Unit Title	Renewable energy systems (H/506/1618)
Level	4
Credit Value	8

Learning Outcomes – *the learner will be able to:*	**Assessment Criteria** – *the learner can:*
1. Understand the carbon cycle, biomass and climate change	1.1 explain the carbon cycle. 1.2 explain that all organic matter in the bio-sphere is a biomass resource. 1.3 explain the carbon neutral nature of biomass and how carbon sequestration coupled with biomass generation can contribute to reversing the build-up of atmospheric carbon dioxide. 1.4 explain the other pollutant emissions that can arise from biomass and energy from waste systems. 1.5 explain typical **biomass calorific values** and compare them to fossil fuel equivalents.
2. Understand the forms and diverse nature of biomass resource in the waste water industry	2.1 describe examples of **water and waste water derived sludge** and their different characteristics. 2.2 describe how preliminary and primary treatment processes and their operation can affect the organic and volatile matter content of waste water sludge. 2.3 describe how secondary treatment processes and their operation can affect the organic and volatile matter content of waste water sludge. 2.4 describe the **sources of fat, oil and grease (FOG)**. 2.5 describe sources of **imported industrial bio solids**.
3. Understand the treatment and utilisation of biomass resource in the water industry: mesophilic anaerobic digestion (MAD)	3.1 explain the principal system features of **anaerobic digestion coupled with combined heat and power systems**. 3.2 describe a range of mesophilic anaerobic digestion (MAD) **pre-treatment processes** to enhance MAD performance. 3.3 describe how fat, oil and grease (FOG) can be utilised in renewable energy production. 3.4 describe how imported industrial bio solids waste can be treated to benefit renewable energy production.
4. Understand the treatment and utilisation of biomass resource in the water industry: combined heat and power (CHP)	4.1 explain the principal system features of **direct combustion technologies**. 4.2 explain the methods and benefits of transforming biogas for use in reciprocating internal combustion engines in **vehicular transport**. 4.3 explain typical **biomass and biogas calorific values** and how they compare to fossil fuel equivalents. 4.4 explain biogas treatment required to remove **constituents** that have the potential to damage combined heat and power engines. 4.5 describe how **waste heat** from combined heat and power (CHP) can be utilised. 4.6 explain how waste heat from treatment processes can be utilised by **those outside water service companies**.

5. Understand the treatment and utilisation of biomass resource in the water industry: incineration	5.1 explain how energy can be extracted from the **bio solids incineration process**. 5.2 describe the bio solids incineration process and the importance of achieving auto-thermic operation.
6. Understand the treatment and utilisation of biomass resource in the water industry: strategy formulation	6.1 produce a strategy for bio solids logistics and treatment, with optimised renewable energy production fossil fuel consumption for given situations. 6.2 explain how renewable energy production and fossil fuel consumption can influence a water service company's sludge treatment strategy. 6.3 explain how positive environmental and socio-economic benefits can be realised through strategic investment, implementation of treatment processes and renewable energy production and utilisation.
7. Understand the forms of renewable energy in the water industry not related to biomass	7.1 explain the principles and limitations of hydroelectric schemes for water and waste water applications. 7.2 explain the **principles, applications and limitations** of heat recovery from ground source, air source and water body source. 7.3 explain the **principles and limitations** of wind power schemes for water and waste water applications. 7.4 explain the **principles and limitations** of photo-voltaic power schemes for water and waste water applications.
8. Understand the key elements of the relevant legislation and their influence on the water industry	8.1 explain how the management of the water industry is influenced by the "Renewable Obligation Certificate". 8.2 explain the financial benefits of the "Renewable Obligation Certificate" scheme. 8.3 explain the financial and security of service implications of contractual obligations for the production, use and export of renewable energy. 8.4 describe how predicted changes in the UK electricity market (with Feed-in Tariffs with Contracts for Difference replacing the Renewables Obligation as the main renewable generation support mechanism) will affect how water companies invest and operate. 8.5 describe a typical contract for the purchase of electricity produced from fossil fuel source.

