environmental protection uk Scotland

Biomass and Air Quality Guidance

for Scottish Local Authorities

About Environmental Protection UK

Environmental Protection UK's vision is of a cleaner, quieter, healthier world. We seek changes in policy and practice to minimise air, noise and land pollution, bringing together stakeholders to inform debate and influence decision making. We are a national membership based charity and have been playing a leading role in environmental protection in the UK since 1898.

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Image on front page: Salvez Dodds

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Executive Summary

In common with other combustion appliances, emissions from biomass boilers and biomass combined heat and power systems should be managed to ensure potential air quality impacts are controlled. Management of combustion appliances can include product and fuel standards, emissions abatement equipment, regulatory controls and / or planning controls to restrict where certain appliances can be installed. This guidance aims to help local authorities understand and manage emissions from biomass combustion, with a focus on the most common biomass fuel – wood.

Biomass fuels are currently being encouraged to help Scotland meet ambitious targets under the Climate Change (Scotland) Act and the related Renewables Action Plan. Unabated climate change presents a major environmental and health hazard to the whole world, and de-carbonising our energy supply is therefore a priority. At the same time the UK is currently failing to meet legally binding EU air quality standards in many areas, including parts of Scotland, and public health is suffering as a result. Management of biomass combustion should therefore seek to encourage biomass use, whilst limiting any negative effect on, or indeed improving, air quality.

As a general rule of thumb biomass boilers fuelled by clean, new wood have lower pollutant emissions than coal, roughly equivalent emissions to oil, but higher emissions than equivalent gas fired boilers. The process of assessment should therefore follow a risk-based approach based upon:

- The location of the boiler, e.g. could it affect areas of poor air quality? Is it in a densely populated area?
- Whether the biomass plant is substituting for a boiler using a different fuel; i.e. if it's substituting for oil or coal, emissions might actually drop, but if it is replacing a gas fired system they are likely to rise
- The likely emissions standard of the boiler
- The type, quality and quantity of biomass fuel used.

The approach to assessment should therefore have a lighter touch where risk is low (for example in a rural area where air quality is good, and coal and oil are the realistic alternative fuels), and more rigorous where risk is high (for example in or adjacent to an Air Quality Management Area).

The declared view of the Scottish Government is that the air quality impacts of a major expansion in biomass heat can be controlled through the use of high quality, low emission plant and targeting rural areas off the gas grid where coal and oil fired plant are currently used. In urban areas, or where an Air Quality Management Area has been declared, they would expect biomass heat deployment to be less common, and larger (and therefore cleaner) biomass units to be more prevalent.

This guidance document contains information on the policy background to biomass, climate change and air quality, details of the technology used in biomass plant and their regulation, and finally advice on the management and mitigation of biomass emissions. Several tools have been developed alongside this guidance to help local authorities and their partners manage emissions. These are listed on the contents page, and are also available for download from www.environmental-protection.org.uk/biomass.

This guidance does not intend to be a complete guide to biomass, and suggested reading links have been placed in the text if more detailed information is needed about any of the policies, technologies and methodologies raised. This guidance is intended as a companion to the more general Environmental Protection UK planning guidance 'Development Control – Planning for Air Quality' which was updated in April 2010. Environmental Protection UK will be launching 'Air Quality and Climate Change' integrated guidance towards the end of 2010.

Chapter 1 - Background

1.1 Biomass burning is perhaps the oldest method of providing heating and hot water. In recent years pressure to reduce our reliance on fossil fuels such as coal, oil and gas has encouraged a large expansion in the use of biomass heat. Concerns have been raised that this may have an adverse effect on air quality and public health, particularly in densely populated urban areas.

1.2 Biomass can have a variety of meanings, but in the context of this guidance it refers to deriving energy from biological material through a transformation process. The energy provided may be heat, electricity or mechanical power. The biological material may come from animal or plant sources (including animal wastes and composts), whilst the transformative process may be direct combustion or perhaps involve gasification, fermentation or pyrolysis.

1.3 The status of biomass as a renewable low carbon fuel means there is growing interest in using it to help meet local and national targets for renewable energy. As a relatively mature renewable energy technology, biomass can be one of the most cost effective and therefore attractive technologies to use.

Scope of this Guidance

1.4 This guidance covers the burning of dry and seasoned woody fuels only as this is the most popular form of biomass deployed in the UK (e.g. wood chips, pellets and logs with up to 50% moisture content). The document is aimed at Scottish local authorities and is intended to help officers and elected members with strategic planning and decisions on individual planning applications. This guidance relates to good practice and the legislative position in Scotland; a version of this guidance for England and Wales is also available on the Environmental Protection UK website.

1.5 The guidance focuses on assessing and managing the effects of biomass on air quality – specifically nitrogen dioxide (NO_2) and particulates (PM_{10} and $PM_{2.5}$). It does not cover other pollutants in depth. Lifecycle carbon dioxide (CO_2) emissions from different biomass fuels are beyond the scope of this guidance. The Environment Agency report 'Biomass – Carbon Sink or Carbon Sinner?' can provide further information on this subject (see Chapter 1 reading links).

1.6 Biomass does have other environmental and sustainability impacts associated with its use. These are mentioned in this guidance and links are given to sources of further information. Dry, woody fuels are most commonly burnt in a boiler to produce heat for space heating and / or hot water or in a Combined Heat and Power (CHP) unit to produce both heat and electricity. This guidance uses the term 'biomass boilers' to cover both boilers and CHP units.

1.7 The burning of waste wood may be subject to more stringent environmental regulation than the burning of clean, new wood. These issues are examined in Chapter 3.

1.8 At the time of writing this document, technology and legislation surrounding the air quality effects of biomass were developing quickly. Updates to this guidance will be posted at www.environmental-protection.org.uk/biomass and we strongly recommend checking for updates when using this guidance.

1.9 Where biomass plants occur as part of a larger development there will be a need to meet regulatory (pollution) conditions and also gain planning approval. Both issues are looked at in Chapter 3 of this guidance. Wider air quality issues surrounding development control are considered in the guidance document 'Development Control: Planning for Air Quality' which is available to download from the Environmental Protection UK website.

1.10 An information leaflet for developers has been produced alongside this guidance document. This leaflet explains the issues surrounding biomass and air quality, the information that local authorities may need to assess the air quality impacts of a proposed biomass boiler and the reasons why they may request this information.

Types of Biomass

1.11 There is a wide range of biomass fuels which can be broadly described in terms of 'wet' and 'dry' sources. Under these two broad headings they can be grouped into five sub-categories (Table 1.1).

Table 1.1: Original Sources of Biomass Fuels

Virgin wood	Dry – includes roundwood, harvesting residues (brash), bark, sawdust, crowns, needles and residues of tree surgery
Energy crops	Dry – includes woody energy crops (short rotation forestry, willow, eucalyptus, poplar), grassy energy crops (miscanthus and hemp), sugar crops (sugar beet), starch crops (wheat, barley, maize/corn), oil crops (rape, linseed, sunflower), and even hydroponics (lake weed, kelp, algae)
Agricultural residues	Wet – includes pig and cattle slurry, sheep manure, grass silage
	Dry – poultry litter, wheat or barley straw, corn stover
Food residues	Wet – includes wastes from various processes in the distillery, dairy, meat, fish, oils, fruit and vegetables sectors
Industrial residues	Wet – includes sewage sludge
	Dry – includes residues from sawmills, construction, furniture manufacturing, chipboard industries, pallets

Introduction to the Air Quality Impacts of Biomass Plant

1.12 In common with other combustion processes, the combustion of biomass for energy can affect air quality in a variety of ways. Emission levels of pollutants such as particulates (PM), polyaromatic hydrocarbons (PAHs) and carbon monoxide (CO) depend on the completeness of the combustion process. The temperatures in conventional biomass combustion are considered to be not sufficiently high enough to oxidise atmospheric nitrogen and oxides are almost exclusively formed from fuel nitrogen (note that this may not be the case for newer biomass technologies such as gasification that have higher combustion temperatures). Emission levels of NO_x are therefore heavily dependent on the chemical composition of individual fuels (as are the emissions of SO_x). Overall emissions will therefore be dependent on:

- The specification and design of the combustion plant,
- The chemical and physical qualities of the fuel (fuel quality)
- The presence of any emissions abatement fitted to the plant

1.13 In many cases the introduction of new biomass combustion plant will displace heat and / or power that would otherwise have been provided by other combustion appliances. The relative contribution will depend on the type of fuel(s) and combustion technology displaced. For example, whilst the sulphur and nitrogen content of wood biomass is low it is higher than that of gas and hence the replacement of gas fired stoves may lead to a modest increase in SO_2 and NO_x emissions. Conversely, displacement of fuels such as coal may lead to an overall reduction in emissions. Table 5.5 of the document “Review of Greenhouse Gas Life Cycle Emissions, Air Pollution Impacts and Economics of Biomass Production and Consumption in Scotland” provides a simplified explanation of this (see Chapter 1 Reading Links).

1.14 Planning applications proposing the installation of a biomass boiler should be accompanied with an air quality assessment, the complexity of which should follow a risk-based and staged approach. Key questions to consider when making an initial broad assessment should include:

- Geography – what is the planned location of the biomass boiler? Is it near densely populated areas and could it potentially negatively affect any areas of poor air quality? Is it near sensitive receptors such as children, especially if installed in schools?
- Topography – is the location in a built-up area?
- Fuel substitution / alternatives – will the biomass boiler be displacing a boiler running on a different fuel and if so, what fuel? If the development containing the boiler is on a new site, what other fuels might be available (and what would be their comparative effect on air quality)?

- What is the likely emissions performance of the boiler?
- What type of biomass fuel will the boiler be running on?

1.15 The use of biomass can also cause nuisances most commonly dust, smoke and odour. Emission of smoke in smoke control areas is likely to be an offence under the Clean Air Act. Problems outside smoke control areas can either be addressed through nuisance legislation or the Clean Air Act provisions prohibiting the emission of dark smoke. Odour is most likely to be associated with a combination of inadequate combustion and poor plume dispersion or from fuel storage.

1.16 Indirect air quality effects will also arise from increased biomass use. For example, emissions associated with transporting biomass fuel to the site (e.g. vehicle, rail or ship emissions) and the potential for increased nitrous oxide (N_2O) emissions (a potent greenhouse gas associated with a greater use of fertilisers in the increasing production of biomass fuels).

The Policy Context

1.17 Policies to encourage the use of biomass have primarily been driven by climate change, the need to reduce greenhouse gases (GHGs) and renewables targets (20% of Scotland's total energy use by 2020). Other relevant drivers include sustainability, energy security and rural employment. UK legislative drivers have developed within the framework of EU and other international policies, strategies and instruments such as the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC).

1.18 CO_2 in the atmosphere is understood to have a warming effect. Since pre-industrial times the level of atmospheric CO_2 has increased from about 280 parts per million to 380 parts per million largely due to emission from the combustion of fossil fuels and human induced land use changes. Observations have shown that the world is now warming as a result and modelling predicts that if we continue to emit CO_2 and other GHGs at present rates there will be a significant change in climate over the coming decades. The consequences of unabated climate change would be widespread with increased temperatures, sea level rises and a greater frequency of extreme weather events having serious effects on the natural environment as well as on human health and wellbeing. Biomass, when used appropriately, can reduce emissions through the displacement of fossil fuels and can contribute towards carbon abatement.

1.19 In 2008 the Department for Environment, Food and Rural Affairs (DEFRA) commissioned a biomass impact study to help inform the development of the UK Renewable Energy Strategy, the results of which were communicated to Environmental Protection UK in a letter from DEFRA and DECC Minister Lord Hunt of Kings Heath in May 2009. The study modelled the potential air quality impacts of a large increase in biomass heat (installed capacities of 38TWh and 50TWh, total heat demand in 2005 was 844TWh).

1.20 In May 2009 the Minister for Environment, Roseanna Cunningham MSP, sent a letter to all local authority Chief Executives which clarified the Scottish Government's position on biomass and how Scotland will meet its target of 20% of energy produced from renewable sources by 2020. The Minister re-iterated this message whilst addressing delegates at Environmental Protection UK Scotland's event in November 2009. Results of DEFRA's analysis and the Minister's key message are shown in Box 1.2.

1.21 Implementation of the Minister's key message has implications for local planning and strategic policy, however some of the important technical requirements (e.g. product emission standards) are not yet in place. Many of the issues raised are covered in this guidance including current technologies, standards and certification (Chapter 2), risk based approaches to assessment (Chapter 4), assessing cumulative impacts (Chapter 5) and abatement technologies (Chapter 6). Chapter 7 looks at some of the anticipated developments that will help implement the targeted approach outlined by the Minister and updates to this guidance will be posted as new information becomes available.

1.22 **The Climate Change (Scotland) Act 2009** commits the Scottish Government to achieving an 80% cut in CO_2 emissions (from 1990 levels) by 2050. The Act also sets an interim target of at least a 42% reduction in emissions by 2020 and establishes a framework of annual targets.

1.23 The Scottish Government's **Renewables Action Plan** is updated every 6 months and was last published in July 2010 (see Chapter 1 Reading Links for the latest version). Under the Climate Change (Scotland) Act there is also a statutory obligation to publish a separate, more detailed Renewables Heat Action Plan. This was published in November 2009 and outlines Scotland's commitment to 11% of heat demand from renewable sources by 2020.

1.24 **European Renewable Energy Targets** – the EU has adopted a target of 12% renewable energy in the EU by 2010 and has produced a range of implementation measures. These include Directives with targets for renewable use in electricity generation and transport fuels and a Biomass Action Plan. Further to the 2010 target, the EU has agreed a 20% renewable energy target for 2020. This relates to all energy consumed and thus for the first time includes heat as well as electricity. Under a burden sharing agreement the UK has agreed to a target of 15% of all energy to come from renewable sources by 2020.

Box 1.2: Results from DEFRA Biomass Impacts Assessment and Minister's Key Message

Results of the Impact Assessment – 'where certain conditions are met … impacts can be reduced to a manageable level, and that no additional breaches of the current EU air quality directive's air quality limit values[a] would occur. These conditions are:

- That all new biomass plant are of high quality[b], corresponding to the best performing units currently on the market;
- That the majority of biomass heat uptake replaces or displaces existing coal and oil fired heating;
- That the majority of uptake is located off the gas grid and therefore away from densely populated urban areas;
- That levels of uptake where the local authority has declared an Air Quality Management Area under Section 83 of the Environment Act 1995 are substantially lower than other areas.

As conditions move away from this scenario, the modelled adverse / negative impacts on air quality and public health increase significantly'.

Current Levels of Biomass in the UK – 'Biomass use in the UK is currently at a very low level; to achieve 7% of the UK heat market, the level of biomass use in the UK would have to increase 20 fold… The fact that the market penetration of biomass is very low is an advantage here rather than a drawback: by setting the right conditions now we can ensure almost all of the eventual installed capacity is of a high standard, and in locations unlikely to have air quality issues – meaning that early installations will not result in exceeding air quality limits'.

The Minister's Key Messages for Local Planning Policies – 'In the development of local planning policy and the consideration of development planning applications, the evidence points toward the following key points:

- To meet the 2020 targets for renewable energy, the UK needs to increase very substantially the amount of renewable heat generated, and biomass heat is one of the key technologies;
- The potential conflicts between these goals and air quality can be avoided through the use of high quality, low emission plant. The replacement of old coal and oil fired plant with high quality wood fired plant located off the gas grid and away from densely populated urban areas may actually benefit air quality. In urban areas or where an Air Quality Management Area has been declared, we would expect biomass heat deployment to be less common and larger (and therefore cleaner) biomass units to be more prevalent.
- Encouraging the use of larger plant, for example in conjunction with the development of heat networks, will result in a system where air quality emissions are easier to control than from a larger number of small plant'.

a: The Scottish LAQM annual mean standard for PM_{10} is more stringent than the EU Air Quality Directive's PM_{10} air quality limit

b: The outcome of the DEFRA impact study was based on high quality biomass emissions of 20g/GJ PM_{10} and 50g/GJ NO_2

1.25 **Current UK Policy – The Climate Change Act 2008** commits the UK Government to the same reduction in CO_2 emission by 2050 as the Scottish Government. Under the 2008 Act, the UK Government sets out a series of five year carbon budgets with three successive budgets always in legislation. The first three budgets were set in 2009, committing to cuts (from 1990 levels) of 22% by 2010, 28% by 2017 and 34% by 2022.

1.26 The **UK Energy White Paper**, released in May 2007, has acknowledged the role of biomass and its potential contribution to renewable energy in the UK. This follows the UK Government's **Biomass Strategy** which acknowledges the role of biomass in helping to meet climate change and renewable energy targets, and brings together the various government policies that encourage biomass. Whilst a UK document, it acknowledges that separate strategies have been, or are being, developed to address the specific conditions that apply in Scotland, Wales and Northern Ireland. It does not include any binding targets; instead its main aims are to:

- Realise a major expansion in the supply and use of biomass in the UK.
- Facilitate the development of a competitive and sustainable market and supply chain.
- Promote innovation and low-carbon technology development so biomass can deliver relatively higher energy yields.
- Contribute to overall environmental benefits and the health of ecosystems through the achievement of multiple benefits from land use.

1.27 Currently the main mechanism to encourage renewable energy development is the **Renewables Obligation (RO)**; both the UK and Scottish Governments have mechanisms in place which support the generation of electricity from renewable resources through a system of Renewable Obligation Certificates (ROCs). As of 2009, large biomass CHP systems will receive double ROCs (i.e. twice as many certificates for every unit of energy generated) and a new feed-in tariff will provide benefits for smaller biomass CHP systems (up to 5MW). The UK Government has confirmed that the **Renewable Heat Incentive (RHI)** will go ahead.

1.28 The Scottish Government's Renewables Action Plan identifies collective actions by government, its agencies and partners to ensure at least 20% of Scotland's energy comes from renewables by 2020. A routemap for renewable heat and bioenergy are included in this plan. The routemaps are supplemented by a more detailed **Renewable Heat Action Plan for Scotland** (published November 2009) which sets out a framework for activity across a wide range of areas which will contribute to Scotland meeting its 2020 target.

1.29 Planning and biomass – Regional (Regional Spatial Strategies) and local (Local Development Frameworks) plans must be developed in accordance with Government planning guidance (planning issues are looked at in more depth in Chapter 3). For biomass, relevant guidance is provided by:

- Renewable Energy – PAN 45. SPP 6 has recently been revoked and has been subsumed by the new SPP (February 2010)
- Pollution Control – PAN 51.

