

Biomass and air quality

Reports and studies

Introduction

With both the current increasing deployment of biomass heating systems around the UK and projected massive increase featuring in scenarios presented in documents such as the UK Renewable Energy Strategy, concern has been raised as to the effect this is likely to have on local air quality, particularly in urban areas.

There is no doubt that while natural gas is a very clean burning fuel, giving rise to very low levels of particulate emissions, other fuels, such as oil, coal and wood give higher levels of particulate emissions per MWh of heat delivered, and usually higher levels of NO_x emissions also. Many environmental health officers in local authorities in urban areas, especially cities, are already struggling to achieve mandatory targets for PM₁₀ and NO_x levels, principally as a result of high levels of road traffic, and they are naturally very reluctant to permit the installation of equipment that is likely to give rise to increase in those levels, however small.

It is vital that in attempting to address the issue of anthropogenic climate change we do not inadvertently cause unwanted side effects of a negative impact on local air quality in our cities. However, although burning biomass (and many other) fuels gives rise to higher emissions of particulates and NO_x the quality and efficiency of many modern appliances is extremely high, and the absolute emission levels are now extremely low. In addition, while boiler designers are working to decrease emission levels in the flue, a range of technologies are being developed, including very high efficiency particulate filters, to provide end of flue abatement.

This report gives a review of reports, studies and other documents relating to biomass combustion and air quality in the UK and around the world in an attempt to get a snapshot of current understanding and research, and some of the key areas of development and centres of research.

UK: England

Title	Review of the Potential Impact on Air Quality from Increased Wood Fuelled Biomass Use in London
Author(s)	AEA E&E for London Councils
Date Published	Dec 2007
<p>The original report on modelling performed on behalf of the London Councils to look at the potential impact on air quality of increased biomass usage in London. Now viewed as very much a first attempt, this study used the unrealistic biomass deployment projection of the London Energy Plan and the emissions factors of the Corinair Handbook which do not represent best practice, or even particularly good performance. This study achieved its own aim of demonstrating that if biomass were deployed across London with no regard for emissions performance or sensible deployment, then the effect could be an (unacceptable) increase in PM and NO_x. Unfortunately it did not also model the effect of deployment of BAT, low emission equipment, and the only reference to the very major reductions achievable from modern abatement equipment was in the footnote to one table. It therefore failed to demonstrate the potential impact of good regulation and planning control in ensuring the effective deployment of biomass technology while ensuring minimal impact to local air quality. This was, however, addressed in a later study by the same group</p> <p>www.londoncouncils.gov.uk/London%20Councils/LondonbiomassreportIssue33010%5B1%5D.pdf</p>	

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Title	Technical Guidance: Screening assessment for biomass boilers
Author(s)	AEA E&E for DEFRA
Date Published	July 2008
<p>Part of a suite of guidance to assist local authorities in assessing applications for biomass boilers, provided by AEA. This guidance presents methods for assessing the local air quality impact of both individual and multiple installations in order to determine whether there is a risk of exceeding the objectives of the Air Quality Strategy, which are also set out within the document. This is intended as an initial screening in order to suggest where a more detailed assessment may be required.</p> <p>www.airquality.co.uk/reports/cat18/0806261519_methods.pdf</p>	

Title	LAQM Tool v1.02
Author(s)	AEA E&E for DEFRA
Date Published	Dec 2008
<p>Another part of the suite of guidance provided for local authorities in assessing the potential impact of biomass boilers, provided by AEA. This is a spreadsheet based tool that performs the calculations behind the graphs in the DEFRA Local air quality management Technical Guidance (LAQM.TG). It covers the range of boilers from 50 kW to 20 MW and provides a tool to assess whether, for a given set of parameters, including stack height and diameter, height of neighbouring buildings and background concentrations, whether limits will be exceeded.</p> <p>www.airquality.co.uk/laqm/tools/biomass_calculator_tool6.xls</p>	

Title	Biomass for London: Wood fuel guide
Author(s)	London Energy Partnership
Date Published	Jan 2009
<p>A general report addressing many aspects of using biomass in London. Chapter 6 covers "Meeting legislation and planning requirements", addressing visible and actual emissions, and the Clean Air Act, Local Air Quality Management (LAQM), etc.</p> <p>www.lep.org.uk/files/?ref=X925N6FY-209</p>	

