Best practice guidance for biomass boiler operation

Simple guidance for owners and users

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Simple guidance for owners and users

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Commercial in confidence

The Department for Business, Energy & Industrial Strategy (BEIS), previously the Department for Energy and Climate Change (DECC), commissioned Kiwa to study the in-situ performance of solid biomass boilers in the UK under contract 1055/08/2015. This guide has been written to advise owners and operators of biomass boilers on ways to improve the performance (in terms of efficiency and emissions) of existing biomass systems, based on the knowledge gathered during the study.

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1 Preface

The operation and maintenance of biomass boiler systems have a major impact on their performance, both in terms of efficiency and atmospheric emissions. This simple guidance is written for owners and users of biomass systems, primarily within the domestic or small commercial sectors, who are operating biomass boilers on wood pellets, chips or logs. A parallel, detailed guidance document for operators, maintenance and service personnel is also available.

Before making changes or adjustments to biomass boilers or connected heating systems ensure that the consequences of any changes are well understood. Changes made without full understanding of the operation of biomass systems may cause damage to both the boiler and connected heating system and can potentially lead to unsafe situations occurring within the boiler itself. Ensure that any changes made to the boiler do not go against the manufacturer's instructions.

The performance and efficiency of a biomass boiler system partly depends on the operation and demand of the heating system it serves. This document does not cover the heat distribution part of the heating system.

2 Introduction

As a response to climate change and increasing fuel costs, the development of biomass systems in the UK continues to expand, supported by measures such as the Renewable Heat Incentive and the Renewables Obligation. The rapid development of this industry has had a positive global environmental impact by reducing fossil CO_2 emissions from heating systems. However, there are concerns over local environmental impacts due to atmospheric emissions from biomass systems, which can adversely affect local air quality and human health.

Concerns have been raised over emissions of **particulates** (also called smoke or dust) and **oxides of nitrogen** (also called NO_x). Smoke contributes to the concentrations of PM_{10} (particulate matter smaller than 10 microns in size) and NO_x contributes to concentrations of nitrogen dioxide (NO_2) in the air. Both of these pollutants have adverse effects on human health and are regulated by law. The concerns over PM_{10} and NO_2 concentrations are greatest in areas where atmospheric pollutant concentrations are already high due to emissions from other sources, for example in large cities or in areas close to major roads where transport emissions are already affecting local air quality.

It well known that the operating practices for biomass boilers have a strong impact on performance in terms of efficiency and emissions. Good operational practice will maximise boiler efficiency and minimise pollutant emissions. Operational practice influences component and plant life and how often maintenance interventions are needed.

In 2015, DECC[1] commissioned a consortium of companies including Kiwa Gastec, Ricardo Energy and Environment, Energy Saving Trust, HETAS, and Optimum Consultancy to carry out a **field trial of biomass installations**. Performance (in terms of efficiency and emissions) was measured remotely from a wide range of biomass boilers.

The most effective biomass systems we observed were the result of a **close working partnership** between client, architect, mechanical and building services engineer where all aspects of design, management and operation were carefully considered and integrated, with an emphasis on **good operating practice**.

Biomass systems are subject to the same general health and safety principles, codes of practice, and design, installation and operation standards that apply to gas or oil-fired boiler systems. However, there are differences in the way that the boiler plant can respond to changes in demand for heat. As a result, different operational strategies are needed for biomass boilers compared with oil or gas boilers.

[1] Department of Energy & Climate Change, which became Department for Business, Energy & Industrial Strategy (BEIS) in June 2016

2.1 Purpose of this document

This guide provides users with a summary of the key problems that may be encountered when operating a biomass system and offers some practical solutions or advice on the best remediation action.

2.2 Key components

A biomass system typically comprises the following key components. Some items may only be present on larger commercial sites.

Component	Description
Accumulator	A water-storage tank which is integrated into the heating system. It collects and stores heat energy to allow flexible use at all times and to smooth out daily demand profiles.
Biomass Boiler	Appliance in which biomass fuel is burnt to generate heat. The boiler usually includes a grate to support the fire bed in a combustion chamber, a hot air ignitor to light the fuel, fans to supply the combustion air, and a system to collect and remove the ash
Biomass fuel	Solid biofuel in the form of wood pellets, wood chips, logs, or plant material grown for fuel (e.g. miscanthus or short rotation coppice).
Boiler house	Building or area which contains the primary components of the biomass system (including the boiler, accumulator, chimney, controls etc)
Chimney and flue gas clean-up system (including fans)	A device to remove the products of combustion from the boiler and vent to atmosphere. In a biomass system the chimney is likely to include a method of cleaning the flue gas before being vented to atmosphere such as additional filters and cyclones to collect particulate matter.
Fuel feed system	Method of biomass fuel delivery to the boiler. Includes augers, gravity feed, conveyor and moving floor systems
Fuel store	An area or container where the biomass fuel is stored, below or above ground. This may include hoppers, silos, bunkers and an area for fuel delivery
Heat distribution system	See heating system
Heat exchanger	A device which transfers heat from the fire bed and flue gases to the working heat transfer fluid (usually water), whilst maintaining a physical separation of the heat provider and means of heat delivery.
Heating system	A system of pipes which takes a flow of hot water from the biomass boiler system and returns cooler water to it, after heat has been extracted from it for uses such as space heating and hot water. It is best practice for the heat distribution system and boiler system to be designed together to match the heat demand to the capacity of the boiler. Room thermostats are one of the ways in which the heating system signals demand to the boiler system.
System controls	Mainly electrical components which monitor and control different aspects of the system. Controls are usually present to set the hot water temperature output, monitor the combustion conditions and control combustion through the fuel feed rate and combustion air flow

2.3 Key differences between biomass, gas and oil-fired systems

The widespread use of biomass systems is a recent development in the UK compared to gas or oil heating installations. There are key differences between the systems:

Gas fired boilers

- Startup period: 30 seconds – 5 minutes
- Fuel present in boiler: 1 second
- Shutdown period: 1 second or less
- Natural gas is not stored on site but delivered through pipes which are metered
- Gas quality defined & maintained by law
- Carbon monoxide concentrations in exchaust gas are low (<50ppm)

Oil fired boilers

- Startup period: 30 seconds – 1 minute
- Fuel present in boiler: 1 second
- Shutdown period: 1 second or less
- Oil is stored on site but due to a higher energy content takes up less space
- Fuel is easily transported
- Fuel quality generally consistent and maintained by standards

Biomass boilers

- Startup period: 10 – 20 minutes
- Fuel present in boiler: 20 minutes (some unburned fuel may remain)
- Shutdown period: 20 minutes
- Biomass fuel stored on site
- Fuel quality, especially moisture content, can vary considerably
- Carbon monoxide emissions can be high (up to 10,000ppm, or 1%)

3 Operating principles of biomass systems

Every model of biomass boiler will have its own control regime; however, there are four primary phases:

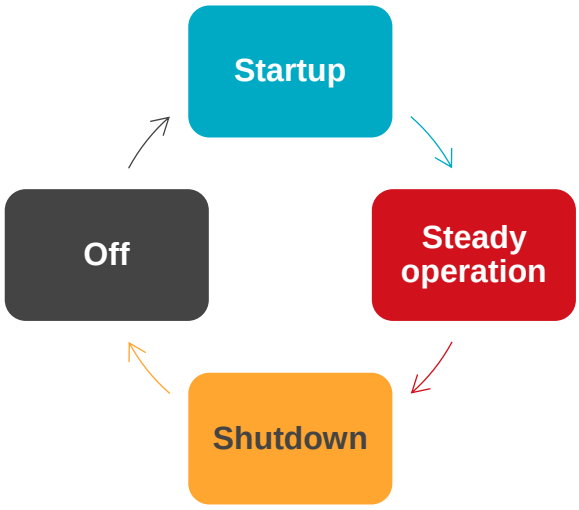

Figure 1: Four phases of boiler operation

The ***startup sequence*** is the period from when the boiler begins to ignite the fuel, to when combustion is established.

Steady operation includes the boiler warm-up time and then continued operation with flue gas oxygen around 10%.

The ***shutdown sequence*** is from when the combustion in the boiler begins to stop, and flue gas oxygen levels rise. There is no significant combustion at the end of the period, however there may still be a fire bed which will slowly cool.

The ***off period*** is from the start of this cooldown period until the boiler fires again.

Boiler efficiency is highest and pollutant emissions lowest during long periods of steady state operation close to the maximum output of the boiler. Frequent switching on and switching off of the boiler (on / off cycling) produces the worst emissions and lowest efficiencies.

4 Fault Finding and Possible Solutions

Problem
Smokey Operation **During startup and shutdown phases it is common for biomass boilers to emit visible smoke. However, if this continues during normal operation then it can indicate a problem. A modern boiler set up correctly with the right specification of fuel should emit no visible smoke during normal operation.** **Excess smoke can indicate high emissions which may result in infringement of emission limits.**

Explanation of possible causes	Solution
a) Boiler is too large for the heat demand it is supplying Biomass boilers are designed to run for extended periods. When a biomass boiler is too large it only needs to fire for a very short time to satisfy the heat demand placed upon it. This leads to many short periods of firing during operation known as cycling. If a boiler cycles regularly it goes through multiple startup and shutdown phases which are known to reduce efficiency, increase emissions, increase component wear and increase auxiliary electricity consumption for components such as fans running at a higher speed than during steady operation. In the case of automatically fed boilers, excessive cycling means the boiler fails to reach its most efficient state of operation and temperatures never reach those required for optimal combustion and heat transfer. This results in increased emissions. It may be possible to see the number of startups each day on the boiler control panel.	Contact your installer or a trained operator to discuss possible solutions. They may suggest: • Increasing the heat load of the boiler by adding new demands such as supplying heat to additional buildings • Reducing use of other supplementary heating sources • Increasing the size of the accumulator tank • Optimising the operating regime • Turning off biomass system during periods of low heating demand • Replacing your boiler with a boiler with a lower output (not normally the favoured option due to high capital costs)

Explanation of possible causes	Solution
b) Poor adjustment of boiler and system controls Well-adjusted controls ensure the safe, efficient and optimum operation of the biomass boiler whilst satisfying the heat demand of the site. When controls are unavailable, set incorrectly, or not regularly reviewed the performance and efficiency of the biomass boiler can suffer. Controls include time clocks, temperature sensors, fuel delivery rates, fan speeds, automatic cleaning mechanisms and ignition sequences. They are used to regulate and optimise each aspect of combustion and system operation. Controls should ensure consistent burn periods maximising efficiency and reducing heat losses. Some controls are protected by passwords and can only be changed by service engineers. Poorly adjusted controls can result in the boiler operating when there is little demand for heat. This leads to multiple startup and shutdown phases, known as cycling, which reduces efficiency, increases emissions and leads to excessive wear on boiler components. In the case of automatically fed boilers, excessive cycling means the boiler fails to reach its most efficient state of operation and temperatures never reach those required for optimal combustion and heat transfer. This results in increased emissions.	Contact your installer or a trained operator to discuss possible solutions. They may suggest changes to: • Time clock settings to ensure the boiler is only set to operate when there is a heat demand to satisfy • Flow and return temperature set points to ensure a wide enough temperature difference to maintain consistent operation • Air supply rates and the fuel-to-air ratio to ensure a suitable level of air is supplied for combustion

