Higher National Unit specification

General information for centres

Unit title: Biomass: Technologies for Energy and Bioproducts

Unit code: F21H 35

Unit purpose: The purpose of this Unit is to introduce the candidate to concepts of biomass availability and production, biomass structure and biomass utilisation. Physical, chemical and microbial conversion processes will each be studied to examine the extraction, processing and manufacturing technologies that are necessary for the production of natural products. These products will include biofuels such as bioethanol & biodiesel, biosolvents, essential oils & biolubricants.

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

1 Explain biomass sources for the production of energy and natural products.
2 Evaluate the processing of biomass for energy.
3 Explain the processing of biomass for fine chemicals and other bioproducts.
4 Discuss techniques for the recovery and purification of products from biotechnological processes.

Credit points and level: 1 HN 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 Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre. However, a prior knowledge of Chemistry and Physics at SCQF level 6 would be desirable but not essential. It would also be of benefit if candidates had completed the Unit:

F21J 34 *Chemistry and Physics for the Life Sciences* or equivalent units of study.

Core Skills: There are opportunities to develop the component 'written communication' of the Core Skill Communication, the component 'using numbers' of the Core Skill Numeracy and the component 'critical thinking' of the Core Skill Problem Solving, all at SCQF level 6 although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

General information for centres (cont)

Assessment: Extended and restricted response questions could be used for all Outcomes although the assessments for Outcomes 2 and 3 involves sampling and must therefore be closed book, unseen and conducted under supervised conditions. Report based submissions would be acceptable for Outcomes 1 and 4.

Higher National Unit specification: statement of standards

Unit title: Biomass: Technologies for Energy and Bioproducts

Unit code: F21H 35

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 biomass sources for the production of energy and natural products

Knowledge and/or Skills

- Biomass sources
- Chemical and physical properties
- Biomass supply chains
- Advantages and disadvantages of utilising different types of biomass
- Current UK targets and legislation

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- identify and explain three different sources of biomass used for the production of energy and natural products
- explain the chemical and physical properties of three types of biomass
- explain one supply chain for energy and one for natural products from two different biomass sources
- explain three advantages and three disadvantages of three different biomass types for their subsequent processing and end use
- explain the current UK targets and legislation for energy from biomass

Assessment Guidelines

Evidence for this Outcome could be generated through extended response questioning sufficient to generate all assessment evidence. A word count of 1,000 words or equivalent could act as a guideline if a report based format was preferred. Assessment could be either closed-book or open-book.

Higher National Unit specification: statement of standards (cont)

Unit title: Biomass: Technologies for Energy and Bioproducts

Outcome 2

Evaluate the processing of biomass for energy

Knowledge and/or Skills

- Energy end uses
- Transport fuels
- Conversion technologies
- Energy conversion efficiencies
- Life cycle analysis
- UK environmental accreditation and assurance

Evidence Requirements

Evidence for this Outcome will be generated via sampling. Four of the six Knowledge and/or Skills items must be sampled on each assessment occasion.

Candidates will need to provide evidence to demonstrate their knowledge and/or skills by showing that they understand the principles of processing biomass for the production of energy.

Where an item is sampled, a candidate's response will be judged to be satisfactory when the evidence provided shows that the candidate can:

- evaluate two types of energy end use from biomass
- evaluate the biomass processing involved in the production of two transport fuels
- explain one microbial, one biochemical, one physical and one chemical conversion technology
- compare two types of conversion technologies and their energy conversion efficiencies
- explain the significance of undertaking a life cycle analysis in relation to energy balance and greenhouse gas emissions
- describe one current UK system of environmental accreditation and assurance

The assessment should be unseen and conducted under closed book, supervised conditions and a different sample should be chosen on each assessment occasion to prevent candidates being able to predict what they will be asked.

Assessment Guidelines

Evidence for this Outcome could be generated through an extended and restricted response questioning requiring answers to be completed within a specified time frame.

Outcome 3

Explain the processing of biomass for fine chemicals and other bioproducts

Knowledge and/or Skills

- Fine chemicals
- Bioproducts

- Biomass processing for bioproducts
- Cell culture systems for fine chemical production
- Reactor design

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they understand the principles of processing biomass for the production of energy.

