SQA Advanced Unit Specification: general information for centres

Unit title: Energy: Nuclear Power and the Environment

Unit code: HV5W 48

Superclass: XK

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Unit purpose

This unit has been designed to develop candidates' knowledge and understanding of nuclear power generation and how it effects our present and future environment. This unit is part of a suite of SQA Advanced Units dedicated towards energy issues and in particular renewable energy solutions. Candidates will have opportunities to gain a knowledge and understanding of the principles of nuclear reaction/fission and how this energy is harnessed to generate electricity for the national grid. The financial aspects of nuclear generation and the environmental effects of nuclear energy on the environment will also be studied.

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

1 describe the nuclear fission energy process and associated hazards
2 explain the processes and systems of a nuclear power plant
3 analyse and evaluate the role of nuclear energy on future electrical power generation systems

Recommended prior knowledge and skills

It is recommended that candidates have a knowledge and understanding of energy and engineering systems. This may be evidenced by possession of the SQA Advanced Unit: *Renewable Energy Systems: Overview of Energy Use* or the SQA Advanced Unit: *Renewable Energy Systems: Technology*.

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.*

Core skills

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

Written Communication	SCQF level 6
Reading Communication	SCQF level 6
Critical Thinking	SCQF level 6
Planning and Organisation	SCQF level 6
Review and Evaluation	SCQF level 6

Context for delivery

This unit has been developed for the SQA Advanced Diploma in Engineering Systems. 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:

Outcome 1 — should be assessed by candidates sitting an assessment paper at a single assessment event lasting 30 minutes.

Outcome 2 — should be assessed by candidates sitting an assessment paper at a single assessment event lasting one hour. Both papers should be sat under controlled, supervised, closed-book conditions.

Outcome 3 — should be assessed by candidates undertaking an investigation into the role of nuclear energy in current and future energy production and preparing a report on their findings. The report should be 2,000 words plus diagrams and appendices. The report should be prepared in the candidate's own time.

SQA Advanced Unit Specification: statement of standards

Unit title: Energy: Nuclear Power and the Environment

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

Describe the nuclear fission energy process and associated hazards.

Knowledge and/or skills

- Radioactivity, natural processes — alpha, beta and gamma
- Fission of materials, induced mass
- Ionisation/radiation
- Units of radiation
- Safe levels of radiation
- Contamination
- Half-life
- Critical mass
- Harnessing nuclear energy
- Materials used to attenuate gamma radiation
- Materials used to control the fission process — neutron absorbers

Evidence requirements

All knowledge and/or skills items in Outcome 1 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:

- state what is meant by radioactivity — fission of materials
- explain what is meant by ionisation/radiation
- state the units of radiation
- state basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation
- explain what is meant by the term half-life
- explain what is meant by the term critical mass
- explain approaches to harnessing nuclear energy
- state materials used to attenuate gamma radiation
- state materials used to control the fission process — neutron absorbers

The assessment for Outcome 1 should be in the form of an assessment paper. This assessment paper should be taken at a single assessment event, lasting 30 minutes and 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 may consist of short answer and restricted response questions. For example, the assessment paper could comprise of 15 multi-choice questions.

Outcome 2

Explain the processes and systems of a nuclear power plant.

Knowledge and/or skills

- Reactor types — advanced gas reactors (AGR), light water and boiling water reactors (PWR)
- Control rods and fluids
- Nuclear system layouts and components — primary, secondary and tertiary loops
- Steam generation/heat exchangers/cooling systems
- Steam turbines
- Electrical generators
- Reactor safety features

Evidence requirements

All knowledge and/or skills items in Outcome 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:

- describe the following reactor types — light water and boiling water reactors
- explain the function of control rods
- sketch nuclear system layouts and components — primary and secondary loops
- explain the function of steam generation/heat exchangers in a nuclear power plant
- describe steam turbines used in nuclear power stations
- describe electrical generators used in nuclear power plants
- state four reactor safety features

The assessment for Outcome 2 should be in the form of an assessment paper. This assessment paper should be taken at a single assessment event, lasting 1 hour and 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 may consist of short answer and restricted response questions. For example, the assessment paper could comprise of 30 multi-choice questions.

Outcome 3

Analyse and evaluate the role of nuclear energy on future electrical power generation systems.

Knowledge and/or skills

- Level of carbon emissions and effect on greenhouse gases
- Effects of other emissions, sulphur dioxide (SO_2) and nitrogen oxide (NO_x)
- Unit costs of nuclear power compared to oil and coal power generation
- Plant construction, running and decommissioning environmental issues and costs
- Reliability of nuclear power generation compared to wind or solar power generation
- Nuclear waste processing
- Safety in nuclear power stations
- Nuclear accidents and terrorism
- Environmental impact over reactor lifetime

Evidence requirements

All knowledge and/or skills items in Outcome 3 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:

- describes levels of carbon emissions and effects on global warming
- compare unit costs of electricity generation of nuclear power with oil, coal and wind power
- describe plant construction, running and decommissioning environmental issues and costs
- describe nuclear waste processing and storing
- explain safety in nuclear power stations
- describe the consequences of nuclear accidents and terrorism
- explain environmental impact over reactor lifetime

Evidence for this outcome should be gathered by the candidate preparing a report which covers the knowledge and skills items for the outcome. 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. The report should not be less than 2,000 words long plus diagrams and appendices.