Explanation of possible causes	Solution
c) Poor quality fuel Biomass combustion is heavily influenced by the type and quality of fuel burned within the boiler. Your biomass boiler will have been designed to burn a particular type and grade of fuel cleanly and efficiently. This is specified by the manufacturer. The use of poor quality fuel causes increased emissions, low efficiency, component failure, increased repair costs, high running costs and poor performance of the system. Fuels with a high moisture content can lead to difficulties maintaining operating temperatures, leading to an increase in particulate emissions, incomplete combustion, loss of efficiency and even damage to the boiler or flue. Using waste wood, even from clean sources is likely to increase pollutant emissions particularly particulate emissions and NOx. Even small changes to the fuel can lead to immediate changes in pollutant emissions, which may breach emission limits. Waste wood can also contain high levels of heavy metals and other contaminants hazardous to health. It also often has a very low moisture content and burns at very high temperatures which can cause damage to boilers and flues. If you will only be able to source out-of-specification fuel for a period of time, it may be worth having your boiler re-commissioned for the alternative fuel.	Monitor your fuel quality: • Use only the type of fuel specified for your boiler • Check that the specification for the fuel you are using matches that detailed in the boiler manufacturer's instructions. Details such as calorific value, moisture content, fines content, pellet size, etc. should be provided • Ensure your fuel is from a reputable supplier. If you are using pellets, you may wish to consider suppliers registered with the ENplus scheme, an internationally recognised quality certification scheme covering the entire wood pellet supply chain • Unless permitted to use contaminated wood via an environmental permit, avoid any 'second hand' or reclaimed wood if you do not know the source. Especially important if you are claiming schemes like the RHI • Avoid wood containing paints, glues, metal fixings and added fines such as saw dust. Perform a visual inspection of fuel to ensure it does not contain waste material, although remember it is often difficult to detect these contaminants visually • If you are self-supplying wood, review your method of production and get expert advice if required. Try to avoid small branches and other forestry material which increases ash production • Ensure fuel is stored correctly in an appropriately sized, dry, well ventilated environment. For wood logs that are undergoing seasoning, ensure that they are covered and stacked in such a way so that cross ventilation can occur • Examination of ash from the combustion chamber may identify contaminated wood • Further information can be found in the Health and safety in biomass systems – Design and operation guide, published by the Combustion Engineering Association

Problem
Unburned fuel in the ash **This will appear as charred or unburnt pieces of wood or chip.**

Explanation of possible causes	Solution
a) Boiler is too large for the heat demands it is supplying Biomass boilers are designed to run for extended periods. When a biomass boiler is too large it only needs to fire for a very short time to satisfy the heat demand placed upon it. This leads to many shorts periods of firing during operation known as cycling. Each boiler cycle will produce a small amount of unburned fuel in the ash. This is normal and the amount will depend on boiler technology, fuel, burner and grate design. However, if the boiler is cycling frequently, excessive unburned fuel may accumulate in the ash container.	Contact your installer or a trained operator to discuss possible solutions. They may suggest: • Increasing the heat load of the boiler by adding new demands such as supplying heat to additional buildings • Reducing use of other supplementary heating sources • Increasing the size of the accumulator tank • Optimising the operating regime • Turn off biomass system during periods of low heating demand • Replacing your boiler with a boiler with a lower output (not normally the favoured option due to high capital costs)
b) Poor adjustment of boiler and system controls Well-adjusted controls ensure the safe, efficient and optimum operation of the biomass boiler whilst satisfying the heat demand of the site. When controls are unavailable, set incorrectly, or not regularly reviewed the performance and efficiency of the biomass boiler can suffer. Incomplete combustion can be caused by the incorrect control of the fuel to air ratio in the boiler. The boiler requires air for combustion. This is supplied by fans, the rate of which can be controlled. If the boiler is supplied with too little air, it can lead to incomplete combustion where some of the fuel passes through the boiler without being burnt.	Contact your installer or competent service provider. They may: • Carry out an analysis of the flue gas • Check the boiler settings to identify any issues such as incorrect excess air levels

Explanation of possible causes	Solution
c) Poor quality fuel Biomass combustion is heavily influenced by the type and quality of fuel burned within the boiler. Your biomass boiler will have been designed to burn a particular type and grade of fuel cleanly and efficiently. This is specified by the manufacturer. The use of poor quality fuel causes increased emissions, low efficiency, component failure, increased repair costs, high running costs and poor performance of the system. Fuels with a high moisture content can lead to difficulties maintaining operating temperatures, leading to an increase in particulate emissions, incomplete combustion, loss of efficiency and even damage to the boiler or flue.	Monitor your fuel quality: • Use only the type of fuel specified for your boiler • Check that the specification for the fuel you are using matches that detailed in the boiler manufacturer's instructions. Details such as calorific value, moisture content, fines content, pellet size, etc. should be provided • Ensure your fuel is from a reputable supplier. If you are using pellets, you may wish to consider suppliers registered with the ENplus scheme, an internationally recognised quality certification scheme covering the entire wood pellet supply chain • Unless permitted to use contaminated wood via an environmental permit, avoid any 'second hand' or reclaimed wood if you do not know the source. Especially important if you are claiming schemes like the RHI • Avoid wood containing paints, glues, metal fixings and added fines such as saw dust. Perform a visual inspection of fuel to ensure it does not contain waste material, although remember it is often difficult to detect these contaminants visually • If you are self-supplying wood, review your method of production and get expert advice if required. Try to avoid small branches and other forestry material which increases ash production • Ensure fuel is stored correctly in an appropriately sized, dry, well ventilated environment. For wood logs that are undergoing seasoning, ensure that they are covered and stacked in such a way so that cross ventilation can occur • Examination of ash from the combustion chamber may identify contaminated wood • Further information can be found in the Health and safety in biomass systems – Design and operation guide, published by the Combustion Engineering Association

Problem
Low efficiency **Will be indicated by:** • **An increase in fuel use** • **The boiler never entering a state of steady operation and goes straight from ignition to burnout** • **Operation is dominated by frequent startup / shutdown cycles of short duration**