1.30 **Local Climate Change and Renewable Energy Targets** – Many local authorities have developed renewable energy targets for new developments in their area. These became known as the 'Merton Rule' after the London Borough of Merton which was the first local authority to introduce such targets.

1.31 The Scottish Government has set 15 National Outcomes, several of which are relevant for biomass, in particular:

- We value and enjoy our built and natural environment and protect it and enhance it for future generations.
- We reduce the local and global environmental impact of our consumption and production.

1.32 Each Scottish local authority has now agreed its **Single Outcome Agreement** (SOA) with the Scottish Government. SOAs set how local authorities will work towards improving outcomes for residents in a way that reflects local circumstances and priorities within the context of the National Outcomes.

1.33 **Support and Funding** – Funding and support for the use and production of biomass is available from many organisations and schemes, including:

- The Scottish Biomass Heat Scheme
- The Scottish Rural Development Programme
- Regional Biomass Advice Network
- The Community and Renewable Energy Scheme (CARES)
- Enhanced Capital Allowances
- EU funding for research, demonstration and Intelligent Energy Europe, which may fund information dissemination and study tours
- Low Carbon Buildings Programme (closed for new applications in May following change in UK Government)
- The Carbon Emission Reduction Target (for energy supply companies)
- The Carbon Trust
- Energy Saving Scotland Home Renewables
- Community Renewables toolkit

The Policy Context (Air Quality)

1.34 The House of Commons' Environmental Audit Committee reported in March 2010 that poor air quality reduces the life expectancy of everyone in the UK by an average of seven to eight months and up to 50,000 people each year may die prematurely because of it. Air pollution also causes significant damage to ecosystems (see Chapter 1 Reading Links). Consequently, policies to reduce concentrations of pollutants in the air are aimed at countering the negative effects of air pollutants. Air quality standards are still failing to be met in many parts of the UK, particularly in densely populated urban areas.

1.35 The most widespread air quality problems relate to contribution from particulate matter (PM), nitrogen dioxide (NO_2) and ozone (O_3), with PM being the pollutant most strongly associated with biomass combustions. Particulates are referred to as PM_{10} or $PM_{2.5}$ with the number denoting their maximum size in micrometers. The smaller particles ($PM_{2.5}$) are understood to have the greatest effect on human health. PM and NO_2 are strongly associated with combustion processes; vehicles normally being the most significant source of both. O_3 is a product of polluted air reacting in strong sunlight; as a long-lived pollutant it can often build up to significant concentrations well away from the urban areas where the pollutants are emitted.

1.36 Developments in air pollution policy during the 1990s resulted in the UK Government introducing the first **National Air Quality Strategy** in 1997 as a requirement of the Environment Act 1995. A series of national air quality standards and objectives was also introduced. The Act also established **Local Air Quality Management** (LAQM) as a way to address localised 'hot spots' of poor air quality which could not be resolved effectively through national policy measures. Following devolution, a revised Air Quality Strategy for England, Scotland, Wales and Northern Ireland was published in 2000 with an addendum issued in 2003.

1.37 Since the development of the first Air Quality Strategy legally binding standards for several air pollutants have been set at a European level, including standards for PM_{10}, $PM_{2.5}$ and NO_2. These EU standards have been incorporated into revisions of the UK Air Quality objectives and Air Quality Strategy, the most recent revision having taken place in 2007 (note that objectives for $PM_{2.5}$ are not as yet incorporated in the LAQM regime). Details of the current air quality standards are presented in Appendix D.

1.38 The 2007 revision introduced a target value and exposure reduction target for $PM_{2.5}$, the former to be achieved by 2020. The exposure reduction target calls for a 15% cut in urban background exposure between 2010 and 2020. Urban areas are defined as agglomerations with a population over 100,000.

1.39 The **Scottish Government** has introduced tighter PM_{10} and $PM_{2.5}$ air quality objectives than the rest of the UK. Whilst these objectives are not enforceable by the European Commission, they are applicable to LAQM in Scotland.

1.40 In 2008 a new **European Air Quality Directive** came into force. This tidied up existing legislation by merging several Directives into one, introduced standards for $PM_{2.5}$ and provided member states with a means of applying for 'compliance flexibilities' (deadline extensions) to address breaches of air quality standards. The UK has applied for an extension to meet PM_{10} standard and is in the process of doing so for NO_2. The applications will need to be accompanied by a robust plan for achieving the standards by the new deadlines.

1.41 The LAQM regime requires individual local authorities to periodically assess air quality and identify locations within their boundary where the air quality objectives may be exceeded by their target dates. Where any such exceedences are predicted, and where there is relevant public exposure, local authorities have a duty to declare **Air Quality Management Areas** (AQMAs). Such designations are a statutory requirement and UK local authorities have a duty to work towards achieving the air quality objectives based upon standards for seven key pollutants. The legislative basis for LAQM in England, Scotland and Wales is the Environment Act 1995 and in Northern Ireland the Environment (Northern Ireland) Order 2002.

1.42 Following the designation of AQMAs, local authorities are required to develop **Air Quality Action Plans** (AQAPs) to identify and implement actions to improve air quality locally. Such plans require effective collaboration between authority departments and external agencies and stakeholders (e.g. SEPA, Transport Scotland and industry). Land-use planning and transport planning underpin the development of effective AQAPs.

1.43 Local authorities have taken different approaches to establishing AQMAs. Some have declared only the exact areas where exceedences are expected to take place; this often leads to the declaration of multiple AQMAs in, for example, a city centre. Others have chosen to declare the whole area around where exceedences are found to form a single AQMA or even make a whole administrative area declaration (common in London). It should therefore be noted that air quality standards might not be exceeded across an entire AQMA.

1.44 Local authorities have been provided with technical and policy guidance by the Scottish Government to assist them with their duties under LAQM. The technical guidance applies UK wide and was last updated in 2009. The policy guidance was also updated in 2009 and only applies to Scotland; there are separate documents for other UK administrations.

1.45 The Environment Act 1995 also forms the legislative basis linking the actions of SEPA (the environmental regulator) and the Air Quality Strategy. The Act requires SEPA to 'have regard to the Air Quality Strategy in discharging pollution control functions'. Broadly this means that regulators will base permit conditions for applicable installations upon Best Available Techniques (BAT). This is covered in more depth in Chapter 3.

Chapter 1 – Reading Links

- Environmental Protection UK Biomass Guidance Update Page

  (http://www.environmental-protection.org.uk/biomass)

- Environmental Protection UK Planning Guidance

  (http://www.environmental-protection.org.uk/assets/library/documents/8691_Air_Quality_Guidance_(final_web).pdf)

- The Scottish air quality website and database

  (http://www.scottishairquality.co.uk/)

- The UK Air Quality Archive (UK Air Quality portal)

  (http://www.airquality.co.uk/)

- Air Quality Strategy Objectives

  (http://www.airquality.co.uk/standards.php)

- Scottish Government LAQM Technical and Policy Guidance

  (http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/TG09)

  (http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6151)

- Environment Agency Report 'Biomass – carbon sink or carbon sinner?'

  (http://www.environment-agency.gov.uk/business/sectors/32595.aspx)

- The Scottish Government's Renewables Action Plan

  (http://www.scotland.gov.uk/Publications/2010/08/02141416/0)

- The Scottish Government's Renewables Heat Action Plan

  (http://www.scotland.gov.uk/Publications/2009/11/04154534/17)

- The House of Commons' Environmental Audit Committee report on air quality

  (http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/229/22902.htm)

- Scottish Government's "Review of Greenhouse Gas Life Cycle Emissions, Air Pollution Impacts and Economics of Biomass Production and Consumption in Scotland" report

  (http://www.scotland.gov.uk/Publications/2006/09/22094104/0)

- DECC Annual Energy Review

  (http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20UK%20energy%20supply/237-annual-energy-statement-2010.pdf)

Chapter 2 – Boilers, Fuels, Standards and Certifications

2.1 The performance of a biomass boiler will depend heavily upon the design of the boiler and the type of fuel used. The relationship between the boiler and the fuel is crucial – boilers are usually designed to burn a specific fuel type and quality. Deviation from this fuel specification without adjustments to the boiler set up can lead to poor efficiency and increased emissions of air pollutants.

2.2 Current UK and EU wide emission standards for biomass boilers are largely inadequate as tools for setting demanding air quality conditions, as they mostly do not directly cover emissions for NO_x, $PM_{2.5}$ and PM_{10}.

2.3 Emission standards and eco-labels have been developed in other European countries and may be quoted in the information provided to local authorities. These standards are however difficult to apply to the UK due to a wide range of approaches used for testing cycles and emissions measurement. Whilst emission standards provide some general indication of how polluting an appliance may be, compliance with emission standards cannot guarantee that breaches of the LAQM air quality standards will be avoided.

2.4 This chapter provides a brief overview of boilers, fuels, standards and certification. More detailed information on boilers and fuels can be found in Appendices A and B as well as the Carbon Trust document 'Biomass heating: a practical guide for potential users'.

Biomass Boilers

2.5 Biomass appliances usually fall into two categories – batch fuelled or continuously fired. Batch fuelled appliances are usually small (<50kW output) units fuelled by logs or lump wood. They can be stoves, where the main output is the direct heating of the room they are situated, or hot water boilers. Until the recent introduction of pellet stoves, log fuelled batch units were the only type found in the domestic sector where they still make up the majority of sales. In a continuously fired boiler, or stove, fuel is added continuously to the combustion air in the correct proportion to give the desired heat output. Combustion air is regulated to match. In general continuously fired appliances have lower emissions of pollutants than batch fuelled appliances.

2.6 In continuously fired appliances two main fuels are used: (i) wood chips and (ii) pellets. Pellets are a modern form of manufactured biomass fuel and they have many advantages. They are free flowing with low moisture content and a consistent size and geometry. Designing an efficient and effective combustion device is therefore much simpler, when compared with other fuels. Pellets can be a more expensive fuel than chips, however the simplicity and convenience they provide often outweighs the additional cost, particularly in smaller installations.

2.7 In terms of emissions, the performance of appliances varies significantly, however some generalisations can be drawn and are shown in Table 2.1.

Table 2.1: Broad Factors Affecting Emissions
(note that these are generalisations only and emissions will vary significantly between different makes and models of boilers)

Appliance category	Continuously fired appliances tend to have lower emissions than batch fired appliances as the combustion conditions are more consistent.
System design	Boilers that are on for long periods of time tend to have lower emissions than those that have to start up and shut down regularly. Unlike gas or oil boilers biomass boilers do not 'like' to be stopped and started regularly or vary their output significantly. A system designed correctly around the estimated heat load, with a heat store (e.g. buffer tank) if necessary and should optimise efficiency and low emissions.
Automated maintenance	Automated maintenance systems (e.g. de-ashing, heat-exchange cleaning) usually mean the appliance is cleaner and more efficient.
Fuel type	Appliances burning wood pellets usually have lower emissions than those burning larger wood particles (i.e. chips and logs). However exact emissions will depend upon the fuel quality and in particular its moisture content.

2.8 More detailed information on biomass appliances and their operation is available in Appendix A and in the Carbon Trust document 'Biomass heating: a practical guide for potential users'.

Biomass (Wood) Fuels

2.9 Wood fuels are available in a variety of different formats and qualities. The most common formats for wood fuels are shown in Table 2.2.

Table 2.2: Common Wood Fuel Formats and their Utilisation

Fuel format	Utilisation
Logs	Batch fuelled. Most commonly used in small-scale systems (<50kW$_{th}$ – domestic to light commercial scale) requiring daily input to load the system with fuel.
Bales (of wood)	Generally either manually fed 'batch-firing' systems below 300kW$_{th}$ (as above, requiring daily input to load the system with fuel) or alternatively very large (multi-MW$_{th}$) automatically-fed heating/CHP plant.
Pellets	Most commonly used in smaller or urban systems (light commercial <150kW$_{th}$) due to their greater energy density, although 1MW+ pellet fuelled systems are in use. Wood pellets are also used for 'co-firing' within existing electricity power stations.
Chipped/shredded wood	Typical fuel for most automated biomass systems (50kW$_{th}$ – multi-MW$_{th}$ applications).
Woodworking off-cuts / sawdust	Some biomass plant is specifically designed to burn co-products from the wood industries such as furniture off-cuts and sawdust.

2.10 Wood fuels will also vary in their characteristics. A detailed list of wood fuel characteristics is listed in Appendix B, however they can generally be described under three headings:

- Physical characteristics (including particle size, bulk density, moisture content and energy density)
- Biological characteristics (including the presence of any allergens and carcinogens)
- Chemical and combustion characteristics (including chemical make-up and ash content)

2.11 Successful operation of a biomass heating system is strongly dependent on the use of properly specified fuel. To aid the matching of heating systems with fuel supplies, fuel standards have been introduced in several European countries. One of the best known sets of standards are the Austrian Önorm standards which specify size, moisture content and various other important properties of solid biomass fuels. These standards are being used by some UK fuel suppliers in the absence of equivalent UK standards.

2.12 The CEN (European Committee for Standardisation) is developing a common methodology for specifying the key characteristics of all forms of solid biomass sold within the EU and also methods for testing these properties. The CEN specifications will eventually be transposed into member states' standards systems (e.g. those of the British Standards Institute). At the time of writing, the specifications are available only in draft form yet they are sufficiently well developed to be suitable for reference in fuel supply contracts and the final versions are likely to be very similar. They can currently be downloaded from the Biomass Energy Centre – a 'one stop shop' for information on biomass fuels and associated conversion technologies (www.biomassenergycentre.org.uk).

2.13 Regardless of which set of standards are referred to, it is important that the site owner works closely with both the fuel supplier and system installer to ensure that:

- The fuel purchased is suitable for the system,
- The fuel supplier undertakes to deliver a consistent quality of fuel,
- The fuel can be stored and handled at the site in the correct manner.

Emission Standards and Certification

EN Standards

2.14 Table 2.3 lists European EN standards for residential solid fuel appliances and for independent boilers with nominal heat output up to 300kW. The Standards include minimum requirements for efficiency, construction and safety of appliances. No EN Standards include NO_x emission performance criteria and only EN 303 Pt 5 (the independent boiler Standard) includes PM emissions criteria. EN Standards for residential appliances are harmonised and mandatory across the EU; EN 303 Pt 5 however is not a harmonised Standard.

2.15 A harmonised Standard is a European standard prepared by CEN/CENELEC under a mandate from the Commission with a view to fulfilling a requirement of a specific Directive (in the case of residential heating appliances this is Directive 89/106/EEC the Construction Products Directive).

Table 2.3: Residential Solid Fuel Appliance EN Standards

Standard	Harmonised	Title
EN 303 Pt 5	No	Heating boilers - Part 5: Heating boilers for solid fuels, hand and automatically stocked, nominal heat output of up to 300kW - Terminology, requirements, testing and marking.
EN 12809	Yes	Residential independent boilers fired by solid fuel - Nominal heat output up to 50kW - Requirements and test methods.
EN 12815	Yes	Residential cookers fired by solid fuel - Requirements and test methods.
EN 13229	Yes	Inset appliances including open fires fired by solid fuels - Requirements and test methods.
EN 13240	Yes	Room heaters fired by solid fuel - Requirements and test methods.
EN 14785	Awaiting formal publication	Residential space heating appliances fired by wood pellets - Requirements and test methods.
EN 15250	Awaiting formal publication	Slow heat release appliances fired by solid fuel - Requirements and test methods.
prEN 15281 (under development)	—	Sauna stoves fired by solid fuel - Requirements and test methods.
prEN 15544 (under development)	—	One off tiled / mortared stoves - Dimensioning.

2.16 Many of the heating appliances covered by the EN Standards for residential appliances can also include boilers in addition to the primary heating (or cooling) function. EN 12809 includes boilers that also provide a space-heating function. Boilers that do not provide a space-heating function are covered by EN 303 Pt 5 which applies to solid fuel boilers up to 300kW output. This Standard defines an efficiency testing procedure and also assigns performance classes based on efficiency and emissions of PM, CO and ‘organic gaseous carbon’ (OGC) – classes for Total PM emissions are summarised in Table 2.4.

Table 2.4: Summary of EN 303 Pt 5 Total PM Emission Classes				
Stoking	**Nominal heat output** kW	**Emission limit,** mg/m³ dry at STP (0°C, 101.3kPa) and 10% O_2		
		Class 1	Class 2	Class 3
Manual	≤50	200	180	150
	>50 to 150	200	180	150
	>150 to 300	200	180	150
Automatic	≤50	200	180	150
	>50 to 150	200	180	150
	>150 to 300	200	180	150

2.17 Although EN 303 Pt 5 includes PM limit values it is not a harmonised Standard and the Standard indicates that national requirements in several member states (including the UK) differ from the Standard in terms of PM measurement protocols and permitted emissions.

2.18 In addition to the performance Standards, there is a draft EN Technical Specification for measurement of gaseous emission components. A draft EN Technical Specification for particulate measurements has not been agreed.

UK Emission Standards

2.19 Solid fuel furnaces up to 20MW$_{th}$ (thermal input) are generally regulated under the Clean Air Act (CAA). For combustion appliances above 20MW$_{th}$, the Pollution Prevention and Control Regulations (PPC) will apply. Appliances smaller than 20MW$_{th}$ can also fall under PPC, e.g. if they are burning waste. Regulatory regimes are covered in more detail in Chapter 3.

2.20 The CAA was introduced to control air pollution arising from widespread use of coal and includes provision for the creation of Smoke Control Areas, general controls on some emissions and emission limits (for grit and dust) for larger solid fuel combustion installations.

2.21 Within a smoke control area appliances either must burn authorised 'smokeless' fuels or the appliance needs to have been assessed and exempted by the Scottish Government for use in some control areas (for further information see http://www.uksmokecontrolareas.co.uk). Emission limits for exempted appliances are detailed in BS PD 6434 covering residential combustion (smaller than about 44kW output). Emission limits for 'grit and dust' are applied to larger appliances (greater than about 240kW output) irrespective of whether they are located in a Smoke Control Area. Assessment of emissions from appliances greater than about 44kW for CAA exemption is generally by interpolation between the BS PD 6434 limits and the grit and dust emission limits.

2.22 If an activity falls under PPC then controls on other pollutants (in addition to PM) can apply.

Other National Regulations

2.23 A number of countries apply emission controls to biomass / wood combustion appliances. For residential appliances, these are generally applied under 'type approval' arrangements under which the manufacturer undertakes tests on an example appliance to assess compliance with emission limits (and EN product Standards). Table 2.5 provides a summary of countries applying emission limit values for biomass combustion.

