fundamental health and safety and installation requirements.

The Unit is suitable for candidates who are undertaking this study for the first time or wish to obtain a basic knowledge of PhotoVoltaic Arrays. The Unit will allow for those currently employed in the building services industry to develop further knowledge specifically related to PhotoVoltaic Arrays.

Outcomes

1 Describe typical PV systems, their components, characteristics and issues of installation.
2 Demonstrate a knowledge of the electrical installation techniques and regulations when installing a PV array.
3 Identify the relevant Standards, Regulations, Guidelines and Codes of Practice used when installing and commissioning a PV array.

Recommended entry

Entry is at the discretion of the centre.

National Unit specification: General information (cont)

Unit title: PhotoVoltaic (PV) Arrays

Credit points and level

1 National Unit credit at SCQF level 6: (6 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes of this Unit specification.

There is no automatic certification of Core Skills or Core Skill component in this Unit.

National Unit specification: statement of standards

Unit title: PhotoVoltaic (PV) Arrays

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Describe typical PV systems, their components, characteristics and issues of installation.

Performance Criteria

(a) Describe correctly the major components in typical PV installations.
(b) Identify correctly the main PV cell technologies and their characteristics.
(c) Describe correctly the main working principles of a PV element.
(d) Describe correctly the current, voltage and power characteristics of a PV module.
(e) State the factors affecting the installation of a PV array.

Outcome 2

Demonstrate a knowledge of the electrical installation techniques and regulations when installing a PV array.

Performance Criteria

(a) Calculate recommended minimum voltage and current ratings for dc components and cables.
(b) Describe protection techniques and components.
(c) State the function of inverters and the factors which influence selection.
(d) State the BS grid connection requirements for metering, ac cables, switch disconnectors and ac fault current protection.

Outcome 3

Identify the relevant Standards, Regulations, Guidelines and Codes of Practice used when installing and commissioning a PV array.

Performance Criteria

(a) Identify correctly the relevant statutory standards and regulations.
(b) Identify correctly the guidelines and Codes of Practice.
(c) Identify correctly relevant safety practices.
(d) Identify correctly requirements to become a registered PV installer.

National Unit specification: statement of standards (cont)

Unit title: PhotoVoltaic (PV) Arrays

Evidence Requirements for this Unit

Evidence is required to demonstrate the candidates have achieved all Outcomes and Performance Criteria.

Written and/or recorded oral evidence should be produced to demonstrate that the candidate has achieved all the Outcomes and Performance Criteria.

Outcomes 1, 2 and 3 may be assessed on an individual basis, as a combination of outcomes (eg Outcomes 2 and 3 assessed together), or as a single assessment covering all three Outcomes. Regardless of which approach is taken the total time for assessment should not exceed 2 hours. Assessment must be conducted under controlled, supervised, closed book conditions in which candidates may use reference materials provided by the centre but are not allowed to bring their own notes, handouts, textbooks or other materials into the assessment. Candidates should be allowed to use a non-programmable scientific calculator during assessment.

Outcome 1

(a) Candidates must correctly describe the major components in three types of PV installations.

(b) Candidates must correctly identify at least two of the following types of PV cell technologies and their characteristics:

- Monocrystalline
- Polycrystalline
- Thin film
- Concentrating systems (III-V semiconductors)

(c) Candidates must correctly describe the main working principles of a PV element.

(d) Candidates must correctly describe three voltage/current relationships.

(e) Candidates must correctly state five factors which affect the installation of a PV array.

National Unit specification: statement of standards (cont)

Unit title: PhotoVoltaic (PV) Arrays

Outcome 2

(a) Candidates must correctly calculate the minimum voltage and current ratings for four dc components.

(b) Candidates must correctly describe four protection techniques and components.

(c) Candidates must correctly state the function of two invertors and the factors which influence selection for each.

(d) Candidates must correctly state the grid connection requirements for meter installation, ac cabling, switch disconnectors and ac fault current protection.

Outcome 3

(a) Candidates must correctly identify a minimum of 2 of 4 statutory standards and regulations.

(b) Candidates must correctly identify a minimum of 2 of 4 of the guidelines and Codes of Practice.

