Biomass Boilers
Operations and Maintenance Guide

Biomass Boilers - Operations and Maintenance Guide

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About SEAI
SEAI is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with Government, homeowners, businesses and communities to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies.

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1. Introduction

Ireland has a long-term vision for a low-carbon energy system aimed at reducing greenhouse gas emissions from the energy sector by 80–95% (compared to 1990 levels) by 2050[1]. Achieving this target means a radical transformation of Ireland's energy system: reducing energy demand and moving away from fossil fuels to zero or low-carbon fuels and power sources.

Sustainably produced biomass is a low-carbon fuel, but resources are limited. Therefore, it is important to ensure that it is used as efficiently and effectively as possible. Other potential impacts from biomass use, such as emissions of pollutants that affect air quality, need to be minimised and biomass installations must be operated safely. Biomass systems differ significantly from those fuelled by gas or oil. It is important to address these differences in planning, design and operation to ensure a well-functioning, safe and efficient biomass system.

This guide is provided as part of a suite of three biomass guides: an Implementation Guide, Technology Guide, and Operation and Maintenance Guide, which collectively aim to provide an understanding of biomass technology, its implementation and operational management.

1.1 Purpose of this guide

This Operation and Maintenance Guide is principally intended for users such as facilities, engineering and environmental managers, and technical maintenance staff. It has two main aims:

1. To provide a guide to the operation and maintenance requirements of biomass systems, good practice and essential issues.
2. To direct the reader towards more detailed information on specific aspects of the technology. This guide and its two companion guides do not seek to duplicate existing publications; rather they are intended as a comprehensive starting point for those wishing to better understand the technology, its implementation and management.

1.2 Scope

- The guides concentrate on solid biomass boilers for non-domestic premises in the heat output range of 50kW to 5MW. Much of the guidance will also apply to smaller and larger scale boilers.
- These guides focus on the distribution of heat from boilers in hot water systems for non-domestic space, water and process heating.
- Power generation, combined heat and power (CHP) and direct air heating systems fuelled by biomass are not covered in these guides.
- These guides focus on wood (both virgin and waste) fuels, mainly in the form of logs, pellets and chips. Other fuels covered are straw and chicken litter (agricultural residues) and energy crops, such as short rotation coppiced (SRC) willow and miscanthus (elephant grass). Liquid and gaseous biofuels are not considered.
- Outside the scope of these guides, are the Support Scheme for Renewable Heat[2] terms and conditions. The Support Scheme for Renewable Heat is a government-funded scheme, to encourage the installation of renewable sources of heat in non-domestic applications in the Republic of Ireland. These guidelines will help applicants identify the appropriate standards and best practice for solid biomass uses. For the avoidance of doubt, these guidelines provide an applicant with guidance on good practice only. The Ministerial Terms and Conditions, the Grant Scheme Operating Rules and Guidelines and the Tariff Scheme Operating Rules and Guidelines, where relevant, set out the basis on which the Support Scheme for Renewable Heat will operate.

[1] https://www.dccae.gov.ie/en-ie/climate-action/publications/Documents/5/National%20Climate%20Policy%20Position.pdf
[2] https://www.seai.ie/sustainable-solutions/support-scheme-renewable-/

2. Fuel procurement

Key messages

- Fuel quality is key and sub-standard fuel can cause a range of issues. Therefore, conducting quality checks on the fuel is important.
- Biomass fuels should be sourced from sustainable suppliers.
- The range of fuel supply options includes self-supply, direct supply from a local site and fuel supply companies.
- Review fuel costs regularly to ensure the price is reasonable. Determine if the cost is a fixed rate per unit (e.g. cost per kWh) or the summation of a unit rate and fixed delivery charge.
- Accreditation of the fuel supplier and/or products provides a degree of quality assurance.
- Keep records to assess fuel consumption and any quality impacts on boiler performance.

Fuel is one of the main ongoing operational costs for a biomass system. Therefore, fuel should be sourced at the lowest available price, while still meeting the relevant quality standards. Cheap, sub-standard fuel may prove to be a false economy as it can decrease boiler performance, increase maintenance costs and cause excessive emissions.

2.1 Sustainability of fuels

Biomass is considered a renewable fuel as the growth of plants is driven by the capture of energy from the sun. While biomass does release carbon dioxide (CO_2) into the atmosphere when it is burnt, this is offset by new plant growth, as plants absorb CO_2 when growing. International climate change agreements recognise biomass as a renewable fuel, which reduces carbon emissions when replacing fossil fuels in energy generation or heat production.

However, the production of biomass fuels can also generate greenhouse gas emissions that are additional to the simple carbon cycle. These emissions can come from fossil fuels used in growing, harvesting, processing and transporting the biomass, and from any agrochemicals used in cultivation. Therefore, to maximise the carbon savings from bioenergy, biomass fuels must be produced as sustainably as possible.

Biomass fuels that are derived from waste streams or residues (such as poultry litter or straw) generally have relatively low overall emissions.

Other aspects of sustainability to consider are ensuring that:

- Carbon stocks in forests are not reduced through the harvesting of wood as a biomass fuel (e.g. by replanting).
- The conversion of land to produce biomass does not lead to high releases of carbon (e.g. if wetlands are cultivated).
- Biomass is not sourced from areas of high biodiversity such as primary forests.

To ensure sustainable production, Government and other professional body schemes may set criteria for the overall reduction in carbon emissions that biomass must achieve (compared to emissions from using fossil fuels) when taking into account emissions from biomass production. They may also require evidence that other sustainability principles have been met. An operator intending to apply for support scheme for the development of a biomass project should check any scheme criteria relating to sustainability and assess whether the proposed fuel supply will meet the criteria.

Even if no support is being sought, it is desirable to minimise carbon emissions and other possible environmental impacts associated with the fuel. Therefore, biomass plant operators should buy from suppliers that source biomass in a sustainable way. Some fuel accreditation schemes, such as the Wood Fuel Quality Assurance (WFQA) scheme for Ireland3 and ENplus4, include sustainability criteria (see Section 2.3 for more information).

Refer to Section 6.2 for details of the revised EU Renewable Energy Directive[5].

[3] http://wfqa.org/
[4] https://enplus-pellets.eu/en-in/
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0767R%2801%29

2.2 Identifying suppliers and market testing

Factors influencing the identification of a fuel supplier are: the availability of fuel on sites owned by the biomass operator, availability of local fuel supplies and fuel type (further information on fuel types and processing is given in the accompanying Technology Guide).

It is recommended that fuel be sourced as locally as possible to reduce transport costs and minimise carbon emissions associated with delivery. Table 1 summarises the advantages and disadvantages of potential fuel supply routes.