Table 2.5: Countries Applying Emission Limits for Biomass Combustion

Country	Emission limit value (ELV)		Comment
	NO_x	PM	
Austria	X	X	ELVs applied to residential appliances and several size ranges of larger boilers including 50-100kW, 100-350kW. Different NO_x ELVs applied for different wood types.
Belgium		X	Proposed PM ELVs for residential appliances.
Denmark		X	PM ELVs for roomheaters and <300kW boilers.
Finland		X	Proposed PM ELVs for residential and <300kW boilers but will distinguish between primary and secondary heat providers.
Germany		X	PM ELVs for residential and larger biomass boilers. Proposed to extend ELVs to cover room heaters and other domestic appliances.
Sweden			VOC ELVs.
Switzerland		X	PM ELVs for room heaters and boilers.
USA / Canada		X	Wood stove performance standards.
Australia		X	Selected areas only.
New Zealand		X	Wood burners on properties less than two hectares.

2.24 Several of these countries have emission measurement Standards or protocols, however a range of approaches are adopted which means that it can be difficult to compare results between countries. The differences in measurement procedure concern test cycles (e.g. whether to include start-up emissions) and emission measurement procedures. The differences in measurement procedure also include whether the procedure only looks at (i) filterable material or (ii) filterable and condensable material also whether measurements are undertaken directly on the chimney flue or through a dilution chamber.

Ecolabelling and Other Emission Controls

2.25 There are a number of ecolabel and biomass grant schemes in Europe that specify performance criteria that are typically higher than the minimum efficiency requirements of the EN product Standards and national regulations. A number of these ecolabel schemes recognise the importance of PM emission and include criteria for assessment. Table 2.6 provides a summary of ecolabelling criteria for biomass combustion with selected weblinks to further information. **A number of products are available in the UK market with one or more ecolabels but note that compliance with an ecolabelling scheme does not indicate that a product is an exempt appliance under the Clean Air Act.**

Chapter 2 – Reading Links

- The Carbon Trust: 'Biomass heating: a practical guide for potential users'– this document includes a detailed introduction to the technicalities of fuel and plant operation (registration required to download)

  (http://www.carbontrust.co.uk/Publications/pages/publicationdetail.aspx?id=CTG012&respos=2&q=Biomass&o=Rank&od=asc&pn=0&ps=10)

Table 2.6: Ecolabelling Criteria for Biomass Combustion

Ecolabel	Country	ELV		Comment
		NO_x	PM	
Blue Angel	Germany	X	X	Includes efficiency and limit values for wood pellet stoves and wood pellet boilers http://www.blauer-engel.de/en/index.php
Nordic Swan	Sweden, Norway, Denmark & Finland	(X)	X	Includes efficiency, PM and VOC limit values for various residential roomheater types and NO_x, PM and VOC limits for boilers <300kW http://www.svanen.nu/Default aspx?tabName=StartPage
EFA	European association of fireplace manufacturers		X	Higher efficiencies than product Standards and also PM ELVs for various residential room heaters www.efa-europe.com
Umweltzeichen 37	Austria	X	X	Higher efficiency and more stringent emission criteria than legislative limits for boilers and room heaters
Flamme Verte	France		X	Differs from other ecolabelling schemes in that criteria show an annual improvement. Efficiency criteria set for room heaters, additional PM and VOC ELVs for boilers http://www.flammeverte.org/
DINplus	Germany	X	X	VOC limit also set and also covers certification of pellet fuels http://www.dincertco.de/en/about_us/our_marks_of_conformity/quality_mark.html
Housing grants	Denmark		X	Efficiency and PM ELVs for biomass boilers
P marking	Sweden		X	Efficiency and PM ELVs for pellet boilers, pellet stoves and wood-fired roomheaters

Chapter 3 – Approvals and Consents

3.1 New biomass boilers will require regulatory approval and in many cases planning consent too. The latter may be required for a development as a whole in cases where the boiler is part of a new building development or, for new buildings, stacks, etc., where a biomass boiler is installed in an existing development.

3.2 This chapter provides only a brief description of biomass in the planning system and should be read alongside the Environmental Protection UK document 'Development Control: Planning for Air Quality'. Another source of guidance is the DEFRA document 'Low Emission Strategies' published as part of their LAQM guidance.

Biomass in the Planning System

3.3 In addition to meeting regulatory requirements, all but the smallest biomass installations will also require planning consent. The basic planning process for renewable energy is described on the BIS website (see reading links).

3.4 Biomass energy proposals >50MW fall within Schedule 2 of the **Environmental Impact Assessment (Scotland) Regulations 1999** (the EIA Regulations) and are subject to an **Environmental Impact Assessment** (EIA) if they are considered likely to have significant effects on the environment. Any 'thermal' biomass power stations with a heat output of at least 300MW would fall under Schedule 1 of the EIA Regulations meaning that an EIA would be mandatory (this also includes all heat plant that co-fire biomass and have an output >300MW).

3.5 The main planning legislation in Scotland is the **Town and Country Planning (Scotland) Act 1997**. The **Planning etc. (Scotland) Act 2006** amends the 1997 Act; from August 2009 the bulk of the 2006 Act is in force with regards to development planning and development management (including appeals, local reviews and enforcement).

General Permitted Development

3.6 Certain types of changes to properties can be made without the need to apply for planning permission. These are called 'permitted development rights' (PDR) and derive from general planning permission granted by the Scottish Parliament and not the local authority. In some areas of the country, known generally as 'designated areas', PDR are more restricted. These may include *inter alia* conservation areas and World Heritage Sites.

3.7 Local planning authorities can remove PDR by issuing an 'Article 4' direction. Article 4 directions are made when the character of an area of acknowledged importance would be threatened and they are most common in conservation areas. Planning departments can provide details of the status of permitted development in a local authority area. PDR tend to focus upon the visual impact of a development and it is imperative that air quality is not overlooked when considering such applications.

3.8 When a biomass boiler or CHP unit is installed in an existing property planning permission is not normally needed if all of the work is internal. Under the **Town and Country Planning (General Permitted Development) (Domestic Microgeneration) (Scotland) Amendment Order 2009** if the installation requires an external flue it will normally be permitted development as long as it:

- Does not exceed 1m above the roof height,
- In the case of land within a conservation area or a World Heritage Site, the flue would not be installed on the principal elevation of the building, and
- It is not located in an AQMA.

3.9 If the project also requires an outside building to store fuel or related equipment the same rules apply to that building as for other extensions and garden outbuildings.

3.10 Further information about permitted development is available on the Planning Portal website (see Chapter 3 reading links).

Section 75 Agreements

3.11 Section 75 agreements are commonly known as 'planning gain'. They attach conditions to the grant of planning consent, e.g. for the developer to fund new community facilities or road improvements. The legislative basis for planning obligations is Section 75 of the Town and Country Planning (Scotland) Act 1997.

3.12 Section 75 agreements can also be used to mitigate air quality impacts. Planning and Advice Note 51 (PAN 51) (which was revised in 2006) outlines the statutory basis for applying a combination of planning conditions and legal obligations to address the environmental impacts of proposed developments. The use of the equivalent Section 106 agreements in England to mitigate transport impacts of development is extensively covered in the Beacon Councils' guidance 'Low Emission Strategies'.

Box 3.1: Examples of Section 75 Conditions

Assessment and Certification Conditions

An air quality assessment using dispersion modelling shall be carried out and submitted to the local authority to demonstrate that the stack height of the biomass boiler is sufficient to prevent emissions having a significant negative impact on the air quality objectives for NO_2 and PM_{10}. Where emissions are shown to result in an increase, a full discussion of any potential breaches of air quality criteria shall be provided and an outline of how emissions will be mitigated.

With regards to energy use on site, the biomass boiler must be certified as an exempt appliance in accordance with the Clean Air Act 1993. Evidence to demonstrate that the boiler has been tested and certified as an exempt appliance shall be provided to the local authority prior to installation. This shall be supplemented with the technical details of the biomass boiler.

Fuel Quality Conditions

The biomass boiler shall only be operated using clean wood pellets that comply with a recognised fuel quality standard (such as CEN/TS 14961:2005). A written guarantee shall be submitted to the local authority prior to commencement of the development with a declaration that wood pellets conform to a recognised fuel quality standard and will be consistently used in the biomass boiler. A statement shall be submitted to the local authority specifying the quantity of wood pellets used in the biomass boiler and the fuel specifications in accordance with CEN/TS 14961:2005 or a similar recognised standard. (The statement shall be obtained from the fuel supplier).

Maintenance Conditions

The biomass boiler shall be associated with a written schedule of maintenance which shall include removal of ash, inspection and maintenance of particulate arrestment equipment, boiler servicing and stack cleaning. The maintenance schedule shall be submitted prior to installation.

Regulation of Biomass Plant

3.13 In common with other combustion appliances, biomass boilers and CHP units are subject to a range of regulatory regimes, depending on its size (based upon its rated thermal input) and the type of fuel it burns.

3.14 Biomass fuels generally fall into three categories depending on whether the fuel is classified as waste and whether it falls under the **Waste Incineration Directive** (WID):

- 'Virgin' fuels, e.g. fuels derived from fresh timber
- Waste or waste derived fuels exempt from WID, e.g. agriculture residues
- Waste or waste derived fuels covered by WID, e.g. treated wood waste

Regulatory Regimes

Pollution Prevention and Control

3.15 The **Pollution Prevention and Control (Scotland) Regulations 2000** (as amended) (the PPC Regulations) came into force on 14 September 2000. Prescribed installations are regulated by SEPA. Part A installations tend to be larger and more complex and permits will contain conditions regarding emissions to air, land and water as well as covering issues such as noise and waste minimisation. Part B installations tend to be smaller and less complex and permits will contain conditions regarding emissions to air only.

Best Available Techniques

3.16 The PPC regulations require SEPA to ensure that installations are operated in such a way that all the appropriate preventative measures are taken against pollution, in particular through the application of **Best Available Techniques** (BAT). The essence of BAT is that the selection of techniques to protect the environment should achieve an appropriate balance between the environmental benefits they bring and the costs to implement them. In seeking through the application of BAT to balance costs to the operator against benefits to the environment, the PPC Regulations define BAT as:

- "The most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole; and for the purpose of this definition:
- "Available techniques" means those techniques which have been developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages, whether or not the techniques are used or produced inside the United Kingdom, as long as they are reasonably accessible to the operator;
- "Best" means, in relation to techniques, the most effective in achieving a high general level of protection of the environment as a whole; and
- "Techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

3.17 The PPC Regulations require Environmental Quality Standards (EQSs), such as air quality limit values, to be taken into consideration. BAT is site specific and there may be circumstances where SEPA will require that the performance of a piece of equipment will exceed BAT, in order to ensure that EQSs are not breached.

Waste Incineration Directive

3.18 The incineration or co-incineration of solid and liquid waste in a technical unit is likely to fall under the Waste Incineration Directive (WID). The WID aims to minimise the impacts on the environment and human health of emissions to air, land and water from the incineration or co-incineration of hazardous and non-hazardous waste. It was introduced by the European Parliament and Council on 4 December 2000 and introduced into Scottish Law by the Waste Incineration (Scotland) Regulations 2003 on 1 April 2003.

3.19 All incineration or co-incineration plants must be authorised under the PPC regulations. Permits are issued by the Scottish Environment Protection Agency (SEPA) that will list (i) the categories and quantities of waste which may be treated, (ii) the plant's incineration or co-incineration capacity and (iii) the sampling and measurement procedures which are to be used. Strict rules will be imposed upon the process to retain the waste at a sufficient temperature to guarantee complete waste combustion and stringent Emission Limit Values (ELVs) will be placed on the emissions from the plant including emissions to air of hydrogen chloride, hydrogen fluoride, heavy metals, SO_x, NO_x, dioxins and furans.

3.20 Plants treating only wood waste (with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating) are excluded plants under the WID.

The Large Combustion Plant Directive (LCPD)

3.21 The LCPD was introduced by the European Parliament and Council on 23 October 2001. The LCPD introduced measures to control the emissions to air of NO_x, SO_2 and PM (dust) from large combustion plants (i.e. plant with a rated thermal input equal to or greater than $50MW_{th}$. The LCPD defines three categories of plant – with a group of boilers discharging through a single stack being counted as a single combustion plant:

- "New-new" plant which are subject to request for a licence on or after 27 November 2002; these must comply with the Directive and meet ELVs from when they are brought into operation.
- "New" plant – licensed on or after 1 July 1987 but before 27 November 2002, or subject to a full licence request before 27 November 2002 and which came into operation before 27 November 2003; these

must comply with the Directive and meet ELVs from 27 November 2002.

- "Existing" plant – licensed before 1 July 1987; for this category member states may choose to meet required emissions reduction by 1 January 2008, either through ELVs or a National Emissions Reduction Plan (NERP).

3.22 The UK's NERP set a 2008 emissions 'bubble' for total emissions of (per annum): SO_2 – 133,345 tonnes, NO_x – 107,720 tonnes and dust – 9,659 tonnes. Emission trading between participating plants is allowed.

3.23 Individual operators of existing plant may alternatively choose not to be included in the ELV or national plan approach and instead undertake to close down after 20,000 operational hours beginning 1 January 2008 and ending 31 December 2015. Operators had to inform the competent authority (i.e. the Regulators) of their decision before 30 June 2004. Implementation of the LCPD is through IPPC (Integrated Pollution Prevention and Control) permits.

The Clean Air Act

3.24 The Clean Air Act 1993 is the primary regulatory legislation for smaller biomass burning plant (domestic and commercial) that fall outside the PPC system. Local authorities are the regulating body for the conditions of the Act. The most commonly known parts of the Act are those that allow local authorities to set up Smoke Control Areas (Sec. 18) where premises are committing an offence if they emit smoke unless using an approved smokeless fuel or an exempt (approved) appliance. The Act also contains other powers regarding the control of emissions from large domestic and industrial boilers. Application of the Act to biomass plant is summed up in Chart 4.3 and described in more detail below.

3.25 When assessing which regulations apply to a particular biomass boiler it is important to note that the moisture content of the fuel can affect the calorific value of that fuel. An increase in moisture content leads to lower calorific values and lower thermal inputs for a given weight of fuel burnt. For example, a furnace burning fuel with a calorific value of 10MJ/kg at 45.4kg/h would represent 126kW (input). A lower moisture content may raise the calorific value to 20MJ/kg, and this would increase the thermal input to 252kW (input). A unit conversion tool has been developed for this guidance – this is in the form of a spreadsheet which is available to download from the Environmental Protection UK website (See Chapter 3 reading links).

3.26 It is important to note the limitations of the CAA which was designed to control the coal smoke smogs of the 20th Century. The CAA does not directly control emissions of the smaller particles ($PM_{2.5}$ and PM_{10}) that are the subject of modern air quality legislation. The cumulative impacts of a large number of exempt appliances (for example) could therefore be significant. Assessing cumulative impacts is discussed in Chapter 5.

Smoke from Chimneys

3.27 The CAA allows local authorities to create Smoke Control Areas (Sec. 18) in which visible smoke emission is prohibited (Sec. 20) unless arising from the burning of authorised fuel or from the use of an exempt appliance. Procedures for testing and approving authorised fuels and appliances have been established via powers given to the Secretary of State under Secs. 20 and 21. Details of currently authorised fuels and exempt appliances can be found on the UK Smoke Control Areas website (see Chapter 3 reading links).

3.28 The acquisition or delivery of a non-approved solid fuel in a Smoke Control Area (other than to be used in an exempt appliance) is an offence (Sec. 23).

3.29 Smoke Control Areas are relatively common across the UK, primarily in urban areas that have had a concentration of industry and / or coal fired dwellings. Unfortunately, due to the passage of time and the age and number of the individual orders passed to establish Smoke Control Areas there are no easily available records for the location of the areas in some authorities (although the local authority can re-designate if necessary). The Scottish Air Quality website contains a map that shows the local authorities that have a Smoke Control Area in place (http://www.scottishairquality.co.uk/laqm.php?a=s&la_id=).

3.30 Knowledge of the conditions of Smoke Control Areas under the CAA can be low amongst the general public and also in some cases amongst installers of smaller wood burning appliances. Some people may be simply unaware that they are committing an offence by burning wood in non-exempt appliances (e.g. open grate fires). Awareness raising can therefore be an effective tool with information for the general public available on the UK Smoke Control Areas and Environmental Protection UK websites (See Chapter 3 reading links).

Emissions from Commercial Premises

3.31 CAA provisions for commercial and industrial premises apply everywhere i.e. not just in designated Smoke Control Areas.

3.32 Under Section 1 of the CAA it is an offence to emit dark smoke from industrial / commercial chimneys unless within the limited periods allowed by the dark smoke permitted periods regulations. Sources of dark smoke can include chimneys, bonfires, skip fires and waste disposal / demolition fires. 'Dark smoke' is defined using a Ringelmann smoke chart; British Standard approved versions of these are available to purchase online.

3.33 Under Section 4 of the CAA before installing a furnace (except a domestic furnace) in a building or fixed boiler, the local authority must be informed. Any such furnace must be capable of being operated continuously without emitting smoke when burning fuel of a type for which the furnace was designed. There is no definition of 'furnace' but a practical interpretation of this word whenever it appears in clean air legislation is usually taken as "any enclosed or partly enclosed space in which liquid, solid or gaseous matter is burned, or in which heat is produced". Domestic furnaces are defined as those with a maximum heating capacity of <16.12kW.

3.34 Larger furnaces fall under the so called 'grit and dust' provisions of the Act. Here the use of a furnace burning solid fuel at 45.4kg/h or more or liquid and gas fuels at 366.4kW or more (other than a domestic furnace) is prohibited unless it has grit and dust arrestment plant fitted which has been agreed by the local authority or unless the local authority has been satisfied that the emissions will not be prejudicial to health or a nuisance (Sec. 6). Emission limits on grit and dust from furnaces (other than domestic furnaces) are prescribed by the Secretary of State under Section 6.

Approval of Chimney (Stack and Flue) Heights

3.35 Effective dispersion of smoke requires an unobstructed flow of air that will disperse the smoke in such a way that the concentrations of pollutants are rendered significantly dilute before they arrive at neighbouring properties. For this reason, it is essential that the stack is well designed. Poorly designed stacks can result in poor dispersion and early grounding of the smoke, leading to neighbour disputes. In extreme cases, the local authority could ban the use of the equipment.

