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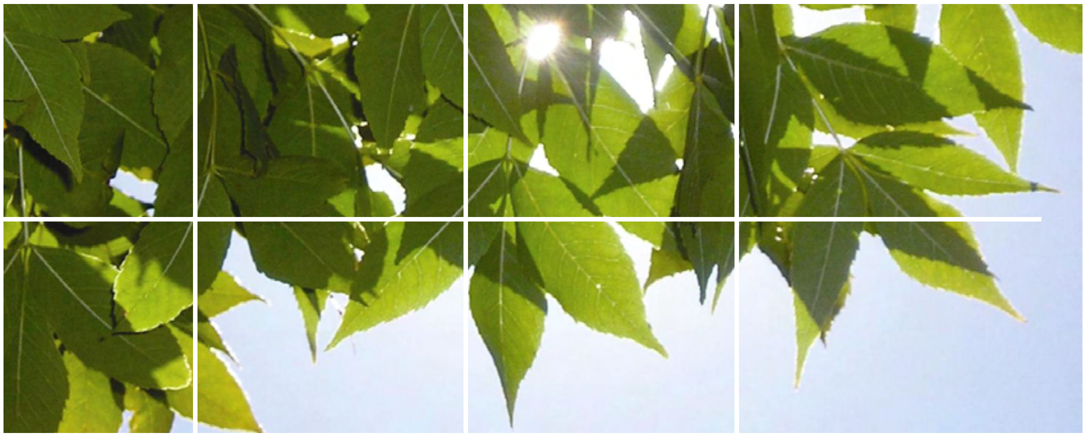

Review of the Potential Impact on Air Quality from Increased Wood Fuelled Biomass Use in London

Report to London Councils
Restricted Commercial
ED43098
AEA/ENV/R/2495/Issue 2
December 2007

Title	Review of the Potential Impact on Air Quality from Increased Biomass Use in London
Customer	London Councils
Customer reference	
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File reference	ED43098
Reference number	AEA/ENV/R/2495/Issue 2

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	Date	5th December 2007

Executive summary

The European Union, the United Kingdom Government and the Mayor of London have set greenhouse gas emission reduction and renewable energy usage targets. The use of biomass to generate energy offers significant potential environmental advantages for the reduction in emissions of greenhouse gases. As a result, biomass is one of the key renewable energy technologies that UK Government policy supports through a range of instruments. The Mayor's Energy Strategy recognises these drivers and examines what London can do to encourage the deployment of renewable energy, including biomass. However, there are concerns, particularly in London, that a significant increase in biomass, particularly wood fuel, could have a detrimental impact on air quality. This is a particularly sensitive issue in areas where Air Quality Management Areas (AQMAs) are in force which presently includes a large part of Greater London.

London Councils, on behalf of Greater London local authorities, commissioned AEA Energy & Environment to undertake a technical review of the potential impacts on air quality of increased wood fuelled biomass use in London. Any conclusions drawn are limited to technical issues, are not policy based and apply solely to London not nationally where there are differences both in terms of air quality climate and in terms of likely energy use scenarios. In terms of the provision of renewable energy, biomass as a fuel encompasses energy derived from biological material. However, this review focuses on wood as a form of fuel as the majority of enquiries that London Boroughs are currently receiving relate to biomass in the form of wood fuel. The review also examined the drivers for biomass use and the regulatory controls that are currently available to local authorities. A toolkit has been produced to aid the assessment of planning applications for biomass burners, which if published would aid developers and architects in specifying appropriate biomass systems.

London Boroughs were interested in assessing the potential cumulative impact of wood fuelled biomass across London. It is uncertain how many dwellings and commercial and industrial premises will install biomass boilers or biomass CHP plant in the City, however, the London Energy Partnership (LEP) have developed five potential scenarios for 2026 for London. These scenarios are based on a stretch target to reduce carbon emissions across the capital by 2026. Stretch targets by their very nature are challenging. In the absence of any alternative scenarios, or projections for the uptake of biomass across the regions, the LEP scenarios were considered in this study.. The spatial distribution of the take up of biomass has not nor could be determined. Hence, an even distribution in proportion to existing industrial, commercial and domestic energy demand was assumed. Two of the LEP scenarios, providing the lower and upper bounds on the potential biomass uptake, and consequently on the potential impact on air quality, were considered in more detail using dispersion modelling to compare projections to 2010 and 2020/2026 against a business as usual case. The predicted concentrations were compared with national objectives for nitrogen dioxide and particulate matter PM_{10} set out in the Air Quality Regulations (2000) and the Air Quality (Amendment) Regulations (2002).

For the business as usual case, predicted annual average concentrations of PM_{10} are less than 24 $\mu g\ m^{-3}$ at background locations throughout London for 2010 and 2020. According to Defra's Technical Guidance (LAQM(TG.03)), it is expected that the 24-hour objective for PM_{10} concentrations will be met where the annual mean is less than 32 $\mu g\ m^{-3}$. Under the renewables-led Scenario 3 from the LEP report, with the highest emissions from wood fuelled biomass, the predicted PM_{10} concentration in central London approaches 37 $\mu g\ m^{-3}$. It is therefore predicted that the air quality objective for PM_{10} will not be met at background locations in Central London under this possible scenario. Concentrations at roadside locations will be somewhat higher than the concentrations at background locations and so the extent of the area of exceedence will be rather greater. Under the more favourable Scenario 1 (large scale CHP led), the predicted PM_{10} concentrations are smaller, nevertheless the predicted increase in concentrations is expected to make it more difficult to achieve the objective at sites near major roads.

Predicted $PM_{2.5}$ concentrations under the "business as usual" scenario are less than 17 $\mu g\ m^{-3}$ at background locations throughout London for 2010 and 2020. It is thus likely that the 25 $\mu g\ m^{-3}$ cap will be met at background locations. Under the renewables-led Scenario 1, with the highest emissions

from wood fuelled biomass, the predicted concentration in Central London approaches 30 $\mu g\ m^{-3}$. Under this scenario, there would be widespread exceedence of the cap throughout central London. Under the more favourable Scenario 1, the predicted concentrations are smaller: nevertheless the predicted increase in concentrations is expected to make it more difficult to achieve the cap at sites near major roads.

Nitrogen dioxide concentrations are predicted to exceed the air quality objective of 40 $\mu g\ m^{-3}$ as an annual mean at background locations in Central London under the business as usual case in 2010 and 2020. The predicted increase in nitrogen dioxide concentrations at background locations in central London ranges from 3-10 $\mu g\ m^{-3}$ under the modelled biomass scenarios. This increase is likely to make other control measures less effective in achieving the objective.

The assessment shows that potentially increasing the contribution from small-scale wood fuelled biomass combustion to meet energy requirements in London under the London Energy Partnership scenarios may lead to a potentially substantial increase in nitrogen dioxide and particulate matter concentrations. It is outside the scope of this review to undertake emissions monitoring of individual appliances and consequently the assessment has been made on the basis that new combustion appliances will have rates of emissions typical of appliances currently being installed. Furthermore, it has been assumed that the spatial pattern of domestic and industrial/commercial emissions will remain the same. The potential impact could be reduced if biomass combustion was limited to larger district heating or CHP schemes outside the centre of London. For these units it would be cost-effective to install effective abatement equipment to reduce the emissions of particulate matter and oxides of nitrogen.

Local Authorities in London have a number of powers under the Clean Air Act (1993) to influence the specification of combustion systems. However, many of these powers have fallen into disuse and the supporting regulations and guidance do not reflect the current objectives of air quality policy or practice.

A toolkit has been produced which provides a means of estimating the scale of air quality impact of wood fuelled biomass appliances of a wide range of sizes and chimney heights. Using the toolkit it should be possible to identify significant air quality impacts of biomass combustion and seek either through reduced emissions or higher chimneys to mitigate the impact.

Table of Contents

1 Introduction

Biomass can have a variety of meanings[1] but in terms of provision of renewable energy includes energy derived from biological material through a transformation process. Energy may be heat, electricity or mechanical power. The biological material may be derived from animal or plant sources (including animal wastes and composts). The transformation may be direct combustion or perhaps involve gasification, fermentation or pyrolysis.

There is growing interest in the use of biomass for energy to help meet local and national targets for renewable energy. The use of biomass to generate energy offers significant potential environmental advantages for the reduction in emissions of greenhouse gases. As a result, biomass is one of the key renewable energy technologies that UK Government policy supports through various instruments. The London Energy Plan[2] recognises these drivers and examines what London can do to encourage the deployment of renewable energy, including biomass.

Management of Air Quality is the responsibility of Local Authorities. There are concerns, particularly in London, that a significant increase in biomass particularly wood fuel could have a detrimental impact on air quality. This a particularly sensitive issue in areas where Air Quality Management Areas (AQMAs) are in force which presently includes a large part of Greater London.

Emission regulation is well established for certain combustion processes however, controls on small combustion plant emissions are limited. The controls available to Local Authorities on small combustion plant comprise either the provisions of the Clean Air Act 1993 and associated Regulations (essentially concerning emission of smoke) or, the assessment of air quality impacts of a development at the planning stage for which there are no relevant national criteria.

The release of pollutants to air from biomass combustion is regulated under two main instruments - the Clean Air Act or Pollution Prevention Control Act (PPC) and their associated regulations. For some waste biomass, the Waste Incineration Directive (WID) is also relevant. The statutory bodies responsible for implementing these regulations in England and Wales are Local Authorities and the Environment Agency.

Most biomass plants will be regarded as development and consequently require planning permission. This is normally dealt with at local level, by Local Planning Authorities, who make decisions taking local and national policy into consideration. Regional policy on renewable energy is set out in Regional Spatial Strategies, which are subject to sustainability appraisals that consider environmental and social effects such as the effects of renewable energy proposals[3].

London Councils, on behalf of Greater London local authorities, commissioned AEA Energy & Environment to undertake a review of the potential impacts on air quality of increased biomass use in London. The main areas considered in the review are summarised below:

- The drivers for increasing use of biomass;
- A summary of legislation and potential controls on biomass plant;
- Sustainability and transport impacts;
- Biomass combustion technologies;
- General impacts, pollutants and nuisance issues;
- Fuels and storage;
- Air quality impacts of different renewable scenarios; and
- A toolkit to assess planning applications for biomass burners.

[1] For example some legislation may define or limit the definition of biomass to include only specific types of biomass.
[2] "Green light to clean power" The Mayor's Energy Strategy, February 2004.
[3] For example, they will consider reductions in carbon emissions, air quality improvements or reductions in waste going to landfill. Biomass energy can contribute to all of these.

2 Air Quality

Poor air quality directly impacts on the health and quality of life of a population. The issue of air quality cannot be viewed in isolation at a local level but also requires national and international perspective. This has resulted in a variety of agreements, legislation and regulation being implemented to improve air quality. Air quality is one of a number of environmental challenges that are linked and have an impact on each other.

Section 5 outlines the legislation that is in place to control and improve air quality. A primary mechanism setting targets for air quality is the Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland July 2007.

2.1 Air Quality in London

London is reported as having the worst air quality in the UK and amongst the worst in Europe. However, care must be taken when comparing data from other areas as a result of differences in the quantity and quality of the data being used to derive the conclusions. The poor air quality in London has been the driving premise for the implementation of legalisation and setting of air quality objectives particularly since the 1950s. As a result of controls implemented there has been a reduction in emissions from industry and domestic heating. The UK National Air Quality data shows significant reductions in smoke and SO_2 and smaller reductions in oxides of nitrogen.

The improvement in the air quality has resulted from actions such as:

- closing or relocating large power generation and major polluting industries to areas outside London;
- implementation of smoke control areas;
- a change of fuel from coal for the majority of domestic, industrial and commercial combustion units as a result of the availability of natural gas. As natural gas has a much low sulphur content than coal, burns without emitting significant concentrations of particles and in modern appliances can be burnt with low emissions of nitrogen oxides, there has been a reduction in the quantity of these pollutants emitted; and
- the virtual elimination of lead and sulphur from motor fuels and the fitting of catalytic converters has reduced emissions from vehicles.

The UK Government has a legal responsibility to meet EU air quality objectives. The government 's Air Quality Strategy contains a number of objectives, some of which are set in regulation for Local Air Quality Management. London Boroughs and the Mayor of London have a statutory duty to work towards meeting those objectives that are set in regulation. The Mayor also has a statutory duty to produce an Air Quality Strategy for London. All 33 London Councils have recognised the government's objectives will not be met throughout their boroughs and have declared Air Quality Management Areas. Most have published Action Plans for improving air quality.

The London Air Quality Network (LAQN) is geographically comprehensive, providing air quality data on the following pollutants: carbon monoxide, nitric oxide, nitrogen dioxide, ozone, PM_{10} and $PM_{2.5.}$ In addition, data is available from a limited number of sites operated by the Department of Environment, Food and Rural Affairs (Defra) and the London data is supported by measurements made by local authorities in surrounding areas. A summary of the provisional air quality measurements made during 2005 to the mid 2006 published by Kings College (London) reported the following conclusions:

- A majority of road and kerbside sites exceeded the annual mean air quality strategy (AQS) objective for NO_2 of 40 $\mu g\ m^{-3}$;
- Eleven sites exceeded the hourly AQS objective of 200 $\mu g\ m^{-3}$ not to be exceeded more than 18 times a year measured as a 1 hour mean;
- The PM_{10} AQS objective (50 $\mu g\ m^{-3}$ not to be exceeded more than 35 times a year measured as a 24 hour mean & 40$\mu g\ m^{-3}$ measured as an annual mean) was exceeded at major and high volume residential road site monitoring sites;

- The Ozone AQS objective (100 $\mu g\ m^{-3}$ not to be exceeded more than 10 times a year measured as the daily max of running 8 hour mean) was exceeded at almost all background sites; and
- The AQS objectives for CO (10 $mg\ m^{-3}$ measured as a 8 hour mean) and SO_2 (350 $\mu g\ m^{-3}$ 1 hour mean, not to be exceeded more than 24 times per annum; 125 $\mu g\ m^{-3}$ as a 24 hour mean not to be exceeded more than three times a year; 266 $\mu g\ m^{-3}$ as a 15 min mean, not to be exceeded more than 35 times a year) were met at all sites.

In addition, the summary reported that trends in NO_2 and PM_{10} were upwards when compared to data recorded in 2005.

Data from the London Atmospheric Emissions Inventory (LAEI) shows that road transport emissions, as a percentage of the total, dominate for all pollutants with the exception of SO_2 where industry produces comparable amounts. For NO_X and PM_{10} the contribution from transport is 41% and 70% of the total respectively.

Factors affecting the air quality in London include: the quantities emitted, the weather and topography. Weather has both positive and negative impacts on air quality by providing a mechanism for dispersing and diluting the emissions under windy conditions. Conversely, there are weather conditions that prevent dilution/dispersion occurring i.e. hot still days and during periods of temperature inversion. The weather also contributes emissions from other areas by acting as a transport mechanism bringing pollutants into London from surrounding areas. London lies in a natural basin, which in some periods restricts the dispersion of pollution. In Central London, the impact of tall buildings can lead to the street canyon effect preventing adequate dispersion and dilution of roadside pollution. Air quality policy most easily influences the emission of pollutants.

The challenge of improving London's air quality is complicated by:

- an increasing population, predicted to reach 8.1 million by 2016;
- pressure to maintain economic growth;
- increasing road vehicle traffic in inner and outer London (Central London is predicted to remain constant);
- London's topography; and
- positioning of large generation, waste disposal and industrial activities in the surrounding areas.

2.2 Pollutants controlled under air quality strategies

The following pollutants are controlled as part of the AQS for England, Scotland, Wales, and Northern Ireland.

2.2.1 Particulate material, PM_{10} and $PM_{2.5}$

Particle pollution is one of the most difficult measurements but most widely understood by the public as it is visible through its effects on soiling and nasal passages. The quantification of particulate material (PM) is defined by its effective aerodynamic diameter i.e. $PM_{2.5}$ is all material up to aerodynamic diameter of 2.5 µm and PM_{10} is all material up to aerodynamic diameter of 10 µm. These two different size fractions represent the depth the particles travel into the respiratory system.

Particles arise from both combustion processes such as coal, biomass or traffic and from abrasive processes such as construction, vehicle movement, grinding and cutting operations. These are both regarded a primary particles. Secondary PM results from atmospheric reactions between other pollutants emitted as sulphur and nitrogen oxides and ammonia and consists of a mix of compounds but to a large degree ammonium nitrate, chloride and sulphate.

Exposure to fine particles is associated with respiratory and cardiovascular illnesses, as these particle sizes are likely to be inhaled into the thoracic region of the respiratory tract.

2.2.2 Oxides of nitrogen

As part of combustion using air as the source of oxygen, oxides of nitrogen are produced as a result of the reaction between the nitrogen present in the air. Oxides of nitrogen include nitric oxide (NO) and nitrogen dioxide (NO_2). In addition to these species, nitrous oxide (N_2O) can be produced under certain conditions and within certain processes e.g. fluidised bed combustion. Road transport is the main source of NO_X associated with the air quality issues but power and industrial sectors using combustion make appreciable contributions.

High levels of NO_x are associated with damage to lung function and enhancement of the response to allergens in sensitive individuals. In addition, NO_X contributes to acidification and/or eutrophication of habitats. This affect does not necessarily impact on the local environment but can impact great distances from the source. N_2O has a contribution to global warming and hence climate change as it acts as a greenhouse gas and is 290 times more effective as a greenhouse gas than methane. NO_X also contributes to ground level ozone via reactions with volatile organic compounds and sunlight.

2.2.3 Ozone (O_3)

Tropospheric or ground level ozone is a secondary pollutant produced by reactions of NO_X and volatile organic compounds (VOCs) emitted from sources such as vehicles, petrol stations and solvent use which react in the presence of sunlight. Control of NO_x and VOCs leads to a reduction in overall formation of ozone at ground level. There are concerns however that as levels of NO_x fall in London levels of ozone may rise as it is no longer being used up in oxidising the emitted NO to NO_2.

Ozone reduces lung function and increases the incidence of respiratory symptoms. In addition to the health impacts ozone is associated with damage to plants resulting in reduced yields and impacts on trees and consequently on biodiversity.

2.2.4 Sulphur dioxide (SO_2)

In the UK emissions of sulphur dioxide are primarily associated with the complete combustion of fuels such as coal, which contain sulphur and sulphur containing compounds. Sulphur dioxide causes constriction to the airways producing chronic effects in individuals suffering from conditions such as asthma.

2.2.5 Polycyclic aromatic hydrocarbons (PAHs)

A number of compounds fall within the definition of PAHs. For the purposes of the AQS a marker compound benzo[a]pyrene is used to monitor those considered to be the most hazardous. The main contributions of PAHs arise from combustion processes (domestic coal, wood, accidental fires, bonfires and industrial processes such as coke production. Road transport is the largest source of total PAHs. Exposure through inhalation to mixtures of PAHs similar to those found in ambient air has been associated with increased incidences of lung tumours. Individual PAHs and some mixtures such as soots have also been shown to cause skin and bladder cancer.

2.2.6 Benzene

The main sources of benzene emissions to the environment are combustion processes and transport. It is recognised as a carcinogen attacking genetic material on a cellular level.

2.2.7 1,3 Butadiene

The primary source of 1,3-butandiene is the combustion of petrol in motor vehicles and other machinery. It is also emitted from processes producing synthetic materials such as rubber. The health effects most associated with this compound are lymphoma and leukaemia.

2.2.8 Carbon monoxide (CO)

Carbon monoxide (CO) is formed during the incomplete combustion of carbon containing fuels. The largest source is transport, with significant contributions from industrial and residential combustion processes. Carbon monoxide substantially reduces the blood's capability to transport oxygen and products of respiration around the body. CO irreversibly attaches to the oxygen sites in the haemoglobin molecule preventing oxygen from being carried. The effect of CO is accumulative if an individual is subjected to prolonged exposure over a period of time.

3 Drivers for Biomass Use

3.1 Overview of national drivers

The primary driver is climate change and the need to reduce greenhouse gases. Other relevant drivers include sustainability and energy security. UK legislative drivers have developed within the framework of EU and other international policies, strategies and instruments such as the Kyoto Protocol[4] to the United Nations Framework Convention on Climate Change (UNFCCC).

The EU has adopted a target of 12% renewable energy in the EU by 2010 and has produced a range of measures including Directives with targets for renewable use in electricity generation and transport fuels (biofuels). In addition, the EU has produced a Biomass Action Plan[5]. The EU has agreed a 20% renewable energy target for 2020. Individual Member State Contributions are now being agreed through an EU burden sharing exercise. This is a challenging target and can only be met if much of the currently economic renewable energy technologies are exploited.

In the UK the main mechanism for the Government to meet its targets under the Kyoto Protocol is the Renewable Obligation (RO)[6], which supports the generation of electricity from renewable resources.

Biomass is one of the most promising of the renewable energy technologies that are currently feasible in the UK. 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. The UK has also produced a Biomass Strategy[7] and established the Biomass Task Force, which produced a report[8], that examined the potential for biomass energy in the UK and the actions needed to realise this potential. Planning Policy Statement (PPS) 22 'Renewable Energy' and its companion guides also recognise the scope for biomass through the planning process.

The UK Energy White Paper announced a number of initiatives related to biomass (for example the biomass strategy) and consultations. These are intended to maintain growth in biomass power and increase support for biomass heat.

Other key instruments relevant to biomass use include:

- the EU Emissions Trading Scheme (EU ETS). This is relevant to industrial schemes of over 20MW; and
- the Energy Efficiency Commitment (the "Carbon Emission Reduction Target" or CERT will replace the EEC in April 2008).

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[4] For more information see the Kyoto Protocol at http://unfccc.int/resource/docs/convkp/kpeng.html
[5] The EU Biomass Action Plan COM (2005) 628 available at: http://ec.europa.eu/energy/res/biomass_action_plan/doc/2005_12_07_comm_biomass_action_plan_en.pdf
[6] See: http://news.bbc.co.uk/1/hi/world/europe/6432829.stm. Background details are set out in the Energy Policy for Europe in January and the Renewable Energy Road map and endorsed by the European Leaders at the summit in Germany on March 9th 2007. The target should be embedded in a new Renewable Energy Directive, which is due at the end of the year. For reference: The renewable energy road map is at: http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0848en01.doc
"Renewable Energy Road Map: renewable energies in the 21st century: building a more sustainable future" SEC(2007)12 Communication from the Commission to the Council and the European Parliament COM(2006)848 final. The Energy Policy for Europe is CEC Communication to the European Council and the European Parliament: Com (2007)1 final,10/1/07 {SEC(2007)12} "An Energy Policy for Europe" (http://eur-lex.europa.eu/lexUriServ/Site/en/com/2007/com2007_001en01.pdf . See also: Report 20/7/07: On the roadmap for renewable energy in Europe Procedure 2007/2090 (INI) A6-0287/2007
www.europarl.europa.cu/sides/getDoc.do?Type=REPORT&Reference=A6-2007-0287&landguage=EN
[6] The Renewables Obligation. For further information see the DTI web site: www.dti.gov.uk/sources/renewabels/policy/obligation/page15630.html
[7] The UK Biomass strategy www.defra.gov.uk/environment/climatechange/uk/energy/renewablefuel/pdf/ukbiomassstrategy-0507.pdf
[8] The Biomass Task Force Report (April 2006). www.defra.gov.uk/farm/crops/industrial/energy/biomass-taskforce/index.htm

- The Carbon Reduction Commitment announced in the Government's Energy White Paper 2007

In addition, a number of schemes and organisations provide support for the use and production of biomass including:

- The Bio-Energy Infrastructure Scheme;
- Bioenergy Capital Grant Scheme;
- Enhanced Capital Allowances;
- EU funding for research, demonstration and Intelligent Energy Europe, which may fund information dissemination and study tours;
- ERDP Energy Crops Scheme;
- Low Carbon Buildings Programme;
- Technology Programme; and
- The Carbon Trust.

More information on these drivers is provided at Appendix A.

3.2 Drivers for London

The key drivers, policy and legislation are shown in Figure 3.1. There are a number of policies and other drivers that will influence the uptake of biomass for heat and power in London.

The Mayor of London is legally required to produce a series of strategies for London, including a climate change and energy strategy. He also has a statutory duty to produce a spatial development strategy (The London Plan) that acts as a framework to integrate these strategies. The London plan is part of the statutory development plan for each London borough council alongside Development Plan documents produced by each borough. These documents are the starting point in the consideration of planning applications for the development or use of land.

The original London Plan and Mayor's Energy Strategy were published in February 2004. The Mayor has published Early Alterations covering waste in June 2006 and draft Further Alterations to the London Plan in September 2006. The latter sets out a new spatial planning framework to mitigate against, and adapt to, climate change. It is due for adoption in February 2008. The Mayor has also published a Climate Change Action Plan and is in the process of producing a Climate Change and Energy strategy, required under new legislation from 2007. In the context of this regional framework, the drivers to tackle climate change include objectives to minimise carbon dioxide emissions from all sectors through energy efficiency, combined heat and power, renewable energy and hydrogen, and to develop the heating infrastructure on and between development sites to facilitate this. Additionally, the Further Alterations to the London Plan require local authorities, in partnership with the GLA, to safeguard existing heat and cooling networks and to maximise the opportunities to provide new networks supplied by decentralised energy. The current and further alterations to the London Plan also support the provision of stand alone renewable energy technologies and require the use of on-site renewable energy in all development as part of the strategy to meet renewable energy targets for London. Decisions on suitable technologies should be subject to the specific circumstances of the site.

The London Plan and London Energy Strategy[9] supports the aim of increasing the proportion of energy used that is generated from renewable energy sources in London by:

- Requiring inclusion of renewable energy technology and design in new developments wherever feasible. This includes biomass heat and power;

- Facilitating and encouraging the use of all forms of renewable energy where appropriate, including giving consideration to the effect of new development on existing renewable energy schemes; and

- Supporting the use of waste wood as a fuel or for producing fuel.

In addition, there are a number of specific policies and proposals associated with biomass energy:

[9] The London Energy Plan, 2004, see http://www.london.gov.uk/mayor/strategies/energy/index.jsp

- Where waste cannot be reused, recycled or composted, value should be recovered in the form of materials and energy. In the case of energy, this should be done using a process that is eligible for ROCs, maximizes the efficiency by using both the heat and power and minimises emissions of pollutants to all media;
- There is support for proposals for the treatment of residual waste through advanced conversion technologies (e.g. anaerobic digestion, pyrolysis and gasification); and
- The Plan encourages the development of anaerobic digestion plants treating segregated biodegradable waste.

Within the UK Biomass Strategy, and other initiatives such as the Code for Sustainable Homes, there are a number of measures that are relevant for development of biomass use in London:

- **Development of biomass supply infrastructure;**
- **Expansion of biomass supply** to deliver more biomass energy. Potential sources that need to be considered include biomass in waste, such as food waste and waste wood. This links to initiatives in the Waste Strategy to reduce the carbon impact of waste management;
- **Local policies to promote and encourage the development of renewable energy resources** (including energy from biomass) **through the planning system**. The Biomass Strategy refers to the draft Planning Policy Statement on Climate Change;
- **Evaluation of biomass energy for all school buildings** within the Building Schools for the Future (BSF) programme. During 2007 it will become a requirement that biomass boilers are installed wherever appropriate in new school buildings and refurbishments;
- **Support for the development of energy markets for waste wood and waste derived fuels** through the Waste Implementation Programme;
- **Support for renewable heat and cooling** through a review of the business case for support of renewable heat (this is due to be made public in the near future);
- **Extension of the Energy Efficiency Commitment (EEC)** so that suppliers could promote micro-generation including biomass as part of their activity to meet their targets;
- **Making all new homes zero carbon by 2016;**
- **Putting climate change at the heart of the planning system** by reducing the need to travel and making best use of low carbon and renewable energy. In addition, there are moves to establish regional carbon targets;
- **Supporting innovation,** for example though lower cost fuels, more energy efficient conversion technologies (such as gasification and pyrolysis).

The definition of biomass and relevant legislation are examined in more detail in Appendix A.

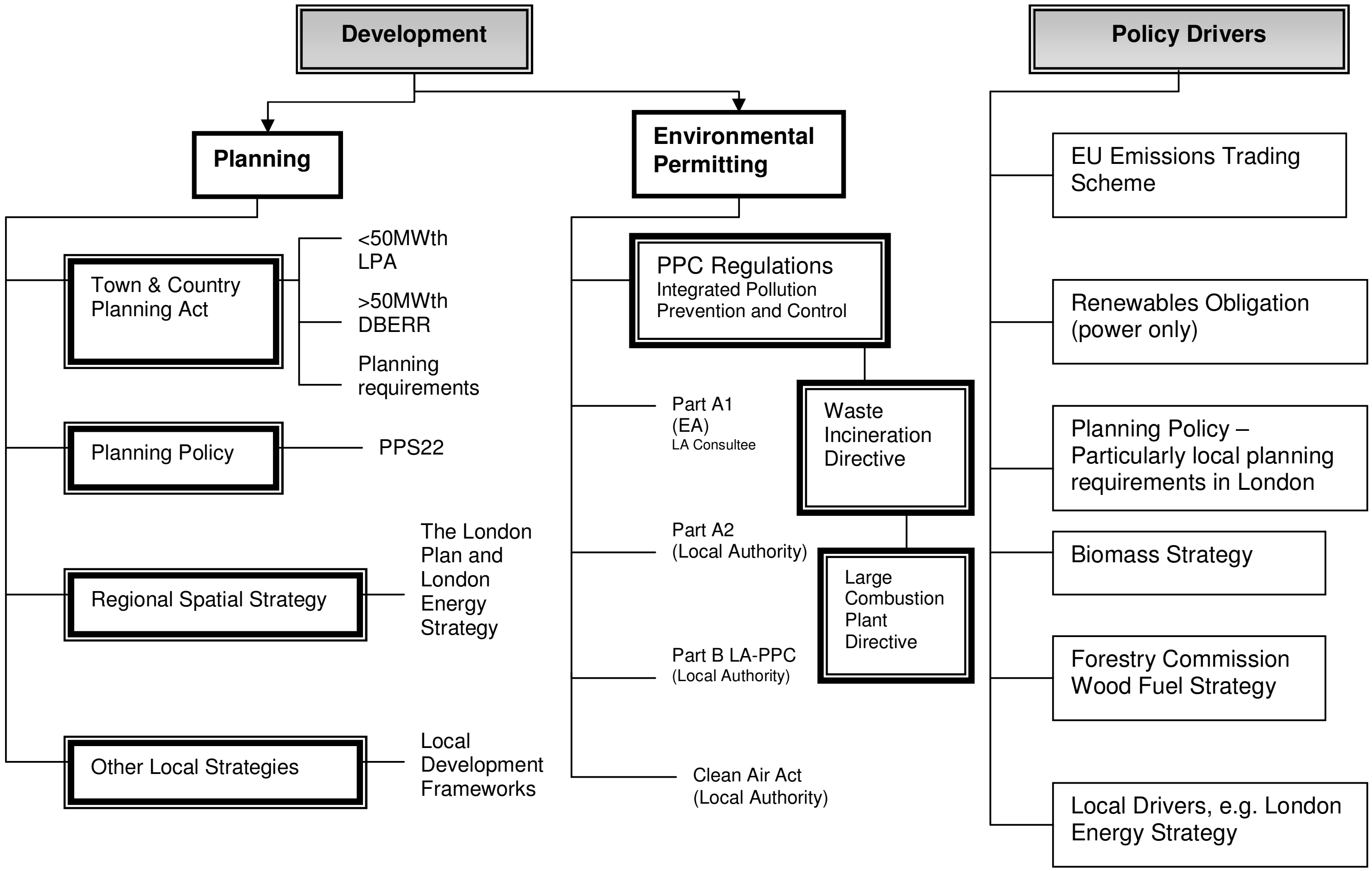


Figure 3.1: Overview of development legislation and policy drivers for biomass developments

4 Pollutants Associated with Biomass Combustion

The combustion of fuels to release energy in the form of heat results in the formation of pollutants that impact on air quality. The following sections briefly describe how the pollutants are formed during the combustion process, their measurement both at source and in their environment, and the impact on air quality. The combustion of biomass (wood) involves the thermal degradation of the material in air. This results in volatile vapours escaping from the surface and mixing with the available air producing a flame under the right conditions. Depending on the temperature present, different reaction routes could be followed:

- Low temperature - produces char and moisture, in the presence of oxygen the combustion of the char continues resulting in the final products of carbon dioxide and moisture; or
- High temperature – undergoes deploymerisation with combustion occurring in the flame i.e. gas phase producing carbon monoxide. If the conditions of oxygen, temperature, turbulence and duration are suitable carbon dioxide and moisture are the end products.

However, if the conditions required are not met then products of incomplete combustion such carbon monoxide and PAHs can be produced.

4.1 Pollutant formation

4.1.1 Oxides of nitrogen (NO_X)

NO_X is formed by three mechanisms during the combustion process; thermal NO_x, prompt NO_x and fuel NO_x contained in the fuel.

The thermal NO_x mechanism describes the oxidation of the nitrogen present in combustion air by oxygen atoms. As the nitrogen bond is very strong it requires high temperatures to break it and so the formation of NO_X is strongly dependant on the temperature of combustion. The thermal reaction route between nitrogen and oxygen molecules increases exponentially above 1100^{o}C to become significant at temperature above 1500^{o}C. It is generally the predominant mechanism in combustion processes. Hence, combustion system designers attempt to maintain good combustion while limiting temperatures. The thermal reaction is summarised in the following equation:

$$2O_2 + 2N_2 \rightarrow 4NO$$

Prompt NO_X is formed by the reaction between nitrogen, oxygen, and hydrocarbon radicals and is summarised in the following reaction:

$$CH_4 + 3\frac{1}{2}O_2 + N_2 \rightarrow NO + NO_2 + CO_2 + 2H_2O$$

This is a relatively fast reaction as the hydrocarbon radicals present a reaction path with a lower barrier to progress than the thermal route. This speed of reaction is what gives this route the name prompt NO_X. In reality, this very complicated process consists of hundreds of reactions and dozens of species. Prompt NOx is an important mechanism in lower temperature combustion processes, but is less important than thermal NO_X formation at the higher temperatures found in many industrial combustion processes. Prompt NOx is especially important under fuel rich conditions.

Fuel NOx is formed by the direct oxidation of nitrogen containing compounds (R_xN) in the fuel (hence, the name fuel NOx) and is given by the overall reaction:

$$R_X N + O_2 \rightarrow NO + NO_2 + CO_2 + H_2O$$

Fuel NOx is not a concern for high-quality gaseous fuels like natural gas or propane, which normally have no organically bound nitrogen. However, fuel NOx may be important when oil (e.g., residual fuel oil), coal, or waste fuels are used, which may contain significant amounts of organically bound nitrogen.

The percentage conversion of nitrogen to NO_x in a given biomass fuel rises sharply as the oxygen concentration in the flue gases increases from 0 to 6% above which the fraction converted remains constant.

4.1.2 Acid gases

Acid gases are oxides of sulphur (SO_X), which include sulphur dioxide (SO_2), sulphur trioxide (SO_3) and hydrogen chloride (HCl). The emissions of these pollutants are primarily dependent on the concentration in which they are present in the fuel. In a comparison of the biomass fuels straw, cereals and wood chips it was found that wood chips contained the lowest concentrations of sulphur.

Sulphur present in the fuel undergoes oxidation forming SO_2, SO_3 and alkaline sulphates. It has been found that the majority of the sulphur present in the flue gas condenses on to the particulate present (40 – 90%) and the remainder is emitted in the gaseous forms SO_2 and SO_3.

During the combustion process the chlorine present in the fuel volatises to a vapour forming HCl (in the presence of H_2O), chlorine (Cl_2) and alkaline chlorides.

4.1.3 Oxides of carbon

Oxides of carbon are carbon dioxide (CO_2) and carbon monoxide (CO). These oxides result from the combustion of carbon present in both fossil and biomass fuels and their formation is the primary reaction releasing of energy from the fuel. The complete combustion of carbon in the fuel results in the formation of CO_2. However, if this reaction is not completed carbon monoxide can be formed. Reducing carbon monoxide formation requires having sufficient oxygen present during combustion for long enough and with enough turbulent mixing in the combustion chamber.

