Making a positive difference for energy consumers

Renewables Obligation (RO) Guidance

Fuel Measurement and Sampling

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This document provides operators using biomass and waste fuels with information on their potential eligibility for Renewables Obligation Certificates (ROCs) and guidance on how to implement fuel measurement and sampling (FMS) procedures to meet the requirements of the Renewables Obligation (RO). It is not intended as a definitive legal guide to the RO.

This guidance document was updated in 2025 owing to IT system changes brought about by the development and implementation of the Renewable Electricity Register (RER).

Contents

Introduction

Overview

The Renewables Obligation scheme closed to all new generating capacity 1 April 2017. More information on this can be found on the closure page and in the guidance on closure.

The Renewables Obligation (RO) scheme was designed to encourage generation of electricity from eligible renewable sources in the UK. The RO scheme came into effect in 2002 in Great Britain, followed by Northern Ireland in 2005.

The scheme places an annual obligation on electricity suppliers to present to Ofgem a specified number of Renewables Obligation Certificates (ROCs) per megawatt hour (MWh) of electricity supplied to their customers during each obligation period (1 April – 31 March). Suppliers can meet their annual obligation by presenting ROCs, making a payment into a buy-out fund or a combination of the two.

ROCs are issued to operators of accredited renewable generating stations for the eligible renewable electricity they generate. Operators can trade ROCs with other parties or sell them directly to a supplier.

The administration cost of the scheme is recovered from the buy-out fund and the rest is distributed back to suppliers in proportion to the number of ROCs they presented to meet their individual obligation.

For more information about the scheme, visit our website.

Relevant guidance

All documents are available at www.ofgem.gov.uk/

- Renewables Obligation: Sustainability Criteria
- Renewables Obligation: Sustainability Reporting
- Renewables Obligation: Biodiesel and fossil-derived bioliquids guidance
- Renewables Obligation: Guidance for Generators
- Renewables Obligation: Guidance for suppliers
- Renewables Obligation: Fuel Classification Flow Diagram
- Fuelled stations and fuel measurement and sampling (FMS)
- RER user guide

Contacts

If you would like to contact us, visit the schemes contact page.

Please note that we can only provide guidance on the legislation that is currently in place. Any queries about changes to the ROO for England and Wales, and wider policy should be directed to the Department for Energy Security and Net Zero (DESNZ). Contact details are at www.gov.uk/guidance/contact-desnz. For the ROS and NIRO Orders, contact details are available at www.scotland.gov.uk and www.economy-ni.gov.uk.

For queries related to the Quality Assurance for Combined Heat and Power (CHPQA) programme, please visit www.gov.uk/guidance/combined-heat-power-quality-assurance for contact details.

Relevant legislation

All legislation can be found at www.legislation.gov.uk:

- The Renewables Obligation Order 2015
- The Renewables Obligation (Scotland) Order 2009
- The Renewables Obligation Order (Northern Ireland) 2009
- Their respective amendment Orders

Executive Summary

This document provides operators of biomass, co-fired, anaerobic digestion (AD), advanced conversion technology (ACT) and waste generating stations, with information regarding the eligibility criteria for certain types of fuelled stations, generation types and fuels under the Renewables Obligation (RO), and guidance on how to meet the necessary FMS requirements. An outline of data submissions and supporting information requirements are also included. This guidance details what we expect from operators based on the legislative requirements and provides suggestions on how generating stations can best meet these requirements.

This document cannot anticipate every scenario which may arise. Where a scenario arises which is not addressed in this guidance, we will adopt an approach consistent with the legislation.

As a working document it may be updated from time to time and should be read in conjunction with other guidance documents listed in the 'Associated documents' section, and the legislation. Any separate guidance published in addition to this document will be posted on our website.

Details of our role as the administrator of the scheme can be found in Appendix 1.

Terms used in this document

This guidance applies to England, Wales and Scotland. Unless apparent from the context, where used in this document, the term "RO" refers to the Renewables Obligation and the Renewables Obligation (Scotland).

The document refers to the Renewables Obligation Order (ROO) 2015 (as amended), the Renewables Obligation (Scotland) Order 2009 (as amended) and the (Northern Ireland) Renewables Obligation Order 2009 (as amended). Collectively these are referred to as 'the Orders'.

The term "ROCs" refers to Renewables Obligation Certificates (ROCs), Scottish Renewables Obligation Certificates (SROCs) and Northern Ireland Renewables Obligation Certificates (NIROCs) unless stated otherwise.

The use of 'Ofgem', 'us', 'our' and 'we' are used interchangeably when referring to the exercise of the Authority's powers and functions under the Orders. The review and agreement of FMS procedures, checking of fuelled monthly output data and ensuring compliance with the RO sustainability criteria are managed by the 'Fuelling and Sustainability' team within the Delivery and Schemes directorate at Ofgem. The term

"the Act" refers to the Electricity Act 1989[1]. The RO and RO(S) were derived from this primary legislation, while the NIRO is derived from The Energy (Northern Ireland) Order 2003[2]. Subsequent changes made via the Energy Act 2008 have given the government the enabling powers to introduce the differential rewards that have fundamentally changed the ROC reward structure.

The terms 'operator', 'generator' and 'generating station' are used interchangeably throughout the document and other Ofgem documents and correspondence

Throughout the document we refer to support levels for fuels and technologies as 'bands' rather than the term 'way of generating electricity used in the ROO 2015 (as amended) and the term 'generation type' used in Schedule 2 of the RO(S) Orders 2009 (as amended) and the NIRO Orders 2009 (as amended).

Within this document, we refer to instances where data is to be submitted by generating stations as typically being a monthly requirement. We are aware that in rare cases, there are exceptions to this stipulation; however, for the sake of simplicity, we decided to use the monthly stipulation as this makes it easily readable and avoids unnecessary complexity.

[1] Electricity Act 1989
[2] The Energy (Northern Ireland) Order 2003

1. Eligibility

This chapter describes the eligibility criteria for certain fuelled stations and the types of generation and fuels that are eligible under the RO. The definitions found below are fundamental to the classification and issuance of ROCs to fuelled stations under the RO.

Overview

1.1 The Orders define several key terms in relation to fuel types and technology types. These help to determine eligibility as well as the ROC bands that are issued to accredited generating stations. Further detail on eligibility requirements and key definitions can be found in our guidance for generators Where this is the case, reference is made to the guidance document.

1.2 When determining ROCs for fuelled stations, the energy content of a fuel or combination of fuels is required as a key part of the calculation that is used to determine the number of ROCs that can be issued to a fuelled generating station, as set out in the Orders,[3] and as referenced in other parts of the Orders.

1.3 Energy content is defined in the Orders,[4] in relation to any substance, as meaning:

1.4 "…the energy contained within that substance (whether measured by a calorimeter or determined in some other way) expressed in terms of the substance's gross calorific value within the meaning of British Standard BS 7420:1991…"

1.5 This chapter sets out key definitions and information regarding eligibility for fuels, and technologies.

Biomass

1.6 To claim ROCs for electricity generated from biomass, the fuel used will ordinarily need to meet the definition of biomass. To meet the definition an individual fuel's energy content must be at least 90% derived directly or

[3] Articles 29 and 30 of the ROO 2015 (as amended), Articles 25 and 26 of the ROS and NIRO Orders 2009 (as amended).
[4] Article 2(1) of the ROO 2015 (as amended), RO(S) 2009 (as amended) and NIRO 2009 (as amended).

indirectly from "relevant material", for example plant matter, animal matter, fungi, algae or bacteria.

1.7 Fuels which are fossil-derived bioliquids (FDBLs) also meet the definition of biomass.

1.8 This definition is important for generating stations wishing to claim ROCs on the biomass related bands, e.g., 'dedicated biomass' or the 'mid-range co-firing' band.

1.9 If less than 90% of the energy content within an individual fuel is derived directly or indirectly from relevant material, it will not itself meet the biomass definition.

1.10 However, if the fuel is used alongside other renewable fuels at the generating station in any month and the combined energy content of these fuels is more than 90% derived from relevant material, then the combination of these fuels can be treated as biomass[5].

1.11 Please note that with advanced conversion technologies (ACT) the feedstock or fuel used by the generating station does not need to adhere to the 90% level as described above to be considered eligible. With these technologies ROCs are awarded as per the energy content derived directly or indirectly from relevant material at whatever banding level this may be, providing this figure is over 10% renewable sources.[6]

1.12 For example, a gasification plant using a feedstock of Solid Recovered Fuel (SRF) with 60% biomass energy content, as defined by their FMS regime, would be eligible to receive ROCs on 60% of its generation within a given month.[7]

1.13 The term "100% biomass" in this document refers to biomass material that is 100% biomass by energy content (and does not therefore derive any of its energy from fossil fuel or fossil-derived sources).

[5] See Article 3(4) of the ROO 2015 (as amended) and Article 4(2) of the RO(S) 2009 and NIRO 2009 (as amended).
[6] This is in accordance with Article 5(1) and 29 of the ROO 2015 (as amended), and Articles 3(1) and 25 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended).
[7] Less (i) any deduction for biomass not converted as a final fuel i.e. lost as char and (ii) any fossil fuel used, whether for permitted ancillary purposes or otherwise, which leads to generation.

1.14 What constitutes "regular biomass" is defined in Schedule 5 of the ROO 2015 (as amended) and some of the bands require that the fuel used meets this definition to be eligible claim ROCs. The following biomass types are not considered to be regular biomass under the Orders[8]:

- Advanced fuel,[9]
- Fuel produced by means of anaerobic digestion (AD),
- Bioliquid,
- Energy crops,
- Landfill gas, and
- Sewage gas.

Bioliquid

1.15 Bioliquid is defined as liquid fuel for energy purposes (other than for transport), including electricity, heating, and cooling, produced from biomass.[10] This definition is also used in determining the proportion of bioliquid ROCs an energy supplier can redeem against their obligation following the introduction of the bioliquid cap on 1 April 2013. The 'Renewables Obligation: Guidance for Suppliers' (see 'Associated documents') provides further information on this as well as describing the exemptions that apply.

Fossil-derived bioliquid

1.16 Fossil derived bioliquid (FDBL) is defined in the Article 2(1) of the ROO 2015 (as amended), as bioliquid produced either directly or indirectly from:

- coal,
- lignite,
- natural gas,
- crude liquid petroleum, or
- petroleum products.

[8] Schedule 5(1) of the ROO 2015 (as amended)
[9] 'Advanced fuels' are defined in Article 2(1) of the ROO 2015 (as amended) as: a liquid or gaseous fuel which is produced directly or indirectly from the gasification or the pyrolysis of a) waste, or b) biomass.
[10] See Article 2(h) of the Renewable Energy Directive

1.17 It is for the operator of the generating station to demonstrate to our satisfaction the proportion of the FDBL's energy content that is to be treated as being composed of (or derived from) fossil fuel. For more information on how to determine the biogenic content of biodiesel and other FDBLs, please refer to the 'Renewables Obligation: Biodiesel and Fossil-Derived Bioliquids guidance document'.[11]

Waste

1.18 Waste is defined in the Orders,[12] as the meaning of waste given in Article 3(1) of Directive 2008/98/EC of the European Parliament and of the Council on waste. This includes anything derived from waste but does not include landfill gas or sewage gas. However, it does not include substances that have been intentionally modified or contaminated to meet the definition. [13]

1.19 Where we refer to waste in this guidance we mean any fuel which meets the definition of waste in the Orders, but does not meet the definition of biomass, as outlined in Article 5 of the ROO 2015 (as amended),[14] and therefore cannot be treated as biomass.

Exclusion by virtue of Article 60

1.20 Article 60 of the ROO 2015 (as amended), [15] effectively excludes generating stations from claiming any ROCs when using waste, unless the station meets one or more of the following criteria:

- The waste is used as a feedstock to produce a liquid or gas using either gasification, pyrolysis or anaerobic digestion.
- The waste is used by a qualifying CHP generating station.
- The only waste(s) used are liquid fossil fuels e.g. Recycled Fuel Oil (RFO) and / or SRF.

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11 http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/FuelledStations/Pages/FS.aspx

12 Article 2(1) of the ROO 2015 (as amended), RO(S) 2009 (as amended) and NIRO 2009 (as amended)

13 Directive 2015/1513, Article 2(1)(p), available at http://eur-lex.europa.eu/legalcontent/EN/TXT/?qid=1512473352448&uri=CELEX:02009L0028-20151005

14 Article 3 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended)

15 Article 22 of the RO(S) (as amended) and Article 21 of the NIRO (as amended).

1.21 Article 3 of the ROO 2015 (as amended), states that wastes of which greater than 90% of their total energy content results from fossil-derived sources cannot be classed as "Renewable Sources". In accordance with the wording of the Orders,[16] this ensures that these wastes cannot receive any ROCs when used for generation.

Liquid Fossil Fuel

1.22 Waste liquid fossil fuels can be used for generation provided they are comprised wholly or mainly of hydrocarbon compounds. This includes Recycled Fuel Oil (RFO).

Solid Recovered Fuel (SRF)

1.23 For the purposes of the ROO and NIRO,[17] SRF is defined as under Article 2(1) as a substance that:

- complies with the classification and specification requirements in BS EN 15359:2011,
- is prepared from a waste which is not a hazardous waste (where hazardous waste has the meaning given in Article 3(2) of Directive 2008/98/EC of the European Parliament and of the Council on waste.),
- has a maximum rate of oxygen uptake of no more than 1500 milligrams of oxygen per kilogram of volatile solids per hour when measured using the real dynamic respiration test specified in BS EN 15590:2011, and
- when subject to a methodology for the determination of particle size in accordance with BS EN 15415-1:2011, is able to pass through an opening measuring no more than 150 millimetres in all dimensions.

1.24 For the purposes of the ROS Order,[18] SRF is defined under Article 2(1) as a substance that:

- complies with the classification and specification requirements in CEN/TS 15359:2006,
- is prepared from a waste which is not a hazardous waste,

[16] Article 29 of the ROO 2015 (as amended), Article 25 of the RO(S) 2009 (as amended) and Article 23 of the NIRO 2009 (as amended).
[17] Article 60 of the ROO 2015 (as amended) and Article 21 of the NIRO 2009 (as amended).
[18] Article 22 of the RO(S) 2009 (as amended).

- has a maximum Respiratory Index value of no more than 1500 milligrams of oxygen per kilogram of volatile solids per hour when measured using the real dynamic respiration test specified in CEN/TS 15590:2007, and
- when subject to a methodology for the determination of particle size in accordance with CEN/TS 15415:2006, is able to pass through an opening measuring no more than 150 millimetres in all dimensions.

Exclusion by virtue of Article 60

1.25 Article 60 of the ROO 2015 (as amended), [19] outlines circumstances in which no ROCs are to be issued for generation from renewable sources. Article 60(2) of the ROO 2015 (as amended),[20] states that no ROCs can be awarded for a month in which generation occurs from renewable sources and fossil fuel, where the fossil fuel consists of or includes waste.

1.26 This means that a station will be excluded in any month where both a fossil fuel and any other fuel (other than biomass) are used. For example, a station generating electricity in a month from a fossil fuel and refuse-derived fuel would be deemed ineligible for ROCs. However, a station which uses biomass and SRF, which meets the definition of SRF as per Article 2(1) of the relevant Order, alongside fossil fuel, would be eligible.

1.27 Where SRF is used alongside biomass and a fossil fuel for generation, either dedicated biomass or co-fired ROCs can be issued This can be either on the total renewable content of the biomass and SRF or on the biomass alone. The method for ROCs being awarded under this scenario is outlined by the flow diagram in Figure 1.1.

[19] Article 22 of the RO(S) 2009 (as amended), and Article 21 of the NIRO 2009 (as amended).
[20] Article 22 of the RO(S) 2009 (as amended), and Article 21 of the NIRO (as amended).

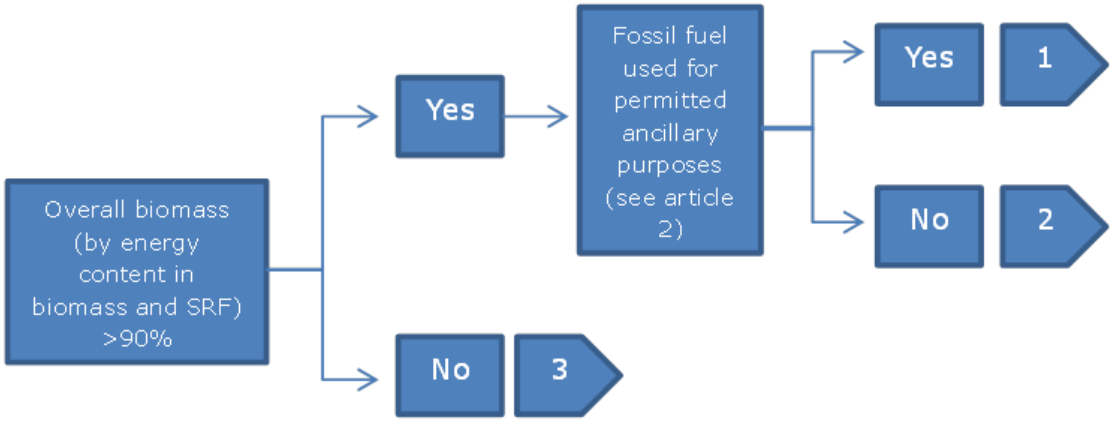

Figure 1.1: ROC award flow diagram for biomass, SRF and fossil fuel generation

According to the diagram above ROCs would be awarded as follows:

1. Dedicated biomass ROCs for the total biomass content (SRF and biomass).
2. Co-fired ROCs for the total biomass content (SRF and biomass).
3. Co-fired ROCs for biomass fuel only.

Energy Crops

1.28 The energy crops definition includes 15 species of crop.[21] Generators wishing to receive energy crop ROCs will only be eligible to claim ROCs for the electricity they generate by using the energy crops specified in this definition.[22]

1.29 The 15 species fall under two categories:

Perennial crops planted at high density, the stems of which are harvested above ground level at intervals of less than 20 years and which is one of the following:

1. Acer pseudoplatanus (also known as sycamore).
2. Alnus (also known as alder).
3. Betula (also known as birch).

[21] Article 2 of the ROO 2015 (as amended). This definition is only relevant for operators wishing to claim energy crop ROCs. For AD generating stations which are using any crop-based feedstocks this definition is irrelevant as such a station would be awarded AD ROCs, not energy crop ROCs.

[22] Any generators using energy crops supported under the previous definition which do not meet the energy crops definition will not be eligible for support under the energy crop bands but may be eligible to claim under the biomass bands.

4. Castanea sativa (also known as sweet chestnut).
5. Corylus avellana (also known as hazel).
6. Fraxinus excelsior (also known as ash).
7. Populus (also known as poplar).
8. Salix (also known as willow).
9. Tilia cordata (also known as small-leaved lime).

Or a **perennial crop** which is one of the following**:**

10. Arundo donas (also known as giant reed).
11. Bambuseae, where the plant crop was planted after 31 December 1989 and is grown primarily for the purpose of being used as fuel.
12. Miscanthus.
13. Panicum.
14. Pennisetum (other than Pennisetum glaucum (also known as pearl millet),Pennisetum setaceum (also known as fountain grass), Pennisetum clandestinum (also known as kikuyu grass) and Pennisetum villosum (also known as feathertop grass).
15. Phalaris.

1.30 Further explanation of various terms used in the energy crop definition is provided here:

- "Perennial crop": This is not defined in the Orders, but the European Commission defines this as: a "plant that lasts for more than two growing seasons, either dying back after each season or growing continuously". Included is the growing of these plants for the purpose of seed production.[23]
- "High density": We consider the 'planting density' of a crop to be the number of individual plants that are planted on a per hectare (ha) basis.
- "Planted": A crop must have been planted for it to be classed as an energy crop. A substance that grows naturally would not qualify as an energy crop for the purpose of the Orders

[23] http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_REV

1.31 To determine this, we would expect the number of individual plants to refer to the number initially planted, irrespective of the eventual germination or survival rate. When determining the planting density, we would exclude any unplanted land such as ditches, streams, crop buffers, etc.

1.32 It should also be noted that we understand the term 'plant' can differ, based on the species and / or cultivation methods used. For example, other terminology that may be used in place of 'plants' to outline planting density could include: cuttings, rods, seeds, seedlings, young trees, rhizomes,[24] maiden stems[22] or stools.[25] Where alternative terminology for 'plants' is used, the planting density should still be provided on a per hectare basis. Further information on demonstrating compliance for energy crops can be found on our Fuelling and Sustainability homepage.[26]

1.33 There are several terms in the energy crop definition that are associated only with Bambuseae, which are set out here. Bambuseae also has specific evidence requirements which are explained in Paragraph 2.42 of this guidance document.

Planted after 31st December 1989

1.34 A Bambuseae crop must have been planted after 31 December 1989 to be regarded as an energy crop under the Orders.

Grown primarily for the purpose of being used as fuel

1.35 For a Bambuseae crop to meet this part of the definition, the main intended purpose at (or in exceptional circumstances, very shortly after) the time of planting the crop must have been for use as fuel.

1.36 In the case of a Bambuseae crop that has been grown for multiple purposes, we need to determine whether the crop was planted primarily for the purpose of being used as fuel. In this scenario, we will look at the proportion of the crop that is to be used as fuel and consider criteria such as energy content, financial

[24] A rhizome is a thick underground horizontal stem that produces roots and has shoots that develop into new plants. 22 'Maiden stem' usually refers to the original cutting used when the crop is first planted. As it matures it produces multiple off-shoots, each of which is referred to as a 'stem'.
[25] 'Stool' refers to a root or stump of a tree or plant from which shoots spring, see http://oxforddictionaries.com/definition/english/stool.
[26] https://www.ofgem.gov.uk/fuelling-and-sustainability-fit-anaerobic-digestion-installations

value, weight, volume and acreage in coming to a view as to the primary purpose for the planting of the crop.