3.36 Local authorities are required to approve the chimney heights of furnaces which burn pulverised fuel and solid fuel at 45.4kg/h or more, or liquid and gas fuels at 366.4kW or more (Secs. 14 & 15). It is an offence to use the furnace if the chimney heights are not approved unless the local authority did not respond within four weeks (or a longer time if mutually agreed) following the provision of relevant information by the applicant.

3.37 There is more than one method available to calculate stack heights and not all methods of stack height calculation consider all pollutants, therefore the method for calculating a suitable stack height to allow sufficient pollutant dispersal should be agreed with an appropriate member of staff within the environmental protection services team.

Powers to Request Monitoring and Information

3.38 A local authority may request that monitoring of grit and dust emissions from furnaces be carried out. Where the furnace is burning pulverised fuel or solid fuel at 45.4kg/h or more, or liquid and gas fuels at 366.4kW or more, the local authority may direct that measurements of the dust emissions are made by the occupiers of the building (Sec. 10). However if the furnace is burning solid matter at less than 1.02tonne/h or liquid or gas at 8.21MW or less, then the local authority can be required to carry out the monitoring at its own expense. Section 36 of the CAA adds to this by requiring occupiers of buildings other than private dwellings or caravans to return estimates (not necessarily monitored) of the emission of pollutants from the premises when requested by the local authority.

3.39 Section 12 of the CAA gives local authorities the power to request information on the furnaces in a building, and the fuels or wastes burnt in them, to properly perform their functions under Sections 5 – 11 of the Act. Notice must be served in writing and the occupier must reply within fourteen days (or a longer time as may be limited by the notice). Note that whilst this applies to both domestic and commercial premises, it is unlikely that any domestic premises will fall under Sections 5 – 11. This power could be used where local authorities suspect breaches of regulations are taking place, e.g. where there is a suspicion that waste derived fuels are being burnt in an appliance designed for clean, new wood.

Chapter 3 – Reading Links
Planning

- Beacon Councils Low Emission Strategy Guidance (http://www.defra.gov.uk/environment/quality/air/airquality/local/guidance)
- Climate Change Northwest Biomass Guides for Planners (http://www.climatechangenorthwest.co.uk/news/archive/new-guidance-available-for-householders-developers-and-planners-on-using-biomass-wood-fuel-heating.html)
- Planning Portal – the Scottish Government's online planning and building regulations resource (http://www.scotland.gov.uk/Topics/Built-Environment)
- Planning and Renewable Energy on the BIS website (includes policy developments) (http://www.berr.gov.uk/whatwedo/energy/sources/renewables/planning/page18405.html)

Regulation

- DECC website (http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/planning/planning.aspx)
- UK Smoke Control Areas website (http://smokecontrol.defra.gov.uk/)
- Domestic smoke on the Environmental Protection UK website (http://www.environmental-protection.org.uk/neighbourhood-nuisance/domestic-smoke/)
- Unit conversion tool can be downloaded from www.environmental-protection.org.uk/biomass

Chapter 4 – Assessing Potential Impacts

4.1 Once a local authority receives notification that a biomass boiler is considered for a particular location (either through the planning process, enquiries to building control or as a Clean Air Act Section 4 notification) a number of steps need to be followed to assess whether the potential air quality impacts are significant. The first (and probably the most important step) is to collect basic information about the proposed boiler to enable a quick risk based assessment to be made. This may be followed by the collection of more detailed information, a screening assessment (such as the screening tool provided by Environmental Protection UK) and proceeding to a more detailed assessment if screening suggests that there may be a significant impact. Chart 4.1 sets out an approach to help local authority officers.

4.2 It is important to collate as much information as possible at the pre-application stage, to ensure the initial risk assessment covers all the potential risks of the proposed development; this should include boiler design specifications and an understanding of the local air quality. It is good practice at the pre-application stage for developers to engage with local authority representatives from environmental protection and planning departments to determine if there are any specific air quality risks associated with the proposed development. Factors to consider within an initial quick risk based assessment are shown in Table 4.1.

4.3 Note that even if this quick assessment suggests that there is very little risk to air quality the proposed boiler should still be checked to ensure it is compliant with the CAA and / or whether it needs a permit to operate (see Charts 4.2 and 4.3). Suitable conditions can then be added to the planning permission if necessary to ensure regulatory conditions are met, e.g. that the boiler is certified as an exempt appliance in accordance with the CAA or that a permit is gained from the appropriate regulator. The risk assessment of the proposed scheme relates to the risk to air quality at relevant receptors in the existing environment from the proposed development and to any additional receptors that may be included as part of the proposed development.

Chart 4.1: Factors to Consider in a Quick Risk Based Assessment

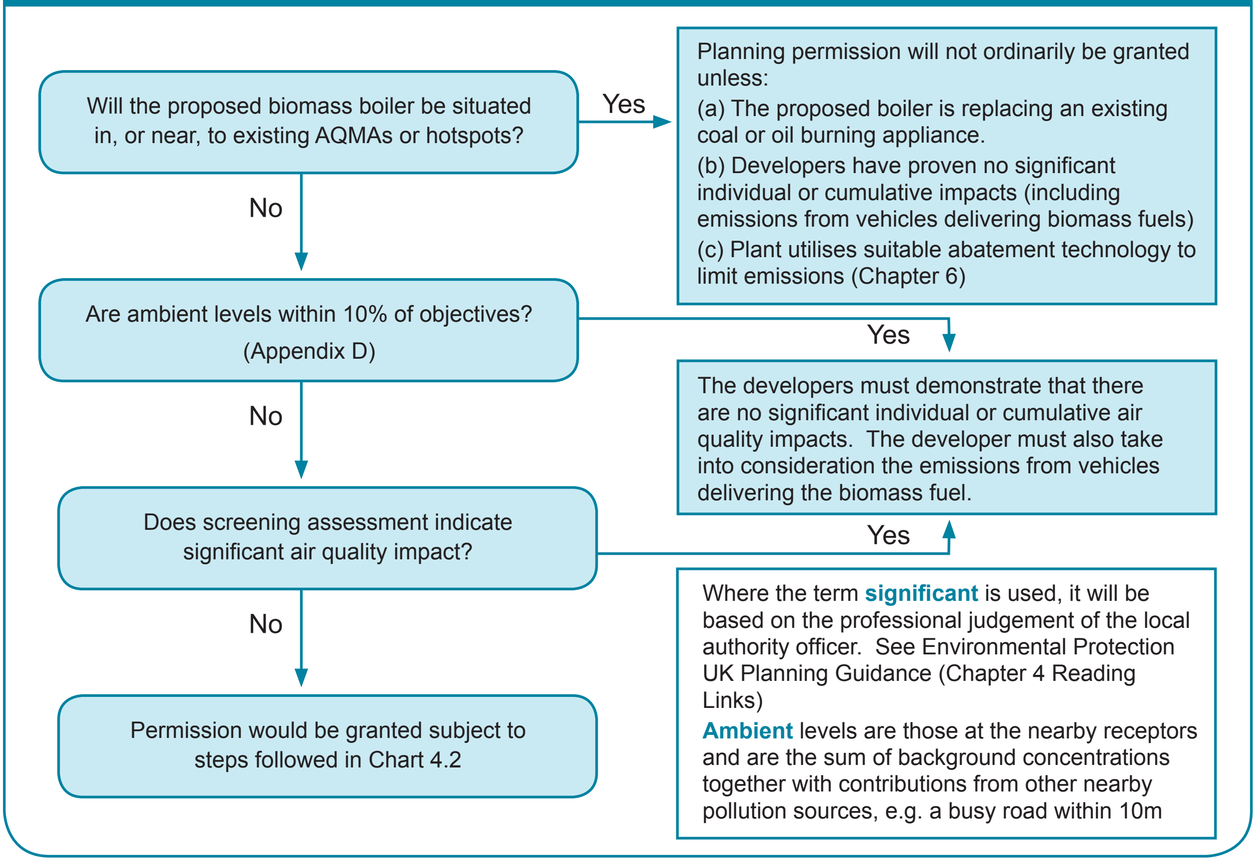


Table 4.1: Factors to Consider in a Quick Risk Based Assessment

Geography	The potential risk of a breach of air quality standards is increased if the boiler is in or near (and could potentially affect) an AQMA. If air quality in the area around the boiler is marginal there is a risk that emissions from the boiler could trigger a new AQMA. Does the terrain and surrounding land use result in air quality conflicts, i.e. is the installation in a valley with nearby properties at stack height or are there flats in the vicinity of the development that may put local residents at a height comparable to the stack emissions.
Fuel substitution/ alternatives	If the biomass boiler is displacing a similar appliance running on a 'clean' fuel such as gas then it will negatively affect air quality. Conversely if the boiler displaces 'dirtier' fuels such as coal or oil there may be little, or even a positive, effect on air quality. If the boiler is being installed on a site with no current combustion appliances some consideration of alternative fuels available should be made – i.e. are 'clean' fuels such as mains gas available, or are the realistic alternatives coal and oil?
Boiler size	Installed capacity will give an indication of emissions and the appropriateness of the boiler plant.
Emissions performance	Although a detailed assessment of the emissions performance of the boiler is unlikely to be available at this stage some simple questions can be asked, e.g. is it an exempt appliance? How does it compare against the general criteria in Table 2.1?
Fuel	Emissions performance for smaller appliances depends heavily on the fuel used. Clean, virgin wood fuels are likely to provide the best emission performance. Appliances burning wood pellets were thought generally to have lower emissions than those burning larger wood particles (i.e. chips and logs); however recent test data has shown that chip and pellet boilers can have similar emissions performance. The performance of the boiler will be dependent upon the consistency of fuel supply. Developers need to ensure there is a sufficient and secure supply of the required fuel quality for the boiler to achieve good emissions performance.

4.4 Note that the CAA is not necessarily sufficient to determine that there will not be adverse impacts from a biomass boiler. In addition to satisfying the CAA it is still necessary to check compliance of the plant and that it will not result in a nuisance or be detrimental to human health.

4.5 If the quick assessment suggests that the biomass boiler may pose a risk to air quality then more detailed information about the biomass boiler will be required. Collecting this at an early stage is key to making a good assessment however it is a step that many local authorities have found to be difficult. There are several reasons for this:

- Decisions on which renewable energy technologies to use are often left until after outline planning permission has been granted.
- The costs of the technical consultants and air quality assessments required to specify a biomass boiler can be high; developers may want to secure planning permission before incurring such costs.
- Planners and developers are often unaware that biomass boilers can have a detrimental impact on local air quality and that the emissions from different boiler types can vary significantly.

4.6 Flagging up air quality issues with planning colleagues and developers at the earliest stage possible is therefore extremely important. The developer's information leaflet produced alongside this guidance can be used for this purpose (www.environmental-protection.org.uk/biomass).

4.7 A biomass boiler information request form has also been produced alongside this guidance which local authorities can tailor to meet their needs in order to request information from developers. Again it is good practice to vary the depth of the information requested according to the risk to air quality suggested by the initial quick assessment. Where the developer is unable to supply information on their proposed appliance(s) generic figures may be available to use in screening assessments. However if this assessment suggests that air quality impacts may be significant, developers should be allowed the opportunity to supply more detailed information on their proposed appliance to enable a more accurate assessment to be made. See Chapter 4 Reading Links

4.8 Once basic information has been collected a screening tool can be used to make an initial assessment. If this shows that the impact may be significant the developer can then be asked to use more detailed dispersion modelling to make a more detailed assessment of the emissions and stack height. If the impact is still judged to be significant the developer can be asked to use abatement technology, choose a cleaner boiler or, if none of these are suitable, use a different renewable energy technology. A simple flow diagram of the process is shown in Chart 4.2. The process for checking CAA compliance is shown in Chart 4.3.

4.9 Energy Supply Company's (ESCO) contracts, which relate to quality standards of equipment, maintenance and fuel supply, may exist between developers and installers. ESCO contracts not-withstanding, it is the developers' responsibility to ensure the plant operates to the correct standards. To achieve certain air quality amenities it may be necessary to have a tall stack; if visual amenity is of high importance and the air quality impact is unacceptable then an alternative location or technology may be required.

4.10 There is no specific Government guidance on determining the significance of air quality impacts within an air quality assessment and the definition of what is a significant impact therefore ultimately lies with the judgement of the individual local authority. The Environmental Protection UK document 'Development Control: Planning for Air Quality' contains guidance on assessing significance which can assist is this area (updated in April 2010).

4.11 To support local authority duties under LAQM three help desks have been established by DEFRA and the Devolved Administrations - Monitoring, Modelling and Emissions Inventories (0870 190 6050), Review and Assessment (0117 328 3668) and Action Planning (0870 190 6050).

4.12 Smaller biomass boilers installed in existing dwellings may be fitted without notification to, or involvement of, the local authority. It is important to note that the provisions of the CAA in its existing form is not enough to ensure that localised increase of $PM_{2.5}$ and PM_{10} concentrations do not occur, especially if a number of small biomass boilers are installed in a particular geographical area. For all properties in a Smoke Control Area any installed appliances should be exempt and use permitted fuels.

Energy Statements and Basic Information About a Biomass Boiler

4.13 All local authorities in Scotland are now required to set renewable energy targets for all new developments and development plans. Developers submitting affected planning applications should include an Energy Statement to detail how the renewable energy target will be achieved. There is no Government guidance on what local authorities should ask developers to include in these statements however a common series of steps within a statement would be:

- A description of measures taken to reduce carbon emissions through energy efficiency (therefore reducing the total amount of renewable energy needed to meet the target).
- A calculation of the predicted energy demand and carbon emissions for the development and the amount of renewable energy provision needed to meet the target.
- A consideration of the technologies that could be used to generate the renewable energy requirement and their advantages / disadvantages for the particular development in question.

- A decision on the type of renewable energy system(s) to be installed and a calculation of their size to comply with the energy demand.

4.14 If a biomass boiler is proposed in the Energy Statement, basic information should be requested about the proposed system to enable an initial assessment to be made. As a minimum this should include:

- The thermal capacity of the proposed boiler and if possible its make and model;
- The type of fuel to be used and its availability;
- If the boiler is covered by the CAA, confirmation that it will be an exempted appliance;
- The precise location of the proposed stack(s).

4.15 To avoid time-consuming conversations for both sides it is advisable that guidance on air quality issues and the type of basic information needed to make an assessment should be provided to developers early in the planning process. It is essential that developers are informed of, and understand, the need to supply this basic information at the earliest stage possible.

4.16 If an Energy Statement is required the planning department should provide the guidance to the applicant regarding the format of the statement and the information that they would like to see included. Information regarding biomass and air quality can be provided to developers alongside (or integrated into) this guidance. The developers' information leaflet produced as a companion to this guidance document may be used for this purpose.

Chart 4.2: An Air Quality Assessment in the Planning Process for Biomass Boilers
(numbers in brackets refer to the relevant sections of this guidance)

