Biomass Boilers - Implementation Guide

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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 boiler 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 boiler 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 aims to provide an understanding of biomass technology, its implementation and operational management.

1.1 Purpose of this guide

This Implementation Guide is principally intended for site or facility owners who are considering installing a biomass boiler system. The aim is:

1. To provide a guide to good practice in implementing biomass boiler systems. It assumes that the reader has already considered different options for heat provision and has decided to investigate biomass further (see Section 3.7 for details of such an initial financial assessment).
2. To direct the reader to sources of more detailed information on aspects of the technology. This guide and its two companion guides do not duplicate existing publications on biomass boilers; rather, they are intended as a comprehensive starting point for those wishing to better understand the technology, and its implementation and management.

1.2 Scope

- The guides concentrate on solid biomass boilers for non-domestic premises with a 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 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.

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[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-/

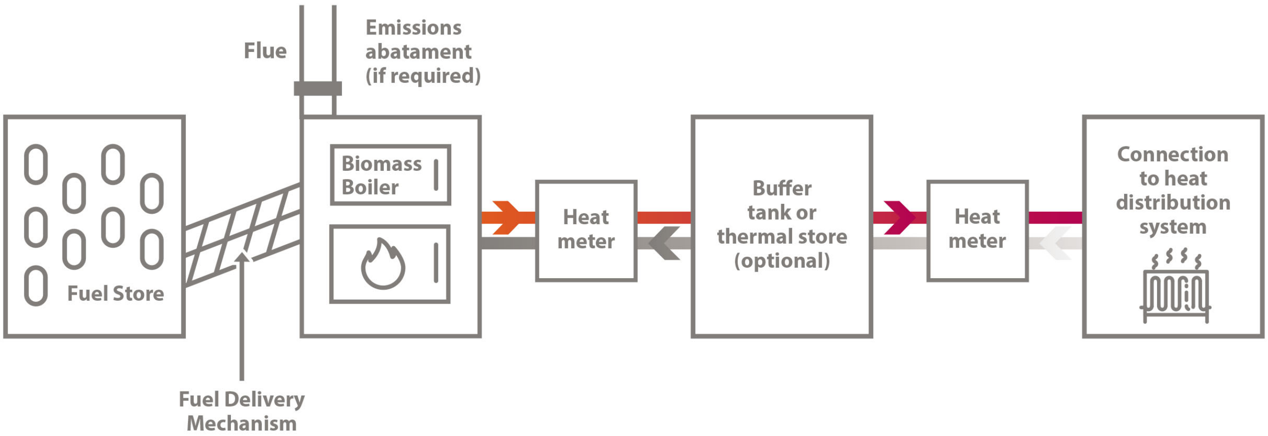
2. Overview

2.1 What is a biomass boiler system?

Figure 2.1 shows an outline of the typical components of a biomass boiler system.

- Biomass fuel is transferred from the store to the boiler where it is burnt to produce heat, most commonly for heating and hot water.
- The hot water flow and return distribution pipework from the boiler is connected to the site's heat distribution system, usually through a buffer tank or thermal store.
- The connection to the distribution system can be direct or through a heat exchanger.
- Heat meters are normally installed at different points in the system, for example at the boiler output, or at the connection to the heat distribution system.
- The location of heat meters depends on the details of the system and any contractual or financial support scheme requirements that may apply.

Figure 2.1: Biomass boiler system components



2.2 Why choose a biomass heating system?

The advantages of choosing biomass may include:

- Operational cost savings.
- Reduced fossil fuel use and exposure to price volatility.
- Significant carbon savings (if sustainably sourced biomass); compliance with climate change legislation and improved green credentials.
- Reduction of the environmental impacts of waste disposal (for systems using biomass by-product or waste as fuel).
- Using sustainably sourced biomass fuels for heating benefits the supply chain by improving the biodiversity of woodlands, and providing opportunities for rural employment and economic diversification.

2.3 Key differences between a biomass and oil or gas heating system

A biomass boiler system is different from gas or oil-fired equivalents.

- More space for a biomass boiler is needed and its buffer tank or thermal store, and for fuel storage, delivery and handling.
- More maintenance is necessary, along with ash disposal.
- The boiler system has a slower response time than oil or gas boilers and a smaller turndown ratio[3].

These issues are discussed in this guide and the accompanying Technology Guide.

2.4 Planning a biomass heating system

This guide sets out all the key steps for planning and installing a biomass boiler system. The accompanying Operation and Maintenance Guide describes the key principles for operating a biomass boiler efficiently and safely.

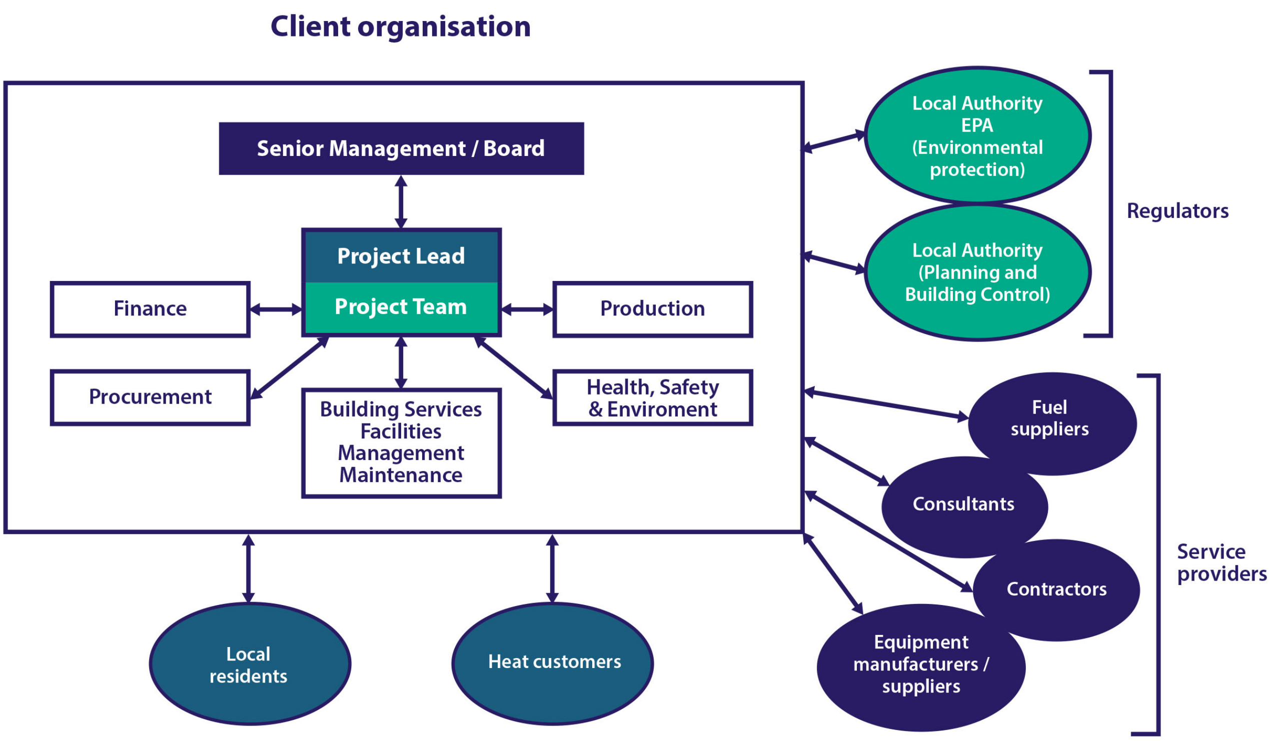
2.5 Communications

Prior to and during the development of a biomass boiler project it is important that the project team responsible for developing the biomass boiler gives careful consideration to engagement with stakeholders who could be affected by the project - both internal and external to the organisation pursuing the project. Figure 2.2 shows the stakeholders who are typically involved (this may vary depending on the nature of the client organisation and the scale and type of project)

- The project team should make a communications plan at an early stage.
  The communication plan should list all the internal and external stakeholders who will need to be involved and/or informed about the prospective project, so that they can understand the relevant implications and input ideas/concerns. The communications plan should set out the nature and timing of communications and identify responsibilities of each project team member.
- Contact with the regulatory authorities at an early stage is important. The project team needs to understand the regulatory requirements and any legislation that may affect the project.
- If supply to external heat customers is likely to be a key aspect of the project, the prospective customers will need to be involved from early on.
- Early engagement with the biomass service industry can provide the project team with information and options for the feasibility, detailed design, construction, and operation and maintenance stages of the project.
- Depending on the scale of the project, consultation with local residents may be advisable.

[3] 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.

Figure 2.2: Internal and external stakeholders



2.6 Energy efficiency first

All viable actions to minimise heat demand should be taken before installing a biomass system. Help with improving energy efficiency may be available through the SEAI EXEED Programme.