4.1.4 Particulate material

Coarse fly ash results from the entrainment of ash and fuel particles from the fuel bed. Aerosols are formed from compounds released during the combustion process. The resulting aerosols are mainly formed of the volatile elements present in the fuel such as potassium (K), sulphur (S), chlorine (Cl) and heavy metals. If combustion is poor then the carbon atoms released as the fuel devolatilises may combine to make C_2 radicals, which polymerise to make larger molecules such as benzene, PAHs and eventually soot particles are formed.

4.1.5 Polycyclic aromatic hydrocarbons

The formation of polycyclic aromatic hydrocarbons (PAHs) is related to the characteristics of combustion and primarily the incomplete combustion of organic material e.g. wood containing carbon. The range of PAHs produced depends on a number of factors including the composition of the fuel, any contamination, the design of the combustion chamber and the conditions of combustion.

It has been reported that the combustion of biomass (especially wood) in small units (domestic type heating) may result in significant PAH emissions. In Sweden, solid fuels are not recommended for primary heating. Larger combustion units show total PAH emissions at a similar level to that found from fossil fuel variants and suggest that these will not be a significant source of PAH emissions. The PAHs emitted are likely to be different as the composition of the fuel is different[10]. As combustion plays such an important role in the emissions of PAHs, combustion control within an appliance is critical in the reduction and control of these emissions.

4.2 Monitoring of AQS pollutants

There are a number of approaches used to monitoring emissions directly from the technology used below the 50Mw level controlled under the LCPD. These include:

- **certification of a design** - testing to prove that a design meets required performance criteria but does not provide a measure of performance throughout its use. The performance of most combustion devices is dependant on a number of factors such as maintenance and changes in fuel composition and type;
- **continuous measurement** - involves the use of instrumentation that provides measurement of specified species. This option gives information throughout the time the unit is in operation enabling intervention if the performance of the system changes; and
- **periodic measurement** - requires spot checks of the emissions to confirm that the unit it still operating within designed parameters.

4.2.1 Standards for monitoring source emissions

There are CEN and International Standards Organisation (ISO) Standards that are applicable to the measurement of emissions at source levels, which could be used to determine the emissions from combustion processes burning biomass. The standards referenced in this section follow the standards hierarchy in the United Kingdom and are referenced the guidance document EA Monitoring Guidance note M2 version 4.2 July 2007. Table 4.1 lists standards that are available and under development to measure the species listed in the AQS. In addition to the standards listed above there are standards that are specific to the use of automated monitoring systems for continuous measurement. These are:

- EN 14181:2004. Stationary Source Emissions – Quality Assurance of automated measuring systems;
- ISO 6879:1995. Air Quality – Performance characteristics and related concepts for air quality measuring methods;
- ISO 9169:1994. Air Quality – Determination of performance characteristics of measurement methods;
- ISO 10396. Stationary source emissions – Sampling for the automated determination of gas concentrations;
- ISO 10849. Stationary source emissions – Determination of the mass concentration of nitrogen oxides – Performance characteristics for automated measuring systems;
- ISO 14164:1999. Stationary Source emissions – Determination of the volume flow rate of gas streams in ducts – Automated method.
- ISO 9169:1994. Air Quality – Determination of performance characteristics of measurement methods;
- ISO 10396:1993. Stationary source emissions – Sampling for the automated determination of gas concentrations; and
- ISO 14164:1999. Stationary Source emissions – Determination of the volume flow rate of gas streams in ducts – Automated method.

[10] PAH Emissions from Combustion of Biomass, Thomas Ramdahl/ Environmental Chemistry Department, Central Institute for Industrial Research, Oslo, Norway.

Table 4.1: Monitoring Standards Applicable to Source Level Monitoring

Pollutant	Standard Reference
Oxides of nitrogen	BS EN 14792:2005 Stationary source emissions – Determination of mass concentration of nitrogen oxides (NO_X) – Reference method: Chemiluminescence. ISO 10849 Stationary Source emission – Determination of the mass concentration of nitrogen oxides – Performance characteristics of automated measuring systems.
Carbon monoxide	BS EN 15058: 2007. Stationary source emissions - Reference method for the determination of carbon monoxide in emission by means of the non-dispersive infrared method ISO 12039:2003 Stationary source emissions – Determination of the volumetric concentration of CO, CO_2 and oxygen – Performance characteristics and calibration of an automated measuring system.
Sulphur dioxide	BS EN 14791. Stationary source emissions – Determination of mass concentration of sulphur dioxide – Reference method.
PM_{10} & $PM_{2.5}$	BS ISO 23210 (currently under development).
Particulate material	EN 13284-1. Stationary Source emissions - Determination of low range mass concentration of dust - Part 1: Manual gravimetric method.
PAH	BS ISO 11338-1:2003. Stationary source emissions. Determination of gas and particle-phase polycyclic aromatic hydrocarbons.
Benzene	BS EN 13649. Stationary source emissions. Determination of the mass concentration of individual gaseous organic compounds. Activated carbon and solvent desorption method.
1,3 Butadiene	BS EN 13649 Stationary source emissions. Determination of the mass concentration of individual gaseous organic compounds. Activated carbon and solvent desorption method.
Flow	ISO 10780:1994. Stationary source emissions - Measurement of velocity and volume flow rate of gas streams in ducts.
Oxygen	BS EN 14789: 2006. Stationary source emissions - Determination of volume concentration of oxygen (O_2) – Reference method – Paramagnetism.

4.2.2 Standards for the measurement of ambient levels of AQS standards

Table 4.2 details measurement standards used to measure pollutants in the ambient environment.

Table 4.2: Standards for Measurement of AQS Pollutants in the Ambient Environment

Pollutant	Standard Reference
Oxides of nitrogen	BS EN 14211:2005. Ambient air quality. Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence.
Carbon monoxide	BS EN 14626:2005. Ambient air quality. Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence.
Sulphur dioxide	BS EN 14212:2005. Ambient air quality. Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence.
PM_{10} & $PM_{2.5}$	EN 12341:1998. "Air Quality – Field Test Procedure to Demonstrate Reference Equivalence of Sampling Methods for the PM_{10} fraction of particulate matter".
Ozone	BS EN 14625:2005. Ambient air quality. Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence.
PAH	EN 12341:1998. "Air Quality – Field test procedure to demonstrate reference equivalence of sampling methods for the PM_{10} fraction of particulate matter".
Benzene	EN 14662:2005 (Parts 1, 2 and 3). "Ambient air quality – standard method for measurement of benzene concentrations.

4.3 Air quality impacts of heat production from biomass

The utilisation of biomass for energy can affect air quality in a variety of ways. A large proportion of the total air pollutants of a bioenergy production chain are released during combustion of biomass or biomass-derived fuels. Emission levels of some of these pollutants, such as NO_x and SO_x depend heavily on the chemical composition of individual fuels while emission levels of other pollutants such as particulates (PM) PAHs and carbon monoxide depend on the completeness of the combustion process. The sulphur and nitrogen content of wood biomass is low but higher than for gas and hence displacement of gas may lead to a modest increase in SO_2 and NO_x emission.

The emissions to atmosphere from combustion can cause impact on the environment at a local, national and transboundary scale. However, the pollutants associated with biomass combustion are also associated with other combustion processes (including transport) and the use of biomass can lead to an increase or decrease in emission. The relative contribution will depend on the type of fuel and combustion technology displaced, typically gas within London. Some of these pollutants (e.g. PM, SO_2 and NO_x) are regulated by British and European legislation on air quality. The air quality strategy pollutants and principle sources are detailed in Table 4.3.

Table 4.3: Air Quality Strategy Pollutants and Main Sources (Percentage of total emissions in London 1999)[11]

Pollutant	Main source	Other key sources
Nitrogen dioxide	Transport (70%)	Power generation and aircraft
Sulphur dioxide	Coal & fuel oil fired power generation (39%)	Transport (38%)
Benzene	Transport (74%)	Petrol stations & petrol storage
1,3-Butadiene	Transport (93%)	-
Lead	Industry	Transport
Carbon monoxide	Transport (94%)	-
Particles (PM_{10} and $PM_{2.5}$)	Transport (68%)	Industry, domestic solid fuel combustion, materials handling and aircraft
PAHs	Domestic solid fuel	Industrial solid fuel use, bonfires accidental fires
Ozone	Formed as a secondary pollutant from reactions between nitrogen oxides and volatile organic pollutants	

Notwithstanding emissions arising from biomass processing or refining, Table 4.3 suggests that changes in emissions from increased biomass use are most likely to impact on those areas of air quality affected by traffic and combustion.

Analysis[12] of the first round of air quality management review and assessment reports for local authorities in England and Wales indicates that traffic sources are the main reason for declaring air quality management areas (75%). Industrial and domestic may be direct or indirect contributory sources (17%) but were rarely the sole reason recorded for exceeding air quality objectives (<10%). Although the review suggests that emissions from biomass combustion in residential and other stationary sources are less likely than traffic to give rise to air quality issues, the analysis was prior to formulation of renewable targets and current air quality objectives include other pollutants and are more stringent.

[11] Percentage of emissions within Greater London from road transport and Industry 1999, The Mayor's Air Quality Strategy.
[12] Leksmono *et al* 2002.

4.3.1 Review of combustion emission factors

An emission factor 'is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant' (USEPA, 1995). Factors are typically expressed as the mass of pollutant released per unit of production or, for combustion processes, per mass of fuel burned ($g\ kg^{-1}$). Other ways of expressing emission factors include relating the amount of pollutant released per unit of energy input ($g\ GJ^{-1}$) or energy output ($g\ kWh^{-1}$).

Residential/Institutional Biomass Combustion Units
Development of wood-fired residential boilers and stoves has been the focus of considerable activity over a number of years in Europe and Scandinavia. However, measurement data on modern combustion units is comparatively scarce. The last decade has seen an improvement in the quality of residential/ institutional heating units, some with efficiencies over 90% not least because of a number of European Standards for heating equipment.

Reinstating traditional fireplaces or use of wood logs in place of current solid fuels will occur to an extent but it is highly probable that most residential biomass combustion would require installation of automatic heating boilers and/or manual/automatic stoves replacing or supplementing existing non-biomass appliances. The modern biomass appliances typically burn wood pellets or wood chips and produce less particulate and in particular, products of incomplete combustion emissions, than traditional fireplaces. Emissions of NMVOC, total organic carbon (TOC) and particulate matter from modern wood boilers and pellet burners are much lower than for old low-efficiency residential heating systems.

Although many countries (including the UK) have type approval schemes for residential solid fuel appliances to demonstrate operation within smoke or particulate matter (PM) emission standards, these data are not often available and cover a limited range of pollutants. The European Standard EN303 Part 5 (1999) includes PM, CO and TOC (referred to as OGC in the Standard) limits for such appliances. However, it should be noted that the EN303 Part 5 Standard is not a 'harmonised' standard and its emission limits are not mandatory. Many countries have national requirements for PM emissions, which differ from those in EN303 Part 5.

The UNECE/EMEP taskforce on emission inventories and projections (TFEIP) recently updated its methodology chapter on emission factors for residential combustion. This Corinair guidance is published to support inventory teams, provide a resource of default emission factors and facilitate consistent inventory reporting.

Following review of the literature, it was concluded that the emission factors within the Corinair handbook for advanced wood fired techniques smaller than 1 MW_{th} are the most applicable to modern residential and institutional wood and biomass combustion appliances. The Corinair default factors cover four appliance types:

- Advanced stoves;
- Pellet stoves;
- Manual boilers; and
- Automatic boilers

A summary of the Corinair emission factors and the derived aggregate factor is provided in Table 4.4.

The impacts of the use of biomass for residential combustion are indicated in general terms in Table 4.5 below, similar impacts can also be expected for larger installations although the scale of change on larger plant will be reduced because of the greater use of emission control technology and the application of PPC regulations.

Table 4.4: Summary of Corinair Default Emission Factors for Advanced Wood Combustion Techniques <1MW

Pollutants	Emission factors, g GJ^{-1}			
	Advanced stove	Pellet stove	Manual boiler	Automatic boiler
SO_2	20	20	20	20
NO_X (as NO_2)	90	90	150	150
PM	250	80	80	70
PM_{10}	240	76	76	66
$PM_{2.5}$	240	76	76	66
CO	3000	500	3000	500
nmVOC	250	20	250	20
	mg GJ^{-1}			
As	0.5	0.5	1	0.5
Cd	1	0.5	0.3	0.5
Cr	8	3	2	4
Cu	2	1	3	2
Hg	0.4	0.4	0.5	0.6
Ni	2	2	200	2
Pb	30	20	10	20
Se	0.5	-	-	-
Zn	80	80	5	80
PAH	400	50	150	40
	ITEQ ng/GJ			
PCDD/F	300	50	300	30

Table 4.5: General Effects of Replacing Gas by Modern Biomass Combustion Technologies in Residential and Commercial Heating

Pollutant	Advantage '+' or disadvantage '-' from change to modern biomass technology (wood) from Gas	
	Gas	Comments
SO_2	-	Some treated woods contain sulphur containing compounds although relatively low typically 0/06 to 0.2% w[13]t which is higher than natural gas. Selection of the biomass could eliminate this.
NO_X	-	Woods and other biomass materials contain nitrogen 0.16%, wt which can result in an increase in the overall NO_x emissions as there will be fuel derived portion that is not present in gas combustion
PM/PM_{10} /$PM_{2.5}$	-	PM emissions increase due to the process of combustion in solid material from air flow through the fuel and ash. Also aerosol formation from volatile materials distilled from the wood
CO	-	Control of solid material combustion in the technologies applicable is less reliable than that of gas
nmVOC	-	Control of solid material combustion in the technologies applicable is less reliable than that of gas
Trace elements	-	Certain biomass materials contain trace elements
PAH	-	Control of solid material combustion in the technologies applicable is less reliable than that of gas
PCDD/F	-	Control of solid material combustion in the technologies applicable is less reliable than that of gas

[13] Analysis data from Phyllis, database for biomass and waste, http://www.ecn.nl/phyllis Energy research Centre of the Netherlands.

4.4 Nuisance impacts of biomass use

Nuisance issues tend to arise from smoke and odour. Emission of smoke in smoke control areas is in general an offence under the Clean Air Act and outside smoke control areas can either be addressed through nuisance 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. Determining stack height for adequate plume dispersion is considered in Section 7. Biomass storage issues are considered at Section 9.3.

5 Regulatory Controls

Summaries of the activities that are covered by which environmental permitting process and the relationship between fuel type and the applicable legislation are given in Sections 5.1 and 5.2 respectively.

5.1 Planning consent and environmental impact assessment

One of the primary influences that impact on the adoption of renewables technologies is that of planning. The following sections describe planning in respect to biomass usage.

5.1.1 General description

Different statutory bodies oversee the planning and permitting processes for biomass energy and the processes can be undertaken in parallel. This may be difficult for biomass plant developers, especially as the planning and permitting authority is different at different scales of operation. For example, for some large plants The Department for Business, Enterprise & Regulatory Reform (DBERR) has authority with regard to planning (although DBERR will consult the local authority). Similarly, environmental permitting may lie with the Environment Agency but the local authority will be a statutory consultee.

The situation is often confusing for the general public, who may regard the news that a plant has been granted a permit for operation by the Environment Agency as potential circumventing of planning requirements. However, both planning and permitting processes are important in ensuring that a biomass plant is developed appropriately within local and national planning and environmental permitting consents. They are examined together in this section, as a plant cannot be built without both permitting and planning consent.

The basic planning process for renewable energy is described on the BERR web site[14]. The majority of renewable energy proposals, including those for biomass plants, are regarded as development and will require planning consent[15]. Biomass energy proposals >50 MWe[16] fall within Schedule 2 of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) 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 300 MW would fall under Schedule 1 of the EIA Regulations, which means an EIA would be mandatory (this also includes all heat plant that co-fire biomass and have an output over 300MW).

Local Planning Authorities (LPAs) have the power to attach conditions to a grant of planning permission and to seek planning obligations from developers. The legislative basis for planning obligations is Section 106 of the Town and Country Planning Act 1990.

[14] Currently this is still: www.dti.gov.uk/energy/sources/renewables/planning/planning-process/process-england/page 18681.html

[15] Planning consent is required unless they constitute "permitted development" (permitted development rights cannot apply to Schedule 1 development or to Schedule 2 development, unless the local planning authority (LPA) has screened to the effect that an environmental impact assessment (EIA) is not required). Domestic scale installations do not require consent unless there is impact on neighbours.

[16] For new electricity-generating stations >50 megawatts development consent is required from the Secretary of State for the Department of Trade and Industry (DTI) under Section 36 of the Electricity Act 1989. In such cases it is also usual for developers to ask the Secretary of State for deemed planning permission under Section 90 of the Town and Country Planning Act 1990 at the same time.

Planning Authorities need to consider the potential impacts on local air quality particularly where the development is proposed in an Air Quality Management Area (AQMA). A local authority declares an AQMA, after it has undertaken an assessment of air quality in their area. This involves measuring air pollution and trying to predict how it will change in the next few years. The aim of the review is to make sure that the national air quality objectives will be achieved throughout the UK by the relevant deadlines. These objectives have been put in place to protect people's health and the environment. If it is found that the objectives are not likely to be achieved, an AQMA must be declared. Once declared a plan to improve the air quality is put in place - a Local Air Quality Action Plan. There are EU and National Air Quality Objectives set for the following pollutants: particulate material (both PM_{10} and $PM_{2.5}$), nitrogen dioxide, ozone, sulphur dioxide, polycyclic aromatic hydrocarbons (PAH), benzene, 1,3-butadiene, carbon monoxide and lead.

5.1.2 National planning guidance

Although each application is viewed on its own merits, the Government has issued guidance for planning authorities on its policies for renewable energy and pollution, which will help the decision making process (Planning Policy Statements 22 and 23, PPS22 & PPS23)[17]. The government has also produced a draft PPS1 on Planning and Climate Change. These Planning Policy Statements suggest that factors that may be taken into account when assessing applications include:

- The environmental impact of any proposed scheme and any impact on the landscape or other features of importance locally;
- Any local targets for the use of renewable energy;
- Local development plans and the history of development on the site;
- Changes in traffic movements locally as a result of the proposal;
- Other intrusion: e.g. visual, noise, dust, odour;
- Proximity to local housing; and
- Air Quality Standards and Objectives.

It also suggests that local planning authorities may wish to consider the following issues when determining an application:

- The positive benefit of the plant to the local economy. For example, the supply of biomass fuel can secure a long-term income for farmers, forestry owners, waste reprocessors and contractors, and transport operators. In this way some 80 to 90% of operational expenditure on biomass fuel supply can accrue to the local economy;
- Visual intrusion. The plant may be an industrial feature with a chimney. In certain weather conditions a plume may be evident from the chimney and/or drying equipment depending upon the design of the equipment;
- Noise from traffic and plant operations. As an industrial development, BS 4142 may be the applicable standard;
- Any effects on health, local ecology or conservation from airborne and water borne emissions;
- Traffic to and from the site in order to transport biomass fuel and subsequent by products;
- Traffic volumes, and the associated noise may increase with the introduction of a large biomass power facility, as the scheme may require a continuous fuel supply;
- Carbon mitigation; and
- The presence of Air Quality Management Areas.

[17] Planning Policy Statement 22 Renewable Energy (2004): www.communities.gov.uk/index.asp?id=1502772
Planning Policy Statement 23 Pollution Control (2004)

PPS22 also suggests that biomass plans may be accompanied by the following:

- Maps, diagrams and drawings showing the location and design of the plant and the general location of fuel sources;
- Details of the technology to be employed;
- In the case of large schemes, a zone of visual impact map of the chimney and photomontages of the plant from selected viewpoints;
- Details of vehicular access and movements and principal transport routes for fuel supply;
- Landscaping provisions;
- Details of noise emissions; and
- Site management measures during construction.

5.1.3 Regional guidance

For London, the relevant mandatory strategies/plans relating to renewable power are:

- The London Plan 2004[18], which provides for strategic planning for London and includes information on London's aspirations for renewable energy and its aspirations to become an exemplary sustainable world city; and
- The London Energy Strategy, 2004: "Green light to clean power"[19], which outlines London's aspirations to reduce its contribution to climate change through initiatives that include renewable energy and combined heat and power; to eradicate fuel poverty; and to contribute to London's economy by increasing job opportunities and improving London's building stock.

5.1.4 Government consultation

The Government recently consulted on the white paper on "Planning for a sustainable future".[20] The consultation document explains the planning process and provides information on environmental impact assessments, strategic assessment and other key issues. It also outlines proposals for a more streamlined and faster application process and to ensure that applications are dealt with at the appropriate level of government. In addition there are proposals to streamline the regional development plan and spatial strategy process, including sustainability appraisals. The White Paper is designed to address specific issues including:

- Meeting the challenge of climate change, including proposals for zero carbon homes; shifting to renewable and low carbon forms of energy; and
- Maintaining and securing energy supply.

The consultation closed in August 2007. It is likely that some of the above processes will be streamlined or changed as a result of the proposals in this White Paper.

[18] www.london.gov.uk/mayor/strategies/sds/london_plan_all.pdf
[19] See: www.London.gov.uk/mayor/strategies/energy/docs/energy_strategy04.pdf
[20] White paper on Planning for a sustainable Future, May 2007. www.communities.gov.uk/pub/669/planningforaSustainableFutureWhitePaper_id1510669.pdf

5.2 Environmental permitting

A summary of the controls available to local authorities, Clean Air Act, statutory nuisance and PPC.

5.2.1 Clean Air Act 1993

This is likely to be the main regulatory control that London authorities will have over biomass burners. Particulate emissions from residential and industrial combustion sources are controlled under the Clean Air Act 1993. The Clean Air Act (CAA) was developed to address the impact of air pollution on public health following appalling smog in 1954. The 1993 Act combines and repeals the 1956 and 1968 Acts along with some other changes such as metrication. The Act restricts smoke emissions from premises, applies particulate emission limits to industrial combustion units and includes the following powers:

- Prohibits the emission of dark smoke from chimneys unless within the limited periods allowed by the dark smoke permitted periods regulations (s1);
- Prohibits the emission of dark smoke from industrial or trade premises unless it was inadvertent and all practical steps taken (s2)
- Requires all new furnaces, other than domestic boilers less than 16.12kW output (defined as domestic furnaces), to be capable of operating smokelessly and to be notified to the local authority (s4);
- Allows the Secretary of State to prescribe emission limits on grit and dust from furnaces other than domestic furnaces (s5);
- Prohibits the use of a furnace other than a domestic furnace in a building or outdoors which burns pulverised fuel, solid fuel at 45.4 kg/h or more or liquid and gas fuels at 366.4 kW or more unless it has grit and dust arrestment plant fitted which have 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 (s6);
- Where a furnace is burning pulverised fuel, solid fuel at 45.4 kg/h or more or liquid and gas fuels at 366.4 kW or more the Local Authority may direct that measurements of the dust emissions are made (s10). However, if the furnace is burning solid matter at less than 1.02 te/h or liquid or gas at 8.21 MW or less then the Local Authority can be required to carry out the measurements (s11);
- Allows the local authority to request the occupier of a building to provide such information as may be reasonably required on the furnaces in the building and the fuels or wastes burnt on them (s12).
- Prohibits the use of furnace with a chimney which burns pulverised fuel, solid fuel at 45.4 kg/h or more or liquid and gas fuels at 366.4 kW or more unless the chimney height has been approved by the Local Authority following the provision of relevant information by the applicant, unless the application was made and the Local Authority did not respond within 8 weeks or a longer time mutually agreed (s14 15);
- Requires Local Authorities other than in Inner London to reject plans for buildings or extensions to buildings other than residences, shops or offices unless the Local Authority is satisfied that the smoke grit dust or gases will not be prejudicial to health or a nuisance (s16);
- Allows Local Authorities to create smoke control areas (s18) in which smoke emission is prohibited (s20) unless from the burning of authorised fuel or from the use of an exempt appliance;
- Allows the Secretary of State to authorise fuels (s20) and exempt classes of fireplaces (s21) which he is satisfied can be used without producing smoke or a substantial quantity of smoke;
- Prohibits the acquisition or delivery of solid fuel in a smoke control area other than to an appliance exempt under s21;
- Requires occupiers of buildings other than private dwellings or caravans when requested by the Local Authority to return estimates of the emission of pollutants from the premises (s36).

The rating of 45.4 kg/h for solid wood fuels will imply a range of heat input rates depending on the moisture content of the wood and the implied calorific value. At 10MJ/kg this would represent 126 kW, and at 20 MJ/kg this would imply 252 kW. Hence, pellet appliances would be caught by the arrestment plant requirements (s6) and chimney heights provisions (s14-15) of the act at larger sizes than wood chip or green timber.

Smoke control areas are primarily urban areas that have had a concentration of industry and/or coal-fired dwellings. The great majority of London Boroughs are completely covered by smoke control areas. 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 accessible records of the location of smoke control areas in some authorities.

In smoke control areas either authorised fuels or exempt appliances must be used. While biomass based fuels easily pass the requirement that authorised fuels have a sulphur content below 2% on a dry basis they normally struggle to pass the smoke test (BS3841) to become authorised fuels. Hence, to use biomass in a smoke control area it must be burnt in an appliance which is exempt under Section 21. Exempted appliances have undergone type-approval emission tests to determine if they can operate within prescribed particulate emission limits (see BS PD 6434) which are related to appliance capacity/output. Exemption testing for appliances is straightforward albeit somewhat dated and with relatively few test facilities able to undertake the test work.

The Clean Air Act 1993 potentially controls PM emissions for wood combustion activities up to 20 MW_{th} (the boundary with the PPC Regulations – Section 5.22. However, if the fuel is deemed to be a waste (or derived from a waste) then PPC Regulations apply at a lower size threshold.

5.2.2 Pollution Prevention and Control (PPC) – Permitting process

Pollution Prevention and Control (PPC) is a regime for controlling pollution from certain industrial activities. Operators are obliged to apply to the appropriate regulator (see below) for a permit for operation and must comply with its conditions.

It is illegal to:

- carry out an activity that is listed in the PPC Regulations without a permit; or
- not comply with the conditions in the permit.

The PPC regime implements the European Directive (EC/96/61) on Integrated Pollution Prevention and Control (IPPC). The system of PPC replaced that of Integrated Pollution Control and Local Authority Air Pollution Control (which was established by the Environmental Protection Act 1990).

The activities to which PPC applies are listed in Part A of Schedule 1 to the PPC regulations (SI 2000/1973) as amended (see http://www.opsi.gov.uk/si/si2000/20001973.htm). The divisions into industry and size determine who will regulate the installation, and hence with whom applications must be discussed and lodged.

“New” installations fall immediately within the requirements of PPC. “Existing” installations were required to apply for permits in accordance with a defined implementation timetable between 2000 and 2007. This timetable and other guidance on definitions have been published by Defra[21]. Further guidance is available on the Environment Agency’s ‘netregs’ web site[22].

The permits issued under PPC are also used to implement the requirements of other legislation and relevant requirements for public consultation, etc. Of particular relevance to waste-derived biomass are the requirements of the Waste Incineration Directive (WID) and, for the larger combustion activities, the Large Combustion Plant Directive. The WID sets stringent emission limits and monitoring requirements that are implemented by introducing its requirements into PPC permits. Further information about the WID and its applicability is provided in Section 5.2.3.

The permit obliges the Operator to meet various technical, management and performance criteria, including emission limits for releases to the environment, to monitor and manage their compliance with these. In addition, the regulator carries out inspections to ensure compliance.

[21] All guidance and other information published by Defra can be accessed on the Defra web site: www.defra.gov.uk/environment/ppc/regs/index.htm
[22] www.natregs.gov.uk/natregs/275207/276364/

Operators must use Best Available Techniques (BAT) to control pollution from their industrial activities. The aim is to prevent, and where that is not practicable, to reduce to acceptable levels, pollution to air, land and water from industrial activities. Matters such as noise, vibration and energy efficiency are also considered. An objective of BAT is to balance the cost to the operator against benefits to the environment.

The regulator for PPC in England is either:

- The Environment Agency Part A(1) installations; or
- The Local Authority (District, Borough or Unitary Authority) Part A(2) and Part B installations.

In general, wherever consideration is being given to the use of biomass as a fuel, this is likely to fall within one of the descriptions given in this legislation, and thus require a PPC permit. PPC covers a very wide range of industrial activities, but the main activities covered by these regulations, and of relevance regarding the use of biomass as a fuel are:

- Burning of any fuel or waste (in any type of plant); and
- Gasification and pyrolysis of any fuel or waste.

The requirement to apply for and hold a relevant permit applies whether the material is processed in a dedicated facility, intermittently or as an admixture. Permits are issued for the plant as operated in the permit application. Variations in operation require a variation in the permit, so that changes in the fuel used in biomass plants will require a variation in the permit.
Further guidance on the PPC procedure may be found on the guidance to IPPC part of the Defra web site: www.defra.gov.uk/environment/ppc/regs/index.htm and www.defra.gov.uk/coporate/consult/epp-guidance/part-a.pdf.

Guidance on the techniques and performance levels that may represent BAT are published by:

- The Environment Agency as PPC Technical Guidance Notes (for Part A activities – see below for guidance on definition);
- Defra as Local Air Pollution Prevention and Control - Process Guidance (PG) Notes (for Part A (2) and Part B activities; and
- BREF notes issued under IPPC directive (EC/96/61).

Table 5.1 provides a summary of the regulation of biomass related activities under the PPC Regulations.

5.2.3 Directive 2000/76/EC on the Incineration of Waste (WID)[23]

The application of the WID to biomass derived from waste can be a difficult area for regulators and developers. The definition of biomass for the purposes of renewables legislation and waste legislation is different. Under renewables legislation the term biomass includes biomass derived from waste. Biomass is excluded from WID. However, the definition under WID is narrower than that under renewables legislation and developers frequently miss this important point. Even when they understand the issue, they frequently challenge it and there have been a number of cases within European Law challenging the definition of waste for the purposes of combustion under WID. The issue is an important one as it increases the capital cost of development and involves the plant operator in monitoring and reporting of emissions from the plant.

Defra[24] guidance on the WID describes the scope, regulatory and technical requirements of the WID and how they should be interpreted and applied. It also describes the UK approach and implementing legislation.

The information provided in the guidance includes:

[23] See Europa for full Directive, e.g. http://eur-lex.europa.eu/LexUriServ/site/en/oj/2000/l_332/l_332200001228en00910111.pdf
[24] Guidance on Directive 2000/76/EC on the incineration of waste Edition 3 July 2006, Defra.

- Interpretation of the meaning of waste, incineration and co-incineration plant;
- Regulatory requirements of the Directive;
- Technical aspects of the Directive including operating conditions;
- Emission limit values for incineration and co-incineration plant, including example calculations for co-incinerators;
- Monitoring requirements; and
- Copies of the regulations, directions to regulators, the Directive itself, and the European Waste Catalogue.

Table 5.1: Summary of the regulation of biomass related activities under the PPC Regulations

Part of PPC Regulations	Regime	Regulator	Activity
Part A (1)	IPPC	Environment Agency	Installations in which any Part A(1) activity is carried out, including: ▪ Combustion plants of > 50 MW rated thermal input burning any fuel; ▪ Combustion plants of 3 – 50 MW net rated thermal input burning fuels containing or derived from waste; and ▪ Incineration of non-hazardous waste in an incineration plant[25] with a capacity of 1 tonne or more per hour.
Part A (2)	LA-IPPC	Local Authority	Installations in which any Part A(2) activity is carried out but no A(1) activity, including: ▪ Co-incineration of non-hazardous waste in any combustion plant associated with any Part A(2) activity and which has a rated thermal input of less than 50 MW; ▪ Incineration of non-hazardous waste in an incineration plant with a capacity of less than 1 tonne per hour; ▪ Co-incineration of non-hazardous waste in a co-incineration plant which is not otherwise an A(1) or A(2) activity; and ▪ Incineration of animal carcasses or animal waste in a plant which is exempt from the WID and which has a capacity of more than 10 tonnes per day but less than 1 tonne per hour.
Part B	LA-PPC	Local Authority	Installations in which any Part B activity is carried out but no A activity, including: ▪ Combustion plants of greater than 20 net rated thermal input but less than 50 MW rated thermal input, burning any fuel except that covered in Part A(1) above; ▪ Combustion plant burning fuels containing or derived from waste with a thermal input of 0.4 net rated thermal input and less than 3 MW rated thermal input and which is exempt from the WID; and ▪ Incineration of non-hazardous waste in a plant which is exempt from the WID but which has a capacity of 50 kilogrammes or more but less than 1 tonne per hour.

[25] Incineration plant and co-incineration plant have specific meanings in the PPC Regulations. In summary, these definitions refer to the incineration or co-incineration of waste in plants where the WID applies. Co-incineration plant here means a plant whose main purpose is the generation of energy or production of material products and which uses waste as a regular or additional fuel.

Table 5.2: Summary of the pollution control legislation applicable to waste and non-waste biomass fuels

Fuel scenario	Plant size	Pollution regulation applicable	Regulator
1 Biomass fuels e.g. coppice willow, and fuel residues of a similar nature arising from the manufacture of these fuels.	< 20 $MWth_{in}$	Clean Air Act	Local Authority
	20 – 50 $MWth_{in}$	LA-PPC (Part B PPC)	Local Authority
	> 50 $MWth_{in}$	IPPC also LCPD[26] applies (PPC Part A1)	Environment Agency
2. Waste or waste derived biomass exempted from WID, and fuel residues of a similar nature arising from their manufacture.	< 0.4 $MWth_{in}$ and < 50 kg/hr	Clean Air Act	Local Authority
	0.4 – 3 $MWth_{in}$ and 50 – 1000 kg/hr	LA-PPC (Part B PPC)	Local Authority
	> 3 $MWth_{in}$ and / or> 1000 kg/hr	IPPC (Part A1)	Environment Agency
	> 50 $MWth_{in}$	IPPC (Part A1). LCPD applies	Environment Agency
3. Waste or waste derived biomass to which WID applies.	< 3 $MWth_{in}$	WID applies. LA-IPPC (Part A2)	Local Authority
	> 3 $MWth_{in}$	WID applies. IPPC (Part A1)	Environment Agency

Note: The above is true for stand-alone combustion plants and incinerators. However, if the combustion activity is associated with an activity that is subject to LA control, then the waste burning plant will remain under LA control provided it is below 50MW.

All plant rating is in thermal capacity.

[26] LCPD: Large Combustion Plant Directive.

The WID applies to incineration and co-incineration plants. Co-incineration plants include those plants where waste (as defined by in the Waste Framework Directive (WFD)) is used as a fuel or where it is disposed of at a plant where energy generation or production is the main purpose. However, this definition is extremely broad and there are, in effect, very few circumstances where by-products, co-products or residues are not classified as wastes. Such wastes include: municipal waste, clinical waste, hazardous waste, industrial and commercial waste and waste-derived fuels. This definition has been clarified by the European courts of law i.e. a waste remains a waste until the point of use. This is relevant to wastes used to generate energy, because they remain wastes until the point of combustion. As a result treated waste wood fuels and any fuels derived from municipal solid waste remain wastes until the point of combustion and are regulated by the Waste Incineration Directive. However, some plants which are burning certain “wastes” (which are defined as waste in the WFD) are, by the means of specific exemptions (see below), excluded from regulation under the WID. This includes plants burning only animal carcasses or, in many circumstances, vegetable and wood waste.

It should be noted that a plant may burn one (or more) of these excluded wastes, alone or in combination with conventional non-waste fuels, and still be excluded from the WID, but the use of a waste that is not excluded will mean that WID applies.

The exclusions in the WID with the greatest potential relevance for solid biomass wastes are wood waste (Article 2(2)(a)(iv)): 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, and which includes in particular such wood waste originating from construction and demolition waste, are excluded from the WID. Wood cannot be taken to include paper and card. This is the most important exclusion for London, as many of the plants installed will use wood. It must be noted that if there is any chance that waste wood is contaminated with waste wood that comes under WID the Environment Agency is likely to classify the wood as waste and apply WID to any plant taking this fuel.