The report should demonstrate the candidate's ability to analyse economic, safety and environmental issues at a national level as well as issues emanating from specific power plants from around the world. It should include a comparison of the size and scale of nuclear power plant in the UK with at least two other countries, one of which must be a European country. Candidates should form an opinion on the future of nuclear power in the UK as well as its benefits or otherwise for emerging economies.

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

Assessment guidelines

The report may include the following headings:

- Introduction
- Nuclear power and the environment
- Nuclear power and safety
- Economic considerations of nuclear power, including issues of 'power on demand'
- Decommissioning of nuclear power plants
- Nuclear materials — waste disposal
- Analysis
- Evaluations
- Conclusion on the need for nuclear power in the UK
- Personal perspective on nuclear power

Candidates must be encouraged to use appropriate software to produce the report and to prepare diagrams and drawings. Handwritten submissions should be discouraged. It may be necessary to provide some assistance with formatting and the selection of an appropriate style, and the candidate should be encouraged to include a title page and contents list to the document.

The candidate should be introduced to the concept of formal report writing and the necessity of logical development and clarity.

The difference between plagiarism and referencing the work of others should be made clear and a standard method of referencing should be specified. As the assignment may include some research, it is important that candidates have access to the appropriate resources. It should be made clear that only credible internet sites should be referred to (and referenced).

SQA Advanced Unit Specification: support notes

Unit title: Energy: Nuclear Power and the Environment

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 forms part of a specialist optional section in the SQA Advanced Diploma in Engineering Systems. It is one of a number of units that have been produced on energy systems.

Other units included are all based on renewable energy systems:

- Renewable Energy Systems: Overview of Energy Use (2, 8)
- Renewable Energy Systems: Technology (2, 8)
- Renewable Energy Systems: Wind Power (1, 8)
- Renewable Energy Systems: Wave and Tidal (1, 8)
- Renewable Energy Systems: Solar Power (1, 8)
- Renewable Energy Systems: Bioenergy (1, 8)
- Renewable Energy Systems: Hydroelectricity (1, 8)
- Geothermal Energy (1, 8)
- Renewable Energy Systems: Hydrogen (1, 8)

The figures in brackets indicate the SQA Credit value and SCQF level of the unit respectively. To present a balanced perspective on future energy generation a unit has also been produced on nuclear energy entitled: *Nuclear Power and the Environment* (1, 8).

In designing this unit, the unit writers have identified the range of topics expected to be covered by lecturers. The writers have also given recommendations as to how much time should be spent on each outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the outcomes. While it is not mandatory for centres to use this list of topics it is strongly recommended that they do so to ensure continuity of teaching and learning.

A list of topics is shown on this and the following page.

Outcome 1 — Describe the nuclear fission energy process and associated hazards. (8 hours)

To give candidates the opportunity to learn and understand the science principles of this technology (natural and induced radioactivity, radioactive hazards to people, basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation), an overview/simulation of a nuclear power station could be introduced in the first instance. Materials could include UO_2, steels, graphite (AGRs), water (PWRs), concrete, boron, etc.

This would allow the necessary principles to be taught in the context of nuclear power.

Outcome 2 — Explain the processes and systems of a nuclear power plant. (12 hours)

This outcome should easily follow on from Outcome 1 where the principles are now applied to an engineering system, ie a nuclear power station. There are some nuclear power simulations available on the internet which could enhance the learning process. Introducing of a convention power station could gain an understanding of easier technologies and then transferring that knowledge to identify the similarities of nuclear power generation, ie:

Heat – water – boiler – steam – turbine – generator
Heat – primary water – secondary water – steam generator – steam – turbine – generator
Advanced Gas and Pressurised Water Reactors should be considered
Primary loop: Reactor core/casing, circulating pumps, water/gas medium and input to steam generator
Secondary loop: steam generator, steam pipe, steam turbine and condenser
Tertiary loop: cooling systems, eg river/loch/tower/sea

Outcome 3 — Analyse and evaluate the role of nuclear energy on future electrical power generation systems. (20 hours)

This outcome will involve a great deal of investigation/research and is the main component of assessment since it involves the candidates in the analysis and evaluation of data/ information. Candidates will be expected to draw conclusions which are based on facts but they will also be given the opportunity to write part of the report based on their own views of this contentious technology.