Table 1: Summary of potential fuel supply options

Supply route	Description	Advantages	Disadvantages
On site or sites under same ownership as the biomass site	Biomass boiler operators source fuel from their own sites. This can include all fuel types (poultry litter, straw, waste wood, forestry residues or energy crops).	• Likely to be the lowest cost option. • Allows complete control of the fuel supply chain. • Avoids disposal costs that might have been incurred (in cases where fuel is derived from waste/residues). • Likely to offer shortest fuel transportation distances.	• Requires fuel-handling and processing equipment. • Potentially additional space requirements. • Fuel might not be produced to the same standards as that from accredited suppliers.
Direct supply from a local site	Sourcing fuel directly from a local site, such as energy crops from a farmer, private timber companies or wood waste from a factory. This is a less common supply route and would require surveying the local area for potential suppliers.	• Potentially lower cost if it avoids other disposal costs for the supplier. • Potentially increased ability to negotiate price and supply contract. • Likely to offer a short fuel transportation route.	• Reduced control of fuel supply chain. • Potentially requires additional equipment and space. • Fuel may not be produced to the same standards as that from accredited suppliers.
Fuel supply company	A company whose business is to supply fuel. This is a common solution but is mainly restricted to woody biomass. Websites, such as the WFQA scheme, have lists of suppliers.	• Requires the least fuel-handling equipment and fuel processing. • Lowest space requirements for fuel storage. • Fuel is usually produced to an accredited standard.	• Likely to be the most expensive. • Decreased control of fuel supply chain. • May have longest fuel transportation distances. • Less control over price and contract terms.

The process for selecting a fuel supplier is shown in Figure 1.1. Biomass fuel costs are subject to variations (although historically variations have been greater for fossil fuels). It is therefore worth conducting regular market testing to verify current fuel prices and consider if a revised price should be negotiated or the fuel supplier changed. Other factors to consider are: the supplier's customer service, fuel quality and ability to meet short-notice deliveries.

Figure 1.1: Process for selecting a fuel supplier

Identify potential suppliers	• Review local area for potential biomass supplies if a direct supply from a local site is sought. • Review local fuel supply companies in the area using websites such as WFQA.
Prepare a fuel specification	• Produce a fuel specification including type of fuel, fuel quality expectations, amounts needed, fuel store size, seasonal variations, site location, site access details and who will be responsible for fuel level monitoring. • If the supply is to cover multiple sites this should be detailed, and whether individual deliveries are required or if a 'milk round' delivery is acceptable.
Request quotations	• Issue the fuel specification to suppliers and request quotations. • Suppliers will generally provide these free of charge.
Review quotations	• Compare the quotations to the fuel specification to ensure the requirements are met. • Compare the costs and their assumptions. The cost may be a single charge per unit of fuel delivered, or a combined charge of cost per unit and a fixed cost of delivery. Assumptions should also be checked for accuracy. • Additional factors such as the suppliers' experience, certification, fuel depot location, customer service and ability to meet unexpected deliveries should be compared. • To enable a consistent review of the quotations a scoring matrix could be used with key requirements of the system and desirable factors in the proposal with an allocated score depending upon their importance.
Review contract of selected supplier	• Review the contract against the fuel specification and quotation. • Review the contract for allocation of risks and responsibilities. • Review duration of contract and early cancellation clauses. • Review the procedure for quality checking the fuel, rectifying fuel quality issues and dispute resolution.

2.3 Certification

There are two main fuel certification schemes relevant to Ireland.

The WFQA scheme for Ireland: The WFQA label certifies that wood fuels are accurately described and meet a supplier's stated product specifications. The WFQA scheme is built around the industry-agreed standard EN 17225 and is tested to ISO 17225-1:2014. WFQA states that all certified wood fuel is sourced sustainably and complies with the EU Timber Regulation (EUTR), ensuring full traceability back to source.

ENplus® quality certification scheme for wood pellets: ENplus®-certified producers are required to document the origin of their pellets and the proportion of certified wood materials in them. ENplus® quality classes are based on ISO 17225-2, with some ENplus® product requirements exceeding this standard. ENplus® acknowledges the certificates from the Programme for the Endorsement of Forest Certification (PEFC), the Forest Stewardship Council (FSC) or equivalent forest management schemes – including their chain-of-custody certificates.

2.4 Fuel quality

If fuels are supplied under a recognised standard, then the quality of the fuel should be assured. As indicated above, wood pellets are usually manufactured to meet an ENplus® quality class.

Wood chip and other fuels are commonly supplied to meet a desired specification, but may not be produced to meet a recognised standard. Therefore, routine sampling and fuel monitoring will be essential to ensure that fuel meets the specification.

The key elements to be monitored are:

- **Moisture content** – boilers are optimised to burn fuels with a moisture content within a specific range. Using fuel outside of that range will result in inefficient combustion, possible damage to the boiler and excessive smoke and tar, as well as emissions limits possibly being exceeded.
- **Particle size** – boilers are designed to operate on fuel that has particle dimensions within a specified range. If the particle size falls outside the range, there may be adverse effects on the fuel feed system to the boiler and the combustion characteristics of the fuel within it.
- **Properties that affect combustion** – including calorific value (CV), and moisture, carbon, hydrogen and nitrogen content. For some fuels it may also be important to check for sulphur and chlorine levels.
- **Contamination** – physical contamination may be present in the form of stones, soil, metals (e.g. nails from used wood pallets) and plastics in the case of biomass derived from waste wood. There may also be chemical contamination in the form of paint and solvents on treated wood (these should generally be identifiable by visual inspection, and they also have an impact on ash appearance). Physical and chemical contamination can damage the fuel feed system and boiler, and impact on its performance, as well as causing elevated levels of emissions.

Fuel monitoring can range from basic on-site tests with limited equipment to laboratory testing. Table 2 summarises the different approaches to fuel monitoring of key parameters.

Table 2: Summary of approaches to fuel monitoring

Parameter	Basic testing	Advanced monitoring
Moisture content	Touch test – does the fuel feel or look wetter than it should? On-site (low cost) moisture meters or conductivity probes can be used to test moisture content.	On-site (higher cost) advanced moisture analysers that weigh a sample, then dry it and reweigh it. Oven-dry method, laboratory testing to recognised standards (i.e. ISO 17225).
Particle size	Visual check for oversized or undersized particles, both of which can cause blockages. Use of hand-held sieves to sample particle size.	Particle size distribution in a laboratory (using ISO 17225 for wood chips).
Contamination	Visual inspection for physical contaminants.	Laboratory chemical testing services to test for trace elements found in timber treatments.

The regular inspection of boiler ash for changes in colour, particle size or clinkering can also help to identify fuel-related problems with combustion or contamination.

2.5 Fuel consumption

The appropriate method for monitoring fuel consumption will depend on the scale and level of automation of the system.

Many larger systems will offer in-built monitoring, and some manufacturers and/or fuel suppliers provide a remote-monitoring function that alerts the operator when fuel needs to be ordered.

In smaller systems without automatic monitoring, fuel records can be kept by logging delivery notes or invoices, or by keeping records of fuel quantities loaded into the fuel store (by volume or weight as appropriate).

The fuel level in a store may not always be even and the location of fuel-level sensors and viewing windows may give a false impression of the store content. It is recommended to have fuel-level sensors in several locations and one or more viewing windows from which the full store can be seen. Regular emptying and cleaning of the fuel store helps to reduce fuel slumping issues by stopping fuel from sticking to the sides of the store or becoming compacted at the bottom and immovable. The fuel can be manually levelled if required.

Fuel consumption should be compared to heat output to verify the energy density of the fuel used and the efficiency of the boiler.

Fuel stores are very hazardous. It is vital that all appropriate health and safety procedures are followed when entering a fuel store – see Section 5.2, Table 7 and refer to the additional references listed in Section 6.4.