The Government recognises that some manufacturers producing, for example fibreboard, do not use chemicals containing halogens or heavy metals in the manufacturing process. However, if the wood waste used for the manufacture of the fibreboard was already contaminated, then the final product may be also contaminated (note: the WID doesn’t specify at what point the contamination has to take place), consequently the exclusion might not be applicable. However, this is a question of fact and the onus is on the operator of the incineration / co-incineration plant to demonstrate that the wood waste originally used did not arise from treated wood.

Some untreated wood products, such as wood pallets, may become unintentionally or accidentally contaminated during their normal use with organic chemicals and / or heavy metals. However, the WID exclusion would still apply because the contamination is not “as a result of treatment with wood preservatives or coating”. Operators wishing to take advantage of this exclusion will have to demonstrate to the regulator that any contamination is accidental and not as a result of treatment.

In general, the Environment Agency should be consulted about all biomass fuels where there remains any doubt as to whether or not they are a waste under the WID. However, plant that burns or co-incinerates only the materials listed in Table 5.3 (alone; in combination with one another or other “excluded plant” wastes; or with non-wastes) would normally be considered to be excluded, and not therefore required to meet the requirements of the WID.

5.2.4 Statutory Nuisance

The 1990 Environmental Protection Act lists nuisances to which abatement procedures apply. These are listed below:

- Any premises that due its condition is harmful to health;
- Smoke from a premises that is harmful to health;
- Fumes or gases emitted from premises that are harmful to health;
- Dust, steam, smell or effluvia from industrial, trade or business premises that could be detrimental health;
- Any accumulation of deposit which is prejudicial to health;
- Any animal kept in such away as to be harmful to health; and

- Emitted noise.

There are scenarios to which statutory nuisance regulations are not applied and as such do not come under the control of these regulations. These are:

- The emission of smoke from a premise that is a private dwelling in a smoke control area;
- The emissions of smoke from a chimney serving a furnace/boiler or industrial plant; and
- The emission of fumes and gases from all premises other than private dwellings.

However, depending on the process it maybe controlled by other regulations such as the Clean Air Act (1993).

5.2.5 Air Quality Strategy for England, Scotland, Wales and Northern Ireland (July 2007)

Following on from the adoption of the first Air Quality Strategy in 1997[27] there has been an improvement in air quality. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland then replaced this in 2003. This established a framework for further improvements in air quality via a strategy of local, national and international actions. After a period of consultation a revised strategy was published in July 2007. The objectives set out in previous strategies were not removed with the exception of a provisional PM_{10} target for 2010.

Within the air quality objectives there are UK only objectives. In this case the regulator has no legal obligation to set emission limits more stringent than those associated with the use of BAT.

An exposure reduction framework for minimising the health impact of particles has been adopted. This approach is based on the lack of an accepted safe level of exposure to fine particulate material ($PM_{2.5}$). The exposure reduction approach requires that the average exposure of the population to fine particles be reduced and differs from the former approach based on an air quality limit value which only requires measures in the most polluted locations that exceed the limit value. The strategy adopts a limit value of 25 ug/m^3 for $PM_{2.5}$ and a target of reducing the urban background concentration by 15% between 2010 and 2020. This changes the policy focus from addressing specific areas that approach or breach the air quality limit to an approach that considers all areas.

The AQS considers the following pollutants: particulate material ($PM_{2.5}$ & PM_{10}), nitrogen dioxide, nitrogen oxides, ozone, sulphur dioxide, polycyclic aromatic hydrocarbons, benzene, 1,3-butadiene, carbon monoxide and lead.

5.2.6 EU Fourth Air Quality Daughter Directive (2004/107/EC)

This EU directive relates to the control of arsenic, cadmium, mercury, nickel and PAHs (represented by benzo(a)pyrene) in ambient air. It establishes target concentration values for these species with the aim of avoiding, reducing and preventing the recognised harmful effects that these species are known to have on human health and the environment as a whole. In addition to setting target values which are designed to ensure that ambient air quality is maintained where it is good and that it is improved in other cases. Also the directive:

- determines common methods and criteria for the assessment of concentrations in air and deposition of these species; and
- ensures that adequate information on concentrations in ambient air and deposition obtained and made available to the public.

The Fourth Air Quality Daughter Directive 2004/107/EC was transposed into UK law by the Air Quality Standards Regulations 2007, which replaced the Air Quality Limit Values Regulations 2003. The associated new regulations came into force on 15 February 2007.

[27] The United Kingdom National Air Quality Strategy, March 1997

Table 5.3: Materials to which WID will not apply because they are either not a waste or are excluded from the scope of WID

Material	Comment
Forest thinnings and residues (lop and top etc)	See Note 1
Forest products (including, inter alia, sawdust, co-products including chip and bark)	See Note 1
Clean recycled wood	See Note 2
Wood pellets	See Note 2
Cereal by-products from the food processing industry	See Note 3
Olive oil by-products including olive stones and olive cake	See Note 3
Rice husks	See Note 3
Rice pellets	See Note 3
Coconut husks	See Note 3
Coconut pellets	See Note 3
Sunflower husks	See Note 3
Sunflower pellets	See Note 3
Straw	See Note 1
Palm nut by-products including the milled palm nut, palm kernel expeller, palm oil and other by-products from the palm oil industry	See Note 3
Palm nut shells	See Note 3
Citrus pulp pellets	See Note 3
Soya bean hull pellets	See Note 3
Shea meal	See Note 3
Shea pellets	See Note 3
Illipe meal	See Note 3
Illipe pellets	See Note 3
Prickly acacia	See Note 1 or 3
Oil seed residue	See Note 3
Oil seed pellets	See Note 3
Eucalyptus	See Note 1 or 3
Oatfeed	See Note 3
Corn Cob pellets	See Note 1 or 3
Recycled/used vegetable oil	See Note 4
Energy crops (i.e. any crop purposely grown for energy, including, *inter alia,* annual and perennial crops, short rotation coppice, grasses such as Miscanthus etc).	See Note 5

Notes:

1. If the material is waste from agriculture or forestry and not contaminated with non-vegetable waste
2. If the material is uncontaminated with halogenated organic compounds or heavy metals as a result of treatment with wood-preservatives or coating.
3. If the material is vegetable waste from the food processing industry" **and** the heat generated by using it as fuel is recovered.
4. If the material, is waste from the food processing industry (uncontaminated by any products of animal origin) **and** the heat generated by using it as fuel is recovered.
5. If the crops were purposely grown for energy, then they would be considered a fuel and not a waste, and the WID would not apply.

Source: Environment Agency

5.3 Emission limit values

A method of control that is used in regulation such as the European Directives on Large Combustion Plant (LCPD) and Waste Incineration (WID) involves the defining of emission limit values (ELVs). These values are set in concentration terms at a reference condition typically standard temperature and pressure at a determined oxygen concentration i.e. 11% for WID. Larger processes fall under the control of these directives i.e. greater than 50Mw thermal for LCPD, with typical biomass combustion units are below this definition.

Currently, there are no common European ELVs set for the combustion of biomass in processes up to 50MW above which are regulated under the European Union Large Combustion Plant Directive (LCPD).

A project undertaken by IEA partner countries reviewed emission limits for combined heat and power based on biomass combustion in Austria, Finland, Belgium, Denmark and Sweden, where the use of biomass is actively encouraged. The ELVs are summarised in Tables 5.4 and 5.5 and a set for particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NO_X), sulphur dioxide (SO_x), volatile organic carbon (VOC) and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F). In fact, the Netherlands has proposed ELVs that are aligned with EU LCPD as shown in Table 5.6 and 5.7.

5.4 Potential Changes to Regulation

Measures which could reduce the environmental impact of wood fuelled combustion plant would include:

- Reducing the size limit for Part B combustion processes from 20 $MWth_{in}$ to a smaller value, however many of the proposed units are under 1MW so this would be a significant change in regulation;
- Amending the Grit and Dust Regulations (1971) to represent current best practice or at least currently achievable by typical practice emissions; and
- Strengthening the criteria for exempting appliances under Section 21 of the Clean Air Act (1993).

However, these are policy conclusions outside the scope of the report and would require thorough technical and political examination before enactment.

Table 5.4: Emission Limit Values used in IEA Member Countries*

Country		**Austria**	**Finland**	**Belgium**	**Denmark**	**Sweden**
Fuel		**Wood**	**Wood, Straw, Peat**	**Biomass**	**Wood, Waste Wood, Straw**	**Biomass**
Parameter	**Fuel Energy Input (MW)**	**mg Nm^{-3} (13% O_2)**	**mg Nm^{-3} (13% O_2)**	**mg Nm^{-3} (11% O_2)**	**mg Nm^{-3} (10% O_2)**	**mg Nm^{-3} (11% O_2)**
Dust	< 0.12	150	-	-	150	350
	0.12 –1	150	-	-	150	100
	1 - 2	150	265	-	150	100
	2 – 5	50	265	-	150	100
	5 – 10	50	397	-	30	100
	10 – 30	50	159	-	30	35
	30 - 50	50	79	-	30	35
CO	<0.12	250	-	250	-	-
	0.12 –1	250	-	250	500	-
	1 - 5	250	-	250	500	-
	5 – 50	100	-	200	500	-
NO_X	<0.1	-	-	-	400	-
	0.1 – 5	250	-	-	400	200-300
	5 - 10	250	-	-	300	200-300
	> 10	200	-	-	300	200
	30 – 50	200	-	-	300	200
SO_X	< 50			300	-	-
				50	-	200
				50	-	200
TOC	> 0.1	50				
PCDD/F	> 5			0.1		

Table 5.5: Emission Limit Values used in IEA Member Countries expressed as Emission Factors

Country		**Austria**	**Finland**	**Belgium**	**Denmark**	**Sweden**	**Modelling Study (Chapter 6**	**Clean Air Act Limits**
Fuel		**Wood**	**Wood, Straw, Peat**	**Biomass**	**Wood, Waste Wood, Straw**	**Biomass**	**Wood fuel**	**Wood fuel**
Parameter	**Fuel Energy Input (MW)**	**g/ GJnet**	**g/ GJnet**	**g/ GJnet**	**g/ GJnet**	**g/ GJnet**	**g/GJ**	**g/GJnet**
Dust	< 0.12	111	-	-	80	207	0.022 MW_{th} 76	0.022 MW_{th}
	0.12 –1	111	-	-	80	59	0.556 MW_{th} 66	185
	1 - 2	111	196	-	80	59	3.33 MW_{th} 40	0.556 MW_{th}
	2 – 5	37	196	-	80	59		1040
	5 – 10	37	293	-	16	59		3.33 MW_{th} 403
	10 – 30	37	117	-	16	21		
	30 - 50		58	-	16	21		
CO	<0.12	184	-	58	-	-		
	0.12 –1	184	-	58	268	-		
	1 - 5	184	-	58	268	-		
	5 – 50	74	-	58	268	-		
NO_X	<0.1	-	-	-	215	-	0.022 MW_{th} 90	
	0.1 – 5	184	-	-	215	118-177	0.556 MW_{th} 150	
	5 - 10	184	-	-	161	118-177	3.33 MW_{th} 206	
	> 10	148	-	-	161	118		
	30 – 50	148	-	-	161	118		
SO_X	< 50			148	-	-		
				25	-	118		
				25	-	118		
TOC	> 0.1	37						
PCDD/F	> 5			0.05 ng TEQ/m^3				

Table 5.6: Netherlands Proposed Emission Limits for Biomass CHP Plants

Parameter	Clean Biomass 6% O_2, dry mg Nm^{-3}	Contaminated Biomass 11% O_2, dry mg Nm^{-3}
NO_x		
>20 MW	100	70
<20 MW	200	130
SO_2	200	40
PM	20	5
Cd + Tl	-	0.05
Hg	-	0.05
Heavy Metals	-	0.5
HCl	-	10
HF	-	1
PCDD/F	-	0.1
VOC	-	10
CO	-	50

Table 5.7: Netherlands Proposed Emission Limits for Biomass CHP Plants converted as emission factors

Parameter	Clean Biomass g/GJnet	Contaminated Biomass g/GJnet
NO_x		
>20 MW	39	41
<20 MW	79	77
SO_2	79	24
PM	8	3
Cd + Tl	-	0.03
Hg	-	0.03
Heavy Metals	-	0.3
HCl	-	6
HF	-	0.6
PCDD/F	-	0.06
VOC	-	6
CO	-	30

6 Potential Impacts on London Air Quality of Widespread Biomass Use

6.1 Impacts from increased biomass scenarios

In addition to the potential local impact on air quality from individual biomass boilers, there is concern over the potential cumulative impact of widespread biomass use in London. Moving from gas to biomass as a fuel will potentially lead to increases in the emissions of oxides of nitrogen and particulate matter. This will lead to changes in the background concentrations of these pollutants throughout London.

It is uncertain how many dwellings and commercial and industrial premises will install biomass boilers or biomass CHP plant in London. At a national level, the Biomass Strategy estimates uptake of biomass heat of between 7 and 10% of total energy requirements with wood biomass combustion perhaps making up 2% of the total. Again, at a national level it is thought that the majority of this wood fuel combustion will be in rural areas without existing relevant air quality issues, excluding ozone, and probably in areas not currently served by the national gas grid. Hence, biomass will be replacing fuels such as coal, oil or liquefied gas in many instances reducing or eliminating any air quality impact. However detailed modelling of biomass take up on a geographic grid does not yet exist either nationally or for London.

In the absence of any alternative scenarios on which to base future predictions regarding the take up of biomass, scenario modelling was based on information contained in the London Energy Partnership report ‘London Carbon Scenarios to 2026’. The London Energy Partnership was set up by the Mayor of London to respond to the challenges of climate change and other energy issues. The Partnership brings together a range of sectors and organisations to deliver energy action more effectively. The LEP report was published in November 2006 and presents different ways of meeting a stretch target for carbon savings to 2026. Stretch targets by their very nature are challenging. The actual number of appliances installed across London may not end up being as presented in the report, however as it is the only published report available containing potential biomass uptake across the Capital it was used as a basis on which to base potential predictions. The scenarios were taken and modelled as an example of what could occur in London in terms of impact on air quality if wood fuelled appliances are installed at these rate and no action is taken to adequately minimise emissions and the impact of emissions. Table 6.1 summarises the installed capacity for 2026 for each of these scenarios.

Table 6.1: London Energy Partnership Scenarios for 2026

Source	Units	Scenario 1: Large-scale CHP led	Scenario 2: Buildings and micro-CHP led	Scenario 3: Renewables led	Scenario 4: Insulation and energy efficiency led	Scenario 5: Hybrid scenario
Biomass CHP	MW_e	200	200	800	400	500
Biomass boilers-large	MW_{th}	100	100	500	100	250
Biomass boilers-domestic	Dwellings	5000	5000	50000	5000	25000

There are a number of technologies envisaged for obtaining heat from biomass and a range of potential biomass sources besides wood fuelled combustion and these alternative approaches may have significantly lower emissions than conventional combustion of wood or wood pellets. However, for the modelling scenarios it was assumed that for the purpose of modelling all biomass was burnt in wood fuelled appliances. This is because planning applications currently being received across London are predominantly for wood fuelled boilers.

The potential impact of these scenarios on air quality is considered in this section. To provide London Councils with a picture of how the cumulative impact might affect ground level concentrations , two scenarios; 1 and 3 were considered in detail and output maps generated. Scenarios 1 and 3 were chosen as they provide lower and upper bounds on the potential impact on air quality. The results for Scenario 5 which the LEP report selects as the preferred scenario, would lie somewhere in between Scenarios 1 and 3. The predicted concentrations are compared with national objectives for nitrogen dioxide and particulate matter PM_{10} set out in the Air Quality Regulations (2000) and the Air Quality (Amendment) Regulations (2002) as summarised in Table 6.2. In addition, the Air Quality Strategy (2007) includes a further objective for $PM_{2.5}$ of an average exposure reduction at specified background sites of 15% from 2010 levels by 2020, accompanied by an overall cap of 25 µg m^{-3}.

Table 6.2: Objectives for nitrogen dioxide and PM_{10} particulate matter included in the Air Quality Regulations (2000) and (Amendment) Regulations (2002)

Pollutant	Air Quality Objective	
	Concentration	Measured as
Nitrogen dioxide	200 µg/m^3 not to be exceeded more than 18 times a year 40 µg/m^3	1 hour mean Annual mean
Particles (PM_{10}) (gravimetric)[a]	50 µg/m^3 not to be exceeded more than 35 times a year 40 µg/m^3	24 hour mean Annual mean

a. Measured using the European gravimetric transfer standard sampler or equivalent.

6.2 Dispersion modelling

The additional emissions from the substitution of gas by increased levels of biomass combustion were assessed using a GIS-based modelling tool. The tool adopts a computationally efficient kernel approach to apply the results of ADMS dispersion model runs for 1 km square sources over large areas. The tool was used to calculate annual average background concentrations of pollutants on a 1 km x 1 km grid covering the whole of the Greater London area. Estimates of emissions in London for the "business as usual" case for 2003 and 2010 were provided for each 1 km square of the London area from the 2003 Greater London Area Emission Inventory. Emissions for areas outside the area covered by the London inventory were taken from the National Atmospheric Emission Inventory. The ADMS dispersion model was run using hourly sequential meteorological data for Heathrow airport for 2005. Emissions were assumed to be emitted uniformly into 10 m volume above ground.

A rural background oxides of nitrogen concentration measured at Harwell was added to the modelled oxides of nitrogen concentrations. Nitrogen dioxide concentrations were estimated from the modelled oxides of nitrogen concentrations using empirical relationships developed by the Air Quality Expert Group.

The contribution from secondary PM_{10} and other PM_{10} (i.e. non-primary and non-secondary; 10.5 µg m^{-3}) was added to the modelled primary particulate concentrations following technical guidance (LAQM. TG(03)).

The contribution from secondary $PM_{2.5}$ and other $PM_{2.5}$ was added to the modelled primary particulate concentrations. The secondary $PM_{2.5}$ concentration was assumed to be equal to the secondary PM_{10} concentration. The contribution from other $PM_{2.5}$ was estimated to be 3.5 µg m^{-3}, based on data for construction dusts in the Airborne Particles Expert Group report. In practice, annual mean $PM_{2.5}$ concentrations were estimated as the modelled PM_{10} concentrations minus 7 µg m^{-3}.

Model predictions for years other than 2003 and 2010 were adjusted using factors provided by the Air Quality Archive for Local Authority Review and Assessment.

6.3 Business as usual

Figure 6.1 shows the modelled oxides of nitrogen and nitrogen dioxide concentrations for the existing situation in 2003.

It is outside the scope of this work to carry out a detailed validation of the model. However, Figure 6.2 shows the measured oxide of nitrogen concentrations at suburban and urban background sites within Defra's Automatic Urban and Rural Network in London plotted against the modelled concentrations for 2005.

Figure 6.3 shows the modelled oxides of nitrogen and nitrogen dioxide concentrations for the business as usual situation in 2010. The model predicts that the air quality strategy objective of 40 µgm^{-3} will be exceeded at background locations in the centre of London in 2010.

Figure 6.4 shows the modelled oxides of nitrogen concentrations for 2010 adjusted to 2020 using the factor provided in the Air Quality Archive for Local Air Quality Review and Assessment. The model predicts that the air quality strategy objective of 40 μgm^{-3} will be exceeded at background locations in the centre of London in 2020.

Figure 6.5 shows the modelled PM_{10} concentrations for the existing situation in 2003. It is outside the scope of this work to carry out a detailed validation of the model. However, Table 6.3 shows the modelled and measured PM_{10} concentrations at suburban and urban background sites in Defra's Automatic Urban and Rural Network in London for 2005.

Table 6.3: Comparison of modelled and measured PM_{10} concentrations (2005)

Site	Modelled concentration, $\mu g\ m^{-3}$	Measured concentration, $\mu g\ m^{-3}$ (corrected to gravimetric)*
London Bloomsbury	25.5	27
London Brent	22.9	22
London Eltham	23.3	23
London North Kensington	24.8	25

*Concentrations measured by TEOM converted to gravimetric using a factor of 1.3

Table 6.4 shows modelled and measured $PM_{2.5}$ concentrations for 2006 measured at urban background sites in the London Air Quality Network.

Table 6.4: Comparison of modelled and measured $PM_{2.5}$ concentrations (2006)

Site	Modelled concentration, $\mu g\ m^{-3}$	Measured concentration, $\mu g\ m^{-3}$ (corrected to gravimetric)*
London Bloomsbury	17.9	17.7
Hackney 4	19.4	15.8
Bexley 3	16.0	15.3
Bexley 2	15.7	15.2
Bexley 1	15.7	15.4

*Concentrations measured by TEOM converted to gravimetric using a factor of 1.3

Figure 6.6 shows the modelled PM_{10} concentrations for the business as usual situation in 2010. The model predicts that the PM_{10} concentration will be less than 25 $\mu g\ m^{-3}$ at background locations throughout London. Technical Guidance LAQM TG(03) provides an empirical relationship between the annual average PM_{10} concentration and the number of exceedances of the 24-hour mean standard of 50 $\mu g\ m^{-3}$. An annual mean of 25 μgm^{-3} corresponds to 12 exceedances and so it is expected that the objective of less than 35 exceedances will be met at background locations throughout London. Higher concentrations are expected close to major roads.

Figure 6.7 shows the modelled PM_{10} concentrations for 2010 adjusted to 2020 using factors provided in the Air Quality Archive for Local Air Quality Review and Assessment. It is predicted that the objective of less than 35 exceedances will be met at background locations throughout London in 2020. Higher concentrations are expected close to major roads.

Modelled $PM_{2.5}$ concentrations are 7 $\mu g\ m^{-3}$ less than the modelled PM_{10} concentrations. The model therefore predicts that the $PM_{2.5}$ "cap" will be met at background locations throughout London in 2010 and 2020. The Air Quality Strategy includes an exposure reduction strategy to reduce the average concentrations at specific background monitoring stations throughout the UK in 2010 by 15% by 2020. The monitoring network is not yet fully operational and so a direct assessment against this objective is not possible. However, it may be estimated on a pro-rata basis that a 15 % reduction would be equivalent to a 2-2.5 $\mu g\ m^{-3}$ reduction in background $PM_{2.5}$ concentrations in London between 2010 and 2020. The "business as usual" case would provide a reduction of approximately 1 $\mu g\ m^{-3}$: It may be concluded that the exposure reduction target in London will not be met without additional control measures.

The Air Quality Archive does not provide adjustment factors for years beyond 2020 and so it is not possible to predict the "business as usual" concentrations for 2026. It is therefore assumed that the concentrations will not change much between 2020 and 2026.

6.4 London Energy Partnership scenarios

The London Energy Partnership made various assumptions about the capacity, fuel input and unit availability for biomass CHP units, large biomass boilers and small biomass boilers. The same assumptions have been made for this study and area summarised in Table 6.5.

It was outside the scope of this report to undertake emission monitoring from an actual biomass boiler. However, it is necessary to estimate a typical emission from the appliances depending on the amount of fuel used; a so called emission factor with units of mass of pollutant emitted per mass of fuel burnt. While under the Clean Air Act emissions are limited in the smoke control areas that cover much of London many modern appliances can emit considerably lower amounts of pollutant for a given quantity of fuel burnt. However, there is a wide range of emission performance from the best to the just good enough. The United Nations Economic Commission for Europe's Convention on Long Range Transboundary Air Pollution has produced a Guidebook on Emission Factors "Corinair". This contains emission factors for a wide range of processes including biomass combustion. The factors given are considerably lower than those which represent appliances " just good enough for regulatory compliance", they are also better than is assumed in the UK's National Atmospheric Emission Inventory for wood combustion. However, nor are they the best that is possible. It can be seen in footnote (d) to Table 6.5 below that when equipped with a fabric filter, emissions of particles may be 90% lower than those used in the modelling study. There are no economic or regulatory drivers outside of the planning system that might persuade an installer to specify a fabric filter and bear both the capital and operating costs this would imply. Table 6.5 also shows relevant emission factors taken from the Corinair handbook. The emission factors can be compared with those used for gas combustion in the London Atmospheric Emission Inventory. These are 123 g/GJ of NOx and 2.7 g/GJ PM_{10} for industrial and commercial combustion and 69 g/GJ NOx and 0.5 g/GJ PM_{10} for domestic combustion. In this assessment, it has been assumed that the biomass units are substituted for the equivalent gas-fired unit. The impact from biomass is therefore calculated as the result of the net change in emissions.

Table 6.5: Size of appliances and emission factors assumed in the modelling study

	Biomass CHP	Large biomass boilers	Small biomass boilers
Power output	1 MW_e	0	0
Heat output	1.83 MW	500 kW	20 kW
Fuel input	3.33 MW	556 kW	22 KW
Unit availability	75%	70%	8.5%
NOx emissions, g/GJ	206[a]	150[b]	90[c]
PM_{10} emissions, g/GJ	40[d]	66[e]	76[f]
$PM_{2.5}$ emissions, g/GJ	40[d]	66[e]	76[f]

a) http://reports.eea.europa.eu/EMEPCORINAIR4/en/B112vs3.1.pdf Industrial wood burning boiler, no specification
b, e) http://reports.eea.europa.eu/EMEPCORINAIR4/en/B216v2.pdf Advanced automatic boiler for wood combustion
c, f) http://reports.eea.europa.eu/EMEPCORINAIR4/en/B216v2.pdf Advanced pellet stove
d) http://reports.eea.europa.eu/EMEPCORINAIR4/en/B111_S1_PMv1.pdf Default value. PM_{10} emissions vary according to abatement technology employed from 7 g/GJ for modern fabric filters to 150 g/GJ for minimal control.

The change in emissions of oxides of nitrogen resulting from the use of biomass for each of the 2026 scenarios is shown in Table 6.6. The change in emissions may be compared with the total annual emissions for 2010 given by the London Inventory of 70913 tonnes, of which 25741 tonnes comes from road transport, 16029 tonnes comes from domestic combustion and 14603 tonnes comes from small industrial or commercial installations. The change in emissions resulting from increased biomass combustion is between 2% and 8 % of the 2010 oxides of nitrogen emissions.

Table 6.6: Estimated increase in oxides of nitrogen emissions for London Energy Partnership scenarios

	Change in London emissions, tonnes per year				
	Scenario 1: Large-scale CHP led	**Scenario 2: Buildings and micro-CHP led**	**Scenario 3 : Renewables led**	**Scenario 4: Insulation and energy efficiency led**	**Scenario 5: Hybrid scenario**
Biomass CHP	1307	1307	5230	2615	3269
Biomass boilers-large	66	66	331	66	166
Biomass boilers-domestic	6	6	62	6	31
Total	**1380**	**1380**	**5623**	**2687**	**3465**

The change in emissions of PM_{10} resulting from the use of biomass for each of the 2026 scenarios is shown in Table 6.7. The change in emissions may be compared with the total annual emissions for 2010 given by the London Inventory of 3103 tonnes, of which 2022 tonnes comes from road transport, 116 tonnes comes from domestic combustion and 321 tonnes comes from small industrial or commercial installations.

The change in emissions resulting from increased biomass combustion is between 25% and 108% of the 2010 PM_{10} emissions.

Table 6.7: Estimated increase in PM_{10} emissions for London Energy Partnership scenarios

	Change in London emissions, tonnes per year				
	Scenario 1: Large-scale CHP led	**Scenario 2: Buildings and micro-CHP led**	**Scenario 3 : Renewables led**	**Scenario 4: Insulation and energy efficiency led**	**Scenario 5: Hybrid scenario**
Biomass CHP	588	588	2350	1175	1469
Biomass boilers-large	155	155	777	155	388
Biomass boilers-domestic	22	22	223	22	111
Total	**765**	**765**	**3350**	**1353**	**1969**

Dispersion modelling for Scenarios 1 and 3 was carried out assuming that the domestic and industrial and commercial emissions had the same spatial patterns as the London Atmospheric Emission Inventory estimate of emissions in those sectors for 2010. The LAEI 1 km x 1 km inventory emissions for domestic and industrial/commercial emissions were thus scaled in proportion to the emissions.

Figure 6.8 shows the predicted annual average PM_{10} concentrations in London for 2020/2026 under Scenario 1. Predicted concentrations approach 27 $\mu g\ m^{-3}$ in the centre of London. Correspondingly, predicted $PM_{2.5}$ concentrations would approach 20 $\mu g\ m^{-3}$. Figure 6.9 shows the change in annual average PM_{10} and $PM_{2.5}$ concentrations for Scenario 1 compared with the "business as usual" case. Concentrations are expected to increase by up to 4 $\mu g\ m^{-3}$ in the centre of the city. This may be compared with the estimated 2.5 $\mu g\ m^{-3}$ reduction that might be required under the $PM_{2.5}$ exposure reduction strategy.

Figure 6.10 shows the predicted annual average PM_{10} concentrations in London for 2020/2026 under Scenario 3. Predicted concentrations approach 37 $\mu g\ m^{-3}$ in the centre of London. Correspondingly, predicted $PM_{2.5}$ concentrations would approach 30 $\mu g\ m^{-3}$. Figure 6.11 shows the change in annual average PM_{10} and $PM_{2.5}$ concentrations for Scenario 3 compared with the "business as usual" case. Concentrations are expected to increase by up to 14 $\mu g\ m^{-3}$ in the centre of the city. This may be compared with the estimated 2.5 $\mu g\ m^{-3}$ reduction that might be required under the $PM_{2.5}$ exposure reduction strategy.

Figure 6.12 shows the predicted annual average oxides of nitrogen and nitrogen dioxide concentrations in London for 2020/2026 under Scenario 1. Predicted nitrogen dioxide concentrations approach 53 $\mu g\ m^{-3}$ in the centre of London. Figure 6.13 shows the change in annual average NO_x concentrations for Scenario 1 compared with the "business as usual" case. Concentrations of oxides of nitrogen are expected to increase by up to 6 $\mu g\ m^{-3}$ in the centre of the city. The corresponding increase in nitrogen dioxide concentrations is 3 $\mu g\ m^{-3}$.

Figure 6.13 shows the predicted annual average oxides of nitrogen and nitrogen dioxide concentrations in London for 2020/2026 under Scenario 3. Predicted nitrogen dioxide concentrations approach 58 $\mu g\ m^{-3}$ in the centre of London. Figure 6.15 shows the change in annual average NO_x concentrations for Scenario 3 compared with the "business as usual" case. Concentrations of oxides of nitrogen are expected to increase by up to 25 $\mu g\ m^{-3}$ in the centre of the city. The corresponding increase in nitrogen dioxide concentrations is 10 $\mu g\ m^{-3}$.

6.5 Discussion

For the business as usual case, predicted annual average concentrations of PM_{10} are less than 24 $\mu g\ m^{-3}$ at background locations throughout London for 2010 and 2020. According to Defra's Technical Guidance (LAQM(TG.03)), it is expected that the 24-hour objective for PM_{10} concentrations will be met where the annual mean is less than 32 $\mu g\ m^{-3}$. Under the renewables-led Scenario 3, with the highest emissions from biomass, the predicted concentration in central London approaches 37 $\mu g\ m^{-3}$. It is therefore predicted that the air quality objective for PM_{10} will not be met at background locations in central London under this scenario. Concentrations at roadside locations will be somewhat higher than the concentrations at background locations and so the extent of the area of exceedence will be rather greater. Under the more favourable Scenario 1, the predicted concentrations are smaller: nevertheless the predicted increase in concentrations of 4 $\mu g\ m^{-3}$ is expected to make it more difficult to achieve the objective at sites near major roads.

Predicted $PM_{2.5}$ concentrations under the "business as usual" scenario are less than 17 $\mu g\ m^{-3}$ at background locations throughout London for 2010 and 2020. It is thus likely that the 25 $\mu g\ m^{-3}$ cap will be met at background locations. Under the renewables-led Scenario 3, with the highest emissions from biomass, the predicted concentration in central London approaches 30 $\mu g\ m^{-3}$. Under this scenario, there would be widespread exceedence of the cap throughout central London. Under the more favourable Scenario 1, the predicted concentrations are smaller: nevertheless the predicted increase in concentrations of 4 $\mu g\ m^{-3}$ is expected to make it more difficult to achieve the cap at sites near major roads.

It will be difficult to achieve the exposure reduction target of 15 % between 2010 and 2020 for $PM_{2.5}$ at background sites under the "business as usual" scenario. Additional control measures will be required to limit particulate emissions. The net contribution to $PM_{2.5}$ concentrations from biomass is predicted to be substantially greater in central London than the exposure reduction target even for the more favourable Scenario 1.

Nitrogen dioxide concentrations are predicted to exceed the air quality objective of 40 $\mu g\ m^{-3}$ as an annual mean at background locations in central London under the business as usual case in 2010 and 2020. Further emission control measures will be required to achieve the objective. The predicted increase in nitrogen dioxide concentrations at background locations in central London ranges from 3-10 $\mu g\ m^{-3}$ under the modelled biomass scenarios. This increase is likely to make other control measures less effective in achieving the objective.

The assessment shows that increasing the contribution from small-scale biomass combustion to meet energy requirements in London under the London Energy Partnership scenarios would lead to a potentially substantial increase in nitrogen dioxide and particulate matter concentrations. The assessment has been made on the basis that new combustion appliances installed will have rates of emissions typical of the appliances currently installed. Furthermore, it has been assumed that the spatial pattern of domestic and industrial/commercial emissions will remain the same. The potential impact could be reduced if biomass combustion was limited to larger district heating or CHP schemes outside the centre of London. For these units it would be cost-effective to install effective abatement equipment to reduce the emissions of particulate matter and oxides of nitrogen.