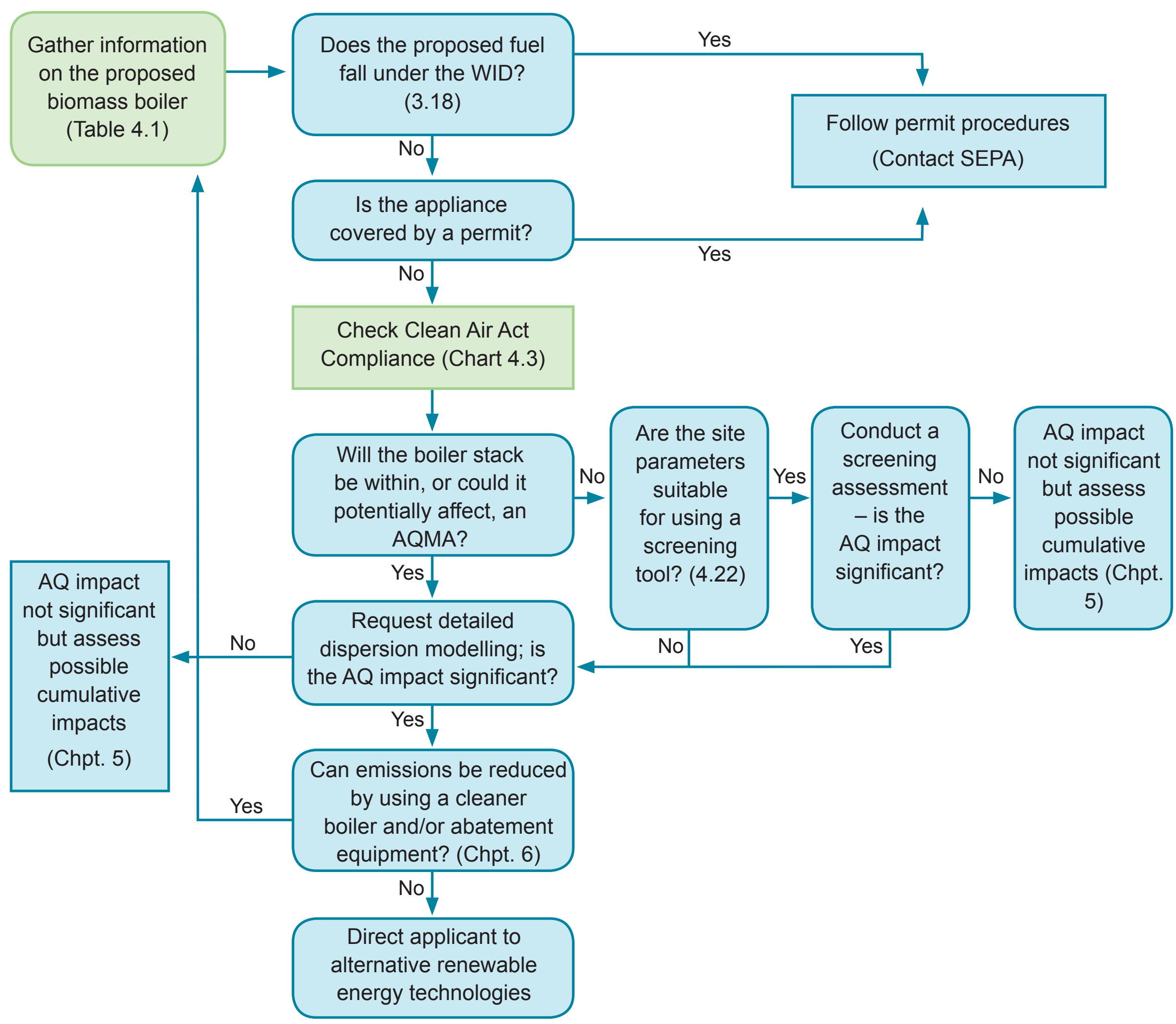
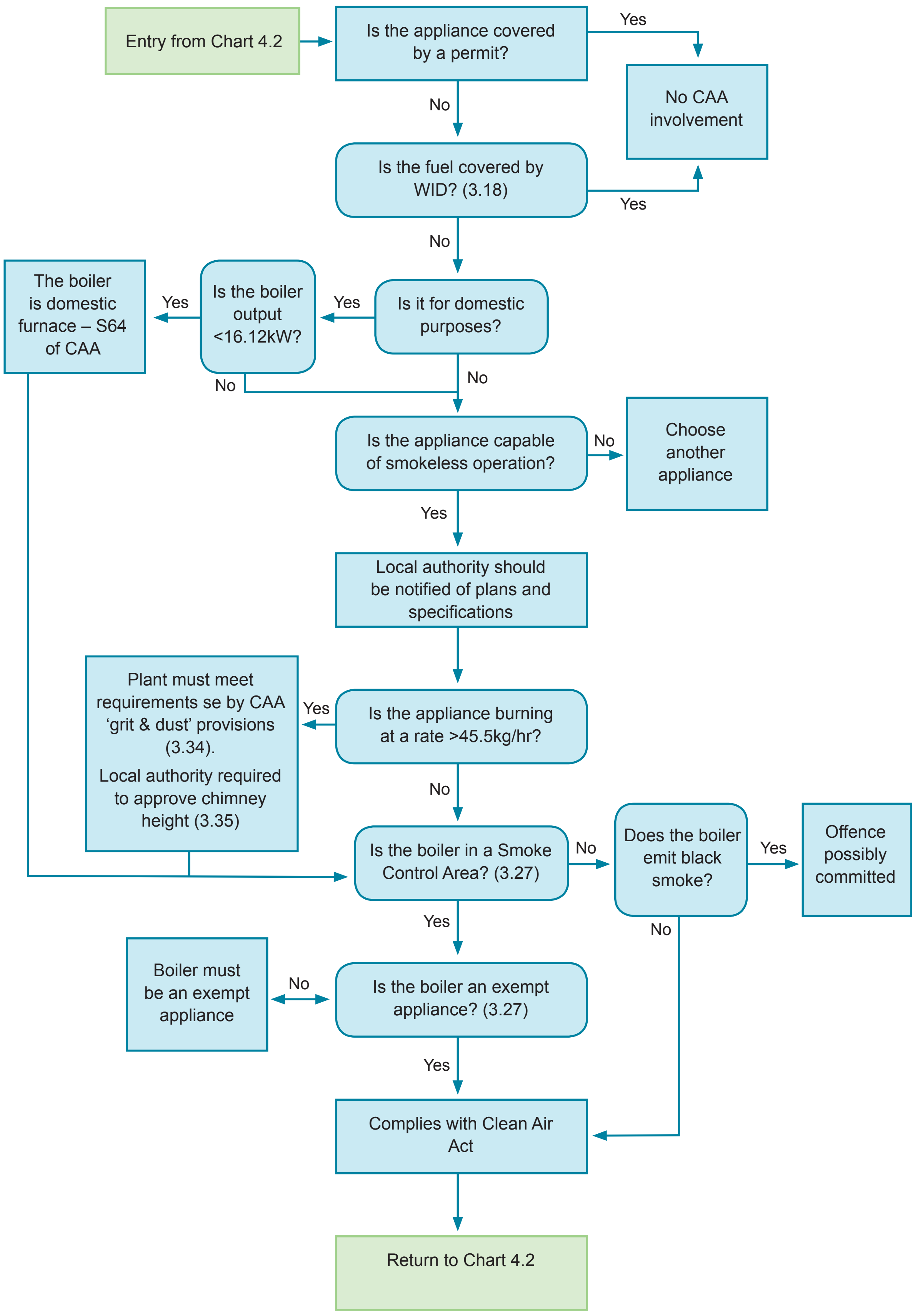


Chart 4.3: The Application of the CAA to Biomass Boilers
(Adapted from a chart produced by AEA Technology for London Councils)



Material Considerations at Planning

4.17 Once sufficient information is available a basic assessment on the suitability of the boiler can be made. Initially this can be a simple checklist:

- Does the boiler require a permit?
- Will the boiler be installed in a Smoke Control Area?
- If the boiler is to be installed in a Smoke Control Area, is it an exempt appliance? (see http://smokecontrol.defra.gov.uk)
- Is the development in an urban area with access to the gas grid?
- Is the boiler to be installed in, or close to, an AQMA / hotspot?
- Could the boiler emissions conflict with, or render unworkable, elements of a local authority's air quality action plan?
- Is air quality likely to be a material consideration in this planning application?

4.18 Any air quality consideration that relates to land use and its development is capable of being a 'material' planning consideration. However, the weight given to air quality in deciding the application will depend on such factors as:

- The severity of the impacts on air quality.
- The air quality at receptors in the area surrounding the proposed development.
- The number of receptors who experience an increase in exposure to pollutants, particularly non-threshold pollutants,
- The likely uses of the development, i.e. the length of time people are likely to be exposed at that location.
- The benefits provided through other material considerations.
- Does the proposal conflict with any local planning policy for biomass uptake, e.g. any policies developed in response to the DEFRA and Scottish Minister's statements (Box 1.2).

4.19 Ultimately the decision on whether air quality is a material consideration comes down to the significance of the effects of the development (and biomass boiler) on air quality. Whether the impact is 'significant' is a judgement made by the local authority and assessing significance can be a difficult process in some cases. The issue of significance of the air quality impacts of a development, and the likely outcomes in terms of planning decisions, is explored in Chapters 6 & 7 of the Environmental Protection UK guidance document 'Development Control: Planning for Air Quality'.

4.20 If air quality is judged to be a material consideration, the planning authority may introduce conditions that are more stringent than those associated with the regulatory regime. In some cases permission might be refused. Before these decisions are taken however, further information about the proposed system should be obtained and a more detailed assessment made.

Technical Information to Obtain on a Biomass Boiler / CHP System

4.21 Table 4.2 shows the type of information that should be collected to enable a more detailed assessment. A template information request form has been produced alongside this guidance document and is available to download. Note that this form is a template and the amount of information requested should be considered against the likely risk the biomass boiler poses to air quality.

Screening Assessment – LAQM Technical Guidance Nomographs

4.22 As part of the 2008/9 review of LAQM technical guidance, nomographs were developed to help local authorities screen the potential impact of both individual and multiple biomass boiler installations. Nomographs are graphical representations of numerical relations and are often used where a quick, approximate answer is appropriate and useful, for example with an air quality screening assessment of a point source. These nomographs should be used for screening purposes only and should not be used 'in reverse' to calculate stack heights. As part of the development of this guidance, spreadsheet versions of the nomographs have been produced and can be downloaded for use (see Chapter 4 reading links). Scotland is working to more stringent air quality objectives for PM_{10} and $PM_{2.5}$, and therefore it is important that the nomographs and screening tools specific

Table 4.2: Typical Information to Obtain on a Biomass Boiler	
Item	**Details of the proposed boiler**
Detail	This should include the make, model and capacity of the boiler, its combustion system, fuel feed system, emissions rates, whether it is fitted with an accumulation tank and details of any emissions abatement equipment fitted. If the boiler is to be installed in a Smoke Control Area its status as an exempt appliance under the Clean Air Act should also be confirmed.
Reasoning	This information on the basic design of the system will help to assess the emissions performance. Biomass boilers often produce relatively high emissions when lightly loaded, hence the need to ask about an accumulation tank (heat store) which can even out load.
Item	**Procedures for Boiler Operation and Maintenance**
Detail	This will include the maintenance schedule associated with the boiler, stack and abatement equipment (if fitted). Plans for identifying and rectifying system failures should also be requested.
Reasoning	System efficiency and emissions performance greatly depends upon regular maintenance.
Item	**Stack Details**
Detail	This will include the height and diameter of the stack, and details of the methodology used to calculate this. The grid reference of the stack should also be requested to help monitor possible cumulative impacts.
Reasoning	The design of the stack greatly affects how pollutants produced in the boiler disperse over the surrounding area. Where the area is heavily built up, or has existing air quality issues, dispersion becomes more complicated.
Item	**Fuel Details**
Detail	This will include details of the type of fuel used (including fuel standards), its compatibility with the proposed boiler and procedures in place to ensure consistent fuel quality. Arrangements for fuel storage and delivery should also be requested.
Reasoning	Emissions from a biomass boiler depend greatly on the type and quality of the fuel used. Reasonable guarantees are therefore needed that the fuel is compatible with the boiler, is of a high quality and that quality will be assured for a reasonable period of time.
Item	**Building Details**
Detail	This will include the height of the building the stack is attached to and details of neighbouring buildings (within a distance of five times the stack height from the chimney).
Reasoning	The height and distance of neighbouring buildings will determine their exposure to emissions from the biomass boiler and therefore the height of the stack needed.
Item	**Plans**
Detail	This will include a site plan of the development and the biomass infrastructure (boiler, stack, fuel stores and delivery routes).
Reasoning	These details can be used to ensure that fuel storage, reception and delivery areas are adequate.

to Scotland are used when considering biomass combustion proposals within Scotland.

4.23 To use the nomographs a minimum level of information is required:

- Height of stack above ground.
- Diameter of stack.
- Dimensions of buildings within a distance from the stack of five times the stack height above ground.
- Description of the combustion appliance.
- Maximum rates of emission of $PM_{2.5}$ and PM_{10} and NO_x when operating at capacity.

4.24 If the maximum rates of emission of the appliance are unavailable thermal capacity can be used instead. Local authorities may then estimate rates of emission based on the CAA exemption limits or on the basis of emission factors provided by the EMEP / CORINAIR Emission Inventory Guidebook 2006 (included in the technical guidance). It should however be noted that these may overestimate the impact of the boiler in many circumstances. If the assessment does show an unacceptable air quality impact, then the planning applicant should be allowed to commission a more detailed assessment.

4.25 Other screening tools are also available; a list is available in Appendix C.

4.26 Assessment using screening models is likely to be appropriate for biomass combustion installations that are not regulated under the PPC provided that the limitations of screening models are not exceeded. For example, most screening models are not applicable in areas where there is a steep hill (slope >1:10) close to the stack (distance <10 stack heights).

Dispersion Modelling and Stack Height Assessment

4.27 Screening assessments are designed to be inherently conservative – they are worst case scenarios to ensure that the worst cases (in terms of emissions and dispersion) are captured by the tool. If the screening tool predicts a significant impact on local air quality then more detailed assessment is required. This is usually achieved by using a dispersion model that will model the emissions from the boiler to ascertain if they are significant. Dispersion modelling is also used to calculate the stack height necessary to ensure adequate dispersal of pollutants (note however that stack heights may be restricted by other considerations within the planning regime).

4.28 Most local authorities will require the developer to commission and fund the dispersion modelling. The modelling itself is usually carried out by a consultant as the costs of software and training are significant. Local industry knowledge is usually enough to select a competent consultant, however, Environmental Protection UK carry a directory of specialists on their website if signposting to a consultant is needed.

4.29 The detailed dispersion models most widely used in the UK for assessing the impact of stack emissions on local air quality are ADMS and AERMOD.

4.30 ADMS has been developed by Cambridge Environmental Research. It is a new generation air dispersion model which means that the atmospheric boundary layer properties are described by two parameters – (i) the boundary layer depth and (ii) the Monin-Obukhov length – rather than in terms of the single parameter Pasquill Class. Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution. The model takes account of the plume rise resulting from the thermal buoyancy and upwards momentum of the discharge. ADMS has a number of model options including the ability to take account of hills and buildings. It includes an in-built meteorological pre-processor that allows the user to input a range of meteorological data.

4.31 AERMOD has been developed by the US Environmental Protection Agency and is also a new generation dispersion model. The model operates with a range of data pre-processors:

- AERMET, a meteorological data pre-processor.
- AERMAP, a terrain data pre-processor.
- AERSURFACE, a surface characteristics pre-processor
- BPIPPRIME, a multi-building dimensions program.

4.32 Various companies have integrated the AERMOD models in proprietary modelling packages including BEE-Line Software, BREEZE and Lakes Environmental.

4.33 Older models used a simpler representation of the atmospheric boundary layer. Examples of these were ISC3 from the US EPA and various models based on the National Radiological Protection Board R91 model. These models are no longer widely used.

4.34 Table 4.3 summarises the input data typically required for detailed dispersion modelling.

Table 4.3: Input Data Typically Required for Detailed Modelling

Data class	Input required	Units	Note
Emissions	Rate of emission of pollutant	g/s	
Discharge characteristics	Stack height above ground	m	
	Stack diameter	m	
	Discharge temperature	°C	
	Volumetric flow	m^3/s	
	Discharge velocity	m/s	
	OS grid coordinates	m	
Building characteristics	Height	m	
	Length	m	
	Width	m	
	Orientation	degrees	
	OS grid coordinates	m	
Terrain	Height above datum	m	Data usually required on a regular grid
	Surface roughness	m	Constant value usually applied, but possible varying across grid
Meteorological data	Wind speed	m/s	Hourly sequential data, typically for 3 to 5 years. Data is typically purchased from the Met. Office or other data suppliers
	Wind direction	degrees	
	Cloud cover	oktas	
	Boundary layer height	m	
Receptor grid	OS grid coordinates	m	Receptors on a regular grid or at specific locations at ground level and at height

4.35 HMIP Technical Guidance Note (Dispersion) D1, or 'D1', is not a suitable tool for assessing the impact of PM or NO_2 emissions from biomass boilers. The reasons for this are covered in Appendix C.

Chapter 4 – Reading Links

- LAQM Helpdesk information (http://www.airquality.co.uk/laqm/helpline.php)
- Examples of Air Quality Supplementary Planning Guidance on the University of the West of England website (http://www.uwe.ac.uk/aqm/review/mplanspd.html)
- Environmental Protection UK Planning Guidance (http://www.environmental-protection.org.uk/assets/library/documents/8691_Air_Quality_Guidance_(final_web).pdf)
- Environmental Protection UK Directory of Specialists (http://www.environmental-protection.org.uk/contact/directory/)
- Environmental Protection UK Biomass spreadsheet (http://www.environmental-protection.org.uk/biomass)
- Environmental Protection UK Biomass boiler information request template (http://www.environmental-protection.org.uk/biomass)

Chapter 5 – Assessing Cumulative Impacts

5.1 Assessment of potential cumulative air quality impacts of multiple biomass boiler installations will become increasingly important as a greater number of biomass boilers are installed over the coming years. Not-withstanding the guidance for urban and AQMA areas given by DEFRA and the Scottish Minister (see Box 1.2), at the present time it would be very difficult to set an overall 'acceptable level' of biomass deployment in terms of air quality as technology and regulation are subject to change. It is however important to consider individual planning applications for developments containing biomass boilers in the context of current and planned biomass deployment.

5.2 Whilst a single boiler is unlikely to affect air quality outside of its immediate vicinity, the cumulative effect of a number of biomass boilers could potentially add to air quality exceedences and raise background levels of air pollutants. Steps should therefore be taken to ensure that biomass deployment is monitored and screening assessments are made to ensure that any significant issues are flagged up. Steps that local authorities should take include:

- Logging information on biomass boiler installations.
- Conducting screening assessments to flag up any potential impacts.
- Establishing common systems with neighbouring local authorities to assess any transboundary cumulative impacts.
- Monitoring the uptake of small (single house) biomass systems.

Logging Information

5.3 When planning approval is given for a development containing a biomass boiler the information collected on the boiler should be logged in a systematic fashion. It is helpful to use a common template to do this so that information can be collected and shared with neighbouring local authorities. A suitable template with essential and desirable information is available to download from the Environmental Protection UK website (see Chapter 5 reading links).

Conducting Screening Assessments

5.4 As part of the 2008/9 review of the LAQM technical guidance nomographs were developed to help local authorities screen the potential impact of multiple biomass boiler installations. The nomographs provide a method of screening emissions from a number of biomass boilers in a 1km x 1km square. As part of the development of this guidance, spreadsheet versions of the nomographs have been produced and can be downloaded for use (see Chapter 5 reading links). Instructions on how to use the nomographs are also provided.

Transboundary Assessments

5.5 Biomass installations in neighbouring local authorities may have an effect on air quality in your own area and it is therefore useful for local authorities to share information on biomass installations close to local authority boundaries. In order to make the sharing of information as easy as possible it is recommended that a common format is used to record information on biomass installations (See 5.3)

Monitoring Uptake of Smaller (Single House) Biomass Systems

5.6 Whilst larger biomass installations will be notified to the local authority, smaller systems can in many cases be installed in existing properties without any local authority involvement. These systems include stoves, room heaters and boilers that could potentially affect air quality if installed in large numbers. It is therefore useful to monitor the prevalence of biomass heating in a local authority area and any trends in installation rates.

5.7 There is currently no requirement for individuals to notify the local authority if they are installing a biomass system outside of a Smoke Control Area or if they are installing an exempt appliance within a Smoke Control Area. Installations of biomass burning appliances to existing dwellings do not require planning consent unless the installation requires alterations to the existing building to accommodate a stack, fuel store, etc. Permitted Development Rights (PDR) also covers the installation of some stacks for household scale biomass boilers.

5.8 Installations may require Building Control approval. The Building Standards Technical Guidance states that installations should be constructed and installed in accordance with the requirements of BS8303. The technical guidance goes on to discuss schemes such as HETAS (Heating Equipment Testing and Approval Scheme), APHC (Association of Plumbing and Heating Contractors) or BESCA (Building Engineering Services Competence Accreditation).

5.9 Whilst notification of individual installations will not be possible, there are sources of data available for estimating the overall level of biomass heating in a particular local authority area:

- Housing Condition Surveys – local authorities with a housing responsibility will periodically undertake private sector housing condition surveys. Survey questions will usually include the main heating fuel used in a house.
- Home Energy Efficiency Officers (HECA Officers) – Under the Home Energy Conservation Act 1995, local authorities were required to report annually on the energy efficiency of housing in their area. Although there is no prescribed monitoring methodology many local authorities have used snapshot postal surveys often in partnership with Energy Efficiency Advice Centres. The questions asked will usually include the main heating fuel used. Although HECA is now being revoked, local authorities are likely to continue working on domestic energy efficiency via their climate change commitments.
- Local Energy Saving Trust Advice Centres – The Energy Saving Trust funds a network of local centres. A core activity of these centres has been to distribute and process Home Energy Check forms which include questions on the main heating fuel used in dwellings within a local authority area. They therefore have a great deal of data on the types of heating used in local authority areas. Many centres have close working relationships with the local authorities in their area which in many cases contract services and project management to them.

