SQA Advanced Unit Specification

General information for centres

Unit title: Renewable Energy Systems: Solar

Unit code: HV5M 48

Unit purpose: This unit has been designed to give candidates a technical overview of solar photovoltaic (PV) and thermal technologies and their application in real world energy systems. The nature of the solar resource as an energy input will be discussed and the implications for conversion efficiency introduced. Practical factors such as shading leading to electrical miss-match, spectral response along with stability issues will be considered as part of PV installation design. Integration issues such as battery storage sizing, inverters, charge controllers and maximum power point tracking shall be considered in the design principles for solar PV systems. For solar thermal installations where thermal storage is a factor, consideration will be given to buffer vessel sizing and integration with existing 'wet' hot water installations such as heat pumps or traditional oil-fired boilers.

On completion of the unit the candidate will be able to:

1 explain the nature of the solar resource
2 explain photovoltaic effect and different PV technologies
3 apply design principles to sizing and specifying a basic solar installation
4 evaluate and predict the performance of PV systems
5 evaluate and predict the performance of solar hot water systems

Credit points and level: 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**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 National 1 to Doctorates.*

Recommended prior knowledge and skills: Entry to this unit is at the discretion of the centre however it is recommended that candidates have a knowledge and understanding of energy and energy systems. This may be evidenced by possession of the SQA Advanced Unit HV48 47 *Renewable Energy Systems: Overview of Energy Use*.

Core skills: There are opportunities to develop the following core skill and core skill components in this unit, although there is no automatic certification of core skill or core skills components:

- Problem Solving SCQF level 6
- Communication SCQF level 6
- Information Technology SCQF level 6
- Numeracy SCQF level 6

Context for delivery: This unit has been developed as one of a series of dedicated renewable energy units that together comprise a specialist thread within the SQA Advanced Diploma in Engineering Systems framework. If this unit is delivered as part of another group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

Assessment: The assessment strategy for this unit is as follows:

The assessment for Outcomes 1 and 2 should be combined in the form of an assessment paper which should be taken at a single assessment event lasting one and half hours. This assessment should be carried out under controlled, supervised conditions.

The assessment for Outcomes 3 and 4 should be combined in the form of an investigation with candidate evidence being provided in the form of a report of 1,400–1,600 words in length plus diagrams and appendices.

The assessment for Outcome 5 should be in the form of an investigation with candidate evidence being provided in the form of a report of 1,400–1,600 words in length plus diagrams and appendices.
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SQA Advanced Unit Specification: statement of standards

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The sections of the unit stating the outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Explain the nature of the solar resource

Knowledge and/or skills

- Daily and seasonal variations in sunlight
- Variable light resource effects on system performance
- Effects of shading on PV installations and electrical miss-match

Outcome 2

Explain photovoltaic effect and different PV technologies

Knowledge and/or skills

- Principles of P-N junctions and photovoltaic effect
- Performance of different PV technologies
- Temperature effect on PV performance
- Spectral performance of different PV technologies (grey light vs. clear sun)
- Environmental issues
- Open circuit voltage/ short circuit current/ maximum power points

Evidence requirements

All knowledge and/or skills items in Outcomes 1 and 2 should be assessed.

A candidate’s response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

Outcome 1

- explain the daily and seasonal variations in sunlight
- explain the effect of variable light resource on system performance:
  — the effect of light intensity on current output
  — the effect of spectral content on voltage
- explain the effect of shading on PV installations electrical miss-match
- explain the concept of ‘air mass’

Outcome 2

- Explain the principles of P-N junctions and photovoltaic effect
- Describe the performance of different PV technologies
- Explain the effect of temperature on PV performance
- Explain the spectral performance of different PV technologies (grey light vs. clear sun)
- Describe the environmental issues associated with PV technologies
- Explain open circuit voltage/ short circuit current/ maximum power points

The assessment for Outcomes 1 and 2 should be combined in the form of an assessment paper which should be taken at a single assessment event lasting one and half hours. Assessment should be carried out under controlled, supervised conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and extended response questions.