Fuel

1.37 This refers to fuel used to generate electricity, transport fuel or fuel used to generate heat.

Evidence required by Ofgem for generators using energy crops

1.38 Before we are able to view a substance as an energy crop, a generating station must provide evidence to us to show that the substance in question meets the energy crop definition. Evidence could include, but is not limited to:

- grant scheme documentation,
- invoices,
- Environmental Impact Assessments (EIA) documentation,
- felling licences,
- advisory notes from planting advisors, and
- woodland management plans.

1.39 Additional evidence is required for the energy crops listed regarding planting density. For bullet number 11 on the list in paragraph 1.29 (Bambuseae), evidence is required that it was planted after 31 December 1989 and specifically for the purpose of being used as a fuel.

For the first 9 energy crops on the bullet list[27]

1.40 In order to demonstrate that the energy crop in use is eligible, we will expect to see suitable documentation. For this category of energy crop, documentation should be submitted to show that the energy crop is one of the listed perennial crops, it has been planted and it has been planted at high density. This documentation could be in the form of a fuel supply contract, fuel specification or other form of evidence. This will be dealt with case by case as necessary.

For the energy crops 10,12,13,14,15 on the bullet list

1.41 We would expect to see evidence stating that the energy crop being used is one of the named perennial energy crops that falls into this category. This

[27] From Sub-chapter 1.29 of this guidance

documentation could be in the form of a fuel supply contract, fuel specification or an alternative.

For energy crop 11 on the bullet list

1.42 Specifically for Bambuseae, we will require evidence that the crop was planted after 31 December 1989 via a fuel supply contract, fuel specification or similar. In addition, we will normally require contractual evidence that the crop has been grown primarily for the purpose of being used as fuel. This documentation could take the form of a binding contract entered into at the time of planting. The information that we will need to see as part of a binding contract should include:

- The common and Latin name(s) of the crop.
- The field in which the crops will be grown.
- The expected yield.
- The price the grower will charge for the crop.
- The dates on which supply is expected to start and end.
- The duration of the contract.

1.43 Contracts in themselves are not automatic evidence that a crop is to be used for fuel. The contracts will need to be sufficiently binding to ensure that the crop will actually be used as fuel and that there is no option for the crop to be used for another primary purpose.

1.44 We realise that putting in place contracts at the time of planting may cause difficulties for operators, given the potential lapse in time between a crop being planted and that crop being harvested. Therefore, as an alternative to a binding contract at the time of planting, we will generally accept a letter of intent containing similar information to a contract at the time of planting, with a binding contract in place following planting.

1.45 Where the generating station has a contract with a fuel processor then, in addition to the binding contract or the letter of intent, between the processor and the operator, we also require copies of the contracts or the letters of intent between the grower and the processor so that the complete chain of intended supply is covered. Similarly, if an operator has an arrangement with a bulk supplier of energy crops, we will need copies of all the contracts or letters of intent between the growers and the bulk supplier.

1.46 The final piece of evidence we are likely to require will need to demonstrate that the crops were sold under contract.

Peat

1.47 Generating stations fuelled wholly or partly by peat are specifically excluded under the Orders.[28]

Ancillary Fossil Fuel use

1.48 Any fossil fuel or waste used to generate electricity must always be accounted for when calculating the number of ROCs to be issued in a given month. This involves determining the proportion of total electricity generation from these fuel sources through agreed FMS procedures and then deducting it from ROC issue.

1.49 Fossil fuel or waste can only be used for the following ancillary purposes which are also outlined in the Article 2(1) of the ROO 2015(as amended):[29]

- cleansing other fuels from the generating station's combustion system prior to using fossil fuel or waste to heat the combustion system to its normal temperature.

1.50 The heating of the station's combustion system to its normal operating temperature or the maintenance of that temperature.

- The ignition of fuels of low or variable calorific value.
- Emission control.
- Standby generation or the testing of standby generation capacity.
- Corrosion control.
- Fouling reduction.

1.51 If a generating station uses either fossil fuel or waste for a purpose other than those listed above, or where greater than 10% fossil fuel or waste is used for ancillary purposes in a month, then the generation occurring at this generating station would be classed as co-firing and will receive support under the relevant co-firing band for that month. This does not apply to AD or ACT generating stations.

[28] Article 56 of the ROO 2015 (as amended), 22(1)(d) of the RO(S) 2009 (as amended) and 21(1)(d) of the NIRO 2009 (as amended).
[29] Article 22(3) of the RO(S) 2009 (as amended) and 21(3) of the NIRO 2009 (as amended).

1.52 FMS procedures are agreed case by case for each generating station. The following example is for illustrative purposes only: in a month where a generating station uses biomass and fossil fuel for permitted ancillary purposes and has a qualifying percentage (the percentage of the total energy content of the fuel which is derived from renewable sources) of 95%, then the generating station would not be classed as co-firing for the month. However, for a station with the same fuel use and qualifying percentage, if the fossil fuel use was not for permitted ancillary purposes, then the station would be classed as co-firing and the relevant co-firing band(s), in accordance with the bands listed in Appendix 3 of this guidance document, would apply in that month.

1.53 Where the use of fossil fuels does not result in the generation of electricity, information for these fuels will not need to be entered on the 'fuel measurements' page of the RER each month for certificate claims. However, we will generally expect the operator to provide information regarding these fuels with evidence of how they can be confident the fossil fuel does not result in generation as part of the FMS approval process.

1.54 Specifically, where a generating station uses a fossil fuel for standby generation or the testing of standby generation capacity the electricity generation should be reported as 'input electricity' on the RER via the 'standby generation' field. The information for the fuel used for standby generation does not need to also be specified on the fuel measurements page when you make a monthly data submission on the RER. However, the information associated with the quantity and energy content of the fossil fuel used for standby generation should be provided as part of the generating station's supporting information.

1.55 For further information on co-firing see the section below.

Co-firing

1.56 Co-firing is the term used to describe generating stations fuelled partly by biomass and partly by fossil fuel. Schedule 5[30] sets out the co-firing bands: low, mid and high-range co-firing. These are awarded according to the percentage of the energy content of all fuels used within the month which is from biomass. The co-firing bands are shown in Table 2.1.

[30] Schedule 5 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended)

Table 1.1: Co-firing bands

Band	**Percentage biomass by energy content**
Low-range co-firing	Regular biomass and energy crops are supported by this band where the percentage biomass by energy content is less than 50% in that month.
Mid-range co-firing	Regular biomass and energy crops are supported by this band where the percentage biomass by energy content is at least 50%, but less than 85% in that month.
High-range co-firing	Regular biomass and energy crops are supported by this band where the percentage biomass by energy content is at least 85% but less than 100% in that month.
Co-firing of regular bioliquid	All bioliquids, regardless of the co-firing percentage, are supported by this band.

1.57 The co-firing bands set out in Table 1.1 above can apply either on an individual combustion unit or on a generating station-wide basis dependent on the fuels used at the generating station. A combustion unit (hereby referred to as a 'unit') is defined as "a boiler, engine or turbine".[31] Therefore, where relevant, generators will need to be able to provide information to us on a monthly basis regarding the fuels used in each individual unit[32] at their generating station and will need to agree FMS procedures with us to provide this information.

1.58 Where a generating station does not co-fire biomass/energy crops in any unit at 50% or above it is possible to apply station-wide FMS procedures. To do this, the operator is requested to submit a notification. An example of a notification document will be provided by us for generators to use. This notification can be

[31] As defined in Article 2 of the Orders.
[32] Including those used for permitted ancillary purposes.

withdrawn in writing by the operator at a later date should the situation at the generating station change.[33] Further detail on FMS requirements for co-fired generating stations is provided in Chapter 2 of this document.

Removal of the energy crop uplift for low-range co-firers

1.59 The energy crop uplift for low-range co-firers provides additional support for each MWh of generation from the use of energy crops. This can only be used by generators with existing energy crop contracts agreed before 7 September 2012 under the RO and the ROS until either the end of that contract or 31 March 2019 – whichever is sooner.

1.60 For the purpose of establishing whether an operator can claim the energy crop uplift, the operator must submit information to us to demonstrate that the existing energy crop feedstock agreement was entered into before 7 September 2012. In order to do this, we require operators to sign and submit to us a letter confirming this for each relevant contractual agreement. We will provide operators with an example of a confirmation letter that they may use for this purpose.

1.61 In some cases, we may require further information supported by evidence to establish that the generating station is entitled to continue to receive ROCs for the energy crop uplift. If required, we will request this on submission of a confirmation letter by an operator for a given energy crop contract.

1.62 We would advise all parties to read the relevant articles in the Orders[34] and take their own legal advice before submitting a confirmation letter.

Conversion and Relevant Fossil Fuel Stations (RFFSs)

1.63 Stations that meet the definition of RFFS[35] which generate electricity from biomass and/or energy crops will be eligible for support under the 'station conversion' or 'unit conversion' bands depending on the monthly fuel mix. The fuels used for electricity generation in any month must be biomass or energy crops in order to gain support under this band.

[33] Article 81 of the ROO 2015 (as amended), Article 36 of the RO(S) (as amended) and Article 34 of the NIRO (as amended).
[34] Article 36 of the ROO 2015 (as amended), Article 28D RO(S) (as amended) and Article 26D of the NIRO (as amended).
[35] See Schedule 5 of the ROO 2015 (as amended), and Schedule 2 of the RO(S) 2009 (as amended) and the NIRO 2009 (as amended).

1.64 When determining whether a station meets the definition of RFFS we will have regard to:

- whether the station received ROCs for generation wholly from biomass that took place between 1 April 2009 and 31 October 2011 (inclusive),
- whether fossil fuel contributed more than 15% by energy content towards the overall output generated by the station in any six-month period since it was first commissioned/since 1 November 2011, and
- for the purposes of determining whether electricity was generated wholly from biomass, no account is taken of fossil fuel used for permitted ancillary purposes.

1.65 Conversion bands apply where only biomass, energy crops or both are burned within the unit. These bands are further defined in Schedule 5[36] of the Orders and in Appendix 3 of this guidance document.

1.66 Once a generating station meets the definition of a RFFS they will not be eligible for the 'dedicated biomass' or 'dedicated energy crop' bands as of the month they become an RFFS. It is possible however for a generating station that is not currently a RFFS to become one at a later stage. These stations will instead be supported under the 'station conversion' band in any month in which they generated electricity wholly from biomass.

1.67 Dedicated biomass generating stations should therefore consider monitoring fossil fuel use which results in generation of electricity closely in line with the RFFS definition. In particular, they should consider the reference to using more than 15% fossil fuel over a six-month period. This is inclusive of periods where the generating station is not claiming ROCs, for example if the generating station is closed for maintenance but using some fossil fuel for testing which results in generation

Advanced Conversion Technologies (Gasification and Pyrolysis)

1.68 ACTs use waste and biomass feedstocks to produce either a synthesis gas (syngas) and/or liquid fuel (bio-oils) which can be used to generate electricity. For advice regarding FMS requirements for these technologies, please refer to Chapter 2 of this guidance document.

[36] Schedule 2 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended).

1.69 Typical feedstocks used with ACTs include SRF, RDF and biomass. For ACTs we consider the final fuel (the advanced fuel) to be the syngas or bio-oil. However, any fossil-derived contamination present in feedstocks will need to be calculated. This contamination percentage will be applied to the final fuel and deducted from the fuel eligible for ROCs.

1.70 Generating stations using ACTs may be eligible for support under either the 'standard gasification/pyrolysis' or 'advanced gasification/pyrolysis' bands. For gaseous fuels, support under these bands is linked to the Gross Calorific Value (GCV) of the final fuel produced as determined by agreed FMS procedures. Further information on the minimum GCV level for gaseous fuels produced by gasification and pyrolysis is provided in section 2.102.

1.71 The 'energy crop' definition set out earlier in this Chapter is not relevant for generating stations that are eligible for support under the 'standard gasification/pyrolysis' or 'advanced gasification/pyrolysis' bands. These stations would be awarded ROCs under these bands rather than energy crop ROCs in which the 'energy crop' definition is used.

Anaerobic Digestion (AD)

1.72 The definition of AD in Article 2(1) of the ROO 2015(as amended), Schedule 2 Part 1(1) of the ROS 2009(as amended and Part 1(2) of the NIRO 2009(as amended) is given as:

- "the bacterial fermentation of organic material in the absence of free oxygen".

1.73 ROCs can be awarded, where a gaseous fuel produced by AD is used for electricity generation, provided the eligible ROC banding definition for AD (given in Appendix 3) is complied with. Generating stations producing gas from sewage or material in landfill are not eligible for the AD band.

1.74 The 'energy crop' definition set out earlier in this Chapter is not relevant for AD generating stations. This is because these stations would be awarded AD ROCs and not energy crop ROCs in which the 'energy crop' definition is used.

Grandfathering

1.75 The number of ROCs that can be issued to a fuelled generating station will depend on the application of grandfathering[37] policy, whether the station is in receipt of a statutory grant issued prior to 11 July 2006 and the application of banding according to the generation type, and fuel mix that is used each month.

1.76 The government set out its grandfathering policy and exceptions to it in its response to the banding review consultation.[38] Among the exceptions are support for RFFSs: the government set out further changes in its response to the consultation on changes to grandfathering policy for future co-firing/conversion projects on the RO[39] published 21 July 2015. This details changes that apply to new biomass conversion and co-firing stations and combustion units, as well as for existing combustion units that move for the first time into the mid-range or high-range co-firing bands or the biomass conversion band. Exceptions do apply to this change of policy. Further detail is available in the government's response document.

1.77 Further information on grandfathering is available in our Guidance for Generators document.

Excluded/Unsupported Capacity

1.78 Adding excluded/unsupported capacity to a fuelled generating station may impact the eligibility of the generating station. We recommend that scheme participants always seek their own technical and legal advice before adding excluded/unsupported capacity. More information regarding excluded/unsupported capacity can be found in the RO Guidance for Generators.

[37] Grandfathering a band means that a fixed level of support is maintained for a station's lifetime under the RO, provided it remains eligible, from the date it is accredited.
[38] Government response to the consultation on proposals for the levels of banded support under the Renewables Obligation for the period 2013-17.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42852/5936-renewables-obligation-consultation-the-government.pdf
[39] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/447327/Biomass_RO_Govt_Response.pdf

2. FMS – in principle and in practice

Chapter summary

Provides an overview of the key principles behind fuel measurement and sampling (FMS) and the practicalities of agreeing FMS procedures. The FMS requirements for different types of fuel and generation technologies are also referred to.

Overview

2.1 An FMS regime is the general term that we use to describe the agreement with operators of suitable procedures for the measurement and sampling of fuels. These are required in order to determine the quantity of fuel used in a month, the energy content of this fuel and the level of any fossil-derived contamination present. While the term 'FMS procedures' usually refers to the agreement of physical measurement and sampling processes, it may also refer to the requirement to provide documentary evidence.

2.2 The principal reason why FMS procedures are required is because ROCs can only be issued for electricity generated from renewable sources in a given month. The Orders[40] set out how to calculate the quantity of electricity generated from renewable sources.

2.3 The amount of electricity is determined according to the energy content attributable to the fossil and non-fossil derived fraction of each of the fuels used in a particular month to generate that electricity. It is due to this calculation that operators of fuelled stations need to propose and agree an FMS regime with us, describing how they will determine the values required for the ROC calculations. For example, in the case of a generating station fuelled partly by fossil fuel and partly by biomass, the contribution of both towards the amount of electricity generated needs to be determined. Therefore, the total energy content from the fossil fuel needs to be determined in addition to that of the biomass portion.

2.4 Additionally, FMS procedures are required for the following reasons:

- when electricity is generated from eligible fuels that are awarded different levels of support (as outlined in Appendix 4),

[40] Articles 29 and 30 in the RO, Articles 25 and 26 in the ROS and Article 23 and 24 in the NIRO Orders.

- when fuels contain fossil-derived contamination,
- when electricity is generated from eligible fuels which are in different states e.g. a mix of solid and liquid biomass fuels[41] and
- to support reporting against the sustainability criteria.

2.5 Additional information on compiling a robust FMS regime is available in Appendix 6 – 10. The information contained in these appendices is designed to provide operators with an indication, rather than a prescriptive guide, as to how they may choose to compile an FMS regime.

2.6 For an overview of FMS in the context of the role it plays for fuelled generating stations within the schemes which we administer, you may wish to consult our guidance note documents that supplement the FMS Questionnaires for the various technology and fuel types42 This document provides a concise overview of the FMS review processes and advice on the completion of the FMS questionnaires. The document is available for download from our website, and we recommend consulting this document prior to making any FMS submission to us.

When to submit FMS procedures

2.7 Generating stations need to submit new or revised FMS procedures when:

- anticipating using a new fuel43 at an existing accredited generating station,
- a change onsite i.e. new equipment requires FMS procedures to be amended[44] and
- when changes to the Orders mean that the current agreed procedures are no longer adequate.

[41] This is both for ROC issue in accordance with the sustainability requirements and to identify bioliquids for the purpose of the bioliquid cap.
[42] The various FMS questionnaire templates can be found on the fuelled measurement and sampling page found on the Ofgem website: https://www.ofgem.gov.uk/environmental-and-social-schemes/renewables-obligation-ro/applicants/fuelled-stations-and-fuel-measurement-and-sampling-fms
[43] This could be a new species of energy crop or type of biomass where use has not previously been agreed with Ofgem.
[44] There may be instances where this will need to be discussed and agreed with Ofgem depending on the nature of the equipment and procedures.

The format of an FMS procedure

2.8 All procedures must be submitted to us in the appropriate fuel measurement and sampling questionnaire (FMSQ). The correct FMS questionnaire to use for a generating station depends on the technology, fuels used, and FMS procedures used. The range of available questionnaires and associated guidance notes can be found on our website45.

2.9 Additional information can be used alongside your FMS questionnaire to support your application.

2.10 Examples of accompanying documentation which could be used to support proposed FMS procedures are internal procedure sheets, process flow diagrams and technical specifications for equipment used. We will agree with you what accompanying documentation is required on submission of your FMS

Table 2.1- Available FMS questionnaires

Title of FMS Questionnaire	Applicability
Standard	This questionnaire should be completed by operators using solid, liquid or gaseous biomass fuels at their generating station, not employing AD or ACT.
ACT	To be completed by operations of ACT (gasification and pyrolysis) stations only.
AD	To be completed by operations of AD stations only.
Carbon-14 (14C)	This questionnaire should be completed in addition to either the Standard or ACT questionnaires for those operators using 14C radiocarbon dating to determine the fossil fuel and

[45] https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro/information-generators/fuelledstations-and-fms

	fossil derived contamination present in their fuels.
BIOMA	This questionnaire should be completed in addition to either the Standard or ACT questionnaires for those operators using the BIOMA method to determine the fossil fuel and fossil derived contamination present in their fuels.

2.11 Operators should complete the document that is most suitable for their station. If the operator is unsure which questionnaire to complete, they should contact the Fuelling & Sustainability team on fuellingandsustainability@ofgem.gov.uk. Additionally, we have provided a guidance note with each FMSQ to assist operators in completing the questionnaires.46

Timeframe for agreeing FMS procedures

2.12 We recognise that no two generating stations are identical and that different operators can use different combinations and volumes of fuels, drawn from different sources. For these reasons, our approach is always to agree FMS procedures case by case, according to the specific set-up and conditions at each generating station.

2.13 There is no set timeframe for the agreement of FMS procedures. Our aim is to agree procedures that will enable operators to fully meet the requirement of providing accurate and reliable information to us. Given that the complexity of FMS procedures will vary greatly from one station to the next, we do not set an arbitrary timeframe for the agreement of procedures. We endeavour to work closely with operators to make the process as efficient as possible.

2.14 To ensure that any FMS procedures meet the requirements of the Orders and are appropriate to the generating station we will review procedures proposed by

[46] The questionnaires and guidance notes can be found on our website at: https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro/information-generators/fuelled-stations-and-fms

generating stations, assess them for suitability and provide comments. Both parties work together to develop robust procedures suitable for agreement.

2.15 This may involve several revisions of the methodology originally proposed to develop robust procedures capable of delivering the accurate and reliable information we need. With this in mind, we recommend that generating stations start work on their procedures in advance of any change in fuel use or the generating station's equipment to ensure that an agreed FMS regime is in place prior to the period that the procedures will apply from. Please note that our review of FMS procedures cannot commence before the proposed FMS procedures are submitted to us.

2.16 While we undertake reviews promptly when an FMS questionnaire is submitted to us, the time a questionnaire is with the operator, awaiting comments from us to be addressed can vary. To ensure agreement is reached as swiftly as possible it is important to ensure that the first submission of FMS documentation is of high quality and during the review process comments are addressed by the applicant promptly and comprehensively. Each FMSQ has an associated guidance note, which operators may find helpful when completing their first submission. We would also encourage participants to fill out and submit our published 'Covering form for amended Fuel Measurement & Sampling (FMS) Questionnaires'47 which will assist us in navigating through any changes to the FMS documentation.

2.17 Operators wishing to change agreed FMS procedures should provide us with as much notice as possible to avoid an interruption in the issuance of ROCs. Where procedures are revised or new fuels are added, and these changes have already taken effect at site, certificate issue is generally suspended while suitable procedures are being agreed.

General Principles

2.18 FMS procedures for a generating station may be required to determine the quantity of a fuel, its energy content, the energy contribution of any fossil-derived contamination and accounting for any end of month stock carryover. As

47 https://www.ofgem.gov.uk/system/files/docs/2020/07/covering_form_for_amended_fmsqs.docx

certificates are issued on a monthly basis, FMS procedures must also be able to provide the data required for ROC issue each calendar month.