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Title	Local air quality management Technical guidance LAQM.TG(09)
Author(s)	DEFRA
Date Published	Feb 2009
<p>Part IV of the Environment Act 1995. Covers a wide range of potential impacts on local air quality, including biomass combustion and provides information on tools and supporting information available, monitoring techniques and procedures. In particular it covers Review and Assessment of emissions of PM₁₀ and NO₂ and provides graphs to assist in the calculation of effective stack height required for effective dispersion. The function of these graphs can also be performed by the AEA LAQM spreadsheet tool (above).</p> <p>www.defra.gov.uk/environment/quality/air/airquality/local/guidance/documents/tech-guidance-laqm-tg-09.pdf</p>	

Title	FAQ on solid fuel burning April 2009 v5
Author(s)	University of the West of England
Date Published	April 2009
<p>Sets out to answer the single question: "How can I identify areas in my district where burning of solid fuels such as coal, smokeless fuel or wood (i.e. biomass) might be leading to exceedences of the 2004 daily mean PM₁₀ air quality objective (and the 2010 annual mean objective in Scotland)?"</p> <p>www.uwe.ac.uk/aqm/review/mfaqfiles/FAQ%20on%20solid%20fuel%20burning%20April%202009%20v5%20final.pdf</p>	

Title	Biomass and air quality guidance for local authorities
Author(s)	Environmental Protection UK, LACoRS
Date Published	June 2009
<p>One of a pair of detailed documents to address in detail the issues associated with the use of biomass and local air quality. This provides detailed guidance for local authorities on all aspects of the potential air quality implications of applications to install biomass heating and CHP equipment. It sets out the policy context in regard to biomass energy and also in regard to air quality. It lists the EN standards potentially applicable to biomass equipment, and also other standards applied around Europe. It then sets out the various regulatory regimes that might apply, and the approvals and consent processes that apply, including EP (Environmental Permitting, including PPC (Pollution Prevention and Control) and LA-PPC), CAA (Clean Air Act), WID (Waste Incineration Directive) and LCPD (Large Combustion Plant Directive). It then discusses the assessment of potential impacts from a proposed project, and how these can be mitigated.</p> <p>www.environmental-protection.org.uk/biomass/ www.environmental-protection.org.uk/assets/library/documents/Biomass_and_Air_Quality_Guidance.pdf</p>	

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Title	Biomass and air quality information for developers
Author(s)	Environmental Protection UK, LACoRS
Date Published	June 2009
<p>A companion document to the above, providing the information to allow project developers considering the installation of biomass equipment to understand the potential impact on local air quality and their responsibilities for providing the information necessary to allow local authorities to assess the likely impact. It provides a list of the information likely to be required, why it is needed, and where to obtain it.</p> <p>www.environmental-protection.org.uk/assets/library/documents/Biomass_Developers_Leaflet.pdf</p>	

Title	Renewable Energy Strategy
Author(s)	DECC
Date Published	July 2009
<p>As part of the RES the potential impacts of different measures were considered. Detailed modelling of the potential air quality impacts of the projected use of biomass in the UK was undertaken by AEA, and recommendations made for performance standards and deployment to minimise impacts.</p> <p>www.decc.gov.uk/Media/viewfile.ashx?FilePath=What%20we%20do\UK%20energy%20supply\Energy%20mix\Renewable%20Energy\Renewable%20Energy%20Strategy\1_20090717120647_e_@@_TheUKRenewableEnergyStrategy2009.pdf&filetype=4</p>	

Title	Study for RES
Author(s)	AEA E&E for DECC
Date Published	This study does not appear to be publically available
<p>A study by AEA to assess the potential air quality impacts of the level of biomass deployment suggested by the RES and suggest measures that could mitigate these. The conclusion was that "biomass boilers should have a small and manageable impact on air quality provided that all new small-scale biomass plant are of high quality". In this context, high quality corresponds to the best performing units currently available on the market: PM₁₀ 20 g/GJ, NO_x 50 g/GJ. It also assumed low deployment in Air Quality Management Areas (AQMAs) and that the majority of biomass heat was to replace coal and oil fired boilers and is off the gas grid or away from densely populated urban areas. Current industry opinion is that, while a limit of 20 g/GJ for PM₁₀ is readily achievable by a range of products already available, a NO_x limit of 50 g/GJ is currently almost unachievable.</p> <p>This study does not appear to be publically available</p>	

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UK: Scotland

Title	Review of Greenhouse Gas Life Cycle Emissions, Air Pollution Impacts and Economics of Biomass Production and Consumption in Scotland
Author(s)	Scottish Executive
Date Published	June 2006
<p>A literature review of the existing information on biomass energy, encompassing energy generation potential, greenhouse gas and energy balances, air quality and associated environmental impacts and economics of a wide range of biomass energy technologies. One chapter is dedicated to environmental impacts of biomass energy options, principally air quality impacts. The principal conclusions are that the fossil fuel to be replaced is an important factor in determining the air quality impact, that while fuel characteristics have an influence, choice of technology, including for abatement, is more significant, and there was less reliable data and fewer studies on air quality impacts than on LCA of GHG impacts.</p> <p>www.scotland.gov.uk/Publications/2006/09/22094104/0 www.scotland.gov.uk/Resource/Doc/149415/0039781.pdf</p>	

