



National Unit specification: general information

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

Unit code: FF43 12

Superclass: QB

Publication date: September 2011

Source: Scottish Qualifications Authority

Version: 02

Summary

This Unit has been designed to provide candidates with a general knowledge and understanding of sustainable and non-sustainable electrical power generation, energy use in the home and sustainable methods of transport. In addition the candidate will be able to obtain, organise and use factual and theoretical information to solve energy problems. The candidate will also identify the technical and environmental challenges to achieve energy sustainability while evaluating and suggesting potential solutions.

The Unit is freestanding but may be used as an optional Unit within the National Certificate in Applied Science (SCQF level 6).

Outcomes

- 1 Describe and investigate non-sustainable and sustainable systems for generating electrical power.
- 2 Investigate and evaluate energy consumption and efficiency in a domestic environment.
- 3 Describe and compare sustainable vehicle transportation systems.
- 4 Identify the challenges to achieve energy sustainability and evaluate the potential solutions.

Recommended entry

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- ◆ Standard Grade at Credit level in a Science subject
- ◆ Intermediate 2 in a Science subject
- ◆ National 5 in a Science subject

National Unit specification: general information (cont)

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

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

Achievement of this Unit gives automatic certification of the following Core Skills component:

- ◆ Critical Thinking at SCQF level 6
- ◆ Using Number at SCQF level 5

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

National Unit specification: statement of standards

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

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 and investigate non-sustainable and sustainable systems for generating electrical power.

Performance Criteria

- (a) Describe the main features of nuclear and coal electrical power generating systems.
- (b) Calculate the theoretical amount of heat capable of being generated by both coal and nuclear fuels.
- (c) Describe the main features of wind and solar photovoltaic (PV) electrical power generating systems.
- (d) Calculate the amount of electrical energy being generated by given wind and solar PV systems and find the overall system efficiencies.
- (e) Identify the main advantages and disadvantages of electrical power generation using sustainable and non-sustainable systems and draw conclusions.

Outcome 2

Investigate and evaluate energy consumption and efficiency in a domestic environment.

Performance Criteria

- (a) Calculate the energy consumption and energy efficiency of a domestic appliance.
- (b) Compare the energy efficiency of appliances which perform the same task from manufacturer's specifications.
- (c) Compare the cost effectiveness of two different types of domestic heating systems.
- (d) Identify and evaluate insulation methods of reducing the energy used in heating the home.

Outcome 3

Describe and compare sustainable vehicle transportation systems.

Performance Criteria

- (a) Describe biofuel, battery and hydrogen methods of vehicle propulsion.
- (b) Compare the sustainability of the energy or fuel used in battery, hydrogen and biofuel vehicles.

National Unit specification: statement of standards (cont)

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

Outcome 4

Identify the challenges to achieve energy sustainability and evaluate the potential solutions.

Performance Criteria

- (a) Identify and describe the main technical and environmental energy sustainability challenges relating to power generation, domestic use and transportation.
- (b) Evaluate potential solutions to meet these challenges.

Evidence Requirements for this Unit

Evidence is required to demonstrate the candidates have achieved all the 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. Candidates must produce written and or oral evidence on their own, in their own words, at appropriate points throughout the Unit.

As most of the work of this Unit may be project based and the candidate will carry out research for the Outcomes the evidence will be built up as the Unit progresses and a folio will be produced including reports and worksheets. This folio will be used as the evidence and no closed-book assessment will be required.

The Assessment Support Pack for this Unit provides sample assessment material. Centres wishing to develop their own assessments should refer to the Assessment Support Pack to ensure a comparable standard.

For gathering evidence for the individual Outcomes the guidelines below should be followed.

Outcome 1

- (a) Candidates must correctly describe with the aid of a diagram and explanation, the main features of a coal electrical power generating system including the fuel source, details of the combustion process, the reactor, method of heat transfer, turbines, transformers, the grid and possible methods of reducing emissions. Candidates must also describe with the aid of a diagram and explanation the main features of a nuclear reactor including the fuel, the fission process, moderator and coolant.
- (b) Candidates must correctly calculate the amount of heat capable of being generated by the fuel in the two systems chosen.
- (c) Candidates must correctly describe, with the aid of diagrams, the main features of wind and solar PV methods of generating electrical energy including the principle behind the method, the siting of the equipment, amount of energy capable of being generated and the factors affecting efficiency.
- (d) Candidates must calculate correctly the amount of electrical energy capable of being generated by a wind turbine given the wind velocity, rotor blade diameter and turbine efficiency. Candidates must calculate the number of solar panels required to produce the average energy use of a typical household and estimate possible costs.