5.10 A useful first port of call within a local authority would therefore be to meet with colleagues in private sector housing and / or domestic energy efficiency to establish what sources of data are available. Although this level of data cannot be used to estimate emissions or biomass contributions to pollutant concentrations, it can help identify whether biomass is more or less prevalent than average in a local authority area (by comparing with others) and also the level of new installations.

Chapter 5 – Reading Links

- Biomass boiler information request template for local authorities
  (http://www.environmental-protection.org.uk/biomass)

- HETAS Guide
  (http://www.hetas.co.uk/public/hetas_guide.html)

- Scottish Government's Building Standards Technical Guidance
  (http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/pubtech)

Chapter 6 – Mitigating Potential Impacts

6.1 If dispersion modelling suggests that air quality impacts would be significant and / or the stack height needed to adequately disperse emissions is unacceptable then mitigation options should be looked at.

6.2 Mitigation of emissions can involve addressing emissions from the boiler itself by choosing a cleaner boiler, or making a requirement for emissions abatement equipment to be fitted. Effective abatement of non-threshold pollutants such as fine particles is particularly desirable in urban areas. It reduces the amount of pollutant emitted from the chimney so there will be less in the urban environment for the population to be exposed to. It should be noted though that emissions abatement equipment is currently costly and is therefore often considered impractical on cost grounds for smaller biomass boilers. Alternatively, mitigation measures can involve offsetting via addressing emissions elsewhere in the development or the wider areas, e.g. through a Low Emission Strategy. The main options are summarised in Table 6.1. Please note that whilst potential mitigation measures are discussed below, specialist advice should be sought to assess which mitigation measures may be suitable for a particular site and biomass installation. Forestry Commission Scotland will publish their abatement technology guidance for wood burning boilers at the beginning of 2011.

Table 6.1: A Summary of Potential Mitigation Measures

Measure	**Description**	**Paragraph**
	Boiler and Flue Measures	
Cleaner boilers	Different boilers and fuels will have varying emissions performance, and cleaner options may be available	N/A
Abatement equipment	‘End of pipe’ abatement equipment may be available, but this is normally only cost effective on larger boilers	6.4
Accumulator tank or buffer tank management	Heat stores can improve boiler efficiency and reduce the number of stop-start cycles, improving emissions performance.	6.6
Automatic heat exchanger cleaning	Sophisticated heat exchanger cleaning systems can reduce PM emissions	6.14
Fan assisted dispersion	Discharge point fanned flue systems can help to maintain stack efflux velocities under a wider range of conditions, potentially improving dispersion of emissions	6.18
	Other Measures	
Design optimisation	Optimisation of the flue design and placement can assist in dispersion of emissions	6.20
Wider or offset measures	Low emission strategies secured through Section 75 agreements can offset emissions from the biomass boiler(s)	6.21

6.3 If the air quality impacts are still judged to be significant even after mitigation measures have been applied or if mitigation measures are impractical, local authorities can ask developers to consider alternative renewable energy technologies (e.g. solar, wind, heat pumps, etc.).

Abatement of Nitrogen Oxides

6.4 NO_x control on combustion plant can be achieved using primary (section 6.5 & 6.6) or secondary methods (sections 6.7 onwards) but in general these are not currently applied to biomass combustion except for combustion plant burning wastes or at very high capacity plant (that is regulated by PPC).

Abatement of Particulate Matter

6.5 Primary measures (combustion management) provide effective control of products of incomplete combustion that can cause PM emission. Residential appliances often employ natural draught (air is drawn into the fireplace by the suction provided by the chimney and buoyancy of the hot flue gases) to provide the required combustion air supply. However, this provides limited opportunity for combustion control. Fan assisted combustion air supplies are applied to boilers larger than about 50kW and also to some residential pellet stoves and residential boilers. Use of a fan in conjunction with a 'Lambda' (oxygen) sensor and mechanical dampers allows active control of combustion air and air distribution.

6.6 In addition, management of boiler load to avoid excessive cycling operation can help reduce PM emissions. For example, use of an accumulator tank and / or advanced buffer tank management is recommended for biomass boilers to allow longer, more efficient operation of the boiler with fewer start-up / shutdown periods.

6.7 End of pipe abatement is also possible for PM control, such devices include:

- Cyclone and multi-cyclones
- Electrostatic precipitator
- Fabric filter
- Ceramic filter
- Catalytic insert

6.8 The catalytic insert is a device which can be fitted into a residential stove to reduce emission of products of incomplete combustion and hence PM emission. However, although these devices have been used in North America they have generally not been popular in Europe due to issues of catalyst life span and blocking of the catalyst.

6.9 Larger (>50kW) boilers often incorporate a cyclone or multi-cyclone to provide emission control for PM although in many instances these are optional. Several boilers exempted for use in UK Smoke Control Areas include cyclone abatement equipment and it should be noted that if the exemption is for a boiler with a cyclone, installation and operation of the boiler in a Smoke Control Area without the cyclone is an offence.

6.10 Cyclones can occupy a small space, tolerate high temperatures and are very good at collecting coarse particles (they can often be used as a first stage gas cleaning device in industrial application) but are much less effective for smaller particulates ($PM_{2.5}$)

6.11 There is considerable research into application of electrostatic precipitator technology (ESP) for PM abatement from wood boilers down to 100kW output. An ESP requires electricity to maintain an electrical field but flow resistance is low i.e. no additional electrical energy is needed to power larger fans. They tend to require a large volume to minimise gas velocity and hence increase opportunity for particle collection. They are effective across all particle sizes and can tolerate high temperatures.

6.12 Fabric or 'bag' filters are commonly used in industrial and in local exhaust ventilation. They provide highly effective particle collection across all particle sizes but may require a pre-cleaning device (e.g. cyclone) if significant carbon is present in the particulate as this can pose a fire risk. A range of fabrics is available which allow operation at high temperatures and in highly corrosive flue gases. Fabric filters can be affected by moisture and may need pre-heating or use of material that is not clogged by moisture. They require a large volume and require additional fan power due to the high pressure drop across the bags.

6.13 Ceramic filters have similar features to fabric filters but can operate at very high temperatures. Ceramic filters have been fitted to a number of biomass boilers installed in Scottish schools, as well as in several similar sized biomass boilers in London.

Automatic Heat Exchange Cleaning

6.14 Certain boilers have advanced heat exchanger cleaning mechanisms which can give similar PM abatement as multi-cyclones.

Abatement Efficiencies and Costs

6.15 Karvosenoja et al (2006)[1] reviewed measures for reducing PM emissions in Finland by 2020 including domestic combustion. Table 6.2 summarises the abatement options and costs considered for domestic biomass boilers. However, note that ESP for residential boilers is not yet commercially available.

Table 6.2: Finnish Data on Costs and ESP Abatement Efficiency for Residential Boilers

Boiler type	Em. factor without ESP (mg/MJ)	ESP removal eff. (%)	Em. factor after the ESP (mg/MJ)	Unit cost (€/mg/$PM_{2.5}$)	Unit cost (€/PJ)
Manual feed log boiler with accumulator tank	100	90	10	3700	333
Manual feed log boiler without accumulator tank	800	95	40	419	318
Automatic feed wood chip boiler	60	85	9	6960	355
Automatic feed pellet boiler	30	80	6	15300	368

6.16 Nussbaumer (2007)[2] compared the availability and costs of ESP and fabric filters for automatic biomass boilers and determined that ESP and fabric filter technology is available and proven for boilers of 500kW to 2MW thermal capacity. Both technologies are capable of operating within an emission limit value of 20mg/m³ at 11% or 13% O_2 dry and STP - 0°C, 101.3kPa (<15g/GJ). ESP technology has a higher investment cost and fabric filters have a higher operation costs but total cost is similar with an additional 6 – 12% in heat production cost. Application to 100kW boilers is possible but the cost of equipment rises below 500kW and application may make the boiler installation uneconomic. It is however noted that there is cost reduction potential for technology <500kW.

6.17 Gunczy et al (2007)[3] reported PM emission reductions of about 80% on a 150 – 300kW wood chip boiler and 80 – 90% on a residential 25kW wood log boiler using prototype ESP systems. In both instances outlet PM concentrations were <10mg/m³ at 13% O_2.

Fan Assisted Dispersion

6.18 Fan assisted dilution systems introduce fresh air into the boiler's discharge flue duct diluting the flue gases. They are usually employed to reduce the height of the stack / flue when this is desirable on either aesthetic and / or cost grounds. Total emissions of pollutants will of course be the same as a standard flue system; dispersion may however be enhanced due to the higher discharge velocity. Note that as a general principle of the CAA and PPC legislation it is forbidden to introduce excess air in order to achieve an emission limit.

6.19 Discharge point systems are systems with a fan mounted at the end of the flue to ensure a constant negative pressure in the whole stack. With biomass boilers these systems are usually employed to meet the efflux velocities recommended by the CAA Memorandum in conditions where other options (for meeting efflux velocities) would involve an undesirable (i.e. too high or narrow) stack design, or compromising the efficient running of the boiler (e.g. through

[1] Karvosenoja et al (2006) 'Fine particle emissions, emission reduction potential and reduction costs in Finland in 2020". Finland Environment Institute. The Finnish Environment 46/2006

[2] Nussbaumer, N. (2007) 'Cost of particle removal for 200kW to 2MW automatic wood combustion by ESP and fabric filters'. Presentation at 3rd IEA Workshop on aerosols from biomass combustion, Finland

[3] Gunczy et al (2007) 'Novel small scale ESP concepts'. Presentation at 3rd IEA Workshop on aerosols from biomass combustion, Finland

introducing excess air flow into the boiler). They are also used to reduce the height of the stack / flue when this is desirable on either aesthetic and / or cost grounds.

Design Optimisation

6.20 In addition to measures addressing the boiler and flue system, mitigation options can also include looking at building and stack design to optimise dispersion of emissions. Measures can include optimisation of stack placement within the development site and, where multiple boilers are in use, consideration of multiple or single flue systems.

Mitigation Through Wider Measures

6.21 If reducing emissions from the boiler itself is impractical, wider mitigation measures can be attached to the development containing the biomass boiler to effectively offset emissions. Potential measures are considered in the Environmental Protection UK guidance ‘Development Control: Planning for Air Quality’ whilst the Beacon Councils’ guidance ‘Low Emission Strategies’ examines transport measures in detail.

Chapter 6 – Reading Links

- Environmental Protection UK Planning Guidance
  (http://www.environmental-protection.org.uk/assets/library/documents/8691_Air_Quality_Guidance_(final_web).pdf)

- DEFRA Low Emission Strategy Guidance
  (http://www.defra.gov.uk/environment/quality/air/airquality/local/guidance/index.htm)

Chapter 7 – Anticipated Progress

7.1 At the time of writing this guidance a number of initiatives were under way that will impact on how local authorities deal with biomass boilers. The 2009 UK Renewable Energy Strategy put forward a number of suggestions that would assist developers in specifying suitable biomass boilers and local authorities to understand, plan and control the deployment of biomass boilers in their area.

The Renewable Heat Incentive

7.2 The Renewable Heat Incentive (RHI) was intended to become the main mechanism for the UK Government to encourage a large increase in renewable heat, including biomass, in order to meet targets set in the UK Renewable Energy Strategy.

7.3 You can read Environmental Protection UK's response to the Renewable Heat Incentive consultation on our website (www.environmental-protection.org.uk)

Emissions Standards

7.4 There are currently no UK emission standards for biomass boilers beyond those detailed in Chapter 2. European emission standards vary in their testing procedures meaning that they are difficult to compare with UK standards for other heating appliances.

7.5 The UK Government has proposed to introduce emission standards at part of the Renewable Heat Incentive. Boiler manufactures would not have to meet these to sell their products in the UK, but boilers that did not meet the standards would be ineligible for RHI payments and therefore economically unattractive. The RHI consultation document proposes to set these standards at 30g/GJ for PM_{10} and 150g/GJ for NO_2. The consultation document also proposes to set up a class exemption for boilers that meet these standards under the Clean Air Act; this would mean that boilers that met the standards would not need to be approved under the exempt appliance system in order to be installed in Smoke Control Areas. A new type approval and enforcement scheme would have to be introduced to implement emission standards on biomass boilers.

7.6 The Greater London Authority's (GLA) draft Mayor's Air Quality Strategy proposes to require biomass boilers installed in PM_{10} Air Quality Management Areas to have PM_{10} emissions abatement equipment fitted. The draft strategy also proposes to restrict installations of biomass boilers to those which meet the RHI emission standards across the whole of London. These conditions would be enforced through the GLA's planning powers.

Maintenance Requirements

7.7 Biomass boilers, stacks and emissions abatement equipment need regular maintenance to ensure efficiency is kept to a maximum and emissions kept to a minimum. In other countries, including Austria, Germany, Denmark and the United States of America, concerns over air quality deterioration caused by older style biomass boilers has led to the introduction of an MOT-type scheme, whereby the owners are required to have their boilers serviced on a regular (e.g. annual) basis. A similar system may be applied to the UK. The UK Renewable Energy Strategy proposed to link maintenance requirements to Renewable Heat Incentive payments; however this appeared to have been dropped when the RHI proposals were later put out for consultation.

Research and Modelling

7.8 The research base on emissions from biomass boilers continues to expand. The 2008 report 'Measurement and Modelling of Fine Particulate Emissions (PM_{10} and $PM_{2.5}$) from Wood-Burning Biomass Boilers' (see Chapter 7 reading links) presented the results of a study that measured emissions from several biomass boilers in Scotland and modelled their likely effects on air quality. Whilst the report concluded that emissions were far from the 'worst case' scenario, emissions between the different boilers studied varied and could be significant in some locations. Further research is required to clarify potential impacts and abatement opportunities.

Chapter 7 – Reading Links

- Report - Measurement and Modelling of Fine Particulate Emissions (PM_{10} and $PM_{2.5}$) from Wood-Burning Biomass Boilers

  (http://www.scotland.gov.uk/Publications/2008/11/05160512/12)

Appendix A – Biomass Boiler Technologies

A1 Boilers and appliances may be categorised according to the direction of the airflow through the fuel bed, the method of fuelling, the size of the appliance, the fuel type and the application. There are units that are fuelled by intermittently loading a batch of fuel, usually logs or lump wood, into the combustion chamber – batch fuelled; and those that are fuelled continuously with a steady flow of fuel logs, chips or pellets – continuous firing. Table A1 lists the main categories of appliance and the types of fuel used.

A2 Historically, wood was burned in open fireplaces, partially enclosed fireplaces and conventional enclosed stoves for domestic heating and the provision of hot water. These appliances were typically characterised by low efficiency and poor emissions performance.

A3 Modern biomass boilers minimise the emissions of unburned volatile compounds by optimising the design of the combustion zone of the appliance. This involves the way in which the biomass is introduced, the way in which air is introduced and the way in which the heat necessary to dry, vaporise and ignite the fuel is retained and transmitted. The following sections describe the main types of modern appliance and the design and operational factors that affect their performance.

Table A1: Types of Biomass Appliance

Capacity of appliance	Class of appliance	Type of appliance*	Fuel types
<50kW$_{th}$ (mainly domestic or residential type applications)	Fireplace	Open fireplace Partly closed fireplace	Log, lump wood and biomass briquettes
	Stove	Manual feed stoves	Log, lump wood and biomass briquettes
		Pellet stoves	Pellets
	Boiler	Over-fire	Log, lump wood and biomass briquettes
		Down draught wood boiler	Log, lump wood and biomass briquettes
		Pellet boiler	Pellets
>50kW$_{th}$ and less than 20MW$_{th}$ (mainly commercial, institutional, community or district heating and, industrial applications)	Manual feed boiler	Overfeed, under fire boilers	Lump wood
		Overfeed, upper fire boilers	Wood chips/fine coal mixture
	Automatic feed boiler	Moving bed combustion	Wood chips, sawdust Co-combustion with coal
		Underfeed boiler, upper fire	Wood chips, sawdust, pellets: particle size less than 50mm
		Down draught wood boiler	Logs
		Gasification	Wood chips, pellets
		Pre-ovens combustion system	Wood chips
		Fluidised bed combustion	Sawdust, woodchips, pellets

** The types of appliance are described in EMEP/CORINAIR Emission Inventory Guidebook – 2007 Chapter B216*

Batch Fuelled Appliances

A4 These are usually small, <50kW output, units fuelled by logs or lump wood. They can either be stoves (room heaters), where the main output is by radiation and convection to the room in which they are placed, or hot water boilers. There are fireplaces and stoves (and cookers) available which also incorporate boilers. Until the recent introduction of pellet stoves, log-fuelled batch units were the only type found in the domestic sector where they still make up the majority of sales.

A5 It is in the nature of batch-fired units that there is always an excess of fuel in the combustion chamber. The only way to regulate output is by controlling the amount of combustion air. If this air is injected at just one point it will always give rise to a fuel rich zone that will create large quantities of unburned volatile matter and gases. This is unacceptable from an operational and environmental viewpoint and further air, 'secondary air', must be injected to ensure complete combustion. The influence of primary air (combustion air which is passed through the fuel bed) on emissions is significant but generally less important than the good management of secondary air. Most differences in stove design stem from the way this secondary air is injected to achieve complete combustion. The level of emissions depends on how well the design has succeeded in achieving this. Given these factors it is not surprising that emissions from unburned volatile organic compounds are the overriding concern for batch-fuelled appliances. Solid ash particles and volatile ash are present but of less concern.

A6 In most appliances the air is introduced in one of two ways; (i) updraft where the air passes upwards through the batch of wood and the secondary air is introduced over the top of the fuel bed and (ii) downdraft where it passes downwards through the fuel bed with secondary air being introduced in a separate combustion chamber. Updraft appliances are the most common, and the cheaper, but downdraft stoves give much better emissions performance because of the better combustion and control inherent in the use of a discrete secondary chamber.

A7 Most of the smaller batch-fuelled appliances make use of natural draught generated by the increased buoyancy of the hot combustion gases. The use of fans to supply combustion air ensures a level of control that is not possible with simple natural draught. This is particularly true of the start phase where a cold flue will reduce the airflow significantly. Unfortunately, fans are not usually provided with smaller appliances due to the increased cost and complexity. The current EN Standards for residential fireplaces, non-pellet room heaters and cookers do not cover appliances with fan assisted combustion air supply (see Chapter 2 for details of Standards).

