

Scottish Qualifications Authority

Workplace Assessed Unit Specification

General information

Unit Number F8XL 04 **Publication date:** June 2010

Title Install, Test, Commission and Handover Solar Photovoltaic Systems

GENERAL COMPETENCE FOR UNIT:

The aim of this Unit is to allow candidates to develop the knowledge and skills required to plan and prepare for, installing (including testing and commissioning) and handover of solar photovoltaic systems. The Unit focuses upon grid connected systems that are within the scope of Engineering Recommendation G83/1 with an electrical output of up to 5 kilowatt peak (kWp) connected to both single and three-phase installations.

OUTCOMES

- 1 Identify and describe the requirements to install, test, commission and handover Solar Photovoltaic Systems
- 2 Install, test, commission and handover Solar Photovoltaic Systems

ACCESS STATEMENT:

Access to this Unit is subject to the following pre-requisites:

Candidates must be qualified in an appropriate Mechanical Engineering Services or Building Services Engineering discipline to SVQ level 3 or equivalent and must have achieved the Unit F8XJ 04 Working Principles, Installation Options and Regulatory Requirements for Micro-renewable Technologies, Water Harvesting and Recycling Technologies.

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Workplace Assessed Unit Specification

Statement of standards

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

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 the Scottish Qualifications Authority.

OUTCOME 1

- 1 Identify and describe the requirements to install, test, commission and handover Solar Photovoltaic Systems.

PERFORMANCE CRITERIA

- (a) Identify the health and safety risks and safe systems of work associated with solar photovoltaic system installation work
- (b) Identify the requirements of the relevant regulations/ standards relating to practical installation, testing and commissioning activities for solar photovoltaic system installation work
- (c) Describe the fundamental differences between a.c and d.c circuits within solar photovoltaic systems
- (d) Identify the purpose of solar photovoltaic system components
- (e) Describe the types, silicon characteristics and typical conversion efficiencies of solar photovoltaic modules
- (f) Identify the fundamental design principles used to determine solar photovoltaic system module array size and position requirements
- (g) Identify the preparatory work required for solar photovoltaic system installation work
- (h) Describe the layouts and the requirements for installing solar photovoltaic module arrays
- (i) Identify solar photovoltaic system d.c and a.c circuit installation layouts within the scope of the relevant Engineering Recommendation for grid tied systems
- (j) Identify solar photovoltaic system protection techniques and components
- (k) Identify the requirements to test and commission solar photovoltaic systems
- (l) Identify the requirements to handover solar photovoltaic systems

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

RANGE STATEMENT

(a) State which aspects of solar photovoltaic system installation work pose risk of:

- ◆ electrocution/electric shock
- ◆ burns
- ◆ a fall from height
- ◆ personal injury though component/equipment handling

(EVTS 1, Kn b)

Propose safe systems of work for solar photovoltaic system installation work in relation to prevention of:

- ◆ electrocution/electric shock
- ◆ burns
- ◆ a fall from height
- ◆ personal injury though component/equipment handling

(EVTS 1, Kn b)

(b) Confirm building regulation/building standards guidance as relevant to solar photovoltaic system installation work in relation to:

- ◆ maintaining the structural integrity of the building
- ◆ maintaining the fire resistant integrity of the building
- ◆ the prevention of moisture ingress (building water tightness)
- ◆ notification of works
- ◆ electrical safety
- ◆ system installation
- ◆ energy conservation
- ◆ inspections and testing
- ◆ commissioning

(EVTS 1, Kn c)

Confirm industry recognised electrical wiring regulation requirements as relevant to solar photovoltaic system installation work in relation to:

- ◆ system installation
- ◆ inspection and testing
- ◆ commissioning

(EVTS 1, Kn c)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

(c) Explain the fundamental differences between a.c and d.c circuits within solar photovoltaic systems in relation to:

- ◆ voltages
- ◆ safe isolation
- ◆ selection of appropriate system components

(EVTS 1 Kn b)

(d) Confirm the purpose of the following solar photovoltaic system components:

- ◆ photovoltaic module
- ◆ module mounting systems
- ◆ d.c.cabling
- ◆ PV connectors
- ◆ blocking diodes
- ◆ d.c. isolator
- ◆ d.c. fuses
- ◆ d.c junction box
- ◆ Inverter
- ◆ a.c isolators
- ◆ a.c. distribution board
- ◆ generation meter
- ◆ generation display unit
- ◆ labels

(EVTS3 kn c, EVTS4 Kn h)

(e) Recognise the following types of solar photovoltaic module:

- ◆ 'On roof' photovoltaic module
- ◆ Thin film photovoltaic module — silicon based and non-silicon based
- ◆ 'In roof' (slate) photovoltaic module
- ◆ 'In roof' (tile) photovoltaic module
- ◆ Building integrated photovoltaic module

(No specific NOS reference but linked to EVTS2, Kn c)

State the silicon characteristics of:

- ◆ Monocrystalline photovoltaic modules
- ◆ Polycrystalline/Multicrystalline photovoltaic modules
- ◆ Thin film photovoltaic modules

(No specific NOS reference)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

State the relevant manufacturing compliance requirements for:

- ◆ Crystalline type modules
- ◆ Thin film type modules

(No specific NOS reference)

State the typical conversion efficiencies associated with:

- ◆ Monocrystalline photovoltaic modules
- ◆ Polycrystalline/Multicrystalline photovoltaic modules
- ◆ Thin film photovoltaic modules

(No specific NOS reference but linked to M8, Kn i)

(f) Determine the information required to enable solar photovoltaic array design in relation to:

- ◆ building design
- ◆ building dimensions/angles
- ◆ building location and orientation
- ◆ building fabric/material details

(linked to EK8, Kn h,i)

Confirm how to calculate the nominal power (kWp) per m² of a given product

(EL8, Kn i)

Explain how annual solar photovoltaic electrical output (kWh) can be affected by:

- ◆ geographical irradiation levels
- ◆ the array mounting angle
- ◆ the array orientation
- ◆ overshadowing of the array or modules within the array

(EL8, Kn h)

Determine the potential benefit(s) of incorporating a solar tracker into the system design

(M8, Kn h)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

Determine the potential effect of shading on:

- ◆ solar photovoltaic module condition
- ◆ solar photovoltaic array condition

(M8, Kn h,i)

(g) Determine the requirements of pre-installation checks in relation to:

- ◆ authorisation for the work to proceed
- ◆ the availability of appropriate access to all required work areas
- ◆ the inspection & testing of existing electrical installations
- ◆ the proposed siting of key internal system components
- ◆ the suitability of the building structure in relation to the proposed installation
- ◆ the suitability of the proposed location and position of the PV modules for optimum collection capacity
- ◆ the suitability of the building fabric in relation to the installation of the PV modules

(EVTS1 Kn d,e)

(h) Recognise the following solar photovoltaic system module array layouts:

- ◆ single array, single string
- ◆ single array, multiple string

(EVTS2 Kn c,d)

Confirm the requirements for handling, moving and storing solar photovoltaic modules

(EVTS2 Kn c)

Determine the requirements for fixing:

- ◆ 'on roof' solar photovoltaic modules to pitched roof slopes
- ◆ 'in roof' solar photovoltaic modules to pitched roof slopes
- ◆ solar photovoltaic modules using secondary frame structures

(EVTS2 Kn c)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

Confirm the requirements for ventilation in relation to solar photovoltaic modules/module arrays

(EVTS2 Kn c)

Confirm how to achieve durable weather-tightness of buildings where array cables pass through the building fabric.