National Unit specification: statement of standards (cont)

Unit title: Sustainable Energy: Power Generation and Use (SCQF level 6)

- (e) Candidates must produce a short report or table, listing the potential advantages and disadvantages of generating power from sustainable and non-sustainable resources, summarising their research of the relevant facts and giving a reasoned conclusion. A checklist should be used to show that all relevant points have been given.

Outcome 2

- (a) Candidates must correctly calculate the energy consumption and efficiency of one domestic appliance in the correct units.
- (b) Candidates must produce written and/or oral evidence or use a worksheet to show a comparison of the energy efficiency of two appliances which perform a similar task using manufacturer's specifications.
- (c) Candidates must produce written and/or oral evidence or use a worksheet to compare the cost effectiveness of two different types of domestic heating systems, using manufacturer's information to estimate costs.
- (d) Candidates must produce written and/or oral evidence or use a worksheet to identify and evaluate methods of reducing the energy used in heating the home.

Outcome 3

- (a) Candidates must produce diagrams or oral evidence with a brief description of each of the following three methods of vehicle propulsion: biofuel, battery and hydrogen.
- (b) Candidates must produce a table or short report to compare the energy or fuel used in battery, hydrogen and biofuel vehicles. The table or report should include the following: effect on the environment — land use, emissions, charging stations; technology — new developments and materials such as catalysts, availability and cost of vehicles and short and long term future.

Outcome 4

Candidates must produce a report of between 600–800 words to identify and describe the main technical and environmental sustainability challenges relating to power generation, domestic use and transportation and evaluate potential solutions to meet these challenges. The following headings can be used:

- ◆ Electricity Generation — the technical challenges
- ◆ Electricity Generation — the environmental challenges
- ◆ Evaluation of possible solutions

- ◆ Use of domestic power — the technical challenges
- ◆ Use of domestic power — the environmental challenges
- ◆ Evaluation of possible solutions

- ◆ Transportation — the technical challenges
- ◆ Transportation — the environmental challenges
- ◆ Evaluation of possible solutions

National Unit specification: support notes

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

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 is part of an exemplar course — Access to STEM - produced by STEM-ED Scotland as part of a SFC funded project titled *Building a New Educational Framework to Address the STEM Skills Gap*. This course has been designed specifically to engage interest, strengthen skills, deepen understanding of the main storylines of the sciences and to take an integrative approach to the sciences. Initially only two Units are being trialled in the SQA catalogue but it is hoped that the other Units will follow.

Outcome 1

Main features of non-sustainable systems:

- ◆ Fuel source — coal or nuclear
- ◆ combustion / fission process
- ◆ reactor
- ◆ method of heat transfer
- ◆ turbines
- ◆ transformers
- ◆ grid
- ◆ methods of reducing emissions / waste storage
- ◆ efficiency

For calculating possible heat generated:

Amount of heat generated coal

- ◆ calculations of heat generated using combustion data

Amount of heat generated by nuclear fuel

- ◆ *The fission process*
 - fissile material
 - critical mass
 - chain reaction
 - mass defect and binding energy
 - calculate energy produced
 - fission products

Sustainable energy sources — there is a lot of material available for wind and solar on the web and it is possible to carry out simple experiments on these two sources. They are probably also the two where the technology is most advanced.

National Unit specification: support notes (cont)

Unit title: Sustainable Energy: Power Generation and Use (SCQF level 6)

Wind energy — this can be done as a project looking at maps of the UK which show the average wind speeds, calculating the maximum energy that can be obtained from the blade size and the wind velocity, calculating the costs involved and estimating the limitations of the wind power i.e. when there is no wind and when there are strong winds.

Small wind power kits are available which are fan operated and experiments can be carried out to show the relationship between wind velocity and power generated for different sizes and different numbers of blades.

Solar PV energy — for photovoltaic power the following should be discussed — p-n conductors, silicon lattice, doping, the photovoltaic effect, band gaps, and efficiency, solar cell arrays, series and parallel. The advantages and disadvantages should be looked at and also possible future developments. Small solar cells can again be purchased quite cheaply and the properties investigated.

Outcome 2

Units of energy and power should be revised. Candidates could work in groups to investigate the amount of electricity needed to boil a certain amount of water in an electric kettle and then calculate how efficient this process was.

The energy efficiency of different types of light bulbs can be looked at and a comparison made between the older type of bulb, a fluorescent and a light emitting diode (LED), or the difference in energy consumption between a microwave and a conventional oven, a shower versus a bath, etc. Candidates should be aware of the estimations and assumptions made in the calculations.

Candidates, as part of a team, can investigate the cost of heating a typical house by a particular method and then the results can be compared.

The cost reduction by insulating the house by installing double glazing, cavity wall insulation plus floor and loft insulation can be calculated using the 'typical' house chosen above.

