SQA Advanced Unit Specification

General information for centres

Unit title: Renewable Energy Systems: Biomass

Unit code: HV5J 48

Unit purpose: This unit has been designed to give candidates a technical overview of biomass resources, biomass energy conversion technologies and their application in real world energy systems. The historical context of biomass as an energy source will be discussed. The linkages between biomass energy, solar energy, the carbon cycle, climate change, fossil fuels, wider environmental issues and socio-economics will also be discussed.

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

1 analyse the carbon cycle, biomass and climate change
2 explain the form and diverse nature of biomass resources
3 explain biomass fuel forms and conversion technologies
4 investigate the system configurations of biomass generation technologies

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: It is recommended that candidates have 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:

- Communication 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 optional section within 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:

The assessment for Outcomes 1 should be in the form of a single assessment paper, taken at a single assessment event lasting one hour and carried out under controlled, supervised, closed-book conditions.

The assessment for Outcomes 2 and 3 should be combined in the form of a single assessment paper, taken at a single assessment event lasting one and half hours and carried out under controlled, supervised, closed-book conditions.

The assessment for Outcomes 4 should be in the form of a single assessment paper, taken at a single assessment event lasting one and half hours and carried out under controlled, supervised, closed-book conditions.

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

Analyse the carbon cycle, biomass and climate change

Knowledge and/or skills

- Carbon cycle
- Storage of energy in plants
- Climate change
- Link between biomass and carbon sequestration

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 carbon cycle
- explain that all organic matter in the bio-sphere is a biomass resource
- explain how fossilised bio-matter (coal, oil and gas) has locked up carbon and has served to stabilise the global climate over millions of years, and now burning fossil fuels is causing global climate change
- explain the carbon neutral nature of biomass, and how carbon sequestration coupled with biomass generation can play a part in reversing the build up of atmospheric carbon dioxide
- explain the other pollutant emissions that can arise from biomass and energy from waste systems

The assessment for Outcome 1 should be in the form of a single assessment paper, 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 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 2

Explain the form and diverse nature of biomass resources

Knowledge and/or skills

- Biomass crops
- Organic waste
- Solid, liquid and gaseous fuels
- Environmental and socio-economic issues related to farming methods

Outcome 3

Explain biomass fuel forms and conversion technologies

Knowledge and/or skills

- Solid fuels
- Liquid bio-fuels
- Gaseous
- Calorific content
- Lower/higher heating values, moisture content

Evidence requirements

Evidence for the knowledge and/or skills items in Outcomes 2 and 3 should be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items shown under the knowledge and/or skills items. In any assessment of the outcomes **three out of four** knowledge and/or skills items should be sampled from Outcome 2 and **four out of five** knowledge and/or skills items should be sampled from Outcome 3.

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 2

- describe examples of wood as a fuel (eg logs, brush, forest residues, chips, pellets, charcoal)
- describe examples of dedicated biomass crops (eg grasses, straw, oil seeds etc)
- describe examples of organic wastes, farm residues (eg corn cobs, pea pods, cow manure kitchen waste, paper, cardboard, municipal solid waste, sewerage waste, used cooking oil, industrial food processing waste eg instant coffee, soft drinks, abattoir waste, fish processing)
- describe examples of other natural biomass energy sources — bacterial and algae by-products
- explain limitations of land availability for biomass crops and the wider environmental and socio-economic issues if intensive farming methods are employed such as fertilisers, pesticides and genetic engineering for biomass crop farming
- explain the importance of matching appropriate fuel selection for geographic location of biomass plant
- explain the positive environmental and socio-economic benefits that can be realised through careful implementation of sustainable biomass crop farming — habitat creation, eco-diversity, small farm (especially third-world farmers') competitiveness and increased rural income

Outcome 3

- explain how biomass crops and wood can be converted into useful (transportable) solid fuels such as logs, wood chips, pellets, charcoal, bails
- explain how biomass resources can be converted into liquid bio-fuels eg oil seed presses, pyrolysis, fermentation and distillation, estrification
- explain how biomass resources can be converted into gaseous fuels: pyrolysis, up/down draft gasifiers, anaerobic digestion
- explain the concept of calorific content of a biomass raw feedstock and processed bio-fuel by weight/volume and the implications for transporting and using the fuel
- explain the concept of lower and higher heating values, moisture content etc
- explain typical values of biomass calorific values and compares to fossil fuel equivalents

The assessment for Outcomes 2 and 3 should be in the form of a single assessment paper, taken at a single assessment event lasting one hour and half hours 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 should be composed of an appropriate balance of short-answer, restricted-response and extended-response questions.

Outcome 4

Investigate the system configurations of biomass generation technologies

Knowledge and/or skills

- Direct combustion technologies
- Bio-fuels for transport
- Integrated gasification/pyrolysis combined cycle systems, combined heat and power
- Energy from waste

Evidence requirements

Evidence for the knowledge and/or skills items in Outcome 4 should be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that he/she can answer correctly questions based on a sample of the items shown under the knowledge and/or skills items. In any assessment of the outcome **three out of four** knowledge and/or skills items should be sampled.

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, with the aid of diagrams, the principle system features of direct combustion technologies eg solid fuel/oil/gas stoves, boilers, incinerators and thermal power stations
- explain the principle considerations and performance changes when converting transport vehicles and generation plant to use bio-fuels eg bio-diesel and bio-ethanol fuels as substitutes for fossils fuels in reciprocating internal combustion engines, bio-gas in gas engines
- explain, with the aid of diagrams, the principle system features of integrated gasification/pyrolysis combined cycle systems, combined heat and power systems

- explain, with the aid of diagrams, how energy can be extracted from waste: land fill gas, anaerobic digestion, incineration

The assessment for Outcome 4 should be in the form of a single assessment paper, taken at a single event lasting one 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 should be composed of an appropriate balance of short-answer, restricted-response and extended-response questions.

