Making biomass heat work for you

Biomass Boiler Emission Abatement Technologies

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About Us

Established in 2003

Specialise only in biomass heating

Team of 50 staff

Design & engineering led company

More than 300 commercial-scale projects

Small district heating schemes to large hospitals
## Air Quality Regulations:

### Table 21 Summary of environmental permissions for biomass heating equipment

<table>
<thead>
<tr>
<th>Biomass fuel</th>
<th>Scale of project</th>
<th>Relevant environmental permissions</th>
<th>Regulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin wood derived biomass fuels and energy crops</td>
<td>&lt;20 MW(_{th})</td>
<td>Clean Air Act</td>
<td>Local Authority</td>
</tr>
<tr>
<td></td>
<td>20-50 MW(_{th})</td>
<td>IPPC (PPC Part B)</td>
<td>Local Authority</td>
</tr>
<tr>
<td></td>
<td>&gt;50 MW(_{th})</td>
<td>IPPC (PPC Part A1)</td>
<td>Environment Agency</td>
</tr>
<tr>
<td></td>
<td>&lt;0.4 MW(_{th}) (&lt;50kg/hr)</td>
<td>Clean Air Act</td>
<td>Local Authority</td>
</tr>
<tr>
<td></td>
<td>0.4-3 MW(_{th}) (50-1000kg/hr)</td>
<td>IPPC (PPC Part B)</td>
<td>Local Authority</td>
</tr>
<tr>
<td></td>
<td>&gt;3 MW(_{th}) (&gt;1000kg/hr)</td>
<td>IPPC (Part A1)</td>
<td>Environment Agency</td>
</tr>
<tr>
<td>Residues or waste derived biomass exempted from WID: untreated wood e.g. disused pallets</td>
<td>&lt;3 MW(_{th})</td>
<td>WID applies (IPPC Part A2)</td>
<td>Local Authority</td>
</tr>
<tr>
<td></td>
<td>&gt;3 MW(_{th})</td>
<td>WID applies (IPPC Part A1)</td>
<td>Environment Agency</td>
</tr>
</tbody>
</table>

(IPPC): Integrated Pollution Prevention and Control
(LA-IPPC): Local Authority Integrated Pollution Prevention and Control
Source: AEA Energy and Environment
Air Quality Requirements:

To qualify for the Renewable Heat Incentive biomass boilers must have maximum emission level of:

- PM - 30g/GJ net heat input
- NOx - 150g/GJ net heat input
- or have an Environmental Permit

Local air quality and background pollutant levels will generally mean boiler emissions will need to be less than those required for RHI compliance.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>RHI Criteria, g/GJ</th>
<th>Emission concentrations at specified O₂ (% dry), mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>net thermal input</td>
<td>(dry gas at 0°C, 101.3 kPa)</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>PM</td>
<td>30</td>
<td>119</td>
</tr>
<tr>
<td>NOx</td>
<td>150</td>
<td>593</td>
</tr>
</tbody>
</table>

Source: AEA report “Conversion of biomass boiler emission concentration data for comparison with Renewable Heat Incentive emission criteria”
Control of Emissions:

Primary measures within the boiler to control emissions are:
• Fan assisted combustion air e.g. induced draught fan
• Automatic control of primary & secondary combustion air
• Lambda sensor and control
• Automatic cleaning of heat exchanger

Increasing the chimney stack height can allow greater dispersion of pollutants and therefore achieve compliance with emission concentration limits at ground level.

Where this is either impractical or undesirable, e.g. visual impact, then other emission mitigation measures may be necessary.
Control of Emissions:

Additional emission abatement technologies:
Particulate control:
• Cyclone or multi-cyclone
• Bag filter
• Ceramic filter
• Electrostatic precipitator
• Wet electrostatic precipitator

NOx control:
• SNCR treatment
Cyclones:

Cyclones and multi-cyclones are the most basic form of particulate emission control external to the combustion chamber and heat exchanger of the boiler. Particulates are removed through centrifugal forces and gravity.

Cyclones and multi-cyclones:
• occupy a relatively small space
• tolerate high temperatures
• often used on their own or as a first stage gas cleaning device in industrial applications
• good at collecting coarse particles (~80-90% efficient for PM5 & PM10)
• less effective at smaller particle sizes (~0-10% efficient for PM2.5)
Bag Filters:

In bag filters, flue gases are passed through fine woven media where particulates are retained by impingement. They are commonly used in industrial and in local exhaust ventilation systems.

Bag filters:

• highly effective collection across all particle sizes above PM1
• separation efficiency up to 99.9%
• particulate removal to <5mg/Nm³
• normally used in conjunction with a pre-cleaning device e.g. a cyclone
• generally limited to around 250°C flue gas temperature
Bag Filters:

- available in range of fabrics which allow operation with corrosive flue gases or higher temperatures
- fabric filters can be affected by moisture & may need preheating or use of alternate media material
- occupy a large volume and require additional fan power due to the high-pressure drop across the filter media
- automatic cleaning by mechanical shakers or compressed air
- automatic ash removal to waste container
Ceramic Filters:

Ceramic filters use a number of micro-porous elements to attract and retain particulates in the flue gas stream.