2.6 Record keeping

It is important to keep the following records relating to fuel:

- A copy of the fuel contract if such exists (rather than ad-hoc individual orders) – to be referred to when renewing the contract or if problems arise.
- Fuel suppliers' specifications for fuels purchased, which should be checked prior to an order being placed if there is no fuel contract. Where there is a fuel contract, the relevant specifications should be included in it.
- Fuel invoices, which provide a record of fuel quantity, type, costs and suppliers. Invoices may not provide exact dates of each delivery.
- Fuel delivery notes provide a record of the date and quantity of each delivery. They are frequently accompanied with weighbridge tickets as confirmation of the quantity of complete loads. Delivery notes provide supporting evidence for invoices.
- Fuel quality checks – to monitor against the specification.
- Stock levels taken at appropriate intervals.

3. Maintaining efficient operation

Key messages

- Well-planned maintenance and monitoring are vital to ensure the boiler functions smoothly.
- Site staff can provide some of the ongoing manual input, which may be less costly but requires a certain level of training. Alternatively, it can be conducted by a contractor, which is likely to cost more.
- When selecting a contractor, consider their credentials, remote monitoring capabilities, helpline facilities, charges and ability to consistently provide access to support engineers.
- Boiler operators should be familiar with the manufacturer's guidance for, the individual components of the heating system, including the boiler, the flue, metering and fuel handling equipment.

Like any equipment, properly planned maintenance and monitoring of a biomass system is vital in ensuring that:

- The safe operation of the system is maintained.
- The system continues to function as designed and commissioned.
- Outages (breakdowns) are minimised.
- The service lifetime of plant is maximised.

This section provides guidance on how to ensure optimum operation. The organisation undertaking the day-to-day operation of the boiler is referred to as the 'operator'. This could be the site owner/occupier or a services company to whom responsibility for the boiler operation has been contracted out. The services company may provide qualified staff itself or sub-contract this to others.

3.1 Contracting for operation and maintenance – options

It is common for the boiler owner to operate the system but contract out servicing and repairs to the company that installed the system.

Alternatively, operation and maintenance may be contracted out to a third-party services company, which may or may not be a fuel supplier. Through remote system monitoring the responsible party can carry out simple adjustments without the need for a permanent presence on site.

It is common for that site staff to take responsibility for some of the operational duties related to the biomass heating system (i.e. ash removal). This can be a less costly option, but staff will require a certain level of training. Alternatively, it can be conducted by a contractor, which will incur higher costs. Table 3 details the options for operation and maintenance.

Table 3: Operation and maintenance options

Option	Suitability	Advantages	Disadvantages
Original installer operates and maintains the heating system	This is suitable for clients with little or no knowledge of biomass systems and available staff. This is a relatively common solution. Distance of O&M operator should be taken into consideration	• Requires minimal interaction with the biomass system from the site staff. • Should ensure a high-performing system due to a strong knowledge of the technology.	• Is likely to be the highest cost solution. • Offers a low level of control to the client and may cause delays in identifying and rectifying issues due to possible remote nature of contractor.
In-house operation of heating system with original installer providing maintenance	This is suitable for sites with a member of staff, such as facilities manager, who can be trained to operate the system and provide basic checks and maintenance. This is a common solution.	• Lower costs than having everything done by the installer. • May allow more rapid identification of issues and rectifying minor issues. • Offers greater control of system.	• Requires a level of knowledge and training of member(s) of staff. • May result in issues not being spotted or incorrectly rectified.
In-house operation of heating system with third party rather than original installer providing maintenance.	This solution is usually undertaken when the original installer is no longer available/ too costly. As such, it is less common.	• Offers flexibility to choose the contractor. • May result in lower costs and/or better service.	• Care needs to be taken not to void any warranties. • Knowledge level of the system may not be as good as original installer. • May not be capable of the same levels of remote monitoring as the original installer.
In-house operation and maintenance of heating system	This is suitable for a site that has strong biomass capabilities. This is less common and is still usually supported by external contractors in the cases of severe breakdowns.	• Likely to be lowest cost solution. • Offers complete control over operation and maintenance process.	• This may void a system's warranties unless written dispensation is received. • Requires staff with biomass capabilities if good performance is to be maintained.

The following should be considered when selecting a contractor:

- Credentials – including experience, certification, training and accreditation.
- Remote monitoring capabilities – such as remote access to the boiler, heat meters and building management system (BMS).
- The level of telephone support offered. Does the contractor have the facility to talk on-site staff through checks and resolution of minor issues?
- Can the contractor offer an on-call service with a maximum response time for attendance at site?
- Location and number of engineers. This will affect how rapidly contractor's staff can attend the site.
- The ability to provide an engineer familiar with the installation for maintenance works. Using the same engineer enables him/her to build up knowledge of the system, and identify issues and solutions more readily.
- Charges and charging structure. This will usually be made up of fixed costs for planned maintenance (and operation if applicable), plus costs of repair parts (i.e. non-consumables) and call-out rates for unplanned maintenance.

3.2 Biomass system maintenance

Boiler operators should be familiar with the manufacturer's guidance for the individual components of the heating system, including the boiler, the flue, metering and fuel handling equipment. The following general information is in the context of that guidance.

3.2.1 The boiler and flue

Biomass boiler maintenance can be divided into the following categories:

- Ash bin emptying and basic checks – undertaken by the operator.
- Regular cleaning and checks – normally undertaken by the operator.
- Services – normally undertaken by the boiler supplier or other specialist.
- Dealing with breakdowns and undertaking repairs – normally undertaken by the boiler supplier or other specialist.

Intervals between maintenance tasks and servicing depend on boiler usage, warranty, size and type. It is typical for services to be carried out every 2,000 full-load equivalent (FLE) operating hours[6] or annually, whichever occurs first.

Boiler cleaning and regular checks might be monthly, or more frequent for heavily used boilers. An ash bin within the boiler house (either integral to the boiler or standalone) will require regular manual emptying (see Section 3.2.2).

The control systems of many modern boilers will provide an alert if cleaning is required or there is another urgent issue. Table 4 provides an indication of the typical maintenance tasks for a biomass boiler, but the **guidance and recommendations provided by the boiler manufacturer and its authorised agents should be followed and take precedence.** Before tasks are undertaken by personnel other than those of the boiler manufacturer or its authorised agents, operators should ensure that this will not invalidate any warranties, and that the personnel have the relevant training.

All boiler maintenance tasks present potential hazards and require strict adherence to established health and safety procedures. Further details are provided in Section 5 of this guide.

[6] The full-load equivalent operating hours for a particular period is the actual heat generated in that period divided by the heat that would have been generated if the boiler had operated continuously at its full rated output.