Outcome 3

Apply design principles to sizing and specifying a basic solar installation

Knowledge and/or skills

- Annual solar resource available on a collection surface
- Output of an electric or thermal solar installation
- Calculation of solar module configurations

Outcome 4

Evaluate and predict the performance of PV systems

Knowledge and/or skills

- Performance limiting factors associated with a solar installation
- Suitability of different PV technologies for a given application
- Power output of fixed and alignable PV structures for different latitudes
- Integration methods and performance – maximum power point tracking

Evidence requirements

All knowledge and/or skills items in Outcomes 3 and 4 should be assessed.

A candidate’s response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

Outcome 3

- determine the annual solar resource available on a collection surface
- calculate the output of an electric or thermal solar installation of a given area
- calculate the solar module configurations, in series and parallel, required to integrate the system

Outcome 4

- describe the performance limiting factors associated with a solar installation
- compare the suitability of different PV technologies for a given application
- compare the power output of fixed and alignable PV structures for different latitudes
- compare integration methods and performance — maximum power point tracking

The assessment for Outcomes 3 and 4 should be combined in the form of an investigation with candidate evidence being provided in the form of a report of 1,400–1,600 words plus diagrams and appendices. The report should include any necessary calculations and include evidence of analysis and evaluation. Candidates should prepare their reports in their own time. Centres should make every reasonable effort to ensure the report is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

Candidates should have access to course notes, relevant textbooks, papers, reports and the internet while completing this report.

Assessment guidelines

Centres may wish to issue candidates with suitable guidance notes giving advice on the best way to structure their reports.

Outcome 5

Evaluate and predict the performance of solar hot water systems

Knowledge and/or skills

- Basic principles of solar hot water systems
- Performance limiting factors associated with a solar thermal installation
- Suitability of different solar hot water technologies for a given application
- Storage and buffer vessel, phase change materials, heat exchangers

Evidence requirements

All knowledge and/or skills items in this outcome should be assessed.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

- explain the basic principles of solar hot water systems
- describe the performance limiting factors associated with a solar thermal installation
- evaluate the suitability of different solar hot water technologies for a given application
- evaluate the use of storage and buffer vessel, phase change materials, heat exchanges for a given application

The assessment for Outcome 5 should take the form of an investigation. Candidate evidence should be in the form of a report of between 1,400 and 1,600 words plus diagrams and appendices. The report should include any necessary calculations and include evidence of analysis and evaluation. The report should be prepared in the candidate's own time. Centres should make every reasonable effort to ensure the report is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

Candidates should have access to course notes, relevant textbooks, papers, reports and the internet while completing this report.

Assessment guidelines

Centres may wish to issue candidates with suitable guidance notes giving advice on the best way to structure their reports.

Administrative information

Unit code:	HV5M 48
Unit title:	Renewable Energy Systems: Solar
Superclass category:	XH
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History of changes:

Version	Description of change	Date

Source: SQA

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For further information, please call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

SQA Advanced Unit Specification: support notes

Unit title: Renewable Energy Systems: Solar

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

This unit has been written as one of the 10 renewable energy units within the SQA Advanced Diploma in Engineering Systems. These are:

- Renewable Energy Systems: Overview of Energy Use (2 credits, SCQF level 7)
- Renewable Energy Systems: Technology (2 credits, SCQF level 8)
- Renewable Energy Store: Hydrogen (1 credit, SCQF level 8)
- Renewable Energy Systems: Wind Power (1 credit, SCQF level 8)
- Renewable Energy Systems: Wave and Tidal Energy (1 credit, SCQF level 8)
- Renewable Energy Systems: Biomass (1 credit, SCQF level 8)
- Renewable Energy Systems: Geothermal Energy (1 credit, SCQF level 8)
- Renewable Energy Systems: Hydroelectricity (1 credit, SCQF level 8)
- Renewable Energy Systems: Microgeneration Systems (1 credit, SCQF level 7)

This solar power unit covers both solar thermal and solar PV technologies from an engineering perspective. Candidates should examine the variable nature of solar power as a renewable energy resource and be aware of the empirical methods and uncertainties for calculating the solar resource but will not be expected to replicate any calculations. Lecturers should, at an early stage in the delivery of the unit, provide examples of where to obtain solar resource data for evaluating solar performance prediction, eg UK Meteorological Office. Through the remainder of the unit candidates will only be expected to work with annual average global horizontal solar radiation figures and will only need to consider latitude and tilt angles of PV arrays.