2.19 One of the fundamental principles of FMS is that the procedures allow a generating station to fully meet the requirements of Article 80(6) in the ROO 2015 (as amended), Article 36(4) of the RO(S) 2009 (as amended), and Article 34(6) of the NIRO 2009 (as amended), in that they will be able to provide us with "accurate and reliable" information. We will work with operators as closely as possible to ensure that FMS procedures meet this requirement, but the onus for the development of suitable procedures ultimately lies with the generating station.

2.20 If operators of generating stations propose to sample and measure fuels according to a recognised standard, they should refer to that standard (or relevant part thereof) in their proposed FMS procedures. The FMS questionnaire should detail how these procedures will be carried out in practice.

2.21 There are circumstances where an operator may need to use estimated values as part of their monthly ROC claim such as where in each month it has not been possible to carry out agreed FMS procedures. In these situations, we will assess how estimates, rather than actual measurements will allow an operator to provide accurate and reliable information. Generating stations will be expected to clearly outline why the use of estimates is necessary. Applications by operators to use estimated data will be reviewed case by case.

2.22 In order to avoid the need for estimated data cases, operators should consider how they might verify the results of their measurement techniques and whether they may want to consider using a second method of measurement at the stage of agreeing FMS procedures. This may be particularly important should measurement uncertainty be considered high.

2.23 Traditionally the measurement and sampling of fuels has taken place on-site, at the generating station (with samples usually analysed at a laboratory off-site). Article 80(7)[48] of the Orders however recognises that measurement and sampling may be conducted off-site. If considering off-site sampling further

[48] Article 36(5) of the RO(S) 2009 (as amended) and Article 34(7) of the NIRO 2009 (as amended).

information can be found in Appendix 11. This approach may not be appropriate for all instances.

2.24 We rely on industry to lead the way in piloting new and improved FMS procedures. Where we can, we are happy to assist operators in the development of their FMS procedures. However, generally we look to industry to utilise its expertise and resources to continually improve FMS standards and set the benchmark for good practice.

Sustainability

2.25 The requirements of the FMS process are to agree suitable procedures for the issue of ROCs, as well as to fulfil the sustainability reporting requirements that apply to the fuel(s) used at a generating station.

2.26 The sustainability criteria consider the land from which the biomass is sourced, as well as the life-cycle greenhouse gas (GHG) emissions associated with the biomass. Detailed information on the criteria can be found in our 'Renewables Obligation: Sustainability Criteria' guidance document.

2.27 Generating stations which have a DNC (Declared Net Capacity) of less than or equal to 50kW, only using solid biomass and/or biogas to generate electricity are exempt from providing sustainability information and thus do not need FMS procedures that consider sustainability reporting requirements.

2.28 This exemption also applies to generating stations using only sewage and/or landfill gas to generate electricity.

2.29 Generating stations using bioliquid fuels and stations greater than or equal to 1MW using solid biomass and/or biogas fuels to generate electricity, must meet the sustainability criteria to be eligible for ROCs. Any generating stations using solid biomass and/or biogas between 50kW and 1MW need to report on the criteria to the 'best of their knowledge and belief',49 but this does not link to ROC issue.

[49] For solid and gaseous biomass see Article 82 of the RO, Article 54 of the ROS and Article 46 of the NIRO Orders. 46 Article 82 of the ROO, Article 54 of the ROS, and Article 46 of the NIRO for solid biomass and biogas. Article 61 of the ROO, Article 22A of the ROS and NIRO for bioliquids.

Reporting by consignment

2.30 The Orders require operators to report per consignment of biomass.46

2.31 In determining what constitutes a consignment, the classification of a fuel must be taken into consideration (such as waste or residue) as well the performance of the fuel against the sustainability criteria. These factors, which are used to determine what constitutes a consignment, are considered as the "sustainability characteristics" of the fuel. A full list of the sustainability characteristics as well as more information on determining a consignment can be found in Chapter 5 of our 'Renewables Obligation: Sustainability Criteria' guidance document.

2.32 As part of the FMS process, we require operators to consider whether they are using multiple consignments and whether there is any mixing of these consignments at the generating station or in the supply chain, including mixing with any fossil fuel.

2.33 Reporting on the sustainability for each consignment of fuel is mandatory and as such, where consignments are mixed, operators need to implement a system to track individual consignments and the associated sustainability information.

2.34 Where bioliquid consignments have been mixed, the Order specifies that a mass balance system must be used when withdrawing an amount of bioliquid from the mixed consignments.50 We recommend a mass balance system is used where any biomass consignments have been mixed, irrespective of whether it is in the liquid, solid or gaseous state.

2.35 Should an operator wish to use a system other than mass balance to track consignments and associated sustainability information, they will need to outline the suitability of the alternative system, particularly where mixing of consignments with fossil fuel and/or consignments that are contaminated with fossil fuel takes place. This is important as we can only issue ROCs on generation occurring from renewable sources.

2.36 For stations using only waste fuels for electricity generation, please see paragraph xxx on audit requirements.

[50] Article 61 of the ROO, Article 22A of the ROS and NIRO Orders.

AD and ACT generating stations

2.37 For stations using liquid or gaseous final fuels produced by either the gasification, pyrolysis or anaerobic digestion of feedstock, sustainability characteristics are passed from the feedstock to the final fuel. A feedstock consignment consists of any feedstocks that have identical sustainability characteristics. A consignment of final fuel is derived from a feedstock consignment.

Generating stations with a TIC less than1MW

2.38 Generating stations with a DNC less than or equal to 50kW (i.e. microgenerators) remain exempt from sustainability reporting for solid biomass and biogas and therefore these operators can remain on a 'simplified' FMS regime as they will not need to report their fuels per consignment.

2.39 Generating stations with a DNC of greater than 50kW but a TIC of less than 1MW, using solid biomass and biogas will be required to report against the sustainability criteria. However, they will not be required to submit an annual sustainability audit report to verify sustainability information provided to us.

2.40 For generating stations using bioliquids, as per the existing legislative requirement, there is no lower capacity threshold for reporting and therefore all bioliquids must be reported on a per consignment basis and must have the appropriate FMS procedures in place to allow for this.

Reporting by consignment on biomass pellets

2.41 We recognise that biomass pellets can be made from multiple types of biomass with differing sustainability characteristics. We will work with operators during the FMS review process to develop appropriate procedures to report on a consignment basis.

Use of biomass pellet binders

2.42 Reporting by consignment is key to ensuring the correct information is supplied to us for fuels used by operators at a generating station. In order to report per consignment of biomass, it is recognised that binders used in biomass pellets may have differing sustainability characteristics to that of the biomass making up

the bulk of the pellet. The legislation states[51] that up to 2%, by weight, of solid biomass material, for binding or other performance purposes, will be considered to have the same sustainability characteristics as the rest of the pellet. Therefore, any binder with up to 2%, by weight of solid biomass material, does not require a separate reporting procedure for sustainability purposes and will not be required to have a separate entry on the RER.

2.43 Operators are required to declare (through their FMS questionnaire) the percentage contribution, by weight, of the binder to the biomass pellets.

2.44 Additional information will need to be submitted to support this statement. This can be in the form of a fuel specification, contract or letter, on headed paper, from the fuel supplier. The percentage contribution must be stated explicitly on whichever form of evidence is submitted.

2.45 Where the binder is greater than 2% by weight of solid biomass material, operators will need to report separately on the sustainability characteristics of the binder and will require a separate entry on the RER. This will be based on the whole contribution of the binder and not just that over 2%. We recognise that the percentage contribution of binders to the fuel are typically low. Therefore, if appropriate information is provided (see paragraph 3.44) to demonstrate the maximum possible contribution (by weight of the binder to the fuel, along with the corresponding GCV of the binder) this information can form the basis of FMS procedures for this particular consignment of pellet binder. These values will be those used as entries on the RER, to report the binder as a 'separate fuel'. If operators cannot provide supporting information about the binder's contribution (mass and GCV) to the fuel, these values will need to be determined by measuring and sampling.

2.46 For more detailed information regarding the sustainability requirements, mass balance, and how a consignment can be determined, please refer to our 'Renewables Obligation: Sustainability Criteria' guidance document.

Mass or Volume measurement in the month of use

2.47 Measuring the mass or volume of biomass used in a month is needed to form part of the ROC calculation for the majority of stations. It is also important for

[51] Schedule 3(7) of the ROO 2015 (as amended), Schedule A2(7) of the RO(S) 2009 (as amended) and Schedule A2(7) of the NIRO 2009 (as amended).

supporting the sustainability reporting requirements. This means that the mass or volume of any stocks carried over from the previous month must also be measured. To accurately measure the amount of biomass used for electricity generation in a month, mass or volume measurements must relate to the month of use.

2.48 A strict interpretation of the requirement to account accurately for the mass or volume of biomass used within a month would mean that measurements would have to be taken at the stroke of midnight on the last day of each month. We realise that there are practical implications for some generating stations in achieving this. We will therefore accept measurements taken within 12 hours before or after midnight on the last day of the month.

2.49 In deciding when to take mass or volume measurements of stock carried over from one month to the next, good practice would be to measure the fuel at the same time each month. While there is some flexibility, measurements should be taken at the same time each month so that ROCs can be issued for generation over the period of a month, for example at 9am on the first day of each month.

Excluding biomass not used for electricity generation

2.50 We can only issue ROCs for biomass used that has resulted in the generation of electricity. This is because, under the Orders, ROCs are issued to an accredited generating station for each MWh of electricity generated from renewable sources, provided that all relevant criteria have been met.

2.51 If the generating station is on hot standby, is being tested or there is a cancelled start, it is unlikely that electricity has been generated. Any biomass used in these situations, or any other in which biomass is consumed without the generation of electricity, must therefore be measured and deducted from the total quantity of fuel recorded within data submissions.

Sampling fuels for energy content

2.52 Sampling is required to determine the energy content of a fuel. This is needed for each fuel used which forms part of ROC issue calculations. Samples taken must be in sufficient quantities for analysis, and representative of the fuel used in that month.

2.53 The approach that should generally be used when developing a robust sampling regime is to:

Step 1: Take a series of incremental samples.

Step 2: Combine these to form a composite sample.

Step 3: Extract a representative sub-sample of the composite sample for analysis.

2.54 Some factors that can affect the precision and accuracy of sampling are:

- fuel homogeneity,
- the size of the sample relative to the whole,
- the number of increments taken during the sampling period to produce a composite sample,
- the method used to extract the sample,
- the location of sample extraction. It is generally expected to be as close to the point of combustion as possible, and
- the method used to extract a sub-sample from the composite sample for subsequent analysis.

2.55 Standards are available which outline recognised good practice for extracting samples and forming composites for biomass and waste fuels. A sample of these standards can be found in Appendix 12.

Frequency of sampling

2.56 To ensure that ROCs are issued for fuel used in the month, the energy content reported within monthly data submissions must relate to the fuel used in that month. This means that fuel sampling is required within the month of burn. This may include both sampling from the fuel delivered that month as well as re-sampling stock carried over from deliveries in previous months.

2.57 Where sampling is required, samples are usually taken either from each delivery or from the fuel stream immediately prior to combustion. Operators can also propose other sampling intervals, for example once per day, providing it can be demonstrated that this frequency is able to provide accurate and reliable results.

2.58 When considering how frequently to take samples, generating stations should consider factors such as how consistent the GCV of their biomass fuel is, how many fuel sources they have and how much biomass they are using.

Weighted averaging

2.59 Good practice when calculating the average GCV of a number of composite samples is to use a weighted average.

Contamination

2.60 Generating stations must determine the level of any fossil-derived contamination in a fuel, as this will affect the calculation of the quantity of electricity generated from renewable sources. Operators must:

- identify all possible contaminants.
- put in place preventative measures to reduce the potential for contamination, where possible.
- measure contamination (as a percentage contribution to the total energy content of the fuel).

2.61 In some cases, it will be possible for a generating station to ensure that the fuel they are using does not contain contamination by putting a robust fuel specification in place. Further information regarding the format and content of fuel specifications is provided from section 2.71 of this chapter.

2.62 Please note, in the context of FMS, the term 'contamination' refers to fossil fuel and fossil derived elements which contribute to the calorific value of the fuel. Inert materials, e.g., stones, pieces of metal etc., are not considered as contaminants for FMS purposes. For further information on methods for determining contamination in fuels, please refer to Appendix 10.

Carbon-14 analysis

2.63 One of the ways to determine contamination is using Carbon-14 (14C) analysis of fuels, feedstocks or flue gases. This shows the biogenic energy content of the fuel used to generate electricity.

2.64 Operators are welcome to propose the use of this method and we have provided a bespoke FMS questionnaire for applicants wishing to use this technique. This should be completed alongside the questionnaire appropriate for the generating station since the ^{14}C method will only provide a figure of contamination and not, for example, the mass/volume of fuel used.

2.65 When proposing to use ^{14}C analysis as a technique to ascertain biomass energy content of a fuel, the applicant should make sure that it is an appropriate test to

use given the fuels used at the generating station. If testing feedstocks or fuel using the ^{14}C approach applicants should make sure that a representative sample can be taken and analysed.

2.66 We would like to emphasise that generators are under no obligation to use the ^{14}C technique and that this technique is not applicable in all circumstances. We will continue to consider proposals using alternative methods used by industry. Refer to Appendix 10 for more information on how to determine levels of fossil-derived contamination within fuels.

Storage

2.67 Where fuels are not sampled immediately before combustion, we need to be sure that what is sampled actually reflects what has been combusted. Fuel deterioration and storage should be considered. Where deterioration occurs, the original sample taken will no longer reflect the properties of the fuel combusted. It is also important that the risk of contamination during storage e.g. through contact with fossil fuels, is minimised.

2.68 The length of time a fuel spends in storage should also be considered. Each fuel must be accurately and reliably measured and sampled in the month in which it is used. This means that fuels can be kept for long periods, even if they deteriorate, as long as they are measured and sampled in the month of use

Stations using only 100% biomass fuels

2.69 Where generating stations are only using fuel(s) that are 100% biomass, i.e. where there is no fossil fuel contamination and no fossil fuel is being used, simplified FMS procedures can be implemented. While it is clear that where only 100% biomass fuels are used, all of the net electricity generated is attributable to biomass, determining the quantity and GCV52 for each consignment of fuel is important for the purposes of sustainability reporting.

2.70 We will also need to be certain that each consignment of fuel(s) being used is 100% biomass and therefore free from fossil fuel contamination. This may be evidenced by contract(s), suitably robust fuel specification(s) or letter(s) from

[52] For stations using only 100% biomass fuel(s), and where the station as a whole using is 100% biomass, determining the energy content of the fuel(s) used may be done using literature values rather than direct sampling. It will be our decision as to whether this approach is appropriate and will be determined case by case.

the fuel supplier (see Appendix 2 for more details). Any correspondence from a fuel supplier should be on headed paper.

2.71 Whether providing contractual information, a fuel specification or supplier letter we would expect the document to:

- confirm the name of both the supplier and generating station,
- provide dates,
- provide details of the fuel purchased,
- confirm that 'the fuel is 100% biomass and free from fossil fuel and fossil-derived contamination'.[53]

2.72 Where generating stations choose to purchase fuels on the spot market rather than by agreeing a long-term contract with a fuel supplier, they need to either confirm in writing that they require all their fuel suppliers to meet this specification or provide a separate specification for each consignment of fuel.

2.73 For information on FMS procedures for AD, please refer to paragraph 2.127 of this chapter.

FMS Procedures for stations using waste

2.74 Where a fuel does not meet the definition of biomass, for the purpose of ROC issue it is classed as a 'waste'. The biogenic content of wastes can be awarded ROCs under various ROC bands, dependent on the other fuel(s) used at a generating station or technology employed.

2.75 There are certain arrangements for stations using waste fuels, as set out in the Orders.54 ROCs cannot be issued to any generating station for electricity generation attributable to "non-renewable waste" i.e. waste that derives more than 90% of its energy content from fossil fuels.55

2.76 ROCs cannot be awarded for electricity generated from fossil fuel or fossil-derived material. The operator must be able to account for this. The Orders56 determine that the fossil fuel proportion (which, as with any other fuel needs to

[53] See Appendix 2 – 100% biomass example evidence for further details.
[54] Article 5 of the ROO 2015 (as amended), Article 3 of the RO(S) (as amended) and NIRO 2009 (as amended).
[55] As outlined in Article 5(1) of the ROO 2015 (as amended), Article 3(1) of the RO(S) (as amended) and NIRO (as amended).
[56] Article 5(2) of the ROO 2015 (as amended), Article 3(2) of the RO(S) 2009 (as amended) and NIRO 2009 (as amended).

be known for the purposes of the ROC calculations set out in the Orders57) of a waste fuel is to be determined by us. The Article clearly states that the fossil fuel proportion of a waste fuel must be determined by its percentage contribution by energy content.[58]

2.77 The onus for the production of suitable FMS procedures lies with the operator, however, we can look at any source of information that may be used to determine the fossil-derived content within the fuel (whether or not this information has been provided by the operator[59]).

2.78 We will need to be satisfied regarding the appropriate classification of any fuel in relation to the relevant reporting and audit requirements. At this stage stations using only waste which does not meet the definition of biomass are not required to submit an annual sustainability audit.

Municipal waste

2.79 The Orders show specific provisions where municipal waste is used at a generating station. Municipal waste is defined in the Waste and Emissions Trading Act 2003 as:

- waste from households, and
- other waste that, because of its nature or composition,[60] is similar to waste from households.

2.80 It is clear from this definition that, where a generating station uses household waste only, this waste can be viewed as 'municipal waste' within the requirements of the Orders.

2.81 Where an operator wishes to use a mixture of household waste and other waste ('mixed waste'), for the purposes of the municipal waste provisions, we will need to be satisfied that all of this mixed waste can be regarded as municipal waste.

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[57] Articles 29 and 30 of the ROO 2015 (as amended), Articles 25 and 26 of the RO(S) 2009 (as amended) and Article 23 and 24 of the NIRO 2009 (as amended).
[58] A special exception to this is detailed within the legislation relating to an AD generating station using sewage and non-sewage feedstocks within the digester. This is explained further in section 3.288-3.2829 of the document.
[59] Article 85 of the ROO 2015 (as amended) and Articles 3(3) and (4) of the RO(S) 2009 (as amended) and NIRO 2009 (as amended).
[60] "Composition" is not defined in the Orders, but this could refer to factors such as the GCV of the two streams, the contribution of different primary categories (paper, plastics etc.) to the two streams or other factors.

2.82 We will use the Department of Environment, Food and Rural Affairs' (Defra) interpretation of municipal waste given in its Consultation on Meeting European Union Landfill Diversion targets to assess what constitutes municipal waste, as well as the definition above.[61]

2.83 The Defra Guidance regards waste as meeting the definition of municipal waste when it falls into specified categories of the List of Wastes (formerly known as the European Waste Catalogue). This List of Wastes is provided in the Defra Guidance and outlines those wastes that should and should not be classed as municipal waste.

Deeming the renewable energy content of municipal waste

2.84 Where a generating station is utilising municipal waste, it has the option to use literature-based evidence to demonstrate that the fossil fuel content of the stream is unlikely to exceed 50% (and as such the renewable energy content of the waste stream is at least 50%). Only relevant and up-to-date evidence produced from an allocating body, waste disposal authority or waste collection authority, is suitable for this purpose. Evidence of direct sampling carried out at a generating station can also be used. If such evidence is provided and considered acceptable by us, the generating station can deem the renewable content of the municipal waste at 50%.

2.85 This evidence will relate to waste received at the station prior to any processing. Where the municipal waste has been processed before use, this may have materially increased the proportion of fossil-derived materials within it. A generating station may opt to separate and remove certain parts of a municipal waste stream prior to using the remaining fuel for electricity generation or an operator may decide to remove certain materials that are likely to have a high biomass content so that these materials can be recycled.

2.86 Where processing has taken place, we would look firstly for a generating station to provide an explanation of the process. We would then look to the operator to demonstrate that, in spite of the process taking place, the fossil fuel proportion of the waste is still unlikely to exceed 50%.

[61] Contact Defra for further details on this guidance: www.defra.gov.uk

Monitoring changes in waste stream composition

2.87 Operators must ensure that changes in the nature and composition of a waste stream are monitored and, where necessary, revised FMS procedures or data sets are agreed and then followed. This is particularly important where an operator has based their FMS regime on literature data rather than a sampling procedure.

2.88 There may be circumstances where a generating station becomes aware of a significant change which will have a material impact on the percentage energy content of the stream that is attributable to fossil fuel, in the composition of its waste stream. In this instance we would expect the operator to inform us of this change at the time and review its FMS regime accordingly.

Using tyres as a fuel

2.89 If a generating station uses tyres as its sole fuel source it could only qualify for support under the RO in any month where biomass accounts for at least 90% of the energy content of the tyres used. Where this is not the case, the tyres would need to be used as a fuel within a qualifying CHP generating station or as a feedstock in an ACT station. See Chapter 1 for further information on qualifying CHP generating stations and ACT generating stations.

2.90 In either of these scenarios the operator would need to agree FMS procedures with us to accurately determine the energy content of the biogenic fraction of the tyres combusted, within each month.

FMS procedures for stations using waste wood fuel

2.91 Generating stations wishing to use waste/recycled wood for generation will need to undertake measurement and sampling on a monthly basis. This is to determine any fossil fuel derived contamination within the fuel (which could be present as a result of the previous use of the material).

2.92 Typically, this contamination may come from paints, preservatives, adhesives and binders. Although contamination will typically be in low quantities, its contribution to energy content will need to be determined and deducted from ROC issue. This is a requirement of the Orders.[62]

[62] Article 29 of the ROO 2015 (as amended)

2.93 When using this type of fuel, operators can develop their own way of determining the fossil fuel or fuel-derived contamination. This will be considered by us case by case. Some approaches currently used by industry are:

2.94 the selective dissolution method, and

2.95 a lab and calculation-based method approved by us based on using standard values for common contaminants.

2.96 It can be hard to visually detect and separate contamination in this form, so manual sampling is not a suitable practice with respect to FMS.