EXEED

Excellence in Energy Efficiency Design (EXEED) enables organisations to establish a systematic approach to design, construction and commissioning processes for new investments and upgrades to existing assets. The EXEED Certified programme aims to influence and deliver new best practices in energy efficient design management. EXEED designs, verifies and manages optimum energy performance and management at the earliest stages of a project's lifecycle. There is also an EXEED grant scheme worth up to €500,000 per year per project.

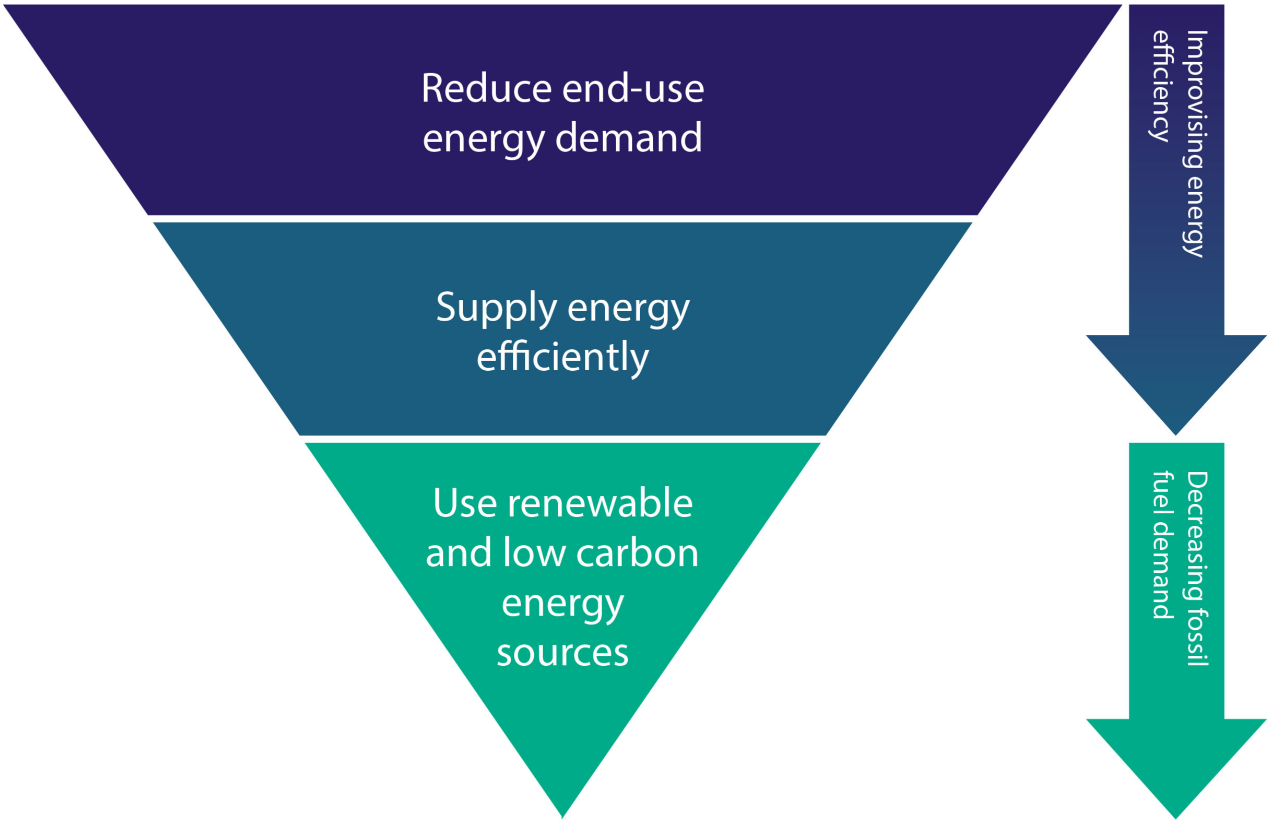
For further information, please visit www.seai.ie

The biomass system itself should be designed to be energy efficient and include such measures as effective system controls, good practice levels of insulation for distribution system pipework, heat storage vessels and other elements that will improve energy efficiency of the installation.

When developing any low-carbon energy system, it is good practice to follow the energy hierarchy (see Figure 2.3). This identifies ways to minimise the total energy demand of a project in a cost- and resource-efficient manner. The key principles of the energy hierarchy are as follows:

1. End-use demand is limited to what is necessary.
2. Measures that increase the efficiency of supplying the total demand are installed (these are usually of moderate cost) helping to ensure that demand can be met in the most cost-effective way.
3. Renewable and low-carbon technologies are sized and installed (these tend to be more expensive).

Figure 2.3: Energy hierarchy



Reduce end-use energy demand
This can be through technologies and measures, such as:

- Insulation of the existing external building envelope and draught-proofing buildings.
- Reducing the heat loss through external doors by replacing them, or adding door closers and/or draught-proofing.
- Optimising time and temperature settings of heating system.
- Behaviour modification of building users.
- Zoning or local controls, using that heating only when needed.
- Improving the energy efficiency of heat-using processes through better control systems, heat recovery, and plant insulation.

Supply energy efficiently
This includes improving the insulation on the heat distribution system, and the efficiency of circulating pumps and improved control strategies.

Use renewable and low-carbon energy
As well as biomass systems, this could include combined heat and power systems, heat pumps and solar thermal technologies.

3. Feasibility study

Key messages

- An important first step is to undertake a feasibility study to establish the technical, physical, practical and financial viability of a biomass system. Evaluating a wider set of options can help to identify the most appropriate solution.
- Energy efficiency measures should be implemented before developing a low-carbon system (the energy hierarchy – see Figure 2.3).
- Heat demand can be assessed using past records (such as bills and meter readings), accounting for any planned energy efficiency measures and operational changes that will affect demand.
- The selection of the biomass fuel is a key element.
- The approach to biomass system sizing and design is different from that for systems fired on oil or gas. The use of buffers/thermal stores, the number of boilers, provision of top-up and standby capacity, and integration with existing heating systems all require careful consideration and design.
- Biomass systems take up more space than fossil-fuel-fired boilers and may necessitate a new plant room or an extension. Assess access for fuel deliveries and space for fuel storage.

This section provides guidance on how to undertake a feasibility study and what it includes, such as:

- Choosing a suitably qualified person to undertake the feasibility study and the steps to be taken.
- Assessing the heat demands and heat load of the building/process to be supplied.
- Reviewing how regulations might restrict the project or make it unfeasible.
- Selecting the appropriate fuel.
- Considering preliminary design and size options and establishing an initial outline of the system.
- Considering the ongoing operation and maintenance (O&M) requirements.
- Conducting an initial review of capital and operating costs, revenues and savings to establish if the project is likely to be financially viable.
- Considering implementation options for system ownership and responsibility for detailed design and installation.

3.1 Conducting a feasibility study

The feasibility study aims to establish the technical and financial viability of a biomass system, and to outline a provisional high-level system design, and system criteria. It should cover, as a minimum, the areas discussed in this section. The size and complexity of the project will dictate the depth of the feasibility study required.

3.1.1 Who should conduct the feasibility study?

A competent party, who are impartial and suitably qualified to propose the most appropriate solution, must conduct the feasibility study, which should include:

- Knowledge of the tasks to be undertaken and the risks involved.
- The experience and ability to carry out the task.

Table 1 summarises the pros and cons of carrying out the feasibility study in-house, or contracting it out to a consultant, installer or supplier.

Table 1: Summary of advantages and disadvantages of feasibility study options

	In-house	Consultant	Installer/supplier
Advantages	Likely to be the lowest cost solution.	Selection of an experienced and competent consultant should provide the necessary level of skills and independence.	Should have a high level of knowledge of biomass systems. May do the study at low or no additional cost.
Disadvantages	Individual(s) may not have the competency to conduct the study.	Likely to be the most expensive option.	Knowledge may be limited to biomass components and not cover integration with other technologies.
Risks	Key costs or considerations may be overlooked or miscalculated resulting in an inappropriate system being put forward.	The contracted consultant does not have sufficient experience of biomass systems.	Lacks independence.

3.1.2 Initial site assessment

An initial site inspection and discussions with relevant staff (e.g. facilities manager) should review:

- The overall site layout.
- Access conditions for delivery of biomass fuel (including width of local roads and byways).
- Possible planning restrictions for the flue (height), fuel storage facilities (e.g. tall silos), and any new buildings or extensions for the plant room.
- Proximity of neighbouring properties (potential for noise or emissions nuisance).
- Local air quality restrictions.
- Site layout and space for external boiler house and storage, or containerised biomass plant room, or conversion of existing plant room.
- Location and nature of heat loads to be served.
- Type, configuration and condition of the existing heating plant and distribution systems.
- Availability and suitability of electricity supply (many biomass boilers require a 3-phase supply) and, if applicable, an internet connection.
- Level of ongoing operational capacity of site staff and any training needs.
- Early contact with potential fuel suppliers is important to identify type and quality of their product, types of delivery equipment and the costs for different delivery methods.