Explanation of possible causes	Solution
a) Boiler is too large for the heat demands it is supplying Biomass boilers are designed to run for extended periods. When a biomass boiler is too large it only needs to fire for a very short period of time to satisfy the heat demand placed upon it. This leads to multiple startup and shutdown phases and short periods of firing during operation known as cycling. During each startup phase, air is blown through the boiler to remove any flue gases from the combustion chamber, known as purging. This cools the boiler and pushes any hot flue gases up and out of the flue. The control system then feeds the boiler with fuel and ignites it in the air flow. If the heat demand on the heating system is met by the startup procedure alone, the boiler will never operate in steady state, and components will not have enough time to come to operating temperature for optimal combustion and heat transfer. This can have the effect of simultaneously decreasing efficiency and increasing emissions	Contact your installer or a trained operator to discuss possible solutions. They may suggest ways to ensure longer running periods from the boiler such as: • Increasing the heat load of the boiler by adding new demands such as supplying heat to additional buildings • Reducing use of other supplementary heating sources. • Increasing the size of the accumulator. • Optimising the operating regime • Turning off biomass system during periods of low heating demand • Replacing your boiler with a boiler with a lower output (not normally the favoured option due to high capital costs)

Explanation of possible causes	Solution
b) Poor adjustment of boiler and system controls Well-adjusted controls ensure the safe, efficient and optimum operation of the biomass boiler whilst satisfying the heat demand of the site. When controls are unavailable, set incorrectly, or not regularly reviewed the performance and efficiency of the biomass boiler can suffer. Controls include time clocks, temperature sensors, fuel delivery rates, fan speeds, automatic cleaning mechanisms and ignition sequences. They are used to regulate and optimise each aspect of combustion and system operation. Controls should ensure consistent burn periods maximising efficiency and reducing heat losses. Some controls are protected by passwords and can only be changed by service engineers. Poor control can result in the boiler operating when there is little demand for heat. This leads to multiple startup and shutdown phases, known as cycling, which reduces efficiency and leads to excessive wear on boiler components. Poor controls can lead to excessive heat losses, especially if the boiler operates when there is no demand for heat, or to maintain the temperature of a large volume of water in an accumulator. The latter is particularly important if the water is not being used. Incorrectly controlled pumps which are continuously circulating hot water, or uncontrolled valves increase heat losses and reduce system efficiency.	Contact your installer or a trained operator to discuss possible solutions. They may suggest changes to: • Time clock settings to ensure the boiler is only set to operate when there is a heat demand to satisfy • Flow and return temperature set points to ensure a wide enough temperature difference to maintain consistent operation • System operating temperatures to reduce heat losses • Fuel feed rates • Air supply rates and the fuel to air ratio to ensure a suitable level of air is supplied for combustion without supplying too much which results in heat losses up the flue • Accumulator heating regimes to ensure the accumulator is to temperature when it is needed but the temperature is not maintained when not required

c) Poor quality fuel Biomass combustion is heavily influenced by the type and quality of fuel burned within the boiler. Your biomass boiler will have been designed to burn a particular type and grade of fuel cleanly and efficiently. This is specified by the manufacturer. The use of poor quality fuel causes increased emissions, low efficiency, component failure, increased repair costs, high running costs and poor performance of the system. Fuels with a high moisture content can lead to difficulties maintaining operating temperatures, leading to an increase in particulate emissions, incomplete combustion and loss of efficiency. In contrast fuels with very low moisture content can cause high flue gas temperatures increasing heat losses and reducing boiler efficiency. In some cases, this can also result in boiler overheating and emergency shutdown.	Monitor your fuel use and quality: • Use only the type of fuel specified for your boiler. • Periodically inspecting the fuel entering the boiler will allow you to detect issues with moisture content. Pellet fuels have very consistent moisture contents and are easily identified as they expand when wet • Check that the specification for the fuel you are using matches that detailed in the boiler manufacturer's instructions. Details such as calorific value, moisture content, fines content, pellet size, etc. should be provided • Ensure your fuel is from a reputable supplier. If you are using pellets, you may wish to consider suppliers registered with the ENplus scheme, an internationally recognised quality certification scheme covering the entire wood pellet supply chain • Unless permitted to use contaminated wood via an environmental permit, avoid any 'second hand' or reclaimed wood if you do not know the source. Especially important if you are claiming schemes like the RHI • If you are self-supplying review your method of production and get expert advice if required • Ensure fuel is stored correctly in an appropriately sized, dry, well ventilated environment. For wood logs that are undergoing seasoning, ensure that they are covered and stacked in such a way so that cross ventilation can occur • If possible keep a log of the quantity of fuel burnt (from delivery records) and heat output from the boiler (from heat meters if installed) to give an indication of how efficiently the boiler is operating. Although not as accurate as standardised efficiency measurement, a sudden increase in fuel use could indicate a problem with the boiler If in doubt contact your installer or competent service provider for advice.

Problem
Excess Electricity Use **Boiler starts to use more electricity than it used to**

Explanation of possible causes	Solution
a) Faulty components If you notice that the boiler is using more electricity than normal, it may be an indication of damage to boiler components such as fans, augers, pumps, or automatic ignitors. If these components are failing prematurely or more often, it may indicate the boiler is over sized or incorrectly controlled resulting in multiple startup and shutdown phases and many short periods of firing known as cycling. This is known to increase wear on components and increases maintenance requirements.	Contact your installer or a trained operator to discuss possible solutions. They may suggest changes to the system or system controls to reduce cycling.
b) Poor adjustment of boiler and system controls Well-adjusted controls ensure the safe, efficient and optimum operation of the biomass boiler whilst satisfying the heat demand of the site. When controls are unavailable, set incorrectly, or not regularly reviewed the performance of the biomass system can suffer. Poor control can result in the boiler operating when there is little demand for heat. This leads to multiple startup and shutdown phases, known as cycling. This leads to an increase in electricity consumption. Boilers and system components such as pumps which are left on when there is no demand for heat from the heat delivery system will lead to excessive and wasteful electricity consumption.	Contact your installer or a trained operator to discuss possible solutions. They may suggest changes to: • Time clock settings to ensure the boiler is only set to operate when there is a heat demand to satisfy • Flow and return temperature set points to ensure a wide enough temperature difference to maintain consistent operation • Accumulator heating regimes to ensure the accumulator is to temperature when it is needed but the temperature is not maintained when not required. • System components such as pumps are interlocked with boiler operation to ensure they are not in use when not required