2.97 For further information regarding the selective dissolution and manual sampling methods, see Appendix 6 of this document. For further information on the lab and calculation-based approach, please consult the Renewables Obligation: template methodology for measuring fossil-derived contamination within waste wood guidance note.

FMS procedures for Advanced Conversion Technologies (ACTs)

2.98 As outlined in Chapter 1, gasification and pyrolysis technologies are ACTs.

2.99 The biomass sustainability criteria require operators to report per consignment of final fuel. A consignment of final fuel is derived from a feedstock consignment.

2.100 To determine the consignments of final fuel produced by gasification or pyrolysis, operators need to measure and sample the feedstock consignments.

2.101 Using feedstock classified as waste[63] will result in the consignment of final fuel derived from the waste to be exempt from reporting sustainability information. An operator using such fuels for generation will still be required to report monthly on the quantity, GCV and contamination (where appropriate) of the fuels.

Banding provisions for ACTs

2.102 ACTs receive ROCs under the RO through the 'standard gasification/pyrolysis' or 'advanced gasification/pyrolysis' bands. Qualification for these bands is based on the GCV of the final fuel produced and the GCV requirements for these bands are outlined in Table 2.2 below.

[63] Article 2(1) of the ROO 2015 (as amended)

Table 2.2: GCV requirements

Type of Advanced Fuel	GCV requirement[64] for standard gasification/pyrolysis	GCV requirement advanced gasification/pyrolysis
Liquid Fuel	less than 10 MJ/kg	Greater than or equal to 10 MJ/kg
Gaseous Fuel	Greater than or equal to 2 MJ/m3 & less than 4 MJ/m3	Greater than or equal to 4 MJ/m3

2.103 For the level of ROCs/MWh associated with both of these bands for generating stations accredited prior to 1 April 2013 and generating stations accredited on or after 1 April 2013 please refer to Appendix 3. For generating stations or additional capacity accredited on or after 1 April 2013 the 'standard gasification/pyrolysis' and 'advanced gasification/pyrolysis' bands are supported at the same number of ROCs/MWh.

ACTs accredited on or after 1 April 2013:

2.104 Generating stations accredited on or after 1 April 2013 using ACTs may be eligible for one of the 'standard gasification/pyrolysis' or 'advanced gasification/pyrolysis' bands each month. Eligibility for these bands require that either a waste and/or biomass feedstock is used, either directly or indirectly, to produce a liquid or gaseous fuel by means of gasification or pyrolysis (both of which are defined in Article 2 of the Orders).

2.105 For gaseous fuels produced from gasification or pyrolysis, eligibility for support under the RO in any month depends on the fuel having a GCV of at least 2 MJ/m3. The operator must measure the GCV of the gaseous fuel that is used to generate electricity, at the inlet to the generating station, each month. This is to demonstrate eligibility for either the 'standard gasification/pyrolysis' or 'advanced gasification/pyrolysis' band in a given month. This measurement must provide a representative GCV of the fuel produced each month. How this is undertaken will be agreed with us through the FMS review process.

2.106 There is no minimum GCV requirement for liquid (bio-oil) fuels produced by means of gasification or pyrolysis in order to qualify for the 'standard

[64] All GCV requirements must be measured at 25°C and 0.1 megapascals.

gasification/pyrolysis' band. Any generating stations wishing to claim under the 'standard gasification/pyrolysis' or 'advanced gasification/pyrolysis' bands will have to demonstrate at the time of accreditation that they meet the definition of gasification or pyrolysis as set out in Article 2 of the Order. We have produced a dedicated FMS questionnaire for gasification and pyrolysis generating stations to complete when submitting FMS procedures to us.

2.107 As stated above, for gaseous fuel produced by gasification or pyrolysis the operator needs to demonstrate that the GCV of the gaseous fuel (syngas) produced is at least 2 MJ/m3 each month. To ensure that this requirement is met, operators using gasification or pyrolysis technologies to produce a syngas will need to include specific procedures within their FMS regime to outline how the GCV of the fuel used for electricity generation will be measured.

2.108 These procedures will also need to explain how the GCV will be measured at, or normalised to, the specific temperature and pressure conditions detailed in the Orders65. FMS procedures should be submitted via the gasification and pyrolysis FMS questionnaire. Some established techniques for the measurement of the GCV of gaseous fuels produced from ACTs are outlined below.

2.109 Due to the potential for fluctuations in the GCV of the syngas produced over a generation month, we consider that the best means to obtain an accurate figure for the average GCV of the syngas produced is to use an analyser to sample the gas at frequent intervals. The average of the results over the month can then be calculated to determine the most representative GCV for the syngas produced. We do not specify suitable analyser technologies, although we require a technical specification of the technology to be used when applying for full accreditation.

2.110 We do not specify a set frequency at which samples are to be taken by the analyser, although generating stations are required to outline the frequency with which samples are taken within their FMS procedures. Analysers must be located at the inlet to the generating station i.e. immediately before the point of generation, as specified in the 'standard gasification/pyrolysis' and 'advanced gasification/pyrolysis' definitions in the Orders.66 Generating stations should

[65] Schedule 5 of the ROO 2015 (as amended), Schedule 2 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended).
[66] Schedule 5 of the ROO 2015 (as amended) Schedule 2 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended).

provide us with suitable evidence of the location of the analyser e.g. a schematic diagram with the sampling location highlighted.

2.111 Although the use of an analyser is considered best practice, another alternative available to operators is to undertake monthly bag sampling of the syngas produced and have these samples analysed for GCV using an appropriate standard test in an accredited laboratory. The test to be undertaken should be clearly stated in FMS procedures. The number of bag samples to be taken per month will be agreed with us case by case. We will require more frequent sampling if the predicted GCV of the syngas is close to the 2MJ/m3 threshold. The average of the bag sample results over the month can then be taken to produce a GCV.

2.112 As bag sampling frequency is typically lower in number compared to an analyser, we require the station to undertake a back calculation of syngas GCV (at the temperature and pressure conditions stated in the Orders[67]). This should be at more frequent intervals based on input data including the gross output of the generator, volume, temperature and pressure of the syngas at the inlet of the generating station and the efficiency of electricity generation. The operator should provide details of how the data for such a calculation is to be collected, as part of the FMS review process, alongside evidence for any fixed values used in the back calculation. The results of this analysis can be used to support the bag sample GCV result produced.

2.113 If this option is selected, the results from both the average of the bag samples analysed in the month and the average GCV from the back calculation undertaken must both be at least 2 MJ/m3 to demonstrate eligibility for support under the RO with the lower of these two values being entered into the Fuel Measurements page of the RER each month. As the definitions for the 'standard gasification/pyrolysis' and 'advanced gasification/pyrolysis' bands in Schedule 5 of the ROO 2015 (as amended) require the GCV of the syngas to be measured at the inlet to the generating station to meet a threshold GCV level, back calculations alone, without frequent gas bag sampling, are not suitable for FMS purposes.

[67] Schedule 5 of the ROO 2015 (as amended), Schedule 2 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended)

2.114 Operators are welcome to propose alternative means of measurement which involve gas sampling at the inlet to the generating station. We will review each proposal case by case to assess their ability to provide a representative GCV for the syngas produced over a month.

ACTs accredited before 1 April 2013:

2.115 ACT stations accredited before 1 April 2013 are also supported under the 'standard gasification/pyrolysis' or the 'advanced gasification/pyrolysis' bands defined in the Orders.68. Support under these bands requires the operator to measure the GCV of the syngas or pyrolysis oil used to generate electricity to determine which band they will receive. The GCV requirements to qualify for each band are shown in Table 3. There is no change required to FMS procedures agreed for ACT generating stations accredited prior to 1 April 2013. However, the 2013 amendment Order enables those stations using a liquid fuel to receive ROCs where the GCV is less than 10 MJ/kg.

Volume

a. ACT generating stations are required to input the volume of syngas or bio-oil combusted in a month on the RER when making monthly data submissions. As per other fuels this is to support the requirements for sustainability reporting. We will discuss with operators as regards the exact requirements for each individual station at the time of application.

Determining the renewable content of the fuel

2.116 With ACT generating stations, the fuel in its final form is considered to be the syngas or bio-oil. In keeping with Articles 29 and 3069 of the Orders, where contaminated feedstocks are used to produce the final fuel, generating stations will be required to determine the qualifying percentage of this fuel, i.e., the percentage of the fuel's total energy content which is derived from renewable sources and therefore eligible for ROCs.

[68] Schedule 5 of the ROO 2015 (as amended), Schedule 2 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended)
[69] Articles 25 and 26 of the RO(S) 2009 (as amended) and Articles 23 and 24 of the NIRO 2009 (as amended)

Feedstock

2.117 There will be limitations to analysing and determining the renewable content of a final fuel produced via gasification or pyrolysis. In order to overcome these, we have agreed FMS procedures put forward to us by operators where the initial feedstock, rather than the final fuel, is analysed for contamination.

2.118 In the case of a generating station using an ACT to convert feedstock into a fuel, the operator is required to determine the proportion of the fuel that is derived from biomass and the proportion that comes from fossil-derived sources by energy content. This will involve analysis of the initial feedstock used to generate the syngas, e.g., recycled wood or SRF.

2.119 The information required to determine the contamination of the feedstock using this method on a monthly basis would be:

- mass of feedstock utilised,
- GCV of feedstock, and
- fossil-derived contamination percentage.

2.120 The information provided in this chapter of the guidance document and appendices will aid the development of suitable FMS procedures to obtain this information for the feedstock. Appendix 10 in particular relates to determining the contamination percentage of waste wood and solid recovered fuels (SRF).

Char

2.121 ACT FMS procedures we have agreed have also accounted for the char that is produced as a part of the gasification and pyrolysis process. This is a necessary consideration because some of the energy content within the initial feedstock is transferred to the char rather than the syngas. The energy content within this char does not contribute to electricity generation and must therefore be deducted in some way from the remainder of the energy content that (setting aside the consideration of any heat losses) is held within the syngas.

2.122 Key information to be determined by FMS procedures for the char is:

- mass char produced, and
- GCV of char produced.

2.123 Operators will also need to take into account the origins of the energy content held by the char, i.e., whether the char's energy content derives from the

biomass or fossil fuel elements of the initial feedstock. To date, due to a lack of established analysis techniques to ascertain this information, we have agreed to an assumption with generating stations whereby it is assumed that 100% of the energy content of the char is derived from biomass.

2.124 Where possible we encourage industry efforts in identifying another way for operators to assess the relative biomass and fossil derived content of char.

Uncontaminated feedstock

2.125 Where the initial feedstock does not contain fossil-derived contamination, for example virgin wood, contamination analysis of feedstock and char is not required.

Overall contamination percentage

2.126 Once the data above has been obtained the overall contamination percentage can be calculated. This is the figure required to be submitted on the RER. The calculation is outlined in Table 2.3.

Table 2.3: Overall contamination percentage calculation

Initial calculations
A. Total energy content of feedstock = ∑(Mass x GCV for each consignment)
B. Total fossil-derived energy content of feedstock: ∑(Contamination percentage of each consignment) × A.
C. Total biomass energy content of all consignments of feedstock: ∑(Biomass percentage of each consignment) × A.
D. Energy content lost as char (assumed 100% biomass): Mass of char × GCV of char.

Step	Calculation
1.	A – D = E, where E = Total energy transferred to syngas
2.	E – B = F, where F = Total eligible energy in the syngas
3.	(F ÷ E) × 100 = G, where G = percentage biomass energy to syngas
4.	100 – G = H, where H = per cent fossil-derived energy in feedstock and percentage of generation occurring from fossil sources. Thus, figure for H is to be submitted on the RER

2.127 We are aware that this calculation may appear complex. We are happy to discuss it in more detail with operators once an application for the RO has been submitted and FMS procedures are being developed for a particular site.

FMS procedures for AD

2.128 Operators of AD generating stations need to measure and sample their final fuel (biogas) to determine the quantity and GCV of the fuel for reporting and ROC issue purposes. Information on common practices for doing so can be found in Appendix 9.

2.129 In addition, the biomass sustainability criteria require operators to report per consignment of final fuel. A consignment of final fuel is derived from a feedstock consignment.

2.130 To determine the consignments of final fuel produced by the anaerobic digestion process (biogas), operators need to measure and sample the feedstock consignments.

2.131 For stations with a DNC of greater than 50kW, using non-waste feedstock (other than animal manure or slurry) for the production of biogas, operators are subject to reporting on the land and GHG criteria and general profiling information reporting requirements. This includes the quantity of each consignment of feedstock used.

2.132 In Figure 2.1 below, he final fuel (biogas) for combustion is apportioned according to Consignment A and Consignment B.

2.133 The example shows how an operator can group feedstock with identical sustainability characteristics together to form Feedstock Consignment A (Maize crop from two different suppliers). Feedstock Consignment B represents those

feedstocks (pig manure and cattle slurry) which are exempt from reporting on the sustainability criteria.

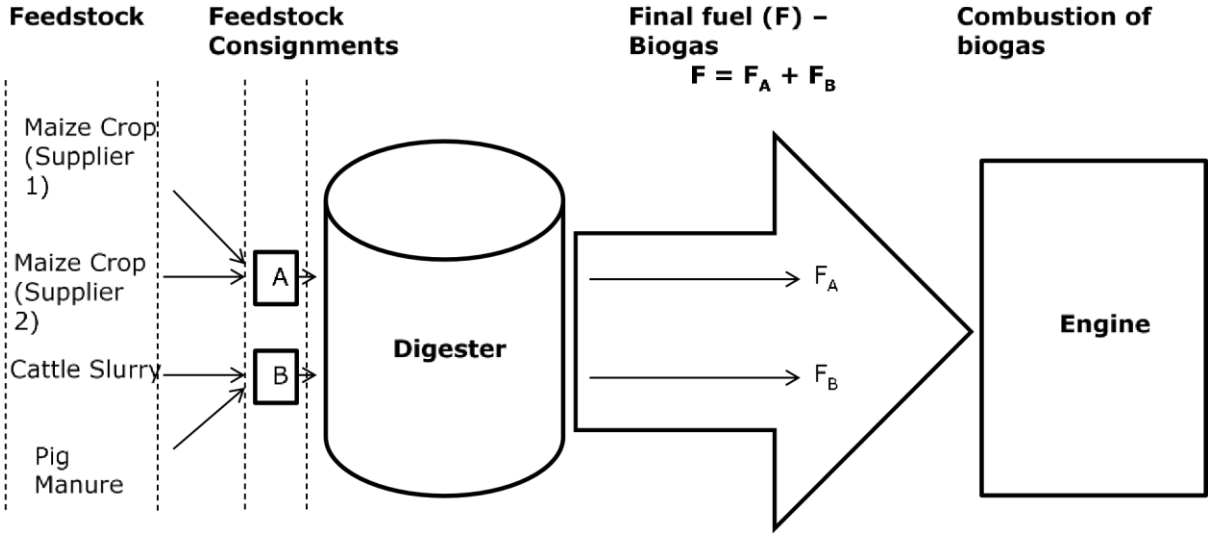

Figure 2.1: Example of how to apportion biogas derived from multiple feedstock consignments

2.134 The resulting final fuel (F), in this case biogas, can then be apportioned according to the consignments of the feedstock Consignment A and Consignment B. FA and FB would be represented in volumes and reported on the RER.

2.135 Operators of AD generating stations can use our 'Biogas Apportioning Tool' to apportion their resultant biogas. The tool requires the user to input the mass (dry or wet) of each feedstock used. Together with built in default literature data on biogas yield and moisture content, the tool calculates the contribution due from each feedstock by percent.

2.136 Operators are welcome to propose an alternative method to apportion their biogas.

Operators electing to use glycerol in their AD generating station

2.137 Operators proposing to use glycerol, in any process, will need to provide additional information regarding its process of production and the matter organic non-glycerol (MONG) content, along with any other fossil fuel or fossil-derived contaminants present in the feedstock. This information will be reviewed by us on a case by case basis.

Procedures for operators of AD generating stations with a DNC of less than 50kW

2.138 Operators of AD generating stations with a DNC less than or equal to 50kW will be required to complete certain sections of the AD FMS questionnaire. The exact instructions can be found on the questionnaire itself.70 As with any of the FMS procedures, where new feedstocks are used, the questionnaire will need to be revised and resubmitted to us.

Energy content measurement for AD plants using a combination of sewage and non-sewage material

2.139 Where a generating station uses AD to convert a combination of sewage and non-sewage material into a biogas, as described above, the Orders67 direct us to divide the total number of ROCs to be issued between the generation that is attributable to the sewage material fraction and the non-sewage material fraction.

2.140 This Article states that this division should be determined according to the dry mass of the sewage and non-sewage material. Therefore, a generating station using a combination of sewage and non-sewage material will not be required to sample either the biogas produced as a result of the AD process, or the initial feedstocks used for energy content.71 A station must measure the dry mass of the sewage and non-sewage material used on a monthly basis.

Energy content measurement for AD plants using fuel(s) alongside biogas to generate electricity

2.141 AD stations using a fuel, including fossil fuels, alongside the biogas will be required to agree FMS procedures with us so that ROCs can be allocated accurately against generation from biogas and that generated from the other fuel

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[70] Available from the Fuelled Stations and FMS homepage: https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro/information-generators/fuelled-stations-and-fms

[67] Article 31(3) of the ROO 2015 (as amended), Article 25(4) of the RO(S) 2009 (as amended) and Article 23(4) of the NIRO 2009 (as amended).

[71] Monthly data submissions for a combination of sewage and non-sewage material should apply a standard GCV value for both fuels to ensure that ROCs are split based on the dry mass of the materials. We suggest using a standard GCV value of 37.706 MJ/m^3, as per ISO 6976.1995. Generators seeking to apply this GCV value should include a comment to this effect within their FMS procedure.

(if appropriate). Stations will need to measure the volume and GCV of the biogas and the quantity and GCV of the other fuel(s).

FMS procedures for co-firing and conversion generating stations

Co-firing

2.142 For some generating stations, the co-firing ROC bands can apply unit-by-unit basis (see Appendix 3) rather than on a station-wide basis. Therefore, it is possible for a single generating station to be awarded ROCs under multiple co-firing ROC bands within a given month. This depends on the number of units at the generating station, the fuels used within each unit and their relative contribution to the total energy content of all the fuels used.

2.143 For co-firing generating stations with multiple units, we will agree FMS procedures in order to determine the following:

- the mass/volume of each fuel used in each individual unit in the month,
- the GCV of each fuel used in each individual unit in the month, and
- the mass/volume and GCV of any fossil fuel or waste used for permitted ancillary purposes used in each individual unit in the month.

2.144 Generating stations will also need to supply us with the number of units at a generating station so that these can be recorded within the RER for making certificate claims. Any plant or piece of equipment that meets the definition of a unit, and combusts fuels to generate electricity, should be declared. Even if only fossil fuel(s) are used in such a unit these may need to be reported on a monthly basis. This will be agreed as part of the FMS procedures.

Generating stations which only low-range co-fire

2.145 Where the biomass fuels used at the generating station are co-fired at levels which would receive support under the 'low-range co-firing' band (less than 50% biomass by energy content) in all units at the generating station, generators will be able to employ generating station-wide FMS procedures rather than those which provide fuelling data per unit.

2.146 In this case we will need written confirmation that the biomass combusted in each individual unit is less than50% by energy content of all fuels combusted in that unit. This can be done by completing the notification of low range co-firing

document which will be provided to generators by us.72 FMS procedures for the generating station cannot be approved until this document has been signed and returned to us. To withdraw this notification, document an application must be made in writing to us in advance. This application should:

- be completed on headed paper,
- be signed by the 'Super User' of the organisation's generator account on the RER where the accreditation details are held,
- name the generating station,
- specify the date from which this withdrawal is to take effect, and
- mention the date on which the earlier notification document was signed.

2.147 When we receive this application for withdrawing the notification document, we will assess whether this will require an update to the agreed FMS procedures.

2.148 Such a notification document gives us with the necessary assurance that we are issuing the correct ROC band(s) to generation in any month. Generators who believe this option is relevant to them are advised to contact us to discuss further. Where greater than or equal to 50% biomass by energy content is co-fired in one or more units at a generating station, or individual units are converted to 100% biomass, FMS procedures must be in place to provide individual unit fuelling data as outlined above.

Biomass conversion generating stations

2.149 The 'station conversion' and 'unit conversion' bands apply where either a whole generating station or individual unit respectively are converted to using only biomass/energy crop fuels. For these bands to apply, if any fossil fuel is used within the station or unit, it must be for permitted ancillary purposes and account for less than 10% of the total energy content of all fuels used in a month. The 'station conversion' band only applies to RFFSs as defined in Chapter 1.

2.150 If an individual unit meets the 'unit conversion' definition, but other units at the generating station are co-firing or using fossil fuel only, then an FMS will need to be agreed on to provide individual unit fuelling data.

[72] Article 81 of the ROO, Article 36 of the ROS and Article 34 of the NIRO Orders.

2.151 If a generating station meets the 'station conversion' definition, then FMS procedures will be able to be agreed on a generating station-wide basis. Where bioliquid fuels are used in such a generating station they would be supported under the 'station conversion' band.

2.152 However, if at any point such a generating station was to use fuels which do not meet the biomass or energy crop definition or use fossil fuels for reasons other than the permitted ancillary purposes, the relevant co-firing bands would apply and FMS procedures to provide individual unit fuelling data would be required to determine these.

2.153 If such a generating station was to use fossil fuels for permitted ancillary purposes only and these accounted for more than 10% of the energy content of all fuels used in the month, the 'station conversion' band would not apply and, as above, individual unit FMS procedures would be required to determine which of the co-firing bands would apply to each unit at the generating station. Where bioliquid fuels are used in either of these scenarios, generation from these would be supported under the 'co-firing of regular bioliquid' band.

2.154 For more information on how we expect data to be submitted for co-firing and conversion stations please see Chapter 3.

