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SERIES 16 | MODULE 10 | BIOMASS BOILERS

Biomass boilers and systems

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Finding the balance between the correct size of biomass boiler and what it serves requires several aspects to be considered. This article introduces biomass as a fuel source and then explores some of the key considerations when reviewing the potential for biomass boilers and their associated equipment.

Biomass as a fuel for heating systems is a well-proven route to decarbonise heat in a building or in an industrial setting. Biomass is viewed as being carbon neutral due to its energy being captured and stored via the process of photosynthesis, even though it does release CO₂ when combusted.

The CO₂ released is largely offset by what is absorbed in the original growth of the biomass, or which will be captured in the growth of new biomass to replace the biomass being used. For it to be truly considered carbon neutral, the fuel source should be from a sustainable source. The main difference between other fossil fuels and biomass is the time for the CO₂ to be formed. With most fossil fuels this is over millions of years as opposed to a life time or a relatively short period. It's the difference between a time to grow rather than a time to form.

It is generally considered that biomass is fuel from wood-based sources such as woodchips or wood pellets, but it can also include other materials such as short rotational coppice, straw bales, more conventional wood logs or waste wood. However, there are



examples of other sources of fuel being considered biomass as well as biogas installations.

With some projects the downstream emissions for the producing and delivery of the fuel may need to be considered.

To have a holistic approach to the potential for a biomass installation you need to consider:

- fuel delivery and handling to the location;
- storage and fuel delivery to the biomass boiler;
- fuel quality;
- biomass boiler(s);
- key system equipment: accumulator tank; flue; ash extraction; integration with existing or additional heat source; and
- ancillary items: expansion and pressurisation unit; controls; pipework, valves and isolations.

The ancillary items mentioned would be like any heat or energy centre, so we shall not go over

here except for an overview of the control's integration. For the other items, we shall briefly describe some of the key considerations.

Biomass is generally delivered to site as woodchips or wood pellets, albeit it maybe from other sources. This is usually delivered by lorry, so it is essential to ensure that it can access where the boiler house and/or fuel storage is sited. The next main thing to consider is how the biomass is transferred from the lorry to the storage. The handling of biomass at this point by the fuel supplier does come at a cost. The options would be that a lorry comes and tips its contents into a lower ground or ground level area, much the way a large coal lorry would have in the past. However, it maybe that this isn't possible at a site, so it may need to be blown into a hopper or picked from a lorry into a hopper in large bags (or indeed a purpose-built store).

The handling costs of the second two options can impact the economics of your project by an additional 10-30 per cent on the fuel costs. So key thing here is easy access for the lorry and off-loading of the fuel to minimise the costs as a function of the amount of fuel required.

Once the fuel is delivered to the fuel store, it then needs to be transferred in an appropriate way to the boiler. To some extent this is dependent on the size and amount of fuel the boiler requires. This is generally through some form of mechanical handling system like a screw auger or ram stoker. In larger storage systems, a moving floor may aid the supply to the screw. The quality of the fuel (mainly the moisture content) can often cause issues with the mechanical handling system where blockage may be an issue.

When it comes to the wood storage itself, it should be water tight to avoid water being absorbed. Another consideration may be around the spores that can grow on old wood if not stored correctly. The size of storage shall be a function of demand for heat from the boiler, how much and often fuel can or will be delivered, and how much of a buffer in supply you would feel comfortable with.

Importance of fuel quality

The quality of fuel is important for several reasons, but not exclusively to:

- moisture content shall affect the heat content (calorific value), the lower the moisture the lower the heat content;
- the boiler will need to be able to deal with the moisture content in the wood, meaning a larger combustion chamber. Generally, boilers have a minimum amount of moisture they are able to cope with;
- if the moisture is high, it can lead to darker smoke from the flue and can carry some of the combusted material through to the flue. It is not uncommon for smoke dispersion being modelled during



development as part of planning.

- the higher moisture content can lead to handling issues, for example, woodchips clumping in the screw or worse damaging the screw with the increased weights. There are other handling and storage issues.
- impurities in the wood need to be dealt with or there may be emissions issues. This can cause chemical emissions/particulates that are not acceptable;
- physical impurities and/or non-combustible items in the fuel stock (this can be common in reclaimed wood. This may damage the handling equipment as well as in the boiler itself;

- the size of the wood, particularly with woodchip supplies, also needs to be taken into consideration so the handling equipment can cope (as well as the quicker burning of smaller sized); and
- bulk density - this is mass of many particles of the material divided by the volume they occupy including the spaces between them. Fuel sources with higher moisture have higher weight and lower bulk densities.