Figure 6.1: Modelled oxides of nitrogen and nitrogen dioxide concentrations (μg/m^3): Existing case 2003

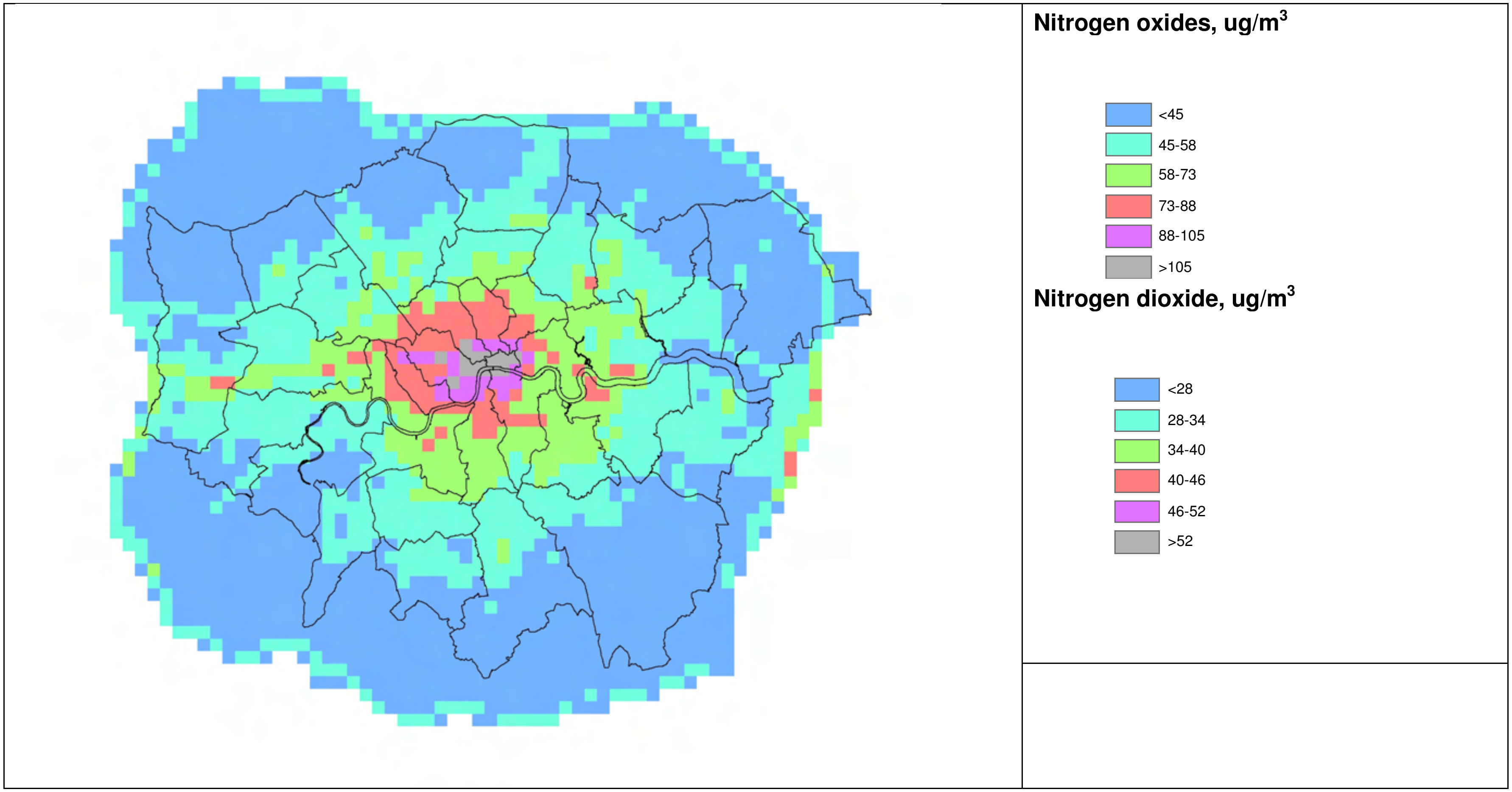


Figure 6.2: Comparison of modelled and measured oxides of nitrogen concentrations

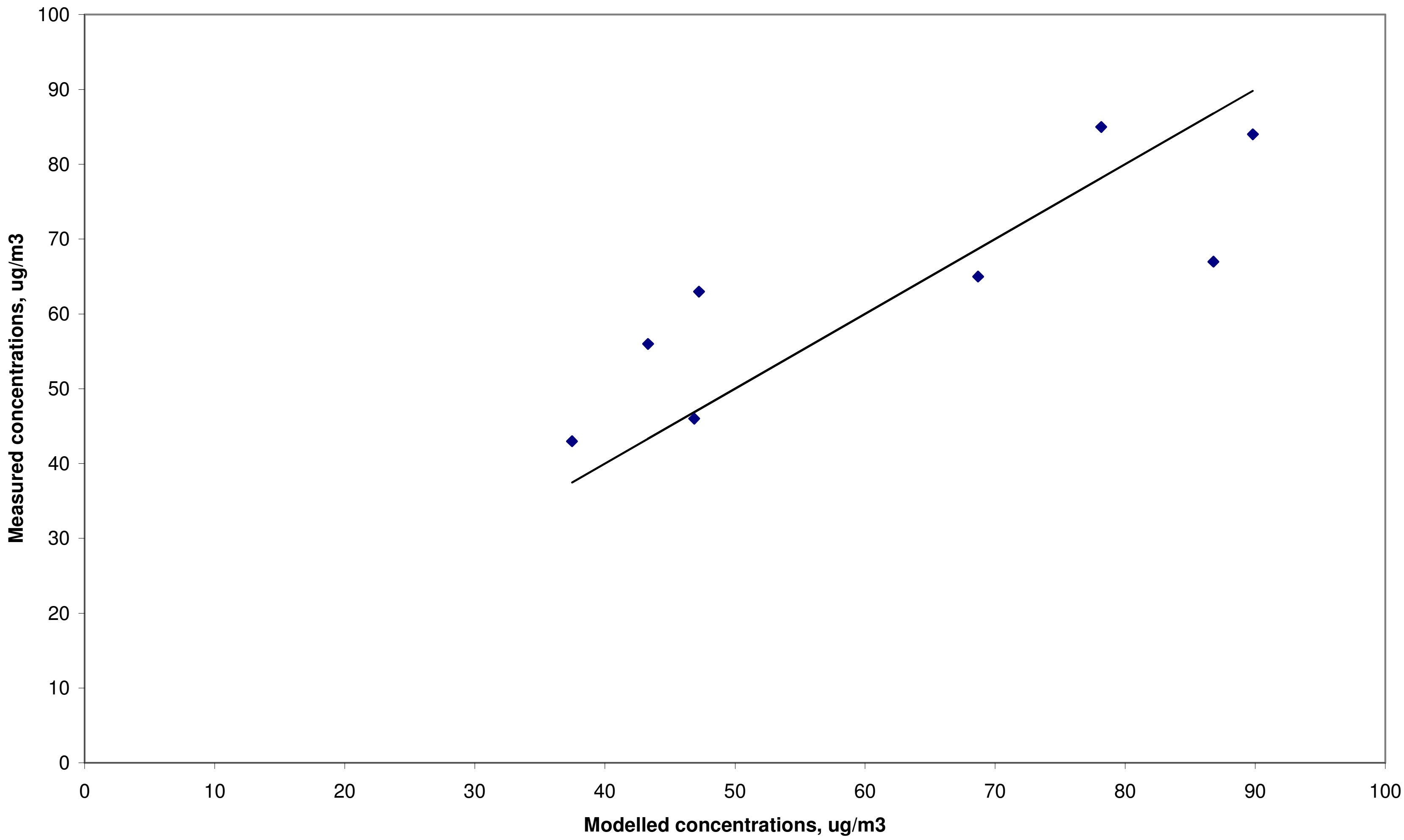


Figure 6.3: Modelled oxides of nitrogen and nitrogen dioxide concentrations ($\mu g/m^3$): Business as usual 2010

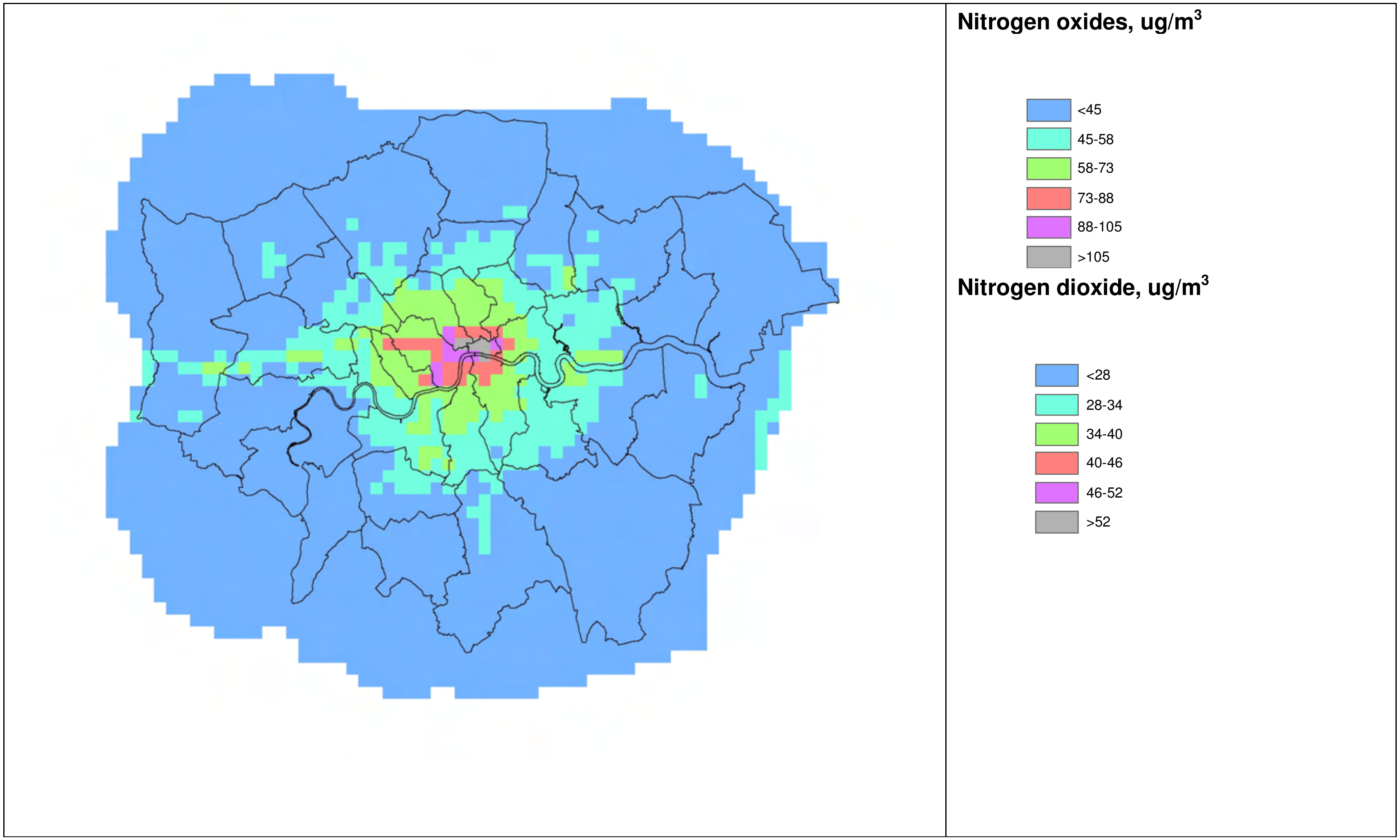


Figure 6.4: Modelled oxides of nitrogen and nitrogen dioxide concentrations (μg/m³): Business as usual 2020

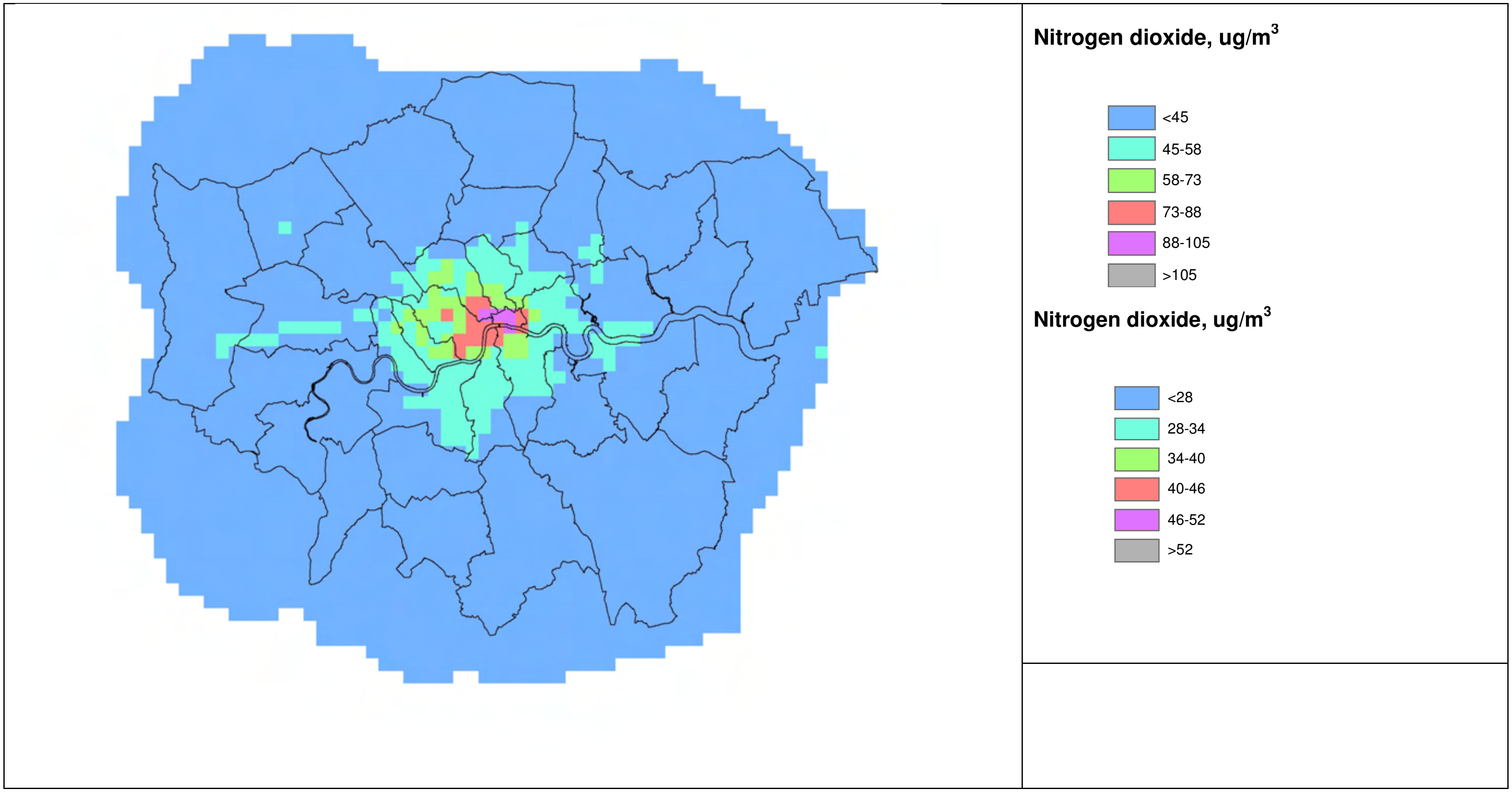


Figure 6.5: Modelled PM_{10} concentrations ($\mu g/m^3$): Existing case 2003

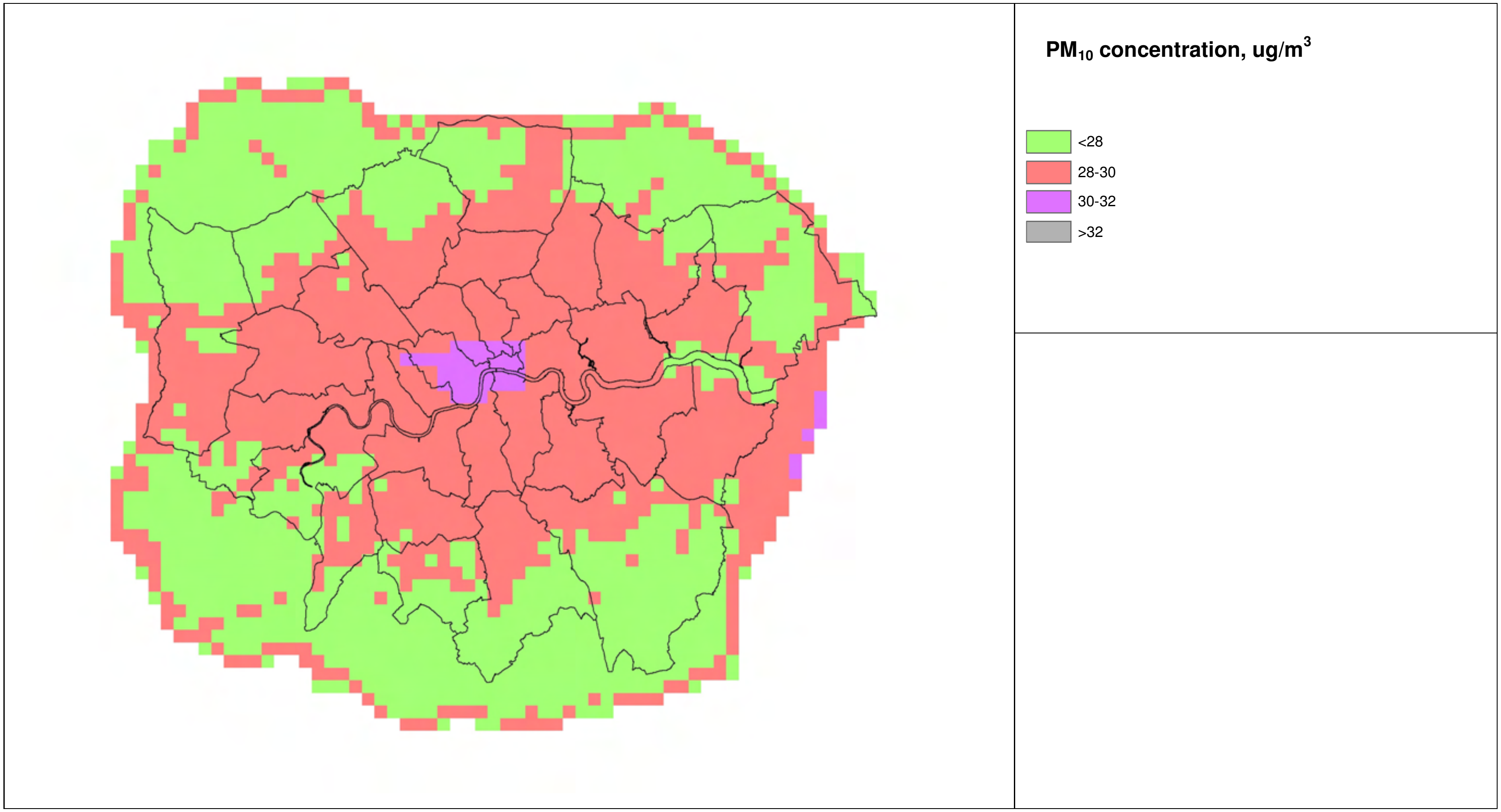


Figure 6.6: Modelled PM_{10} concentrations ($\mu g/m^3$): Business as usual 2010

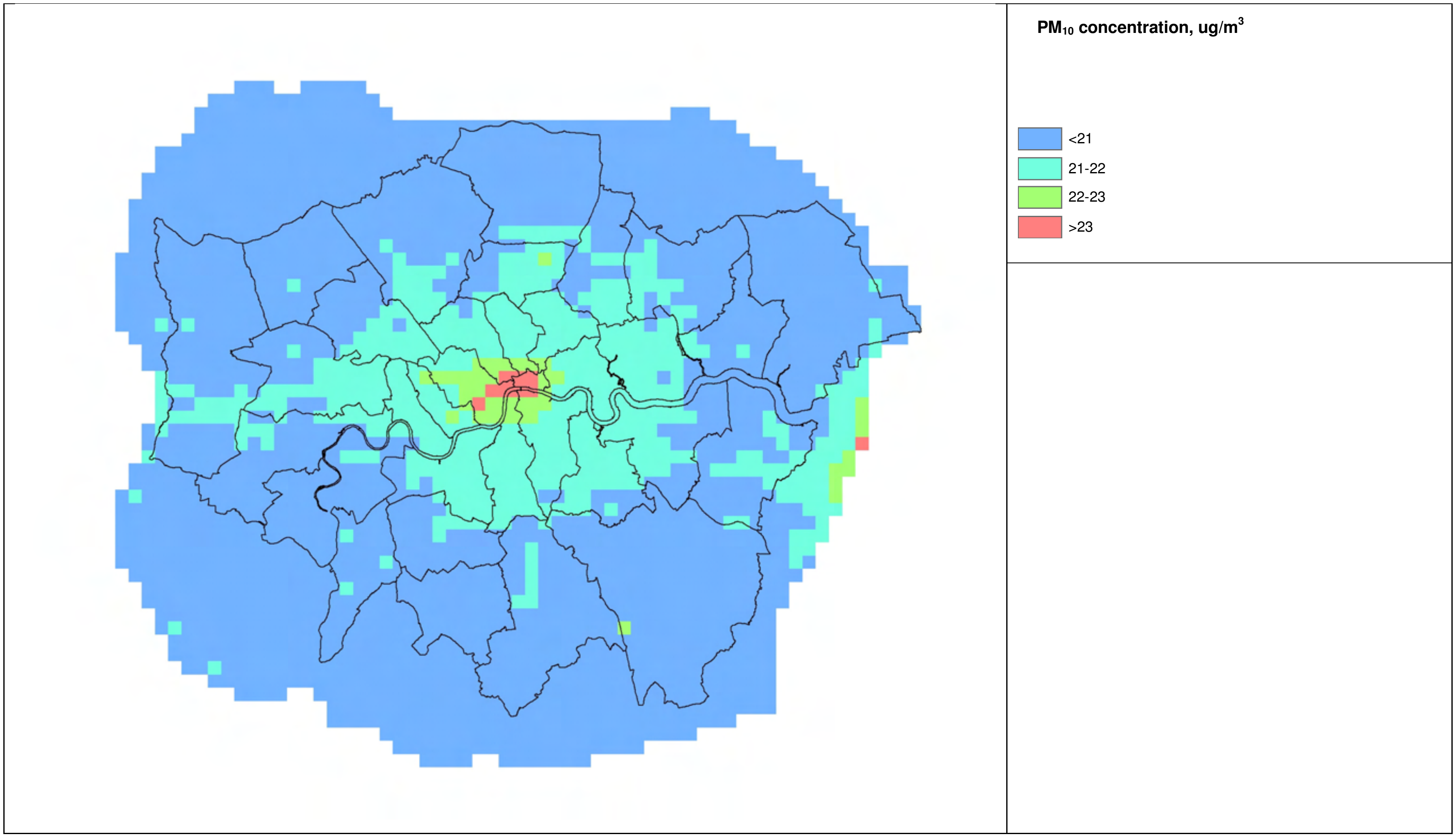


Figure 6.7: Modelled PM_{10} concentrations ($\mu g/m^3$): Business as usual 2020

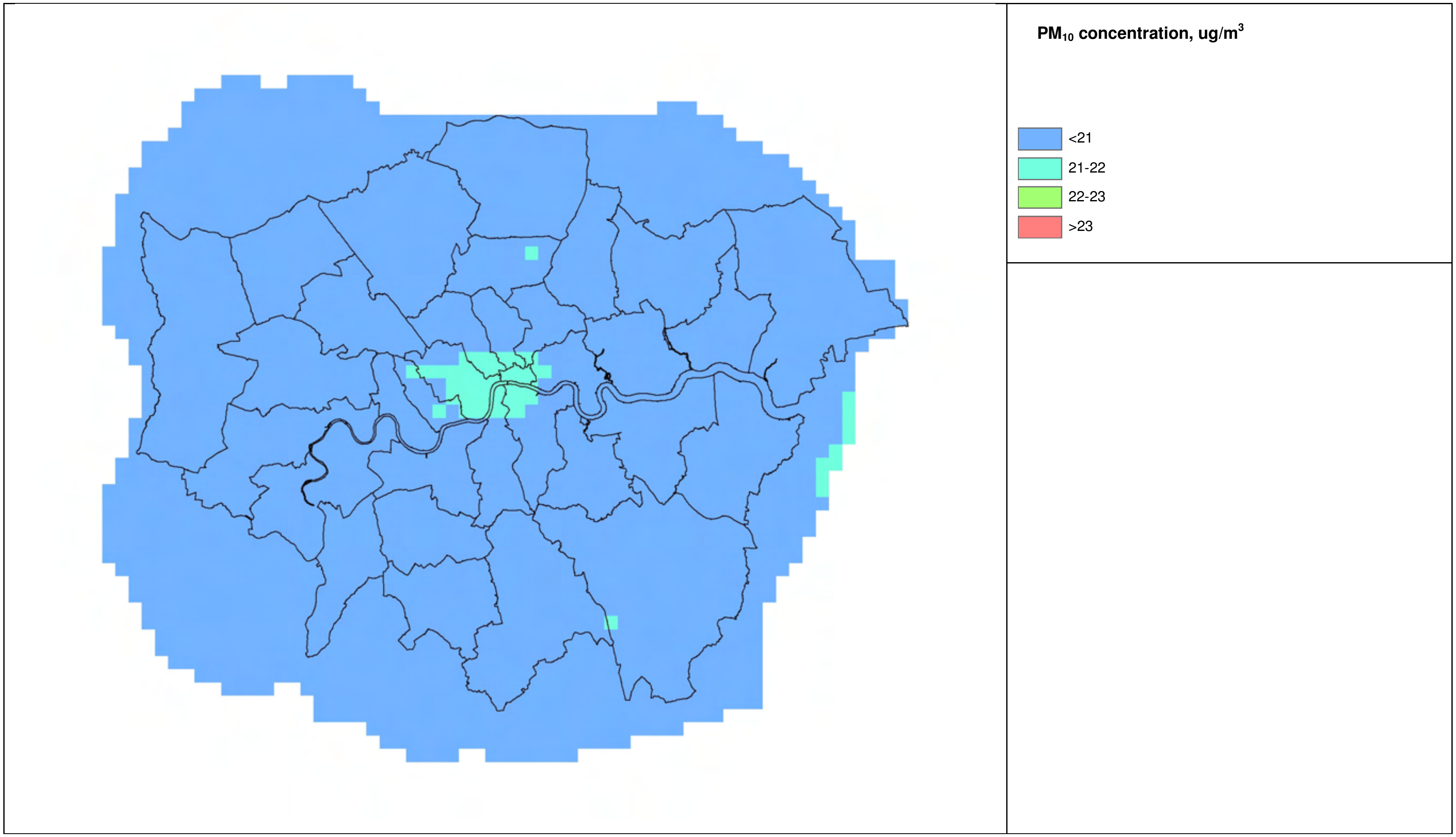


Figure 6.8: Modelled PM_{10} concentrations ($\mu g/m^3$): Scenario 1: 2020/2026

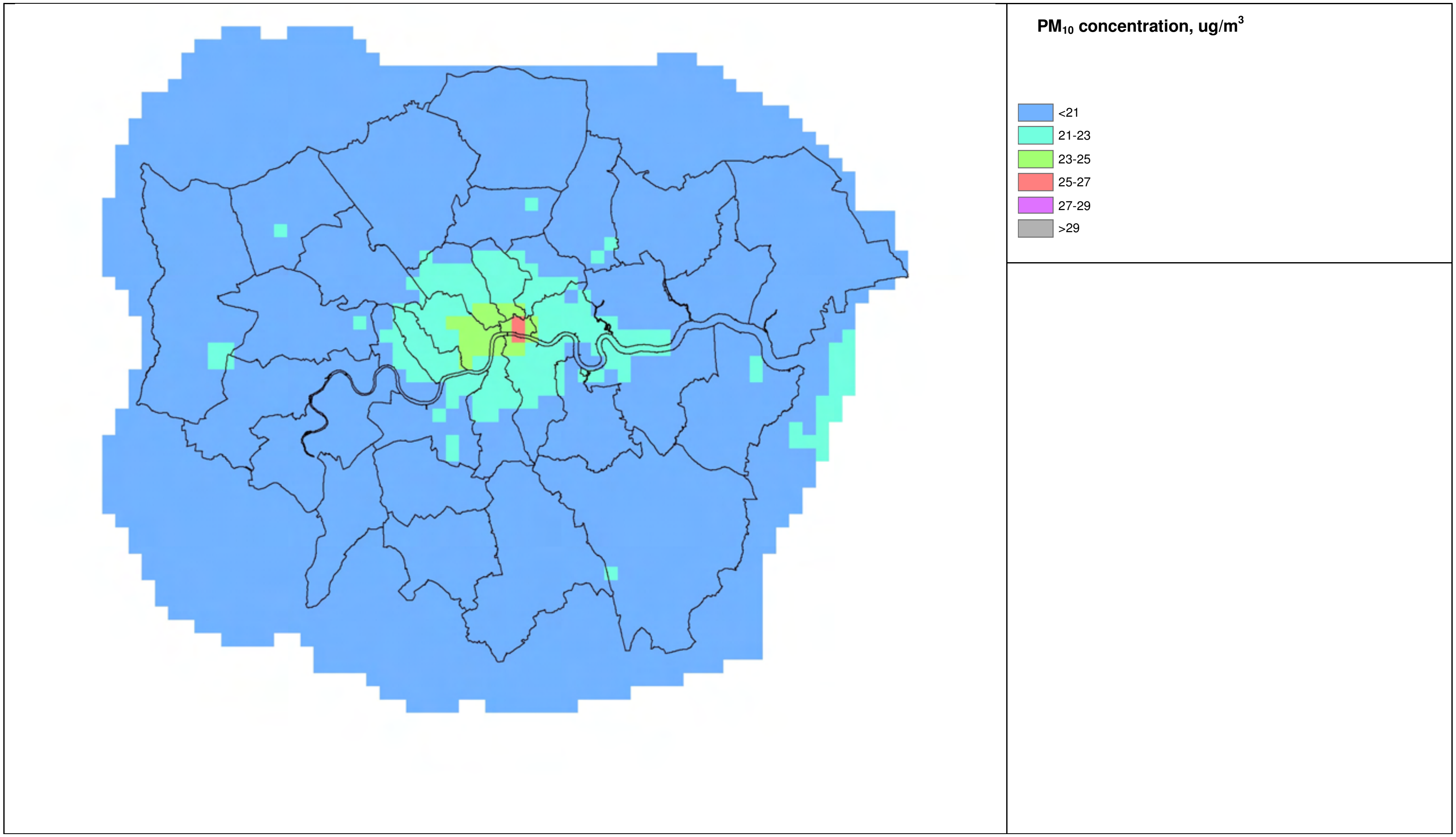


Figure 6.9: Incremental change in modelled PM_{10} concentrations ($\mu g/m^3$): Scenario 1 2026

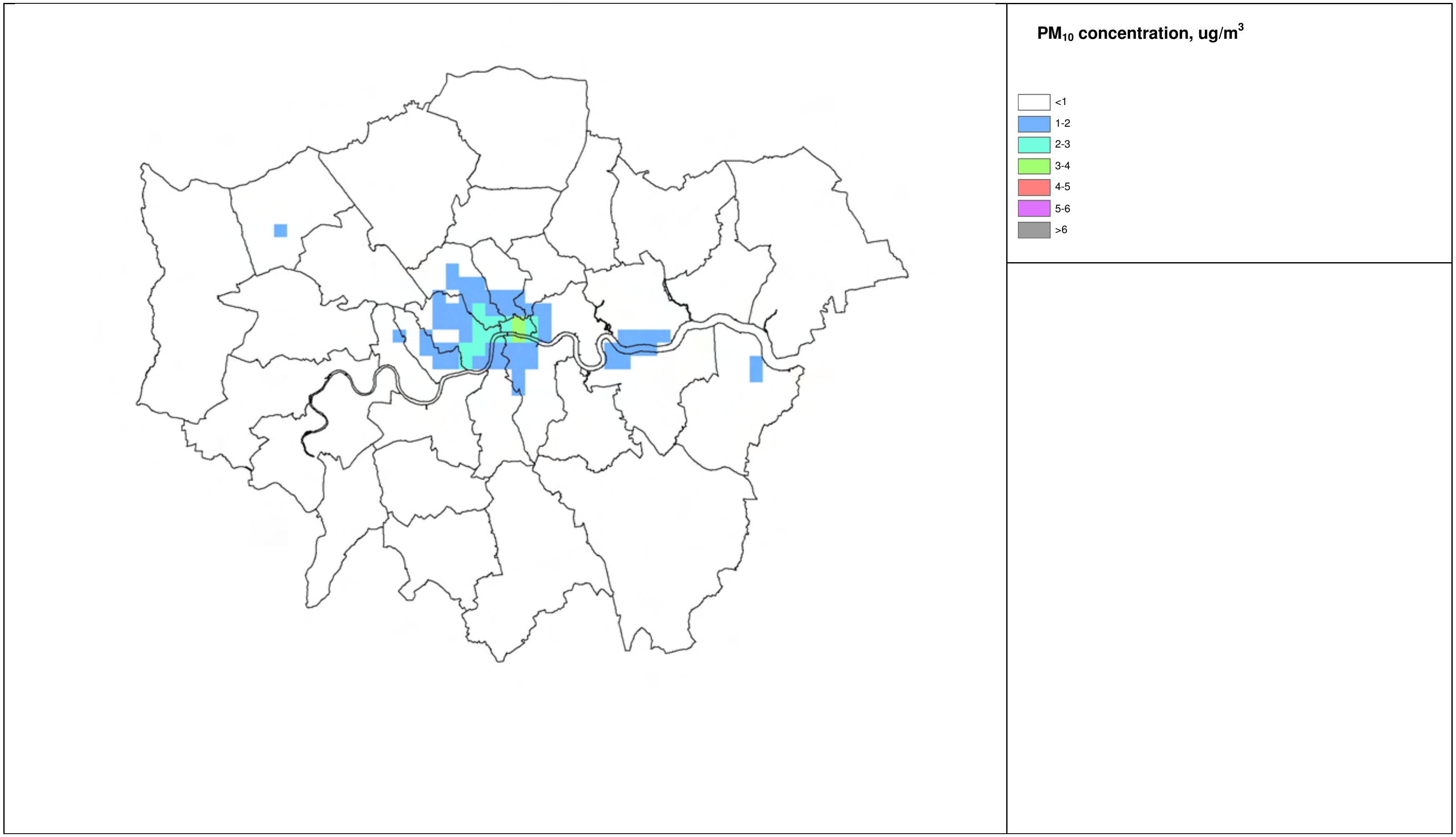


Figure 6.10: Modelled PM_{10} concentrations ($\mu g/m^3$): Scenario 3: 2020/2026

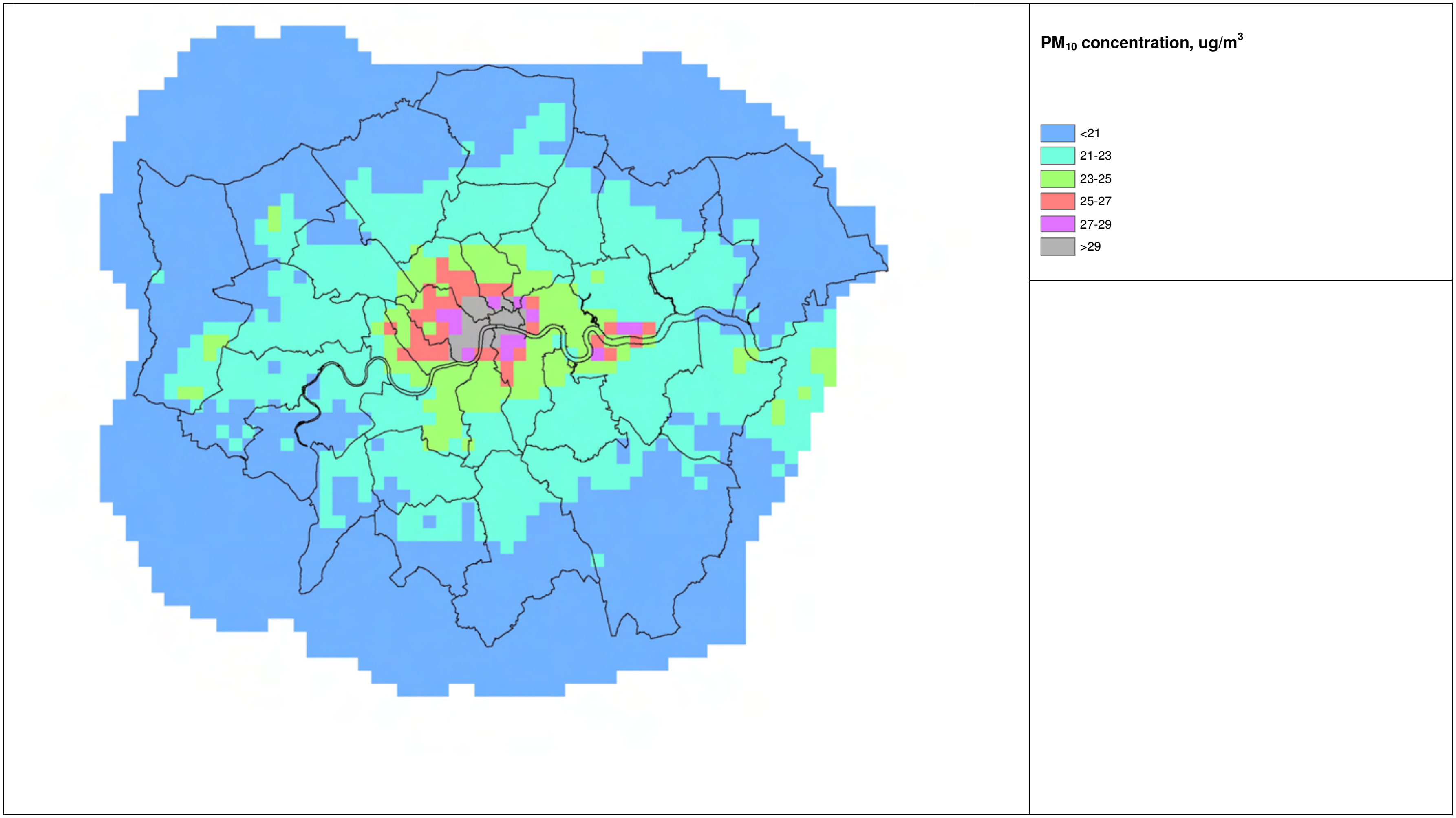


Figure 6.11: Incremental change in modelled PM_{10} concentrations ($\mu g/m^3$): Scenario 3 2026