Evidence for this Outcome will be generated via sampling. Four of the five knowledge and skills items must be sampled on each assessment occasion.

Where an item is sampled, a candidate's response will be judged to be satisfactory when the evidence provided shows that the candidate can:

- identify and explain the type and nature of two fine chemicals
- identify and explain the nature of two bioproducts
- explain two biomass processing requirements for the manufacture of one selected bioproduct
- explain four potential problems posed by cell culture systems for fine chemical production
- explain how current and future reactor design can effect fine chemical production

The assessment should be unseen and conducted under closed-book, supervised conditions and a different sample should be chosen on each assessment occasion to prevent candidates being able to predict what they will be asked.

Assessment Guidelines

Evidence for this Outcome could be generated through extended/restricted response questioning requiring answers to be completed within a specified time frame.

Outcome 4

Discuss techniques for the recovery and purification of products from biotechnological processes

Knowledge and/or skills

- Product recovery technology
- Product separation, concentration and extraction
- Mechanisms of industrial scale purification

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- discuss four problems associated with product recovery and two subsequent necessary pretreatments
- explain the steps needed to separate and purify intracellular products
- explain the steps needed to separate and purify extracellular products

- explain two processes of product, separation, concentration and extraction on an industrial scale
- discuss how pilot scale systems may be enlarged and mechanised to industrial scale

Assessment guidelines

Evidence for this Outcome could be generated through an extended and restricted response questioning requiring answers to be completed within a specified time frame. A word count of 1,000 words or equivalent could act as a guideline if a report based format was preferred.

Administrative Information

Unit code: F21H 35

Unit title: Biomass: Technologies for Energy and Bioproducts

Superclass category: YC

Original date of publication: September 2007

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Biomass: Technologies for Energy and Bioproducts

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 included in the frameworks of the group awards HND Applied Bioscience, HND Agricultural Science and HND Green Technology. It is appropriate for any land-based, biological, biotechnology or environmental group award.

This Unit has been designed to provide students with a detailed introduction to the different types of biological materials that are available for the purpose of either producing energy/fuels or commercially useful products and fine chemicals. These products may be of use as fuels, chemical feedstocks or biologically active agents.

Petrol, diesel, liquefied petroleum gas and compressed natural gas are fossil fuels in finite supply. Combustion of these fuel sources cause emissions of carbon dioxide, sulphur dioxide and particulate pollutants. Biofuels offer an attractive alternative energy source since they ultimately originate from carbon dioxide which was fixed by cellular based systems. This results in a zero sum gain (not taking into account CO_2 produced during the processing of the biomass) since the carbon dioxide returns to the atmosphere when the fuel is utilised — hence the term carbon neutral. The challenge for biomass based technology is to obtain a biomass raw material which has a high energy content, available for transformation into a usable and sustainable fuel source and/or high value end product. These end products include material such as biofuels, biosolvents, biolubricants and a range other products including composites, pigments, inks, waxes and esters.

The candidate would be introduced to the term biomass meaning all organic matter that is created using the photosynthetic conversion of solar energy. In particular, polysaccharides such as cellulose, hemicellulose, starch and lignin which constitute the main four biomolecules would be examined. Non food crops, straw, wood, lignin and cellulose waste materials offer a vast potential for biomolecule manufacture. However, with all these carbon based molecules, there is a need to convert from one form to another. The processes needed for conversion include, enzymatic, microbial, physical and chemical.

There is now an increasing global demand for renewable energy sources both in direct and indirect forms to lower carbon dioxide emissions and to improve energy security. Liquid transport fuels (LTFs) play a role in supplementing reductions in fossil fuels usage. These LTFs include those based on alcohols such as Bioethanol, Biomethanol and Biobutanol. Each may be used as a complete fuel package in its own right (provided the engine has been adapted to accommodate the fuel) or may be utilised in a mix with conventional fuels such as petrol. Other LTFs include biodiesel and pure vegetable oil. Biodiesel has the advantage that is it is a much safer, biodegradable alternative to the diesel produced from oil. As with bio alcohols, blending is the favoured route with fossil fuels. Increased interest with biodiesel has occurred since the fuel may be created using a wide variety of waste products including, animal fats, vegetable oils, and other grease materials.