A8 High quality insulation installed around the combustion chamber retains heat where it is needed to encourage complete combustion of volatile compounds.

A9 The performance of boilers is improved if the appliance operates at a high and constant output. It is good practice to install a hot water storage tank, or accumulator, and fire a log boiler at maximum constant rating until the charge has been consumed. This is done two or three times per day with the connected heating system supplied from the accumulator. This configuration is so effective in reducing emissions that it is a legal requirement in Germany and Switzerland. It is bad practice to try to follow the heating load by controlling the air flow to the boiler because particulate formation is encouraged under conditions of restricted air flow.

A10 Tests have shown that emissions of unburned organic compounds are typically two orders of magnitude greater in the few minutes after the appliance is started or refuelled. They can be reduced significantly if the wood charge is ignited from the top of the charge.

A11 Good quality fuel with a consistent size and low moisture content will promote consistent air flow and prevent excessive heat loss from drying in the combustion zone. An ideal log fuel would be produced from small round hardwood, split in quarters with a moisture content of below 15%.

Continuously Fired Boilers

A12 In a continuously fired boiler, or stove, fuel is added continuously to the combustion air in the correct proportion to give the desired heat output. Combustion air is regulated to match.

A13 The processes of drying, devolatilisation and combustion of volatiles and char occur as in the batch-fuelled appliances and the design must take this into account. An important difference is that the fuel rich situation does not occur and consequently the production of unburned volatile emissions will be to a large extent avoided. The particulate emissions will therefore be largely comprised of vaporised and physically entrained ash. In contrast to batch-fuelled appliances, the resulting level of emissions will be largely independent of the combustion conditions and be more a function of the type of equipment installed to clean the flue gas.

A14 The most common types of woody fuel used in continuously fired boilers are pellets and woodchips. There are automatic log boilers that apply downdraft gasification techniques to achieve very low particulate emissions but due to fuel handling constraints these tend to be smaller than 150kW. At present the relatively high cost of pellets (compared to wood chip) means that use of pellets tend to be rare in boilers larger than about 300kW.

A15 A key feature of larger (>50kW) boilers will be the need for automatic fuel handling from a storage area to the boiler (residential boilers will typically have a small hopper beside or as part of the appliance which the user will fill at intervals). Similarly larger boilers need to incorporate equipment for ash handling (and storage). Residential boilers generally incorporate a small bin that can be removed at intervals by the user however this is not practical for large units. Fuel tends to be moved by screw conveyors which can be of varying length to suit the distance to, and design of, the storage area.

A16 Accumulation of deposits on heat transfer surfaces reduces efficiency and modern boilers tend to incorporate cleaning devices. Cleaning is either mechanical or, for larger boilers, by use of soot blowers.

A17 Most modern boilers incorporate automatic fuel ignition which allows fully automatic operation.

A18 The performance of continuously-fired boilers is improved if the appliance operates at a high and constant output. It is good practice to install a hot water storage tank, or accumulator, where there is a variable demand for hot water. In this way a smaller boiler may be specified to meet the variable heat demand.

Pellet boilers

A19 Pellets are a modern form of manufactured biomass fuel that has many advantages. Pellets are free flowing with low moisture content and a consistent size and geometry. Designing efficient and effective combustion devices is therefore much simplified when compared with other fuels. Pellets are however an expensive fuel when compared with chips and they are usually confined to smaller domestic and commercial units where the simplicity and convenience they offer outweighs the additional cost.

A20 Pellet combustion appliances, whether stove or boiler, are sold in three variants: (i) underfeed where the fuel is pushed up into the combustion chamber by a screw feeder, (ii) overfeed where the fuel falls down a chute into the combustion chamber and (iii) horizontal firing where the fuel is burned in the end section of a screw feeder. The choice depends largely on the manufacturer and there seems not to be any overwhelming advantage in one over the others.

A21 Almost all pellet-fired appliances use a fan powered supply for the combustion air so accurate control is possible. This is often complemented by a control circuit including an oxygen sensor in the flue gas to determine excess air level. Both of these measures improve the emissions performance of pellet-fired appliances.

Wood Log Boilers

A22 Automatic log boilers are sold for residential use and small commercial / institutional use (they tend to be smaller than 150kW output). Modern appliances incorporate internal storage hoppers (filled at intervals by the users) and are based on the downdraft principle where logs are slowly heated and evolved vapours are burned in a secondary combustion chamber. The process resembles gasification and as a consequence they tend to have very low particulate emissions.

Continuous Firing of Woodchips

A23 Equipment for chip firing is supplied in a wide variety. Smaller units designed to burn dry (<35% moisture) chip with a top size below 50mm are similar to overfeed and horizontal pellet burners; indeed many pellet burners were developed from these.

A24 Higher moisture content chips require more time in the combustion chamber to dry the fuel and an arrangement to recycle heat from combustion to drying. This is usually achieved by spreading the fuel on a grate that conveys the burning fuel bed slowly through the appliance. Heat for drying is usually supplied by radiation from a firebrick arch mounted over the feed end of the grate. The grate is moved forwards by one of many different mechanisms depending on the manufacturer. The combustion air is supplied partly under the grate and partly above the grate to ensure complete burn out of the volatile compounds.

A25 To guarantee complete combustion of volatile compounds all biomass boilers are built with very well insulated combustion chambers that maintain a high temperature for several seconds.

Factors Influencing Boiler Efficiency

A26 The aim of biomass combustion is to convert the energy stored chemically within the fuel to useful heat. There are no ideal processes of energy transformation and it is impossible to transform energy into another form with 100% efficiency. Energy losses arise as the result of the following:

- **Chemical loss in exhaust gas:** as a result of incomplete combustion the exhaust gas contains combustible substances, like CO and hydrocarbons. These substances contain energy in chemical bonds which can be released in a combustion process and are a cause of energy loss. The methods for minimising this loss are to design the combustion chamber so as to maximise the combustion efficiency of the intended fuel.

- **Thermal or physical loss in exhaust gas:** exhaust gases from combustion contain energy since they are at a higher temperature than the ambient temperature. Thermal losses are increased as the temperature of the exhaust gas from the chimney increases or if additional 'tramp' air is passed through the chimney. Such losses can be minimised by design measures that improve heat recovery in the heat exchanger (where fitted) or measures that increase the emission of heat into the room and that control the air supply.

- **Chemical loss in ash:** solid residues from the combustion process (ash, including fly ash) may contain carbon that was not burnt in the combustion chamber. Insufficient combustion time of fuel particles, fuel dimension and fuel composition are reasons for chemical loss in ash.

- **Physical loss in ash:** the ash, which is removed from the lower part of the appliance, also has a temperature above the ambient one. This means that some part of released energy during combustion process was not passed to the other medium, thus this energy may also be lost (if material is removed while hot).

- **Heat loss from the surface of the appliance:** the surfaces of the appliance will be greater than the ambient air and so there will be transfer of heat from the appliance by radiation or convection. In many domestic applications this heat is usually considered a useful transfer of heat to the room but in larger installations for steam or hot water generation the heat is considered to be lost. The heat loss from the surface area is minimised by means of effective insulation and the reduction of the surface area.

A27 Awareness of energy losses allows designers to design appliances that minimise these losses.

A28 A substantial part of the emissions of un-burnt organic matter occurs when there is an excess of fuel in the combustion chamber. It follows that the efficiency of the boiler should be improved if the appliance operates at a constant load. Most modern biomass boiler designs are intended to operate over a range of heat outputs with little loss of efficiency. Recently reported tests on a range of modern log wood, pellet and wood chip boilers with capacity >50kW indicated that the efficiency remained at approximately 91% when operating at a third of the boiler capacity. Nevertheless, correct sizing of the plant is essential if efficiency is to be maintained over the full range of operating conditions.

Combined Heat and Power

A29 With a conventional boiler the aim is to collect as much of the heat generated as possible in the boiler in order to provide a supply of hot water or steam for process heating, space heating or hot water. With a combined heat and power (CHP) plant part of the heat produced is used to generate electricity.

A30 Electricity generation is a relatively low efficiency use for biomass except where there is a high level of heat demand throughout the year, e.g. an industrial application requiring process heat, or a hotel or hospital requiring a constant supply of hot water. Above about 1 – 2MW conventional superheated steam turbine technology can be used with reasonable efficiency. Alternatively biomass gasification used with a gas turbine in a number of configurations may also be appropriate at high output levels. However, at lower output requirements neither of these options is likely to make efficient use of the fuel. Several technologies suitable for smaller scale applications are under active development, these include:

- Organic Rankine Cycle systems using a low boiling point organic compound to replace the heat transfer medium;
- Gasification combined with an internal combustion engine;
- Reciprocating steam engine;
- Stirling engine;
- Gas microturbine.

Appendix B – Fuel Specification

Introduction

B1 The term "biomass" covers a range of materials of biological origin, some of which may also be regarded as wastes.

B2 The most frequently used term to define biomass is the one included in the Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market. This defines biomass as "the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste". This definition remains the same in the new Renewable Energy Directive that will repeal Directives 2001/77/EC and 2003/30/EC.

B3 Biomass fuels are characterised according to their chemical and physical properties. Paragraph B5 onwards examine the types of biomass fuels that are commonly proposed for biomass heat and power in the UK and the impact of biomass properties on combustion. Paragraph B7 onwards provides an overview of the characteristics of wood fuels and Paragraph B8 onwards provides an overview of standards.

An Overview of the Effects of Fuel Specification on Operational and Emissions Performance

B4 Biomass fuels represent a variety of different materials. For fuel use these are typically characterised according to their physical and chemical properties, particularly those that impact combustion. Table B1 summarises how these properties affect the operational and emissions performance of combustion systems.

Biomass Fuel Types

B5 Table B2 describes the main types of biomass fuel, sets out the most important issues relating to their handling and storage and also summarises the relative advantages and disadvantages of each type of fuel.

B6 The most common fuels used for heat and power at present are wood fuels and agricultural residues. For small-scale heat or CHP in urban areas, most stand-alone applications use some form of wood fuel. However specific plant may use agricultural residues if there is a local source, for example in conjunction with local production of food, drink or biofuels.

Specific Characteristics of Wood Fuels

B7 The most common fuels used in urban areas for heat and power are wood fuels.

Table B3 provides a summary of the properties of typical wood fuels.

Standards for Biomass Fuels

B8 The European Standards Agency (CEN) has worked (or is working) on a number of standards that are relevant to biomass fuels. Table B4 provides an overview of the contents and status of the most relevant standards.

B9 CEN 335 includes solid biofuels originating from the following sources:

- Products from agriculture and forestry;
- Vegetable waste from agriculture and forestry;
- Vegetable waste from the food processing industry;
- Wood waste, with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating, and which includes in particular such wood waste originated from construction and demolition waste;
- Continued-fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and heat generated is recovered;
- Cork waste.

B10 Table B5 provides a summary of the grades of woody fuels specified in CEN335.

B.11 The British BioGen code of good practice for biofuel pellets (Version 2.3) specified issues related to pellets' raw materials, physical and chemical attributes and quality assurance and miscellaneous. The code was voluntary but all members of the industry were strongly encouraged to comply with it. The code was an interim measure whilst no other standards exist in the UK and has been superseded by the European Standard for solid biofuels.

References

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- Cox, A. 2002. Low carbon heating with wood pellet fuel. www.bioenergy.org/downloads/PelletReport.pdf

Table B1 Impact of Properties of Biomass Fuels on Combustion

Sources: Hahn (2004); Transport Information Service (2008); Supergen WP2, Cox (2002). SWS (2002)

Characteristic	Issue
Physical characteristics	
Bulk density	Storage space and capacity of materials handling equipment and boilers.
Energy density	Storage space and capacity of materials handling equipment and boilers.
Particle size	Flow of particles in materials handling equipment including their tendency to bridge in storage. Combustion efficiency and consequent production of smoke.
Presence of fines	Dust explosion risk. Dust emissions from handling operations.
Durability of pellets	Poor quality pellets are liable to break up on physical handling and in storage. This will result in poor handling, flow, loss of fuel and production of dust.
Biological characteristics	
Allergies	Some biomass fuels, e.g. peanut husks are known allergens.
Carcinogens	Some tropical and North American hardwoods are carcinogenic.
Chemical and combustion characteristics	
Water content, hygroscopicity	Influences calorific value from specific weight of fuel. Self heating and fire risk. Flow properties in materials handling equipment. Tendency to bridge. Mould formation and associated health risks from dispersion of spores.
Calorific value	Storage space and capacity of materials handling equipment and boilers.
Chlorine	Corrosion. Dioxin and furan production during combustion. Formation of clinker deposits in ash and reduced ash melting temperatures. Hydrogen chloride emissions.
Sulphur	SO_2 emissions. Fouling of heat transfer surfaces. Corrosion of exhaust ductwork.

Characteristic	Issue
Nitrogen	NO_x, HCN and N_2O emissions.
Potassium	Corrosion in superheaters. Reduction of ash melting point (which may result in slagging and fouling). May affect mechanism of pyrolysis, decrease oil quality and increase char.
Magnesium, Calcium, Phosphorous	Raising of ash melting temperature, effect on pollutant retention in ash and the use of the ash. May affect mechanism of pyrolysis, decrease oil quality and increase char.
Silicon	Alkaline silicates can be formed with low melting or softening temperatures.
Heavy metals	Use or disposal of ash. Pollutant emissions.
Ash content	Particulate emissions. The quantities of ash for disposal.
Ash softening behaviour	Operational safety, level of pollutant emissions.

Table B2 Biomass Fuel Types

Description	Supply source	Storage	Handling	Advantages	Disadvantages
Wood based fuels					
Round wood and logs Logs are the traditional source of fuels. Today logs are usually obtained from timber or trees unsuitable or unwanted for building or construction. Logs are usually seasoned for up to two years to decrease moisture content	Forestry - UK	During seasoning – store under cover with good air circulation. Keep dry.	Few issues in handling.	Familiar fuel, which can be used on domestic fires, stoves and wood burners. Can be stored outside with minimal shelter. Growing demand stimulating supply.	Expensive to transport and store at large scale. Generally used at small scale only. Automatic feed not possible at this scale. Log burners require regular de-ashing.
Chips from fresh wood The term woodchips refers to mechanically processed wood particles. Depending on the moisture the chips can be: - **wet:** moisture content > 30% - **dry:** moisture content < 30%	UK or imported Usually saw mill or other wood processing residues or short rotation coppice	Keep dry. Store as loose piles. Open air storage is possible, but permeable water shedding cover must be used to reduce re-watering.	Loss of dry matter may occur. There is a potential for self heating that can lead to fires. Dust – may be explosive hazard. Emission of organic compounds during drying. Degradation may result from fungal growth, which produces spores.	More suited to automatic handling than logs. More efficient combustion than logs. Lower risk of dust explosions than sawdust due to large particle size. Extensive experience of production, handling and storage from associated sectors including timber and paper industries. Minimal requirements for storage; can be stored outside with limited shelter. Growing demand and market stimulating increased international trade. Cheaper than pellets.	Further processing may be required (e.g. milling) depending on plant design. Moisture content in virgin wood chip (c. 30-60% of dry mass), results in a lower net calorific value. Long term storage: high moisture wood degrades quickly which can result in risk of self heating and potential spontaneous combustion. Low moisture wood can be stored longer. Wood stack height should be less than 10m to prevent composting and spontaneous combustion. Mitigation: “turning over” of stockpiles to avoid build-up of heat within stockpiles.
Saw mills residues - sawdust Sawdust is either sourced from sawmills or from wood processing plants using un-treated timber.	UK	Best to keep all sawdust under dry cover, with good air circulation. This prevents the potential for degradation and self heating and will keep low moisture content sawdust dry.	Dust hazard Potential for loss of dry matter in storage. Need to avoid self heating that can lead to fires.	Needs minimal further processing in order to be used.	Low bulk density = large transport and storage requirements. Can become air borne in even low wind conditions - should be sheltered/ covered and tipped carefully. Self heating and loss of dry matter in storage. There are often large quantities of dust, representing a health hazard. Some hardwood dusts are carcinogenic.

Description	Supply source	Storage	Handling	Advantages	Disadvantages
Wood based fuels					
Saw mills residues – wood pellets Wood pellet fuel is made from compressed sawdust, shavings and fines from the processing trees for timber and other wood products. At a pellet mill the material is dried, compressed, and formed into small uniform sized pieces. They should be clean, pleasant smelling and smooth to touch. Wood pellets are usually approximately cylindrical because they are made by forcing wood particles through a sieve with circular holes. They are usually referred to by the diameter of the chips, typically between 4-10mm.	UK or imported (from EU, Russia or North America)	Keep dry. Stored under cover, preferably in enclosed areas. Should be kept away from other fuels with higher moisture content	Careful handling needed to prevent mechanical damage of the pellets (break down of the structure). Pellets absorb water and are liable to degradation if wet.	Higher bulk (and energy) density than sawdust material: reduced transport and storage volume requirements. Generally good storage characteristics. Less dust generated in mechanical handling compared to sawdust (with exceptions, see weaknesses). Good flow characteristics compared to sawdust. Low moisture content. Available in increasing quantities. Can be shipped in bulk. Good experience of combustion; good combustion characteristics. Should be able to be sustainably sourced. However, source of material may be obscure.	Hygroscopic, must be kept dry. Exposure to water will break down pellets and cause them to swell considerably. Can degrade to sawdust as a result of excessive, or poorly designed, mechanical handling processes. Tendency to be formed from very fine wood particles. If breakage of pellets does occur levels of dust can rise dramatically. In the most severe cases this has the potential to create a dust explosion hazard. Expensive (due to processing cost and competition). Sustainability: there may be issues with contaminated wood in some pellets, poor quality pellets in peak market conditions and environmental sustainability for pellets made from tropical timber in the Far East.
Waste wood The main source of wood waste is the untreated wood from processing / manufacturing facilities (potential sources include: joinery works, planning mills, furniture manufacturers, pallet manufacturers, timber kit frame manufacturers etc).	UK – some may be imported from the EU.	Sheltered storage to maintain low moisture content. Storage as loose piles.	Loss of dry material.	Extensive experience of production, handling and storage from associated sectors (e.g. timber and paper industries). Typically lower moisture content than virgin wood chip. Generally low bark content.	Difficult to separate contaminated wood in some waste streams. Combustion may need to be compliant with Waste Incineration Directive. Quantity available limited by supply. May require further processing (e.g. milling). Contamination in wood can directly affect emissions from combustion process and ash content. Needs to be separated and collected.