Problem
Frequent failure of boiler components **Systems components do fail during normal operation through general wear and tear. However, if failure becomes regular or repeated then this can indicate an issue with the boiler and / or boiler system.**

Explanation of possible causes	Solution
a) Boiler is too large for the heat demands it is supplying Biomass boilers are designed to run for extended periods. When a biomass boiler is too large it only needs to fire for a very short time to satisfy the heat demand placed upon it. This leads to multiple startup and shutdown phases and short periods of firing during operation known as cycling. Frequent cycling places increased stress on boiler components such as refractory linings, fuel feed and ignition systems as they are subjected to more frequent temperature cycles. Some boilers also have self-cleaning features which normally operate once every cycle. If the boiler is cycling excessively these operate more often than is necessary and this can result in premature failure.	Contact your installer or a trained operator to discuss possible solutions. They may suggest ways to ensure longer running periods from the boiler such as: • Increasing the heat load of the boiler by adding new demands such as new buildings • Reducing use of other supplementary heating sources. • Increasing the size of the accumulator. • Optimising the operating regime • Turning off biomass system during periods of low heating demand • Replacing your boiler with a boiler with a lower output. Not normally the favoured option due to high capital costs

b) Poor quality fuel Biomass combustion is heavily influenced by the type and quality of fuel burned within the boiler. Your biomass boiler will have been designed to burn a particular type and grade of fuel cleanly and efficiently. This is specified by the manufacturer. The use of poor quality fuel causes increased emissions, low efficiency, component failure, increased repair costs, high running costs and poor performance of the system. Waste wood materials have a low moisture contents and burn at very high temperatures which can cause damage to boilers and flues. Poor quality fuels can increase the formation of clinker because: • It may contain minerals that fuse at a lower temperature. • As the ash content of the fuel increases, so does the rate of clinker formation. Clinker material is very hard and causes damages to internal boiler surfaces and de-ashing mechanisms such as auger screws.	Monitor your fuel use and quality: • Use only the type of fuel specified for your boiler • Periodically inspecting the fuel entering the boiler will allow you to detect issues with moisture content. Pellet fuels have very consistent moisture contents and are easily identified as they expand when wet • Check that the specification for the fuel you are using matches that detailed in the boiler manufacturer's instructions. Details such as calorific value, moisture content, fines content, pellet size, etc. should be provided • Ensure your fuel is from a reputable supplier. If you are using pellets, you may wish to consider suppliers registered with the ENplus scheme, an internationally recognised quality certification scheme covering the entire wood pellet supply chain. • Unless permitted to use contaminated wood via an environmental permit, avoid any 'second hand' or reclaimed wood if you do not know the source. Especially important if you are claiming the RHI. • If you are self-supplying review your method of production and get expert advice if required. • Ensure fuel is stored correctly in an appropriately sized, dry, well ventilated environment. For wood logs that are undergoing seasoning, ensure that they are covered and stacked in such a way so that cross ventilation can occur. • Avoid wood containing paints, glues, metal fixings and added fines such as saw dust. Perform a visual inspection of fuel to ensure it does not contain waste material • Examination of ash from the combustion chamber may identify contaminated wood • Further information can be found in the Health and safety in biomass systems – Design and operation guide, published by the Combustion Engineering Association If in doubt contact your installer or competent service provider for advice.

Explanation of possible causes	Solution
c) Poor maintenance schedule The maintenance requirements of a biomass boiler are more involved than the equivalent oil or gas boiler. Regular checks and maintenance aids the identification of faults, damage or component wear within the system. Small problems picked up during maintenance may indicate more important underlying issues. Failure to maintain biomass boilers may lead to unexpected downtimes, expensive repairs, use of backup systems, and loss of RHI revenue. Maintenance of safety features should be a priority. Unburnt material and pieces of clinker not removed from the combustion chamber can cause mechanical problems with ash removal systems. Failure to correctly check and lubricate mechanical components can lead to otherwise preventable damage. Over time components such as fans and sensors can become ineffective and less accurate leading to drift in the control settings such as air to fuel ratio. This leads to suboptimal operation and increased wear on components. Without maintenance and replacement as required this will worsen over time.	Contact your installer or competent service provider to organise a regular maintenance schedule. This should include as a minimum: • Cleaning of the boiler and removal of ash • Lubrication of mechanical parts and check for wear • Check boiler settings and operational history (if possible) • Check boiler and associated components for wear and damage • Periodic service If a schedule is already in place, review the maintenance plan and discuss how it can be improved with your contracted operative. Be proactive about repairs and resolve problems as they arise before more serious issues occur.

Problem

Formation of Clinker

Clinker can occur in all biomass systems but is exacerbated when using poor fuels. It is the fusion of ash into hard, glassy material at high temperatures and can build up to form large deposits which interrupt the air flow through the fuel bed. This results in incomplete combustion, an increase in pollutant emissions, reduced efficiency and in severe cases, forced shutdown and increased maintenance requirements of the system.