(EVTS2 Kn c)

State the safety requirements that must be applied when a solar photovoltaic array has been installed prior to the installation of other system components

(EVTS2 Kn b)

Determine the requirements for connecting solar photovoltaic modules:

- ◆ in a single string array
- ◆ with multiple string array

(EVTS2 Kn b,c)

Confirm how to check that string voltages and currents are suitable for the:

- ◆ inverter rating
- ◆ overall system installations

Confirm the requirements for cable routing within solar photovoltaic module arrays in relation to:

- ◆ avoidance of inductive loops
- ◆ other requirements

(EVTS2 Kn b,c)

Propose the correct sequence of work to minimize the risk of injury through electrocution

(EVTS2 Kn b)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

(i) Recognise the industry approved d.c and a.c circuit layout for single array systems connected to:

- ◆ single phase installations
- ◆ three phase installations

(EVTS2 Kn b,c,d)

(j) Determine the techniques and components used to protect system and or/building users in relation to:

- ◆ d.c. circuit over and under voltage protection
- ◆ d.c. circuit over and under current protection
- ◆ a.c. circuit over and under voltage protection
- ◆ a.c. circuit over and under frequency protection
- ◆ a.c. circuit over and under current protection

(EVTS2, Kn b, c)

(k) Determine the pre-commissioning procedures and/or requirements for a solar photovoltaic system in relation to:

- ◆ compliance with relevant installation instructions/regulatory requirements
- ◆ compliance with the system design
- ◆ the security and integrity of system components
- ◆ the provision of adequate ventilation for system components
- ◆ electrical safety
- ◆ electrical over-current protection arrangements

(EVTS3, Kn b)

Determine the regulatory and industry pre-commissioning test requirements for the a.c and d.c circuits within a solar photovoltaic system

(EVTS3, Kn a, b, c)

State the conditions that are required to implement commissioning and activities for solar photovoltaic systems

(EVTS4, Kn b)

Determine regulatory and industry requirements for the commissioning of the a.c and d.c circuits within a solar photovoltaic system

(EVTS4, Kn b, c, f)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

- (l) State the pre-handover checks that need to be carried out for solar photovoltaic systems

(EVTS4, Knowledge)

Determine recommended industry handover procedures for solar photovoltaic systems in relation to the:

- ◆ provision of written information
- ◆ provision of diagrammatic information
- ◆ provision of verbal information/demonstration relating to system operation and use

(EVTS4, Knowledge)

EVIDENCE REQUIREMENTS

Written and/or oral evidence is required to demonstrate knowledge defined in the PCs and must be produced in controlled supervised, open-book conditions. This may be done by a balance of multiple choice, short answer, restricted response and structured questions.

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

OUTCOME 2

Install, test, commission and handover Solar Photovoltaic Systems

PERFORMANCE CRITERIA

- (a) Plan and prepare for the installation of a solar photovoltaic system
- (b) Install solar photovoltaic system components
- (c) Inspect and test a new solar photovoltaic system installation
- (d) Commission a new solar photovoltaic system installation
- (e) Handover a new solar photovoltaic system installation

RANGE STATEMENT

(a) Undertake pre-installation checks in relation to:

- ◆ authorisation for the work to proceed
- ◆ the availability of appropriate access to all required work areas
- ◆ the inspection of existing electrical installations
- ◆ the proposed siting of key internal system components
- ◆ the suitability of the building structure in relation to the proposed installation
- ◆ the suitability of proposed location of the PV modules for optimum collection capacity
- ◆ the suitability of the building fabric in relation to the installation of the PV modules

(EVTS 1, Perf. 1, 6, 9)

Confirm that the tools, materials and equipment required for the installation work are available and are in a safe usable condition.

(EVTS 1, Perf. 2)

(b) Install a solar photovoltaic array in accordance with:

- ◆ manufacturer's guidance
- ◆ regulatory requirements
- ◆ industry recognised procedures

To include as a minimum the positioning, fixing and connection of the array

(EVTS 2, Perf. 6,7,8,9,10)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

Install a solar photovoltaic d.c. circuit in accordance with manufacturer's guidance, regulatory requirements and industry recognised procedures to include as a minimum the positioning, fixing and connection of the following components:

- ◆ d.c. isolator
- ◆ inverter
- ◆ d.c. cabling from module(s) to d.c. isolator
- ◆ d.c. cabling from d.c. isolator to inverter

(EVTS 2, Perf. 6,7,8,9,10)