3.2 Assessment of heat demand

Assessing the patterns of heat demand is the next step. If a neighbouring site is to be included in the scheme, potentially under a heat sales agreement, then assess its heat demand (taking into account the distribution losses from delivering the heat).

Heat from a boiler may be used to:

- Heat premises (space heating).
- Produce hot water.
- Provide process heating (e.g. for drying or in manufacturing).

Establish the following for all heat uses served by the system:

- Annual fuel consumption.
- Peak heat load – the maximum rate at which heat is required in kilowatts (kW). When calculating peak heat load distinguish between space heating, hot water and processes, as well as calculating an overall peak load.
- The daily and seasonal profiles of heat demand, which will inform system design factors, such as turndown capability and thermal storage volume. Several typical daily profiles will be needed to represent varying heat demand profiles throughout the year.
- Ways in which the heat requirement may change in the future (e.g. from expansion of the site and increased throughput of processes) and the associated effect on the system. This will help to enable future-proofing of the system.

It is important to obtain the most accurate information available relating to heat demand by:

- Examining existing metered records (e.g. natural gas) covering at least one full year of consumption (ideally two or three years if possible) to observe any predictable variations. Weather (via degree-days) and operational variations and the effect on the heat demand should be noted.
- Checking delivery notes for oil and liquefied petroleum gas (LPG) to establish the volume delivered. The volumes will need to be converted into energy units (for conversion details, please visit www.seai.ie)
- Examining the rating plates on existing boilers, if fitted, as these will state the maximum rate at which the boiler can supply heat. It must not be assumed, however, that this represents the current peak load.
- Taking account of the efficiency of existing boilers (i.e. the difference between input [fuel entering the boiler] and output [heat output of the boiler]). Efficiencies stated on a rating plate represent efficiency under particular test conditions and as such are likely to be optimistic. Boiler efficiency also tends to degrade over time.
- Taking regular on-site spot measurements, which can be used if no metering data are directly available. This can be done manually (e.g. manually logging the main meter at the site) or by hiring temporary 'strap-on' heat metering with data logging capability. Take a range of readings, as heat demands can vary considerably by time of day and time of year.
- Using the services of a Chartered Engineer is advisable if the heat load assessment is not straightforward. Check the lists of qualified consultants published by the Chartered Institution of Building Services Engineers (CIBSE), Engineers Ireland (EI) and other professional bodies.

3.3 Regulatory review

An early review of regulations is needed to identify possible restrictions on a potential biomass boiler project.

3.3.1 Planning permission

The need to obtain planning permission may arise if, for example:

- New buildings, such as a boiler house or fuel store will be required.
- The boiler chimney (flue) is going to be particularly visible (including any visible plume from the flue at boiler start-up).
- Modified or additional vehicle entrances to the site will be required.

There will be a significant impact on vehicle movements to/from the site.

3.3.2 Local air quality regulations

Restrictions may arise if, for example:

- It is intended to burn contaminated waste wood or agricultural by-products.
- Restrictions on air emissions are in place (e.g. in built-up areas).

As air quality legislation is evolving, it is important to confirm regulatory requirements at the time of project development. Approach the relevant departments of the Local Authority where the project is being planned, once the nature and scale of the project is clear so that potential restrictions can be identified and assessed. Other regulatory requirements, such as adherence to building regulations, will need to be met but are unlikely to significantly restrict the project.

3.4 Fuel selection

3.4.1 Fuel choice

One of the most sustainable and in some cases the cheapest fuel source is likely to be biomass material available on site or locally. Examples include poultry litter, straw and waste wood or other bi-product fuels. Some site owners may have their own forestry resource or access to locally grown energy crops (grown specifically for use as a biomass fuel). Such energy crops could include willow, which is grown using a short rotation coppice technique and is harvested every three to four years, or miscanthus (a woody rhizomatous grass), which is harvested annually.

Otherwise, the most common choice is to buy wood pellets, wood chip or logs. The final decision on what fuel(s) to select is determined by various factors, including:

- Relative availability/security of supply and cost of producing or purchasing the fuels.
- Certification under the Wood Fuel Quality Assurance (WFQA) scheme for Ireland[4] and/or ENplus®[5] (see Section 3.4.3.)
- Boiler size requirement and relative costs between suitable boilers, and their respective fuel-handling equipment.
- Availability of space for fuel delivery, storage and any processing.
- Availability of on-site staff to attend to any problems.
- Relative maintenance costs.
- Emissions limits and any associated additional costs.

[4] http://wfqa.org/
[5] https://enplus-pellets.eu/en-in/

3.4.2 Fuel delivery and storage

Fuel delivery and storage are fundamental issues. Site constraints will affect the type of storage and fuel used. Consider these from the outset so that options can be identified.

The storage volume needed depends on:
- The rate of use (amount of heat generated from boiler).
- The frequency of deliveries.
- Contingency in case of delays in deliveries, perhaps due to adverse weather.

More frequent or smaller deliveries may result in higher charges by the supplier.

Example estimate of fuel storage capacity required

A 200kW boiler operates for 1,750 full-load-equivalent (FLE) hours annually. It is assumed the boiler has an efficiency of 85% and uses wood pellets with a net calorific value of 4,700kWh/tonne and bulk density of 620kg/m^3.

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).

Assuming monthly deliveries, this would require storage for at least 7.5 tonnes on average. However, assuming the heat use is mainly for space heating, the monthly winter use will be much higher and it is also sensible to allow contingency in case of difficulties in obtaining deliveries, for example due to adverse weather. The most the boiler would ever require if running continuously at full rated output would be approximately 37 tonnes in a month (equivalent to 730 FLE hours). A silo of 25 to 30 tonnes capacity (40 to 50m^3) should be sufficient to cover the coldest periods and disruptions in supply, depending on considerations such as the risks given the site's location and fossil fuel back-up capacity.

Figure 3.1: Wood chip extraction by sweeping arm and auger

The type of storage will largely dictate the type of delivery vehicle. Compatibility with potential suppliers' vehicles should be thoroughly checked. Normally wood pellets are delivered by lorry with a blower system. Wood chips are often delivered by a tractor with tipper trailer, a large lorry with tipper, or via walking floor fuel delivery system.

The suitability of potential delivery methods will need to be assessed against vehicle access to the site, including the width and condition of local roads and byways, and within the site itself.

3.4.3 Wood fuel quality

Poor quality fuel, or fuel not suitable for a particular boiler, can lead to reduced performance, higher maintenance costs and excessive emissions. Using fuel that has been certified under a recognised quality scheme is therefore strongly recommended. There are two main fuel certification schemes relevant to Ireland:

1. The Wood Fuel Quality Assurance (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.

2. The 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) and equivalent forest management schemes – including their chain-of-custody certificates.

Further information can be found in the Technology and Operation and Maintenance guides and the websites of the WFQA[6] and ENplus® [7].

3.4.4 Sustainability of fuels

Sustainably sourced 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 bioenergy 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 generate greenhouse gas emissions. 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.

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).
- Not sourcing biomass 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 should check any scheme criteria on sustainability and assess whether the proposed fuel supply will meet the criteria.

[6] http://wfqa.org/
[7] https://enplus-pellets.eu/en-in/

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 system operators should buy from suppliers that source biomass in a sustainable way. For example, wood (as logs, chips or pellets) should come from forests that are managed in a sustainable manner. Some fuel accreditation schemes include sustainability criteria for forestry management and there are a range of sustainable forest management certifications which can be used to verify if a forest is managed sustainably

Refer to Section 6.2 for details of the proposed revised EU Renewable Energy Directive.

3.5 Initial sizing and design options

An initial size and outline design of a biomass project needs to be established. Sizing of the biomass plant should aim to maximise its use across the year to get the best return on investment. Further detail on biomass heating systems is provided in the accompanying Technology Guide.

3.5.1 Initial sizing and additional generation

The required biomass boiler capacity (typically stated in kilowatts) will not necessarily be the same as the existing fossil-fuelled boiler plant. Fossil-fuelled boilers tend to be sized based on peak heat demand plus some contingency (which can be significant). In addition, it is important to consider that the heat demands may have changed since specifying the existing system.

Due to the slower response of biomass boilers to changes in demand when compared to fossil fuel boilers or electrical heating systems, it is important to assess their sizing needs with due regard to thermal storage. Within this, there are various boiler configuration considerations, including:

- Single boiler or multiple boilers. Biomass boilers' efficiencies decrease as they modulate down to supply lower heat demands. A large variation in demand can be met with multiple boilers, which allow the system as a whole to modulate down with less efficiency loss. The boilers can also act as back-up for each other.
- Base load boiler, and top-up and standby boiler. In many situations, the peak heat load requirement for building heating will be needed for relatively short periods (during the coldest part of the year). A biomass boiler could therefore provide the base load, with another technology (e.g. heat pumps) providing the peak load. This base load boiler could also be used in times of low demand, such as the summer months. An oversized biomass boiler can result in poor fuel efficiency and reliability problems, leading to high running costs.
- Back-up/standby boiler. If security of heat supply is critical to a site's operations, back-up boiler(s) may be required in addition to any top-up capacity. Retaining one or more existing boiler is common (depending on their condition) as back-up to a new biomass system. Alternatively, new boiler capacity could be installed. Generally, it will not be cost effective to install biomass boiler capacity solely for standby purposes.