Table 4: Typical maintenance tasks for a biomass boiler (this is not an exhaustive list)

Task	Typical frequency	Typically undertaken by
Basic checks: • Walk-around inspection looking for anything unusual • Heating system pressure • Leaks • Heat meter operation • System operation	Daily/weekly	Operator
Empty ash bin(s)	Weekly/monthly as required	Operator
Check safety devices: • Safety and relief valves • Fire protection/prevention in fuel transport mechanisms	Monthly	Operator/specialist contractor
Flue: • Check integrity of flue components. • Clean flue path to stack. • Clean stack condensate drain		
Clean combustion chamber: • Clean grate • Clean combustion air openings • Clean ignition tubes • Check refractory linings for damage		
Clean the heat exchanger: • Clean the heat exchanger tubes and channels • Clean the lambda probe • Check heat exchanger tubes for damage • Check operation of heat exchanger cleaner (where fitted) • Check integrity of cover seals		
Clean flue-gas recirculation piping (where fitted)		
Clean induced-draught fan.	Service annually or every 2,000 hours full-load equivalent (which ever come first)	Specialist contractor
Clean temperature sensors.		
Check operation of primary and secondary combustion air valves.		
Check and lubricate mechanical drives.		
Check functioning of de-ashing systems.		
Clean and check ignition.		
Check fitting and sealing of boiler doors.		
Calibrate lambda probe.		
Check and adjust specified mechanical clearances.		
Reset maintenance interval counter (if fitted).		
Test boiler and heating system post-service.		
Any other specific maintenance detailed by the manufacturer.		

Please ensure that the above list does not affect the heating system/boiler/s warranty

3.2.2 Ash disposal

The quantity of ash produced depends on boiler usage and the fuel ash content.

Example estimate of ash production

A 200kWth boiler operates for 1,750 full load equivalent hours annually. Assuming the boiler has an efficiency of 85% and uses wood pellets with a net calorific value of 4,700kWh/tonne and an ash content of 1.0%, the bulk density of the ash will be approximately 920kg/litre.

In one year the boiler will:

- Produce 350,000kWh of useful heat (200 x 1,750).
- Use 87.6 tonnes of pellets (350,000 ÷ 0.85 ÷ 4,700).
- Generate around 876kg of ash.

Assuming the boiler has two integral ash bins, each with a capacity of 50 litres, they will need to be emptied around once a month or more frequently.

There are two types of boiler ash: bottom ash and fly ash. Bottom ash makes up approximately 98% of the ash from a biomass boiler and arises at the grate.

Fly ash is fine ash that is entrained in the combustion gas flows and is collected through a drop-out chamber within the boiler and/or as part of separate flue-gas cleaning, such as a cyclone grit arrestor. Fly ash may contain toxic particulates from volatised metals and metal salts. Therefore, it should be treated as a hazardous waste and disposed of appropriately.

Bottom ash from contaminated fuel, such as treated waste wood, and poorly combusted bottom ash, should also be treated as a hazardous waste. The options for disposal are:

- To landfill where ongoing arrangements will need to be made with a licensed waste company for disposal.
- Alternative disposal - with appropriate authorisations from the competent authority, it may be possible to find alternative disposal routes, such as to land. This should be easier for bottom ash from clean biomass, which generally poses lower risks than fly ash.

Relevant waste categorisations for ash from the Environmental Protection Agency's (EPA) Waste Categorisation, 2015[7]

Reference number & Categories of Wastes from thermal processes		Type
10 01	***wastes from power stations and other combustion plants (except 19)***	
10 01 01	bottom ash, slag and boiler dust (excluding oil boiler dust)	Non-hazardous
10 01 03	fly-ash from peat and untreated wood	Non-hazardous
19 01	*wastes from incineration or pyrolysis of waste*	
19 01 11	bottom ash and slag containing hazardous substances	Hazardous
19 01 12	bottom ash and slag other than those mentioned in 19 01 11	Non-hazardous
19 01 13	fly ash containing hazardous substances	Hazardous
19 01 14	fly ash other than those mentioned in 19 01 13	Non-hazardous

[7] www.epa.ie/pubs/reports/waste/stats/wasteclassification/EPA_Waste_Classification_2015_Web.pdf

3.2.3 Fuel store and fuel handling equipment

Mechanical fuel extraction systems that extend to the boiler are the principal maintenance burden for fuel stores. Depending on the fuel type, these can include augers (fixed or sweeping), sweeping arms or walking floors.

Maintenance requirements are likely to include:
- Clearing blockages;
- Lubricating drive chains and bearings;
- Alignment checks and mechanical adjustments;
- Mechanical, hydraulic and electrical repairs.

Clearing blockages is normally carried out by the operator. Other maintenance requirements might be undertaken by the operator, or by specialist contractors. From time to time it may also be necessary to clean out fuel stores and ensure that they remain ventilated.

All these tasks pose significant hazards for the personnel concerned and require strict adherence to established health and safety procedures. Further details are provided in Section 5 of this guide.

3.2.4 Heat metering

Day-to-day checks
Correctly installed heat meters should require very little maintenance other than regular checks to ensure that they are functioning correctly and the components have not been inadvertently damaged. These checks can be undertaken at the same time as manual meter readings, but should be at least weekly. Where meter readings are taken remotely, visual checks of meters should still be undertaken, but may be less frequent.

The temperature and flow sensor leads and electrical connections are particularly vulnerable to accidental physical damage, though this should be mitigated by good installation practice. Temperature sensors can also become dislodged or loose in their pockets, which may cause reading errors. Heat meter integrators (calculators with display units) and their electrical connections can become damaged through carelessness.

Most heat meter integrators will display error codes if any input parameters from the flow or temperature sensors go out of range or if a communications failure is detected (if a data communications module is fitted). A failure of the integrator itself is usually self-evident.

Heat meters on biomass systems are often installed in dusty environments. Therefore, it’s important that the integrator and areas around electrical connections are kept clean. The user should be aware of the Protection class (IP) of the integrator, which varies between manufacturers and models.

Checks of boiler efficiency (see Section 3.4) that show deviations from normal values could be an indication of a heat meter not reading correctly, rather than of a boiler issue.

Heat meter power sources
Heat meters are powered through the integrator. Depending on the integrator model and the options available, the power can be provided by a lithium ion battery (or batteries), mains electricity or a lower voltage supply (e.g. 12V or 24V direct current).

If the integrator is battery powered, the user should be aware of the lifetime of the battery as specified by the manufacturer. This can range from 5 to 15 years, depending on the type of battery and whether additional integrator modules, such as for data communications, have been specified. The user should plan for battery replacement, but also be aware that batteries can suddenly and unexpectedly fail.

Recalibration
Heat meters should be supplied with calibration certificates that are ideally valid for a fixed period. However, manufacturers do not always state recalibration intervals or expected meter lifetimes, and there is no requirement in the Measurement Instrument Directive[8] or EN1434 to do so[9]. In the absence of guidance from the manufacturer, a period of no longer than 5 years between recalibrations would be considered good practice.

An incentive scheme may specify intervals for meter recalibration or sample checks of accuracy. Similarly, contracts for heat sales or district heating, where consumers are billed based on metered heat use, may have specifications for recalibration or accuracy checks.

3.3 Control and monitoring systems

All controls and monitoring systems associated with the biomass boiler and wider heating system should be checked regularly, particularly if there are changes to the demands from heat loads. Such checks and any remedial action have two main purposes:

1. To ensure that the boiler and associated systems are operating as intended.
2. To identify any modifications to settings needed in response to changes on site or that will improve the efficiency of operation.

