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CURRENT THINKING ON...

Integrating biomass heating

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Biomass heating is currently seeing an increase throughout the UK. due to the rising costs of fossil fuels and the financial benefits proposed by the imminent launch of the Renewable Heat Incentive (RHI). Together, they have produced a strong financial case for commercial and industrial biomass heating. In many cases, biomass heating has also proven to be the most effective way to make significant reductions in CO2 emissions in the built environment.

However, biomass may not always be the right heating solution; there are many factors to take into account when assessing the suitability of a site for biomass heating, such as the heating demand profiles, available space and whether the application will be a new build or retrofit. Also, if the biomass heating solution is not correctly integrated, it may fail to deliver the cost and carbon savings that appear so attractive at the initial planning stages. This module aims to provide an insight into the key considerations when integrating automatic fed biomass heating systems into a new build or retrofit within an existing heating system.

Pellets and chips

The two main biomass fuels for commercial and industrial heating systems are wood pellets and wood chip; different classifications are used for each fuel type which outline the fuel properties. Wood pellets produced under the CEN/TS 14961 standard are a dry, compressed pellet of typically 6mm or 8mm diameter, produced from virgin wood. With a moisture content of less than 8 per cent, wood pellets have a typical net calorific value of 4,800kWh/tonne. In their compressed form they have a typical bulk density of 650kg/m^3. Therefore wood pellets have an energy density of 3,120kWh/m^3.



Wood fuel in the form of wood chip is also classified by standards. However, due to the irregular nature of chipped wood, the specification allows for greater variance in particle size and moisture content. In the UK, it is common for wood chip to be classified by either the European or the Austrian national standards, which are CEN/TS 14961 and the ONORM M7 133 respectively. The EU standard characterises the size of chip from P16 to P100 while the Austrian standard characterises similar sized chip from G30 to G150. As the calorific value of oven dry woody biomass does not vary much with species or variety, wood chip energy content is largely influenced by the moisture content. For wood fuel, this is calculated as a percentage on a wet basis as stated with a prefix 'W', for example, a W35 wood chip maintains 35 per cent of its wet weight as water. The energy content per tonne of wood chip can vary considerably from 2,000kWh/tonne for wet wood chip to 4,000kWh/tonne for dry wood chip. The bulk density of a typical wood chip with a moisture content of 30-35 per cent is approximately 250kg/m^3; this equates to an energy density of around 800kWh/m^3, which significantly increases the space required for fuel storage as well as frequency of deliveries when compared to wood pellets.

Fuel oil typically maintains an energy density of 10,800kWh/m^3, therefore the use of wood pellets and wood chip will require storage solutions requiring 3.5 to 13.5 times greater volume respectively than for liquid fossil fuels.

Due to the increased processing requirement during production, wood pellets cost more per unit of delivered energy than wood chip. However, fuel selection should not just be seen as a simple volume versus cost consideration, but should also consider issues such as:

- delivery logistics; and
- boiler technology and maintenance regimes.

The impact of these issues will be addressed later.

Delivery to the wood store

When considering biomass heating the available space, site infrastructure, maximum delivery frequency and possible delivery methods to and from the wood fuel store should all be assessed to see whether biomass is both possible and viable for operation over the lifetime of the boiler.

Wood pellets are generally delivered by 4-axle lorry in quantities of up to 20 tonnes, which