When both biomass and fossil boilers are used, effective integration of the whole system is vital to ensure the best return on investment.

3.5.2 Integration with the existing distribution system

The biomass boiler system may require a new distribution system, although it can often be integrated into the existing system. The heat transfer medium of the existing system will need to be established.

- Most buildings use a water system that operates at a flow temperature of less than 95°C (typically 80°C to 85°C), referred to as low temperature hot water (LTHW).
- Some heating systems (particularly very large installations, older buildings or production facilities) use water at between 95°C and 120°C, known as medium temperature hot water (MTHW). MTHW systems operate at higher pressures, so a boiler designed for LTHW cannot be used on an MTHW system.
- Other systems use high temperature hot water (HTHW), steam or thermal oil.

To aid understanding of an existing system, examine the system's schematics and O&M manuals, and consult with the individuals responsible for operating and maintaining the current system. If the system is anything other than LTHW, the boiler selection and system design is likely to require more specialist input.

3.5.3 Buffer vessels and thermal stores

As biomass boilers are slower to heat up and cool down relative to fossil fuel boilers or electrical heating systems, most systems need an appropriately sized thermal store or buffer tank. These terms, often used interchangeably, refer to vessels with different functions:

- **Buffer vessels** improve efficiency and protect the boiler from excessive heat (see Section 7 – Glossary); they are designed to receive the residual heat from the boiler that must be removed once the heat demand is no longer present. If the downtime is not too long, the heat stored within a buffer vessel is used when the demand for heat returns. This improves efficiency and protects the boiler from excessive heat.
- **Thermal stores** enable a smaller boiler to run for longer at peak efficiency by smoothing out a variable heat demand (from the perspective of the boiler). This helps a biomass boiler to meet a greater proportion of the annual heat energy required.

Thermal stores are often configured to also provide the role of a buffer vessel. Having a thermal store can provide a body of water for other technologies to feed into, such as solar thermal.

3.5.4 Boiler room options

Biomass boilers can be as much as five or six times larger than their fossil fuel counterparts. It is therefore important to obtain details of boiler dimensions from suppliers together with details of the recommended minimum access space required for maintenance.

Factoring in a thermal store and fuel store, much more space is likely to be required than for an existing fossil fuel or electrical heating system. Boiler room options include the following (for which there may be planning permission requirements):

- In some larger plant rooms, there may be space for a biomass boiler or it may be possible to extend the plant room. Utilise areas previously used for fossil fuel storage (oil or LPG tanks) for biomass fuel storage, noting that the energy density of biomass is lower than that of oil or LPG.
- If space is not available, a new plant room may need to be built.
- Installation of a containerised biomass plant room, also known as a 'plug and play' plant room. Some biomass boiler manufacturers produce a self-contained biomass plant room that can be placed on site and connected to the existing system.

Figure 3.2: Plant room with small biomass boiler and thermal store

3.6 Operation and maintenance requirements

Biomass boilers can require more manual input than fossil-fuel systems - design the system to facilitate this. While systems that require more manual input tend to have lower capital and fuel costs, they may have higher labour costs. Automated systems can cost more initially, but they offer significant labour savings and may suit organisations where labour costs are higher or operational budgets are restricted.

Equipment that can be included in the design to increase automation include:

- Automatic ignition.
- Automatic de-ashing.
- Automated heat exchanger cleaning mechanisms.

Personnel (e.g. facilities personnel) will require a basic level of training in the system operation and in health and safety requirements. This training should be part of the handover process by the contractor/installer. Alternatively, a contractor may offer to provide a maintenance service. The accompanying Operation and Maintenance Guide provides further detail on how to operate and maintain a biomass system.

3.6.1 Performance monitoring

Metering and logging the heat output is essential to ascertain correct performance and is likely to be a requirement for any incentive scheme.

Reviewing metered data regularly can also help the early detection of problems within a heating system (which may not necessarily relate to the biomass plant). Other operational parameters which may be useful to measure are:

- Combustion efficiency.
- Grate temperature.
- Pressure.
- Oxides of nitrogen (NOx).
- Particulate matter (PM) emissions levels.

The accompanying Technology Guide discusses metering and monitoring in further detail. It is easier and cheaper to integrate metering into the original system design than to retrofit it. Incentive schemes may stipulate the accuracy class and standard of meter as well as its position.
As a minimum, meter the heat delivered by the biomass boiler, with additional meters measuring the output of any other heat-generating technology and the consumption of individual or groups of loads. Where possible clearly label heat meter displays and place them at eye level.

3.6.2 Maintenance

To operate efficiently and reliably, a biomass boiler needs to be regularly maintained. This includes boiler checks, cleaning, interim boiler services, annual service and responding to breakdowns. Include the access necessary for maintenance in the system design. It is often possible to set up an O&M contract with the installation company.

Alternatively, O&M responsibilities and duties may be allocated to internal, on-site staff or contracted out to a third-party facilities manager. Remote system monitoring may enable the responsible O&M contractor to carry out simple maintenance or adjustments before a major intervention is required.

3.7 Initial financial assessment

An initial financial assessment should be conducted, preferably comparing biomass systems with other potentially suitable technologies. The aim of this is to provisionally establish if there is a commercial case for installation of a biomass system. It is recommended to carry out a financial assessment over the whole lifetime of the boiler (e.g. over a 20-year period). Standard techniques such as calculating the internal rate of return on the investment or the simple payback period for the system can be used to assess viability.

Costs to be included in the calculation are:

- Capital costs – often established from other similar installations, benchmark figures or discussions with suppliers.
- Maintenance costs – comprising regular servicing; allowance for breakdowns and spare parts; and day-to-day tasks carried out by on-site staff such as boiler cleaning, ash removal, attending to fuel blockages.
- Fuel costs of biomass – established through discussion with fuel suppliers. Estimate the quantities required from the site's heat demand and the boiler efficiency.

Savings and income streams include:

- Savings in fuel costs of the existing fuel displaced by the biomass – established from historical fuel invoices.
- Government incentive payments.
- The value of any heat sales.
- Avoided waste disposal costs (if the biomass system uses waste products).
- Avoided costs of standard boiler replacement (if applicable).

Sensitivity analysis should be undertaken, particularly regarding future fuel prices (biomass and existing fuels). Fuel prices are difficult to predict and can have the significant impact on financial viability over the plant lifetime. It is worth noting that biomass prices have not tended to follow oil prices and have shown greater stability over the past number of years. Sensitivity analysis is best carried out on the assumed difference between the biomass fuel and the alternative fossil fuel.

Biomass heating systems generally have higher initial capital cost than fossil-fuel systems of equivalent-rated capacity. However, this difference may be recouped through annual fuel cost savings. Given this, biomass heating tends to be most cost effective in:

- Locations that are off the national gas grid. The capital recovery from the annual fuel cost savings is fastest when biomass heating replaces heating oil, LPG or electricity in off-grid sites.
- Building and processes that have relatively consistent and high heat loads. The more the biomass boiler is used, the greater the impact on the payback of the capital expenditure.
- Cases where biomass supplies are readily available, low-cost and there is a reliable supply of biomass fuel of sufficient quality.
- Where limited building/reconfiguration works are required. Compared to fossil-fuel alternatives, installation of a biomass system entails increased space requirements. Using or modifying existing buildings will reduce capital costs.

3.8 Implementation options

Table 2 summarises the options for implementing the design, installation and commissioning phases for a biomass heating system.

Table 2: Summary of biomass heating system implementation options

Option	Suitability	Advantages	Disadvantages
In-house design, installation and commissioning.	Suitable for an owner with strong in-house capabilities and knowledge of biomass. Not a common situation.	• Likely to be lower external costs. • Gives owner a high degree of control. • Enables work within own timeframes.	• Requires a strong knowledge, and preferably prior experience, of biomass systems and heating system design. • Owner takes on all the project risk. • Risk of voiding warranties on the plant. • Potentially fewer supplier connections.
In-house design with third-party installation and commissioning.	Suitable for an owner with strong design capabilities, but not manufacturer connections. Not a very common situation.	• Requires less knowledge of biomass systems compared to in-house design only (as detailed above). • Supplier may have connections in the industry to utilise.	• Requires a high degree of knowledge of biomass systems. • Requires close collaboration between in-house design team and third party. • Risk of lack of ownership of potential errors. Requires clearly defined responsibilities.
Consultancy design with third-party installation and commissioning.	Suitable for most situations. A common solution. Consultant and contractor should be experienced in biomass systems.	• Does not require the owner to have knowledge of biomass systems • Reduced project risk resting with owner. • Supplier may have connections in the industry to utilise. • Consultant can also act as project manager. • Design not influenced by installer bias for particular manufacturers.	• Likely to be higher external cost than the first two options. • Requires definition of the interface between and role of consultant and contractor which may increase contract cost. • Risk of lack of ownership of errors. Requires clearly defined responsibilities.