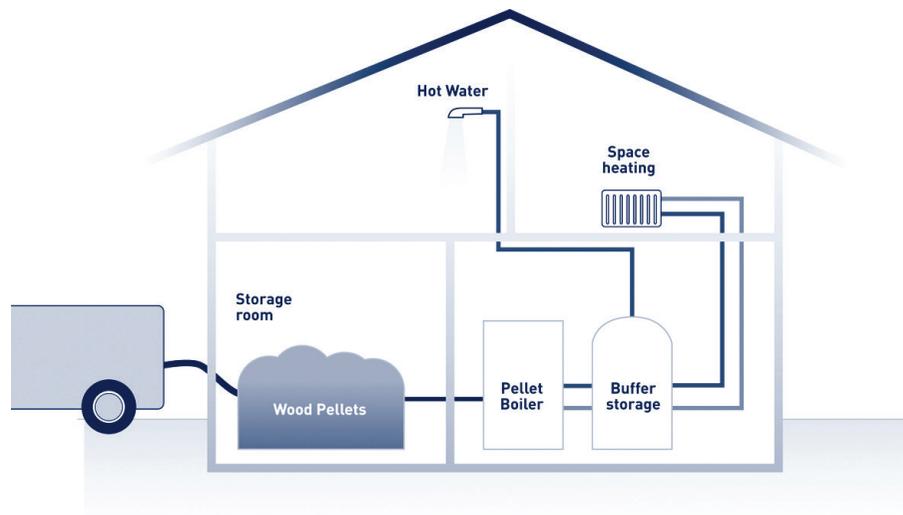
The energy density of a fuel is the multiplication of bulk density and calorific value (Energy Density in MJ/m³ = calorific value in MJ/kg x bulk density in kg/m³).

Therefore, it is critical in the biomass development and planning that fuel quality is reviewed and understood and then carried through into operations. It is not unusual to have a quality check procedure (which includes sampling) periodically in the operational phase.

Addition of tanks

With most biomass installations, the capacity of heat available is normally with the utilisation of an accumulator tank or tanks as well as the boiler. The tanks are added to the system to do several things: aid the biomass boiler running at higher loadings when running; provide capacity and a buffer between supply and demand; and, some form of resilience in the system. Therefore, in most applications, you will find that it is key to size both the boiler and the accumulator tank in a robust fashion. The consequence is that you will either not load the boiler enough and for long enough, similar to short cycling a gas boiler but also run the boiler inefficiently; or, the accumulator tank struggles to maintain enough heat (reach temperature) for the peak loads or for large parts of operations (with the short fall generally picked up by a second heat source).

The sizing also has an impact if integrated into a secondary



heat source like a gas boiler. For example: if the accumulator tank is too large for periods of low demand (like in summer), the gas boiler is likely to short cycle with not enough demand on the biomass boiler and the turndown ratios of biomass boilers are not as low as gas. Short Cycling is where a boiler is cutting in and out in short periods of time, this is less efficient than longer loading period due to firing up. It also increases maintenance and reducing the life time of the boiler.

Turndown ratio is the ability of the burner in a boiler to low fire, so a turn down of 1:10 means it can go as low as 10 per cent of rated output. This can be in staged increments or in a fully modulating. Typically, biomass boilers don't go below 30 per cent and are in a staged increment.)

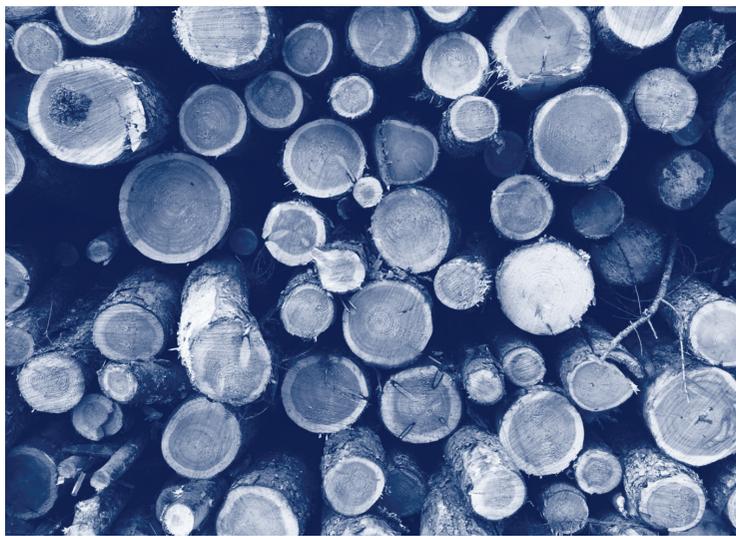
The Carbon Trust has a freely available sizing tool which aid in both the sizing of the tank and boiler: <https://www.carbontrust.com/media/672921/biomass-boiler-sizing-tool-version-6-8-3.xlsm>.