Additional information about the unit	
Unit purpose and aims	This unit is designed to give learners 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 learner will be able to: • analyse the carbon cycle, biomass and climate change. • explain the forms and diverse nature of biomass resource in the waste water industry • explain the methods of treatment and utilisation of biomass resource in the waste water industry • explain the forms of renewable energy in the water industry that are not related to biomass • explain the key elements of the relevant legislation and how these influence the water industry.
Unit expiry date	31/03/2019
Assessment requirements or guidance specified by a sector or regulatory body (if appropriate)	In the assessment of this unit, the learner must ensure that the evidence that they produce covers the following: 1. The learner must explain the **carbon cycle** using a diagram with explanations. 2. The learner must explain <u>two</u> examples of **typical biomass calorific values** and compare them to fossil fuel equivalents. 3. The learner's description of **water and waste water derived sludge** must include <u>one</u> example for a water treatment works and <u>three</u> examples for a waste water treatment works. 4. The learner's description of the effect of **preliminary and primary treatment processes** on the content of waste water sludge must include: (a) the impact of process design (b) the benefits of following best practice. 5. The learner's description of the effect of **secondary treatment processes** on the content of waste water sludge must include yield and organic and volatile matter content of sludge produced from high-rate, conventional and extended Activated Sludge (AS). 6. **Sources of fat, oil and grease (FOG)** must include: (a) waste water network (b) waste water treatment works inlet works (c) waste water treatment works primary treatment (d) industrial (e) commercial. 7. The learner must describe <u>four</u> examples of sources of **imported industrial bio solids**.

8. The learner's explanation of the principal system features of **anaerobic digestion and combined heat and power systems** must include a process flow diagram with labels and explanation.

9. The learner must describe three mesophilic anaerobic digestion (MAD) **pre-treatment processes** that enhance MAD performance.

10. Examples of how fat, oil and grease (FOG) can be used in renewable energy production could include production of biogas via anaerobic digestion, and direct fuelling of combined heat and power (CHP).

11. The learner's explanation of the principal system features of **direct combustion technologies** must include a process flow diagram with labels and explanation. Examples of direct combustion technologies could include oil/gas/biogas boilers and incinerators.

12. **Vehicular transport** includes:
    (a) bio solids tankers
    (b) public transport
    (c) commercial transport.

13. The learner must explain three examples of **typical biomass and biogas calorific values** and compare them to fossil fuel equivalents.

14. The learner must explain two examples of biogas treatment to remove **constituents** that can damage combined heat and power engines (examples could include hydrogen sulphide, siloxanes).

15. The learner must provide two examples of how **waste heat** from combined heat and power can be utilised.

16. **Those outside water service companies** include:
    (a) municipal heating schemes
    (b) industrial processes
    (c) gas utilities.

17. The learner must provide an explanation of two examples of how energy can be extracted from the **bio solids incineration process**, and include the use of diagrams.

18. The learner's **strategy** for bio solids logistics and treatment must include a diagram and explanation for a range of

	waste water treatment facilities within a given geographical area. 19. The learner's explanation of **how renewable energy production and fossil fuel consumption** can influence a sludge treatment strategy must include: (a) de-watering (b) transportation (c) centralised treatment (d) power and heat generation and consumption. 20. In explaining the **principles, applications and limitations** of different forms of renewable energy (ACs 7.2, 7.3 and 7.4), the learner should consider asset and utility location. The assessment of this unit will be via a combination of centre-devised assignments and tests, and will be conducted in supervised conditions. The assessment strategy for the unit has been agreed with industry stakeholders.
Location of the unit within the subject/sector classification system	4.1 Engineering
Name of the organisation submitting the unit	CABWI Awarding Body
Availability for use	Shared
Unit guided learning hours	32