Explanation of possible causes	Solution
a) Poor quality fuel Biomass combustion is heavily influenced by the type and quality of fuel burned within the boiler. Your biomass boiler will have been designed to burn a particular type and grade of fuel cleanly and efficiently. This is specified by the manufacturer. The use of poor quality fuel causes increased emissions, low efficiency, component failure, increased repair costs, high running costs and poor performance of the system. The use of poor fuel increases the formation of clinker in two ways: • It may contain minerals that fuse at a lower temperature. • As the ash content of the fuel increases, so does the rate of clinker formation. Clinker material is very hard and causes damages to internal boiler surfaces and de-ashing mechanisms such as auger screws **b) High grate temperatures** Clinker is also formed by excessive temperatures in biomass boilers often above 1200°C. If this occurs in biomass boilers it is often caused by incorrect primary air supply caused by a build-up of ash or clinker in the boiler effecting air supply.	• Ensure the grate is cleaned regularly and unblock any primary air holes in the boiler • Monitor the ash removed from the boiler. It should be fine and of a uniform consistency. If you find hard, glassy objects within the ash, or the ash has a gritty consistency then review the fuel being used. • Use only the type of fuel specified for your boiler and check the specification for the fuel you are using matches that detailed in the boiler manufacturer's instructions. Details such as calorific value, moisture content, fines content, pellet size, etc. should be provided. • Periodically inspect the fuel entering the boiler which will allow you to detect issues with moisture content or waste material. • Ensure your fuel is from a reputable supplier. If you are using pellets, you may wish to consider suppliers registered with the ENplus scheme, an internationally recognised quality certification scheme covering the entire wood pellet supply chain. • Unless permitted to use contaminated wood via an environmental permit, avoid any 'second hand' or reclaimed wood if you do not know the source. Especially important if you are claiming the RHI. • If you are self-supplying review your method of production, get expert advice if required. • Ensure fuel is stored correctly in an appropriately sized, dry, well ventilated environment. For wood logs that are undergoing seasoning, ensure that they are covered and stacked in such a way so that cross ventilation can occur. • Avoid wood containing paints, glues, metal fixings and added fines such as saw dust. Perform a visual inspection of fuel to ensure it does not contain waste material • Further information can be found in the Health and safety in biomass systems – Design and operation guide, published by the Combustion Engineering Association

Problem
Boiler Overheating **More likely to occur with biomass systems than gas or oil due to the amount of energy that remains in the fuel bed when the boiler shuts down.**

Explanation of possible causes	Solution
a) Poor adjustment of boiler and system controls Well-adjusted controls ensure the safe, efficient and optimum operation of the biomass boiler whilst satisfying the heat demand of the site, e.g. space or water heating. When controls are unavailable, set incorrectly, or not regularly reviewed the performance and efficiency of the biomass boiler can suffer. If the boiler is performing unscheduled shutdowns it may be suffering from overheating and indicates the temperature set points are too high. Setting boiler water temperatures higher than required can lead to high internal and flue gas temperatures. Similar to gas and oil boilers, it is not advisable to exceed 100°C in the heating water. Limit stats are usually set between 90°C - 95°C. Using flow temperatures near the limit may help the boiler to fire for longer. However, it can lead to premature degradation of the boiler and may cause the boiler to overheat and go into emergency shutdown. Setting return temperatures can also increase the likelihood of boiler cycling and increases the heat lost from the system.	Contact your installer or a trained operator to discuss possible solutions. They may suggest changes to: • Flow and return temperature set points to ensure a wide enough temperature difference to maintain consistent operation. • Accumulator heating regimes and temperature set points.

Explanation of possible causes	Solution
b) Poor maintenance schedule The maintenance requirements of a biomass boiler are more involved than the equivalent oil or gas boiler. Regular checks and maintenance aids the identification of faults, damage or component wear within the system. Small problems picked up during maintenance may indicate more important underlying issues. Failure to maintain biomass boilers may lead to unexpected downtimes, expensive repairs, use of backup systems, and loss of RHI revenue. Maintenance of safety features should be a priority. Without appropriate maintenance pumps or valves can fail resulting in the heat distribution system being unable to remove sufficient heat from the boiler leading to overheating or boiling. If valves become stuck, it may also mean that a boiler system cannot meet a space heating or hot water demand or is unable to switch between the two. Any damage to the grate and refractory material surrounding the combustion chamber should be routinely repaired as it may lead to overheating or sudden failure of the refractory material. Ash fusion caused by the wrong air to fuel ratio in the boiler could indicate a problem with the lambda probe. Biomass boilers are fitted with limit stats which shut the boiler down if their temperature set point is exceeded. Failure of any limit stat could cause the boiler to overheat and therefore these should be maintained and replaced as soon as a fault is found.	Contact your installer or competent service provider to organise a regular maintenance schedule. This should include as a minimum: • Cleaning of the boiler and removal of ash • Lubrication of mechanical parts and check for wear • Check boiler settings and operational history (if possible) • Check boiler and associated components for wear and damage • Periodic service If a schedule is already in place, review the maintenance plan and discuss how it can be improved with your contracted operative. Be proactive about repairs and resolve problems as they arise before more serious issues occur.

Problem

Noisy Operation

Biomass boiler components are prone to wear and damage due to the large variations in operating conditions and fuel quality. This often leads to noisy operation of components such as ash removal, fuel feed and moving grate systems.

Explanation of possible causes	Solution
a) Poor maintenance schedule The maintenance requirements of a biomass boiler are more involved than the equivalent oil or gas boiler. Regular checks and maintenance aids the identification of faults, damage or component wear within the system. Small problems picked up during maintenance may indicate more important underlying issues. Failure to maintain biomass boilers may lead to unexpected downtimes, expensive repairs, use of backup systems, and loss of RHI revenue. Maintenance of safety features should be a priority.	Contact your installer or service provider to organise a regular maintenance schedule. This should include as a minimum: • Cleaning of the boiler and removal of ash • Lubrication of mechanical parts and check for wear • Check boiler settings and operational history (if possible) • Check boiler and associated components for wear and damage • Periodic service Ensure any personnel you employ to operate the biomass system are fully trained and that a maintenance schedule according to the manufacturer's instructions has been put in place. Be proactive about repairs and resolve problems as they arise before more serious issues occur. Keep a log of issues as they occur and note any changes in the boiler and or system operation. A good maintenance log will allow subtle changes that happen gradually to become noticeable. Listen for unusual noises or vibrations when the boiler performs any mechanical operation such as running augers. If these are identified contact your installer or service company.