The nature of this assessment will involve the students working on their own, it maybe therefore prudent to set milestones for review where assessors can monitor the candidate's accuracy and progress and provide feedback on a regular basis before final submission of the report.

Guidance on the delivery and assessment of this unit

It is important that emphasis throughout the unit is placed on an integrated approach to generating energy.

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 nuclear power. The use of case studies can be a particularly powerful tool in illustrating the applications of nuclear power.

Industrial visits may prove useful in allowing candidates to observe the working environment within nuclear power stations. This may prove difficult for some centres to carry out but video or simulation materials could prove useful in enhancing learning.

Candidates will have opportunities to develop their investigation and research skills in Outcome 3 by analysing a range of data and evaluating issues relevant to nuclear energy. Candidates will be able to form conclusions based on the evidence they have obtained and also give a more personal reflective view point on nuclear energy.

Candidates will have opportunities to develop reading communication skills while reading materials on nuclear energy and its effects on the environment from both paper-based and electronic sources. Lecturers may choose to ask candidates questions on the materials they have read to check understanding. Candidates may develop their written communication skills through the preparation of the report for Outcome 3.

Critical thinking skills may be developed throughout the unit but, in particular, in Outcome 3 when candidates evaluate current and future applications of nuclear energy. Planning and Organisation skills may be developed while candidates are planning their reports (eg thinking of the best way to structure the materials in the report) and review and evaluation skills may be developed while candidates are evaluating the benefits and drawbacks of introducing nuclear power plants.

Details on the approaches to assessment are given under evidence requirements and assessment guidelines under each of the outcomes in the SQA Advanced Unit Specification: statement of standards section. It is recommended that these sections are read carefully before proceeding with assessment of candidates. It is strongly recommended that candidates are provided with clear details about assessment at the beginning of the unit (eg dates and times of assessment papers, date of submission of written report, etc).

Opportunities for developing core skills

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

Written Communication	SCQF level 6
Reading Communication	SCQF level 6
Critical Thinking	SCQF level 6
Planning and Organisation	SCQF level 6
Review and Evaluation	SCQF level 6

Open learning

The delivery of this unit will normally require a high level of lecturer/candidate interaction and support for Outcomes 1 and 2. Outcome 3 is much more candidate centred where a candidate will carry out his/her own investigations and from the information gathered write up a report. Thus, it may be possible to deliver Outcome 3 by open or distance learning but it is not recommended to deliver Outcomes 1 and 2 by such delivery modes.

Where open learning is considered due regard 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 assessment papers for Outcomes 1 and 2 are done under controlled, supervised conditions.

E-learning materials could be used to deliver the teaching content of this unit.

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.

History of changes to unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

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.

General information for candidates

Unit title: Energy: Nuclear Power and the Environment

This unit is about developing knowledge and understanding of nuclear power generation and how it affects our present and future environment.

It is recommended that candidates have a knowledge and understanding of energy and engineering systems. This may be evidenced by possession of the SQA Advanced Unit: *Renewable Energy Systems: Overview of Energy Use* or the SQA Advanced Unit: *Renewable Energy Systems: Technology*.

You will gain knowledge and understanding of the following:

Nuclear fission energy process and associated hazards:

- radioactivity, natural processes-alpha, beta and gamma
- fission of materials, induced mass
- ionisation/radiation
- units of radiation
- safe levels of radiation
- contamination
- half-life
- critical mass
- harnessing nuclear energy
- materials used to attenuate gamma radiation
- materials used to control the fission process — neutron absorbers

The assessment for Outcome 1 should be in the form of an assessment paper. This assessment paper should be taken at a single assessment event, lasting 30 minutes and carried out under controlled, supervised conditions. Assessment should be conducted under closed-book conditions and as such you should not be allowed to bring any textbooks, handouts or notes to the assessment.

Processes and systems of a nuclear power plant:

- reactor types — advanced gas reactors (AGR), light water and boiling water reactors (PWR)
- control rods and fluids
- nuclear system layouts and components — primary, secondary and tertiary loops
- steam generation/heat exchangers/cooling systems
- steam turbines
- electrical generators
- reactor safety features

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

Analysis and evaluation of the role of nuclear energy on future electrical power generation systems:

- level of carbon emissions and effect on greenhouse gases
- effects of other emissions, sulphur dioxide (SO2) and nitrogen (NOx)
- unit costs of nuclear power compared to oil and coal power generation
- plant construction, running and decommissioning environmental issues and costs
- reliability of nuclear power generation compared to wind or solar power generation
- nuclear waste processing
- safety in nuclear power stations
- nuclear accidents and terrorism
- environmental impact over lifetime

Evidence for this outcome should be gathered by you preparing a report which covers the knowledge and skills items for the outcome. The report should be prepared in your own time. Centres should make every reasonable effort to ensure the report is your 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 your knowledge and understanding. The report should not be less than 2,000 words long plus diagrams and appendices.

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