Ceramic filters:
- highly effective collection across all particle sizes above PM1
- separation efficiency up to 99.9%
- particulate removal to <3mg/Nm³ (typically <1mg/Nm³)
- does not require a pre-cleaning device e.g. a cyclone
- suitable for flue gas temperature up to 450°C
- uses compressed air for automatic cleaning of elements
Ceramic Filters:

Operating principle of ceramic filter:
- The micro-porous elements (01) hang vertically from a header plate (02) within the filter vessel, the header plate separates the filters clean and dirty compartments.
- Hot gas is drawn through the filter medium (03) from the outside to the inside.
- Submicron particles are collected on the outer surface (04).
- The submicron particles are removed from the element by reverse jet pulse (05).
- The particles are discharged through the hopper outlet (06) or directly to a tray for collection and disposal.
- The filter body is insulated (07) and trace heating (08) is an option.

Courtesy of Glosflume
Electrostatic precipitator (ESP) technology uses high-voltage electricity to negatively charge the dust particles which are then collected on positively charged electrodes.

Electrostatic precipitators:
• highly effective collection across all particle sizes above PM1
• separation efficiency up to 99.9%
• particulate removal to <10mg/Nm³
• normally used in conjunction with a pre-cleaning device e.g. a cyclone/multi-cyclone
• suitable for flue gas temperature up to 450°C
Electrostatic Precipitator:

- most likely to be used in systems above 100 kW thermal output
- requires electricity to maintain the electrical field
- tend to require a large volume to minimise gas velocity and hence increase opportunity for particle collection
- flow resistance is low, so little or no additional electrical energy is needed to power larger fans
- mechanical shaker cleaning and automatic ash removal
Wet Electrostatic Precipitator

A wet electrostatic precipitator works in the same way as a dry ESP but uses water to continually clean the dust collection surfaces.

Wet electrostatic precipitators:
- highly effective collection across all particle sizes
- separation efficiency up to 99%
- particulate removal to $<10\text{mg/Nm}^3$
- normally used in conjunction with a pre-cleaning device e.g. a cyclone & flue gas condenser
- operate with flue gas at 50°C & unaffected by moisture content
- requires sludge removal
SNCR Treatment:

Selective non-catalytic reduction uses urea or ammonia as a reagent directly within the combustion chamber of the boiler to reduce NOx emissions.

Ammonia reacts with the harmful nitrogen monoxide (NO) and nitrogen dioxide (NO₂) from the flue gas to form harmless nitrogen (N₂) and water.

SNCR treatment:
- up to 80% NOx reduction
- reaction temperature of 850 – 1050°C
- needs specialist design to match injector positions to combustion chamber
SNCR Treatment:

- normally used in industrial scale boiler systems & those burning recycled biomass fuel e.g. WID compliant plant
- urea and ammonia available in dry solid form for mixing on site or delivered in solution at different concentrations
- may need demineralised water for dilution of reagent, particularly in hard water areas
- more stringent health & safety measures required when using ammonia vs urea as the reagent
- ammonia “slip” can occur if reaction temperature too low
- NOx can be generated if combustion temperature too high
<table>
<thead>
<tr>
<th>Abatement Technology</th>
<th>Efficiency PM2.5</th>
<th>Efficiency PM10</th>
<th>Achievable PM, g/GJ</th>
<th>Capital Cost</th>
<th>Operational Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclone</td>
<td>&lt;10%</td>
<td>&lt;80%</td>
<td>30</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Multi-cyclone</td>
<td>&lt;10%</td>
<td>&lt;90%</td>
<td>30</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Bag filter</td>
<td>&lt;99.9%</td>
<td>&lt;99.9%</td>
<td>&lt;5</td>
<td>Medium high</td>
<td>Medium high</td>
</tr>
<tr>
<td>Ceramic filter</td>
<td>&lt;99.9%</td>
<td>&lt;99.9%</td>
<td>&lt;5</td>
<td>High</td>
<td>Medium high</td>
</tr>
<tr>
<td>ESP</td>
<td>&lt;99.9%</td>
<td>&lt;99.9%</td>
<td>&lt;10</td>
<td>High</td>
<td>Medium high</td>
</tr>
</tbody>
</table>
Summary

So what determines which technology is right?

- What are the maximum allowable PM & NOx emissions for the specific site?
- What are the maximum expected emissions at the boiler outlet?
- What is the maximum expected flue gas temperature and moisture content?
- Are there space restrictions on the site?
- Financial implications?
Any questions?

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