Problem

Water Leak

Leaking water should be treated very seriously and the location of the leak identified as soon as possible. Leaks from inside the boiler heat exchanger or from the flow and return pipework could lead to overheating which can cause major damage to biomass boilers.

For evidence of water leakage, the floor area around the boiler should be checked for wet patches. Pipework and boiler casing should be checked for corrosion. Water on the floor may also be an indication of pressure relief valves activating due to boiler overheating.

Explanation of possible causes	Solution
a) Poor maintenance schedule The maintenance requirements of a biomass boiler are more involved than the equivalent oil or gas boiler. Regular checks and maintenance aids the identification of faults, damage or component wear within the system. Small problems picked up during maintenance may indicate more important underlying issues. Failure to maintain biomass boilers may lead to unexpected downtimes, expensive repairs, use of backup systems, and loss of RHI revenue. Maintenance of safety features should be a priority.	Contact your installer or service provider. If a maintenance schedule is not in place, ensure this is created with identification of responsible persons. As a minimum a regular maintenance schedule should include: • Cleaning of the boiler and removal of ash • Lubrication of mechanical parts and check for wear • Check boiler settings and operational history (if possible) • Check boiler and associated components for wear and damage • Periodic service Ensure any personnel you employ to operate the biomass system are fully trained and that a maintenance schedule according to the manufacturer's instructions has been put in place. Be proactive about repairs and resolve problems as they arise before more serious issues occur. Keep a log of issues as they occur and note any changes in the boiler and or system operation. A good maintenance log will allow subtle changes that happen gradually to become noticeable.

Problem
Ignition Failure

Explanation of possible causes	Solution
a) Faulty components If the biomass boiler fails to ignite or only partially ignites, damage or malfunction of the ignitor gun or air inlets may be at fault. Failed ignition can lead to the build-up of carbon monoxide or other flammable gases inside the boiler case. This can lead to carbon monoxide poisoning and the risk of explosion.	Contact your installer or competent service provider. If a maintenance schedule is not in place, ensure this is created with identification of responsible persons.

Problem
Pump and/or Valve failure

Explanation of possible causes	Solution
a) Faulty components Failure of pumps or valves can lead to overheating of the boiler system or underheating of heat demand, e.g. space heating. This will have a negative impact on performance of the system and emissions.	Contact your installer or competent service provider. If a maintenance schedule is not in place, ensure this is created with identification of responsible persons.

Problem
Flue Corrosion

Explanation of possible causes	Solution
a) Poor maintenance schedule Wet flue gases can lead to condensate build up within the flue pipe leading to corrosion and the escape of flue gases. In turn this offers a risk of carbon monoxide poisoning. Gas leaks can be identified by damage to the boiler casing such as discoloured paint or metal caused by hot flue gases. This should be identified during boiler checks as part of the maintenance schedule and should be rectified upon identification	Contact your installer or competent service provider. If a maintenance schedule is not in place, ensure this is created with identification of responsible persons.

Problem
Fire in the fuel delivery system

Explanation of possible causes	Solution
a) Faulty components Fuel delivery systems often feature a sprinkler system to douse the fire should a high temperature be detected in the fuel delivery mechanism upstream from the boiler. If this fails there is a risk of fire spreading from the combustion chamber to the fuel store, a phenomenon known as “burn back”.	Contact your installer or competent service provider. Ensure that the burn back protection is serviced at regular intervals and that if it uses water, the water works independently of the boiler.
b) Poor maintenance schedule Regular checks carried out as part of the maintenance schedule should identify errors or problems with systems such as the sprinkler system. If this is not identified the maintenance schedule requires improvement.	Contact your installer or competent service provider and discuss the maintenance schedule in place. If a maintenance schedule is not in place, ensure this is created with identification of responsible persons.

Problem
Strong Odour **A strong wood burning smell during boiler operation could suggests incomplete combustion even if there is no visible smoke. The smell is caused by unburnt hydrocarbons and is indicative of poor operation.**

Explanation of possible causes	Solution
a) Poor adjustment of boiler and system controls Well-adjusted controls ensure the safe, efficient and optimum operation of the biomass boiler whilst satisfying the heat demand of the site, e.g. space or water heating. When controls are unavailable, set incorrectly, or not regularly reviewed the performance and efficiency of the biomass boiler can suffer. If the boiler is performing unscheduled shutdowns it may be suffering from overheating and indicates the temperature set points are too high. Poor control can result in the boiler operating when there is little demand for heat. This leads to multiple startup and shutdown phases, known as cycling, which reduces efficiency, increases emissions and leads to excessive wear on boiler components. In the case of automatically fed boilers excessive cycling means the boiler fails to reach its most efficient state of operation and temperatures never reach those required for optimal combustion and heat transfer. This results in increased emissions.	Contact your installer or a trained operator to discuss possible solutions. They may: • Carry out an analysis of the flue gas • Check the boiler settings to identify any issues such as incorrect excess air levels

Explanation of possible causes	Solution
b) Poor maintenance schedule If a boiler is not cleaned thoroughly or often enough, dust can build up inside the boiler and flue gas pathways. This can become entrained in the flue gas and result in higher than normal emissions. This can be exacerbated if cyclones and filters are not cleaned regularly meaning they cease to remove particulate matter effectively.	Contact your installer or competent service provider. They may: • Carry out a visual inspection of the flue gases leaving the boiler during steady state operation. This may result in identification that he boiler requires cleaning or that cyclones or filters have become blocked • Carry out a flue analysis to identify higher than normal flue gas temperatures which may indicate that boiler tubes have a build-up of deposits reducing reduce heat transfer If a service schedule is not in place, organise a regular maintenance schedule. Be proactive about repairs and resolve problems as they arise before more serious issues occur.