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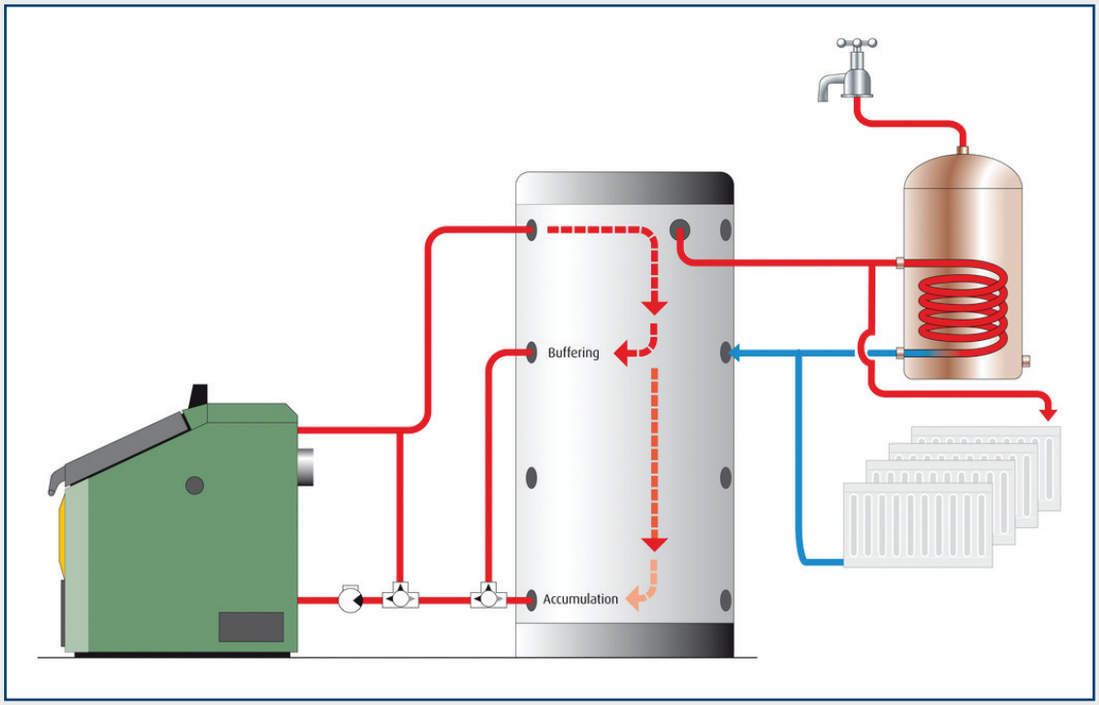
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are pneumatically conveyed from the vehicle by an onboard blower. This pneumatic pellet delivery allows wood pellets to be conveyed up and into the pellet store, which could comprise free-standing silos, bespoke above-ground bunkers or any contained structure that is weatherproof and within 10 to 20m of the parked delivery vehicle. A 20-tonne delivery will have an energy content of around 96MWh (based on an energy density of 4,800kWh/tonne); to put this in perspective, a recent biomass heating project at a large office development employing 1,400 staff with a fuel store of 40m3 requires deliveries every 10 days in the coldest months.

Wood chip can be delivered by a range of vehicles, from a basic 30m3 tipping lorry that will delivery 7 tonnes of chip, up to a 110m3 articulated lorry comprising a walking or push floor, which can deliver 25 tonnes of chip. Experience has shown that wood chip is almost always best delivered directly into a subterranean store, which minimises the requirement for secondary handling. However, there are occasions where subterranean storage is not possible due to site limitations; in these situations more complex systems to lift wood fuel into above ground stores can be used. These include wood chip delivered in dedicated walking floor containers, which are delivered and placed in position on site by a hook lift vehicle; this requires more than one container (so that when one is empty and taken away to be refilled, there is another in place to continue supply) and restricts delivery quantities to typically 7 tonnes.

To put this in perspective, for the same office development mentioned earlier, if wood chip was delivered via 7-tonne deliveries, a fuel store of around 40m^3 would still be needed, but deliveries would be required every 2.5 days during periods of high demand; if a larger delivery was considered, for example 25 tonnes, a much larger fuel store would be required – 140m^3, but the delivery frequency could be reduced to every 8.5 days.

Above-ground stores can be filled with wood chip by two main methods, either by a scissor lift and tipping vehicle or by a permanently installed conveyer system which lifts wood fuel that is tipped into a trough up and into the fuel store.



Specification variation

The types of biomass boiler available in the UK market can vary quite considerably in specification; the main selection criteria are fuel type, thermal output and level of planned maintenance.

A typical modern automatic feed wood fuel boiler would be expected to include automatic features for ignition, heat exchanger cleaning and ash removal so that the boiler would require a low level of intervention in normal operation. Where boilers require manual ignition and regular shut downs for cleaning, the increased costs and inconvenience when compared to equivalent fossil fuel boilers reduce the appeal of biomass heating, and in some cases may make it inappropriate for the application. The selection of the right biomass boiler is an important decision; as with any high capital cost investment, the technical and financial performance over the project lifetime is what will define success.