- (c) Inspect and test the a.c. circuit in accordance with the design specification, manufacturer's and the relevant regulatory requirements

(EVTS 3, Perf. 4)

Inspect and test the d.c. circuit in accordance with the design specification, manufacturer's and the relevant regulatory requirements

(EVTS 3, Perf. 4)

Complete relevant inspection and testing records in accordance with manufacturer's and the relevant regulatory requirements

(EVTS 3, Perf. 4)

- (d) Undertake relevant pre-commissioning checks in accordance with the design specification, manufacturer's and the relevant regulatory requirements

(EVTS 3, Perf. 4)

Identify the design, manufacturer's, client's, regulatory and industry requirements for the commissioning of the system

(EVTS 4, Perf. 1)

Confirm that conditions are suitable to implement commissioning procedures

(Related to EVTS 4, Perf. 1)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

Commission the system in accordance with design, manufacturer's, client's, regulatory and industry requirements for the commissioning of the system

(EVTS 4, Perf. 3, 4)

Complete relevant documentation to record the commissioning activities in accordance with manufacturer's and the relevant regulatory requirements

(Related to EVTS 4, Perf. 3, 4)

- (e) Undertake relevant checks to ensure that the system is ready for handover and compliant with manufacturer's guidance, regulatory and industry recognised requirements

(EVTS 4, Perf. 5)

Explain and demonstrate to the end user the operation and use of the system using manufacturer's guidance and industry agreed handover procedures

(EVTS 4, Perf. 5)

Identify and explain to the end user any aspects of the system that varies from the agreed specifications and requirements

(EVTS 4, Perf. 5)

Obtain acceptance by the end user of the system according to the industry agreed handover procedures

(EVTS 4, Perf. 5)

Ensure that all relevant handover documentation is correctly completed and recorded in the appropriate information systems and passed to the end user in accordance with manufacturer's guidance and industry recognised procedures

(EVTS 4, Perf. 5)

Workplace Assessed Unit Specification

Statement of standards (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

EVIDENCE REQUIREMENTS

A practical assessment is required to demonstrate the candidate's ability to Install, test, commission and handover Solar Photovoltaic Systems. The Unit focuses upon grid connected systems that are within the scope of Engineering Recommendation G83/1 with an electrical output of up to 5 kilowatt peak (kWp) connected to both single and three-phase installations.

ASSESSMENT

In order to achieve this Unit, candidates are required to present sufficient evidence that they have met all the Performance Criteria for each Outcome within the range specified. Details of these requirements are given for each Outcome. The assessment instruments used should follow the general guidance offered by the SQA assessment model and an integrative approach to assessment is encouraged. (See references at the end of support notes).

Accurate records should be made of the assessment instruments used showing how evidence is generated for each Outcome and giving marking schemes and/or checklists, etc. Records of candidates' achievements should be kept. These records will be available for external verification.

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Support notes

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

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 60 hours.

LINKS TO NATIONAL OCCUPATIONAL STANDARDS

Please Note: Whilst a number of the learning outcomes within this Unit will have some relevance to larger scale solar photovoltaic system installations that are the scope of Engineering Recommendation G59/1, achievement of the learning outcomes **will not** provide the full underpinning knowledge required to plan, install and handover photovoltaic system installations that are within the scope of Engineering Recommendation G59/1.

Throughout the Unit and where appropriate we have identified where the evidence relates to the SummitSkills National Occupation Standards (NOS) for Environmental Technology Systems for example:

EVTS 1 Kn b relates to the NOS	
EVTS 1	Plan for Environmental Technology Systems, Equipment and Components
Kn b	Knowledge Criteria b
EVTS, Perf 1	
EVTS 2	Plan for Environmental Technology Systems, Equipment and Components
Perf 1	Performance Criteria 2

APPROACHES TO GENERATING EVIDENCE

Written and/or oral evidence is required to demonstrate knowledge defined in the PCs and must be produced in controlled supervised, open-book conditions.