Option	Suitability	Advantages	Disadvantages
Third-party design, installation and commissioning (turnkey model) – standard systems.	Suitable for smaller, less complex installations. A common solution. Requires experienced third-party provider.	• Requires least knowledge on the part of the owner. • Reduced risk for owner. • Supplier may have connections in the industry to utilise.	• Often the second most expensive option. • May not be suitable for a site with specific/unique requirements which standard systems may not be designed for.
Third-party design, installation and commissioning (turnkey model) – bespoke systems.	Suitable for larger, more complex installations. Less common as these are fewer in nature. Requires experienced third-party provider.	• Requires least knowledge on the part of the owner. • Reduced risk for owner. • Supplier may have connections in the industry to utilise. • Produces a system specific to the site's requirements.	• Often the most expensive option due to increase design and installation cost.
ESCO (Energy Services Company)[8]	Suitable where the client organisation is unable or does not wish to provide the capital investment. Also, where the client wishes to focus on their core business.	• ESCO provides the capital for the plant • Client avoids the management and technical burden of operating and maintaining the plant • Client avoids most of the technical and operating risk and in some cases financial risk.	• The financial benefits to the client may be lower. • Client becomes reliant on the ESCO, but this risk can be mitigated through contractual terms.

[8] The ESCO model is a type of energy contracting employing a 'pay for performance' approach to installing energy technologies for client organisations. Usually, the ESCO will design, build, own and operate the plant, and sell the client heat (and other forms of energy) at an agreed price. Both organisations will have contractual obligations related to performance. There are many possible variations of the ESCO model.

See https://www.seai.ie/energy-in-business/energy-contracting/

4. Project development

Key messages

- Using contractors' knowledge can help refine the design.
- Producing a technical specification against which contractors can quote provides a more fruitful procurement process.
- Development of a scoring matrix, with key requirements of the system and desirable factors allocated a score, enables a consistent review of proposals.
- Select contractors according to the suitability of their proposal, their experience, training, certification and professional membership.
- Heat sale systems can be implemented to sell the biomass heat, but there may be financial risks associated with the potential future loss of heat customers.
- Health and safety measures need to be included in the design of the system and the relevant regulations and legislation followed during design and installation.

This section describes the key stages of project development:

- Procurement: identifying and selecting a suitable installer, including producing a technical specification and reviewing quotations.
- Detailed sizing assessment and system design: normally, the contractor should undertake this with oversight by the client or the client's consultant.
- Detailed financial assessment: improving the initial financial assessment with detailed design including sizing, system details and prices provided after the procurement and detailed design stages.
- Development of a heat sales system: Where the installation owner sells heat to a user, develop a heat sales agreement.
- Regulatory considerations: reviewing regulatory requirements such as planning permission, environmental permitting, emission standards and building regulations that require addressing prior to installation.
- Health and safety: follow mandatory and best practice health and safety practices in the design and during construction.

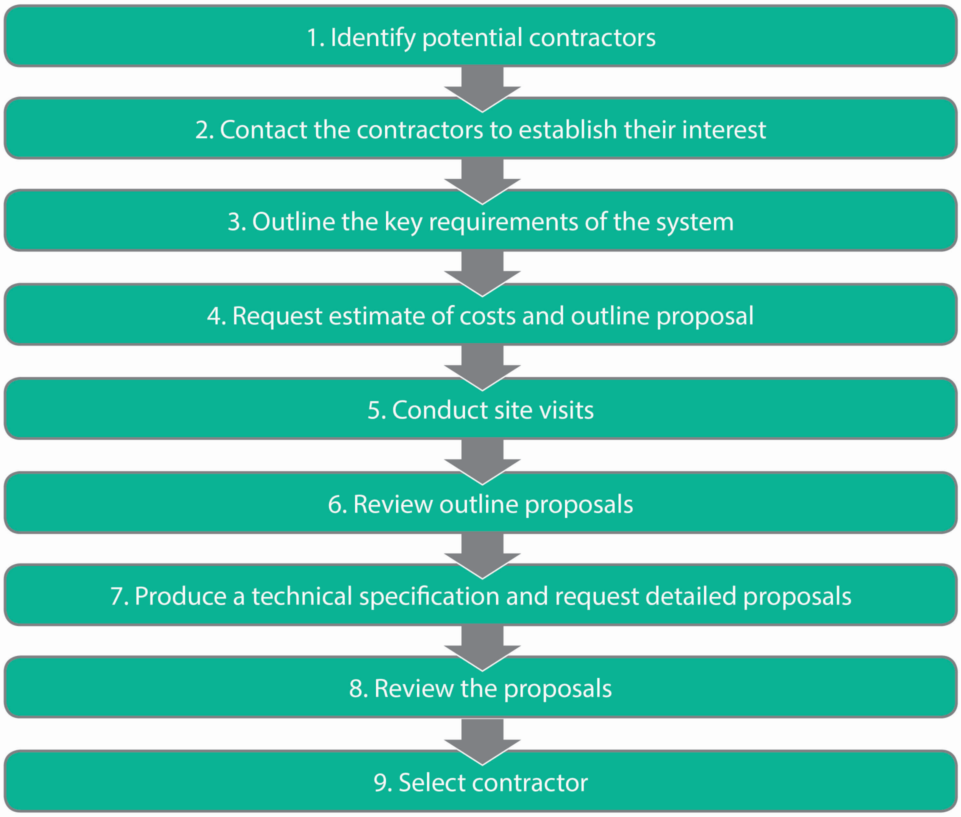
4.1 Procurement

3.1.1 How to appoint a consultant/contractor?

Depending on the implementation option chosen (see Section 3.8), it may be necessary to appoint a competent designer and an installer or a contractor who will cover the complete process. Apart from the ESCO model, the procurement process is very similar for each of these options (see Figure 4.1).

Implementing improvements to energy efficiency could form part of the same exercise or be a separate tender exercise. In either case, it is important to ensure that the impacts of energy efficiency measures on heat requirements are taken account of in the design of the biomass system.

Figure 4.1: Process for appointing a contractor



4.1.2 Identifying suppliers and installers

Identify biomass suppliers or installers through internet searches. Biomass boiler manufacturers will often have local accredited installers or business partners.

Contacting organisations with existing installations for information is also a valuable method of identifying suitable suppliers. Suppliers should be able to provide potential customers with several reference sites to visit. Review the training, certification and experience of the companies to assess their suitability.

4.1.3 Producing a technical specification

A technical specification should underpin the procurement process. It helps contractors to deliver proposals more quickly and accurately, ensures the proposals meet the requirements for the system and allows for easier comparison of proposals. Potential content includes:

- General description and scope of work.
- Biomass system requirements – heat requirements and buildings to be heated, operational requirements (such as level of involvement from site staff), control system, thermal store, integration with existing system and additional technologies.
- Boiler requirements – boiler output, quality criteria, grate system, boiler efficiency, turndown capability, de-ashing and boiler emissions.
- Fuel requirements – fuel type and moisture content, fuel store capacity, fuel store location and fuel-handling mechanism including burn-back[9] protection.
- Building requirements – location of boiler and building changes or construction, aesthetics and flue size (often wholly or partially dictated by planning and air quality restrictions).
- Additional site details – power supply, power consumption and water supply.
- Access arrangements – for installation and ongoing fuel deliveries, boiler room and fuel store maintenance, and flue cleaning.
- Associated works – who will do them and when (these are discussed further in Section 5.2).
- Ongoing support and maintenance – technical support, warranties, remote monitoring, operator training and service agreements.
- Additional requirements – any timings that must be adhered to, external activities on which the impact needs to be minimised and site-specific requirements such as security arrangements.