Outcome 3

- ◆ Biofuels can be used in combustion engines, small percentage in present fuels. Biodiesel comes from oil seed rape or waste oil and is obtained by transesterification with methanol. Bioethanol comes from sugar cane sugar beet or cereals and is obtained by treating the raw material with enzymes followed by yeast and then distillation. Advantage is that it is a sustainable form of fuel- it is carbon neutral apart from fertiliser use and distribution. Biofuels used in combustion engines. Land for food or biodiesel debate.
- ◆ Battery driven cars — different types of rechargeable batteries including lithium ion, how far they can go before recharging and problems with recharging (time and lack of points). These cars have fewer moving parts and there is no combustion engine, just the battery and electric motor. No emissions, but use electricity to charge and this may come from a non-sustainable supply.

National Unit specification: support notes (cont)

Unit title: Sustainable Energy: Power Generation and Use (SCQF level 6)

- ◆ Hydrogen cars — the hydrogen fuel cell and how it works including the polymer exchange membrane, catalyst and platinum nanoparticles, list the advantages such as cheap starting materials, no emissions and silent running but expensive to produce and heavy. Hydrogen can come from water or from natural gas but this may defeat the object. There is also a storage problem. Cars may also run by using liquid hydrogen as a fuel in a combustion engine. For assessment purposes either can be described.
- ◆ Electricity for battery charging and electrolysis should come from a sustainable source such as PC or wind turbines at night when domestic/industrial consumption is less.

Outcome 4

Technical and environmental sustainability challenges with possible solutions relating to:

Power generation — bulk of our power generation is non-sustainable, sources are finite and running out. Alternative methods will have to be used. Power use reduction is also important. Solar, wind, wave and tidal technologies require to be further developed and this will be costly. A lot of resources are not close to centres of population and this will require modifications to the grid.

Domestic use of power — here the emphasis will be on using less power with more efficient gadgets such as energy efficient light bulbs, efficient condensing boilers etc, houses should also be better insulated and solar panels may be fitted (either water heating or solar PV). Energy consumption can also be reduced by turning down radiator thermostatic valves, boiling only the amount of water required etc.

Transportation — alternative fuels or methods of transportation will be needed as the oil runs out. Present fuels also cause global warming due to emissions. Fuel saving possible by using public transport, car sharing, walking more, using a smaller car etc. Biodiesel is meant to be carbon neutral and this is a future possibility. Battery and hydrogen cars have no emissions, but at present the technology is expensive and for battery driven cars there is the problem of limited range and power points being available.

Guidance on learning and teaching approaches for this Unit

It is recommended that this Unit is delivered using a student centred approach with the candidate being given the opportunity to find information for themselves with appropriate guidance. Lectures may be given to explain the more complex theoretical aspects of the Unit. Practical work will be carried out within the Unit.

The internet contains a rich source of materials on Energy Sustainability and candidates should be guided in its use.

This Unit should also be fully supported with relevant learning materials such as handouts in paper or electronic form, text books, on-line materials and relevant laboratory instruction. A visit to a suitable work site would also be beneficial.

National Unit specification: support notes (cont)

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

Guidance on approaches to assessment for this Unit

Candidates will keep a portfolio of their work as they progress through the Outcomes and this should be regularly checked by the tutor to ensure that it is of the required standard. The material should contain evidence for all the Performance Criteria of all the Outcomes. Evidence may take the form of completed worksheets, laboratory reports and written or oral presentations.

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)*.

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 *Problem Solving*, *ICT* and the 'Working Cooperatively with Others' component of *Working with Others*.

Problem Solving — if experimental work is carried out during delivery of the Unit the candidate may be expected to plan, organise and complete an experiment, then review and evaluate the results obtained. The 'Critical Thinking' component may be developed in Outcome 4 where the candidate has to identify the factors involved and assess their relevance in evaluating potential solutions to meet the environmental challenges.

ICT — the Accessing Information component of the ICT Core Skill should be developed as the candidate will be expected to access information from the web. The candidate may also cover Processing Information if software is used to produce reports or presentations.

Working with Others — the candidate may develop the 'Working Cooperatively with Others' component either when performing laboratory experiments as part of a team or when searching cooperatively for information on the internet.

The 'Using Number' element of **Numeracy** may be developed in Outcomes 1 and 2 where calculations are performed involving power and efficiency, nuclear fission and energy use. The 'Using Graphical Information' component may be developed if graphical data is interpreted and drawn as part of Outcome 1 or in experimental work.

National Unit specification: support notes (cont)

Unit title: Sustainable Energy: Power Generation and Use
(SCQF level 6)

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
02	Core Skills Components Critical Thinking at SCQF level 6 and Using Number at SCQF level 5 embedded.	29/09/2011

© Scottish Qualifications Authority 2011

This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.