Explanation of possible causes	Solution
c) Poor quality fuel Biomass combustion is heavily influenced by the type and quality of fuel burned within the boiler. Your biomass boiler will have been designed to burn a particular type and grade of fuel cleanly and efficiently. This is specified by the manufacturer. The use of poor quality fuel causes increased emissions, low efficiency, component failure, increased repair costs, high running costs and poor performance of the system. Fuels with a high moisture content can lead to difficulties maintaining operating temperatures, leading to an increase in particulate emissions, incomplete combustion and loss of efficiency. Using waste wood, even from clean sources is likely to increase pollutant emissions particularly particulate emissions and NOx. Even small changes to the fuel can lead to immediate changes in pollutant emissions, which may breach emission limits set under the RHI. Waste wood can also contain high levels of heavy metal and other contaminants hazardous to health. It also often has a very low moisture content and burns at very high temperatures which can cause damage to boilers and flues.	Monitor your fuel quality: • Use only the type of fuel specified for your boiler. • Check that the specification for the fuel you are using matches that detailed in the boiler manufacturer's instructions. Details such as calorific value, moisture content, fines content, pellet size, etc. should be provided • Ensure your fuel is from a reputable supplier. If you are using pellets, you may wish to consider suppliers registered with the ENplus scheme, an internationally recognised quality certification scheme covering the entire wood pellet supply chain • Unless permitted to use contaminated wood via an environmental permit, avoid any 'second hand' or reclaimed wood if you do not know the source. Especially important if you are claiming the RHI. • Avoid wood containing paints, glues, metal fixings and added fines such as saw dust. Perform a visual inspection of fuel to ensure it does not contain waste material • If you are self-supplying wood, review your method of production and get expert advice if required. Try to avoid small branches and other forestry material which increases ash production • Ensure fuel is stored correctly in an appropriately sized, dry, well ventilated environment. For wood logs that are undergoing seasoning, ensure that they are covered and stacked in such a way so that cross ventilation can occur • Examination of ash from the combustion chamber may identify contaminated wood • Further information can be found in the Health and safety in biomass systems – Design and operation guide, published by the Combustion Engineering Association

5 Glossary

Auger – a screw in a pipe which conveys solid material

Boiler grate – metal grille or plate on which the burning fuel sits

Burnout – is when a bed of fuel burns completely and the fire goes out

Calorific value – the energy content of a fuel, normally in KJ/kg

Carbon monoxide (CO) – a toxic gas formed from incomplete combustion

Clinker – hard, glassy material formed when ash is exposed to very high temperatures

Combustion chamber – the space inside a boiler where the fire sits

Firebed – the collection (bed) of fuel which is burning in the combustion chamber

Flow (and return) – the flow of heated water leaving the boiler to go round the heat distribution circuit. The return is the cooled water returning to the boiler

Flue gas – hot gas carrying the combustion by-products to atmosphere and made up of nitrogen, oxygen, carbon dioxide, water vapour, with smaller quantities of carbon monoxide, nitrogen oxides and particulate matter

Hydraulics – the behaviour of the flow of water in the heat distribution circuit

Lambda Probe – probe measuring oxygen/carbon dioxide ratio in the flue gas, as a measure of the completeness of combustion

Load factor – the heat generated by a boiler, divided by its nominal plate rating, multiplied by a time factor

Limit stat – 'stat' is an abbreviation of 'thermostat'. A limit thermostat is a heating water temperature measurement control, which controls the boiler around a temperature setting. For example, a high limit stat will switch the boiler off when the set limit in the heating water is exceeded

Organic Gaseous Carbon (OGC) – also referred to as volatile organic carbon (VOC), this is the collection of carbon compounds given off during combustion; quantities are affected by the combustion conditions

Refractory – solid blocks of insulating mineral material lining the boiler which can withstand very high temperatures

Appendix 1: Maintenance schedule

This appendix is provided as an example of a maintenance schedule. Its intention is to highlight the maintenance activities which should be undertaken so that deficiencies can be identified. This maintenance schedule ***MUST NOT*** be used as a substitute for ***the maintenance schedule produced by the biomass boiler manufacturer*** as not maintaining the boiler with the correct interval between maintenance activities ***may damage the biomass boiler and connected systems***. Activities listed below may be added to maintenance schedules if applicable.

Frequency of activity	Description of activity	Description of task
Weekly	Frequent cleaning of the boiler and removal of ash	Remove ash
		Clean smoke tubes
		Clean cyclone / bag-filters
Monthly	Regular lubrication of mechanical parts and checking for wear	Check/clean fuel delivery system
		Lubricate motors
Monthly	Checking the boiler is operating correctly and checking for damage	Check ash for clinker and unburnt fuel
		Check for leaks on water pipes
		Check boiler grate and refractory lining for damage
		Check ignitor guns
		Check de-ashing system works
		Check pneumatic cleaning system works
		Check burn-back protection
		Check fans, pumps and mixing valves
		Check sight-glass
		Check flue soundness
		Check draught-diverter
		Check boiler control system and BMS for faults / alarm codes
		Check pipe and flue temperature sensors
		Check for condensation in /corrosion of heat exchanger
		Check seals on combustion chamber are air-tight
		Check lambda sensor
		Check for unusual noises / vibrations
		Check are around boiler is tidy
		Check CO alarm is working and for previous activation
		Check pressure relief valves not activated
		Check light-barriers / level-switches
Yearly	Intermittent servicing of the boiler	Check boiler flue O2/CO2 and CO levels
		Clean hopper
		Check boiler control system and BMS for software updates

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