Administrative information

Unit code: HV5J 48

Unit title: Renewable Energy Systems: Biomass

Superclass category: XK

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Version	Description of change	Date

Source: SQA

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.

SQA Advanced Unit Specification: support notes

Unit title: Renewable Energy Systems: Biomass

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: Solar (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)

Biomass fuels can be derived from any organic matter. Biomass fuels are chemical fuels and contain stored solar energy. The carbon cycle, climate change, sustainable agriculture and security of fuel supply are introduced as the context for biomass energy. Biomass fuel types and conversion technologies are introduced in this unit. The emphasis in the unit is on breadth of knowledge rather than detailed design. This is due to the wide variety of biomass fuels and conversion technologies available. The focus is on introducing the technologies at a systems level, and the decisions for choosing the right technology for the right application. Technology selection will be based on factors including biomass fuel types, installation location, volume and form of energy required.

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.

Outcome 1

Explain the carbon cycle, biomass, and climate change (6 hours)

To fully understand the significance of biomass fuels the candidate will first learn about the intimate relationship between biomass and the carbon cycle and where this fits with climate change. Candidates should first consider the carbon cycle and the storage of solar energy to present the scale and diversity of biomass resources. Within the context of the carbon cycle, candidates should be taught how, over geological timescales, natural carbon sequestration has fossilised organic material (chalk, limestones, coal, oil & gas) and stabilised global temperatures.

The more recent relationship between atmospheric carbon dioxide levels, global temperature and ice-ages should be presented using empirical evidence, highlighting the impact of the industrial revolution.

Outcome 2

Explain the form and diverse nature of biomass resources (7 hours)

Having learnt about the carbon cycle principles in Outcome 1, the candidate will learn what biomass resources are, where they come from, their differing forms, their relevance, their sustainability, how they can be harvested and transported. The raw biomass feedstock forms will be discussed building directly on the knowledge gained from Outcome 1, which highlights that any organic matter including waste may be considered a biomass resource. Candidates will realise that they are completely surrounded with potential biomass resources: lawn clippings, trees, kitchen waste, newspapers are easily identifiable resources. Other more specialised biomass crops and socio-economic considerations should be discussed; economics, yields per hectare and land availability, sustainability etc.

Outcome 3

Explain biomass fuel forms and conversion technologies (13 hours)

Through the knowledge gained in Outcome 2 the candidate will understand the wide variety of raw biomass feedstocks that can be converted into useful fuels. There are three basic fuel forms to be considered, solid, liquid and gaseous fuels. The technologies for converting the raw biomass feedstocks into useful fuel forms will be introduced in this section. The concepts of calorific values and moisture content and the implications for transport of, and energy generation from, bio-fuels will also be discussed such that the candidate will be able to differentiate between useful and non-useful forms for a particular application.

Assessment: for a given application the candidate should be able to describe the conversion technology for turning a raw feedstock into a useful fuel. A simple (illustrative) example of this could be a chainsaw is used to cut a tree into logs for an open fireplace — the candidate can describe wider considerations as well, the benefit of transporting the tree whole then cutting it up at its point of use vs. cutting up on site, transporting as logs and composting the waste residues.

Outcome 4

Describe the system configurations of biomass generation technologies (14 hours)

This section will consider the engineering principles for the design of biomass systems, and the differences to fossil fuel systems. The emphasis will be on systems level configurations of biomass conversion/generation technologies. The candidate will be taught how key system elements link together to form a biomass conversion/generation system. The emphasis will be on introducing the candidate to the wide diversity of biomass systems, highlighting the common elements and design/operational considerations.

The candidate will be assessed on their ability to describe with the aid of diagrams the system components and configuration of complete biomass/energy from waste system, which may include: feedstock/crops, transportation of raw feedstock, biomass processing/fuel conversion facility, transportation of processed bio-fuel (solid, liquid or gas), combustion/generation system (including the key system components) for extracting useful energy from the fuel, as well as any waste products (including possible uses of these waste products).

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.

Opportunities for developing core skills

Access to a wide range of background source materials will support knowledge and skills in formative work and develop key skills in reading and evaluating complex information. Materials accessed could also provide examples and models of the formal style, structure and terminology needed in extended written responses. Candidates should be advised that the presentation of complex ideas and information should be technically accurate and supported by clearly annotated diagrams. Formative work can provide opportunities for candidates to discuss, review and evaluate biomass energy conversion technologies and their application and impact in real world energy systems. This would encourage the development of oral communication skills in a practical context.

Open learning

This unit could 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 assessment papers for all outcomes are 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: Biomass

The use of biomass fuels (eg lawn clippings, trees, kitchen waste, newspapers) to generate heat and energy is not new but interest in it, along with other forms of renewable energy, has grown as concerns about global warming and climate change have increased.

In this unit you will learn about the relationships between the carbon cycle, biomass and climate change. You will also study the form and diverse nature of biomass resources and different forms of biomass fuel forms and conversion technologies. You will also learn about the engineering principles for the design of biomass systems, and the differences to fossil fuel systems.

The unit is likely to be delivered by a combination of lecturing, group work, investigation (including the use of the internet) and case studies.

Formal assessment in the unit is likely to take the following form:

Outcome 1 may be assessed by a single assessment paper, taken at a single assessment event lasting one hour.

Outcomes 2 and 3 may be assessed by a single assessment paper, taken at a single assessment event lasting one and half hours.

Outcomes 4 may be assessed by a single assessment paper, taken at a single assessment event lasting one and half hours.

All three assessments will be carried out under controlled, supervised, closed-book conditions.