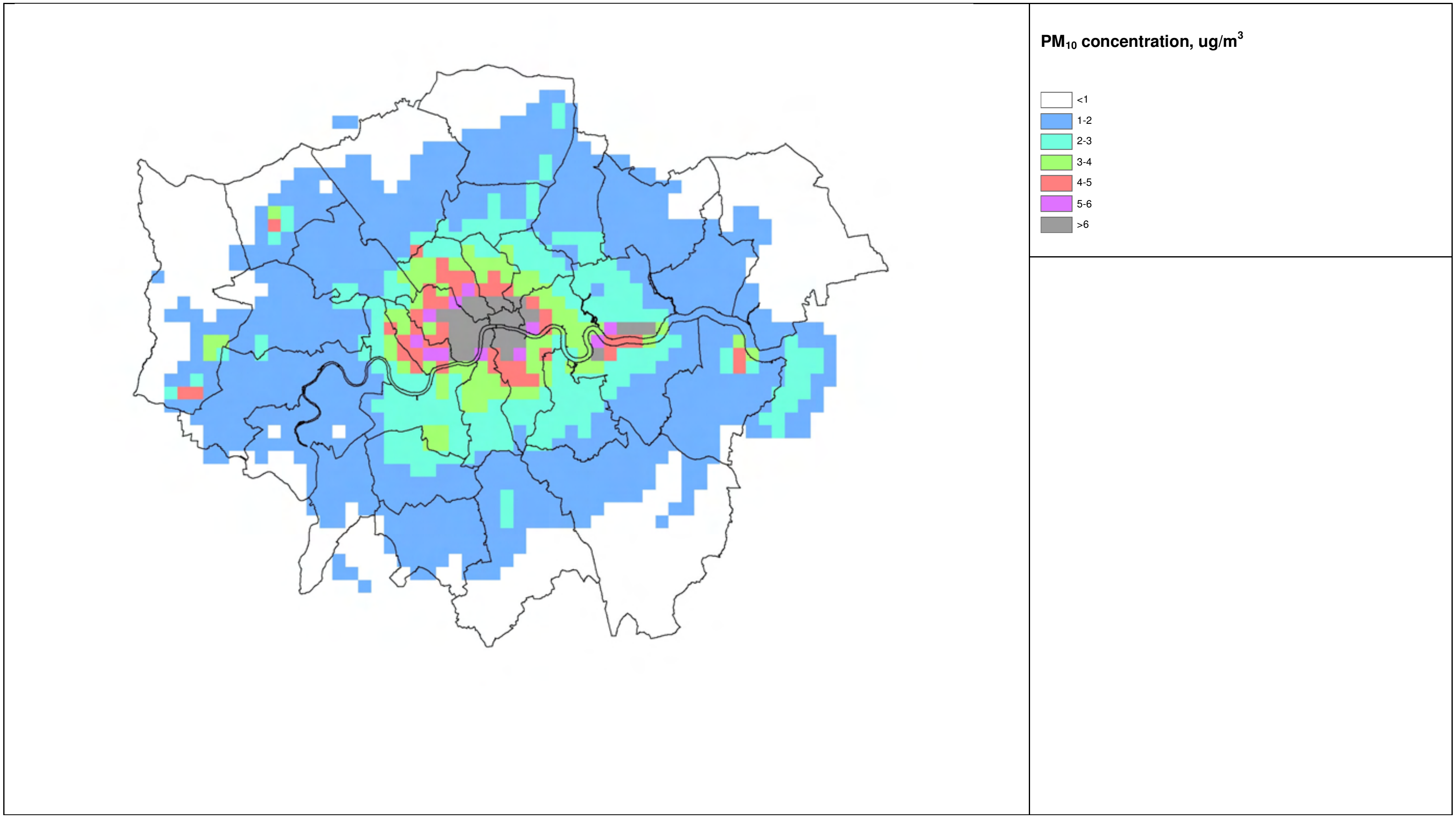


Figure 6.12: Modelled oxides of nitrogen and nitrogen dioxide concentrations (µg/m³): Scenario 1: 2020/2026

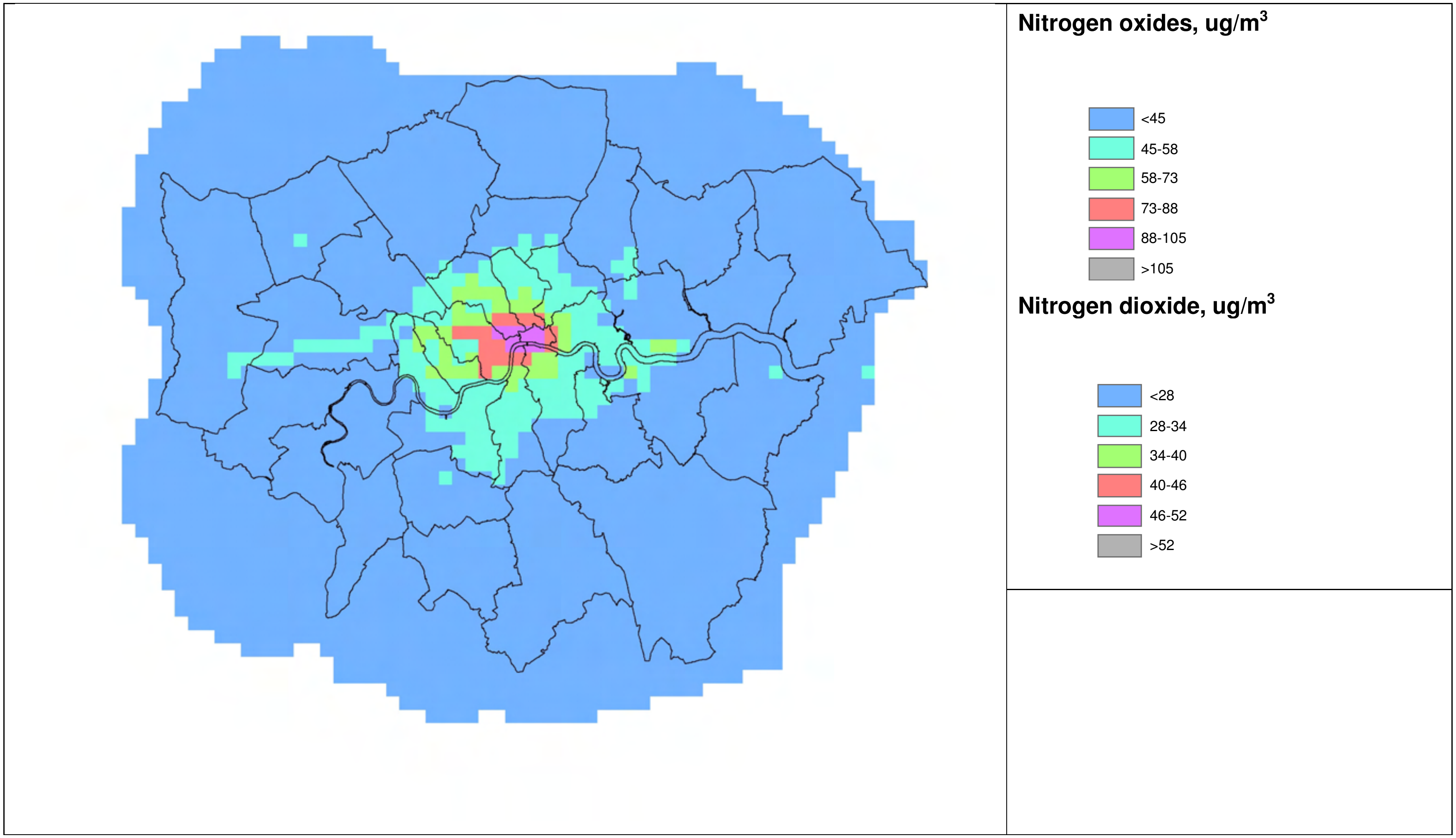


Figure 6.13: Incremental change in modelled oxides of nitrogen concentrations ($\mu g/m^3$): Scenario 1 2026

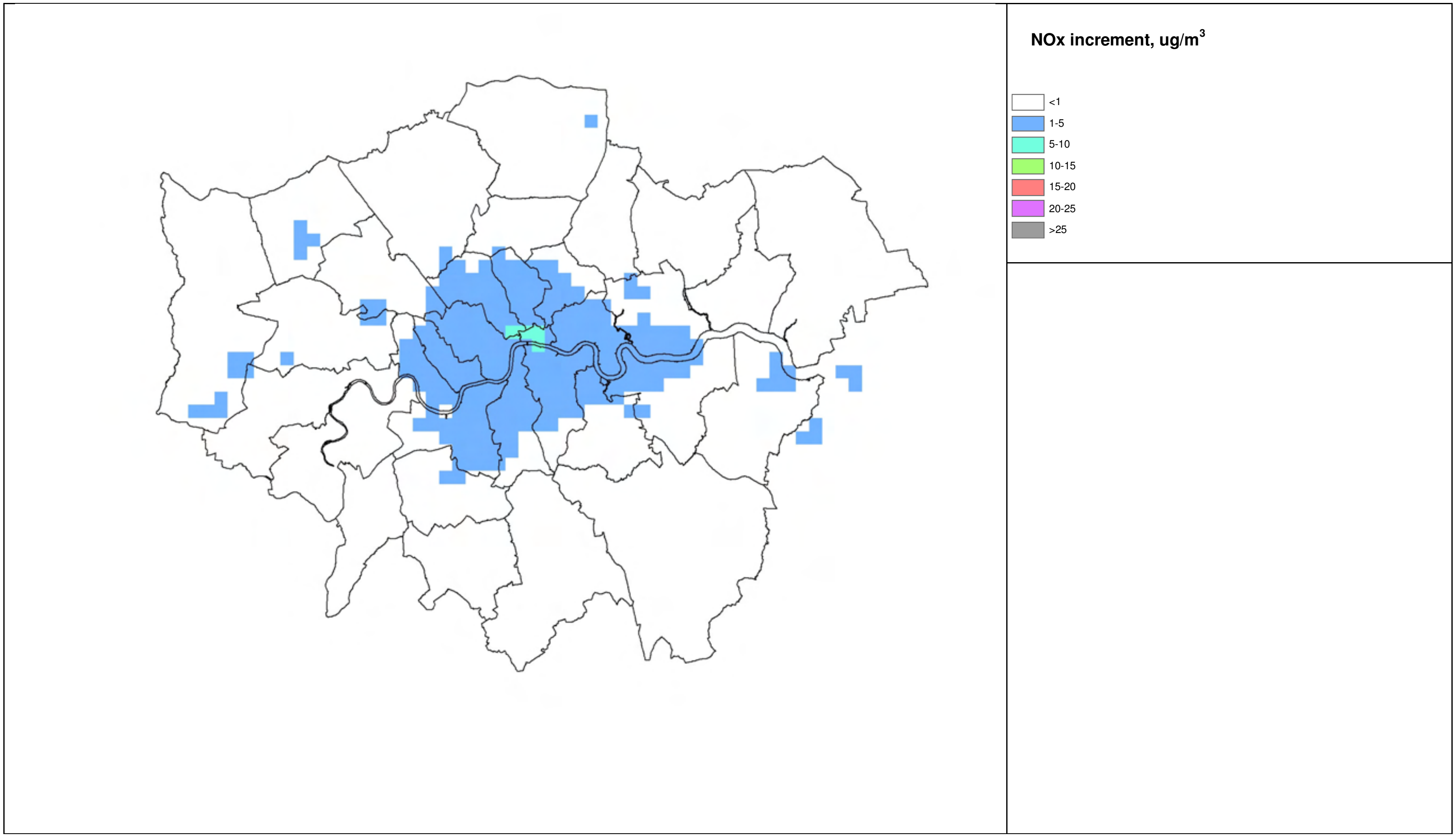


Figure 6.14: Modelled oxides of nitrogen and nitrogen dioxide concentrations ($\mu g/m^3$): Scenario 3: 2020/2026

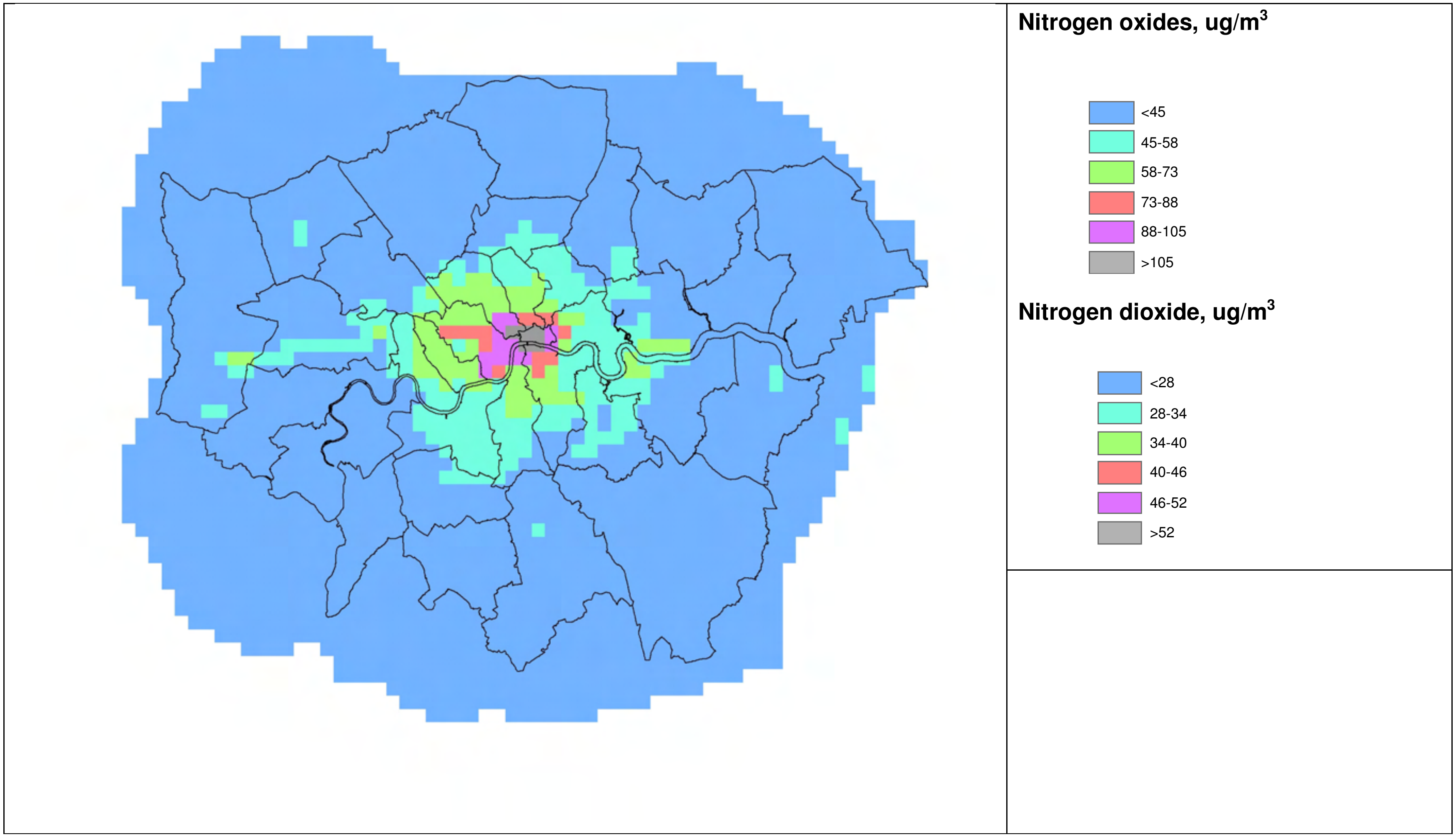
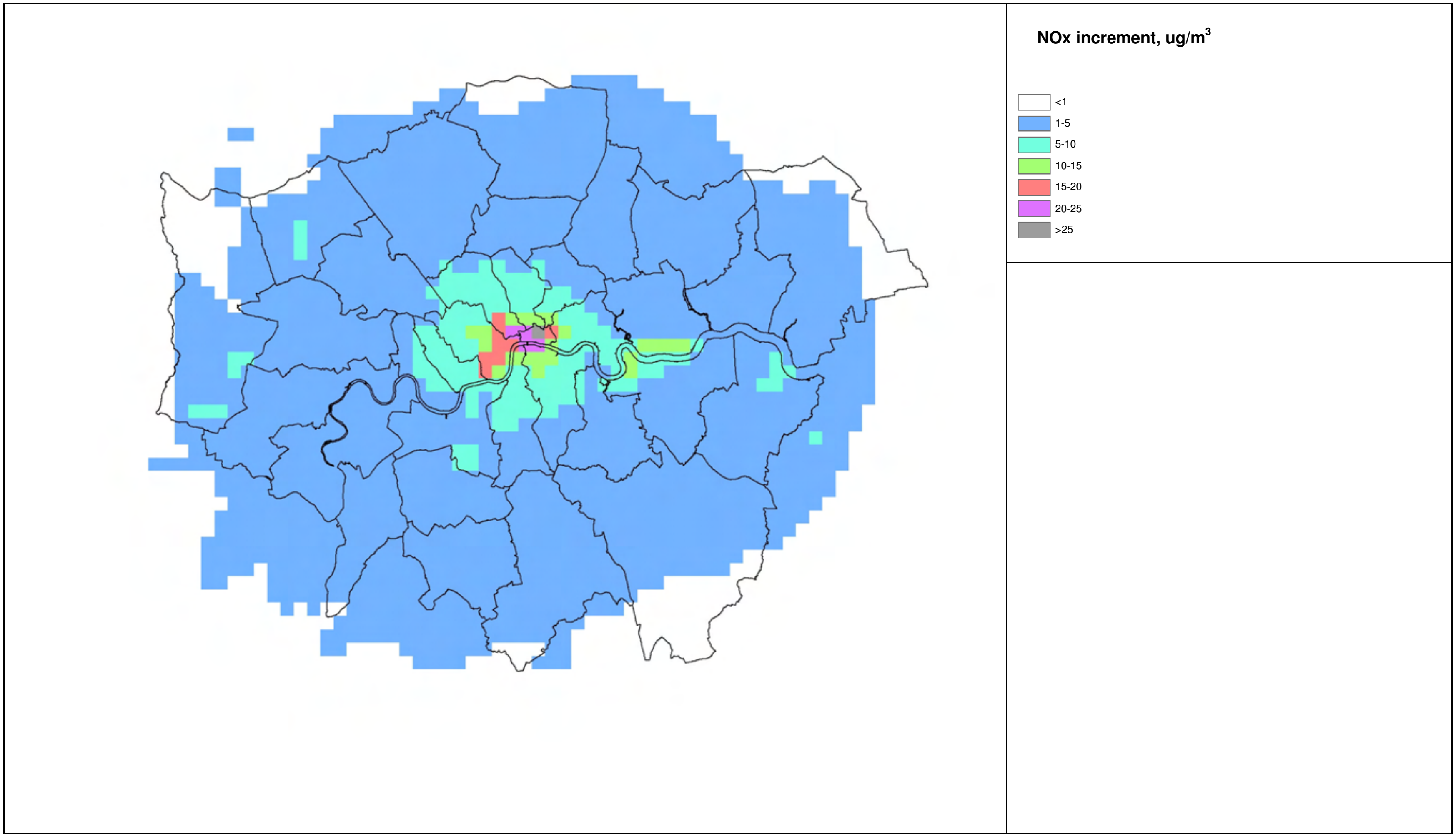


Figure 6.15: Incremental change in modelled oxides of nitrogen concentrations (µg/m³): Scenario 3 2026



7 Planning Toolkit to Minimise Impact on Air Quality

7.1 Air quality objectives

The London Boroughs require planning guidance on the assessment of the air quality impact of proposed biomass combustion plant installations. Figure 7.1 shows a useful flow chart to summarise key decisions in considering compliance of appliances with the Clean air Act (1993). Biomass burners emit particulate matter (PM_{10} and $PM_{2.5}$) and oxides of nitrogen. Local Authorities are required under the Environment Act to assess air quality in their areas from time to time against air quality objectives set out in the Air Quality Regulations (2000) and the Air Quality (Amendment) Regulations (2002). The objectives are set out in Table 7.1.

Table 7.1. Air quality objectives included in the Air Quality Regulations (2000) and Amendment Regulations (2002) for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 µg/m^3	Running annual mean	31.12.2003
Authorities in England and Wales only	5.00 µg/m^3	Annual mean	31.12.2010
Authorities in open areas and coastal areas should be cleaner as air changes more frequently and Northern Ireland only	3.25 µg/m^3	Running annual mean	31.12.2010
1,3-Butadiene	2.25 µg/m^3	Running annual mean	31.12.2003
Carbon monoxide Authorities in England, Wales and Northern Ireland only	10.0 mg/m^3	Maximum daily running 8-hour mean	31.12.2003
Authorities in Scotland only	10.0 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.5 µg/m^3 0.25 µg/m^3	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen dioxide[a]	200 µg/m^3 not to be exceeded more than 18 times a year 40 µg/m^3	1 hour mean Annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)[b,c] All authorities	50 µg/m^3 not to be exceeded more than 35 times a year 40 µg/m^3	24 hour mean Annual mean	31.12.2004 31.12.2004
Sulphur dioxide	350 µg/m^3 not to be exceeded more than 24 times a year 125 µg/m^3 not to be exceeded more than 3 times a year 266 µg/m^3 not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31.12.2004 31.12.2004 31.12.2005

a. The objectives for nitrogen dioxide are provisional.
b. Measured using the European gravimetric transfer standard sampler or equivalent.
c. These 2010 Air Quality Objectives for PM10 apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

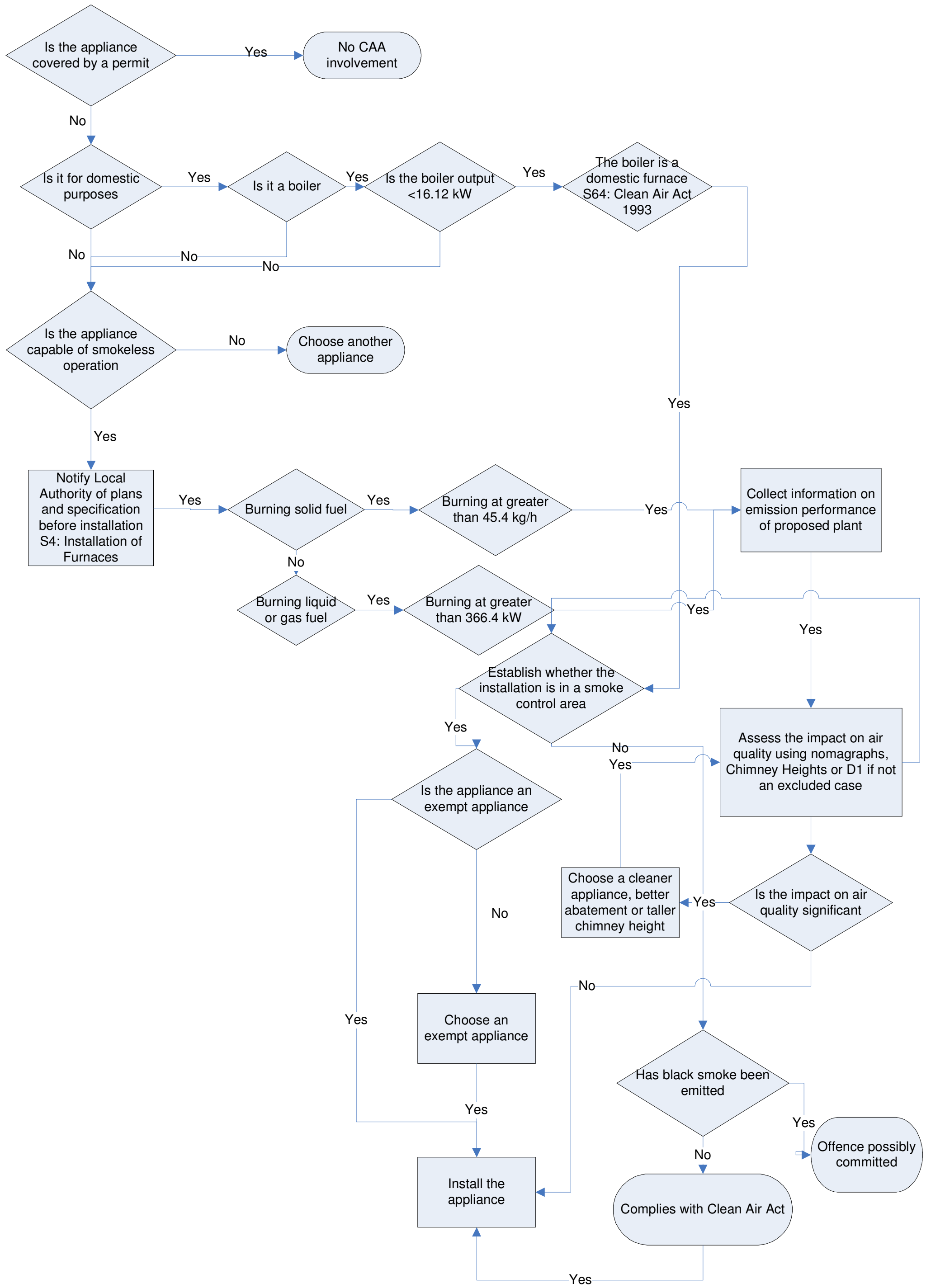


Figure 7.1: Decisions relating to compliance of appliances with the Clean Air Act (1993)

Local Authorities are required to declare an Air Quality Management Area where it is likely that these objectives will not be achieved and to prepare an Action Plan to set out the measures to be taken to achieve the objectives. All 33 London Boroughs have declared Air Quality Management Areas for nitrogen dioxide and some for particulate matter, PM_{10}. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (2007) introduced two further objectives for $PM_{2.5}$. These are a "cap" of 25 µg m^{-3} to be achieved by 2010 and an exposure reduction target of 15 % reduction in average concentrations at urban background locations. These $PM_{2.5}$ objectives have not yet been set in Regulations, however, if they are implemented they will be difficult to achieve in parts of London.

Local Authorities require a simple tool for assessing whether a proposed biomass combustion installation in the range 50 kW to 2 MW thermal will lead to pollutant concentrations exceeding the air quality objectives or will compromise the effectiveness of measures set out in their Action Plans.

In many cases in London, the background concentrations of pollutants already exceed the air quality objectives. In these cases, it will not be possible to install additional combustion plant without further increasing the pollutant concentrations. However, local authorities may choose to allow a small increase in pollutant concentrations locally in small areas in order that development is not unduly constrained.

The provision of chimneys for biomass burners less than 50 kW thermal is covered by the Building Regulations.

Defra provides Technical Guidance (LAQM.TG(03)) for Local Air Quality Management. The Technical Guidance provides some simple nomographs for assessing the air quality impact of industrial sources. A simple spreadsheet tool has been developed to implement the nomographs on personal computers. However, biomass burners in the range up to $2MW_{th}$ are outside the range of application of the Technical Guidance nomographs. Nomographs suitable for application to biomass combustion plant less than $2MW_{th}$ are developed in this chapter. The Defra Technical Guidance has separate nomographs for stacks and for low level sources. For biomass combustion in the range 50 kW-2MW, the required stacks are relatively short and so a single nomograph has been prepared to cover both low-level sources and isolated stacks.

Defra's Technical Guidance also provides nomographs to estimate the density of houses using solid fuel below which the emissions are unlikely to result in the air quality objectives being exceeded. The nomographs are applicable to biomass burners. However, the Defra Guidance does not provide a nomograph for the $PM_{2.5}$ cap. A new nomograph is provided here.

The nomographs developed are intended to prevent localised concentration "hot spots". Individual combustion appliances are unlikely to result in relevant increases in average exposure over widespread areas. Consequently, the exposure reduction target for $PM_{2.5}$ has not been considered in the development of the nomographs. The effect of widespread use of biomass combustion on urban background concentrations in London is considered elsewhere in this report.

7.2 Dispersion modelling

The dispersion model ADMS3.3 was used to predict ground level concentrations for a unit (1 g s^{-1}) emission rate of pollutant from discharge stacks with heights in the range 10.6-40 m and diameters in the range 0.1-1m. ADMS 3.3 is an up-to-date dispersion model widely used to assess the air quality impact of pollutant emissions. The discharge stack was assumed to be located at the centre of a 10 m cubical building. The discharge temperature was assumed to be 100^oC, typical of biomass combustion appliances. Discharge velocities from the stacks were estimated on the basis that the appliances operate with forced draught just sufficient to overcome the pressure drops through the appliance. Table 7.2 lists the model runs and input values. Table 7.3 shows both the actual stack height above ground, C and the effective stack height, U:

$U = 1.66(C - H)$ for C<2.5H; otherwise U=C, where: H is the building height.

Table 7.2: Actual and effective stack height modelling

Run	Stack height, m	Effective stack height, m	Stack diameter, m	Discharge velocity, m s^{-1}
A1_1	10.6	1	0.1	1.3
A2_1	11.2	2	0.1	1.3
A5_1	13	5	0.1	1.3
A10_1	16	10	0.1	1.3
A20_1	22	20	0.1	1.3
A40_1	40	40	0.1	1.3
A1_2	10.6	1	0.2	1.9
A2_2	11.2	2	0.2	1.9
A5_2	13	5	0.2	1.9
A10_2	16	10	0.2	1.9
A20_2	22	20	0.2	1.9
A40_2	40	40	0.2	1.9
A1_5	10.6	1	0.5	3
A2_5	11.2	2	0.5	3
A5_5	13	5	0.5	3
A10_5	16	10	0.5	3
A20_5	22	20	0.5	3
A40_5	40	40	0.5	3
A1_10	10.6	1	1	4.2
A2_10	11.2	2	1	4.2
A5_10	13	5	1	4.2
A10_10	16	10	1	4.2
A20_10	22	20	1	4.2
A40_10	40	40	1	4.2

The model was run with hourly sequential meteorological data for Heathrow Airport, 2005 with surface roughness 1 m locally and 0.1 m at the airport. The model was run with receptor locations on a 1 km square grid centred on the stack at 10 m intervals. Maximum annual mean, 90th percentile 24-hour mean and 99.8th percentile hourly mean concentrations were calculated. The emission rate, E_A (g/s) that would lead to an increase in the maximum ground level concentration of 1 µg m^{-3} was then calculated[28] (as the inverse of the maximum ground level concentration for unit emission). Cubic polynomial curves were fitted through the modelled data of the form:

$$y = ax^3 + bx^2 + cx + d$$

where: x is $\log_{10}(U)$; and $y=\log_{10}(E_A)$.

[28] The nomographs were developed based on a contribution of 1 µg m^{-3} to ground level concentrations. The allowable contribution to ground level concentrations from the plant will depend on the background concentration and on local authority policies. The procedures developed below allow these factors to be taken into account.

Table 7.3: Shows the values of the constants a, b, c and d

Statistic	Stack diameter, m	a	b	c	d	Range of effective stack heights, m
90th percentile of 24 hour means	0.1	0.4192	0.1084	0.2548	-3.2281	1-40
	0.2	0.3903	0.1441	0.2478	-3.1593	1-40
	0.5	0.3785	0.0686	0.3328	-2.9665	2-40
	1	0.2525	0.2928	0.2298	-2.7296	5-40
Annual mean	0.1	0.4990	-0.1051	0.4351	-2.8062	1-40
	0.2	0.4920	-0.1211	0.4478	-2.7296	1-40
	0.5	0.4790	-0.1904	0.5228	-2.5349	2-40
	1	0.2923	0.1984	0.2894	-2.2548	5-40
99.8th percentile of hourly means	0.1	-0.2570	1.4398	-0.3227	-3.896	1-40
	0.2	-0.2412	1.2842	-0.1655	-3.7481	1-40
	0.5	-0.9642	3.3411	-1.9382	-3.0675	2-40
	1	-1.6681	5.8307	-4.6034	-2.0738	5-40

Figures 7-1, 7.2 & 7.3 show nomographs based on the polynomial curve fits.