Stations with excluded/unsupported capacity

2.155 FMS procedures for stations adding excluded/unsupported capacity may need to be revised and agreed with Ofgem.

2.156 Fuel measurement data will need to be entered into the RER as part of your monthly data submissions for the entire capacity of the generating station. Where the excluded/unsupported capacity is separately metered, fuel use in the RO capacity must be reported separately to the fuel use in the excluded/unsupported capacity on the RER In these circumstances, the FMS procedures will need to be updated to account for this.

2.157 Please see the RO: Guidance for Generators (see Associated Documents) for more information.

3. FMS and Data Submission

Chapter summary

Provides information about submitting an FMS on the Renewable Electricity Register. Also shows the process for submitting monthly data and supporting information to us and how the submission of late or estimated data will be handled.

Overview

3.1 In order to claim ROCs, fuelled generating stations must submit information to us on a monthly basis about a station's electricity generation and fuel use.[73] Where a station is fuelled and has agreed FMS procedures with us, the results of these and supporting information (where required) should also be provided with the data submissions.

3.2 On the RER, FMS questionnaires may be uploaded to the Station application.

3.3 Each FMS submission must have a start date. Current FMS procedures will not have an end date while FMSs that have been superseded will show an end date.

3.4 These dates are linked to the data submissions for a relevant period, which will be affected accordingly if the FMS for the period is amended. For example, if output data has already been submitted for months where a revised FMS applies that has not been approved yet, it may cause output data to go into the status of Draft and flagged for Ofgem review.

3.5 If there is a historic FMS with similar fuels selecting "Clone existing FMS procedure" will allow the fuel details to be cloned to the currently proposed FMS. Any new fuels can then be added by clicking 'Add fuel'.

3.6 If there is no existing FMS to clone or the existing fuels are not being carried forward to the new/revised procedures, please click amend current FMS and add the fuels that you intend to submit reports under.

3.7 Once the FMS is approved, the status will change accordingly, and the operator will receive an FMS approval email notification. Please note that data cannot be submitted unless fuels have been set up under the period's FMS. Data that have

[73] If you are a microgenerator that submits information on an annual basis, then each reference to monthly in this chapter should be taken to mean annual.

been submitted for periods where the FMS has not been agreed yet will remain suspended. Following approval of the FMS, any relevant data submissions can be reviewed.

Monthly Data Submissions

3.8 The issue of ROCs requires operators to submit certain information to us on a monthly basis.

3.9 Data must be provided to us **before the end of the second month following the month of generation**. For example, if the month of generation was May 2016, data should be submitted by 31 July 2017 at the latest.

3.10 Information required as part of a fuelled station's data submission includes:

- electricity generation and use information,[74]
- the mass or volume of all fuels used (with relevant units of measurement),
- the GCV of all fuels used (with relevant units of measurement),
- the fossil fuel contamination percentage (by energy content) present within any biomass or waste fuels. If uncontaminated, '0' can be entered here,
- sustainability information on land and greenhouse gas (GHG) criteria against each renewable fuel/consignment and
- where fossil fuel has been used, confirmation whether this was for ancillary purposes.
- where there is excluded/unsupported capacity that is separately metered, the capacity type in which the fuel was used should be declared.
- where applicable, additional information regarding exceptional circumstances during generation for that month (for example downtime for maintenance).

Monthly data submissions for co-firing and conversion generating stations

3.11 Generating stations which have FMS procedures in place to provide individual unit fuel data are required to select 'Unit by Unit Fuel Data' on the fuel measurements page of the RER when making monthly data submissions.

[74] For more information on submitting the electrical aspects of your data claim, see the Guidance for Generators.

3.12 The number of units available for selection will match that provided to us. There will also be a question whether any fossil fuel used, is for permitted ancillary purposes, for each unit.[75] In calculating ROCs, the RER will determine a renewable qualifying percentage for each unit specified.

3.13 Co-firing and conversion generating stations which require station-wide FMS procedures should select 'Station Fuel Data'. Where this is the case the RER will not show the additional 'unit' column in the fuel measurement grid and will ask the permitted ancillary purposes question once in relation to the whole station. ROCs will be calculated based on a single renewable qualifying percentage as determined by the energy contribution of all renewable fuels used at the generating station.

Sustainability

3.14 As previously outlined, operators must provide information each month as part of their data submission to report against the RO sustainability criteria.

3.15 This information is used to determine whether ROCs should be issued for the use of that fuel based on whether the sustainability requirements were met. Meeting the criteria in order to obtain ROCs is applicable to operators using bioliquids and stations greater than or equal to 1MW using solid biomass and/or biogas fuels for electricity generation.

3.16 The operator does not need to provide supporting evidence to demonstrate compliance with the criteria each month, they only need to enter a response to the sustainability questions asked when submitting fuelling data. This evidence needs to be maintained for audit purposes.

3.17 For more information on the sustainability criteria, please refer to the 'Biomass Sustainability' section of our website where the 'Renewables Obligation: Sustainability Criteria' and 'Renewables Obligation: Sustainability Reporting' guidance documents can also be found.[76]

[75] Article 2(1) of the ROO 2015 (as amended), Article 22(3) of the RO(S) 2009 (as amended) and 21(3) of the NIRO 2009 (as amended).
[76] https://www.ofgem.gov.uk/environmental-and-social-schemes/renewables-obligation-ro/applicants/biomass-sustainability

Excluded/Unsupported Capacity

3.18 "Excluded capacity" means generating capacity which in Ofgem's view formed part of a generating station from a date no earlier than 1st April 2014, does not form part of the original capacity of the station, does not have registered additional capacity,[77] and is not an offshore wind turbine. Unlike the ROO and the RO(S), NI legislation does not define 'excluded capacity'. For clarity and consistency, we therefore refer to all capacity that is not eligible for NIROCs as 'unsupported capacity'.

Supporting information

3.19 It may be a requirement of the agreed FMS procedures for additional supporting information to be provided alongside each monthly data submission. Any omissions in the submitted supporting information that has been agreed with us may result in delays to processing certificate claims. Examples of supporting information which may be required from an operator are:

- A stock level spreadsheet detailing the opening and closing stock levels of each fuel used, incorporating any deliveries and/or transfers and clearly denoting any biomass used that did not result in the generation of electricity. A sample stock levels spreadsheet can be found in Appendix 5 of this document.
- A copy of a sample analysis sheet provided by a laboratory or a copy of sampling analysis output from a company database e.g. to determine the GCV or contamination percentage of a fuel.
- A spreadsheet with any additional calculations, such as those for liquid fossil fuels mixed with biomass fuels using the mass balance or marker methods.
- A spreadsheet including any special circumstances that the operator would like to be taken into consideration.

3.20 The supporting information required from a generating station on a monthly basis will be determined case by case, depending on FMS procedures agreed with us. We will notify the generating station at the time of FMS agreement of the supporting information that is required.

[77] Article 92 of the ROO 2015 (as amended)

3.21 Supporting information may be submitted with the fuelling data submission on the RER or via email if there any issues to: monthlyoutputdata@ofgem.gov.uk. The email should clearly state the name of the generating station (as it appears on the RER) and the month it relates to.

3.22 Generating stations must ensure the information they send to us is accurate and reliable. Operators should put in place checking procedures to ensure the accuracy of calculations.

3.23 The quantity of fuel(s) used should be given to an appropriate level of accuracy (typically two decimal places) whether the measurement is in tonnes or kg. GCVs should also be given an appropriate degree of accuracy (typically two decimal places) if provided in GJ/tonne, MJ/kg, kJ/kg (or equivalent) or Nm^3.

3.24 All calculations should be left unrounded. If operators choose to send us sampling analysis from a database rather than the original sampling analysis sheet, they should retain the original sampling analysis from the laboratory for audit purposes.

3.25 Please adhere to the following, in order to avoid delays with certificate issue:

- ensure all agreed information is provided,
- remove unnecessary information,
- highlight important figures in bold, e.g. those submitted on the RER,
- retain formulae within spreadsheets where they have been used; if a pdf file has been provided, ensure that any formulae used are clear or provide this information in a different format,
- indicate the content of each sheet of additional information,
- ensure the headings, dates and comments are up to date,
- ensure that the sampling date relates to when the sample was taken and not to when the sample was analysed, and
- explain the origin of all values, for example if an average GCV is derived from several analysed samples, ensure the GCV result from each sample and the averaging formula is included.

3.26 If information is not clear or accurate, we will not be able to issue ROCs until any queries raised or inaccuracies identified have been resolved.

Estimated Data

3.27 Subject to our consent, a generator may need to provide estimated data if there are problems in producing accurate and reliable information using the FMS procedures agreed. For example, in the event of a fault occurring with an electrical or fuel meter an estimate will be required for the month of generation.

3.28 When a generating station wishes to use estimated data, an official request must be made via the RER whilst submitting that months' output data. We will then work with the operator to ensure that the means of estimation can provide accurate and reliable information. Output data that is based on an estimate must be reviewed and agreed by us in advance of certificate issue. Please see Chapter 3of the Guidance for Generators for more information on estimated data.

Late Data

3.29 Please provide monthly output data to us before the end of the second month following the month of generation. Data submitted to us after this period will be considered a late data case. Where this occurs, certificate issue for the month in question is at our discretion.

3.30 If there is a problem with providing data to us before the end of the second month following the month of generation (for example in the event of a problem with the RER), information can be provided by email to the renewables team on renewable@ofgem.gov.uk.

3.31 Please see Chapter 3 of the 'Renewables Obligation: Guidance for Generators' (see Associated documents) for more information on late data.

Electronic Information

3.32 All fuelling information should be provided in electronic format where possible, firstly via the RER or via email to monthlyoutputdata@ofgem.gov.uk.

Appendices

Appendix 1. 100% biomass example evidence

A1.1 An example of a fuel specification which would be suitably worded to evidence a fuel as being 100% biomass:

Schedule A: Sample Fuel Specification – Virgin Wood

A1.2 The product shall be forestry wood defined as wood from trees and wood from other forestry material arising directly from forestry operations.

Contamination

A1.3 The product shall not contain any constituents that are not naturally found in timber. Such substances shall include (but are not limited to):

- Chemicals such as paint, preservatives and artificial resins.
- Rot and mildew
- Snow, ice and frozen structures
- Stones, metal, glass and other extraneous materials
- Plastics

A1.4 The product is 100% biomass and is free from fossil fuel and fossil fuel derived contamination.

Moisture Content

A1.5 The moisture content of the product, as measured by representative sampling of each load, shall be no less than 30%.

Size Distribution

A1.6 The size distribution of the product shall be such that:

- 100% by mass shall pass through a 150mm screen.
- 95% by mass shall pass through a 100mm screen.
- 80% by mass shall pass through a 5mm screen.

Fuel Letter

A1.7 An example of a fuel specification which would be suitably worded to evidence a fuel as being 100% biomass:

A1.8 Where a letter is provided from a fuel supplier in order to declare that a fuel is 100% biomass, we will look for the following information:

- the name of the supplier,
- the name of the fuel,
- the name of the Generating Station using the fuel,
- date of delivery/purchase,
- if this is a one-off fuel purchase, the quantity of the fuel, and
- confirmation that the fuel is free from fossil fuel and fossil fuel derived contamination.

A1.9 This should be completed on the suppliers' headed paper.

Appendix 2. ROC band definitions

A2.1 Defining the RO bands is important, as ROCs are issued to a generating station based on the band the station falls into. Bands on the RO are determined by the technology used by the generating station, as well as the fuel mix in a given month.

A2.2 Banding is applicable to certain stations (mainly conditional on the date of commissioning) according to Part 6 of the Orders. For more information on key dates in relation to banding and grandfathering, please refer to the Guidance for Generators. A

A2.3 Tables A2.1 and A2.2 set out the band definitions for capacity accredited pre-April 2013 and post April 2013 (or pre-May 2013 and post May 2013 under the NIRO)

Table A2.1: Pre-April 2013 (or pre-May 2013 under the NIRO): RO fuelled band definitions

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	**Definition**
Electricity generated from Landfill Gas	Electricity generated from gas formed by the digestion of material in a landfill. "Landfill" has the meaning given in Article 2(g) of the Landfill Directive (1999/31/EC).
Electricity generated from Sewage Gas	Electricity generated from gas formed by the anaerobic digestion of sewage (including sewage which has been treated or processed).
Energy from waste with CHP	Electricity generated from the combustion of waste (other than a fuel produced by means of anaerobic digestion, gasification or pyrolysis) in a qualifying combined heat and power generating station in a month in which the station generates electricity only from renewable sources and those renewable sources include waste which is not biomass.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Standard Gasification	Electricity generated from a gaseous fuel which is produced from waste or biomass by means of gasification and has a gross calorific value when measured at 25 degrees Celsius and 0.1 megapascals at the inlet to the generating station which is at least 2 megajoules per metre cubed but is less than 4 megajoules per metre cubed.
Standard Pyrolysis	Electricity generated from a gaseous fuel which is produced from waste or biomass by means of pyrolysis and has a gross calorific value when measured at 25 degrees Celsius and 0.1 megapascals at the inlet to the generating station which is at least 2 megajoules per metre cubed but is less than 4 megajoules per metre cubed.
Advanced Gasification	Electricity generated from a gaseous fuel which is produced from waste or biomass by means of gasification and has a gross calorific value when measured at 25 degrees Celsius and 0.1 megapascals at the inlet to the generating station of at least 4 megajoules per metre cubed.
Advanced Pyrolysis	Electricity generated from a liquid or gaseous fuel which is produced from waste or biomass by means of pyrolysis, and (a) in the case of a gaseous fuel, has a gross calorific value when measured at 25 degrees Celsius and 0.1 megapascals at the inlet to the generating station of at least 4 megajoules per metre cubed, and (b) in the case of a liquid fuel, has a gross calorific value when measured at 25 degrees Celsius and 0.1 megapascals at the inlet to the generating station of at least 10 megajoules per kilogram.
Anaerobic Digestion	Electricity generated from gas formed by the anaerobic digestion of material which is neither sewage nor material in a landfill.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Co-firing of Biomass	Electricity generated from regular biomass in a month in which the generating station generates electricity partly from fossil fuel and partly from renewable sources.
Co-firing of Energy Crops	Electricity generated from energy crops by a generating station in a calendar month in which it generates electricity partly from fossil fuel and partly from renewable sources.
Co-firing of Biomass with CHP	Electricity generated from regular biomass by a qualifying combined heat and power generating station in a month in which it generates electricity partly from fossil fuel and partly from renewable sources, and where the fossil fuel and regular biomass have been burned in separate boilers or engines.
Co-firing of Energy Crop with CHP	Electricity generated from energy crops by a qualifying combined heat and power generating station in a month in which it generates electricity partly from fossil fuel and partly from renewable sources, and where the fossil fuel and energy crops have been burned in separate boilers or engines.
Dedicated Biomass	Electricity generated from regular biomass in a month in which the generating station generates electricity only from regular biomass or only from biomass.
Dedicated Energy Crops	Electricity generated from energy crops in a month in which the generating station generates electricity only from energy crops or only from biomass.
Dedicated Biomass with CHP	Electricity generated from regular biomass by a qualifying combined heat and power generating station in a calendar month in which it is fuelled wholly by biomass
Dedicated Energy Crops with CHP	Electricity generated from energy crops by a qualifying combined heat and power generating station in a calendar month in which it is fuelled wholly by biomass.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Unspecified	As per Article 33(4)[78] of the RO – This default value is in respect of electricity that is eligible for ROCs but not described in the first column of Part 2 of Schedule 5.[79] The use of this generation type will be reviewed case by case, but will apply to eligible fossil derived bioliquids.

Table A2.2: post-April 2013 (or post May 2013 for the NIRO): RO fuelled band definition

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Advanced Gasification/Pyrolysis	Electricity generated from an advanced fuel which in the case of a gaseous fuel has a gross calorific value of at least 4 megajoules per meter cubed when measured at 25 degrees Celsius and 0.1 megapascals when measured at the inlet to the generating station and; in the case of a liquid fuel, has a gross calorific value of at least 10 megajoules per kilogram at 25 degrees Celsius and 0.1 megapascals when measured at the inlet to the generating station
AD	Electricity generated from gas formed by the anaerobic digestion of material which is neither sewage nor material in a landfill.

[78] Article 27(5) of the ROS and Article 25(5) of the NIRO Orders
[79] Schedule 2 of the ROS and NIRO Orders

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Closed Landfill Gas	Electricity generated from landfill gas (other than electricity generated using the heat from a turbine or engine) in any month in which the generating station generates electricity only from gas formed by the digestion of material in a landfill which no longer accepts waste for disposal.
Co-firing of regular Bioliquid	Electricity generated from regular bioliquid in a month in which the generating station generates electricity partly from fossil fuel and partly from renewable sources.
Co-firing of regular Bioliquid with CHP	Electricity generated from regular bioliquid in a month in which the qualifying CHP generating station generates electricity partly from fossil fuel and partly from renewable sources.
Dedicated Biomass	Electricity generated from a regular bioliquid or regular biomass by a generating station which is not a relevant fossil fuel station and which, in any month, only generates electricity from biomass.
Dedicated Biomass with CHP	Electricity generated from a regular bioliquid or regular biomass by a qualifying combined heat and power generating station which is not a relevant fossil fuel station, and which, in any month, only generates electricity from biomass.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Dedicated Energy Crops	Electricity generated from energy crops by a generating station which is not a relevant fossil fuel station, and which in any month, generates electricity only from energy crops or only from biomass.
Energy from waste with CHP	Electricity generated from the combustion of waste (other than an advanced fuel produced by means of anaerobic digestion) in a qualifying combined heat and power generating station in a month in which the station generates electricity only from renewable sources and those renewable sources include waste which is not biomass.
High-range Co-firing	Electricity generated from regular biomass or energy crops in a month in which the generating station generates electricity partly from fossil fuel and partly from renewable sources; and where the energy content of the biomass burned in a combustion unit is at least 85% (but is less than 100%) of all the energy sources burned in that unit in that month.
High-range Cofiring with CHP	Electricity generated from regular biomass or energy crops in a month in which the qualifying CHP generating station generates electricity partly from fossil fuel and partly from renewable sources; and where the energy content of the biomass burned in a combustion unit is at least 85% (but is less than 100%) of all the energy sources burned in that unit in that month; and where the fossil fuel and biomass or energy crops have been burned in separate combustion units.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Landfill Gas Heat Recovery	Electricity generated using the heat from a turbine or engine which is generating electricity from landfill gas.
Low-range Co-firing	Electricity generated from regular biomass or energy crops in a month in which the generating station generates electricity partly from fossil fuel and partly from renewable sources; and where the energy content of the biomass burned in a combustion unit is less than 50% of all the energy sources burned in that unit in that month.
Low-range Cofiring with CHP	Electricity generated from regular biomass or energy crops in a month in which the qualifying CHP generating station generates electricity partly from fossil fuel and partly from renewable sources; and where the energy content of the biomass burned in a combustion unit is less than 50% of all the energy sources burned in that unit in that month; and where the fossil fuel and biomass or energy crops have been burned in separate combustion units.
Mid-range Co- firing	Electricity generated from solid and gaseous biomass or energy crops in a month in which the generating station generates electricity partly from fossil fuel and partly from renewable sources; and where the energy content of the biomass burned in a combustion unit is at least 50% but less than 85% of all the energy sources burned in that unit in that month.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Mid-range Cofiring with CHP	Electricity generated from solid and gaseous biomass or energy crops in a month in which the qualifying CHP generating station generates electricity partly from fossil fuel and partly from renewable sources; and where the energy content of the biomass burned in a combustion unit is at least 50% but less than 85% of all the energy sources burned in that unit in that month; and where the fossil fuel and biomass or energy crops have been burned in separate combustion units.
Standard Gasification/Pyrolysis	Electricity generated from an advanced fuel which— in the case of a gaseous fuel, has a gross calorific value which is at least 2 megajoules per metre cubed but is less than 4 megajoules per metre cubed at 25 degrees Celsius and 0.1 megapascals when measured at the inlet to the generating station, and; in the case of a liquid fuel, has a gross calorific value which is less than 10 megajoules per kilogram at 25 degrees and 0.1 megapascals when measured at the inlet to the generating station.
Station Conversion	Electricity generated from regular bioliquids, regular biomass or energy crops by a RFFS (relevant fossil fuel station), in a month in which the station generates electricity only from biomass or only from energy crops.
Station Conversion with CHP	Electricity generated from bioliquids, regular biomass or from energy crops by a relevant fossil fuel CHP station, in a month in which the station generates electricity only from biomass or only from energy crops.

ROC Band (Pre-April 2013 for RO and ROS and pre-May 2013 for the NIRO)	Definition
Unit Conversion	Electricity generated from regular bioliquids, regular biomass or energy crops burned in a combustion unit in any month in which that combustion unit burns only biomass or only energy crops, and the generating station generates electricity partly from fossil fuel and partly from renewable sources.
Unit Conversion with CHP	Electricity generated from regular bioliquids, regular biomass or energy crops burned by a qualifying CHP station in a combustion unit in any month in which that combustion unit burns only biomass or only energy crops, and the generating station generates electricity partly from fossil fuel and partly from renewable sources.

Appendix 3. ROC Support Levels

A3.1 The Tables list the banding level that applies to stations accredited and capacity added to accredited generating stations during each specific time period. For the definitions of each capacity type see Appendix 5.

A3.2 The Tables reflect the current Tables in the Orders[80] but have been adapted for ease of reference. The Tables also contain footnotes that point to Articles of the Orders that make alterations to the banding levels set out in the Tables.

A3.3 For stations with more than one unit that use regular biomass on or after 1 April 2013 (or 1 May under the NIRO), banding is determined on a unit by unit basis rather than a station-wide basis. See Chapter 2 for further information.

A3.4 Please note that there is no separate band for stations that meet the 'station conversion' band definition and that use bioliquid fuels. They are supported under the 'station conversion' band.