In terms of biomass boiler technology, there are three main types of combustion grate:

- the simple stoker burner is usually most appropriate for smaller pellet boilers; they can be simple in construction, thus being cost effective as well as reliable;
- underfed hearth boilers which push the wood fuel up and into the grate are also simple in terms of low number and complexity of moving parts. They are suitable for both wood pellets and smaller grades of wood chip (G30 and G50) for applications up to several hundred kW. They require grate cleaning intervention at a weekly or sometimes higher frequency.
- at the larger scale, reciprocating grate furnace designs allow wood chip to be fed onto one end of the grate, which reciprocates until fuel is burnt out along the length of the grate. Ash is continually ejected from the boiler and therefore longer periods of operation can be undertaken between planned interventions, which can be required quarterly or annually. These reciprocating grates (sometimes called step or moving grate systems) allow a larger flexibility in wood fuel size and moisture content, but comprise more equipment and moving parts, which increase capital and operational costs.

For efficient operation, the biomass boiler heat exchanger tubes must be kept clean. Manual cleaning requires the boiler to be shut down despite automatic cleaning can increase the cost of a boiler. However, in most cases this is more appropriate as it results in lower intervention, boiler downtime and operation costs. Cleaning systems can include mechanical scraping devices fitted within vertical tube heat exchangers, compressed air jets within horizontal heat exchangers and other variations which can affect boiler physical geometry and requirement for ancillaries such as air compressors.

The safety of biomass boilers up to 300kW is covered by the EN303/5 standard, which requires various levels of burn back protection as well as high-pressure and high-temperature safety devices. Burn back of wood fuel from the furnace to the fuel store is prevented by control measures on the fuel in-feed system, mechanical

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separation within the fuel transport path by means of a flap or rotary valve and lastly via a water quench system that douses the wood fuel in-feed system. Over pressure is prevented by pressure relief valves set within the maximum design pressure. Over temperature is protected against by flooding an in-direct heat exchanger with cold water. Boilers above the 300kW systems require additional equipment to ensure system safety when power fails, due to the larger inventory of wood fuel within the boiler.

Additional capacity

A thermal store is a volume of water which is heated when the load is lower than the maximum output of the biomass boiler and can be drawn from as additional capacity when the load is greater than the boiler output. For the majority of heating applications, the use of a thermal store with biomass boilers offers a number of advantages; a higher thermal output than the biomass boiler alone, a faster response time to changes in thermal demands, supply of low heating loads without causing the biomass boiler to cycle and improved control integration with fossil fuel boilers.

If sized, configured and operated correctly, the thermal store will increase seasonal efficiency be reducing the period of time the boiler is starting and stopping, it will increase the lifetime of the boiler by giving it a more even heat load and will provide a higher proportion of on site heat from the biomass boiler.

The thermal store is utilised most effectively if the operating temperatures of the thermal store are higher than the secondary flow temperatures, and if the downstream hydraulics are arranged to ensure the lowest volume flow rate through the store with the lowest return temperatures. These are critical design considerations for correct integration.

The correct sizing of biomass boilers and thermal stores to suit a particular heat profile is more important than when sizing conventional gas and oil boilers; this is because a biomass system that is too large will not only incur higher capital costs, but could potentially suffer from reduced efficiency, increased maintenance and reduced boiler life.

To correctly size the biomass boiler and thermal store, rules of thumb and sizing tools can be used. However, every heat demand profile is different and the specific site conditions should be considered fully to ensure the system supplied best meets the site requirements. A residential heat profile will require a different boiler and thermal store size combination than a commercial office building or an industrial heat load; sometimes a thermal store will not offer any significant advantage, whereas in other applications a thermal store may decrease the size of the boiler by more than half of the peak load, but yet still supply the building with 100 per cent of its demand. It is therefore important that the sizing of biomass boilers is done on a case by case basis.