4.1.4 Reviewing proposals

When reviewing proposals, the following should be considered:

- Technical specification – check each proposal to ensure suppliers have quoted for what has been asked for.
- Exclusions – check for exclusions and seek separate quotations for any work that is outside the main contractor's scope.
- Assumptions – in cases where contractors have made assumptions as part of their proposal, verify their suitability and accuracy. If a contractor's assumptions are unsuitable or inaccurate (for example regarding annual operating hours), the system proposed may be inappropriate.
- System design – if the contractor is designing the system, it is recommended that a suitably qualified designer of biomass systems verify the system is designed to all applicable regulations and best practice.
- After-sales support and servicing – many contractors provide extended guarantees or servicing agreements. Compare differences, including proximity of engineers to the site. Review the training that will be offered to on-site staff.
- Capital cost of buying the system and installing it – this must include all works, including any enabling works within the contractor's scope.
- Operating costs – this should include maintenance, repair, any additional labour to operate the system if the contractor is providing the ongoing servicing and any additional items within scope, such as fuel deliveries.
- Time validity of price – it is common practice for tenders to include a limit on the amount of time for which their quotation remains valid. However, the time between the receipt of tenders and finally placing an order may exceed this time limit. If so, discuss the ability to extend the amount of time for which the quotation remains valid.
- References – review examples of the contractor's work and speak to people who have previously engaged their services. It is important to know if the contractor has a track record of quickly and appropriately resolving problems that may arise. The contractor's training and certification can also be reviewed.

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[9] Burn-back refers to fuel within the delivery system being ignited by the burning fuel in the combustion chamber and burning back towards the fuel store.

To enable a consistent review of the proposals, develop a scoring matrix with key requirements of the system and desirable factors in the proposal having an allocated score depending upon their importance. Score proposals against these criteria.

4.2 Review of financial assessment

The quotations/proposals submitted in response to the procurement process should provide details of capital and ongoing servicing costs. Other operational costs, particularly assumed fuel prices, should be revisited prior to selecting, as should any projected loan interest payments. With this and any other revisions to assumptions previously made, the project financial assessment should be re-run to determine whether the project economics remain acceptable.

4.3 Developing a heat sales agreement

For projects where the biomass boiler will be supplying heat to sites not under the ownership of the biomass system owner, a heat sales process will be required. In such cases, the financial risks associated with the potential future loss of heat customers need to be assessed against the benefits of heat sales and managed through heat sale contract terms.

Selling heat is similar to selling other energy products – a meter is installed and users are billed for each kilowatt hour (kWh) of heat. Selling heat allows the biomass boiler owner to install a system larger than is required for their own demand, potentially decreasing costs through economies of scale, while possibly increasing the cost of capital cost of the project. The heat buyer benefits from potentially cheaper, low-carbon heat with reduced space requirements and reduced responsibility compared to installing their own biomass system.

Considerations for establishing a heat sales agreement include:

- **Heat sales customers:** These need to be in close proximity to the biomass boiler to minimise heat losses in distribution. In order to design the system appropriately, the customer's heat demand levels and profiles need to be understood. The customer(s) will need to update the heat supplier with any substantial changes in their expected demand, and provision for this and the commercial consequences will need to be set out in the heat sales contract.
- **Pipework route:** The route for pipework to transport the heat from the biomass boiler to the buyer will need to be determined and agreements made with the relevant landowners.
- **Pricing:** The tariff established is likely to be a compromise between a price that is competitive with fossil-fuel heat generation for the buyer and one that allows the heat supplier to make a suitable return. It might be indexed by setting an initial price based on the full costs of supplying the biomass heat to the site and an appropriate profit margin. Adjusting this in the future may be required according to indices such as fossil fuel costs, the retail price of heat or costs of operating the biomass system, including fuel costs. Split the price into a unit charge for the heat used and a standing charge for administrative costs.
- **Contract:** Sources of possible templates for heat sales contracts are included in Section 6. Both parties are advised to seek legal advice before entering into a legally binding contract. A regular review (potentially annual, depending on the size and scale of the operations) of the contract may be required, including reviewing heat consumption, generation, costs and heat pricing.
- **Sales system:** The buyers will need to be regularly invoiced for the heat they have consumed. This will require the boiler owner to produce invoices and process payments.
- **Maintaining the biomass system and its performance:** As the buyer will be paying for heat delivered, the income from the heat sales will remain the same whether the biomass system performs efficiently or not. It is therefore important to maintain the good operation of the system to maximise profits for the biomass system owner. If the buyer does not have a back-up heat supply, this places additional importance on the reliable operation of the biomass boiler. Compensation for periods without heat provision may be included in the contract.

4.4 Health and safety

Having a biomass system that operates safely is paramount. This should be addressed during design, implemented during installation and managed on an ongoing basis, as discussed in the accompanying Operation and Maintenance Guide.

It is important to undertake a comprehensive health and safety risk assessment, apply health and safety regulations and follow best practices. There are various specialist guidance documents on this area, some of which are listed in Section 6. In particular, the Combustion Engineering Association's 'Health and safety in biomass systems: Design and operation guide'[10] should be referred to as this Implementation Guide only provides an overview of the considerations.

4.4.1 Design features

Incorporate various safety features into the design of a biomass system, as appropriate, including:

- All Building Regulations requirements
- Adequate space around the system for maintenance.
- Emergency lighting and exits in the boiler room.
- Design measures ensuring complete combustion to minimise the risk of carbon monoxide (CO) build-up.
- Installation of a carbon monoxide (CO) alarm system.
- A fuel store that is safe to access and use. Display suitable and prominent warning signs at fuel store entrances and other relevant locations in and around the plant room.
- A flue that minimises deposit build-up and is accessible for cleaning.
- A system, including the flue, which ensures negative boiler pressure is maintained under failure conditions, to avoid the build-up of potentially explosive wood gases in the boiler and toxic gases, particularly CO, entering the boiler house.
- A fuel delivery system that minimises the risk of burn-back, with features such as rotary valves and fire quenching systems.
- A safe access route to the fuel store for vehicles.
- Explosion relief measures and fire safety measures, such as water drench valves and bottles.
- Ensuring all relevant staff are trained in the safe use of the system.
- Informing the local fire officer of the existence of the installation before completion.

4.4.2 Construction Phase

The Health and Safety Authority (HSA) sets out the requirements for health and safety during construction in 'Safety, Health and Welfare at Work (Construction) Regulations 2013 (S.I. No. 291 of 2013)'[11]. This is the most up-to-date legislation at the time of writing, but the HSA website should be reviewed for more recent additions. These regulations prescribe the main requirements for the protection of the safety, health and welfare of people working on construction sites and give further effect to Council Directive 92/57/EEC on the minimum health and safety requirements at temporary or mobile construction sites. As such, they are applicable to all construction sites, including biomass systems. Full details of the parties responsible can be found on the HSA website[12].

[10] http://cea.org.uk/resource/health-and-safety-in-biomass-systems/
[11] http://www.hsa.ie/eng/Legislation/Regulations_and_Orders/Construction_Regulations_2013/
[12] http://www.hsa.ie/eng/Your_Industry/Construction/Construction_Duty_Holders/

In summary the responsibilities relating to health & safety are:

- **Client**: Employ competent third parties and appoint them in writing before work starts, supply necessary information, keep and make available the safety file for the completed structure, and provide a copy of the health and safety plan to every person tendering for the project.
- **Project supervisor (design process)**: Identify hazards arising from the design and eliminate or reduce them, communicate necessary control measures, prepare a written health and safety plan, and prepare a safety file for the completed structure and give it to the client.
- **Designers:** Identify hazards that the design may present and eliminate or mitigate them, communicate the control measures and remaining risks to the project supervisor, take account of any existing health and safety plan, and comply with the project supervisor's instructions.
- **Project supervisor (construction stage)**: The role of the project supervisor is to manage and co-ordinate health and safety matters. The project supervisor is appointed before the construction work begins and remains in that position until all construction work on the project is completed.
- **Contractors**: Co-operate and comply with the project supervisor, provide information required for the safety file, report accidents, comply with site rules, identify hazards and reduce or eliminate them, facilitate the appointment and use of site safety representative(s), provide workers with a site-specific induction and safety awareness card, and monitor compliance and take corrective action if required.

4. Installing and commissioning

Key messages

- It is crucial to prepare and agree a robust contract before the works begin to protect the client and contractor.
- Address and mitigate project risks in the contract.
- Standard contracts are generally well understood by contractors and the legal profession. Bespoke contracts are generally drafted to favour the party presenting them and should be reviewed carefully.
- Develop a comprehensive project plan.
- Appoint a professional project manager to ensure the installation stage runs to time, budget and quality.
- Additional works to enable the biomass system installation should be included in the project plan.
- The biomass boiler and system should be commissioned by suitably qualified people and commissioning records kept.
- Records of warranties should be kept, and warranties used if faults occur. Care should be taken to avoid any actions that void the warranties.

This section provides guidance on what needs to be considered when the biomass system is being installed and commissioned, including:

- **Contracting:** producing a suitable contract between the owner and installer.
- **Installing:** installing the biomass system and enabling works.
- **Commissioning:** formal acknowledgment that the biomass boiler and system are operational.
- **Warranty:** the written guarantee from the installer committing to repair or replace the system or parts thereof within a specified period.