A3.5 The following Tables detail fuelling related bands only. Table A3.1 below shows the banding related to the RO (in England and Wales) and the RO(S) (in Scotland). Table A3.2 shows the banding levels related to the NIRO (in Northern Ireland). Table A3.3 shows the banding levels applicable to RO stations (in England and Wales) and ROS stations (in Scotland) and NIRO stations (in Northern Ireland) generating electricity using regular biomass.

[80] Schedule 5 of the ROO 2015 (as amended), Schedule 2 of the RO(S) 2009 (as amended) and NIRO 2009 (as amended)

Table A3.1: RO and ROS banding (excluding regular biomass bands).

Band	pre-13 capacity	13/14 capacity	14/15 capacity	15/16 capacity	Post 2016 capacity
Advanced gasification/pyrolysis	2	2	2	1.9	1.8
AD	2	2	2	1.9	1.8
Energy from waste with CHP	1	1	1	1	1
Landfill gas [81]	0.25*	0	0	0	0
Landfill gas -closed landfill gas	New band	0.2	0.2	0.2	0.2
Landfill gas- heat recovery	New band	0.1	0.1	0.1	0.1
Microgeneration (less than or equal to 50kW DNC) [82]	2	2	2	1.9	1.8
Other	1	1	1	1	1
Sewage gas	0.5*	0.5	0.5	0.5	0.5
Standard gasification/pyrolysis	1	2	2	1.9	1.8

*Some of these stations may be eligible to receive 1 ROC/MWh (Article 37 and 38). See 'Exceptions to banding and grandfathering' on page 105 for further information.

[81] Article 57 of the ROO 2015 (as amended) and Article 24 of the RO(S) 2009 (as amended) state that no ROCs are to be issued in respect of post-2013 capacity for landfill gas unless the electricity is generated using pre-2013 capacity, closed landfill gas or landfill gas heat recovery

[82] Article 34 of the ROO 2015 (as amended), Article 29 of the RO(S) (as amended) and Article 27 of the NIRO 2009 (as amended).

Table A3.2: NIRO banding and DNC limits (excluding regular biomass bands)

Band	**Pre-2013 Capacity 2009 banding**	**Pre-2013 Capacity 2010 & 2011 changes** [83]	**13/14 capacity**	**14/15 capacity**	**15/16 capacity**	**Post 2016 capacity**
Advanced gasification/pyrolysis	2	2	2	2	1.9	1.8
Anaerobic digestion[84][1] less than or equal to 500kW	2	4	4	4	4	4
Anaerobic digestion[85][1] 500kW-5MW	2	3	3	3	3	3
Anaerobic digestion[86][1] greater than 5MW	2	2	2	2	1.9	1.8
Energy from waste with CHP	1	1	1	1	1	1
Landfill gas[87]	0.25*	1	1	1	0	0
Landfill gas – closed landfill	New Band	New Band	New Band	New Band	0.2	0.2

[83] Article 27 to 27B and 29 of the NIRO 2009 (as amended).
[84] AD less than 5MW based on Articles 27 to 27B and 29 of the NIRO 2009 (as amended)
[85] AD less than 5MW based on Articles 27 to 27B and 29 of the NIRO 2009 (as amended)
[86] AD less than 5MW based on Articles 27 to 27B and 29 of the NIRO 2009 (as amended)
[87] Article 22 of the NIRO 2009 (as amended) states that no ROCs are to be issued in respect of post-2013 capacity for landfill gas unless the electricity is generated using pre-2013 capacity or 2013/15 capacity, closed landfill gas or landfill gas heat recovery.

Band	Pre-2013 Capacity 2009 banding	Pre-2013 Capacity 2010 & 2011 changes [83]	13/14 capacity	14/15 capacity	15/16 capacity	Post 2016 capacity
Landfill gas heat recovery	New Band	New Band	New Band	New Band	0.1	0.1
Microgeneration (less than 50kW DNC)[88]	2	2	2	2	1.9	1.8
Sewage gas	0.5*	0.5	0.5	0.5	0.5	0.5
Standard gasification/pyrolysis	1	1	2	2	1.9	1.8

[1] Applies to generating stations that were first accredited on or after 1 April 2011. If the station, at any time after 26 April 2010, had a DNC above the specified maximum it would not qualify for the band[89] and standard banding rules apply.

* Some of these stations may be eligible to receive 1 ROC/MWh (Article 28 and 29 of the NIRO).

[88] Article 27 of the NIRO 2009 (as amended) applies.
[89] Article 27C of NIRO.2009 (as amended)

Table A3.3: RO, ROS and NIRO banding for stations using regular biomass (note - for post 31 March 2013 generation (or post 30 April 2013 under the NIRO), banding for multi-unit stations is determined on a unit by unit rather than station-wide basis)

Band	Pre-2013 capacity	13/14 capacity	14/15 capacity	15/16 capacity	Post 2016 capacity
Conversion (station or unit)	1	1	1	1	1
Conversion with CHP (station or unit)	1.5	1.5	1.5	1.5	1.5
Co-firing of biomass	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation
Co-firing (low range) †	0.5	0.5	0.5	0.5	0.5
Co-firing (mid-range)	0.6	0.6	0.6	0.6	0.6
Co-firing (high-range) †	0.9	0.9	0.9	0.9	0.9
Co-firing (low range) with CHP †	1	1	1	1‡	1‡
Co-firing (mid-range) with CHP	1.1	1.1	1.1	1.1‡	1.1‡
Co-firing (high range) with CHP †	1.4	1.4	1.4	1.4‡	1.4‡
Co-firing of biomass with CHP	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation

Co-firing of energy crops	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation
Co-firing of energy crops with CHP	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation	No ROCs issued under this band for post 31 March 2013 generation
Co-firing of regular bioliquid †	0.5	0.5	0.5	0.5	0.5
Co-firing of regular bioliquid with CHP †	1	1	1	1	1
Co-firing of relevant energy crops (low range)[90]	See footnote				
Dedicated biomass*	1.5	1.5	1.5	1.5	1.4
Dedicated biomass with CHP*	2	2	2	1.9	1.8
Dedicated energy crops*	2	2	2	1.9	1.8

†**Note**: For some co-firing generating stations, the banding rates differed from those set out in this table for generation prior to April 2015. Please refer to the ROO 2009 (as amended).

[90] Under Article 36 ROO 2015 (as amended), 28D of the RO(S) 2009 (as amended) and 26D of the NIRO 2009 (as amended), 1 April 13 – 31 March 15 generation receives 0.8 ROCs/MWh and 1 April 15 – 31 March 19 generation receives 1 ROC/MWh.

Please also note the change in the definition of biomass and energy crops as of 1 April 2013. Please refer to Chapter 1 for further information.

*Generating stations meeting the definition of a relevant fossil fuel stations are not eligible to claim under these bands for any post 31 March 2013 generation[91].

‡ These support levels are only available in circumstances where support under the RHI is not available. See Article 35 of the RO, Article 28 ROS and Article 26 of the NIRO.

[91] Refer to Schedule 5 of the ROO 2015 (as amended), and Schedule 2 of the RO(S) 2009 and NIRO 2009 for the definition of the bands.

Appendix 4. Example stock calculation template

Table A4.1: Example stock level indicator template

Step	Information required	Data	Possible Data Source
A	Month	Oct 2021	N/A
B	Fuel	Wood Pellets	N/A
C	Opening stock at 1 Oct	135 tonnes	Visual estimation
D	Σ Deliveries	220 tonnes	Weighbridge records
E	Transfers	0	Internal record keeping
F	Subtraction of biomass fuel combusted where no generation takes place. If applicable.	16 tonnes	SCADA system
G	Closing Stock at 1 Nov	90 tonnes	Visual estimation
H	Total consumed in month	249 tonnes	(C+ D) - (G+F) = H

A4.1 The above can be provided as part of a monthly data submissions e.g. in spreadsheet format, in order to support the Figure for 'H'; which may need to be entered as part of the month's output data submission on the RER

Appendix 5. Mass energy content measurement for solid fuels

Mass measurement guidance for solid fuels

A5.1 The information contained in this appendix is designed to provide operators with an indication, rather than a prescriptive guide, as to the ways in which they may opt to compile a robust fuel measurement and sampling regime. This relates to the use of solid fuels and covers, methods and standards for volume and energy content measurement, contamination identification and prevention, and appropriate fuel storage conditions.

Table A5.1: Mass measurement using a weighbridge

Questions	Answer
When is the mass measurement taken?	At station on delivery
How is the mass measurement taken?	By totalising weighbridge deliveries
How often is the mass measurement taken?	Every delivery
How is any fuel carried over from one month to the next accounted for?	Stocks run down at month end
Are any industry standards met?	The British Standard BS EN ISO 10012 for weighbridge calibration. This presents in detail methods of calibration for static weighing devices and for determining periodic confirmation intervals. This is reviewed with further details in the following code of practice: Code of Practice for the Calibration of Industrial Process Weighing Systems, Institute of Measurement and Control, October 2003.

Questions	Answer
How is accuracy ensured?	Weighbridges will normally achieve an accuracy of +/- 0.5% of the load. Operators of public weighing equipment have responsibilities to ensure that they can perform their duties competently and honestly. No one may operate public weighing equipment unless they hold a certificate from a Chief Trading Standards Officer. Although the weighbridge at a power station is unlikely to be a public weighing facility, good practice would be that the weighbridge is operated as if it were, and that the appropriate certificate is obtained. Regular calibration is an integral part of the quality assurance of all mass measurements.

Table A5.2: Mass measurement using a weighbridge and stock calculation

Question	Answer
When is the mass measurement taken?	At station on delivery and stock calculation at month end.
How is the mass measurement taken?	By totalising weighbridge deliveries and performing a stock calculation at month end.
How often is the mass measurement taken?	Every delivery and at a stock calculation at month end.
How is any fuel carried over from one month to the next accounted for?	By a stock calculation at month end. This can be done typically by transit over a weighbridge, survey of the stockpile, or level measurement of a bin.

Question	Answer
Are any industry standards met?	BS EN 45501 and BS EN ISO 10012 are the British Standards for Metrological aspects of non-automatic weighing instruments and for Measurement management systems respectively. These present in detail methods of calibration for static weighing devices and for determining periodic confirmation intervals. This is reviewed with further details in the following code of practice: Code of Practice for the Calibration of Industrial Process Weighing Systems, Institute of Measurement and Control, October 2003.
How is accuracy ensured?	Accuracy can be maximised by operating the stocking area so as to reduce the remaining quantity to a very low level at the period end. This could be achieved by separating each period's stock. Weighbridges have to achieve tolerances in regards to weights that are set as +/- xx kg within different weight categories i.e., +/- xx kg from 0 – 5000 kg. As the standards change over time, accuracies should adhere to the current versions. Operators of public weighing equipment have responsibilities to ensure that they can perform their duties competently and honestly. No one may operate public weighing equipment unless they hold a certificate from a Chief Trading Standards Officer. Although the weighbridge at a power station is unlikely to be a public weighing facility, good practice would be that the weighbridge is operated as if it were, and that the appropriate certificate is obtained where possible Regular calibration is an integral part of the quality assurance of all mass measurements and these procedures should be conducted within the appropriate BS standards t

Table A5.3: Volume measurement using a belt weigher

Question	Answer
When is the mass measurement taken?	Immediately prior to combustion
How is the mass measurement taken?	Directly from a belt weigher
How often is the mass measurement taken?	Throughout the burn
How is any fuel carried over from one month to the next accounted for?	n/a
Is any method of verification used?	Totalised weighbridge delivery figures and stock level calculation at month end (if applicable).

Accuracy

A5.2 Belt weighing devices vary substantially in accuracy according to their principle of operation, construction, and installation. The Organisation Internationale de Métrologie Légale (OIML) has classified those intended for commercial use into three classes as per the Table below. Good practice is considered to be class 0.5.

Table A5.4: Accuracy of belt weighers

Class	**Percentage of the mass of the totalized load for:** Initial verification	**Percentage of the mass of the totalized load for:** In-service
0.5	0.25	0.5
1	0.5	1.0
2	1.0	2.0

A5.3 There is an international recommendation from OIML that specifies the metrological and technical requirements for belt conveyor equipment. This

provides standardised requirements and test procedures for evaluating this equipment in a uniform and traceable way.[92]

A5.4 Please note regular calibration is an integral part of the quality assurance of all weighing devices. It is recommended that, where possible, inaccuracies from excessive tension or stiffness in the belt, irregular loading, or installation too close to non-weighing rollers should be avoided. Guidance for the calibration of stand-alone electronic weighing devices can be found on the OIML website.

Energy content measurement for solid fuels

Table A5.5: Sampling immediately prior to combustion

Question	Answer
How is the energy content measurement taken?	Increments are taken from the nearest possible point immediately prior to combustion.
How often are sample increments taken?	Depends on the material being burned and the number of deliveries: at a minimum this will be once a month.
How is any fuel carried over from one month to the next accounted for?	N/A
How is the sample prepared?	The overall size of the composite sample may be over 200kg, but the actual amount of material that is required for chemical analysis is usually less than five grams. Therefore, it is necessary to obtain a representative sample of the composite sample that is suitable for chemical analysis. This can be achieved by using a combination of sample size reduction (using a suitable shredder) and sample splitting procedures to produce a finely powdered sample.

[92] International recommendation titled: 'Continuous totalizing automatic weighing instruments (belt weighers). Part 1: Metrological and technical requirements – Tests. OIML R 50-1 Edition 1997 (E)'. Further information can be found at www.oiml.org.uk

Question	Answer
What steps are in place to ensure that the sample is representative of the whole?	Generating stations should explain how sampling will be undertaken, which demonstrates that the sample taken is representative of the whole. The objective of any sample extraction procedure is to ensure that all particles have an equal chance of reporting to the sample. This is particularly important when the material being sampled contains a wide range of particle sizes (such as chipped wood), as the finer sized particles will tend to settle towards the bottom of the material in a delivery vessel or in a stockpile, and towards the bottom of the flow of material on a conveyor. For a given accuracy, the required sample mass is directly proportional to the size of the largest particle in the mixture being sampled. This means that the mass of sample needed reduces as the particle size reduces, and thus the total size of a sample of sawdust will be smaller than that of a sample of woodchips.
Is any method of verification used?	Previous month's results are used as a comparison.

Table A5.6: Energy content measurement from delivery vessels

Question	Answer
How is the energy content measurement taken?	Increments are taken manually from delivery vessels.
How often are sample increments taken?	Every delivery.
How is any fuel carried over from one month to the next accounted for?	Stocks run down at month end.

Question	Answer
How is the sample prepared?	The overall size of the composite sample may be over 200kg, but the actual amount of material that is required for chemical analysis is usually less than five grams. Therefore, it is necessary to obtain a representative sample of the composite sample that is suitable for chemical analysis. This can be achieved by using a combination of sample size reduction (using a suitable shredder) and sample splitting procedures to produce a finely powdered sample.
What steps are in place to ensure that the sample is representative of the whole?	Generating stations should explain how sampling will be undertaken, which demonstrates that the sample taken is representative of the whole. The objective of any sample extraction procedure is to ensure that all particles have an equal chance of reporting to the sample. This is particularly important when the material being sampled contains a wide range of particle sizes (such as chipped wood), as the finer sized particles will tend to settle towards the bottom of the material in a delivery vessel or in a stockpile, and towards the bottom of the flow of material on a conveyor. For a given accuracy, the required sample mass directly proportional to the size of the largest particle in the mixture being sampled. This means that the mass of sample needed reduces as the particle size reduces, and thus the total size of a sample of sawdust will be smaller than that of a sample of woodchips.
Is any method of verification used?	Previous month's results are used as a comparison.

Table A5.7: Energy content measurement from stockpile

Question	Answer
How is the energy content measurement taken?	Increments are taken manually from delivery vessels and from a stockpile.
How often are sample increments taken?	Every delivery and from stockpile at the beginning of month.
How is any fuel carried over from one month to the next accounted for?	Stockpile sampled at the beginning of the month.
How is the sample prepared?	The overall size of the composite sample may be over 200kg, but the actual amount of material that is required for chemical analysis is usually less than five grams. Therefore, it is necessary to obtain a representative sample of the composite sample that is suitable for chemical analysis. This can be achieved by using a combination of sample size reduction (using a suitable shredder) and sample splitting procedures to produce a finely powdered sample.

Question	Answer
What steps are in place to ensure that the sample is representative of the whole?	Generating stations should explain how sampling will be undertaken, which demonstrates that the sample taken is representative of the whole. The objective of any sample extraction procedure is to ensure that all particles have an equal chance of reporting to the sample. This is particularly important when the material being sampled contains a wide range of particle sizes (such as chipped wood), as the finer sized particles will tend to settle towards the bottom of the material in a delivery vessel or in a stockpile, and towards the bottom of the flow of material on a conveyor. For a given accuracy, the required sample mass is directly proportional to the size of the largest particle in the mixture being sampled. This means that the mass of sample needed reduces as the particle size reduces, and thus the total size of a sample of sawdust will be smaller than that of a sample of woodchips.
Is any method of verification used?	Previous month's results are used as a comparison.

Contamination identification and prevention

Table A5.8: Contamination information for selected fuel sources

Key Questions	**Wood fuels**	**Animal processing residues/agricultural residues**	**Other plant fuels (e.g., PKE, olive residues, shea nuts)**	**Sewage sludge**
Analysis required for wider environmental purposes	Chlorine Sulphur Heavy metals Nitrogen Advanced thermogravimetry with analysis of evolved gas to detect binder agents.	Chlorine Sulphur Heavy metals	Chlorine Sulphur Hydrocarbon may be useful if the fuel is not of animal feed quality.	Chlorine Sulphur
What contaminants could occur through the fuel production process?	MDF may contain preservatives, polishes, glues, tannalising fluids. Pellets may contain glues or binders.	n/a	PKE/olive residues - addition of oil, residual solvent from the extraction of palm oil (it is unlikely that residual solvent contributes significantly to its CV).	Contaminants present in influents into sewage works. Chemicals added during treatment e.g. polymers for de-watering.
How could this be prevented?	-	-	Fuels for cattle feed are unlikely to contain solvents.	n/a

Key Questions	Wood fuels	Animal processing residues/agricultural residues	Other plant fuels (e.g., PKE, olive residues, shea nuts)	Sewage sludge
What contamination could occur from the previous use of the fuel if the fuel is not virgin biomass?	May be a variety of contaminants due to the variety of possible previous uses e.g. demolition wood, recycled pallets, paints and spillages.	n/a	n/a	-
How could this be prevented?	Heavy metal analysis will show some preservative contaminants. Nitrogen analysis may indicate glues and resins.	-	-	n/a
What contamination could occur from the packaging of the fuel?	Binder cord, ropes, bags, plastic packaging.	Plastic packaging.	n/a	-
How could this be prevented?	Manual removal.	Manual removal.	-	Contamination from previous transport use, possibly fossil fuels.

Key Questions	**Wood fuels**	**Animal processing residues/agricultural residues**	**Other plant fuels (e.g., PKE, olive residues, shea nuts)**	**Sewage sludge**
What contamination could occur during transportation?	Contamination from previous transport use, possibly fossil fuels.	Contamination from previous transport use, possibly fossil fuels.	Contamination from previous transport use, possibly fossil fuels.	Manual removal. Cleaning transport prior to use. Dedicated transport.
How could this be prevented?	Manual removal. Cleaning transport prior to use. Dedicated transport.	Manual removal. Cleaning transport prior to use. Dedicated transport.	Manual removal. Cleaning transport prior to use. Dedicated transport.	Storage with fossil fuels e.g., coal.
What contamination could occur from storage at power station?	Storage with fossil fuels e.g., coal.	n/a	Storage with fossil fuels e.g., coal.	Using separate stores. Measuring and sampling prior to mixing. No mixed fuel carried over.

Key Questions	**Wood fuels**	**Animal processing residues/agricultural residues**	**Other plant fuels (e.g., PKE, olive residues, shea nuts)**	**Sewage sludge**
How could this be prevented?	Using separate stores. Measuring and sampling prior to mixing. No mixed fuel carried over.	Using separate stores. Measuring and sampling prior to mixing. No mixed fuel carried over.	Using separate stores. Measuring and sampling prior to mixing. No mixed fuel carried over.	

Storage considerations

A5.5 The following Tables indicate good practice for the storage of different solid fuels and how long they can be stored without a material change in composition.

Table A5.9: Wood storage

Key Questions	**Forestry co-products**	**Sawmill co-products**	**Mixed forestry/sawmill co-product pellets**	**Waste wood**
How should the fuel be stored?	Barn/silo/outside heap. Wood should be dried in loose piles. Dry wood must be stored under cover.	Barn/silo/outside heap. Dry wood must be stored under cover.	Barn/silo. Should be stored under cover with minimal handling to prevent break down.	Barn/silo. Should be kept dry.
How long the fuel should be stored for?	Wood chip (50% moisture) – a few days. 30% moisture - up to two months.	Wood chip - if high moisture (40-55 %) - a few days Dry - up to three months	Up to six months, providing it is kept dry.	Up to two months.

Table A5.10: Animal processing residues

Key Questions	**Dried sludge**	**Meat and Sludge bone meal cake (MBM)**	**Meat and Sludge bone meal cake (MBM)**	**Blood and meat slurry**	**Fish waste, soup and blood**
How should the fuel be stored?	Sealed silo.	Sealed silo.	Dry, enclosed storage facilities. May be stored in silos.	Dedicated storage.	Dedicated storage.
How long the fuel should be stored for?	Dried sludge can be stored for an extended period. Best practice is to ensure storage conditions prevent renewed absorption of moisture from the environment.	Sludge cake may degrade on storage. Use rapidly.	Tendency to degrade rapidly depending on the quality of the fuel.	Tendency to degrade rapidly depending on the quality of the fuel.	High moisture waste has tendency to degrade rapidly and should be used immediately. If stored dry may not deteriorate so rapidly.