The checks that should be made are too system specific to be described in detail in this guide. However, they are likely to include:

- The boiler control system (as provided by the boiler manufacturer), including:
  - Boiler flow and return temperature settings and confirmation they are being achieved.
  - Thermal store target temperatures and settings for demanding heat from the boiler (may or may not be integral to the boiler control system).
  - Status and error indicators for the boiler itself, the buffer vessel/thermal store, and primary pumps and control valves.

- Heating system controls (may be a BMS), including:
  - Time settings for space heating and hot water services, including for different zones.
  - Optimum start for space heating (integrated with boiler/thermal storage settings).
  - Target temperatures (heated spaces and hot water services).
  - External temperature compensation.
  - Correct operation of secondary circuit pumps and control valves.

3.4 Performance evaluation

Metering and logging the heat output is essential for verifying the unit's correct performance and is likely to be required for any incentive scheme.

A regular review of metering data can provide a method for early detection of problems within a heating system (which may not necessarily be due to the biomass plant). This is in addition to monitoring other operational parameters such as combustion efficiency, grate temperature, pressure and emission levels. Metering and monitoring are discussed further in the Technology Guide.

[8] Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of measuring instruments (recast). Applicable from 20 April 2016.
[9] Heat meter accuracy testing, November 2016, Building Research Establishment for UK Department for Business, Energy & Industrial Strategy https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/576680/Heat_Meter_Accuracy_Testing_Final_Report_16_Jun_incAnxG_for_publication.pdf

The heat meter readings and fuel consumption values (see Section 2.4) should be logged over time to build up a performance profile for the boiler. This can be by taking manual readings, using the heat meter memory or remote logging incorporated into the remote monitoring. Half-hourly or daily consumption rates are preferable, but not always practicable.

The heat meter readings and fuel consumption data can then be analysed using a spreadsheet or specialist software. The performance profile can be checked against the following to evaluate the system's performance:

- The expected performance in the system specification or manufacturers' manuals.
- The performance against a previous period (e.g. the same month in the previous year).
- The correlation of the profile against any demand factor profiles, such as increased output or shutdown periods. If the correlation is poor, this may suggest more heat is being supplied than is needed or the heat demand is not being adequately met. This can be investigated in more depth by comparing against data stored in the BMS.
- The output of any fossil-fuel boilers, and whether the balance between fossil and biomass heat is as expected.

Other operational parameters (e.g. combustion efficiency, grate temperature, pressure and, if possible, emissions levels) should be monitored against those stated in the system specification and manufacturers' manuals. A divergence from their specified ranges may indicate that the system is not operating correctly.

3.5 Emission limits and monitoring

Statutory emission limit values (ELVs) for biomass combustion plants in Ireland apply or will apply as follows:

The Medium Combustion Plant Directive (EU) 2015/2193[10] applies to plants with a rated thermal input of over 1MW but less than 50MW, excluding those covered by the Industrial Emissions Directive, 2010/75/EU (IED) (i.e. biomass boilers burning contaminated waste wood and plants of 50MW or more). There is also an exemption for on-farm combustion plants that exclusively use unprocessed poultry manure where the total rated thermal input is less than or equal to 5MW.

Table 1 summarises the MCPD ELVs for solid biomass in milligrams per normal cubic metre (mg/Nm^3) of flue gas[11].

Table 1: Summary of MCPD ELVs for solid biomass

<table>
<tr><th rowspan="2">Applicability</th><th rowspan="2">Rated thermal input (MW)</th><th colspan="3">Emission limit values (mg/Nm^3)</th></tr>
<tr><th>NOx*</th><th>Dust/PM**</th><th>SO_2***</th></tr>
<tr><td rowspan="3">New plants from 20 December 2018</td><td>1 to ≤ 5</td><td>500</td><td>50</td><td rowspan="3">200†</td></tr>
<tr><td>5 to ≤20</td><td rowspan="2">300</td><td>30</td></tr>
<tr><td>20 to ≤50</td><td>20</td></tr>
<tr><td rowspan="2">Existing plants from 1 January 2025</td><td>5 to ≤20</td><td rowspan="3">650</td><td>50</td><td rowspan="3">200†
300‡</td></tr>
<tr><td>20 to ≤50</td><td>30</td></tr>
<tr><td>Existing plants from 1 January 2030</td><td>1 to ≤5 Δ</td><td>50</td></tr>
</table>

Δ On-farm combustion plants that exclusively use unprocessed poultry manure are exempt
† Does not apply to plants firing exclusively woody biomass
‡ If firing straw

*Oxides of nitrogen
** Particulate matter
*** Sulphur dioxide
≤ Less than or equal to

[10] Implemented in Ireland under the European Union (Medium Combustion Plants) Regulations 2017 http://www.irishstatutebook.ie/eli/2017/si/595/made/en/print

[11] Defined at 273.15K and 101.3kPa after correction for water vapour content and at 6% oxygen content

From 1 January 2020, new solid fuel boilers up to 500kWth (thermal output) will be required to comply with the ecodesign requirements of Directive 2009/125/EC as implemented by Commission Regulation (EU) 2015/1189, but they do not apply to non-woody biomass boilers. The requirements include the following ELVs.

Applicability	Rated heat output, kWth	Emission limit values (mg/Nm^3)			
		CO*	NOx	Dust/PM	OGCs**
Manually stoked	≤500	700	200	60	30
Automatically stoked		500		40	20

*Carbon monoxide
**Organic gaseous compounds

Since ecodesign requirements are product standards, there are no related obligations on users to monitor performance.

- The standard EN 303-5:2012 'Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500kW' sets ELVs for appliances up to 500kW rated heat output, but adherence by manufacturers is voluntary. The standard defines three Classes: 3, 4 and 5 – 5 being the best. The ELVs for this standard are the same as the ecodesign requirements above.
- Prospective operators should consult the requirements of any incentive scheme to which they are intending to apply for specific ELVs required.
- Irish legislation in the area of local air quality is evolving. Developments can be monitored via the Department of Communications, Climate Action and Environment's website at: https://www.dccae.gov.ie/en-ie/environment/topics/air-quality/national-clean-air-strategy/Pages/default.aspx

3.6 Record keeping

The following records should be kept for the biomass system:

- Performance records as detailed in Section 3.4.
- Maintenance records for reference, including details of what was checked and what was done.
- An issue and resolution log. This should cover ongoing and historical issues and related actions and resolutions. This makes it easier to rectify repeat issues and keep on top of current ones.
- The record-keeping requirements relating to any financial support schemes should be verified and adhered to.
- Documents from construction for reference, such as the construction contract, operating and maintenance manual, installation photos, safety file, system design specification and as-built drawings, commissioning certificates, and meter calibration certificates.
- The maintenance contract for reference.
- Copies of warranties. Also create a schedule of the warranties so it is clear when they expire. Operating hours should be verified and monitored as some warranties are based on whichever occurs first – a given time period or a number of operating hours. Schedule a service before the end of the warranty to ensure any repairs and replacements can be identified and rectified under the warranty. Replacement parts may have their own warranties and a record of these should be kept in case the part requires a second replacement within that warranty period.