Figure 7.1: Particulate emissions to give a 90th percentile of 24 hour mean ground level concentrations of 1 $\mu g\ m^{-3}$

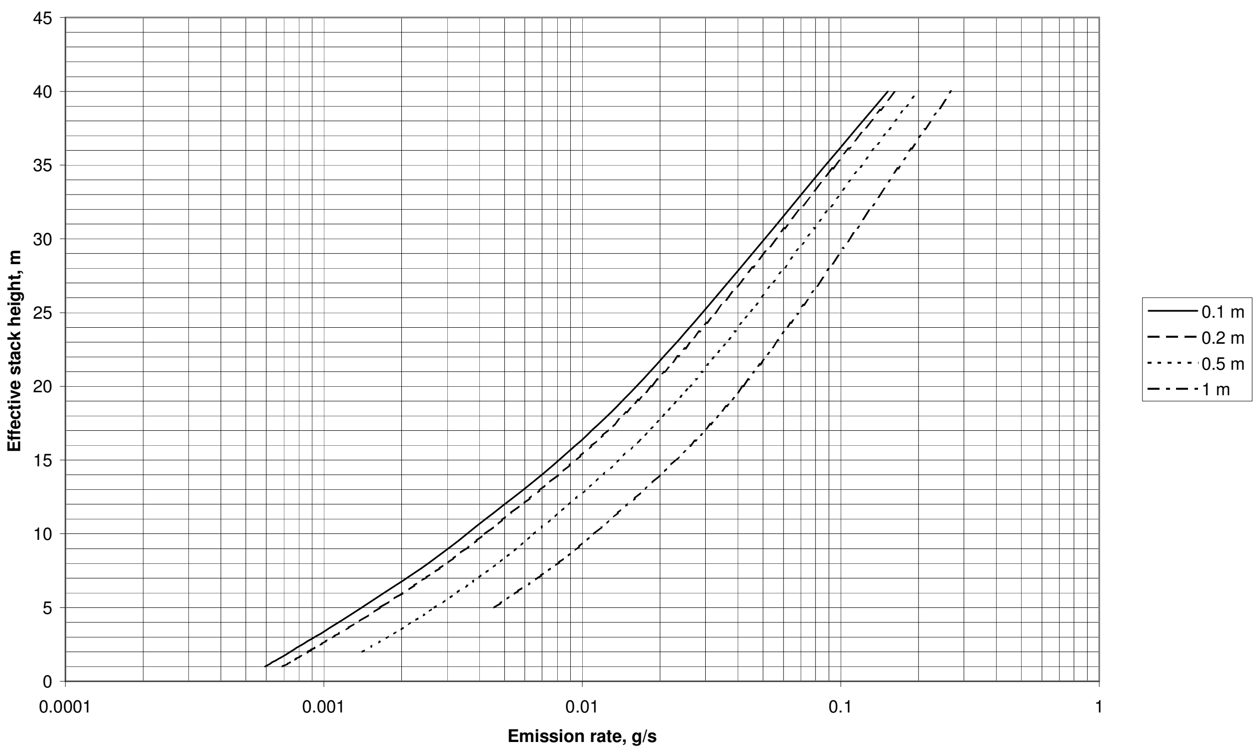
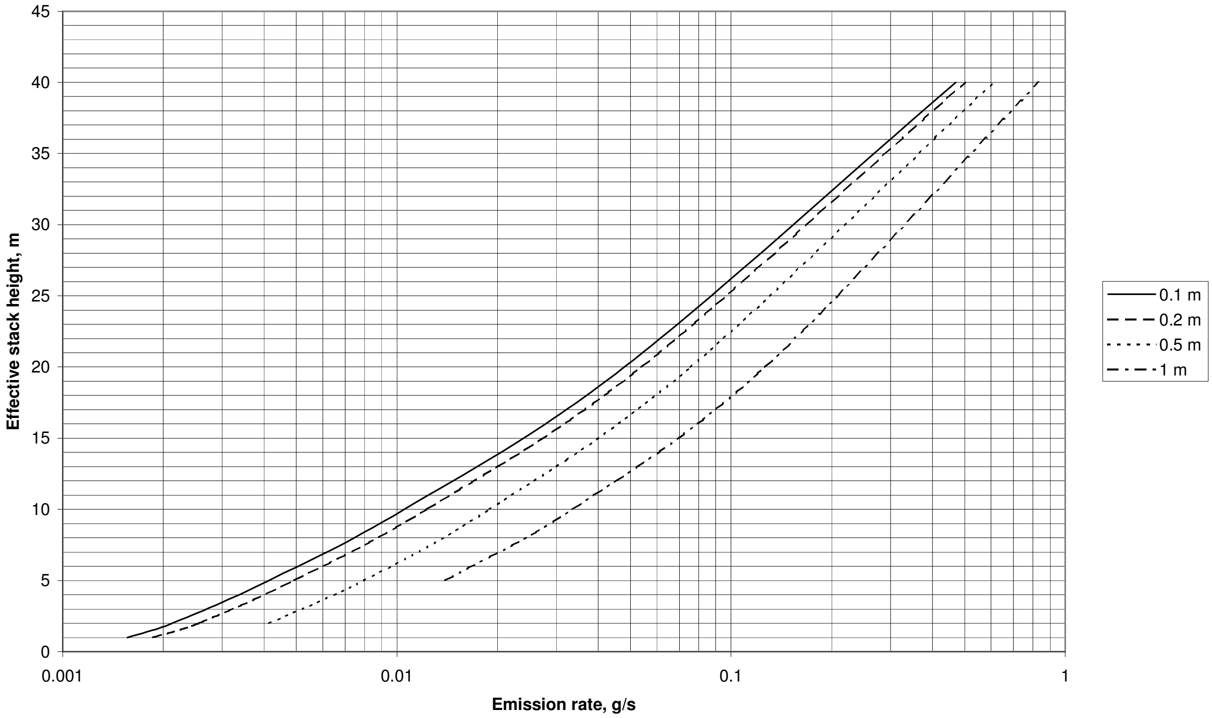
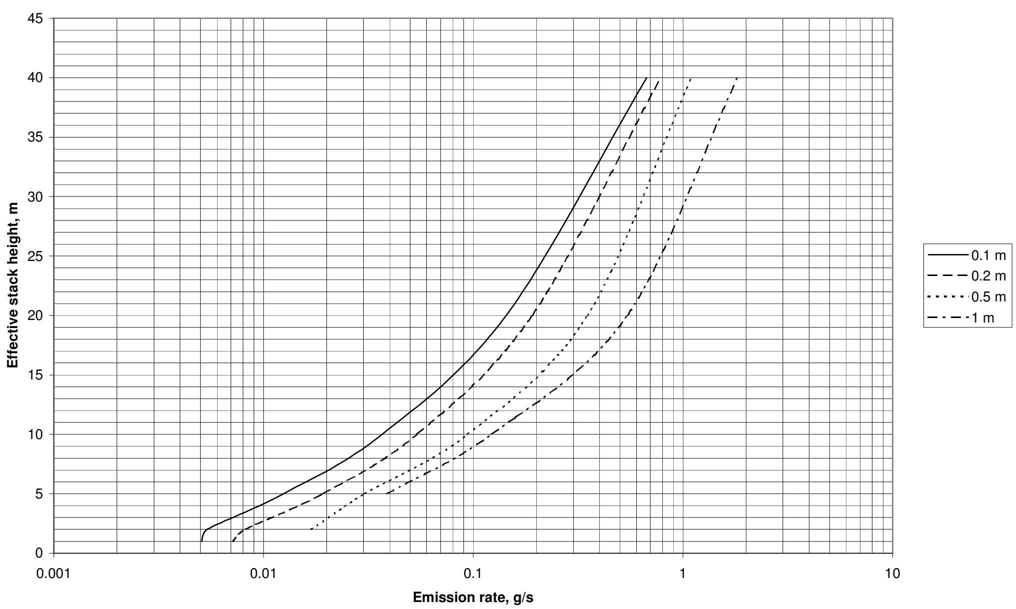


Figure 7.2: Emissions to give an annual mean ground level concentration of 1 µg m^{-3} of oxides of nitrogen, particulate matter or PAHs [a]



(a) For PAHs as the target value is in ng/m^3 the nomagraph can be regarded as being to achieve the EU Target Value of 1 ng/m^3 and the emission rate in units of mg/s. For assessment of significance against the National Air Quality Objective of 0.25 ng/m^3 then the actual appliances emission rate in mg/s should be multiplied by four.

Figure 7.3: Emissions of oxides of nitrogen that will give a 99.8th percentile hourly mean concentration of 40 µg m^{-3}



7.3 Procedures

The following sections describe how local authorities should use the nomographs to assess the potential impact on local air quality of proposed developments involving biomass combustion appliances. In order to facilitate the assessment, the developer should provide the following information:

- Location of the stack with OS grid coordinates;
- Height of stack above ground;
- Diameter of stack;
- Dimensions of buildings within a distance of five times the stack height above ground from the stack;
- Description of the combustion appliance; and
- Maximum rates of emission of particulate matter (PM_{10} and $PM_{2.5}$) and oxides of nitrogen when operating at capacity.

The developer may supply details of the maximum thermal capacity of the appliance instead of the maximum rates of emission. Local authorities may then estimate rates of emission based on the Clean Air Act exemption limits or on the basis of emission factors provided by the EMEP/CORINAIR Emission Inventory Guidebook – 2006. In smoke-controlled areas of London, biomass burners require exemption under the Clean Air Act. Exempted appliances are required to emit less than 5 g/h particulate matter plus 0.1 g/h per 0.3 kW of heat output. The EMEP/CORINAIR Emission Inventory Guidebook – 2006 gives typical emission factors for advance wood burning appliances less than 1 MW_{th} shown in Table 7.4.

Table 7.4: Summary of Corinair emission factors for an advanced wood-burning appliance

Appliance Type	PM_{10} Emissions, /GJ	$PM_{2.5}$ Emissions, g/GJ	NOx Emissions, g/GJ
Advanced fireplaces	240	240	90
Advanced stove	240	240	90
Pellet stove	76	76	90
Manual boiler	76	76	150
Automatic boiler	66	66	150

Note that for modern appliances with well –designed combustion the particles emitted are all thought to be less than 2.5 um, hence the total particles, PM_{10} and $PM_{2.5}$ emissions are equivalent. For traditional appliance designs this may not be so but is a conservative assumption in the absence of size fractionated measurements.

In addition, local authorities should estimate background pollutant concentrations in their area from 1 km x 1 km maps provided for Local Authority Review and Assessment (http://www.airquality.co.uk/archive/laqm/tools.php?tool=background04) or from measurements at similar background locations in the London Air Quality Network (http://www.londonair.org.uk/london/asp/datadownload.asp). In some places, the existing background concentrations already exceed the air quality objectives: it will not then be possible to install an additional combustion appliance without increasing pollutant concentrations further. However, local authorities may choose to allow a small increase in pollutant concentrations locally in small areas in order that development is not unduly constrained. London Councils Air Quality and Planning Guidance (http://www.londoncouncils.gov.uk/doc.asp?docId=19119) and the NSCA report “Development control: Planning for air quality” provide guidance on the significance of pollutant impacts in excess of the air quality objectives.

7.3.1 PM_{10}

The nomograph at Figure 7.1 may be used to assess whether the proposed biomass combustion installation is likely to lead to an exceedence of the 24 hour objective for PM_{10}. First, calculate a "background- adjusted" emission rate using:

$$E_A = \frac{E}{(32 - G)}$$

where: E is the emission rate in g s^{-1} at capacity; and G is the annual average background concentration in $\mu g\ m^{-3}$. The 32 $\mu g\ m^{-3}$ represents the annual average concentration at which given a typical distribution of concentrations with time the 90^{th} percentile of 24 hour means will exceed the objective. If the annual average background concentration exceeds 32 $\mu g\ m^{-3}$, then calculate:

$$E_A = \frac{E}{\Delta C}$$

where: ΔC is the maximum increment in pollutant concentrations allowed by the local authority. If the local authority is not prepared to allow any exceedence of the air quality objective, then no combustion appliance may be installed.

Then, lookup the effective stack height, U, from Figure 7.1, for the appropriate stack diameter. If the value of the effective stack height is less than 2.5 times the height of the building to which it is attached or any other building within 5 times the effective stack height then it will be necessary to calculate a corrected stack height based on the 3^{rd} Chimney Height Memorandum as follows.

1. List all the buildings within a distance of 5U of the chimney and record the height, H and width B (measured at right angles to a line joining the chimney and the nearest point) for each building.
2. Calculate K, the lesser of the building height and the building width for each building.
3. Calculate T for each building=H+1.5K.
4. Find H_m, the largest value of H.
5. Find T_m, the largest value of T.
6. If U is greater than T_m, the height needs no correction and the corrected height C = U
7. Otherwise calculate the corrected chimney height from the following equation:

$$C = H_m + U\left(1 - \frac{H_m}{T_m}\right)$$

There are three overriding requirements for chimney height:

a) a chimney should terminate at least 3 m above the level of any adjacent area to which there is general access (i.e. ground level, roof areas or adjacent open-able windows);
b) a chimney should never be less than the calculated effective stack height; and
c) a chimney should never be less than the height of any part of an attached building within a distance of 5U.

7.3.2 $PM_{2.5}$

A similar procedure applies for $PM_{2.5}$. Firstly, determine the emission rate at capacity. The emission rate of $PM_{2.5}$ may be conservatively assessed as equal to the PM_{10} emission. The background annual average $PM_{2.5}$ concentration, G, may be determined from measurements at similar locations in the London Air Quality Network (http://www.londonair.org.uk/london/asp/datadownload.asp).

The background adjusted emission rate for $PM_{2.5}$ is calculated using:

$$E_A = \frac{E}{(25 - G)}$$

where: E is the emission rate in g s^{-1} at capacity; and G is the annual average background concentration in µg m^{-3}. The 25 µg m^{-3} represents the annual average concentration at which given a typical distribution of concentrations with time the 90th percentile of 24 hour means will exceed the objective. If the annual average background concentration exceeds 25 µg m^{-3}, then calculate:

If the annual average background concentration exceeds 25 µg m^{-3}, then calculate:

$$E_A = \frac{E}{\Delta C}$$

where: ΔC is the maximum increment in pollutant concentrations allowed by the local authority. If the local authority is not prepared to allow any exceedence of the air quality objective, then no combustion appliance may be installed.

Look up the effective stack height, U, from Figure 7.2 for the appropriate stack diameter. If the value of the effective stack height is less than 2.5 times the height of the building to which it is attached or any other building within five times the effective stack height then it will be necessary to calculate a corrected stack height based on the 3rd Chimney Height Memorandum. The correction procedure is set out above.

7.3.3 Nitrogen dioxide, annual mean

A similar procedure applies for the annual mean nitrogen dioxide. First determine the emission rate at capacity. The background concentration may be determined from 1 km x 1 km provided for Local Authority Review and Assessment (http://www.airquality.co.uk/archive/laqm/tools.php?tool=background04). The background adjusted emission rate for annual average oxides of nitrogen is calculated using:

$$E_A = \frac{E}{(40 - G)}$$

where: E is the emission rate in g s^{-1} at capacity; and G is the annual average background of nitrogen dioxide concentration in µg m^{-3}. The 40 µg m^{-3} represents the annual average objective.

If the annual average background concentration exceeds 40 µg m^{-3}, then calculate:

$$E_A = \frac{E}{\Delta C}$$

where: ΔC is the maximum increment in pollutant concentrations allowed by the local authority. If the local authority is not prepared to allow any exceedence of the air quality objective, then no combustion appliance may be installed.

Lookup the effective stack height, U, from Figure 7.2 for the appropriate stack diameter. If the value of the effective stack height is less than 2.5 times the height of the building to which it is attached or any other building within five times the effective stack height then it will be necessary to calculate a corrected stack height based on the 3rd Chimney Height Memorandum. The correction procedure is set out above.

7.3.4 Nitrogen dioxide, 1 hour average

A similar procedure applies for the 1 hour average objective for nitrogen dioxide. Firstly, determine the emission rate at capacity. The background concentration may be determined from 1 km x 1 km provided for Local Authority Review and Assessment (http://www.airquality.co.uk/archive/laqm/tools.php?tool=background04).

The background adjusted emission rate for the hourly oxides of nitrogen is calculated using:

$$E_A = \frac{E}{(200 - 2G)}$$

where: E is the emission rate in g s^{-1} at capacity; and G is the annual average background nitrogen dioxide concentration in µg m^{-3}. The background is multiplied by two to represent the typical ratio between the annual mean and the 99.8^{th} percentile of 1 hour means taking into account the partial correlation between the variation in background concentration and the dispersion of a given plume which is then subtracted from the objective.

Lookup the effective stack height, U, from Figure 7.3 for the appropriate stack diameter. If the value of the effective stack height is less than 2.5 times the height of the building to which it is attached or any other building within five times the effective stack height then it will be necessary to calculate a corrected stack height based on the 3^{rd} Chimney Height Memorandum. The correction procedure is set out above.

7.3.5 Examples

Example1: A 500 kW thermal capacity biomass boiler is installed in a building 30 m high and 20 m x 20 m in plan. The stack diameter is 0.5 m.

The particulate emission rate is estimated from the Clean Air Act exemption limits as 5+500/0.3 x 0.1 =172 g/h or 0.048 g/s. The oxides of nitrogen emission is estimated from the Corinair factors for an automatic boiler= 500000/1000000000x150=0.075 g/s.

The background annual average nitrogen dioxide concentration is 35 µg m^{-3}. The background annual average PM_{10} concentration is 25 µg m^{-3} and the annual average background $PM_{2.5}$ concentration is 15 µg m^{-3}. Table 7.5 shows the calculated background adjusted emission rates and the effective stack heights determined for each pollutant metric from Figures 7.1 to 7.3.

Table 7.5: Background adjusted emission rates and effective stack heights

	PM_{10}	$PM_{2.5}$	Annual mean NO_2	Hourly mean, NO_2
Emission rate, g/s	0.048	0.048	0.075	0.075
Background concentration, µg m^{-3}	25	15	35	35
Background adjusted emission rate, g/s	0.007	0.005	0.015	0.023
Effective stack height, m	9.5	3	9	5

The effective stack height (9.5 m) is largest for PM_{10} and this is the critical effective stack height. The effective stack height is less than 2.5 times the building height and so it is necessary to correct the stack height.

Calculate width, B: B=√ (20^2+20^2) = 28.3 m
Calculate K: K = 28.3 m
Calculate T: T=30+1.5x28.3 = 72.5 m
Calculate C: C=30+9.5x(1-30/72.5) = 35.6 m

The required stack height is 35.6 m above ground or 5.6 m above the top of the building. This chimney meets the overriding requirements set out above, provided that there are no other taller buildings within 47.5 m of the stack.

Example 2: A 60 kW thermal capacity biomass pellet boiler is installed in a building 10 m high and 30 m x 20 m in plan. The stack diameter is 0.2 m.

The particulate emission rate is estimated from the Clean Air Act exemption limits as 5+60/0.3 x 0.1 = 25 g/h or 0.0069 g/s. The oxides of nitrogen emission is estimated from the Corinair factors for a pellet boiler = 60000/1000000000x76=0.0046 g/s.

The background annual average nitrogen dioxide concentration is 35 µg m^{-3}. The background annual average PM_{10} concentration is 25 µg m^{-3} and the annual average background $PM_{2.5}$ concentration is 15 µg m^{-3}. Table 7.6 shows the calculated background adjusted emission rates and the effective stack heights determined for each pollutant metric from Figures 7.1 to 7.3.

Table 7.6: Background adjusted emission rates and effective stack heights

	PM_{10}	$PM_{2.5}$	Annual mean NO_2	Hourly mean, NO_2
Emission rate, g/s	0.0069	0.0069	0.0046	0.0046
Background concentration, µg m^{-3}	25	15	35	35
Background adjusted emission rate, g/s	0.00099	0.0007	0.0003	0.0014
Effective stack height, m	3	<1	3	<1

The effective stack height (3 m) is largest for PM_{10} and this is the critical effective stack height. The effective stack height is less than 2.5 times the building height and so it is necessary to correct the stack height.

Calculate width, B: $B=\sqrt{(30^2+20^2)}=36$ m
Calculate K: K=10 m
Calculate T: T=10+1.5x10=25 m
Calculate C: C=10+3x(1-10/25)=11.8 m

The required stack height is 11.8 m above ground or 1.8 m above the top of the building. This chimney meets the overriding requirements set out above, provided that there is no general access to the roof and there are no other taller buildings within 15 m of the stack.

7.4 Screening assessment for domestic biomass burning

Technical guidance LAQM.TG(03) provides nomographs for assessing whether there is a risk of exceeding the air quality objectives for PM_{10} as the result of high densities of domestic emissions over an area. Calculating the density of 'effective' coal-burning houses, and then comparing these results with the nomographs may determine the risk of exceeding the objectives. The nomograph for assessing the risk of exceedence of the 24 hour PM_{10} objective is shown in Figure 7.4.

Figure 7.5 shows a new nomograph for estimating whether there is a risk of exceedence of the 25 µg m^{-3} cap for $PM_{2.5}$.

Figure 7.4: LAQM TG(03) nomograph for PM_{10}

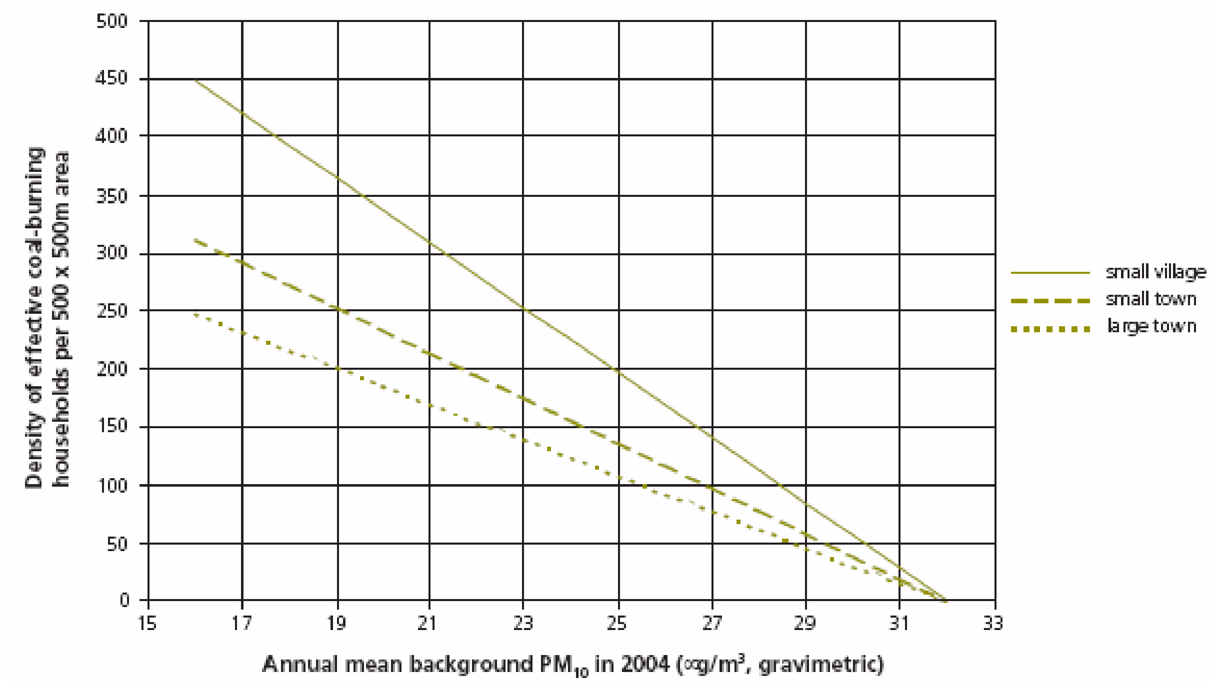
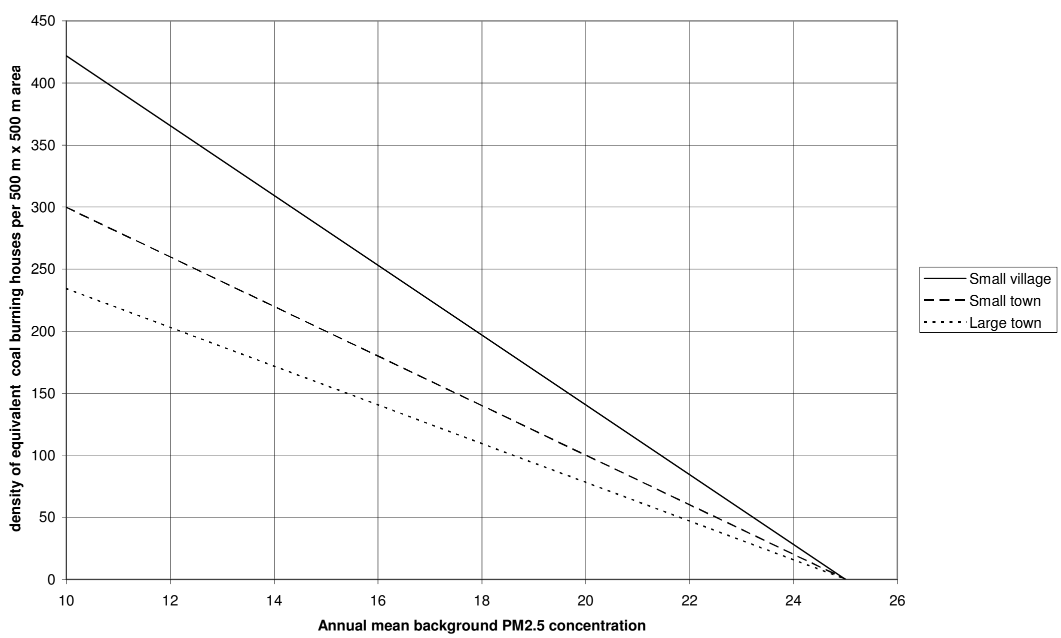


Figure 7.5: Nomograph for determining risk of exceedence for $PM_{2.5}$



The procedure therefore requires authorities to identify the area with the highest density of solid fuel-burning houses, and to then estimate the number of houses burning coal, anthracite, smokeless fuel or wood within a 500 m x 500 m grid square. Solid fuels other than coal are weighted to give a 'coal equivalent'. The equivalent number of coal burning houses in the 500 m x 500 m grid square is calculated using:

C_{eq}=C+0.36A+0.56S+0.79W

Where:
Ceq is the equivalent number of coal-burning households;
[C] is the number of coal-burning households;
[A] is the number of anthracite-burning households;
[S] is the number of smokeless-fuel-burning households; and
[W] is the number of wood-burning households.

The proportion of space in the 500 m x 500 m grid not occupied by solid fuel-burning houses is also required, together with the annual mean background concentration for 2004.

The equivalent number of coal burning houses is adjusted to take account of the proportion of open space in the 500 m x 500 m area:

[Deq] = [Ceq]/(1-L).

Where: L = proportion of open space.

Three representative 'area types' are considered:

- A small village (approx 1 km^2 area);
- A small town (approx 16 km^2 area); and
- A large town (approx 100 km^2 area).

Users should select the area most appropriate to their location. Where there is in doubt, the larger area should be chosen. For example, a solid fuel-burning area within a large village (8 km^2) would be represented by a 'small town'.

Figure 7.4 describes the density of equivalent coal burning houses in a 500m x 500 m square which may give rise to an exceedence of the 24 hour objective for PM_{10} for a particular annual mean background concentration. Similarly, Figure 7.5 describes the density of equivalent coal burning houses in a 500m x 500 m square which may give rise to an exceedence of the annual average cap for $PM_{2.5}$ for a particular annual mean background concentration. If the actual density of equivalent coal-burning houses is less than the threshold density shown in Figures 7.4 and 7.5, then it is unlikely that the objectives will be exceeded.

8 Technologies for Biomass Use

8.1 Overview of biomass fuel applications

In recent years the use of biomass has grown significantly in several countries in Europe and in North America, both for single dwelling heating (for example USA, Canada, Austria using mainly wood pellets) and for community heating (for example Austria, Germany, Sweden, Denmark), using initially wood chips and logs but increasingly wood pellets particularly in small-scale installations.

Figure 8.1: Pellets, chips and logs

Wood pellet fuels consist of short cylinders of compressed wood particles. Pellet fuel is an internationally traded commodity that has become widely used in mainland Europe as a result of its convenience – it is clean and can be supplied in tankers or paper sacks. The regularity of form of the pellets ensures that they flow easily though bunkers, into combustion appliances and burn in a predictable manner compared to logs or chip allowing easier control and handling.

Although biomass combustors are physically larger than gas or liquid fuel heating systems for residential use, it is anticipated that there will be an increasing number of pellet stoves and boilers in the UK and particularly in London where the driver will be to meet planning requirements at minimum inconvenience to the occupants.

Commercial applications
These are hot water boilers fuelled by chips or pellets that are connected to commercial or public sector premises. Typically they would be from a few tens of kW output for an office or showroom to a few MW for a large complex. In the public sector, biomass systems have proved attractive for large schools with leisure facilities attached and council offices and facilities with a high occupancy factor.

The operating principle is the same as the larger automated domestic units. Most will be fitted with flue gas cleaning equipment (typically cyclone or multi-cyclone particulate abatement).

Because of the quantities involved, wood will be delivered by bulk tipper or blower lorry – typically once or twice a week as shown in Table 11-2 small scale biomass combustion. Provision will be needed for tipping and storage of the fuel in silos or bays. As can be seen from the information given in Table 11-2 there will be an increase in vehicle movements to support these appliances whereas natural gas is piped directly to a majority of units.

District heating

District heating is the provision of heat to several properties as a utility service in the form of hot water generated in a central boiler house. The water is distributed by a network of insulated pipes buried in culverts under the street. Heat is usually paid for on a metered basis with the quantity being determined by the flow of water to the property and its temperature drop.

The scale of operation can range from very large to small. For example, most properties in Stockholm are connected to the city district heating scheme which has 765 km of pipework and delivers 5.5 TWhper year. There has been a recent trend in the UK to connect small clusters of buildings to small networks supplied by a small biomass boiler. Union Road flats in Barnsley, for example, has a 500kW biomass boiler.

An advantage of this type of installation is the ability to pick up heat from several locations that could include waste heat from industrial process or distributed generators and deliver it to multiple users.

District heating is a good way of delivering renewable energy to multiple locations in high density urban areas without impacting on local air quality. This is because the central boiler is large enough to be fitted with good quality flue gas cleaning equipment. Research undertaken into wood burning in the Nordic countries came to the conclusion that it was only economically to fit devices such as ESPs and bag filters to boilers of capacity > 500kW[29].

There are however drawbacks to the system:

- The pipework distribution infrastructure is expensive and difficult to fit in to existing built up urban areas;
- The heating demand is often not adequate to justify the capital expenditure on distribution pipework; and
- To be economically successful, the system needs a high take up rate amongst consumers who are prepared to accept long-term contracts, but this is culturally difficult in the UK where we have become accustomed to a free energy market.

Some larger networks in European cities have installed systems that deliver cooling in the summer months using chilled water to improve the overall economy of the system.

Industrial and process heating

These are larger boilers with typically an output of 1MW and above that supply steam or hot water to an industrial process. They are often fuelled by a residue available from the process itself such as waste wood, husks or shells. If these are not available then wood chip is usually the preferred fuel.

Power generation

This is electricity generally produced on a large scale by an independent company for trade into the wholesale market. Generally, power plants tend to be above 10 MWe to gain economy of scale and are focussed on the generation of revenue from the sale of power and ROCs to licensed suppliers. Each will contract with local forestry companies, growers and merchants for fuel supplies. There is usually a preference to contract with a few larger organisations for most of the fuel. England and Scotland currently have four installations with Denmark having a few more.

There are also a number of installations in the US. Finland and Sweden have many large biomass boilers, up to 50MWe, these are usually CHP installations connected to district heating networks and industrial complexes but the equipment is the same.

In London, potential power generation is more likely to be focussed on the use of waste wood and waste derived fuels.

[29] Particulate matter emission and abatement options in residential wood burning in the Nordic Countries. C Sternhufvud, N Karvosenoja, J Illerup, K. Kindbom, A Lukewille, M Johannsson & D Jensen, January 2004.

Combined Heat and Power
This is likely to be an attractive option in London for two reasons:

- It is a way of meeting planning requirements for renewable generation without problems associated with other forms of renewable energy sources such as; the expense of photovoltaic panels and consistency of supply of wind; or

- The reformed Renewables Obligation is likely to reward electricity generated from biomass in CHP installations with two Renewable Obligation certificates giving it a value of approximately 12 p/kWh.

CHP is complex and is most likely to be applied to buildings with an electrical demand over 100kWe or district heating schemes. There are two main technology options:

- Conventional steam boiler and a steam turbine. This is reliable and available from many suppliers but is expensive on a small scale and has relatively low conversion efficiency for electricity; or

- Advanced conversion technology. These are new technologies recently developed that are more cost effective at small scale and have higher electrical efficiency.

Steam cycle CHP installations are widely used throughout the world but they become uneconomic below 2MWe. They also have the inherent characteristic that the removal of heat from the cycle inevitably leads to the reduction of electricity production, which is serious in the UK where electricity production from biomass is heavily incentivised. These two drawbacks have led manufacturers to develop alternatives that do not rely on the Rankine steam cycle.

The technologies generally involve gasification of the biomass with subsequent combustion of the fuel gas. However, conversion has not proved easy and there are many examples of failures through poor availability and misconceived technical solutions. In recent years, companies have introduced products that show great promise in overcoming the technical problems. We would expect several to be proposed for use in London.

8.2 Combustion and generation technology

8.2.1 Domestic heating

Log Systems
Open fires using logs. Open fire type room heaters have traditionally been used in many parts of the UK, particularly in rural homes. Such fires have very poor efficiency of fuel utilisation, typically around 10%-15% and do not meet the particulate emission requirements of the Clean Air Act when using anything other than smokeless fuels. The use of open fires is not a credible scenario for biomass use in new developments in London. The use of existing fireplaces as supplementary heating in rooms with alternative sources of primary heat is increasing but is likely to remain a small scale occasional activity. Although there may be potential for re-opening fireplaces and the use of the limited number of biomass based authorised fuels in older properties the high operator input required to run these units is unlikely to prove attractive other than as an occasional heat source.

Closed Appliances (Stoves) using logs. To overcome the problems of open fire type heaters, closed appliances (stoves) have been developed that contain the burning fuel behind a door. Efficiencies are high at approximately 75%. Some are exempted under the Clean Air Act.

Central heating boilers using logs. These are very common in Scandinavia, Austria and Germany. To guarantee a clean burn they are fired for a few hours each day at maximum output. The heat generated is stored in a hot water accumulator and released on demand into a pumped central system. An accumulator should always be fitted to ensure good environmental performance. The accumulator also gives the opportunity to connect other energy sources such as solar or heat pumps – this option may be used in London in “aspirational” builds. Boilers are often provided with oil burners for use in summer or electrical heaters in the accumulator.

Wood Pellets
Room heaters using wood pellets. Wood pellets are now a major fuel source for heating in many parts of Europe (Sweden, Germany, Austria) as well as in the USA and Canada. Fully automated room heaters for single dwellings (unit size with thermal output in the range 3 – 10kW) are now well developed and mature with several thousand of such appliances being used in these countries. These can provide an aesthetically-pleasing glass-fronted combustion chamber. A fuel storage hopper can feed the fire bed by gravity. The room temperature can be maintained by thermostatic control. Refuelling is usually by emptying a bag or bin of fuel into the top of the unit, although it is possible to arrange an auxiliary storage hopper on an outside wall for some units. They are often sold as a focal point for a room and as supplementary heating. There are many designs on the market ranging from simple, manually ignited heaters with little fuel storage to sophisticated units with electric ignition and several days auxiliary storage.

Pellet fired central heating boilers. These units are comparable to oil-fired heating systems in levels of convenience and achieve high thermal efficiency (around 90% plus). They differ significantly from log based systems in that they are based on designs for oil fired boilers and do not need accumulators. They will follow the heat load (modulate) in the same way that an oil or gas boiler will. Ignition and control is automatic. Ash will need removing from time to time – say weekly. The fuel storage bin will take up a considerable amount of space and because it is connected to the boiler by an augur its installation is less flexible than an oil tank. In Sweden it is common to convert an oil fired boiler to pellets by removing the oil burner and replacing it with a small pellet stoker and storage bin.

Wood chip systems
The technologies applied for handling and combustion are similar to those used for wood pellets. Although the cost of wood chips is well below that of wood pellets wide variation in its quality e.g. moisture content, size, calorific value, foreign matters such as mud, rubbish etc and problems of its handling makes it less suitable for single dwelling applications. However, a relatively large size wood chip boiler (thermal output 100kW and above) installed to serve a number of dwellings in a building, sheltered housing for example can be convenient and economic.

Standards
There are number of CEN Standards for the solid fuel heaters and boilers which set out minimum requirements for construction and performance.

8.2.2 Boilers for commercial and industrial heating and power

For commercial and smaller industrial applications, larger pellet and wood chip units are well-established (wood chip predominates for larger units).

Larger combustion units clearly require greater fuel handling and storage provision and the potential for particulate and dust emission needs to be considered. The number of fuel deliveries also increases.

For the largest industrial units, there are two main categories of burner in biomass applications, the grate and fluidised bed. The first has evolved from designs that have been used widely throughout this century whilst the second is a fairly recent innovation, although it is rapidly becoming well established.

Grate burners
In grate-firing the fuel burns in a layer on a supporting grate. Air for combustion is blown both through the grate and over the top of the fuel layer. The processes of drying, pyrolysis and combustion of the volatiles and char take place sequentially as the material proceeds through the boiler on the grate. Various types of grates have evolved to move the fuel through the boiler and eventually remove the ash. Some grates vibrate, some move slowly forward on chains whilst others have a reciprocating action. Free flowing, dryer materials can be burned as a small pile that is continuously replenished from below with a screw feeder – an underfeed stoker.

Fluidised bed burners
In a fluidised bed furnace, the fuel burns in a bed of sand or other mineral that is violently agitated by the combustion air. The fuel is fed at a controlled rate to keep the temperature of the sand bed at 800-900^{0}C. With moderate air velocities the bed has the appearance of a boiling liquid, hence the name bubbling fluidised bed. If a higher velocity is used the sand will be carried out of the furnace and must be recycled to the base via a cyclone – this is known as a recirculating fluidised bed. Heat is removed and steam is raised by tubes in the bed of sand, the walls of the furnace and in the exhaust flue.

This type of boiler is proving very popular for medium to large industrial boilers for solid fuels and is taking an increasing share of this market. It is very popular in Scandinavia for district heating schemes. Two large boilers of this type firing biomass have recently been installed in the UK on Teesside (31MWe) and Lockerbie, Scotland (43MWe).

Grates are reliable and relatively inexpensive but are considered somewhat inflexible and are usually designed to cope with a limited range of fuels. Experience in the UK has shown that high, and variable, moisture content fuels can lead to uneven combustion and high dust emissions.

A great advantage of the fluidised bed to the operator is its fuel flexibility. This feature has been used to great advantage by CHP plants in the Nordic Countries, where it is common practice to fire wood chip, coal, peat, oil and wastes both together and separately. This flexibility is bought at the cost of greater complexity however and they are unlikely to be cost effective below 40MW_{th}.