Table A5.11: Agricultural residues

Key Questions	Poultry litter	Straw	Miscanthus	Pellets from agricultural crops
How should the fuel be stored?	Barn/silo. Should be under cover.	Should be under cover.	Store under cover at power station.	Barn/silo. Should be under cover.
How long the fuel should be stored for?	Up to 10 days at plant.	Up to 12 months if kept dry.	Up to 12 months if kept dry.	Up to one month. Need minimal handling to prevent mechanical deterioration. Compaction in storage may cause some pellets to break up.

Table A5.12: Other plant fuels

Key Questions	PKE/Olive Cake and pellets	Shea Nuts	Cereal or maize pellets
How should the fuel be stored?	Should be under cover. Need to control temperature, moisture/humidity and ventilation conditions in storage to prevent self-heating.	Should be under cover. Moisture content must be kept very low to prevent fungal growth.	Should be under cover to prevent wetting and microbial degradation. Need to control temperature, moisture/humidity and ventilation conditions in storage to prevent self-heating. Handle carefully to prevent mechanical break up and release of dust.

Key Questions	PKE/Olive Cake and pellets	Shea Nuts	Cereal or maize pellets
How long the fuel should be stored for?	Up to 2 months. May begin to degrade in store, depending on moisture and oil content and ventilation.	Up to 1-2 years providing temperature and moisture are kept low.	Depends on properties. Modified feed pellets should be used rapidly.

Appendix 6. Volume and energy content measurement for liquid fuels

A6.1 The information contained in this appendix is designed to provide operators with an indication (rather than a prescriptive guide) to the ways in which they may choose to compile a robust fuel measurement and sampling regime when using liquid fuels. This includes methods and standards for volume and energy content measurement, contamination identification and prevention and appropriate fuel storage conditions.

Volume measurement

Table A6.1: Volume measurement using flow meters

Question	Answer
When is the mass measurement taken?	Direct measurement immediately before combustion.
How is the mass measurement taken?	Flow meter or calculated from flow meter reading and fluid density.
How often is the mass measurement taken?	Throughout fuel burn.

Question	Answer
How is accuracy ensured?	The most accurate meters are those that have an inaccuracy of less than 1% of the measured value and it is this type of meter that is normally used for commercial and legal compliance purposes. These are positive displacement meters, Coriolis meters, turbine meters and possibly vortex and electromagnetic meters. Regular calibration to accredited standard methods is necessary to ensure accuracy. Modifications to pipework may be necessary to accommodate this. Inaccuracies due to differentiation in specific gravity, temperature and viscosity should be kept to a minimum. If a flow meter that does not measure mass flow directly, but some other effect caused by the velocity of the fluid in the pipe is used then measurements of specific gravity, temperature and viscosity must be taken and corrected for.

Table A6.2: Volume measurement using tank level measurement

Question	Answer
When is the mass measurement taken?	At station on delivery and from storage tank(s) at month beginning/end.

Question	Answer
How is the mass measurement taken?	Tank level measurement – ultrasonic/tape dips. An indirect method is usually employed, which involves measuring the level in the tank and calculating the volume geometrically. A correction must be applied for temperature (to allow for the expansion of the tank). The level can be measured by the traditional methods of inserting a graduated rod or weighted tape measure and noting the wetted length, or an automatic meter using an ultrasonic or radar echo ranging system. If operators are calculating the mass in the tank, they will also need to know the density of the fluid. This can be determined in the laboratory by a standard method or in the tank by measuring the difference in hydrostatic head between two points at known depths.
How often is the mass measurement taken?	Before and after every delivery and transfer to another storage tank.
How is any fuel carried over from one month to the next accounted for?	Measurement taken in addition at month beginning/end.

Question	Answer
How is accuracy ensured?	The overall accuracy of this method depends critically on the homogeneity of the material in the tank. If the top is less dense than the bottom, then the mass will almost certainly be wrong. If there is a suspicion of segregation, densities should be measured at several points in the tank and a representative average determined.

Table A6.3: Volume measurement using a weighbridge

Question	Answer
When is the mass measurement taken?	At station on delivery.
How is the mass measurement taken?	By totalising weighbridge deliveries.
How often is the mass measurement taken?	Every delivery.
How is any fuel carried over from one month to the next accounted for?	Stocks run down at month end.
Are any industry standards met?	The British Standard BS EN ISO 10012 for weighbridge calibration. This presents in detail methods of calibration for static weighing devices and for determining periodic confirmation intervals. This is reviewed with further details in the following code of practice: Code of Practice for the Calibration of Industrial Process Weighing Systems, Institute of Measurement and Control, 2011.
How is accuracy ensured?	Weighbridges will normally achieve an accuracy of +/- 0.5% of the load. Operators of public weighing equipment have responsibilities to ensure that they can perform their duties competently and honestly. No one may operate public weighing equipment unless they hold a certificate from a Chief Trading Standards Officer. Although the weighbridge at a power station is unlikely to be a public weighing facility, good practice would be that the weighbridge is operated as if it were, and that the appropriate certificate is obtained. Regular calibration is an integral part of the quality assurance of all mass measurements.

Question	Answer
Does this method work for stations with more than one storage tank?	Weighbridges work best for stations that only have one storage tank and do not carry over fuel from one month to the next. This is because transfers from one tank to another and carryover are difficult to measure using a weighbridge. Our experience is that larger stations tend to use a weighbridge alongside another measurement.

Table A6.4: Volume measurement using a weighbridge and tank level measurement

Question	Answer
When is the mass measurement taken?	At station on delivery and from storage tank(s) at beginning/end of month.
How is the mass measurement taken?	Combination of tank level measurement and totalising weighbridge deliveries. Measurements may also be used to measure the transfer of fuel from one tank to another. The mass burned is calculated as follows: Mass burned = Opening balance – closing balance + deliveries (+/- transfers). Opening balance = tank measurement at the beginning of the month of burn. Closing balance = tank measurement at the end of the month of burn. Deliveries = Weighbridge measurements within the month of burn.
How often is the mass measurement taken?	Weighbridge measurement taken every delivery; tank level measurement taken at month end/beginning.
How is any fuel carried over from one month to the next accounted for?	Tank measurement taken at month end/beginning.

Question	Answer
Are any industry standards met?	The British Standard BS EN 10012 for weighbridge calibration. This presents in detail methods of calibration for static weighing devices and for determining periodic confirmation intervals. This is reviewed with further details in the following code of practice: Code of Practice for the Calibration of Industrial Process Weighing Systems, Institute of Measurement and Control, 2011. http://resource.npl.co.uk/docs/sciencetechnology/massforcepressure/clubsgroups/instmcweighingpanel/wgc0496.pdf
How is accuracy ensured?	Weighbridges will normally achieve an accuracy of +/- 0.5% of the load operators of public weighing equipment have responsibilities to ensure that they can perform their duties competently and honestly. No one may operate public weighing equipment unless they hold a certificate from a Chief Trading Standards Officer. Although the weighbridge at a power station is unlikely to be a public weighing facility, good practice would be that the weighbridge is operated as if it were, and that the appropriate certificate is obtained. Regular calibration is an integral part of the quality assurance of all mass measurements.
Does this method work for stations with more than one storage tank?	Weighbridges work best for stations that only have one storage tank and do not carry over fuel from one month to the next. This is because transfers from one tank to another and carryover are difficult to measure using a weighbridge. Our experience is that larger stations tend to use a weighbridge alongside another measurement, as in Method 4.

Energy content measurement

Table A6.5: Energy content measurement from delivery vessels

Question	Answer
How is the energy content measurement taken?	Increments are taken manually from delivery vessels via a manual tap on pipe. Samples are usually taken by a probe through the top hatches of the tanker. Samples could also be taken from the discharge line.
How often are sample increments taken?	Every delivery.
How is any fuel carried over from one month to the next accounted for?	Stocks run down at month end.
What steps are in place to ensure that the sample is representative of the whole?	By following one of the standards for manual sampling. Where a station has several deliveries in a month, samples may be combined and a sample of the combined sample sent to the laboratory to be tested.
Is any method of verification used?	Previous month's results are used as a comparison.
Are any industry standards met?	ISO 3170, BS 2000, part 61, ASTM D 4057.

Table A6.6: Energy content measurement from a storage tank

Question	Answer
How is the energy content measurement taken?	Manual dip from top, middle and bottom of the storage tank.
How often are sample increments taken?	Dependent on number of deliveries, minimum, once a month.

How is any fuel carried over from one month to the next accounted for?	Sample taken at month end/beginning.
What steps are in place to ensure that the sample is representative of the whole?	By following one of the standards for manual sampling. Sample increments are drawn from tanks or a pipeline through a sampling valve specially constructed to prevent material accumulation. This procedure can be manual or automatic. The standard followed may or may not have been developed specifically for the fuel being used. Where the standard was not developed for the fuel being sampled, the fuel should have similar properties to the fuel for which the standard was developed. To further reduce the risk of an unrepresentative sample being sent to the laboratory, one of two processes is used. For either process three samples are taken at the same time one each from the top, middle and bottom of the tank. Then either all three samples are sent to the laboratory, or the three samples are combined and a sample is taken from the combined samples. For consistency, samples should be taken at the same time that the tank volume is measured. Where fuel is carried over from one month to the next, samples are taken at the beginning of each month.
Is any method of verification used?	Previous month's results are used as a comparison.
Are any industry standards met?	ISO 3170, relevant Parts of BS 2000, ASTM D 4057.

Table A6.7: Energy content measurement using a flow meter

Question	Answer
How is the energy content measurement taken?	Increments taken from flow close to flow measurement. Sampling should be done next to the flow metering so that the energy flow can be determined at a fixed point. The flow meter should be located as close as practicable to the point of combustion.
How often are sample increments taken?	Dependent on number of deliveries, minimum, once a month.
What steps are in place to ensure that the sample is representative of the whole?	The standards for automatic pipeline sampling is followed, ASTM D 4177. This describes the automatic extraction of sample increments from a pipeline. It was designed for petroleum products but should be applicable to most biomass liquids.
Is any method of verification used?	Previous month's results are used as a comparison.
Are any industry standards met?	ISO 3171, BS 2000, part 61, ASTM D 4177.

Contamination identification and prevention

Table 6.8: Contamination identification and prevention for select liquid biomass fuels

	Tallow /tall oil /palm oil	Waste vegetable oil
Analysis required	Sulphur Sometimes hydrocarbons	Sulphur Sometimes hydrocarbons
What contamination could occur through the fuel production process?	None identified.	n/a

How could this be prevented?	n/a	n/a
What contamination could occur if the fuel is not virgin biomass through previous use of the fuel?	n/a	Could be a wide variety.
How could this be prevented?	n/a	
How could the fuel be contaminated in storage away from the station, during transportation, and while in storage at the station?	If the fuel is stored in a tank previously used for fossil fuel.	If the fuel is stored in a tank previously used for fossil fuel.
What contamination could occur from the previous use of the storage tank?	HFO or another fossil fuel previously stored.	Diesel or another fossil fuel previously stored.
How could this be prevented?	Purging of storage tank before filling with biomass or measured, or another operating procedure to ensure pipes are clean.	Purging of storage tank before filling with biomass, or another operating procedure to ensure pipes are clean.
What contamination could occur from the previous fuel in pipes?	HFO or another fossil fuel previously used.	Diesel or another fossil fuel previously used.
How could this be prevented?	Purging of pipes before filling with biomass, or	Purging of pipes before filling with biomass, or another
	another operating procedure to ensure pipes are clean.	operating procedure to ensure pipes are clean.

How could the fuel be contaminated as part of the combustion process?	If joint pipes for vegetable oil and diesel to engine are used.	If joint pipes for vegetable oil and diesel to engine are used.
What contamination could occur from joint pipework with fossil fuel?	HFO or other fuel used.	Diesel or other fuel used.
How could this be prevented?	Taking measurements from storage tanks and/or via delivery vessels. Taking measurements via a flow meter immediately before combustion can be used if taken before joint pipework or if measurements are taken using the methods for liquid biofuels mixed with fossil fuels.	Taking measurements from storage tanks and/or via delivery vessels. Taking measurements via a flow meter immediately before combustion can be used if taken before joint pipework.

Storage

A6.2 Generally liquid biomass fuels should be stored in a watertight tank for a period of up to six months before combustion.

Appendix 7. Mixing liquid biomass fuels with liquid fossil fuels

A7.1 This appendix covers liquid biomass fuels that are mixed in the same tank as a liquid fossil fuel. It provides operators who wish to do this with some methodologies to measure stock that is carried over from one month to the next and provide figures for volume and energy content of the biomass fuel.

A7.2 Three methods generating stations could use are described below. These are the mass balance method, the marker method and the analytical method. It may be appropriate for generating stations to use the same method for measuring volumes and GCVs or it may be appropriate for generating stations to use one method for volume and a different method for GCV. *T*he mass balance method referred to in this appendix relates to the proportional mass balance method, as opposed to the non-proportional mass balance method which can be used for determining consignments of bioliquid fuels for reporting against the RO sustainability criteria.

The proportional mass balance method (MBM)

Definition of the MBM

A7.3 The MBM calculates the quantity of biomass burned from the relative amount of biomass and fossil fuels that have entered the tank and the total amount of mixed fuel that has been burned. The Gross Calorific Value (GCV) of both the biomass and fossil fuels in the tank is also calculated. This data is required by us on a monthly basis for ROC issue purposes.

A7.4 The MBM works on the principle that what enters the tank directly corresponds to what is burned and assumes the ratio of biomass and fossil fuel combusted is the same as the ratio of biomass and fossil fuel that entered the tank. Therefore, the fuels need to be perfectly mixed for this method to work.

Acceptable uses of the MBM

A7.5 Normally fuels need to be sampled in the month of use. However, we are aware that it can be difficult to sample for the GCV of the biomass in a mixture of fuels. In addition, if there are two well mixed fuels held within the same tank exact scientific analysis as regards the proportions of each held may be unfeasible to conduct.

A7.6 Therefore, where liquid fuels are mixed in a tank with fossil fuels, we will accept robust estimates of the volumes of each combusted and equivalent GCV values. The MBM is a means of estimating this information. Before use of the MBM is accepted by us, an operator will need to outline why its use will be suitable via the FMS Questionnaire. When deciding if the MBM is suitable for use by a particular operator, we will take account of the following factors:

Mixing

A7.7 If operators want to use this method, they will be expected to provide evidencethat the fuels in the tank are well mixed.

A7.8 We may look for information on whether any tests have been conducted to show the fuels mix well and there is a uniform mix of the fuels in the tank.

Other considerations

A7.9 Since this calculation relies on an assumption, we may be more willing to accept its use over a short period of time e.g., during a conversion period where the tank will eventually only hold 100% biomass.

A7.10 Other considerations are:

- how frequently the proportions of biomass to fossil fuel are being recalculated,
- how accurately the tank level can be measured,
- the stability of the biomass fuel's GCV and if there are any means of GCV verification used. If an alternative method is also used we will consider how closely the results from this match the GCV figure obtained from the MBM, and
- whether the fuel is likely to deteriorate under the conditions in the tank.

Data required for the MBM

A7.11 The data required in order to undertake the MBM is outlined below:

- opening tank level,
- closing tank level,
- fuel delivery data (GCV and quantity),
- opening biomass stock*,
- opening fossil fuel stock*, and

- GCV fuel carried over.

*Not necessary for the first calculation month using the MBM.

Undertaking the MBM calculation – a step-by-step overview

A7.12 The key stages of the process are outlined below in Table 28. Steps 1-8 should be undertaken for each fuel present in the tank. For simplicity however, the example below shows the required steps for one fuel only, nominally named fuel A. Stock level can be measured in tonnes, kg, litres etc.

Table A7.1: Key steps of the MBM calculation

Steps 1 - 3 are to be undertaken after a fuel delivery but before any fuel is burned.

MBM Step	Explanation	Example
1	Calculate the total stock of each fuel in the tank.	Opening stock of fuel A + any delivery of fuel A.
2	Calculate the total stock of all fuels in the tank.	total stock of fuel = total stock of fuel A + total stock of fuel B.
3	Calculate the percentage of each fuel in the tank.	Total stock of fuel A (from 1.) ÷ Total stock of fuel (from 2.).

Before the next delivery but after a period of combustion the new total stock of fuel in the tank is read e.g., via a gauge.

4	The closing stock (after a period of combustion) of each fuel is then calculated.	Percentage of fuel A (from 3.) × Total stock of fuel in tank (from post combustion reading).
5	Calculate the stock of each fuel combusted.	Total stock of fuel A (from 1.) - closing stock of fuel A (from 4.).
6	Repetition of the calculation.	Steps 1 to 5 should be repeated every time there is a delivery, period of combustion and at the end of the month.
7	Calculate the total stock of fuels combusted in a month.	Sum of the stocks of fuel burned for fuels A & B during the month (Σ results from 5.).

8	Calculate the weighted average GCV for fuel combusted in the month	Σ Stock fuel A x GCV of fuel during that combustion period*/total stock of fuel A combusted in the month (from 7).

GCV Calculations*: At the point of each delivery, if the new fuel which enters the tank (whether fossil fuel or biomass) has a different GCV than what is already in the tank, the new GCV for this fuel as a result of mixing the two in the tank should be calculated as a weighted average, as shown below:

((Initial stock of fuel A × GCV fuel A) + (Stock of delivery fuel A × GCV delivery fuel A)) ÷ (Opening stock of fuel A + delivery of fuel A)

The image below shows how the MBM method may look in a spreadsheet for an example month. Steps 1 – 8 are shown.

Figure 3: MBM template example

Month Overview:	In the month shown below there is a period of generation and then two deliveries, one for fossil fuel and one for biomass. There is no generation between the two deliveries. After the biomass delivery there is generation until the end of the month. The numbered steps (1-8), as outlined in the Fuel Measurement & Sampling guidance document, are shown in the top right hand corner of the relevant cells.

Month	Jul-10

		Fossil Fuel			Biomass Fuel			
	Date	Tonnes	GCV (GJ/t)	%	Tonnes	GCV (GJ/t)	%	Total Mixed Fuel
Opening stock	01/07/2010	159	40.70	79.41%	41	36.32	20.59%	200
End of combustion period A	07/07/2010	64	40.70	79.41%	16	36.32	20.59%	80
Fuel burned in combustion period A	07/07/2010	95	40.70 *		25	36.32		
Delivery 1 (FF)	08/07/2010	200 1	40					
Stock after delivery 1	08/07/2010	264	40.17	94.12% 3	16 1	36.32	5.88% 3	280 2
Delivery 2 (Biomass)	10/07/2010				220 4	35		
Stock after delivery 2	10/07/2010	264 4 5	40.17	52.71%	236 5	35.09	47.29%	500
Closing stock balance B	31/07/2010	37	40.17	52.71%	33	35.09	47.29%	70
Fuel burned in combustion period B	31/07/2010	227	40.17		203	35.09		

Ofgem: The data in Row 16 is the starting data for the following month: August.

	Fossil Fuel		Biomass	
Combustion Period	Weight (t)	GCV (GJ/t)	Weight (t)	GCV (GJ/t)
Fuel burned in combustion period A	95	40.70	25	36.32 8
Fuel burned in combustion period B	227 7	40.17	203	35.09
Figures to report to Ofgem for July	322	40.33	228	35.23

A7.13 We have produced an MBM template spreadsheet that provides a worked example covering two months which is available on request. If desired, the spreadsheet can be adapted and used as the basis for monthly data submissions.

The marker method

How the marker method works

A7.14 A marker is a property of the two fuels being mixed that differs significantly between the two fuels.

A7.15 For example, the percentage of sulphur in tallow may always be less than 0.01 and the percentage of sulphur in HFO may always be greater than 0.8. If the percentage of sulphur in the mix carried over is measured, this can be used to calculate the volume and GCV of biomass carried over into the following month. The amount of the marker in the fuel will generally be given in sampling analysis as a percentage of the whole fuel.

When the marker method can be used

A7.16 To use a marker there will need to be a clear difference in the amount of one of the properties of the two fuels. The bigger the difference, the more accurately the calculation can be carried out. We would generally expect the difference to be at least an order of magnitude (x10).

A7.17 Some examples of markers accepted are:

- Tallow mixed with HFO – sulphur content.
- Tall oil mixed with HFO – acidity level.
- Palm oil mixed with HFO – sulphur content.

The marker calculation: Data required

A7.18 Generating stations using the marker method should complete the marker method spreadsheet which will automatically calculate burn and energy content values. The information required by the marker method spreadsheet is given below. The calculations performed by the spreadsheet are also described below for information.

A7.19 For the volume and GCV calculations the following data is required:

- Percentage marker in biomass, as determined by sampling analysis of the deliveries of biomass in the month of burn.
- Percentage marker in fossil fuel, as determined by sampling analysis of the deliveries of fossil fuel in the month of burn.
- Percentage marker in mixed fuel, as determined by sampling analysis of the mixture of fuel at the end of the month of burn.

A7.20 For the volume calculation only the following data is required:

- opening balance of biomass,
- opening balance of fossil fuel,
- deliveries, and
- closing balance of mixed fuel at end of month.

A7.21 In the first month, the opening balance should be straightforward. For example, the tank may have 3000 tonnes of fossil fuel and 0 tonnes of biomass fuel. In the following months the opening stock will generally be the closing stock as calculated for the previous month.

A7.22 For the GCV calculation only the following information is required:

- GCV of fossil fuel, and
- GCV of combined fuel.

Step by step overview of the marker method

A7.23 **Steps 1 and 2: percentage of biomass in mix:** The calculations in the first two steps are performed to work out the percentage of biomass and fossil fuel in the mix. This is used when calculating both the volume and GCV of fuel carried over.