(c) Candidates must correctly identify the relevant safety practices for securing circuit isolation and a minimum of:

- 2 of 3 precautions to prevent electric shock
- 1 of 2 safe practices
- 2 of 3 working at height
- 1 of 2 international standards for PhotoVoltaics

(d) Candidates must correctly identify a minimum of 1 of 2 requirements to become a registered PV installer.

National Unit specification: support notes

Unit title: PhotoVoltaic (PV) Arrays

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

Outcome 1

The following should be covered:

- Knowledge of the major components in typical photovoltaic (PV) installations.
  - grid connected
  - building integrated
  - non-integrated
- Knowledge of main PV cell technologies, subsystems and characteristics.
  - Types
    - Monocrystalline
    - Polycrystalline
    - Thin film
    - Concentrating systems (III-V semiconductors)
  - Subsystems
    - PV cell
    - module
    - string
    - array
    - invertor
    - grid connection
  - Characteristics
    - PV cell principles – light forces electrons in the material to move, thereby generating electricity
    - *IV* (current/voltage) curve
    - open circuit voltage and short circuit current (V_{oc} and I_{sc})
    - maximum power current and voltage (I_{mpp} and V_{mpp})

- Knowledge of the factors which affect the installation of a PV array.

  - inspection and storage of modules
  - siting of modules (orientation, angle of inclination, free from shade)
  - load bearing capacity
  - configuration of modules
  - fixing methods, integrated and non-integrated
  - alignment and levelling of secondary structures to minimise stress on modules
  - maintaining the integrity of the roof (weather seal)
  - aesthetic considerations
  - environmental conditions
  - methods of performance monitoring

Outcome 2

- dc components

  - plugs
  - connectors
  - switches
  - double pole switch (isolation from the inverter)
  - minimum cable sizing for main and string dc cables (V_{oc} and I_{sc})
  - cables (temperature rating, UV and weather resistance)
  - labelling requirements for a dc system

- Protection techniques and components

  - short circuit proof installation
  - protective insulation recommended for PV modules including systems with high open circuit voltage
  - protection types for small PV systems
    - anti-islanding protection
    - over and under voltage protection
    - over and under frequency protection
  - G59/1 requirements for large PV systems
  - earthing requirements in BS 7671 and BS 7430 with reference to
    - array frame earthing
    - dc conductor earthing
    - inverter earthing
  - state lightning protection system requirements in BS 6651 with reference to
    - type of system
    - connection to array and mounting
    - surge protection
  - ac switch disconnector requirement in accordance with BS EN 60947-3 and G83/1
  - ac fault current protection requirements

- String fuses and blocking diodes with reference to:
  - type of system
  - fuse ratings
  - point of installation
  - selection factors for a blocking diode
  - potential problems
- Invertor
  - type of inverter
    - string
    - ac module
    - single phase
    - 3-phase
  - location
    - effect of weight
    - length of dc cable
    - environment
    - inverter sizing
  - compliance with G83/1
    - meter installation
    - ac cabling

Outcome 3

- State relevant statutory standards and regulations.
  - Electricity at Work Regulations 1989
  - Building Regulations 2000
  - Health and Safety at Work etc Act 1974
  - Control of Substances Hazardous to Health Regulations 1988
- State guidelines and Codes of Practice.
  - Engineering recommendations G83/1 and G59/1
  - Department of Trade and Industry guidelines *'Photovoltaics in Buildings: Guide to the installation of PV systems'* and *'Photovoltaics in Buildings: Testing, Commissioning and Monitoring Guide'*
  - BS 7671 IEE Wiring Regulations for Electrical Installations
  - HSE Guide GS38 Electrical test equipment for use by electricians
- State methods of verifying and securing (locking off) circuit isolation.

National Unit specification: support notes (cont)

Unit title: PhotoVoltaic (PV) Arrays

- State precautions to be taken and procedures to be followed to prevent electric shock.

  - Identify hazards arising from the use of electrical equipment.
  - Apply general safety rules in respect of checking of cables, leads and plugs, earthing and use of portable equipment and reduced voltage equipment.
  - Recognise that PV cannot be switched off and that measures are necessary to ensure contact cannot be made with live connections.
  - Recognise that voltage is generated at low light levels and can lead to risk of electric shock.
  - Identify PV modules as current limiting devices not damaged by short circuits and therefore not liable to be protected by fuses.