Standards
There are number of European (CEN) Standards for the solid fuel heaters and boilers which set out minimum requirements for construction and performance. There is a specific standard for pellet stoves however apart from efficiency it does not address air quality issues. The Standard BS EN 303 Part 5 applies to biomass fuelled boilers up to 300kW in capacity also allows classification of appliances based on particulate emission standards as well as other measures of combustion quality (See Appendix A).

8.3 Control and abatement technologies

There are two approaches that can be used to control the emissions associated with the use of biomass in residential combustion processes. These include technical and non-technical. The technical approaches involve the design, control and abatement and the non-technical involve the use of regulation. The following sections review the use of technology to control and reduce emissions to the environment for the processes used in the combustion of biomass.

8.3.1 Control of oxides of nitrogen emissions

Measurements undertaken on grate firing and under fed stokes burning wood chips showed an logarithmic relationship between the nitrogen in the fuel and the NO_X produced. The air supply, furnace geometry and the type of furnace all influence NO_X formation. The primary route for control is to control the temperature, primary and secondary air. There are a number of approaches to control the emissions of NO_X from large combustion plants[30].

[30] Integrated Pollution Prevention and Control, Reference Document on Best Available Techniques for Large Combustion Plants July 2006.

These include primary measures, such as:

- low excess air;
- air staging;
- flue gas recirculation;
- reduced air preheat;
- fuel staging; and
- Low NO_X burners.

There are also secondary parameters that involve the introduction of catalysts such as ammonia and urea i.e. selective catalytic reduction (SCR) and Selective non-catalytic reduction (SNCR). A number of these techniques are being investigated fro use on small units below 50 MW.

8.3.2 Control of carbon monoxide

Carbon monoxide (CO) is a product of incomplete combustion of the carbon present in the fuel. Hence, combustion is used to control its emissions. This achieved by combustion chamber design, control of air flow to primary and secondary combustion zones.

As a consequence of CO being produced during periods of incomplete combustion it is often used as a parameter to ensure that other species such as PAHs that are produced under these conditions are also controlled by setting ELVs or performance values. This also enables monitoring of a process by continuous measurement methods.

8.3.3 Control of sulphur dioxide

It is not necessary to abate the emissions of sulphur dioxide from the combustion of biomass due to the low sulphur content found in these fuels.

8.3.4 Control of particulate material emissions

There has been significant amount of study undertaken into the technical measures: the reduction efficiency of these measures range between 30 and 90%.

Approaches available include the following:

- **Switch in fuel** by changing the structure of fuel used in appliances can have significant reduction efficiency (50 to 90%). Using pelletised material improves the combustion efficiency resulting in a reduction in PM and an increase in heat production.
- **Switch burner type** to a burner suitable for pellets.
- **Catalysis** to reduce the emissions of PM, VOC and CO by enabling the combustion process to follow lower energy pathways.
- **Installation of a secondary combustion chamber** to provide a region of combustion with turbulence and additional combustion air to ensure that the unburnt hydrocarbons from the primary chamber undergo complete combustion.

The arrestment of grit and dust is required for plant greater than 45.4 kg/hour and is normally based around banks of multicyclones. However, other abatement techniques such as bag filtration or electrostatic precipitation are available. Removal of the sub micron size of the aerosol fraction using sophisticated dust separation devices such as bag filtration units can reduce the emission by around 90% depending on maintenance regimes. However, there is little evidence that these sophisticated abatement devices have been used in UK plant probably as a result of the costs of installation and operation and the absence of a regulatory driver to require them. If the assessment referred to above demonstrates a significant air quality impact, which cannot be mitigated by reduced energy consumption, an alternative appliance or a higher chimney then developers may seek to comply by following this route.
There is research and development that has been undertaken on smaller units that have shown promising results[31][32]. One premium biomass application installed a packed bed scrubber with carbon as a dust and odour abatement device however, this led to problems with fires in the sorbent bed.

[31] Linda Johansson, Bo Leckner, Lennart Gustavsson, David Cooper, Claes Tullin, Annika Potter, Morten Berntsen, 2005, Particle emissions from residential biofuel boilers and stoves – old and modern techniques

A further source of particle emission and possible nuisance is the ash handling. Measures are required at a design and management process specification stage to ensure that this is handled adequately.

8.3.5 PAH

Complete combustion is the primary route of control for PAHs as they form during the oxidation of organic molecules containing carbon.

Emissions of pollutants from biomass units can be most effectively controlled by appropriate fuel selection for the boiler concerned.

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[32] Volker Schmatloch, 2005 Exhaust gas after treatment for small wood appliances – percent progress and field results

9 Biomass Fuels

9.1 Availability of wood and wood-based biomass

The London Biomass Study provided estimates for biomass within a 40km radius of London (Table 9.1).

Table 9.1: Total Biomass Arisings in London and within 40km from the London Biomass study[33]

		Total Arisings	Current Use				
Sector	Material	Tpa	Landfilled	Energy Recovery	Digested	Recycled / Reused	Other
Sewage	Sludge	245,584	0	78,890	54,000	112,694	0
MSW	Paper/Card	1,409,414	1,028,872	267,789	0	112,753	0
	Putrescibles	1,098,187	801,676	208,655	0	87,855	0
	Misc Combustible	318,785	232,713	60,569	0	25,503	0
	Wood	239,629	174,930	45,530	0	19,170	0
Commercial & Industrial Waste	Paper/Card	447,573	223,787	8,951	0	147,699	67,136
	Putrescibles	220,928	110,464	4,419	0	72,906	33,139
	Wood	53,529	10,165	442	0	37,816	9,972
	Used cooking oil	37,000	0	1,850	0	0	35,150
	Animal fats	53,000	0	2,650	0	0	50,350
Construction Waste	Wood	68,403	24,861	2,098	0	31,166	10,278
Aboricultural	Wood	185,340	94,523	20,387	0	70,429	0
Woodland	Wood	4,390	0	0	0	0	4,390
Farms in GL	Straw	216,816	0	0	0	216,816	0
	Vegetable/Cereal Residue	20,799	20,799	0	0	0	0
	Manure	0	0	0	0	0	0
SRC Potential in London	Willow	240	NA	NA	NA	NA	NA
SRC Potential in 40km Radius	Willow	349,800	NA	NA	NA	NA	NA
Forestry in 40km radius	Wood	126,882	0	0	0	0	126,882
Total		5,096,299	2,722,791	702,230	54,000	934,807	337,297

It can be seen that a number of sources of biomass fuel are available in and around London. The London Biomass study comments on the uncertainties surrounding the above figures. Hence, they are not examined further here. The availability of wood fuels and key issues are summarised in Table 9.2.

[33] Feasibility study into the potential for non-building integrated wind and biomass plants in London: final biomass report. (2006) – SEA/RENUE, I Bright and D Collins. Available from www.lep.org.uk

Table 9.2: Summary of wood fuel availability and suitability for energy use in London

Fuel	Resource, tonne/yr	Availability now	Suitability for use in combustion	Relative Cost	Likely actions needed to develop resource
Forest Residues	126,882	++ Needs investment in collection, storage and processing.	Suitable for combustion. WID not applicable.	High	Support FC in plans to bring under-managed woodland back into use. This will help deliver ~500,000m^3 wood fuel in South East.
Energy Crops – Short Rotation Coppice	350,000	+ There are a few plantations, with great potential for more.	Suitable for combustion. WID not applicable.	High	Planting of energy crops supported under ERDP. Good market conditions for wood fuel/energy crops in London could provide further incentive to establish more mature supply of energy crops around London. Part of this can be achieved through co-firing, but London could also support use of energy crops in heat schemes in the capital.
Arboricultural residues	185,340	+++ Available now, but some used in other applications (e.g. as mulch)	Suitable for combustion. WID not applicable but note that it must not be mixed with contaminated wood or WID will apply.	Medium	Dispersed resource. Needs separating and processing. Support more centralized collection stations with good facilities for appropriate processing.
Imported wood fuels – forestry residues and wood pellets.	Not Known- large quantities available from Baltic and North America.	++++ Available now. Competition from world trade in clean wood waste.	Suitable for combustion. Should not come under WID providing source of wood is clearly clean wood.	High	Good port infrastructure required for importing wood. Need handling, storage and transport facilities at port.
Saw mill residues.	Not known	++++ Available now, but competition from large power stations or panel board mills	Suitable for combustion. WID not applicable if wood is not treated.	Medium	Dispersed resource, but also most easily available as markets are currently available. Secure bioenergy market in London will pull this fuel in to the capital.
Commercial and Industrial waste	53,529	++ Needs reprocessing and fuel preparation.	Suitable for combustion. WID probably applicable.	Low (even negative)	- Establish potential for market for waste wood from mixed waste streams, with clear guidance on what schemes can burn waste types of wood waste. - Establish requirements regarding emission controls . - Good information and guidance directed at waste wood producers is needed to assist in the separation and recovery of this resource, including a clear understanding of what wood comes under WID and what does not. - Re-processing stations are required for separation and processing of potential waste wood fuel.
Construction and demolition waste	68,403 (figure for construction wood waste only)	++ Competition from re-use. Needs separation and processing for fuel use.	Suitable for combustion. WID likely to be applicable.	Low (unprocessed waste will be available at negative price)	
MSW	239,629	+++ Separate collection and processing required.	Suitable for combustion in WID compliant systems.	Low (unprocessed waste will be available at negative price)	- Establish potential for market for waste wood fuel from mixed waste streams, with clear guidance on what schemes can burn what types of fuels. - Establish requirements regarding emission controls. - Establish clear guidance for public on what waste wood can be recycled /recovered. - Establish waste wood collection stations, with wood processing and storage facilities, in association with waste re-processors.

9.1.1 Forestry residues

The large-scale use of forestry residues as fuels is relatively recent in the UK. This means that in many places forestry is not managed to produce wood fuel and the residues from normal forestry operations are left on the forest floor as brash. To produce more forest residue there needs to be considerable investment in infrastructure, a fact recognised in the Wood Fuel Strategy for England[34]. Infrastructure require includes roads to transport wood fuel out of forests, harvesting equipment, storage facilities which allow the wood to dry and remain dry, and equipment to chip (and pelletise) the wood. In the South East, the Forestry Commission indicates:

- There are many under managed woodlands that could benefit from improved management. The potential to develop the wood fuel market is an opportunity to bring these back into management.

- The Forestry Commission is currently working with the main players in the wood fuel sector in the South East to develop a costed action plan to help deliver ~ 500,000m^3 to the wood fuel market in the South East.

This wood fuel is not available at present although there are suppliers operating in the South East.

9.1.2 Energy crops

There are very little energy crops planted around London at present and without contracts for the fuel produced it is unlikely that more will be planted. Thus, the potentials indicated in Table 9.1 remain only a potential resource until greater demand provides a more certain market for farmers. Currently, most farmers are contracted to sell their supply to wood supply companies. These in turn are contracted to supply the major power stations. In the South East, Didcot power station has made it known that it is willing to buy energy crops. It is also highly likely that other power stations will contract for energy crops if the changes proposed in the current Renewable Obligation Consultation go through.

It will be possible to bring energy crops into the UK from abroad and this may be the route for energy crop supply to London.

9.1.3 Arboricultural residues

Table 9.1 indicates that there is a considerable arboricultural resource in and around London. This reflects the findings of previous studies. The big issue with arboricultural residues is the dispersed nature of the resource. The London Biomass Study suggests that free disposal stations for arboricultural wastes are being considered for London. This would make collection and processing of arboricultural residues easier and enable wood fuel strategies to be established for this potential fuel.

9.1.4 Waste wood

Waste wood could be extracted from a number of different sources including: saw mill waste, waste wood from commerce and industry, construction and demolition waste. The best source of this data for the UK is WRAP which has supported a series of reports on waste wood arisings and competing uses[35].

[34] A Woodfuel Strategy for England (2007), available from the Forestry Commission web site: www.forestry.gov.uk/pdf/fce-woodfuel-strategy.pdf/$FILE/fce-woodfuel-strategy.pdf
[35] See www.wrap.org.uk/

There are a number of issues that are important for waste wood:

- The composition of different streams of waste wood may be diverse both in their combustion characteristics and the pollution produced. Composition depends on the degree of treatment, preservation and coatings. The source of waste wood is important in determining its composition. The composition will determine whether or not the wood comes under the Waste Incineration Directive, as discussed above.
- There are few statistics available on waste wood and often they rely on the sampling of a relatively small sub-sample of companies. National and regional statistics can be extrapolations of these, so the figures are uncertain.
- The wood processing industry is a tough one. Many furniture businesses have closed recently as a result of competition from abroad. In addition, a lot of businesses that can use their waste wood on site to raise heat will already do so. This means that the available resource is variable.
- Probably the best potential route for collecting waste wood for energy would be the waste re-processors. It is the business of these companies to collect waste for re-processing and they are probably best placed to collect and process waste wood. However, processing costs money and requires investment in separation and processing equipment. Waste wood fuel prices will reflect this.
- The major market for waste wood at present is the panelboard mills (chipboard and related products), mainly based in the Midlands/North and Scotland. WRAP indicates that there are a number of waste wood processors and collectors in the South East, but little market for waste wood (see Figure 9.1).
- There are new initiatives to stimulate better collection of waste wood at demolition and construction sites. However, there have been previous attempts at this which have not been very successful. Demolition waste wood should be assumed to be WID material unless it can be shown otherwise. Modern construction wood waste should be traceable to show the absence of halogenated and heavy metal containing pesticides.

Table 9.3: Estimate of total wood waste arisings in the UK (WRAP)[36]

Waste stream	Total wood waste arisings, tonnes				
	England	Wales	Scotland	Northern Ireland	UK total
Municipal waste (not furniture waste)	913,000	29,000	85,000	37,000	1,065,000
Commercial and industrial	-	-	-	-	4,481,000
Construction and demolition (average of minimum and maximum estimates)	4,105,000	232,000	290,000	42,000	5,040,000
Total wood waste					**10,586,000**

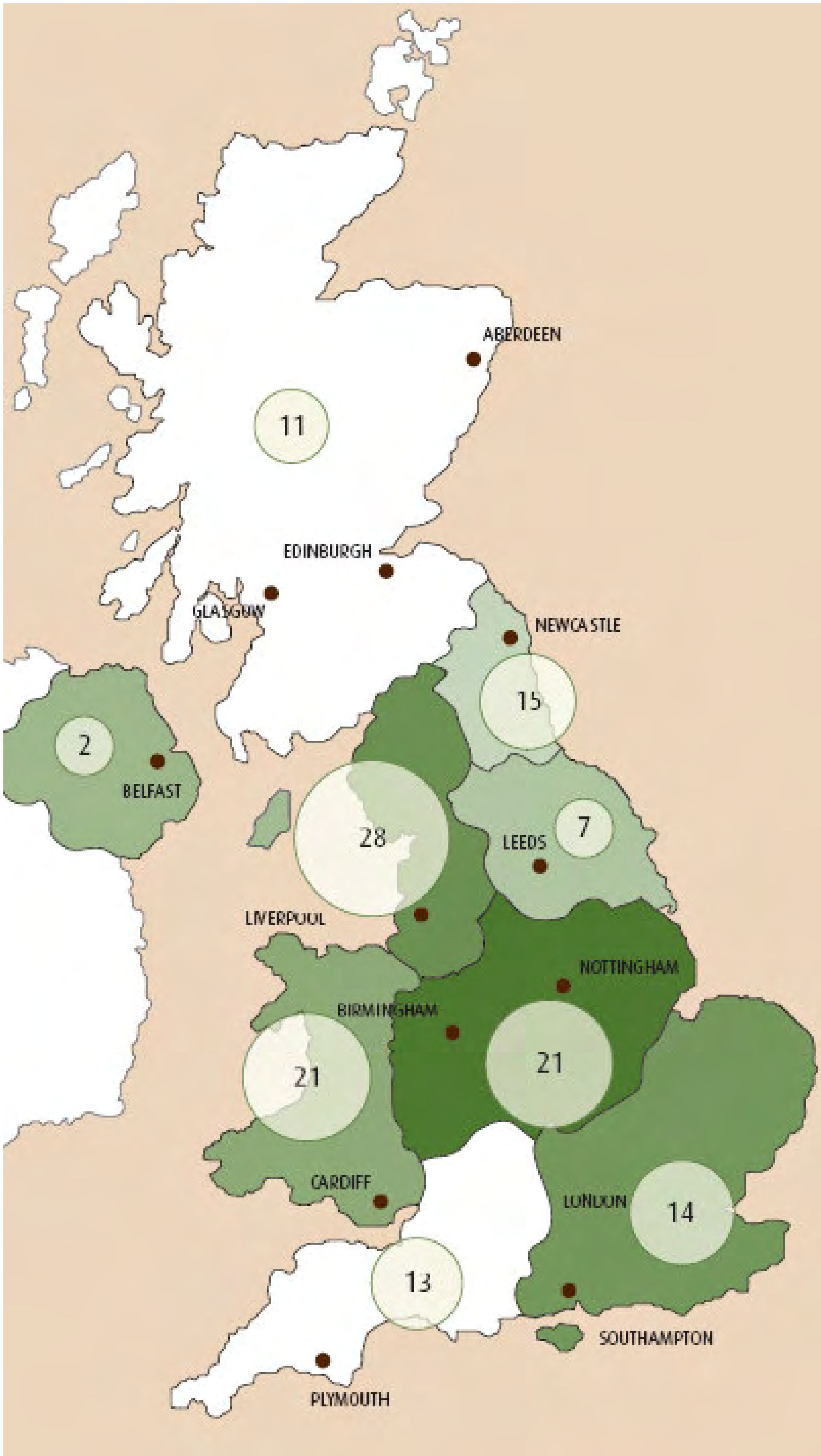
Waste wood is one of the sources of wood of greatest interest to developers of large biomass plants. In particular, the clean sawmill wastes are used in a number of biomass plants around the country. The more contaminated streams are of less interest, but a number of developers are interested in developing WID-compliant plants that would take waste wood and be eligible for ROCs. This is an ideal opportunity for London, as waste wood is produced within the region and could be used locally.

9.1.5 Imported wood residues

There is a growing trade in imported wood residues. There are large resources world wide, particularly in the Baltic States, Russia and North America. Much of this wood can be sourced from sustainable resources. The UK co-firing power stations are importing wood chips and pellets for co-firing and pellets are also imported for use in small-scale heat applications.

[36] Available from http://www.wrap.org.uk/downloads/WOO0041_Final_Report_June_20051.d2ff74d0.pdf

Figure 9.1: Distribution of wood waste collectors and processors in the UK



9.1.6 Other available biomass

There are a number of other fuels available in London that can also be used to generate energy. These are outlined in the London Biomass Study, and indicated in Table 9.1 above.

The following issues are important to these fuels:

Waste cooking oils
These could be used as fuels directly or converted to biodiesel. There is a good potential within London to use unrefined oils or converted biodiesel as a substitute fuel for heat and power. However, glycerine produced as a by-product of the biodiesel process has no immediate market and many biodiesel producers are stockpiling their glycerine in the hope that a market will materialize. The Environment Agency has indicated that the glycerine from biodiesel produced from used cooking oil is a waste and needs to be handled as such (it comes under WID, for example, when burnt). Any drive to increase bio-diesel production should also examine the situation regarding the by-products.

Food processing residues
There are major food processors in London, but little information on the potential energy resource in their waste. These waste streams have the potential for both combustion and anaerobic digestion. For example, solid wastes such as wheat milling residues and coffee grounds can be burnt whereas dairy, abattoir and fruit and vegetable waste is more suited to anaerobic digestion.

Fractions of MSW other than wood
There is a potential to generate solid recovered fuels from MSW or to use the wetter fractions in anaerobic digestion. However, the use of MSW to generate heat and power will depend on the London Waste Strategy and is not commented on here.

9.2 Wood fuel standards

There are a number of relevant standards that apply to wood fuels. Information on these is summarised in Table 9.4.

9.3 Fuel storage issues

By definition, biomass fuels are natural plant (or animal-derived) materials and are thus prone to degrade in the same way that natural materials do. However, biomass fuels have frequently been processed to improve their characteristics as a fuel and this processing increases their stability, particularly where the moisture content has been decreased.

There are three ways in which biomass fuels may degrade: microbiological, physical or chemical:

- **Microbiological degradation** is the natural process whereby microorganisms breakdown complex organic molecules ultimately to carbon dioxide and water, providing that sufficient oxygen is present (aerobic). Under reduced oxygen a complex reaction takes place forming methane and carbon dioxide. Other reaction routes can also occur resulting in chemicals such as alcohol hydrogen sulphide, ammonia and other nitrogen compounds. This may lead to other issues such as odour.
- **Physical degradation**. There are a number of physical processes that can result in deterioration of a fuel. The most important of these is mechanical break up of particles through handling and conveying, resulting in an increase in fines and dust that can create issues in the storage (increased fire hazard) and use of the fuels. Many biomass fuels are also hydroscopic – that is, they have a tendency to absorb moisture from the atmosphere. Thus, it is important to store such fuels under cover in dry conditions.
- **Chemical degradation** also affects some fuels, e.g. bio-oils, biodiesel. In this case, chemical reactions alter the composition of the fuel, making it less suitable for use.

Table 9.4: Standards for wood and solid recovered fuels

Standard	Application	Reference
Various – CEN/TC 335: Solid biomass	Technical committee developing Technical Specifications to describe all forms of biomass fuels in Europe, including wood pellets and briquettes, logs, sawdust and straw bails. Allows all relevant properties of the fuel to be described and includes both normative information that must be provided about the fuel and informative information that can be included, but is not required	Further information is available on the CEN site: www.cen.eu and technical committee work area.
Various -CEN/TC343: Solid recovered fuels	Developing technical specifications for the market for solid recovered fuels. Includes standards on terminology, fuel specifications and classes, sampling, physical and mechanical tests, chemical tests etc.	For further details see CEN site: www.cen.eu and technical committee work area.
Wood pellet standards: The Austrian standard ÖNORM M 7135 and German DIN 51731 standard Swedish SS 187120 and SS187121 standards.	Ensures high quality densified biomass pellets using natural materials only. Regulates raw material, moisture content, ash content and other factors.	There are also ÖNorm standards for transport and storage.
UK Woodland Assurance Standard and UK Forestry Standard	Addresses environmental concerns in woodland management. Adherence to the UK Forestry Standard is mandatory for felling licenses and Forestry Commission grant schemes.	UK Forestry standard: www.forestry.gov.uk/pdf/fcfc001.pdf/$file/fcfc001.pdf UK woodland assurance scheme: www.ukwas.org.uk

Large-scale power generators are aware of these issues and monitor fuel energy and moisture content as it is delivered. They do this because there are important consequences to their use of the fuel and the way it is handled. In some cases there may be health and safety issues for the fuel supplied. Provisions for these issues can be made and strict specifications can be drawn up for fuels that the suppliers must meet.

Information that is available in the open literature regarding the degradation of biomass fuels is summarised in Table 9.5 below. Useful information, particularly for small-scale users, is also available on the biomass energy centre web site: www.biomassenergycentre.org.uk and from the log pile web site: www.nef.org.uk/logpile/.

In addition to degradation, another important issue relating to storage is that of moisture for example wood or wood residues that is transported directly can have high moisture content about 50%. This can require drying of the material prior to its use.

The issue of moisture and improved storage can be achieved by producing pellets or briquettes. Wood pellets are a compacted form of wood fibre with low moisture content (<12%) and high-energy density, but are more expensive than chips or logs to produce. Briquettes are manufactured in a similar way to pellets, but are generally larger, have a low moisture content and high energy density but are susceptible to mechanical damage. It is important to keep both dry and handled carefully to minimise the generation of emissions and fines. Sawdust is either sourced from sawmills, with a moisture content of 35-50%, or from wood processing plant such as furniture manufacturers, with a much lower moisture content.

Standards and Technical Specifications for wood pellets have been summarised in Table 9.4.

It is important to keep the wood pellets, briquettes and sawdust dry, and to handle carefully to prevent mechanical damage to the pellets (i.e. break up of the structure) and hence minimise generation of fines. The pellets and briquettes must be stored under cover, preferably in an enclosed area, and should be kept away from other fuels with higher moisture contents.

It has been suggested that a silo is ideally the best way to store pellets to keep them dry and handle them appropriately[37].

Emissions of aldehydes and carbon monoxide from the storage of wood pellets have been reported[38]. This is not limited to wood pellets, but is caused by the general degradation process of wood, facilitated by drying at elevated temperatures.

A study in 2000[39] showed a low level of degradation in pellets after 5 months unheated undercover storage, and showed that pellets formed from fresh wood were more susceptible to decay than those from waste wood. In particular, the pellets from fresh wood were more hydroscopic. Microbial growth was observed on some of the stored pellets.

Waste wood includes furniture and demolition wastes, MDF, chipboard and other panel board. The waste wood will initially have a low moisture content (<20%), and in most cases will be treated to reduce degradation. If kept under cover the waste wood will have a long storage life. Storage requirements are likely to be similar to those for wood chip.

Table 9.5: Storage of wood-based biomass fuels

Fuel	Areas of concern	Likely effects of degradation	Recommendations for storage	Recommended storage times
Wood fuels				
Clean wood fuels – chips	Moisture content. Compaction in storage pile. Size distribution of chips.	Loss of dry matter. Self heating which can lead to fires. Emission of organic compounds, fungal growth.	Store as loose piles. Open air storage is possible, but permeable water shedding cover reduces rewetting.	Wet chip (50% moisture)- few days. <30% moisture, up to 2 months.
Wood pellets Briquettes	Degradation by wetting. Mechanical damage (i.e. break up of the structure of the pellet).	Loss of flow characteristics and loss of dry matter. Production of fines.	Keep dry. Minimise handling.	Up to 6 months.
Waste wood	Moisture content. Contaminants	Loss of dry matter.	As woodchips for shredded materials.	As woodchips.
Saw dust	Moisture content. Compaction in storage piles.	Loss of dry matter. Self heating.	As woodchips for high moisture sawdust. Under cover for low moisture sawdust.	As woodchips.
Agricultural crops				
Straw Miscanthus	Moisture content. Shape of bales.	Loss of dry matter. Difficulty stacking in store.	Store under cover to keep dry. Will rot if kept in the open in the rain.	Up to 1 year if kept dry.

[37] Wood pellets in Europe. A Viak et al. Thermie B DIS/2043/98-AT. Industrial network on wood pellets, January 2000.
[38] Emission of Hexanal and carbon monoxide from storage of wood pellets, a potential occupational and domestic health hazard. U R A Svedberg et al. Ann. Occup Hyg Vol 48 No 4 pp339-349, 2004.
[39] Storage effects on pelletised sawdust, logging residues and bark. P Lehtikangas. Biomass and Bioenergy 5 Vol 19, 2000.

It is likely that fuel properties will have an influence on the emissions from a unit. For example, dried pellets have a higher energy density than wood chip and so will burn better with less particle emissions. Individual appliances are designed for the fuel which they burn hence appliance manufacturers will take into account fuel properties to ensure adequate performance. Clearly, waste wood and other biomass are more susceptible to variability than virgin timber chip. It is hoped that quality standards will come into place, which will be usable, by local authorities as minimum standards to ensure the cleanliness and adequate combustion of biomass fuels.

10 Sustainability

10.1 Biomass sustainability

Biomass has the prospect of providing a sustainable energy resource, provided the necessary controls are implemented to ensure that this is achieved.[40] It also has a low carbon impact on the environment in that is a low carbon fuel. In addition, assessments of other impacts/benefits of biomass use indicate that there are frequently benefits and that many of the impacts are low and are local (e.g. noise from harvesting or fuel preparation or visual impact of conversion plant)[41]. The main exceptions to this for most biomass applications are emissions from the conversion process, that have local, region and global impacts.

For example, the implications of importing oils and other feedstocks for liquid biofuels have caused some concerns recently, particularly where virgin rain forest is being destroyed to make way for palm plantations for the purpose of producing palm oil and residues used for biodiesel production. The whole issue needs careful analysis and there have been calls for consistent sustainability criteria to be applied to all biomass energy schemes.

Life cycle analysis indicates that the fuel and conversion technology used can make a significant difference. Analysis for the Biomass Strategy indicated that there is a clear hierarchy for carbon-effective use, with heat being the most carbon-efficient use and biofuels being the least[42]. The fuel production methods can also influence how carbon efficient the fuel is – biomass crops that require high fertiliser input, or energy intensive drying and fuel preparation have lower carbon efficiency than those that are co-products of other agricultural or industrial production processes.

The EU Biomass Action Plan[43] indicates that sustainability concerns regarding biofuels production will be addressed by pan-European initiatives to ensure that minimum sustainability standards are met. The EU is also examining sustainability standards for other biomass energy use. The concern that biofuels should be produced in a sustainable manner is echoed in the Biofuels Directive[44], in which the EU again indicates that minimum sustainability criteria should be met.

These are not the only initiatives. There are a number of sustainability agreements being established[45]. For example, the Roundtable on Sustainable Palm Oil[46], which promotes the sustainable production of palm oil and the Pan-European Forestry Certificate, which is a global umbrella organisation for the assessment and mutual recognition of national forest certification schemes. In addition there are a number of green electricity labels, such as the Dutch Green Gold Label, which aims to track the biomass fuel used to sustainable sources. In the UK the certification scheme for the Renewable Transport Fuels Obligation will provide a means of certification of the sustainability of biofuels[47].

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[40] Overview of recent developments in sustainable biomass certification, Jinke van Dam, Martin Junginger, Ingmar Jurgens, Gustavo Best, Uwe Fritsche, Paper written within the frame of IEA Bioenergy Task 40.

[41] See for example, the IEA/OECD report "Benign energy? The Environmental Implications of Renewables" (1998); The Environmental implications of Renewables in the UK, DTI March 1998; the Environment Agency's Review of power production from renewable and related sources, R&D technical report P4-097/TR (2002); or "How much bioenergy can Europe produce without harming the Environment?" EEA report No 7/2006.

[42] The most controversial life cycle analyses address liquid biofuels and waste to energy. The carbon emissions of liquid biofuels vary considerably, depending on the source of the biomass, the conversion process, what happens to the co-products and sources of process heat and power. The life cycle analysis of energy from waste varies considerably, dependent on the basic assumptions that are made concerning the biogenic content of the waste, the displacement of methane emissions from landfill and the efficiency of the conversion process.

[43] Biomass Action Plan – Communication from the EC, SEC(2005) 1573. COM(2005)628 final.

[44] An EU strategy for Biofuels - Communication from the EC, SEC(2006) 142. COM(2006)34 final.

[45] Lewandowski I and Faaij A., Steps towards the development of a certification system for sustainable Bio-energy trade. – FAIR biotrade project. Available from the IEA Bioenergy Agreement Task 40, www.bioenergytrade.org/downloads.fairbiotradecertification.pdf

[46] RSPO – the round table on sustainable palm oil, see http://www.rspo.org

[47] For a review of certification world wide see: Van Dam et at "Overview of recent developments in sustainable biomass certification" written as part of the IEA bioenergy Task 40.

Typically sustainability criteria taken into account in certification schemes include:

- Greenhouse gas balance;
- Competition with food, local energy, medicines and building materials;
- Impact on biodiversity;
- Impact on economic prosperity and other socio-economic factors; and
- Environmental impact, such as use of agro-chemicals, waste management, prevention of soil erosion, effect on ground water or the quality of surface water, emissions to air etc.

Local authorities are increasingly taking sustainability into account when establishing policy for renewable energy. The London Energy Strategy includes a proposal for the London Development Agency to monitor and evaluate how carbon reductions are achieved. As part of this it is developing a set of sustainability indicators. It is clear from the Strategy that sustainability is an important criteria for London.

Taking all of this together, it is suggested that a review of sustainability criteria for biomass energy schemes and of the current status of certification schemes is undertaken. This will help define the impact of biomass schemes using local, national and global criteria such as:

- **Local impacts** of noise, odour, visual impact, transport, carbon balance compared to conventional alternatives, local emissions to all media and socio-economic benefits/impacts.
- **National impacts** of production of bioenergy crops including land use, impacts on biodiversity, water resources and quality, and on soil, transport and socio-economic impacts.
- **Global impacts** including greenhouse gas impacts, transportation, sustainability of production, including impact on local land use and socio-economic impacts.

10.2 Sustainable transport distances

Dutch studies on the import of biomass fuels to meet high targets for biomass use in the Netherlands have shown that biomass can be traded across long distances without adding excessively to the carbon burden. In a workshop held by the International Energy Agency's Biomass Trade task in 2003[48] it was indicated that the export of forest residues from the Baltic to the Netherlands (inland transport 1500km, smaller vessel size) demands 5% of the overall energy content of the biomass transported. Export of (cultivated) wood from Latin America to the Netherlands (inland transport, transfer, 10,000km, large vessel size) required 10% of the overall energy content of the biomass. Export of ethanol is more “expensive” due to the high conversion costs: currently Sweden meets its liquid biofuels targets using bioethanol imported from Brazil; and the Scandinavians also import large quantities of wood chips from Canada to burn in their district heating plant. In the UK, biomass has been transported across the country for co-firing at Slough Heat and Power.

The Biomass Energy Centre[49] provides the CO_2 emissions in biomass transport (Table 10.1) from work done for the European Environment Agency.

Table 10.1: CO_2 emissions in biomass transport

Transport method	Grammes CO_2 per tonne-km
Inland waterway	30.9
Maritime	13.9
Rail	22.8
Road	123.1
Light duty vehicle	397.4
Heavy duty vehicle	92.0

[48] Faij A., Introduction to workshop in Faaij A., Munnesma M. and Wieczorek A.J. (2003) Workshop on the International debate in international bio-energy trade, Amsterdam. www.bioenergytrade.org/downloads.2gave0306draftnovemapportbiotrade.pdf
[49] www.biomassenergycentre.or.uk

The Biomass Environmental Assessment Tool (BEAT) is a life cycle assessment software tool for biomass energy. It was developed by AEA Energy and Environment in association with North Energy Associates for the Environment Agency. Analysis with this tool indicates that increasing transport distances does not significantly increase carbon emissions.

The form of transport most commonly used for biomass is road. This is because of the dispersed and usually rural nature of the fuel and the high cost of handling to transfer the fuel to rail freight or barge. Whilst it is likely that this will be the case for small-scale and microgeneration schemes, London has some opportunity to change this for large-scale schemes. A number of the sites being considered for large scale biomass energy are directly on, or very near to, the Thames. This provides opportunity to barge biomass to the sites.

Development of sea transport links on the West Coast of Scotland also mean that forestry residues could be transported by sea from Scotland to London (although large biomass energy plants are being planned for the West of Scotland). In addition, the river links enable London to consider participating in the Baltic biomass trade, trade with Russia and through Rotterdam, which has ambitions to be a "biomass trade hub". These options could be considered alongside inland trade.

Biomass is brought into Didcot power station by rail from the port in Bristol. This is biomass imported from Canada. However, apart from some flows to board mills, this is believed to be the only biomass transported at large-scale by rail in the UK. In the past, AEA Energy & Environment has made enquiries on behalf of customers sited near to rail freight depots, but has never found rail transport to be competitive with road transport. London may be an exception. The cost of transport through the congestion charge zone[50] may make rail transport more attractive for large-scale biomass energy, especially if biomass plants are situated on brown field sites where former uses had rail freight links.

According to DTI information, it will take 2 two-way vehicle movements per MWe per day to supply a biomass power station. Smaller schemes require more infrequent deliveries. The Royal Commission on Environmental Pollution report on biomass as a renewable energy source[51] indicated vehicle movements for biomass use as summarised in Table 10.2.

Table 10.2: Deliverables required by plant size and fuel type

Plant	Truck volume (m^3)	Deliveries (/day) wood chips	Deliveries (/day) straw bales	Deliveries (/day) miscanthus bales
Large scale biomass combustion (30MWe)	120	21	28	17
Large scale biomass gasification (30MWe)	120	17	23	13
Small scale biomass combustion (5MWe)	120	5	6	4
Small scale biomass gasification (500kWe)	60	1	1	1
Industrial biomass heat (1 MWth)	60	0.5	1	0.5
Co-firing 5% biomass (25 MW)	120	16	22	13

50 £7 per day per vehicle for a fleet of 10 or more vehicles.
51 Royal Commission on Environmental Pollution report "Biomass as a renewable energy source" (2004). Available: www.rcep.org.uk

11 Conclusions

Following this investigation into the potential environmental impact of the use of biomass, the following conclusions have been drawn:

1. Given the difference in emission factors between wood fuelled biomass burners and equivalent gas burners, the widespread use of wood fuel across London to replace the use of gas for heat and power generation will have a significantly negative impact on air quality unless measures are taken to prevent this.