Candidates should be introduced to the two principal types of solar technology, thermal and electric, as well as hybrid solar systems, illustrated with examples of the technology breeds within them:

Solar PV:

- Mono-crystalline silicon PV
- Poly crystalline silicon PV
- Thin film amorphous silicon PV
- Cadmium Telluride PV
- Double and Triple Junction PV

Solar thermal:

- Flat plate collectors
- Evacuated tube collectors

Hybrid solar systems

- Solar thermal furnace
- Solar chimney
- Solar PV concentrators and parabolic reflectors
- Hybrid solar thermal-electric
- Photoelectrolysis — hydrogen
- Flexible organic solar cells
- Building integrated solar systems
- Solar cooling

Consideration should be given to the techno-economic reasons for choosing different technology breeds within the application types taking account of:

- cost/performance: cost per installed capacity, cost per square metre, generation per square metre, cost per kWh
- climatic and practical considerations of technology suitability for end use
- environmental considerations: energy intensity of manufacture, energy payback periods, chemical processes in manufacture

Guidance on the delivery and assessment of this unit

This unit may be delivered by a combination of lecturing, group work, investigation (including the use of the internet) and case studies. The internet contains a rich and varied range of materials relating to solar energy. The use of case studies can be a particularly powerful tool in illustrating the applications of solar energy.

Opportunities for developing core skills

All elements of the core skill of Problem Solving, that is, critical thinking, planning, organising, reviewing and evaluating, will be naturally developed and enhanced as candidates undertake the Investigation for Outcomes 3, 4 and 5. A complex range of factors which may improve or limit the performance of solar energy systems is analysed as candidates seek solutions to theoretical and practical problems. They have to determine source, calculate output and configuration examine the variables including system costs, construction and operation before comparing the suitability of different PV technologies for a given application. They must analyse, valuate and predict the performance of solar hot water systems.

Access to and evaluation of complex technical information, using paper based and internet sources, will support knowledge and develop key skills in communication and information technology. Advice could be provided on efficient systems of recording, coding and storing information, using technology to manage the practical aspects of the investigative reports. Candidates should also be provided with guidance on report format, style and structure. They should be advised that technical accuracy of complex ideas and information should be supported by clearly annotated drawings and diagrams. Resources available could include appropriate software packages to support accuracy and the effective presentation of written and graphic information. Formative work will provide many opportunities for candidates to discuss, review and compare different types of schemes, enhancing skills in oral communication of complex information.

A series of complex calculations and measurements underpins the competencies assessed in the unit. Numeracy skills will be naturally enhanced, with the focus on the practical interpretation, application and presentation of complex numerical and graphical data. Formative practical activities should be designed to develop accuracy, flexibility and confidence in handling concepts in the context of renewable energy.

Open learning

This Unit may be delivered by distance learning, which would require some degree of on-line delivery and/or support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence.

Arrangements would be required to be put in place to ensure that the combined assessment paper for Outcomes 1 and 2 is done under controlled, supervised conditions.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Renewable Energy Systems: Solar

This solar power unit covers both solar thermal and solar PV technologies from an engineering perspective. The emphasis in the unit is on the design of solar systems for practical applications.

You will study the nature of the solar resource as the raw power input into solar systems, and the solar technologies that can convert this raw power into useful energy. You will learn about conversion efficiencies and the factors that effect real world performance. You will learn how to design basic solar systems, including integration issues such as how to connect solar panels together to form an array, storage issues, inverters and maximum power point tracking and you will also learn how to predict the performance of the systems from given data.

The centre where you study this unit is likely to place an emphasis on practical experimentation. For example, under laboratory conditions you may compare the performance of different PV technologies under artificial lighting conditions and then compare the results obtained under these conditions with performance from real world PV installations under natural lighting conditions.

You will be introduced to the detailed mathematical ‘first principles’ that underlie solar performance prediction and design, although you will not be expected to replicate them. You will be encouraged to use software simulation tools for the design and optimisation of solar arrays.

Formal assessment in this unit will comprise of an assessment paper covering Outcomes 1 and 2, one investigative assignment covering the work in Outcomes 3 and 4 and an investigative assignment covering Outcome 5. The assessment paper will be taken at a single assessment event lasting one and half hours and will be conducted under controlled, supervised conditions. Assessment evidence for Outcomes 3 and 4 combined and 5 will take the form of reports.