5.1 Contracting

Specialist biomass companies have largely developed biomass outside the mainstream building services sector. As a result, some projects have been installed using less rigorous contractual approaches than would have been applied in mainstream construction. This may increase the risk to the client of unnecessary additional costs and of the installer's inability to resolve performance issues. It is therefore crucial to agree a robust contract before installation work commences.

5.1.1 Factors to consider

Factors that will influence the contract include:

- **Project size:** the larger the project, the greater the commercial risk and effort recommended in setting up the contract.
- **Technical complexity:** a more complicated project, such as one integrating a biomass boiler into an existing heating system, will require a more detailed contract.
- **Associated works:** There is likely to be additional associated construction work (outside the scope of the biomass boiler installer's work), such as the installation of a fossil fuel back-up boiler or

construction of an access road. These works should be listed in the contract and details included on their interdependency with the biomass installation works, work scope boundaries and responsible parties.

- **Familiarity with form of contract:** if the contractor or client has experience working with a particular form of contract, then this may be used. Using a form of contract with which the contractor is unfamiliar may result in an increase in price.
- **Client capability:** the client's capability and risk appetite will determine which roles and risks they will be willing to undertake.

5.1.2 Contract contents

At a minimum, the contract should include the following:

- **Performance measure**: some form of contracted performance measure is essential to ensure the biomass system meets the heat demand. It could include hours of operation, combustion efficiency, and reliability and temperature of heat delivered. It should also include remedial measures if these criteria are not met and could include damages to cover any costs of underperformance.
- **The full scope of works under the contract**: this includes a full description of the system and its intended function (general requirements and restrictions about the design, location and operation of an installation project, but leaving the detailed design choices to the installation companies) and any interfaces with the existing system. Some customers may have the skills to provide certain aspects of the works like, for example civil engineering works – in such cases the contract should make clear which aspects the biomass system installers are responsible for and which aspects other parties are responsible for.
- **The programme of works**: this is needed to ensure any associated works are completed on time and to plan any back-up heat provision in case the system is not commissioned on schedule. If the programme is time critical, then clauses covering delay costs and measures could be built into the contract.
- **Contract preliminaries**: these include details of items such as site access arrangements; site working hours; setting-down areas for equipment; welfare facilities for contractors' staff; site agent provision and any site accommodation; site electrical and water supplies; insurance requirements; and quality, safety and environmental requirements. They also include requirements for approvals, testing and sub-contracting.
- **Dispute resolution**: the procedure for resolving any potential disputes.
- **Details of guarantees**: Details of the warranty and any other guarantees as discussed in Section 5.4. This should include a detailed explanation of warranted performance and any maintenance requirements that need to be fulfilled for the warranty to be valid. Additional contractual protection may be needed where the project is complex, of significant financial value, or where there could be contractual complications. For example, it is possible to put a bond in place to cover the costs of plant replacement or remedial works, should the contractor default or in the case that the plant does not meet specified performance standards. A bond may extend through the contract period until the works are taken over and the purchaser becomes the legal owner.
- **Insurance and liability details**: the standard terms and conditions of contract will require the contractor to have in place third-party liability, employer's liability insurance and, very often, to insure the works and materials – usually until handover to the purchaser. For larger or complex projects, the purchaser might also consider an 'all-risks' insurance policy, which will afford additional recourse if the contractor defaults or if the plant underperforms. The level of insurance cover sought should be proportionate to the size of the project and the risks involved. Seek professional advice when considering the correct levels and extents of coverage. Copies of certificates should be available from the contractor as proof of cover.
- **Reference to key documents**: these should include a full set of contract drawings, a full set of specifications, a risk assessment, a health and safety plan, a cost breakdown and a payments schedule.

In addition to finalising the contract for the biomass installation, this is also the time to finalise any other agreements, such as organising the fuel supply and maintenance.

5.1.3 Form of contract

In some circumstances, a standard design-and-build contract, using a set of formal contract terms and conditions, is appropriate. There are a number of forms of contract that are commercially published, and if a design-and-build contract is to be used, it is recommended that one of these is adopted. In the event of a dispute, these forms of contract are reasonably well understood by the legal profession and the courts.

While other bespoke forms of contract do exist, it should be noted that these may often have been drafted to favour the party presenting them and they may not have the same degree of established legal precedent.

There are various Irish standard forms of contract:

- The Royal Institute of Architects of Ireland (RIAI) form of contract, with or without quantities for building works.
- The Engineers Ireland (formerly the Institute of Engineers Ireland) (IEI) form of contract is generally used for civil engineering works.
- There is also a standard form of subcontract for use with the IEI third edition.
- The Government Construction Contracts Committee (GCCC) developed a suite of contracts for use in public sector works.
- Standard forms for construction professionals developed by the key industry bodies (the RIAI, IEI and the Society of Chartered Surveyors (SCS)). The GCCC has also developed standard conditions of engagement for construction professionals in public works.

Using UK and international forms of contract is also possible. The Institution of Civil Engineers (ICE), Joint Contracts Tribunal (JCT) and New Engineering Contract (NEC) forms are occasionally used, as well as International Federation of Consulting Engineers (Fédération Internationale des Ingénieurs-Conseils) (FIDIC) and Institution of Chemical Engineers (IChemE) forms, and the Institution of Engineering and Technology MF/1 (amended for the Irish market). FIDIC is one of the more commonly used international forms of contract used in Ireland, particularly in the energy sector.

5.1.4 Project risks

Table 3 details risks that could arise during the project and describes how these could be mitigated within the contract. The larger the biomass system, the greater the need to address these kinds of risk in detail in a contract.

Table 3: Potential project risks and mitigation measures

Risk	Impact	Example Mitigation
Construction delay	Installation completed later than expected, potentially incurring temporary heat-generation costs.	• Allow reasonable construction window, including time contingencies. • Use the contract terms to manage the timetable and deal with liability for delay.
Capital overspend	Total capital cost of installation exceeds the original budget.	• Maintain contingency budget. • Enter contracts on fixed price basis, passing risk to contractors.
Commercial risks	Boundaries of responsibility not defined and an area ends up without ownership.	• Ensure all technical and contractual interfaces are documented (e.g. by defining physical boundaries and termination points), understood and agreed to in writing by all parties.

Risk	Impact	Example Mitigation
Inappropriate allocation of risk	If a particular risk is not placed on those who understand it and can manage it, the project costs may rise (e.g. where a contractor does not understand the risk fully, the price may be increased to give protection to the contractor).	• Place risks with those who understand them, have influence over mitigating against them, and can manage them.
Limited scope	Higher costs caused by gaps in scope. Any gaps discovered during the works will generally cost more to rectify at the time of discovery than if they were included in the original scope.	• Examine the completeness of the scope rigorously before any contract is agreed. • Pay particular attention to the integration of the biomass system with the existing system.
Technically immature technology	System breaks down due to issues in design, manufacturing or installation.	• Choose well-tested technologies and reputable installers, which are backed up by customer references. • Include performance and reliability terms in contract.
Technical risks	Fault in design, installation or operation.	• Ensure design, installation and operation are in accordance with pre-established quality control standards – perhaps independently verified.
Overly detailed system design (if contractor is designing)	This may blur the lines of responsibilities and result in contractual disputes. May result in less suitable components/ arrangements being used and prohibit contractors from using their supplier relationships to secure installation warranties.	• Do not produce a contract with an overly prescriptive design. • The use of performance standards and output requirements allows the installer to provide technical solutions that do not transfer risk back to the client.
No provision for performance measuring or for addressing under performance	Incorrectly installed and commissioned boilers are unlikely to yield the expected energy performance.	• Specify performance criteria and monitor after installation. • The performance clauses should lay out solutions to solve issues associated with under-performance.
Incorrect plant operation	System is not operated or maintained as required, causing outages and/or increased operating costs.	• If operated by in-house staff, ensure personnel are properly trained. • Enter into an appropriate call-out support contract.
Unreliable fuel supplies	Supplies insufficient to maintain required operation of the system.	• Choose a system amenable to fuels from a range of potential suppliers. • Include fuel quality and timely delivery terms in contract if a contractor is supplying the fuel.