2. The design of the biomass appliance has a large impact on its combustion efficiency and emissions.

3. Other things being equal, large wood burning appliances emit less particulate pollution per unit of useful energy generated and are more cost effective to fit abatement equipment to.

4. The principal pollutants of concern from wood fuelled biomass use in the context of the United Kingdom's air quality objectives are particles (both PM_{10} and $PM_{2.5}$) nitrogen oxides and PAHs. Modern automatic appliances should not emit significant quantities of PAHs but data is scarce on the performance of appliances.

5. The existing regulatory structure for controlling wood fuelled biomass energy use provides limited opportunities for London Boroughs to influence the impact on air quality except through the planning regime. Consequently, the installation of appliances in existing buildings with existing chimneys will be hard to control.

6. Operators of new appliances, other than domestic boilers less than 16.12kW have a duty to notify the Local Authority of the plans of the appliance. However, few authorities are aware of this power and even fewer appliance installers or specifiers.

7. Operators of solid biomass fuelled appliances burning fuel at a rate greater than 45.4 kg/h are required to seek the approval of the Local Authority for the arrestment plant, or its absence and for approval of the chimney height to be used.

Following this investigation into the potential environmental impact of the use of wood fuelled biomass the following recommendations are made:

1 Additional modelling scenarios should be undertaken.

2 The open discussion of the air quality implications of wood fuelled biomass and the requirements in terms of emission and chimney heights to maintain acceptable air quality should reduce the number of inappropriate applications at planning and notifications under the Clean Air Act.

3 Where applications for planning are received the approach given in Chapter 7 should be followed to establish whether the proposed installation is likely to have a significant impact on air quality. For authorities that already exceed the air quality objectives this may not be appropriate. Local authorities should also use the powers available to them under the Clean Air Act (1993).

4 Where the impact on air quality of an application is found to be significant the applicant should consider initially reducing the energy demand of the development, and where this is not possible, using a lower emitting combustion appliance, then fitting appropriate emission abatement measures and finally seeking planning approval for a higher chimney.

5 Defining Best Available Technology for this sector would ensure that appliances are capable of achieving emissions that enable air quality targets to be met, or where currently not met levels to not be significantly exceeded. There is a need for research and development of abatement equipment.

6. Review the possibilities of setting emissions limits for particles and nitrogen oxides that are aligned with AQ requirements and incorporating these and a monitoring strategy into s 106 agreements with developers.
7. Consider siting larger facilities outside the London area and or combining smaller heat loads to form centralised larger units to which it is economically feasible to apply abatement equipment.
8. Management systems need to be in place to reassure Local Authorities and the community that fuel supplied to appliances is adequately specified and measures in place to stop the use of treated and waste materials unless the unit receiving them is appropriately designed.

Appendices

Appendix A

Biomass Drivers

Contents

A1. Biomass strategy

The biomass strategy proposes a more strategic approach to heat and identifies opportunities for increasing the use of renewables in energy generation. It proposes a hierarchy of use for biomass related to carbon savings, with heat at the top, then Combined Heat and Power (CHP), co-firing and dedicated biomass power plant (that is bio fuels are at the bottom) and states that incentives need to be reordered to reflect this hierarchy. Box 1 is the summary of the biomass strategy taken from the Energy White Paper.

> The strategy identifies significant potential to increase the domestic supply of biomass, through the more efficient utilisation of agricultural land, unmanaged woodland and waste. Our analysis shows a hierarchy of use in terms of cost of carbon saving, with biomass heating as the most cost efficient use for energy. The Strategy is intended to realise a major expansion in the supply and use of biomass by:
>
> - providing targeted support in key areas such as expansion of energy crops and biomass heat installations, through direct grants and other measures such as the schools building programme;
> - sourcing an additional 1 million tonnes of wood from unmanaged woodlands;
> - increasing land used for production of perennial energy crops by some 350,000 hectares;
> - increasing the utilisation of organic waste materials; and
> - stimulating technology development.

Box A1: Energy white paper biomass strategy

However, there are more relevant initiatives in the biomass strategy for London:

- Developments of biomass supply chains. These are seen as an integral part of the regional strategies for renewable energy development. It sees a central role for the Regional Development Agencies (RDAs) in the development of the partnerships needed to develop supply chains. This is an area where it is important for London to be proactive.
- Expansion of biomass supply, to deliver more biomass energy. Potential sources that need to be considered include biomass in waste, such as food waste and waste wood. London produces considerable quantities of waste; separation of biomass fractions for energy recovery as well as recycling has high potential in the region. There is also some interest in ensuring that solid recovered fuel (SRF) realises its potential as an energy source, for example by allowing non-waste biomass to be co-fired with SRF without losing its ROC eligibility. This links to initiatives in the Waste Strategy to reduce the carbon impact of waste management.
- Faster growth in the development of anaerobic digestion (AD), including examination of how and whether economic or fiscal instruments can facilitate increased use of AD.
- Local authorities will be encouraged to put in place policies to promote and encourage the development of renewable energy resources (including energy from biomass) through the planning system. The Biomass Strategy refers to the draft Planning Policy Statement on Climate Change, which makes it clear that local authorities should assess their area's potential for accommodating low carbon and renewable technologies in new residential, commercial and industrial development.
- Evaluation of biomass energy for all school buildings within the DfES Building Schools for the Future (BSF) programme. During 2007 it will become a requirement that biomass boilers are installed wherever appropriate in new school buildings and refurbishments.

- Support for the development of energy markets for waste wood and waste derived fuels through the Waste Implementation Programme.
- Support for renewable heat and cooling through a review of the business case for support for renewable heat (this is due to be made public in the near future).
- Extension of the Energy Efficiency Commitment (EEC) so that suppliers could promote micro-generation including biomass as part of their activity to meet their targets (see section on "CERT" below).
- Making all new homes zero carbon by 2016.
- Putting climate change at the heart of the planning system, by reducing the need to travel and making best use of low carbon and renewable energy. In addition there are moves to establish regional carbon targets.
- Supporting innovation, for example though lower cost fuels, more energy efficient conversion technologies (such as gasification and pyrolysis), and second generation bio fuels and bio-refineries. Much of the support for this will come through the Supergen programme; the £1bn budget allocated to the new Energy Technologies Institute over the next decade; a cross–Government Environmental Transformation fund to invest in low carbon energy, including the demonstration and deployment of low carbon technologies; and the Bio energy Capital Grant scheme. The SUPERGEN Initiative was created by the EPSRC (Engineering and Physical Sciences Research Council in the UK) to encourage the development of sustainable power generation and supply.

A2. Renewables Obligation

Renewable obligation and biomass

In the UK the main mechanism for the Government to meet its targets under the Kyoto Protocol[52] to the United Nations Framework Convention on Climate Change (UNFCCC) is the Renewable Obligation (RO)[53], which supports the generation of electricity from renewable resources. The RO is enforced by an Order (Statutory Instrument), which was introduced in April 2002 and is in place until 2027. The Order places a legal requirement on electricity suppliers to source an annually increasing proportion of electricity from certain eligible renewable energy sources. Suppliers are given Renewable Obligation Certificates (ROCs) for renewable power supplied (currently 1 ROC is awarded for each renewable MWh).

The definition of biomass is taken from the most recent revision of the Order. Note that there is currently a consultation on some aspects of the RO (see below).

Currently, electricity from mixed waste is specifically excluded from the RO, except if it is generated from advanced conversion technologies (e.g. gasification, anaerobic digestion or pyrolysis) or for conventional waste fuelled CHP plant for the electricity associated with the heat generation. In the latter case only the component of the waste that can be demonstrated to be biomass will be eligible for ROCs. In addition, the separated biomass fraction of mixed waste is eligible, providing it can be shown to comply with the requirements for the definition of biomass (i.e. 90% of the calorific value is derived from biomass) and that it is not used in combination with mixed waste.

The requirement for waste CHP generators to prove the biomass content of mixed waste used to generate such CHP is also complicated as there are no standard techniques to demonstrate this biomass content.

[52] For more information see the Kyoto Protocol at http://unfccc.int/resource/docs/convkp/kpeng.html
[53] The Renewables Obligation. For further information see the DTI web site: www.dti.gov.uk/sources/renewabels/policy/obligation/page15630.html

The proposed changes in the current RO consultation that are of relevance to biomass use in London are:

- The banding of the RO;
- The requirements for more information on biomass, particularly the sustainability of the source of biomass;
- Changes to the establishment of the biomass content of mixed waste; and
- Changes to the limits on co-firing.

Banding of the RO

The consultation on the RO proposes radical changes in the way ROCs are awarded, by switching to a "banded" obligation. The banding proposed is provided in Table A1 below. The Government has indicated that the bands will be reviewed (on current expectations) at 1 April 2013 and 1 April 2018. Any changes in bands will be announced 18 months prior to introduction. In addition it has introduced the principle of "grandfathering". This is the principle that the Government does not change the band for a plant after the plant has been developed. The Government indicates that it will consult independent advice and will take into account (among other things) wider strategic issues such as sustainability, carbon emission reduction, cost effectiveness and the Government strategies for waste management and biomass in setting the bands for the RO in the future. This stresses the importance to the Government of waste management and biomass and recognition of their links.

Table A1: **Proposed banding in the current Renewables Obligation Consultation (May 2007, see:** www.dti.gov.uk/files/file39497.pdf)

Band	Technologies	Level of support ROCs/MWh
Established	Sewage gas; landfill gas; co-firing of non-energy crop (regular) biomass	0.25
Reference	Onshore wind; hydro-electric; co-firing of energy crops; EfW with combined heat and power; other not specified	1.0
Post-demonstration	Offshore wind; dedicated regular biomass	1.5
Emerging technologies	Wave; tidal stream; advanced conversion technologies (anaerobic digestion, gasification and pyrolysis); dedicated biomass burning energy crops (with or without CHP), dedicated regular biomass with CHP; solar photovoltaics; geothermal	2.0

Reporting information on biomass use

The consultation also proposes asking all users of biomass for a range of information that captures the benefits of using existing schemes. These reporting requirements should cover all those claiming ROCs on biomass, whether CHP, co-firing or dedicated power stations. The consultation states that in recognition of the different biomass volumes used and relative sustainability impact, it is proposed that a threshold on sustainability reporting is introduced, but there is no indication of what this threshold should be. In addition there are proposals to ask biomass power generators to provide Ofgem with an annual report containing the following information:

- Biomass used, origin and volumes;
- Whether it is a waste/residue or co-product or energy crop;
- Whether it has been sourced under any quality standards (sustainability in particular, RTFO, RSPO, IPPC on land use[54]);
- What land use has been from 2005; and
- Whether producers/generators are under any voluntary code of conduct.

[54] RTFO: renewable transport fuels obligation, in which certification is proposed; RSPO – the round table on sustainable palm oil, see http://www.rspo.org ; IPPC – the principle of examining the health impacts of land use development.

Should operators fail to provide this information, Ofgem will have the power to freeze the issue of those ROCs they are due until such time as they comply. The sustainability criteria are not clear, but it is likely that life cycle analysis of carbon emissions will be considered.

Changes to the establishment of the biomass content of mixed waste

The consultation recognises the cost of establishing the biomass content of mixed waste and the issues this introduces for Energy from Waste (EfW) CHP plants attempting to claim ROCs for power generated but having to prove their biomass content. There are proposals that mixed waste should be "deemed" to have a fossil fuel content of 65%, which should imply a biomass content of 35%. However, it is not certain exactly how this would work:

1. If the government becomes aware that the biomass content is lower, then the deemed fossil fuel content may change. It is not clear what circumstances would trigger this.
2. If the plant operators can demonstrate that the biomass content is higher to Ofgem's satisfaction then the higher level can be claimed. It is not clear what evidence would be required by Ofgem.
3. It is not clear whether or not Ofgem will accept the 35% biomass content (this refers to the biomass contribution to the calorific value of the waste). It is not clear whether or not Ofgem will require evidence of the biomass content and if so, what evidence would be required (would this evidence be related to the treatment of the mixed waste and the level of recycling or to the proof of biomass content?).

Removal of caps for co-firing

Currently there are restrictions on how much co-firing (of biomass with fossil fuels) is eligible for ROCs and the time-scale of eligibility (currently co-firing ceases to be eligible in 2016). The changes proposed mean that these caps are lifted. The main relevance of this to London is that it means that the co-firing power stations will continue to compete for biomass fuels and for energy crops in particular until 2027, unless there is a further change in the RO (which is quite possible). Although the ROCs awarded to co-firing are lower than for other power generation plants, the capital cost of co-firing is also lower, so it is likely that the power stations will remain important players/competitors in the biomass market for the duration of the RO.

A3. Climate Change Legislation

Climate change legislation has been introduced into the UK and EU in order to combat climate change and to meet the EU's green house gas reduction targets under the Kyoto protocol. There are two climate change schemes in the UK: The European Emissions trading scheme (EU-ETS) and the Climate Change levy. These are described below.

The **European Emissions Trading Scheme (EU ETS)**[55] was introduced on 1st January 2005 and is one of the key European Union policy on climate change. The scheme is based on the fundamental premise that creating a price for carbon through the establishment of a liquid market for emission reductions offers the most cost-effective way for EU Member States to meet their Kyoto obligations. The EU ETS is established in phases, the first phase of which runs from 2005-2007. The second phase will be implemented from 2008-2012. Phase 1 only covers carbon dioxide but other greenhouse gases or activities could be covered if Member States choose to do so, or if the EU ETS Directive is amended at a later stage.

[55] See http://www.defra.gov.uk/environment/climatechange/trading/eu/index.htm for UK Government guidance, and http://ec.europa.eu/environment/climat/emission.htm for the legislation and EU guidance ("EU Action against climate change: EU Emissions trading – an open scheme promoting global innovation" (EC, 2005)).

In essence the EU ETS is based on six principles:

- It is a 'cap-and-trade' system;
- Its initial focus is on CO_2 from combustion installations[56] >20MW_{th} and specific industrial processes;
- Implementation is taking place in phases, with periodic reviews and opportunities for expansion to other gases and sectors;
- Allocation plans for emission allowances are decided periodically; and
- It includes a strong compliance framework.

The market is pan-EU but taps global emission reduction opportunities through the use of the Clean Development Mechanism and Joint Implementation, and provides for links with compatible national schemes.

The scheme operates through the allocation and trade of greenhouse gas emissions allowances throughout the EU – one allowance represents one tonne of carbon dioxide equivalent. A cap on the total amount of emissions allowed from all the installations covered is set by each Member State. The allowances are then distributed within Member States to the qualifying installations.

Currently, large energy activities and pulp and paper industries are among the activities covered by EU ETS. All installations carrying out activities in these areas are required to hold a GHG emissions permit, which will require the installations to monitor and report emissions in accordance with a plan that has been approved by the Regulator[57]. Installations with total combustion plant capacity >20 MW_{th} include a number of non-industrial sites such as hospitals, education establishments and commercial and administrative buildings with significant heat, CHP and standby power provision. Emissions are required to stay within the installation cap or the site will need to trade carbon allowances. Biomass or waste boilers are included towards the total site limit. Therefore an operator cannot reduce the site's generating capacity under EU ETS by substituting biomass or waste fuelled plant for fossil fuel plant. However, CO_2 emissions from biomass are rated as zero under EU ETS, which means that any carbon emissions resulting from the biomass will not count towards the site's emissions. This may help a site meet its limit for GHG emissions and be able to trade any surplus. In addition the biomass content of waste is also zero-rated. For high biomass wastes or residues this is a considerable advantage, provided the biomass content can be easily demonstrated.

The Government has made it clear that it wants to strengthen the EU ETS and, along with the EU, would like to see it form the basis of a global trading scheme. The net result of this is that the cost of carbon will rise over the next year as the EU ETS phase II begins and it will probably continue to rise. It is unlikely that the cost of carbon will be as low as it has been over the past year again. Development of Phase III is under consideration and new policies, such as the auctioning of allowances, are being considered[58]. This will put further pressure on carbon prices.

The Climate Change Levy (CCL) is a levy on non-domestic energy supply in the UK[59]. It came into operation on 1st April 2001. Accreditation is carried out via Ofgem. Under the CCL non-domestic electricity customers are required to pay the levy as follows[60]:

- 0.44p/kWh for electricity;
- 0.15p/kWh for gas;
- 1.2p/kg (equivalent to 0.15p/kWh) for coal; and
- 0.98p/kg (equivalent to 0.07p/kWh) for liquefied petroleum gas (LPG).

[56] Note that installation can cover multiple combustion units on a site and there is no minimum size for inclusion into an installation.
[57] This is the Environment Agency for England.
[58] In addition the EU is considering ways to bringing aviation (and, perhaps, shipping) into the scheme, which could be of relevance to London.
[59] Information on the Climate Change Levy (CCL) may be obtained from www.defra.gov.uk/environment/ccl/intro.htm#Introduction and http://customs.hmrc.gov.uk/ . In addition the Environment Agency's www.natregs.gov.uk/natregs provides a summary of the CCL.
[60] These are the rates for 2007. They increase in line with inflation each year.

The CCL does not apply to fuels used by domestic users or the transport sector or fuels used for the generation of other forms of energy (e.g. electricity generation) or for non-energy generation (e.g. the use of "fuels" as carbon sources for other purposes, such as a reductant in metal smelting). In addition there are various ways that the cost of the levy can be reduced. For example, there is an 80% discount from the CCL for sectors that agree to targets for improving their energy efficiency or reducing carbon emissions by specified deadlines ("climate change agreements" (CCA)). There are ten major energy intensive sectors (aluminium, cement, ceramics, chemicals, food & drink, foundries, glass, non-ferrous metals, paper, and steel) and over thirty smaller sectors. Defra has responsibility for the climate change agreements with these sectors. Agreements have been negotiated with the relevant sector trade associations on behalf of the companies within the sectors concerned.

There are various other exemptions (including good quality CHP) but that most relevant here is that electricity from renewable sources (including biomass) is exempted from the CCL. To qualify suppliers of renewable electricity must obtain Renewables Levy Exemption Certificates ("Renewable LECs"). These are issued in respect of eligible renewable output and are used to prove that the electricity supplied is from renewable sources. 1 MWh of renewable power is equal to 1 LEC. If this supply is then made to a non-domestic customer it will not attract CCL payments. Box 2 provides the rules for levy exemption for biomass fuels.

LECS for waste fuelled generating stations

The regulations allow for LECs to be granted for 50% of the electricity from power stations fuelled by waste. If the operator considers that the proportion of renewable energy content of the waste is higher than 50% and he can provide sufficient evidence to Ofgem then more than 50% may be claimed.

LECs for Biomass power generation

To claim LECs the biomass power station operators must provide the following information to Ofgem:

- The proposed % of biomass;
- Full details of the biomass content showing proportions of each category by weight;
- The CV (MJ/kg) of each category of feedstock, giving details of how this was obtained;
- A description of facilities for storing biomass; and
- Details of the supplier(s) of biomass, including names and addresses and a copy of extracts of contracts that detail the biomass content and contract duration.

Box 2: Rules for Levy Exemption for waste and biomass under the CCL

The Carbon Emission Reduction Target (CERT)

This is the Government's policy to encourage energy suppliers to promote micro-generation, including biomass as part of their activity to meet their targets. The statutory consultation for EEC 2008-11 (in which EEC is renamed "CERT") has commenced[61]. The proposed commitment includes measures for increasing the amount of heat produced by any plant that relies mainly on biomass, where the capacity does not exceed 3 MW_{th}. In addition, microgeneration, with a maximum capacity of 50kW, is also under consideration for inclusion. These changes are intended to allow the promotion of community schemes for which the source of energy is biomass. The focus is on low-income customers via a priority group obligation.

The Climate Change and Sustainable Energy Act 2006

The act provides for revision of building regulations in relation to microgeneration and allows summary proceedings for breach of building regulations relating to conservation of fuel and power (that is the provisions in what is currently part L of the building regulations). These provisions concern energy efficiency in new buildings and will be revised every five years or so to lead to incremental increases in energy standards of new and refurbished buildings. The 2006 revisions encourage renewable and low carbon technologies, such as micro CHP in new buildings[62].

61 www.defra.gov.uk/corporate/consult/cert2008-11/index.htm
62 For further information see the Energy Savings Trust web site: www.energysavingtrust.org.uk

The Directive on the promotion of cogeneration, EC/2004/8[63]

The Cogeneration Directive creates a framework for the development of high efficiency cogeneration (CHP), which may give primary energy savings compared to the separate generation of heat and electricity. The Directive sets criteria to define high efficiency cogeneration and makes provision for public support and to ensure fair access to markets for electricity from cogeneration[64]. Countries are required to analyse national potentials and report on progress. More information is available from the Office of Public Sector Information (OPSI) web site[65].

Other relevant legislation

There are other policies that also affect the use of biomass. These are described briefly below.

The **Animal By-Products Order and Regulations 2003** (EC1774/2002)[66] resulted from the BSE and foot and mouth crisis in the UK and, in principle outlines the permitted methods for the collection, treatment and animal by-products and catering wastes, bringing many waste food products from food manufacturers and retailers into the order. The main change was to re-classify some materials as animal by-products that had previously been classified as catering wastes. These wastes could then no longer be sent to any landfill, but have to be managed by approved treatment and disposal routes. Composting, for example, is an approved treatment process, but is not a permitted disposal route for any material that has possibly been contaminated by meat products. The regulations also place restrictions on the use of compost material (that has been produced by material which has or may have contained meat products) on land where animals (including wild birds) may have access.

The Regulations divide animal by-products into three risk categories and specifies the permitted treatment or disposal routes for each category of material and the standards of operation of the permitted outlets. Category 1 represents the highest level of risk and category 3 the lowest. Category 1 wastes must be treated by incineration under specified conditions. Category 2 and 3 wastes can be treated and disposed of by a number of methods, including approved anaerobic digestion (AD) and composting plants. This legislation has lead food retailers to consider AD as a treatment option. However, at present the process is not economic for individual plants. There remains an opportunity to rationalize this situation on a London-wide or regional basis. This option fits well with the strategy to increase AD of food wastes outlined in the London Energy Plan.

The **Urban Waste Water Directive**[67] covers the standards of sewage treatment and disposal. This legislation:

- Set standards for sewage treatment;
- Set out requirements for the treatment of biodegradable waste water from industry;
- Set out requirement for improvement in the collection and treatment of wastewater, with specific requirements to provide secondary treatment; and
- Banned the disposal of sludge at sea from 1998.

As a result of this Directive UK wastewater treatment has changed significantly. The amount of sewage sludge produced due to increased sewage treatment increased by at least 50% in the 1990s. The ban on disposal of sewage sludge at sea resulted in a change in disposal methods. In 2003 52% of sludge was disposed to land, 27% of it was incinerated and 17% was landfilled. The remainder went to other outlets such as land reclamation. In addition standards for disposal to land are increasing. There are new revised Sludge (Use In Agriculture) 2005 Regulations. These have been designed to protect the environment and human and animal health where sewage sludge is used on agricultural land. There are strict requirements for analysis prior to disposal to land and it is not possible to spread sludge on some crops and in some sensitive areas. These regulations also increase the standards of treatment more and demand improved pathogen kill. In addition, pressure from public opinion and members of the British Retail Consortium (BRC) have resulted in the need for

[63] See www.Europaeu.int

[64] For example by guaranteeing electricity from co-generation would be transmitted and distributed on a basis of objective, transparent and non-discriminatory criteria and by ensuring that guarantees of origin of electricity from co-generation could be issued on request by a competent body (in the UK this is Ofgem).

[65] www.opsi.gov.uk/SI/em2006/uksiem_20060170_en.pdf

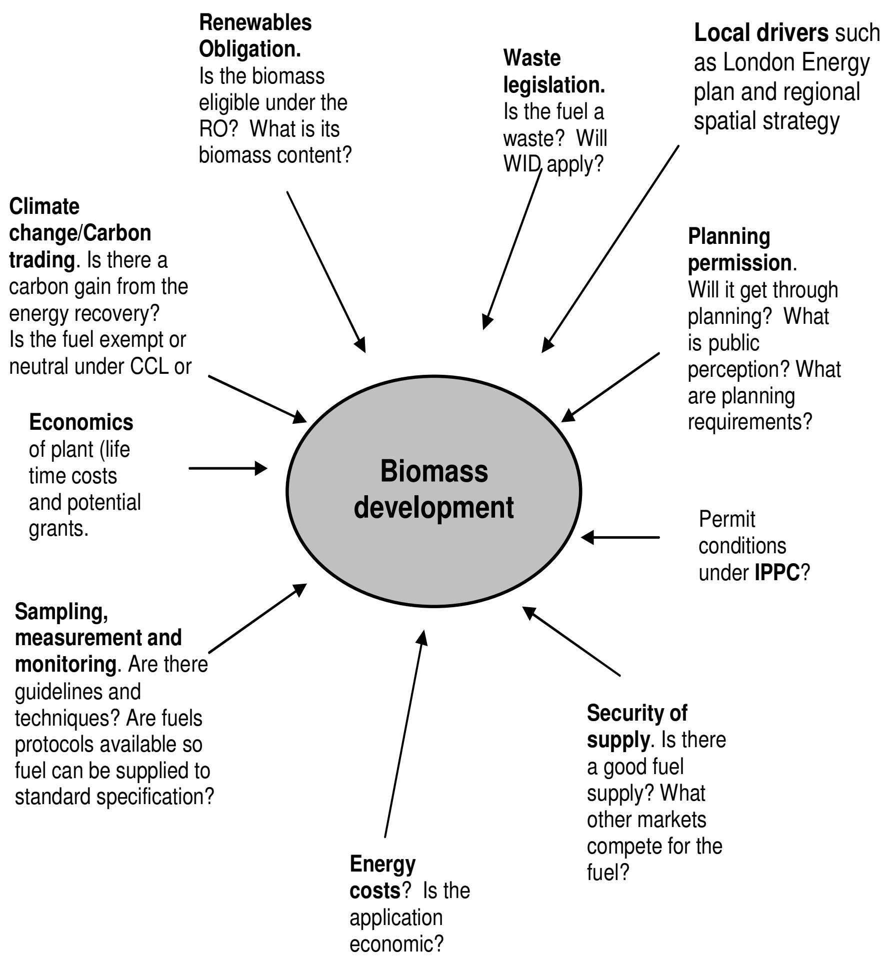
[66] Animal By-products Order and Regulations (2003) (Ec1774/2002) http://www.opsi.gov.uk/si/si2003/20031482.htm

[67] The Urban Waste Water Directive 91/271/EC SI 1884 No 2841

wastewater companies to implement effective and efficient sludge management strategies which take into account the risk of the sludge to agriculture disposal route being reduced or potentially removed in the future. The BRC has worked with ADAS and the Water UK to produce the Safe Sludge Matrix[68] for the application of sewage sludge to land.

This legislation has, in effect, increased anaerobic digestion of sewage sludge and the production of sewage sludge, particularly in urban areas such as London. Together with the safe sludge matrix, it has restricted the outlets for sewage sludge disposal and increased the amount of sewage sludge incineration in urban areas. These are trends that are likely to continue and, as a result, the water companies are also investigating alternatives, such as co-incineration of sewage sludge with MSW or other wastes (including agricultural wastes). London has been affected by these changes, in that it now has two major incineration plants for sewage sludge at Beckton and Crossness and a number of large AD plant. According to the London Wind and Biomass study there is some potential for increasing the biodegradable materials at the Mogden and Beddington AD plants and for developing addition AD capacity at other sewage treatment sites, which, together could treat an additional 600,000 t of biodegradable materials. However, the disposal of sludge from these plants must be considered in any plans to increase their load.

Figure A1: **Considerations for developers for biomass plants**



[68] For more information see the ADAS web site: www.adas.co.uk/media_files/Publications/SSM.pdf

Table A1: Definition of biomass within relevant legislation

Legislation	Biomass Definition	Comments
The Renewables Obligation (RO) Order 2006 (see note 1).	"Fuels used in a generating station of which at least 90%of the energy content (measured over a period of such a period and with such frequency as the Authority deems appropriate) is derived from plant or animal material or substances derived directly or indirectly from (whether or not such matter or substances are waste) and includes agricultural, forestry or **wood wastes** or residues, sewage and energy crops (provided that such plant or animal matter is not or is not derived directly or indirectly from fossil fuel)". • If contamination with fossil fuel derived material exceeds 10% the input cannot be classified as biomass. • Waste derived fuels can be classed as biomass under the RO, providing they can be shown to be 90% biomass and they are not back mixed with waste. However, mixed wastes are not included as a biomass if the fuel taken as a whole is not biomass as defined above. • Energy crops are defined as a plant crop planted after 31st December 1989 and grown primarily for the purpose of being used as fuel or which is one of the following: Miscanthus giganteus; salix (short rotation coppice willow) or populus (short rotation coppice poplar). See: www.dti.gov.uk/files/file34450.pdf	Ofgem must be satisfied that the fuel complies with the requirements of the Obligation. Thus there must be evidence of the fuel's biomass content. Electricity generated from biomass that comes within this definition is eligible for ROCs.
The Waste Incineration Directive (WID) 2000/76/EC (see note 2)	Biomass is defined by the WIDas: "products consisting of any whole or part of a vegetable matter from agriculture or forestry, which can be used for the purpose of recovering its energy content as well as wastes listed below: i. vegetable waste from agriculture and forestry; ii. vegetable waste from the food processing industry, if the heat generated is recovered; iii. 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 the heat generated is recovered; iv. 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 originating from construction and demolition waste; and v. cork waste.	Guidance is available from Defra: www.defra.gov.uk/environment/ppc/envagency/pubs/pdf/wid-guidance-edition3.pdf
European Emissions Trading Scheme (EU ETS) 2003/87/EC (see note 3)	'Biomass' means non-fossilised and biodegradable organic material originating from plants, animals and microorganisms. This shall also include products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilised and biodegradable organic fractions of industrial and municipal wastes. Biomass also includes gases and liquids recovered from the decomposition of non-fossilised and biodegradable organic material. When burned for energy purposes biomass is referred to as biomass fuel. http://eur-lex.europa.eu/pri/en/oj/dat/2004/l_059/l_05920040226en00010074.pdf	Energy from biomass fuels is regarded as carbon neutral for the purposes of carbon emissions (i.e. CO_2 emissions from biomass boilers are rated as zero under EU ETS).
The Climate Change Levy (see note 4)	"Renewable source electricity" is exempt from the levy, and was originally defined by the Climate Change Levy (General) Regulations 2001 No.838. However, this has been subject to a number of amendments via subsequent statutory instruments. The regulations do not contain a specific list of energy sources qualifying as "renewable" in this context, but HM Revenue and Customs have published a list in their Notice CCL1/4, which is their interpretation of SI 2001 No.838. The published list is now out of date since CCL1/4 has not been updated to take account of later statutory instruments. See: HMRC Reference: Notice CCL1/4 http://customs.hmrc.gov.uk	The CCL also has an exemption for wastes (municipal and industrial wastes), with the presumption that only 50% of the energy output is deemed renewable (i.e. not more than 50% of the energy content of the waste is derived from fossil fuel).

Notes:
1. Proposed amendments are outlined in the current consultation: Reform of the Renewables Obligation May 2007, see: www.dti.gov.uk/files/file39497.pdf
2. The Waste Incineration Directive 2000/76/EC on the incineration of waste, http://europa.eu.int/comm/environment/wasteinc/newdir/2000-76_en.pdf
3. Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_275/l_27520031025en00320046.pdf . See also: www.defra.gov.uk/environment/climatechange/trading/eu/index.htm
4. The Climate Change levy and renewables exemptions http://www.defra.gov.uk/environment/ccl/intro.htm

Appendix B

PPC/IPPC Guidance

Contents

PPC Technical Guidance Notes

Defra publishes guidance on LA-PPC (Part B) and LA-IPPC (Part A2) activities; the Environment Agency publishes guidance on the Best Available Techniques (BAT) for A1 activities. The aim of the Guidance is to provide Operators and officers of the Regulator with advice on indicative standards of operation and environmental performance, relevant to the industrial sector concerned. It also aims (through linkage with the Permit Application Form templates) to provide a clear structure and methodology for Operators to follow to demonstrate they have addressed adequately all aspects of the PPC Regulations and relevant aspects of other environmental Regulations.

The ones of interest to the biomass combustion sector are:

1. IPPC Sector Guidance Note Combustion Activities: http://www.environment-agency.gov.uk/commondata/103599/consultation_final_1019680.doc

2. PPC: UK Technical Guidance: S5.01: Guidance for the Incineration of Waste and Fuel Manufactured from or including Waste http://www.environment-agency.gov.uk/commondata/acrobat/incin_bat_guidance_854788.pdf

3. Secretary of State's Guidance for Combustion of Fuel Manufactured From or Comprised of Solid Waste in Appliances Between 0.4 and 3MW Rated Thermal Input www.defra.gov.uk/environment/ppc/localauth/pubs/guidance/pgnotes/pdf/pg1-12.pdf

4. Secretary of State's Guidance for Combustion in boilers of 20-50MW thermal input www.defra.gov.uk/environment/ppc/localauth/pubs/guidance/pgnotes/pdf/pg1-1.pdf

5. PPC : UK Technical Guidance : H1 Horizontal Guidance Note : Assessment & Appraisal of BAT http://www.sepa.org.uk/pdf/ppc/uktech/ippc_h1.pdf The purpose of the IPPC Horizontal Guidance Note for Environmental Assessment and Appraisal of BAT is to provide a methodology to assist Applicants in responding to the requirements described above and in the IPPC Sector and General Guidance Notes. This Note provides:
    - methods for quantifying environmental impacts to all media;
    - a method for calculating costs of environmental protection techniques; and
    - guidelines on resolving cross media conflicts and making cost / benefit judgements.

6. PPC : UK Technical Guidance : H2 Horizontal Guidance Note : Energy Efficiency http://www.sepa.org.uk/pdf/ppc/uktech/ippc_h2.pdf

    The purpose of this IPPC Horizontal Guidance Note for Energy Efficiency is to provide supplementary information, relevant to all sectors, to assist applicants in responding to the energy efficiency requirements described in the IPPC Sector Guidance Notes. In particular, this note provides:

    - Further amplification of the interface between the regulatory requirements of IPPC and climate change or trading agreements, noting that continuing effort will be made to ensure that as far as possible the two regimes are complementary, for example for reporting of energy information;
    - Descriptions of the basic principles of energy efficiency and energy efficiency techniques;
    - Information on the requirements of cost-benefits appraisals for energy efficiency options using discounted cash flow techniques, appropriate discount rates and project lifetimes;
    - A cost benefit benchmark in terms of £/tonne of CO_2, the value of which will be confirmed in the light of information arising from the Government's Climate Change Agreements and Emissions Trading mechanisms; and
    - Conversion factors for assessing the environmental impact of the energy consumption.

Key Requirements

The technical guidance provides information on BAT including on:

- material storage and handling;
- process control and combustion requirements;
- flue gas pollution control techniques; and
- summary tables of achievable emissions.

IPPC BAT reference documents (BREFs)

Best available techniques reference documents (BREFs) are the product of the information exchange on “Best Available Techniques” (BAT), organised by the European Commission under Article 16.2 of the IPPC Directive. This information exchange is coordinated by the European IPPC Bureau (EIPPCB).

The UK guidance documents on IPPC activities take account of information from the relevant BREF documents. Most BREFs cover individual industrial sectors (for example large combustion plants, waste incineration), with other “horizontal” BREFs covering cross-sectoral subjects.

The European IPPC Bureau web site contains information about the IPPC Directive, BREFs and their production: http://eippcb.jrc.es. Available BREFs and draft documents can be downloaded at this site.