A7.24 Step 1 is the average of the percentages given in the analysis of samples taken from the fuel in the month. Step 2 calculates the percentage of biomass and percentage of fossil fuel in the mixture left in the tank. This is calculated by working out the relative difference in the amounts of the marker present in the fuels.

A7.25 This is the difference between the amount of the marker in the mixed fuel and the amount of the marker in the fossil fuel as a percentage of the difference between the amount of the marker in the biomass fuel and the amount of the marker in the fossil fuel.

A7.26 **Step 3 and 4: volume calculation:** Step 3 calculates the closing balance by multiplying the percentage of biomass in the mix by the closing balance of the mixed fuel. This can be used in step 4 to calculate the amount of biomass and fossil fuel used in the usual way, opening balance minus closing balance plus deliveries.

A7.27 **Step 5 and 6: GCV calculation*:*** The GCV of the mix of fuel is expressed per unit of energy, for example, MJ or GJ. The percentage of this GCV made up of fossil fuel and made up of biomass has been calculated in Step 2.

A7.28 Step 5 is used to calculate the GCV in the mix of fuel that is attributable to biomass. This is done by deducting the GCV attributable to fossil fuel from the GCV of the mix of fuel. The GCV attributable to the fossil fuel is the GCV of the fossil fuel multiplied by the percentage of fossil fuel in the mix.

A7.29 Step 6 works out the GCV of biomass per unit of energy. This is done by dividing the GCV attributable to biomass for the percentage of biomass in the mix calculated in Step 5 by the percentage of biomass in the mixture of fuels**.**

Table A7.2: Summary of calculation

Marker method step	**Explanation**
1	**Calculate average percentage of marker in fuels:** Average marker in biomass = sum of marker in biomass samples ÷ number of biomass samples. Average marker in fossil fuel = sum of marker in fossil fuel samples ÷ number of fossil fuel samples.
2	**Work out the amount of biomass in tank at end of month:** Percentage of biomass in mix = (marker in mixed fuel – average marker in fossil fuel) ÷ (average marker in biomass – average marker in fossil fuel). Percentage of fossil fuel in mix = 1 – percentage of biomass in mix.
3	**Calculate the closing balance of biomass and fossil fuel:** Closing balance of biomass = percentage of biomass in mix x closing balance of mixed fuel. Closing balance of fossil fuel = percentage of fossil fuel in mix x closing balance of mixed fuel.

Marker method step	Explanation
4	**Calculate the amount of biomass and fossil fuel burned:** Biomass burned = opening balance of biomass – closing balance of biomass + deliveries of biomass. Fossil fuel burned = opening balance of fossil fuel – closing balance of fossil fuel + deliveries of fossil fuel.
5	Calculate the GCV of the biomass in the combined fuel: GCV of biomass in combined fuel = GCV of mix - (GCV of fossil fuel x percentage fossil fuel in mix).
6	**Calculate the GCV of the biomass:** GCV of biomass = GCV of biomass in combined fuel ÷ percentage biomass in mix. We have produced a template spreadsheet that operators seeking to use the marker method can complete and submit on a monthly basis. This template is available on request from fuelingandsustainability@ofgem.gov.uk.

The analytical method

A7.30 Another way in which operators could satisfy us that they can accurately measure the amount of biomass and fossil fuel carried over each month is to directly analyse samples to find out what percentage of biomass and what percentage of fossil fuel is mixed in the tank. This is the simplest method in terms of the calculation involved, but it may not be practical to do. Because of this, at present, there are no stations using such a method.

Appendix 8. Volume and energy content measurement for gaseous fuels

A8.1 The information contained in this appendix provides generating stations with an indication (rather than a prescriptive guide) to the ways in which they may opt to compile a robust fuel measurement and sampling regime when using gaseous fuels. This provides additional information to that provided in the 'FMS procedures for ACTs' section in Chapter 2.

Table A8.1: Volume measurement using flow meters and a conditions adjustment calculation

Question	Answer
When is the mass measurement and sample taken?	Direct measurement immediately before combustion.
How is the measurement taken?	Integrated volume flow meter or direct volume flow meter.
How often is the measurement taken?	Throughout fuel burn.
Are any industry standards met?	Directive 2004/22/EC on measuring instruments applies to measurements of fuel gas volume. Relevant Standards include BS EN 1359:1999, BS EN 12261:2002, BS EN 12480:2002, BS ISO 14511:1999 all for gas meters.

Question	Answer
How is accuracy ensured?	Good practice is to use a flow meter that falls under Directive 2004/22/EC. This specifies maximum permissible errors (MPEs) for fuel gas meters indicating volume or mass. The MPE of meters is dependent on the flow rate. The most accurate meters are those that have an MPE of less than2% toward minimum flow and less than1% MPE (less than0.5% in certain circumstances) near maximum flow. Typically, mains gas supplies for consumers have been metered used integrating gas meters which work by measuring the total volume of gas passing through the meter; this volume can be converted to an average flow rate if the time between meter readings is recorded. Integrated volume metering devices are less practical for large gas flows and for gas supplies at higher pressures. Other meter types are available which measure the rate of flow – either as a mass or volume flow.
	Calibration of meters to accredited standard methods is necessary to ensure accuracy. Modifications to pipework may be necessary to accommodate this. Inaccuracies due to fluctuations in ambient conditions (in particular temperature) can be reduced by placing the meter in an enclosure.
Is any method of verification used?	Output of generating plant from biogas (and other fuels used where relevant) is accessed.

Table A8.2: Energy content measurement using flow meters and a conditions adjustment calculation

Question	Answer
How is the energy content measurement taken?	Increments taken from flow close to flow measurement.
How often are sample increments taken?	Dependant on size of station, minimum of once a month.
What steps are taken to ensure that the sample is representative of the whole?	As with any sampling system a sample needs to be representative of the fuel gas. Automatic sampling and analysis systems are used throughout the UK natural gas network but sampling may be more difficult at a small biogas facility. Samples can be collected for analysis by a laboratory or testhouse accredited to BS ISO EN 17025 for determination of fuel gas composition, calorific value and other relevant properties. Analysis may be undertaken offsite but care needs to be taken to ensure the integrity of samples which will be stored for a period between sampling and analysis.
Is any method of verification used?	Previous month's results are used as comparison.
Are any industry standards met?	*None identified for sample collection. Analysis of samples can be undertaken by BS EN ISO 6974 (intended for natural gas).*

Volume reference conditions

A8.2 Gas volumes are dependent on temperature and pressure and inappropriate combination of volume flows, calorific value and gas density can lead to significant error.

A8.3 The standard reference conditions for gas volumes are 15 ºC and 1 atmosphere (101.325 kPa). However, there are flow meters that standardise to 0 ºC and 1 atmosphere (101.325 kPa), or other sets of conditions. Therefore, it is important to determine the conditions upon which the equipment measures. Any

standardisation of gas properties to these conditions must be clearly detailed and explained.

Estimating the GCV of biogas

A8.4 Generating stations using biogas may find it difficult to undertake representative monthly sampling of their biogas.

A8.5 In such circumstances we will accept an estimate of the GCV of their biogas based on other monthly measurements. This particular calculation is acceptable because methane is a uniform substance so will have standard energy content. Generating stations wishing to do this will still need to measure their biogas monthly for:

Methane content, Temperature, and Pressure.

A8.6 The calculation that is used to work out the GCV of the biogas each month is given below. The calculation assumes that the only gas in the biogas that has an energy content is the methane. This is a conservative estimate because there are likely to be small amounts of other gases such as hydrogen and hydrogen sulphide which also have an energy content.

A8.7 This calculation also assumes the gas is an ideal gas; this increases the uncertainty in the calculation but not to a great extent. We do not consider the increased complexity in the calculations to account for this is necessary for the increased accuracy it would provide.

The calculation for the GCV of biogas

Step 1 - adjusting the GCV for methane content*:* We suggest using a standard GCV of methane of 37.706 MJ/m^3; this is taken from the latest version of ISO 6976 and is given at standard reference conditions of temperature (15°C) and pressure (101.325kPa). The GCV is based on a gas that is 100% methane, as the biogas includes other molecules the GCV will need to be adjusted to only account for the volume of the biogas that is made up of methane.

Operators will need to adjust the GCV per m^3 according to the percentage by volume of methane in the biogas. This will provide a figure for the GCV at the same standard reference conditions of the biogas per m^3 rather than the methane.

GCV of biogas at standard reference conditions = GCV of methane at standard reference conditions x methane content (%) of biogas

Step 2 - adjusting the GCV for temperature and pressure: The standard GCV of methane figure is given at standard reference conditions for temperature (15°C) and pressure (101.325kPa). Both temperature and pressure affect the number of molecules occupying a given volume. It is reasonable to assume that the relationship between temperature and energy content is linear as is the relationship between pressure and energy content. The calculation should be as follows:

GCV of biogas = GCV of biogas at standard reference conditions x (standard temperature in Kelvin ÷ temperature of biogas in Kelvin) x (pressure of biogas/standard pressure)

The order in which steps 1 and 2 are completed is not important. The GCV of methane at standard conditions (15°C, 101.325kPa) can be adjusted to the conditions the volume is recorded at. This figure can then be used to calculate the GCV of the biogas based on the percentage by volume of methane.

Table A8.3: Summary of calculation

Step	Explanation
1	**Adjusting for methane content:** *GCV of biogas at standard reference conditions = GCV of methane at standard reference conditions x methane content of biogas.*
2	**Adjusting for temperature and pressure:** *GCV of biogas = GCV of biogas at standard reference conditions x (standard temperature in Kelvin/temperature of biogas in Kelvin) x (pressure of biogas/standard pressure).*

Example calculation

A8.12 A generating station uses biogas and measures the methane content, temperature and pressure daily. These are then averaged over the month by the station. The average figures for this example are given under the measured values.

Standard values:

- GCV of methane = 37.706 MJ/m^3
- Adjustment of temperature in degrees centigrade to Kelvin = 273.15

- Standard temperature = 15°C Standard pressure = 101.325 kPa

Measured values:

- Methane content = 67%
- Temperature = 20°C
- Pressure = 108kPa

Step 1: GCV of biogas at standard reference conditions= 37.706 x 0.67 = 25.26302

Step 2: GCV of biogas = 25.26302 x (273.15 + 15)/(273.15 + 20) x 108/101.325 = 25.26302 x 0.9829438854 x 1.065877128 = 26.468 MJ/m^3

Alternative calculation

A8.8 In this example, the GCV of methane is calculated at the conditions the volume is recorded at and then the GCV of the biogas is calculated from this.

Measured values:

1.2. Temperature and pressure are measured but are used to automatically convert the flow meter reading at (0°C) temperature and (101.325kPa) pressure

- Methane content = 67%

Standard values:

- GCV of methane (at 15°C and 101.325kPa) = 37.706 MJ/m^3
- Adjustment of temperature in degrees centigrade to Kelvin = 273.15

Step 1: GCV of methane at (0°C) and (101.325kPa) = 37.706 x (273.15 + 15)/(273.15 + 0) x

101.325/101.325 = 39.777 MJ/m^3

Step 2: GCV of biogas = 39.777 x 0.67 = 26.650**.**

Appendix 9. Further information on alternative methods for determining a contamination percentage for waste fuels

A9.1 Generating stations using SRF or fuels similar in nature eg RDF, may wish to consider using the CEN 343 group of industry standards to support the development of their FMS procedures. CEN 343 is a set of standards covering many aspects of the production, handling and measurement of SRF.

A9.2 Since we can only award ROCs for generation from renewable sources, only generation attributable to the biomass content of SRF waste feedstocks will be considered eligible.

A9.3 Operators must ensure that they are using fuels that meet the conditions set out in the relevant standard in order for a sampling regime based on this standard to be viewed as being reliable. For example, fuels must not contain substances for which the methods prescribed in the standards do not work, such as coal and charcoal.

The Selective Dissolution Method

A9.4 This method is set out in EN ISO 21644:2021 – Measuring the Biomass Content of Solid Recovered Fuels (SRF). A standard that provides methodologies for determining the biomass fraction of a representative waste sample.

A9.5 This method relies on the fact that, under the conditions specified in the standard, biomass materials will dissolve and whatever is left undissolved will therefore be fossil-derived. Since the dissolution method can be used to directly determine the GCV of the biomass in the sample, it's use is preferred over that of the manual sorting.

The Manual Sorting Method

A9.6 This method is also set out in EN ISO 21644:2021.

A9.7 In this method, a representative sample of the solid recovered fuel is sorted by hand into various sub-fractions e.g. plastics, paper/cardboard, wood and inert matter. These constituents are then dried to a constant weight and separated into biomass, non-biomass and inert categories.

A9.8 The calorific value of the biomass content of the sample can now be determined through establishing the average net calorific value for each category on a dry

basis. Manual sorting can also only be applied to waste materials over a certain particle size.

Potential for Error

A9.9 Generating stations seeking to use the selective dissolution and manual sampling methods outlined in EN ISO 21644:2021. should bear in mind that these methodologies have several limitations. These are outlined in Annex G for the standard.

A9.10 For example, as regards selective dissolution, operators will need to consider that the biodegradability of certain non-biomass materials e.g. coal or polyurethane plastics, may lead them to dissolve and therefore they would be considered biomass. A list of such materials is considered in the standard. While the manual sorting method is to some extent reliant on estimation and is therefore prone to human error; this can also arise due to the nature of the sorting process.

Use of the Selective Dissolution Method for Waste Wood Fuels

A9.11 The methods outlined in EN ISO 21644:2021. were primarily designed for use with waste fuels e.g. SRF. However, operators have used the selective dissolution method to determine the fossil fuel derived contamination percentage of waste wood fuels e.g. which are contaminated by small quantities of paint, varnish and adhesives. These fuels naturally have a higher biomass content than SRF or similar waste fuels.

A9.12 Within Annex G of the standard, it states that the reliability of the method may be compromised when used with fuels with very high biomass contents e.g. greater than 95%. Therefore, where the biogenic content of waste wood fuels is analysed using the selective dissolution method, to account for the potential unreliability of the method at high biomass contents we impose a minimum 5% contamination level which will be assumed for ROC award.

A9.13 To avoid the application of a minimum contamination level, operators may seek to use other methods to demonstrate the biogenic content of their waste wood. A further example methodology is outlined in our 'Renewables Obligation: template methodology for measuring fossil-derived contamination within waste wood guidance'.

Re-release of the Standard

A9.14 We will monitor the re-release of CEN Standards and at such point as an updated version of EN ISO 21644:2021. is released this will be reviewed. We may then seek to alter our approach based on any developments in the standard as regards the addition of new methodologies or re-evaluation of those already included.

Carbon-14 (14C)

A9.15 14C techniques are available methods for determining the contamination percentage of a fuel or combination of fuels or feedstocks. In order to ensure that 14C techniques are applied correctly generating stations wishing to use these should complete the dedicated 14C questionnaire available on our website.

Appendix 10. Offsite measurement and sampling

Off-site sampling considerations

A10.1 In addition to the requirements that must be met when fuel is measured on-site, the Orders require us, when determining whether information is accurate and reliable where it has originated off-site, to have regard to:

- the distance over which the fuel was transported, and
- the conditions under which the fuel was prepared and transported.

A10.2 As with on-site measurement, generally the fuel must be measured and sampled within the month of use. Data submitted to us each month must be an accurate reflection of what has been used in that particular month.

A10.3 We recognise that this might cause practical difficulties when off-site measurement takes place at the very end of the month and the fuel is used in the following month. When reviewing FMS procedures, we will work with generating stations to try to find ways to address this.

Distance and transport conditions

A10.4 When employing off-site measurement, it is important to ensure that the fuel does not change in composition while it is being transported. When considering the distance covered, it is also appropriate for us to consider the time taken for the fuel to travel that distance as this could impact on the state of the fuel. Operators will therefore need to have suitable measures in place to assure us that the fuel does not change in composition over the time and distance taken to transport it from the facility where it was measured and sampled, through to the place where it is used for the purposes of electricity generation.

A10.5 Conditions that might cause a fuel to deteriorate over time or change in composition (e.g. exposure to moisture causing the fuel to decompose) need to be taken into account. If the fuel has changed in composition during transit, the generating station will need to re-sample that fuel.

Auditing for stations using off-site measurement

A10.6 Should we wish to conduct an audit of a station using off-site measurement, we will require access to an operator's premises. The granting of such access is one of the standard conditions of accreditation to which all accredited operators are

subject. The condition relates to the granting of access to premises owned by the operator.

A10.7 In the case of an operator seeking to measure and sample fuel off-site, we will require access for audit purposes to the facility where that measurement and sampling takes place. As facilities are often owned and operated by parties other than the generating station being audited, a standard condition of accreditation requires the operator to ensure that we can gain access to such off-site measurement facilities for audit purposes.

Appendix 11. Industry standards

Please note: The below industry standards were active at the time of publication, however it is the participants responsibility to ensure that this is still the case.

ASTM D4057 – 06(2011)

Standard Practice for Manual Sampling of Petroleum and Petroleum Products.

ASTM D4177

This American standard describes the automatic extraction of sample increments from a pipeline. It was designed for petroleum products but should be applicable to most biomass liquids.

ASTM D6866 - 12

Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis.

ASTM D7459 – 08[93]:

Standard Practice for Collection of Integrated Samples for the Speciation of Biomass (Biogenic) and Fossil-Derived Carbon Dioxide Emitted from Stationary Emissions Sources.

BS 2000 PT 61:

Methods of test for petroleum and its products – this specifies methods for sampling and analysis of liquid fuels.

BS EN ISO 10012:2003:

This presents in detail methods of calibration for static weighing devices and for determining periodic confirmation intervals.

BS EN ISO 6974:

This determines the composition of natural gas with defined uncertainty by gas chromatography.

BS 1016:

[93] D7459 Standard Practice for Collection of Integrated Samples for the Speciation of Biomass (Biogenic) and Fossil-Derived Carbon Dioxide Emitted from Stationary Emissions Sources

This shows methods for analysis and testing of coal and coke (for example for moisture content, ash, volatile matter, gross calorific value, sulphur, chlorine, carbon, hydrogen and nitrogen).

BS 1017 (Part 1)

Methods for the automatic or manual sampling of coal. The mechanical sampling aspects of BS 1017 - 1:1989 (coal) and BS1017 - 2:1994 (coke) have been superseded by BS ISO 13909 parts 1 to 8. The manual sampling aspects of BS1017 will be replaced by BS ISO 18383, currently in preparation. BS 1017-1 and BS1017-2 will be withdrawn on publication of BS ISO 18383.

CEN 343

A set of European standards which covers many aspects of the measurement, sampling and management of solid recovered fuels. The most relevant are:

- *EN ISO 21644:2021*: Measuring the Biomass Content of Solid Recovered Fuels (SRF)
- *BS EN 15358:2011*: solid recovered fuels - quality management systems - particular requirements for their application to the production of solid recovered fuels
- *Directive 2004/22/EC* on measuring instruments applies to measurements of fuel gas volume.
- *ISO 3170: 2004* – Petroleum liquids: manual sampling – this specifies the manual methods for sampling from fixed tanks, railcars, road vehicles, ships and barges, drums, cans or from liquids being pumped in pipelines.
- *BS EN ISO 3171:1999*, *BS 2000-476:2002* – Petroleum liquids: automatic pipeline sampling – this specifies procedures for crude oil and liquid petroleum products being conveyed by pipeline.
- *EN ISO 6976:2016* – this specifies the calculation of CV and other properties of natural gas.
- *ISO/FDIS 13833*[94]*:* Stationary source emissions -- Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide -- Radiocarbon sampling and determination

[94] ISO 13833:2013 - Stationary source emissions — Determination of the ratio of biomass (biogenic) and fossil-derived carbon dioxide — Radiocarbon sampling and determination

Appendix 12: Glossary

Glossary

A

ACT	Advanced conversion technology
AD	Anaerobic digestion
ASTM	American Society for Testing and Materials

B

BEIS	Department for Business, Energy and Industrial Strategy
BIOMA	Biophysical Model Applications
BS	British Standard

C

^{14}C	Carbon-14
CHP	Combined Heat and Power
CHPQA	Combined Heat and Power Quality Assurance
CEN	European Committee for Standardisation
CEN/TS	European Committee for Standard/Technical Specification
CV	Calorific Value

D

DNC	Declared Net Capacity
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero
DETI	Department for Enterprise, Trade and Investment, Northern Ireland
DfE	Department for the Economy (NI)

E

EC	European Commission
EU	European Union
EN	European Norm (Standard)

F

FDBL	Fossil-Derived Bioliquid
FF	Fossil Fuel

FMS	Fuel Measurement and Sampling
FMSQ	Fuel Measurement and Sampling Questionnaire
G	
GCV	Gross Calorific Value
GHG	Greenhouse Gas
GJ	Gigajoule
H	
HFO	Heavy Fuel Oil
I	
ISO	International Organisation for Standardisation
IT	Information Technology
K	
Kg	Kilogram
M	
MBM	Mass Balance Method
MDF	Marine Diesel Fuel
MJ	Megajoule
MONG	Matter Organic Non-glycerol
MPE	Maximum Permissible Errors
N	
NIRO	Renewables Obligation (Northern Ireland) Order
O	
Ofgem	Office of Gas and Electricity Markets
OIML	Organisation Internationale de Metrologie Legale
P	
PKE	Palm Kernel Expeller
Q	
QI	Quality Index
QPO	Qualifying Power Output
R	
RDF	Refuse Derived Fuel

RER	Renewable Energy Register
RFFS	Relevant Fossil Fuel Station
RFO	Recycled Fuel Oil
RHI	Renewable Heat Incentive
RO	Renewables Obligation
ROC	Renewables Obligation Certificate
ROO	Renewables Obligation Order
ROS	Renewables Obligation (Scotland) Order
RPI	Retail Price Index
S	
SRF	Solid Recovered Fuel
STP	Standard Temperature and Pressure
Syngas	Synthesis Gas
T	
TPO	Total Power Output
U	
UK	United Kingdom