4. Heat sales

Key messages

- A heat sales system will be required for projects where the biomass boiler will be supplying heat to sites not owned by the boiler/heating system owner or to tenants.
- The heat sales system will require eachheat user's consumption to be metered and then the user to be billed for it.
- The heat sales contract should be reviewed annually, mainly to assess the heat tariff that has been set. The heat generated and consumed should then be reviewed to assess if it is as expected and to identify any differences for discussion. The contract review can also be an opportunity to identify any issues or improvements and discuss any potential changes in demand.

A heat sales system will be required for projects where the biomass boiler will be supplying heat to sites not owned by the biomass boiler owner or to tenants. This guide focuses on the ongoing requirements of a heat sales system. How to identify heat customers and set up a heat sales system is discussed in the accompanying Implementation Guide.

4.1 Metering and billing

The heat sales system will require each heat user's consumption to be metered and then the user billed for it. This process is shown in Figure 4.1.

Figure 4.1: Process for establishing a heat sales system

Produce a schedule	• This should be agreed as part of the contract and include how often the heat consumer is to be billed (monthly or quarterly being common), when meter readings will be taken, in what timeframe they should be submitted and the due date of payment once invoices are received.
Take meter readings	• This may be done by site staff, in which case reminders are likely to be required, along with interim checks that the meter readings submitted are accurate. • In some cases the system may have been set up so meters can be read remotely. Low cost webcams can also be retrofitted to a system if it is decided they are required.
Prepare invoice	• It is recommended to produce a template in Excel of similar software. This can perform the calculations and also store historic invoices. • Invoices should include the invoice date, period covered, start and end read, consumption, tariff, amount due, payment method, payment terms (including due date) and contact details for any issues.
Invoice and collect payment	• The invoice should be dispatched to the heat user. • The heat user should be sent payment reminders nearing the invoice due date. • The receipt of the payment should be verified and logged and confirmed to the heat consumer.

4.2 Contract reviews

The heat sales contract should be reviewed annually, mainly to assess the heat tariff that has been set. The heat tariff should have been indexed against parameters such as fossil-fuel costs, retail price of heat or costs of biomass fuel. The annual review should consider the current price of fossil fuels and biomass and the impact of these on the heat sale tariff. For example, if biomass costs rose, the tariff may increase or if fossil fuel costs fell, the tariff may require reducing.

The heat generated and consumed should be assessed here to enable any differences to be identified for discussion. The contract review can also present an opportunity to identify any issues or improvements and discuss any potential changes in demand.

5. Health and safety

Key messages

- The intention of this section of the guide is to alert readers to the hazards and risks that need to be managed. It does not provide a comprehensive guidance of the subject and additional advice and guidance should be sought by a suitably qualified Health and Safety professional

- Fuel delivery and handling hazards include delivery lorry and other vehicle movements, below ground fuel storage, moving mechanical components and increase in dust levels from pneumatic delivery.

- Fuel storage hazards include carbon monoxide (CO) build-up in fuel stores and oxygen depletion, dust-laden atmospheres, mould growth on the fuel and fuel storage fires.

- Boiler hazards include: sudden boiler shutdown (e.g. due to loss of power), build-up of un-combusted gas mixtures within the boiler and/or its flue, CO escape into the boiler house from boiler and/or flue system, exposure to soot and ash, particularly during cleaning operations, entry into the confined space of larger boilers for cleaning and other maintenance, sudden ash-bin ignition and flue system tar fire.

Biomass systems give rise to a range of potential hazards that either do not arise or arise to a lesser degree with boilers operated on natural gas, liquefied petroleum gas (LPG) or oil. There is often less knowledge and experience of biomass systems amongst heating system designers, installers and operators. Design and installation standards are also less developed for biomass systems.

The accompanying Implementation Guide summarises some of the health and safety considerations in the design of biomass systems. In the following paragraphs, operational health and safety issues associated with biomass fuel delivery and handling, fuel storage and the boiler are considered.

Important Health and Safety Note

The intention of this section of the guide is to alert readers to the hazards and risks that need to be managed. It does not provide a comprehensive treatment of the subject. Readers are strongly advised to consult the Combustion Engineering Association's (CEA) publication 'Health and safety in biomass systems'[12]. While the CEA document references specific UK legislation, equivalent provisions in Ireland can be found on the Health and Safety Authority's (HSA) website[13]. Further advice can also be sought directly from the HSA. t: 1890 289 389 (LoCall) or e: wcu@hsa.ie.

5.1 Fuel delivery and handling

Typically, bulk wood chip loads will be discharged by tipping into a hopper, onto a conveyor or a hard standing. In the latter case, the fuel will tend to be moved in batches to the boiler's local fuel store by a telescopic handler or similar.

It is more common for bulk wood pellets to be pneumatically blown into a silo or store. Small volumes of pellets can be purchased in bags, which will normally be on a pallet and unloaded using a forklift truck.

[12] http://www.cea.org.uk/files/4313/7502/0795/Biomass_HS_final_071211.pdf
[13] http://www.hsa.ie/eng/

Other fuels, such as logs and straw, may be unloaded by a forklift truck, tractor, telescopic handler or similar vehicle, or the lorry's own crane. Bulk bag deliveries of pellets and chips are also possible and handled similarly.

Fuel handling includes the extraction of fuel from stores for delivery to the boiler. Wood pellet and wood chip stores are usually equipped with augers, agitators, walking floors and/or conveyors. These pose a hazard, particularly as they are normally submerged in the fuel and not visible to personnel.

Table 6 summarises the main hazards and associated risks of fuel delivery and handing, but these should not be taken as comprehensive. Likewise, the example mitigation measures referred to may not be suitable for all circumstances. Operators should undertake full risk assessments and establish site-specific health and safety plans and procedures.

Table 6: Summary of the main hazards and associated risks of fuel delivery and handling

Hazard	Risks	Comments	Example mitigation
Delivery lorry movements, particularly when reversing.	Injuries, potentially fatal, to pedestrians and other vehicle operators.	Although oil or LPG deliveries pose similar hazards, due to the higher energy density of these fuels, vehicles tend to be smaller and deliveries less frequent than for biomass.	Establish strict procedures and mandatory use of a banksman.
Movements of vehicles used for unloading deliveries, moving fuels between stores or directly to boilers (e.g. forklift trucks, tractors and telescopic handlers)	Injuries, potentially fatal, to pedestrians, the vehicle driver or other vehicle operators.	Directly from the vehicle concerned or due to items falling from the vehicle.	General staff training. Training vehicle operators. Vehicle reversing alarms. Designated pedestrian routes. Using a banksman
Below ground fuel storage.	Injuries, potentially fatal, caused by falls from a height or crushing by discharging fuel.	Appropriate barriers should be used for fuel delivery	General staff training regarding the dangers. Adopt exclusion zones for non-authorised staff. Avoid lone working.
Augers, conveyors, agitators, walking floors.	Injuries, potentially fatal, from contact with moving parts.	Ensure it is safe to enter the space with supporting personnel in the near vicinity	Staff training and procedures. Erect barriers where possible and display clear warning signs.
Increase in dust levels from pneumatic delivery.	Health problems from dust inhalation. Heightened dust explosion risk in confined areas.	Mainly, but not exclusively, a hazard from bulk wood pellets.	Relevant staff should use appropriately rated face masks. Specify and enforce maximum vehicle offload rates to limit pellet disintegration.