To be able to size systems appropriately, it is important to have a view of the likely daily/seasonal heat demands before deciding on the sizing/ integration strategy. Typical capacity factors for some application are available. For example 20 per cent for a small to medium commercial buildings, which then aids the tank sizing from the boiler. Get the sizing wrong and having an efficient and effective system may be a struggle; so take care and seek advice.

Integration of biomass boiler

There are two main aspects to the integration of a biomass boiler in a new or existing system (there are others like space requirements, flues or access; but we shall concentrate on two here): mechanical integration and control integration.

Mechanically, the biomass boiler should be as a lead boiler in parallel to a secondary source with the accumulator tank in series with both. The accumulator tank should



also be able to be by-passed and isolated for good practice.

For RHI and for good practice, we need heat meters to measure the biomass output separately. This may mean that motorised isolating valves have to be added to the system to prevent the secondary source being measured with the biomass output. OFGEM has published guidance for heat metering for RHI, and even if RHI is not a consideration in your project it does provide good practice to follow. <https://www.ofgem.gov.uk/publications-and-updates/easy-guide-metering-requirements-non-domestic-rhi>

Make biomass lead boiler

The controls need to be set up to utilise the accumulator tank and the biomass as much as possible. This is more than just making the biomass boiler a lead boiler but also setting up to ensure that the boiler is run for as long as possible and as loaded as possible. During commissioning, some fine tuning may be required. Furthermore, a summer and winter strategy will need to be formulated.

The capacity, sizing along with controls will determine the strategy and is likely to be in three scenarios: Base load; peak-load; and optimising. Baseload is continuous demand; peak load meets all the



demand; and, optimising being a balance between the two. The control strategy is much more complicated for the third option over the other two. The controls should never be overlooked when it comes to general maintenance.

As well as the accumulator tank and integration, the two other items that need careful consideration is the flue and ash extraction.

For the flue, it needs to meet good practice in terms of height for appropriate dispersion and does not affect the surroundings in addition to the environmental considerations. For guidance on the flue we need to review: planning; Building Regulations; The Clean Air Act; and Environmental Permitting Regulation. Depending on the fuel stock you may also need to think about the Waste Incineration Directive too. You may need to carry out a dispersion modelling to meet planning.

When we burn biomass we are going to get ash left over from the combustion process. Many boilers have an automated ash extraction to allow for removal. In small systems this may be a drawer tray from the bottom of the boiler while in large systems this may be a moving grate. Either way, consideration for periodic removal of the ash is required or the boiler will choke. Controls can highlight this in the way of an alarm; but it needs to be part of the maintenance regime to not only remove the ash but also check the method of extraction.

With many of the items in biomass system involving mechanical parts, the maintenance requirements need to be adopted to avoid interruption and ensure the system works as designed.

Further reading

If you would like to read further on Biomass as a way of providing heat, then look at the Biomass publication: CTG012 Biomass Heating and the EiBi module Series 14 Module 1 of May 2016 for the health and safety aspect.

BIOMASS BOILERS

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

QUESTIONS

1. Biomass is generally considered carbon neutral when:

- It is from a sustainable source
- It is saved from landfill
- It is from an abundant source close by
- It has not use elsewhere

2. What two items are key for fuel delivery

- Off-loading and price
- Access and off-loading
- Access and price
- Time of year and price

3. Moisture content of wood fuel is pivotal to

- Heat content from wood
- Boiler specification
- Fuel handling
- Both A and B above
- All A, B and C above

4. Energy Density of the fuel is based on

- Calorific Value
- Bulk density
- Calorific Value and Bulk density
- Calorific Value and impurities

5. An accumulator tank provides what in a biomass system

- Resilience to the system
- Increases flow temperature
- Reduces losses in the boiler house
- Improves efficiency and effectiveness of the system

6. A turndown ratio of 1:8 means the boiler is capable of a low firing rate of

- 12.5 per cent
- 10 per cent
- 8 per cent
- 20 per cent

7. What demand profiles should you need to know to size appropriately

- Seasonal profile
- Daily profile
- Seasonal and Daily profiles
- Monthly consumption

8. Who provides guidance on heat metering for biomass installations

- OFGEM
- EPA
- BEIS
- DEFRA

9. For flueing arrangements, it is good practice to consider what

- Clean Cities Act
- Environmental Permitting Regulations
- Ash disposal
- Size of woodchips

10. True or False, Biomass systems are likely to have increased maintenance over a gas only system?

- True
- False

Please complete your details below in block capitals

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Business

Business Address

.....

..... Post Code

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Completed answers should be mailed to:

The Education Department, Energy in Buildings & Industry, P.O. Box 825, GUILDFORD, GU4 8WQ. Or scan and e-mail to editor@eibi.co.uk. All modules will then be supplied to the Energy Institute for marking

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