Hydraulically integrated

An area that is often overlooked when installing biomass heating systems is how it is hydraulically integrated and controlled. It is not uncommon to see boilers intended to supply over 85 per cent of the annual heat load actually achieving less than 30 per cent contribution to heat demand, due to poor integration with fossil fuel boilers.

A system should be configured such that the flow rate to and from the biomass system is variable depending upon load, thus preventing high flow rates through the thermal store. The secondary circuits should be configured such that return temperatures are low by incorporating measures such as 2-port valve control for heat loads.



Unlike conventional gas and oil boilers, a biomass heating system requires a comprehensive maintenance regime to maintain optimal performance. This could involve items such as daily system checks, weekly ash removal and wood deliveries, quarterly tube cleaning and six-monthly lubrication of chains and augers. The level of maintenance required is related to the specification of the boiler and the sizing of the fuel store; in some cases the system can be designed to incur lower intervention. Unsurprisingly, poor design can result in greatly increased maintenance levels, such as daily cleaning routines which require additional staff time and reduce the financial attractiveness of the system.

Biomass heating can offer an attractive rate of return and significant carbon reduction, when compared to heating with fossil fuel. However, in order to achieve this, it is vital that the system design takes into account the fuel type and wood storage solution to best suit the site, the correct sizing and specification of the biomass boiler and thermal store and the correct integration within the heating system. A well-designed biomass heating system supplying over 85 per cent of heating on site can deliver carbon savings of over 30 per cent.

References

- *Carbon Trust CTG012 – Indepth Guide Biomass Heating – 2009*
- *CO2Sense Yorkshire in conjunction with Sustainable Energy Limited – Installing and Operating Woodfuel Heating Systems – 2010*
- *CIBSE AM14:2010 – Non-Domestic Hot Water Heating Systems – 2010*
- *http://www.biomassenergycentre.org.uk/*

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SERIES 9 MODULE 04: QUESTIONS

Integrating Biomass Heating

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.

1. Which green incentive will increase the uptake of biomass heating

- ☐ Capital grant scheme
- ☐ Feed In Tariff
- ☐ Renewable Heat Incentive
- ☐ Renewable Obligation

2. What is the typical water content for wood pellets

- ☐ 0 per cent
- ☐ <10 per cent
- ☐ >12 per cent
- ☐ Varies up to 50 per cent

3. A wood chip store would be how many time larger than equivalent heating oil store

- ☐ 3.5 times
- ☐ Same size
- ☐ Up to 13.5 times
- ☐ 0.25

4. The standard EN 303/5 references

- ☐ Biomass boilers
- ☐ Wood pellets
- ☐ Wood chip size
- ☐ Moisture content

5. To protect against fire travelling from furnace to fuel store

- ☐ The safety heat exchanger will activate
- ☐ The pressure relief valve will lift
- ☐ The grate will reciprocate
- ☐ The stoker auger will be quenched

6. The biomass boiler grate design suited to large boilers and wet wood chips is

- ☐ Automatic ash cleaning
- ☐ Reciprocating grate
- ☐ Underfed hearth
- ☐ Stoker burner

7. What is the function of the thermal store

- ☐ To increase the system volume
- ☐ To raise temperature of flow to heating system
- ☐ To instantly supply a quantity of heat greater than the boiler capacity
- ☐ To allow the installed size of the biomass boiler to be larger

8. When integrating biomass with a fossil fuel boiler

- ☐ It is best to fire fossil fuel boiler constantly
- ☐ Control when the fossil fuel boiler fires
- ☐ It is best to have a high return temperature in secondary system
- ☐ It is best to increase the temperature difference across the thermal store

9. When considering the maintenance requirement for a biomass boiler system;

- ☐ The size of the fuel store is not relevant
- ☐ The specification of the boiler system is not relevant
- ☐ Automatic ash removal and tube cleaning will reduce the requirement for planned interventions.
- ☐ More regular interventions will improve financial case

10. A biomass boiler should always be sized ;

- ☐ At 20 per cent of peak load
- ☐ At 100 per cent of peak load
- ☐ At 120 per cent of peak load
- ☐ Relative to the heat load profile and thermal storage available

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