- State the general rules for observance of safe practices including:

  - being alert
  - maintaining personal hygiene
  - protecting oneself and other people
  - knowing emergency and site evacuation procedures to cover:
    - fire
    - explosion
    - toxic atmosphere
    - security alerts
    - reporting all hazards and notifying appropriate authority

- State suitable access equipment for working at height and on roofs

  - appropriate staging and trestles
  - safe angles for ladders
  - methods of securing ladders
  - safety requirements for tower scaffolds
  - guard rails and toeboards
  - personal safety equipment when working on roofs

- State safe practices for handling, moving and storing PV modules.

- State the international standards with which PV modules should comply.

  - BS EN 61215, IEC 61215 - Crystalline silicon terrestrial photovoltaic (PV) modules. Design qualification and type approval.
  - BS EN 61646, IEC 61646 - Thin-film terrestrial photovoltaic (PV) modules. Design qualification and type approval.

- State the requirements and certification to become a registered PV installer.

  - Completion of a recognised apprenticeship.
  - Completion of a certificated training scheme on PV installation.

National Unit specification: support notes (cont)

Unit title: PhotoVoltaic (PV) Arrays

Guidance on learning and teaching approaches for this Unit

It is recommended that the Outcomes are delivered in the sequence presented in the Unit specification. The Unit may be delivered by a combination of lectures, tutorial work and practical laboratory work. The Unit should be taught very much in an electrical engineering/energy context and as such relevant engineering/energy examples should be used throughout Unit delivery.

While the majority of the Unit can be delivered in a classroom, centres should allow candidates to undertake practical experiments so that they have opportunities to relate theory learnt in the classroom to practice. For example, where PV equipment exists candidates should be allowed to carry out simple performance tests on these systems.

The Internet contains a rich source of materials on Renewable Energy and Photovoltaic (PV) Installations. Candidates should be aware of the different regulations, climates etc when using non UK based web sites.

Small PV kits can be used to support the learning. Candidates can assemble and test small systems and form opinions/evaluations on the merits or otherwise of PV technology.

The Unit should be fully supported with relevant learning materials (e.g. handouts in paper and electronic form, textbooks, on-line materials etc.)

Opportunities for developing Core Skills

There is no automatic certification of Core Skills or Core Skill component in this Unit.

However there may be opportunities for the candidate to develop the Core Skills of Communication, Working with Others, Problem Solving and the component Using Number of the Core Skill Numeracy at SCQF level 5.

Elements of *Numeracy* at SCQF level 5 may be developed in Outcome 2 where various voltage and current ratings are calculated. Using Graphical Information at SCQF level 5 may be developed in Outcome 2, where candidates will use graphical information to describe protection techniques and components.

The Core Skill *ICT* at SCQF level 5 may be developed in Outcomes 1 and 3 where candidates may access and interpret information, research and select differing PV installation techniques, PV characteristics and relevant Standards, Guidelines and Codes. The Critical Thinking component of *Problem Solving* at SCQF level 5 may be developed in Outcome 1 while candidates are identifying different PV technologies and issues that arise when installing PV systems.

Elements of *Working with Others* Core Skill at SCQF level 4 may be developed in Outcomes 1 and 2 while candidates investigate different PV systems in the workshop, the components and the installation techniques used.

National Unit specification: support notes (cont)

Unit title: PhotoVoltaic (PV) Arrays

Guidance on approaches to assessment for this Unit

Centres are encouraged to use formative assessment extensively as it plays a particularly important role in allowing candidates to develop a sound knowledge and understanding of Photovoltaic technologies.

Summative assessment may take the following form:

Outcomes 1 and 2

Assessment may comprise of a single assessment paper covering the outcome and performance criteria requirements for both Outcomes. The assessment paper should be taken at a single assessment event lasting 1 hour and comprise of a suitable balance of short answer, restricted response or structured questions.

Outcome 3

Assessment may comprise of a single assessment paper covering the outcome and performance criteria requirements. The assessment paper should be taken at a single assessment event lasting 1 hour and comprise of a suitable balance of; multiple choice, short answer, restricted response or structured questions.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

History of changes to Unit

Version	Description of change	Date