Assessment of performance shall be carried out using either:

- ◆ evidence sourced from the workplace; and/or
- ◆ through simulation

Use of simulation for the assessment of performance Outcomes

Workplace Assessed Unit Specification

Support notes (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

As agreed with sector stakeholders, within the building services engineering sector footprint, simulation is only normally to be used as an assessment method for performance Outcome assessment in:

- ◆ those extremely rare circumstances where candidate/learner is unable to access the required range of work circumstances and as a result the candidate/learner lacks evidence for completion of the Unit(s); or
- ◆ those circumstances where safety critical and/or technical critical aspects of performance need to be assessed.

SQA and Summitskills recognise that due to the evolving nature of environmental technologies and their integration into the sector, environmental technology system installation, service and maintenance work may not yet be a regular work activity for some sector businesses and as a result restricted or no access to the required range of work circumstances may be more commonplace than for the more established work activities within the sector footprint. In recognition of this SQA and Summitskills considers it appropriate for additional flexibility regarding the use of simulation to be available whilst environmental technology system installation, service and maintenance work becomes more established and commonplace within the sector. However, this flexibility is given on the basis that it will be withdrawn or reduced at an appropriate stage. In order to allow for an initial period of stability in the assessment of environmental technology units the first review of this flexibility will take place in December 2011.

The use of simulation in the assessment of performance Outcomes for environmental technology units is either permissible OR mandatory. Simulation is permitted for all units and all assessed Outcomes until December 2011. This permission is subject to compliance with the requirement for realistic working environment to be used for the simulated activity.

Simulation must take place for key safety critical/technical critical aspects of the environmental technology units. The building services engineering industries cannot afford for the candidates to make mistakes within the workplace and so it is required that candidates, as appropriate, will demonstrate competence of those key safety critical activities and their technical competence in simulated conditions, and under direct assessor observation, as outlined by technology overleaf.

Workplace Assessed Unit Specification

Support notes (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

Technology	Mandatory simulation requirements
Solar Thermal	Commissioning of completed new installations
	All fault identification and rectification activities
Solar Photovoltaic	Installation of solar photovoltaic d.c. circuits and components
	Inspection and testing of the completed installation including both a.c and d.c circuits
	All fault identification and rectification activities
Heat Pumps	Commissioning of completed new installations
	All fault identification and rectification activities
Biomass	To be agreed at upon completion of the Units
Bio-liquids	To be agreed at upon completion of the Units
Water recycling	To be agreed at upon completion of the Units
Micro-wind	To be agreed at upon completion of the Units
Micro-hydro	To be agreed at upon completion of the Units

APPROACHES TO ASSESSMENT

In this Unit an appropriate instrument of assessment for Outcome 1 could be a question paper consisting of a balance of multiple choice, short answer, restricted response and structured questions.

Assessment of underpinning knowledge shall be carried out under controlled supervised, open-book conditions using:

- ◆ centre set, centre marked assessment instruments

SQA will ensure that robust quality assurance arrangements are in place for the assessment of underpinning knowledge.

Realistic working environments for simulated practical activities

SQA are required to ensure that approved centres have appropriately realistic working environments for simulated assessment activities. SQA does not wish to be fully prescriptive regarding the requirements of such facilities as this may restrict the ability of some delivering centres to meet SQA approval requirements. However, the following requirements must be met:

- ◆ installation, testing, commissioning, service and maintenance and fault rectification activities shall be assessed using full size systems that replicate installations in a real working environment;

Workplace Assessed Unit Specification

Support notes (cont)

UNIT NUMBER: F8XL 04

UNIT TITLE: Install, Test, Commission and Handover Solar Photovoltaic Systems

- ◆ the use of mobile rigs and scaled models of system installations shall not be used for the assessment of installation, testing, commissioning, service and maintenance and fault rectification activities.

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

REFERENCES

- 1 For a fuller discussion on assessment issues, please refer to SQA's Guides to Assessment and Quality Assurance.
- 2 Procedures for special needs statements are set out in SQA's guide 'Guidance on Special Assessment Arrangements'. (AA0645/3).
- 3 For details of other SQA publications, please consult SQA's publications list. (FD037).