Higher National Unit specification: support notes (cont)

Unit title: Biomass: Technologies for Energy and Bioproducts

As an alternative to fuels, energy production for electricity using Combined Heat and Power systems (CHP). This form of energy system is becoming increasingly popular since the electricity and useful heat are produced simultaneously in one process. CHP heat can be utilised either for direct heating or for actual industrial processes. Most forms of CHP processes are based on the use of high pressure steam; gas turbines or combustion engines. The primary energy source for CHP can be a wide range of fuels, including biomass and fossil fuels, as well as geothermal or solar energy often using heat pumps to amplify the energy level.

The final stage products will include a vast range of different fuel sources, bioethanol, biodiesel, biogas, bio-oils (rape seed), biosolvents (ethyl lactate), biolubricants (based on vegetable oil). The Unit will then examine in detail the industrial separation and subsequent purification of these biomolecules in order to produce a high quality, biodegradable molecule.

Corresponding to Outcomes:

Outcome 1

This may be taught with reference to examples of biological sources of energy and their uses as a direct form of fuel or use in the manufacture of a natural product. The Outcome will also investigate chemical nature of these biomass sources and the problems associated with their availability and supply. In addition, the advantages and disadvantages that each biomolecules has in terms of its properties and use will be studied. A full review should examine the nature of carbon neutral compounds and their future role in the production of energy. Government strategies and legislation will examine how carbon dioxide taxing affects the green technology industries and their subsequent place in the energy delivery sector.

Outcome 2

This may be taught with reference to how biomass is processed for the production of energy in the form of heat, electricity, CHP and transport fuels. On the fuel side, examples will include bioethanol, biomethanol, biobutanol, biodiesel, biogas and pure vegetable oil. Microbial/biochemical conversion technologies such as anaerobic digestion for biogas and fermentation for bioethanol will be covered as well as the processes of crushing, refining and esterification for the production of biodiesel. There should be opportunities for the candidate to carry out life cycle analysis of biomass energy supply chains in relation to energy balance and greenhouse gas emissions.

Outcome 3

Biomolecules such as fine chemicals may be identified and their subsequent applications within the green technology/biotechnology industries examined. These fine chemicals include aromatics, essential oils, pigments and pharmaceuticals, and candidates will consider new and possible areas of fine chemical production from a wide variety of different biological sources. Biomass processing for other bioproducts such as solvents, lubricants, fibres, polymers, composites and biopesticides will also be studied. Current and future aspects of reactor design used for the culturing of animal, plant and bacterial cells will also be included in the Outcome.

Higher National Unit specification: support notes (cont)

Unit title: Biomass: Technologies for Energy and Bioproducts

Outcome 4

This Outcome could be taught with reference to techniques that are often necessary for the subsequent recovery and purification of a fine chemical or biofuel. Different products with different characteristics, often require different techniques for product isolation and purification. The different strategies employed for intracellular and extracellular products should be examined in detail. The different functional groups of biomolecules will be examined to determine the correct type of recovery technology that must be employed for product purification. This information will include industrial scale down stream processing systems used in both the biotechnological and pharmaceutical industries.

Guidance on the delivery and assessment of this Unit

The principles taught in this Unit can be applied to a wide variety of different industrial sectors involved in the generation and delivery of fuels, energy and power as well as agriculture, food and biotechnology. Global strategies are clear on the problems posed by the availability and supply of future energy sources to the country. Current concern, however, lies with the increasing emissions of carbon from fossil fuels as well as the rising prices of these fuels. Green technology aims to reduce the dependence on fossil based fuels and at the same time attempt to protect the environment in which we live.

The delivery of this Unit may be in the form of variable methods including formal lectures, tutorials, discussion group activity, case studies and specific problem based exercises. Additional material such as PowerPoint presentations, additional supplemental reading, web based activities as well as practice problem based exercises are to be found on Blackboard. This Unit has been deliberately designed to facilitate out of College learning and understanding.

Assessment for Outcome 1 may take the form of extended response questions examining the different forms of biomass derived energy and their overall part in a global energy production scheme.