Description	Supply source	Storage	Handling	Advantages	Disadvantages
Agricultural residues					
Dry residues **Straw** is a by-product of the production of grain or seed and, if it is to be sold, is baled following the harvest of the primary crop.	UK	Major storage issues due to its bulk and short harvest period. Store in bales in stacks in field or under cover in barn. The latter is more expensive but will decrease spoilage.	Chopping, handling and feeding are difficult. Can deteriorate in storage (e.g. it can rot). Fire hazard.	There is no need to develop a new crop with which farmers may be unfamiliar. Techniques for harvesting, storage and transport are already available. Supply limited by production, particularly in poor harvest conditions and by competition for straw when there are poor harvests.	Bulky and expensive to transport over long distances. Contains trace components such as potassium chloride and silicates that cause corrosion in boilers at high temperatures.
Poultry litter is the bedding material from broiler chickens. Usually it consists of materials like wood shavings, shredded paper or straw and chicken droppings.		Strong odour – needs to be stored under conditions that prevent release of odour.	Main impacts: feedstock transport, odour and noise.	Poultry litter is an existing “fuel”. The supply chain is relatively straightforward Low moisture. Combustion of poultry litter well proven in UK.	Require emissions clean up for atmospheric emissions. Combustion falls under the Waste Incineration Directive.
Meat and **Bone Meal**		Often burnt under special licence	Health hazard during handling	Low moisture; Co-combustion of MBM with coal has been demonstrated in EU. Combustion demonstrated in UK	Combustion falls under the Waste Incineration Directive. High content of Ca and ash. Relatively low volatile matter. Supply limited by production.
Food processing and agricultural processing residues/co-products					
Dry residues such as: palm kernel expeller, olive nuts, shea nuts, cereal co-products, sun flower co-products, corn kernels, coffee grounds, etc.	UK and internationally traded	Need specific temperature, humidity, ventilation conditions. Degrades rapidly (forms dust, mould spores), so some residues must be used rapidly.	Relatively good handling characteristics due to their consistency (granular, power-like or pellets). Potential for spontaneous combustion.	Good availability: both from UK and traded internationally. Some food processing residues are relatively dry, so they store well.	Many residues have alternative use as animal feed – this is a high value market where increased demand leads to increased prices. High volatile prices dependent on multiple variables (harvest, food and feed prices). Variable content (some of them with high ash content). Some residues can cause respiratory problems if not stored and handled properly.

Description	Supply source	Storage	Handling	Advantages	Disadvantages
Industrial sludge					
Paper sludge	UK			Good availability Low cost waste fuel.	Can be high in moisture content and bulky to transport. Consequently many paper mills are considering their own use. Variable composition (can be very high in ash and other metals). Explosion hazard for dry paper sludge.
Tall oil	Imported (usually from Nordic countries)	Strong smell. Stores well (up to 1 year)		Liquid fuel; can be used as a replacement for heavy fuel oil in oil or pulverised fuel-fired boilers with minimal modifications. History of use in Scandinavia.	Use of tall oil has been linked to potential boiler corrosion issues in the past. Mixture of chemicals, variable composition.
Energy crops					
Short rotation coppice SRC are trees planted primarily as a fuel for renewable energy production. The main species in the UK are willow and poplar, but eucalyptus is also being proposed.	UK or imported	Keep dry – store as loose piles in covered (but well-aired) storage if possible.	Potential for self heating in storage. Potential for emission of organic compounds. Potential for fungal growth and release of spores.	Wood fuel and energy crop. Sustainable source of wood and should be easy to audit source.	Shortage of planting material and harvesting equipment in UK. Low quantities available at present. Proposed use of eucalyptus as an energy crop is raising concern (deep tap roots impact on water table and it may be invasive).
Energy grasses **(miscanthus, switch grass, reed canary grass)** Are grasses grown specifically for energy production; include reed canary grass, switch grass, spartina, miscanthus	UK or imported	Store under cover to keep dry. Will rot if kept in the open air and in the rain.	Handling problems might occur due to morphology of material. Loss of dry material.	Available in a variety of forms. Energy crops. Annual crops that can have high yield	Relatively high ash content. Relatively low bulk density.
Residues from biofuels production					
Dried distillers grains with soluble – DDGS (residue from alcohol or bioethanol production)	UK	Keep dry.	Explosion hazard.	Low calcium in ash. Low moisture content providing it is dried.	High silica, potassium and phosphorus content in ash. Relatively low fusion temperature. May have issues with corrosion and fouling.

Table B3: Summary of Data on the Combustion Characteristics of Wood Fuels

	Round wood Logs	Chips from fresh wood	Sawdust	Wood pellets	Waste wood
Particle size	100mm to 1000mm[1]	1 – 100mm (can be graded)	1-5mm[1]	0<25mm[1]	Heterogeneous – usually chipped as specified
Moisture content (%)	20 - 65%	10 - 50	10 – 65	8 – 10	5 - 8
Gross Calorific value (MJ/kg) , dry ash free	20 (18.5 - 20.8)	20 (18.5 - 20.8)	18 - 21.8	18 - 21.8	17.6 (15 - 17)
Ash (dry basis)	0.2 - 2%[2]	0.2 - 1.98	0.1 - 4.9 (usually <1.5)	0.5	0.1 - 0.8 (to 2)
Volatile Matter weight (%)	75 - 85%	75 - 85	43 - 76	72	70 - 73
Sulphur (% dry basis)	0.01 - 0.05	0.01 - 0.05	<0.08	>0.08	0.02 - 0.04
Chlorine (% dry basis)	0.01 - 0.03[3]	0.01 - 0.03	0.04	0.01 - 0.36	0.01
Na_2O in ash (%)	0.02 - 0.77	0.02 - 0.77	0.77 - 2.3	0.9 - 2.3	0.7 - 2.3
K_2O in ash (%)	0.05 - 12	0.05 - 11.9	7.6 - 11.9	5.2 - 8.5	7.6 - 11.9
Heavy metals	Typically low (<35mg/kg, depending on the metal)				Levels of Pb, Cu and Zn may be significantly higher than uncontaminated wood.

1. Definition from CEN/TS 14961:2005 (CEN 335)

2. The content of bark will influence some of these values, e.g. ash content, level of chlorine, levels of heavy metals.

Sources of information:

- *Phyllis database: www.ecn.nl/phyllis*
- *Biobib database: www.vt.tuwien.ac.at/biobib*
- *APAS project*
- *WRAP – Project WOO0036 Identification and assessment of types and levels of chemical contamination in wood wastes; August 2006, available at www.wrap.org.uk*
- *CEN 335: Solid biofuels – Fuel specifications and classes CEN/TS 14691:2005.*

German standard DIN51731 specifies limits on specific metals contents of pellet fuels as follows:

Arsenic	*<0.8mg/kg*
Cadmium	*<0.5mg/kg*
Chromium	*<8mg/kg*
Copper	*<5mg/kg*
Mercury	*<0.05mg/kg*
Lead	*<10mg/kg*
Zinc	*<100mg/kg*

3. Chlorine content varies depending on wood and land it is grown on. Values have been observed between: 10 - 200mg/kg

Table B4 : Overview of Standards for Biomass Fuels

CEN Committee	What does the standard cover?	Additional comments
335	Standard for all forms of **solid biofuels** in Europe, including wood chips, wood pellets, briquettes, logs, sawdust and straw bales. These standards allow all relevant properties of the fuel to be described, and include both normative information that must be provided about the fuel, and informative information that can be included but is not required. As well as the physical and chemical characteristics of the fuel as it is, CEN 335 also provides information on the source of the material. **STATUS:** All Technical Specifications* for CEN 335 have now been published.	The Work Programme for TC 335 contains 30 Work Items, which are allocated to 5 Working Groups (WGs): • WG 1 Terminology, descriptions and definitions; • WG 2 Fuel specifications, classes and quality assurance; • WG 3 sampling and sample preparation; • WG 4 Physical and mechanical test methods; • WG 5 Chemical test methods.
343	Standards for **'solid recovered fuels'.** These are defined in the mandate for this standardisation work as: "fuels prepared from non-hazardous waste to be utilised for energy recovery in waste incineration or co-incineration plants regulated under Community environmental legislation". **STATUS:** All Technical Specifications for CEN 343 have now been submitted to the formal vote.	The Work Programme for TC 343 is allocated to 5 Working Groups: • WG1 Terminology and Quality Assurance; • WG2 Fuel specifications and classes; • WG3 Sampling, sample reduction and supplementary test methods ; • WG4 Physical/Mechanical tests; • WG5 Chemical Tests.
383	Standard for **sustainability of biofuels** This Committee has only recently been established. It will develop standards to allow the measurement of the sustainability of biofuels as indicated in the new Renewable Energy Directive	It is not clear whether these standards will be updated for solid biomass in 2010 or if they will include solid biomass from the start.

. **A Technical Specification is published by CEN but is not a full Standard; it provides a mechanism to publish a pre-Standard where, for example, there is a need gather information for a Standard.*

Table B5: Summary of Woody Fuel Categories Specified in CEN 335

Fuel type	Property	Categories
Pellets	**Origin and source**	
	Dimensions	5 grades in range <6<Diameter<25+ mm Length less than 4 or 5 x Diameter
	Moisture content	3 grades in range up to 20%+ by weight
	Ash content	5 grades in range up to 6%+ by weight
	Sulphur content	4 grades in range up to 0.2%+ by dry weight
	Mechanical durability	3 grades in range 90%->97.5% by weight after testing
	Amount of fines	3 grades in range 0-2%+ weight per cent less than 3.15mm at factory gate
	Additives	Weight % of pressing mass
	Nitrogen content	5 grades in range up to 3%+ by dry weight
	Net calorific value or energy density	Stated in MJ/kg as received
	Bulk density	Stated in kg/m^3 loose if traded by volume
	Chlorine content	4 grades in range up to 0.1%+ by dry weight
Wood chips	**Origin and source**	
	Dimensions	4 grades of particle size with 80% of particles in range <16<particle size<100+mm
	Moisture content	5 grades in range up to 65%+ by weight
	Ash content	5 grades in range up to 10%+ by weight
	Nitrogen content	4 grades in range up to 3%+ by dry weight
	Net calorific value or energy density	Stated in MJ/kg as received
	Bulk density	Stated in kg/m^3 loose if traded by volume
	Chlorine content	4 grades in range up to 0.1%+ by dry weight
Log woods	**Origin and source**	
	Dimensions	5 grades in range <200<Length<1000mm <20<Diameter<350+ mm
	Moisture content	4 grades in range up to 65%+ by weight
	Wood type	Deciduous, coniferous or mixed
	Energy density	Stated in kWh/m^3 loose or stacked
	Proportion of split volume	
	Cut-off surface	Even or smooth
	Mould and decay	If greater than 10% by weight
Sawdust	**Origin and source**	
	Moisture content	5 grades in range up to 65%+ by weight
	Ash content	4 grades in range up to 6%+ by weight
	Nitrogen content	4 grades in range up to 3%+ by dry weight
	Net calorific value or energy density	Stated in MJ/kg as received
	Bulk density	Stated in kg/m^3 loose if traded by volume
	Chlorine content	4 grades in range up to 0.1%+ by dry weight

Properties printed in **bold** are normative: provision of this information is a requirement of the standard.

Properties printed in italics are normative only for chemically treated biomass

Properties printed as normal text are informative: it is recommended that the information is provided.

Appendix C – Screening Models

Several screening models are available that may be useful in assessing the impact of biomass combustion installations.

ADMS-Screen is available from the developers, CERC. It is based on the detailed ADMS model but makes use of a number of pre-defined meteorological datasets.

AERSCREEN is the screening model for AERMOD. The model will produce estimates of regulatory design concentrations without the need for meteorological data and is designed to produce concentrations that are equal to or greater than the estimates produced by AERMOD with a fully developed set of meteorological and terrain data. The US EPA is currently working on a beta version of the code that will be released to the public as soon as possible.

The third edition of the 1956 Clean Air Act Memorandum: Chimney Heights "The Clean Air Act Memorandum" provides simple numerical formulae for assessing chimney heights. It was developed based on a simple dispersion algorithm. Separate formulae are used for very low sulphur fuels (less than 0.04% by weight) and for other fuels, i.e. containing sulphur. Most forms of biomass may be considered to be very low sulphur fuels except where the biomass has been chemically treated. The method is applicable for fuel burning plant with gross heat input in the range 150kW to 150MW. The method seeks to determine the minimum height for a chimney that will ensure adequate dispersal of pollutants produced in normal combustion; these include oxides of nitrogen. It does not deal with grit and dust emissions. The calculations assume that an adequate efflux velocity for the flue gas will be achieved to prevent the plume of gas flowing down outside of the chimney. For boilers up to 2.2MW input, the target velocity should not be less than 6m/s at full load although it is recognised that many existing designs of small installations cannot achieve this. For boilers equipped with induced draught fans, higher velocities are required. The Chimney Heights Memorandum provides a simple algorithm for taking account of the effect of nearby buildings on dispersion. The Chimney Heights Memorandum is widely used for assessing the height of discharge stacks for gas boilers: local authorities should consider whether it is reasonable to apply a more stringent criterion for biomass combustion than gas combustion when considering the impact of oxides of nitrogen emissions. The formulae for very low sulphur fuels have been included in the Unit Conversion Tool workbook available at www.environmental-protection.org.uk/biomass.

HMIP Technical Guidance Note (Dispersion) D1 provides a simple set of formulae for assessing the short-term impact of pollutant emissions. It was developed by systematically running a dispersion model based on the NRPB R91 model for a range of discharge conditions. It is not appropriate for assessing the impact of oxides of nitrogen and particulate matter emissions from biomass boilers. D1 was developed in 1993 and addresses short term impacts, typically 15-30 minutes. Current air quality objectives for PM are associated with annual mean and 24-hour mean objectives. D1 is not applicable to the longer-term objectives. D1 should only be used where the discharge velocity exceeds 10m/s: the discharge velocities for natural draught biomass boilers are often considerably less.

Environment Agency Guidance for estimating the air quality impact of stationary sources (GSS) was a chart-based system for calculating the maximum impact of pollutant releases from a process stack. It was developed using results from systematic application of the ADMS2 model for a range of geographical and discharge situations.

Industrial nomographs are provided in Technical Guidance for Local Authority Review and Assessment LAQM.TG(03) for the assessment of NO_x and PM_{10} emissions against the Air Quality Strategy objectives. The nomographs were based on the GSS charts. The method takes account of the effect of the height of nearby buildings using the approach adopted for the Chimney Heights Memorandum. The method is limited to effective stack heights greater than 10m and assumes a discharge temperature of 100°C. The method in LAQM.TG(03) is intended to identify emissions sources that create a potential risk of locally exceeding the Air Quality Strategy objectives. The assessment criteria for development control decision-making are different from those for Local Authority Review and Assessment. The method has therefore been adapted for this study and a spreadsheet tool to calculate maximum annual mean ground level concentrations has been included in the Unit Conversion Tool workbook available at www.environmental-protection.org.uk/biomass.

Biomass nomographs were developed for inclusion in Technical Guidance for Local Authority Review and Assessment LAQM.TG(09). The nomographs were developed using results from systematic application of the ADMS4 model for a range discharge situations appropriate for biomass combustion installations. The method takes account of the effect of the height of nearby buildings using the approach adopted for the Chimney Heights Memorandum. The method was intended to identify biomass emissions sources that create a potential risk of locally exceeding the Air Quality Strategy objectives. The assessment criteria for development control decision-making are different from those for Local Authority Review and Assessment. The method has therefore been adapted for this study and a spreadsheet tool to calculate maximum annual mean ground level concentrations has been included in the Unit Conversion Tool workbook available at www.environmental-protection.org.uk/biomass.

Appendix D – The Air Quality Standards for Scotland

Table D1: Objectives for the Purposes of Local Air Quality Management (included in the Air Quality Regulations, as amended)

Pollutant	Objective	Measured as	To be achieved by
Benzene	3.25µg/m³	Running Annual Mean	31 December 2010
1,3-Butadiene	2.25µg/m³	Running Annual Mean	31 December 2003
Carbon monoxide	10.0mg/m³	Running 8 Hour Mean	31 December 2003
Lead	0.5µg/m³	Annual Mean	31 December 2004
	0.25µg/m³	Annual Mean	31 December 2008
Nitrogen Dioxide	200µg/m³ Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40µg/m³	Annual Mean	31 December 2005
Particles (PM_{10}) (gravimetric)	50µg/m³ Not to be exceeded more than 35 times per year	24 Hour Mean	31 December 2004
	40µg/m³	Annual Mean	31 December 2004
	50µg/m³ Not to be exceeded more than 7 times per year	24 Hour Mean	31 December 2010
	18µg/m³	Annual Mean	31 December 2010
Sulphur dioxide	266µg/m³ Not to be exceeded more than 35 times per year	15 Minute Mean	31 December 2005
	350µg/m³ Not to be exceeded more than 24 times per year	1 Hour Mean	31 December 2004
	125µg/m³ Not to be exceeded more than 3 times per year	24 Hour Mean	31 December 2004

UK Objectives not Included in Regulations

D1 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (the UK Air Quality Strategy) also contains a number of objectives, which are not included in regulations for the purposes of LAQM. They are intended as drivers for UK air pollution policy, as are the other objectives, but it is not thought appropriate for local authorities to assess against them at this time. The main reasons for this are that local authorities lack the necessary policy instruments to address the pollutant in question, or that the pollutant is regional in nature and therefore not suitable for local control (e.g. ozone).

Table D2: National Objectives not Included in the AQ Regulations			
Pollutant	**Objective**	**Measured as**	**To be achieved by**
Objectives for the protection of human health			
Ozone	$100\mu g/m^3$ Not to be exceeded more than 10 times per year	Daily maximum of running 8 hr mean	31 December 2005
Particles ($PM_{2.5}$) (gravimetric)	$25\mu g/m^3$ (target)	Annual Mean	2020
	15% cut in urban background exposure	Annual Mean	2010-2020
PAHs (Benzo(a)pyrene)	$0.25ng/m^3$	Annual Mean	31 December 2010
Objectives for the protection of vegetation and ecosystems			
Nitrogen Oxides	$30\mu g/m^3$	Annual Mean	31 December 2000
Sulphur dioxide	$20\mu g/m^3$	Annual Mean	31 December 2000
	$20\mu g/m^3$	Winter Mean (01 October - 31 March)	31 December 2000
Ozone	$18\mu g/m^3$	$AOT40^+$, calculated from 1h values May-July	Mean of 5 years, starting 01 January 2010