5.2 Fuel storage

Unless well-ventilated and open, biomass fuel stores are likely to be considered as 'confined spaces' under the Safety, Health and Welfare at Work (Confined Spaces) Regulations 2001 and the HSA's associated Code of Practice for Working in Confined Spaces[14].

The storage of biomass fuel gives rise to various hazards, including fire, explosion, asphyxiation and poisoning. The Health and Safety Authority[15] summarises the main hazards and associated risks of wood pellet fuel storage, but this should not be taken as a comprehensive list. Likewise, the example mitigation measures outlined below may not be suitable for all site circumstances or for all fuel types. Operators should undertake full risk assessments and establish site-specific health and safety plans and procedures.

Table 7: Summary of the main hazards and associated risks of fuel storage

Hazard	Risks	Comments	Example mitigation
Carbon monoxide (CO) build-up in fuel stores and oxygen depletion.	Asphyxiation/poisoning.	Greatest risk from the release of CO from stored wood pellets. However, there is potential for CO (and CO_2) from the boiler's combustion chamber to collect in a fuel store.	Establish method statements and a permit-to-work system for fuel stores. Before entry to a fuel store, switch off boilers and fans, isolate extraction equipment, ventilate store and test atmosphere for CO with portable alarm. A second person should always be positioned outside the store to monitor the person in the store.
Dust-laden atmosphere.	Health problems from dust inhalation. Explosion and consequential injuries, and loss and damage to property.	Greatest risk from wood pellets, which produce fine dust when mechanically handled on site and can contain significant dust.	Relevant staff should use appropriately rated face masks. Isolate electrical equipment and only use safe torches. No smoking in the vicinity of the plant room and fuel store, warning signs should be provided. Source certified/accredited pellets to limit dust as delivered and assure mechanical integrity. Regular cleaning of the plant room and associated areas.
Mould growth on the fuel.	Respiratory irritation from spores causing illness.	Greatest risk from wet fuels, particularly wood chips stored for prolonged periods where the moisture content is greater than 30%.	Avoid prolonged storage of wet fuel. Inspect stored fuel regularly for mould. Use any mouldy fuel immediately or remove and dispose of it.
Fuel storage fire.	Injuries, including fatalities Loss and damage to property.	Can arise as a result of: • Boiler burn-back. • Ignition from self-heating. • Ignition from a hot source within the store such as a cigarette or electrical component.	Boiler burn-back should be addressed as part of the design. Keeping fuel dry reduces the risk of self-ignition. No smoking. Good electrical design.

[14] www.hsa.ie/eng/Publications_and_Forms/Publications/Codes_of_Practice/COP_Confined_Space.pdf
[15] https://www.hsa.ie/eng/Safety_Alerts/2018/Wood_Pellets_Toxic_Carbon_Monoxide_Poisoning/

5.3 The Biomass boiler

Hazards associated with the boiler arise from the wet (heating medium) side, the fire (combustion) side, and the flue/chimney system. The main hazards and associated risks listed in the table below should not be taken as comprehensive. Likewise, the example mitigation measures may not be suitable for all site circumstances. Operators should undertake full risk assessments and establish site-specific health and safety plans and procedures.

Table 8: Summary of the main hazards and associated risks of the boiler

Hazard	Risks	Comments	Example mitigation
Sudden boiler shutdown (e.g. due to loss of power).	Excessive wet-side temperature or pressure leading to explosion or ruptures, causing escape of boiling water/steam and consequent physical injuries and/or plant damage.	Biomass boilers cannot be extinguished quickly due to remaining fire-bed and thermal inertia. System design and operating procedures must allow for the safe management and control of sudden shutdown scenarios.	Good system design. Well-trained staff. Clear operating procedures/method statement.
Build-up of uncombusted gas mixtures within the boiler and/or its flue.	Explosion within the boiler or flue and consequent injuries, and loss and damage to property.	Uncontrolled combustion can arise from uncontrolled draught, excessive fuel charging, delayed ignition or uncontrolled air to the combustion space.	Well-trained staff. Clear operating procedures/method statement.
CO escape into the boiler house from boiler and/or flue system.	Asphyxiation/poisoning.	Maintenance of boiler and associated plant reduces the risks of CO escaping from the plant	Place CO alarms in the boiler house and adjacent rooms, particularly if the flue passes through the building.
Exposure to soot and ash, particularly during cleaning operations.	Health effects due to toxic/carcinogenic content of soot and ash in small particulate form.	Health risks arise particularly from polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and heavy metals.	Staff training. Appropriate personal protective equipment (PPE) including full overalls, rated dust masks and eye protection.
Entry into the confined space of larger boilers for cleaning and other maintenance.	Health impacts and/or injury from excessive temperature, presence of mineral fibre insulation, exposure to soot and ash (see above), refractory collapse and ignitors/burners.	Prepare a Health and Safety statement where required	Establish method statement for entry and cleaning. Boiler fuel must be extinguished for long enough to produce a safe working temperature (over 24 hours).
Sudden ash-bin ignition.	Physical injury.	Bottom ash can still contain significant volatile content. Ignition can be caused by the sudden inrush of fresh air from opening sealed ash containers.	Staff training to avoid sudden opening of sealed ash containers.
Flue system tar fire.	Injuries, including fatalities. Loss and damage to property.	A build-up of tar in the flue ductwork and stack can occur from poor-quality fuel and prolonged low fire running.	Flue cleaning and avoiding the conditions for tar production.

6. References and other sources of information

A substantial amount of guidance on biomass systems has been published over recent years. This guidance will not all remain fully correct or accurate, several factors and variables referred to in this guide are likely to change over time, such as technology, costs, fuel availability, financial support schemes, legislations and standards. It is important to cross-reference these factors against the latest publications.

6.1 General

Chartered Institution of Building Services Engineers (CIBSE) (2014). *AM15 Biomass Heating*
https://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I76dAAC

Carbon Trust (2012). *Biomass Heating: A Practical Guide for Potential Users*
https://www.carbontrust.com/media/31667/ctg012_biomass_heating.pdf
It should be noted that the costs and Renewable Heat Incentive (RHI) are mainly UK specific.

Invest Northern Ireland (2014). *Biomass: A Best Practice Guide for Businesses in Northern Ireland*
http://www.elementconsultants.co.uk/wp-content/uploads/2018/02/biomass-a-best-practice-guide-for-businesses-in-northern-ireland1.pdf

Biomass Energy Centre, Forest Research (2011). *Biomass Heating: A Guide to Feasibility Studies*
https://www.forestresearch.gov.uk/tools-and-resources/biomass-energy-resources/reference-biomass/documents-downloads/best-practice-guidance/

Biomass Energy Centre, Forest Research (2011). *Biomass Heating: A Guide to Medium Scale Wood Chip and Wood Pellet Systems.*
https://www.forestresearch.gov.uk/tools-and-resources/biomass-energy-resources/reference-biomass/documents-downloads/best-practice-guidance/

Deutscher Energieholz- und Pellet-Verband e.V. (DEPV) (German Wood Fuel and Pellet Association) (2012). *Recommendations for Storage of Wood Pellets* (English translation produced by COFORD, Department of Agriculture, Food and the Marine).
http://www.dimnikarstvo.si/files/GRADIVA/recommendations_for_storage_of_wood_pellets.pdf
(See also:
http://www.coford.ie/media/coford/content/publications/projectreports/cofordconnects/pp12_pelletstoragefacility.pdf
and www.r-e-a.net/upload/enplus_pellet_storage_guideline_ukpc-v1.pdf)