In Outcome 2 students could examine conversion technologies including combustion, pyrolysis, gasification and co-firing and compare their relative efficiency of energy conversion. Exercises where the candidate looks at the complex nature of energy balances and energy efficiency transfer mechanisms would provide formative assessment opportunities. Positive and negative energy balance equations will be examined in detail showing how small changes in carbon processing may turn around energy balances. Finally the candidate will explore the life cycle analysis and future impact of biomolecule generation on the atmosphere and the environment as a whole. Assessment will be a sampling exercise involving extended and restricted response questions under closed-book, supervised conditions.

In Outcome 3 students will also examine methods of maximising the production of biomass from cellular based systems. Assessment will be a sampling exercise involving extended and restricted response questions under closed book, supervised conditions.

Outcome 4 looks at the processing of biomass for fine chemicals and bio products. Assessment for this Outcome may take the form of extended response questioning examining purification procedures and mechanisms.

Opportunities for developing Core Skills

There may be opportunities to further develop and broaden Core Skills in this Unit, although currently there is no automatic certification of Core Skills or Core Skills components.
There could be opportunities to develop the Core Skills of Communication, Numeracy (Using Numbers), and the Core Skill component 'critical thinking' of the Core Skill Problem Solving, all at SCQF level 6. Discussion group activity and specific problem based exercises could be designed to engage the candidate in lively debate and critical review and commentary. Problem based solving exercises could be used to aid the understanding and resolving capacity of the candidates when examining energy movements through a biomass conversion process. By working in groups exploring issues and developing potential responses and solutions, further opportunities may be created to advance communication and problem solving skills.

Open learning

Elements of this Unit could be delivered via distance learning or via a flexible learning approach. Certain aspects though, such as the measurement of physical variables and the closed-book sampling assessments, may require the candidate to be present at the centre. An appropriately supervised assessment environment could be accomplished via off centre locations with appropriate conditions put in place.

Furthermore activities such as practice problem based exercises could be placed on VLE on systems to support independent learning and facilitate a more flexible delivery mode

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org.uk)**.

General information for candidates

Unit title: Biomass: Technologies for Energy and Bioproducts

This Unit is included in the frameworks of the group awards HND Applied Bioscience, HND Agricultural Science and HND Green Technology. It is appropriate for any land-based, biological, biotechnology or environmental group award. The Unit has been designed to both enhance your capability in resolving problems in order to understand the nature of biological sources of energy and fine chemicals. Biotechnology can play a major role in reducing the need to use oil and gas derived fossil based chemicals in exchange for more carbon neutral molecules which are considered to be more environmentally friendly alternatives.

On completion of the Unit the candidate you should be able to:

1 Explain biomass sources for the production of energy and natural products.
2 Evaluate the processing of biomass for energy.
3 Explain the processing of biomass for fine chemicals and other bioproducts.
4 Discuss techniques for the recovery and purification of products from biotechnological processes.

The delivery of this Unit will be in the form of variable methods including formal lectures, tutorials, discussion group activity and specific problem based exercises, all designed to engage the candidate in lively debate and critical review and commentary.

During the initial part of the Unit you will explore the available sources of biomass, the supply chains for energy and natural bioproducts and the advantages and disadvantages of the different types of biomass. You will also learn how current UK targets and legislation are driving increased use of biomass for energy and fuel.

You will then learn about the technologies for converting biomass to heat and electricity, the anaerobic digestion of wastes to produce biogas and the technologies for using biomass to produce fuels such as bioethanol and biodiesel.

You will also examine how a range of bioproducts including commercially attractive fine chemicals may be produced from different types of biomass including those from animal, plant and microbial origin.

Finally in this Unit you will examine the mechanisms available to isolate fine chemicals whether they are intracellular or extracellular based. The process design will be discussed in terms of its order and function with respect to the properties of the biomolecule. Specific separation technologies will be detailed including those currently used in the large scale industries.

Extended and restricted response questioning could be used for all Outcomes although the assessments for Outcomes 2 and 3 involves sampling and must therefore be unseen and conducted under supervised conditions.

By working in groups exploring issues and developing potential responses and solutions, opportunities will be created to advance the Core Skills of Communication, Numeracy and Problem Solving at SCQF level 6.