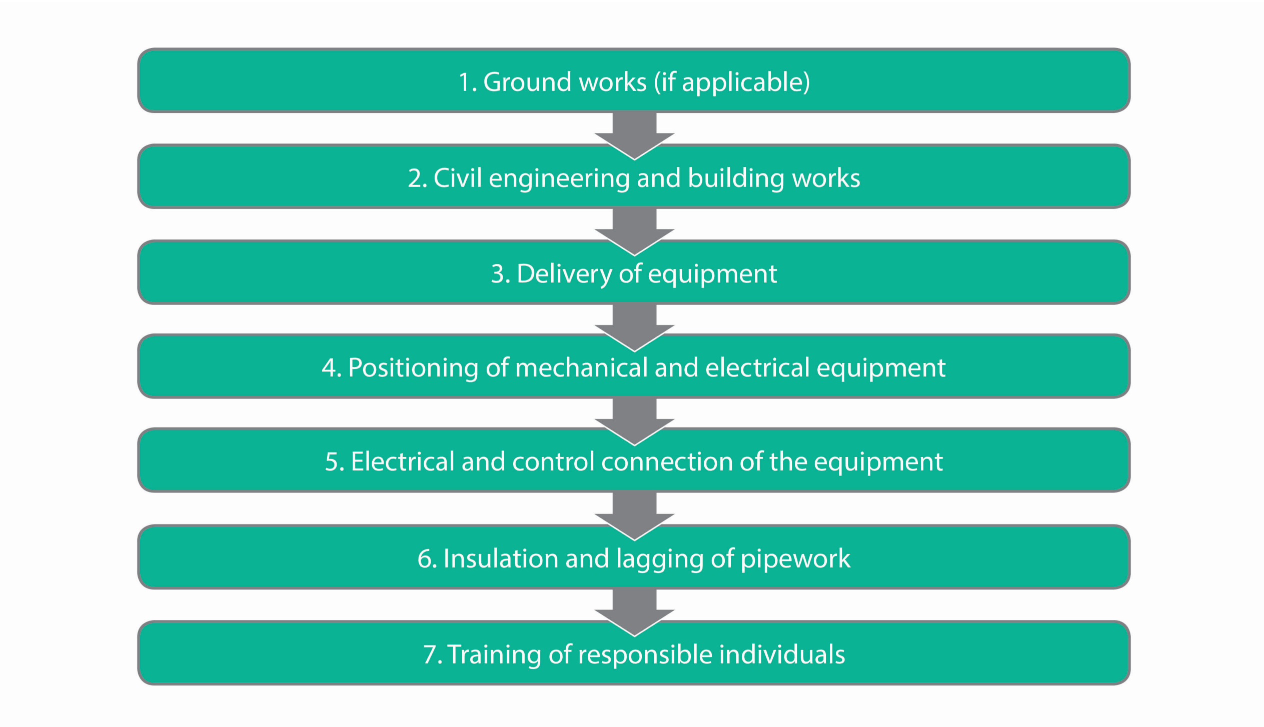
5.2 Installation

As with any project, creating an accurate project plan is key to success. It is recommended that a professional project manager be appointed to ensure the installation stage runs to time, budget and quality. This does not necessarily have to be someone with in-depth technical knowledge of biomass systems, as this should be provided by the contractor. A typical biomass project installation phase is detailed in Figure 5.1 below. A more detailed installation plan should be developed for each stage of the project.

Considerations when developing a project plan for the installation phase include:

- Any disruption to the organisation where the installation will be taking place and how this can be mitigated. It may be necessary to turn off the heat and prevent access to parts of the site, and there may be additional noise or dust.
- With any larger sized units, consideration must be given to ensuring that access to the boiler house is sufficient to enable the boiler to be installed (e.g. enlarged doorways).
- Specification drift may occur, especially if several contractors are involved. Therefore, all contractors should be aware of the site owner's original specification and all sub-contractors should treat this as the primary technical reference.
- Where projects are awarded on a fixed-price basis, the main contractor and subcontractors naturally tend to minimise their costs. Outline clear performance penalties in the specification.
- When placing an order it is important to note that lead times for delivery of the biomass plant may be longer than a fossil fuel plant. The lead time depends on:
    - The size of plant – a larger plant (more than 500kW) will generally be made to order and an allowance of several months might be required.
    - Time of year – late summer/autumn are peak periods for installation activity, which may lengthen lead times.
- Site access arrangements and security arrangements will need to be agreed.

Figure 5.1: Typical key steps during the installation phase



5.2.1 Associated works

There will often be associated works to enable the biomass installation to take place. These may include:

- Removal and safe disposal of existing plant.
- Plinths, to structurally support the new plant.
- Water supply.
- Internal power supply.
- Changes to lighting and emergency lighting.
- New power supply from ESB Networks applied for, where applicable.
- Hard-standings for manoeuvring delivery vehicles.
- Changes to road access.
- Internal building alterations.
- Extensions to buildings.
- Ground works for pipe-runs and in readiness for the construction of building foundations.
- Fuel bunker construction.
- Hydraulics and fuel-handling systems.
- Cleaning/flushing, testing and repairs to the existing heat distribution system.
- Replacement and/or integration/reconfiguration of existing control systems with the biomass system.

The discipline (building, civils, mechanical and electrical) and quantity of associated works will determine the number of internal project interfaces. Each of these interfaces poses a risk to the delivery and the project cost.

5.3 Commissioning

Commissioning involves testing equipment to confirm that it is operational and meets its design specifications.

For biomass systems, commissioning may refer to the boiler itself or to the whole installation consisting of the biomass boiler, heating system and ancillary components. It is important to check the scope of commissioning required by any incentive schemes.

Commissioning will require:

- Pressure testing of components.
- Electrical testing of equipment.
- Testing controls and meters.
- Ensuring safety devices are correctly installed and working.
- Operational testing of individual components of the system (i.e. the boiler, the fluid transfer pumps and the distribution system, balancing of heating system).
- Testing the whole system under the range of normal operating conditions.
- Conducting extended plant performance and reliability tests.

A commissioning certificate showing the scope, date of the commissioning and signed by a qualified person should mark commissioning completion. Where relevant, the date is important as it is likely to be required by any incentive scheme and can determine the rate of support that is applicable.

Keep Commissioning certificates on site as part of the installation records.

Completion of the commissioning will result in the handover of the system from the contractors to the operators. The operators should receive an operating, maintenance and safety manual, and should have received training in operation and basic maintenance. Systems should have a regular servicing regime in place based on the manufacturer's guidance.

5.4 Warranty

Even with well planned and executed installation and commissioning, faults may still occur. The system may need to be modified to ensure optimum performance agreed between the client and consultant/contractor.

It is important to be familiar with the warranties on all equipment, the overall system and workmanship. Any moving parts (such as electric motors and gearboxes, especially those inside the boiler or fuel delivery mechanism) and those subjected to high temperatures (such as refractory linings in the boiler combustion chamber) are particularly important as they are the most likely to fail.

Extended warranties are sometimes available for purchase and the cost-benefit of this should be assessed.

To ensure the warranty is comprehensive and fully used:

- Ensure it covers the whole system, all the components within it and the workmanship. If several installers were involved, check there are no gaps between the coverage of the warranties.
- Check the terms and conditions, especially any areas that may void it, such as use of the incorrect fuel, operating the system outside of the manufacturer's specifications and maintaining the system as per the manufacturer's requirements.
- Ensure the company providing the warranty has a reasonable likelihood of remaining in business for the duration of the warranty, by checking company's history and financial performance.
- Check warranties if they include for parts, labour or both.
- Keep copies, for reference. 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 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 are likely to have their own warranty. Keep a record of these in case the part requires a second replacement within that warranty period.

5.5 Record management systems

A structured record management system should be set up to contain all records associated with the feasibility, design, procurement and implementation of the project, including full as-built drawings, full system schematics and specifications.

The system should be set up to accommodate all operational records into the future regarding maintenance and repairs; future systems changes; fuel use, heat generated and heat sold as described in the Operation and Maintenance Guide.

5. References and other sources of information

A substantial amount of guidance on biomass systems has been published over recent years. Aspects of this guidance document may become outdated over time based on market developments, and therefore it is important to cross-reference details in this guide against other sources. Factors that are likely to vary and should always be cross-referenced include: available technology, costs, fuel availability, financial support schemes, legislation and standards.

5.1 General References

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/

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 Energy efficiency

Excellence in Energy Efficiency Design (EXEED) Certified Program
https://www.seai.ie/grants/business-grants/exeed-certified-grant/

6.4 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

6. Glossary

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.
Associated works	Works that are not included but instead act in support of the main scope of works, e.g. installation of concrete base for support of biomass boiler.
Back-up boiler	An alternative boiler used to provide heat when the primary system is out of service.
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 be sized to 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 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 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 procuring the biomass system.
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 a new heating plant meets the performance specifications as per design; called for in the installation contract.
Consultant	Professional person or organisation appointed to provide assistance of an advisory nature 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.
Flue	The passageway between combustion device and terminal of a chimney that acts as a duct to exhaust combustion gases to a position and height where they will not cause annoyance or health hazard.
Ground works	Work done to prepare sub-surfaces for the start of construction work. May include ground investigations, site clearance and landscaping. Does not include demolition work.
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.
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.
Short rotation coppice	Dense growth of small trees or bushes regularly trimmed back for re-growth. Willow or poplar grown as an agricultural crop on a short (2–5 year) rotation cutting cycle and at a planting density of 10–20,000 cuttings per hectare.
Solar thermal	Device designed to receive solar radiation and convert it into thermal energy for a useful output, typically to heat water for space heating or domestic hot water.
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 such 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 of a smaller size 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 its service or goods that have arisen within a stated period after their installation.

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