Conversion factors for energy units of oil and liquefied petroleum gas (LPG) from SEAI
https://www.seai.ie/resources/seai-statistics/conversion-factors/

6.2 Sustainability legislation

The EU Renewable Energy Directive (under revision at time of writing) will come into effect in 2021, extending the scope of the existing EU sustainability criteria for bioenergy to cover biomass and biogas used for heating, cooling and electricity generation.
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0767R%2801%29

6.3 Health & Safety

Combustion Engineering Association (CEA) (2011). *Health and Safety in Biomass Systems, Design and Operation Guide*
https://cea.org.uk/wp-content/uploads/2018/07/Biomass_HS_final_071211.pdf

Health and Safety Authority (HAS) (2013). *Safety, Health and Welfare at Work (Construction) Regulations 2013* http://www.hsa.ie/eng/Legislation/Regulations_and_Orders/Construction_Regulations_2013/.

Details of the duty holders and responsibilities are included on this website.
http://www.hsa.ie/eng/Your_Industry/Construction/Construction_Duty_Holders/

6.5 Procurement and contracts

Carbon Trust (2012). *Biomass Installation Contracting Guide, Practical Procurement Advice*
https://www.carbontrust.com/media/88611/ctg073-biomass-contracting-guide.pdf

Carbon Trust (2012). *Template Contracts for Supply of Biomass Fuel, Supply of Heat Energy, Operation and Maintenance Agreement and Services Agreement*
https://www.carbontrust.com/resources/guides/renewable-energy-technologies/biomass-heating-tools-and-guidance/

Energy network (produced by North Karelia University of Applied Sciences) (2003). Heat Sales Contract
http://elearn.ncp.fi/materiaali/kainulainens/nwh/heat_energy_entrepreneurship/business_models/material/Contract%20for%20supplying%20district%20heat.pdf

7. Glossary

Ash content	Percentage of a biomass fuel's mass, on a dry basis that will be produced as ash upon complete combustion of the fuel.
Auger	An Archimedean (a rod with a helical projection) screw used to transfer material that is in a particle form.
Base load	The minimum heat demand from a system which is maintained throughout a defined period.
Bioenergy	Renewable energy from living (or recently living) plants and animals e.g. wood chippings, crops and manure
Biomass	Any organic matter that can be burned for energy. Typically derived from solid wood into wood chips and pellets. Also, from short-rotation coppice, miscanthus, sawdust and straw.
Buffer vessel	A form of thermal storage used to capture residual heat on boiler shut-down to improve system efficiency and to protect the boiler. Must have sufficient thermal capacity to absorb residual heat on boiler shut-down. Smaller than a thermal store.
Bulk density	Measure of the mass of the fuel divided by its volume (e.g. kg/m^3).
Calorific value (CV) – net	The net calorific value of a fuel is the total energy released during combustion excluding that needed to evaporate any water arising in the combustion process. Also known as the Lower Heating Value (LHV) of the fuel.
Calorific value (CV) - gross	The gross calorific value of a fuel is the total energy released during combustion including that needed to evaporate any water arising in the combustion process. Also known as the Higher Heating Value (HHV) of the fuel.
Capital costs	Initial setup costs of plant or a project, after which there will only be recurring operational or running costs.
Client	The ultimate person or organisation purchasing the biomass plant.
Combined Heat and Power (CHP)	The simultaneous production of heat and electrical power from a single fuel source for useful purposes. Fuel typically combusted in a reciprocating engine or used to generate steam to be expanded in a turbine.
Commissioning	The process of verifying that the new heating plant meets the performance specifications as per design and called for in the installation contract.
Consultant	Professional person or organisation appointed to provide advisory assistance under a predetermined contract.
Contractor	Person or organisation appointed for the task of executing the scope of works.
Energy Services Company (ESCO)	Services company that sells heat (and/or other forms of energy) to the customer instead of a boiler and/or fuel. May install, own and maintain the boiler, or may sub-contract some or all of that.
Energy crops	Crops grown specifically for energy production purposes e.g. miscanthus.
Energy density	Measure of the energy contained within a unit of fuel in MJ/m^3.
Feedstock	The raw biomass material subsequently used as a fuel.
Firebed	The mound of fuel undergoing combustion within a boiler's combustion chamber.
Flue	The passageway between the combustion device and the terminal of a chimney which acts as a duct to exhaust combustion gases to a position and height where they will not cause annoyance or health hazard.

Flue Gas Recirculation (FGR)	FGR is the feeding of a proportion of the cooled flue gases back to the combustion chamber to reduce the temperature of combustion at the grate with the aim of reducing the production of nitrous oxides. Sometimes referred to as exhaust gas recirculation (EGR).
Heat demand	The demand of heat of a site at any one time, typically expressed in kW or MW.
Heat exchanger	A device that transfers heat between two fluid systems e.g. water flows from boiler system and heating pipework. Many different configurations available but plate-heat exchangers most commonly found.
Heat meter	Device that measures the rate of heat transferred by a system by monitoring the flow rate of water and temperature difference between flow and return pipes.
In-house	Work or activities conducted by employees within an organisation.
Installer	Organisation or person contracted for the installation of equipment. May also be the supplier.
Lambda (λ)	Denotes the ratio between the actual amount of combustion air (oxygen) and the minimum theoretical (stoichiometric) amount of combustion air (oxygen) required for complete combustion of the fuel.
Liability	A person or organisation's legal responsibility to pay debts or fulfil obligations.
Moisture content (MC)	Percentage, by weight, of biomass fuel that contains water. For example, wood pellets typically have an MC of less than 10%. Wood chips and logs are likely to have a more variable MC of between 20% and 60%.
Operating costs	Costs of maintaining the ongoing operation of a process or facility. Do not include any capital outlays or costs incurred in the design or commissioning phases of a project.
Peak load	The maximum heat demand a site experiences across a year, typically expressed in kW or MW. Used to size heating systems.
SEAI	Sustainable Energy Authority of Ireland.
Supplier	Organisation or person contracted for the delivery of a goods or assets.
Technical specification	A document that lays out the design of a system so that a contractor can provide a quotation for its installation.
Thermal store	A reservoir of heat energy provided from the boiler to enable the heating system to meet the majority of energy demands. Allows the boiler to be smaller as well as improving its operating efficiency by allowing running for longer continuous periods. May also perform the role of a buffer vessel.
Turndown ratio	The turndown ratio of a boiler is a measure of its ability to operate at heat outputs less than the full rated output. It is the ratio of the maximum heat output to the minimum level of heat output at which the boiler will operate efficiently or controllably. For example, a boiler with 2:1 turndown ratio will be able to operate down to 50% of its full rated output.
Warranty	Agreement provided by an organisation such as a contractor or manufacturer that it will remedy, without additional charge, deficiencies in their service or goods that have arisen within a stated period after their installation.

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Rialtas na hÉireann
Government of Ireland

e info@seai.ie
w www.seai.ie
t +353 1 808 2100