Title	Measurement and Modelling of Fine Particulate Emissions (PM₁₀ & PM_{2.5}) from Wood-Burning Biomass Boilers
Author(s)	AEA E&E for Scottish Government
Date Published	Sept 2008
<p>A modelling study performed by AEA for the Councils of Edinburgh and Dundee to look at the potential air quality impacts of 15% of heat demand being met by biomass.</p> <p>www.scotland.gov.uk/Publications/2008/11/05160512</p>	

Papers referenced under air quality in Scottish Executive study

Title	LCA of biofuels under different environmental aspects, in Biomass for Energy and the Environment, Proceedings of the 9th European Bioenergy Conference
Author(s)	Kaltschmitt, M & Reinhardt, GA
Date Published	1996

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Title	Life Cycle Analysis of biofuels under different environmental aspects; Biomass and Bioenergy vol 12 121-134
Author(s)	Kaltschmitt, M, Reinhardt, GA & Stelzer, T
Date Published	1996
www.tud.ttu.ee/material/piirimae/LCA/Case%20studies/LCA%20biofuels.pdf	

Title	Bioenergy for Europe – Which ones fit best?
Author(s)	Calzoni, J.; Caspersen, N.; Dercas, N.; Gaillard, G.; Gosse, G.; Hanegraaf, M.; Heinzer, L.; Jungk, N.; Kool, A.; Korsuize, G.; Lechner, M.; Leviel, B.; Neumayr, R.; Nielsen, A. M.; Nielsen, P. H.; Nikolaou, A.; Panoutsou, C.; Panvini, A.; Patyk, A.; Rathbauer, J.; Reinhardt, G. A.; Rivad, G.; Smedile, E.; Stettler, C.; Pedersen Weidema, B.; Wörgetter, M.; Van Zeijts, H.
Date Published	2000
www.oeko.de/service/bio/dateien/en/BLT%20Biofuels%20II.pdf	

Title	Life cycle environmental and economic assessment of willow biomass electricity: A comparison with other renewable and non-renewable sources Report CSS04-05R Center for Sustainable Systems, University of Michigan
Author(s)	Spitzley, D & Keoleian GA
Date Published	2005
http://css.snre.umich.edu/css_doc/CSS04-05R.pdf	

Title	Dynamic Life Cycle Assessment (LCA) of Renewable Energy Technologies" Renewable Energy, Vol. 31, pp. 55 - 71.
Author(s)	Pehnt, M.
Date Published	2006
ftp://ftp.cpuc.ca.gov/LTPP%20Webposting/GHG%20Lifecycle%20Analysis_Research%20Papers/Dynamic%20LCA%20of%20renewable%20energy%20technologies.pdf	

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Europe: Austria

Title	A study at Joanneum, Graz, in 1997/8 to look at emission factors of different small scale biomass-furnaces under different operation conditions
Author(s)	Stiglbrunner, R, Golja, F, & Spitzer, J
Date Published	2001 ~ In Emissionsfaktoren fur feste Brennstoffe. Heiztechnik

Title	Reduction of nitrogen oxide emissions from wood chip grate furnaces Final report from EC Joule III Low NO_x Project 1996-99
Author(s)	R. Padinger, M. U. Alzueta, L. -E. Åmand, R. Bilbao, F. Ghirelli, J. Good, P. Hasler, J. Hämäläinen, V.-P. Heiskanen, H. Hofbauer, J. C. Ibáñez, P. Kilpinen, B. Leckner, O. Leiser, G. Löffler, A. Millera, T. Nussbaumer, M. Oliva, H. Oravainen, J. Saastamoinen, R. Salzmann, H. Schaffner, J. Spitzer, R. Taipale, H. Thunman, B. Waelti, V.J. Wargadalam, C. Wartha, F. Winter
Date Published	2000

Title	NO_x reduction of biomass combustion by optimized combustion chamber design and combustion control. Report from Joanneum, Graz
Author(s)	Padinger, R
Date Published	2003

Title	BIOS Bioenergiesysteme GmbH
Author(s)	Various
Date Published	Various
<p>www.bios-bioenergy.at/en/downloads-publications/de-dustingaerosols.html 8 papers on aerosols, fly ash and particulates from biomass combustion</p> <p>www.bios-bioenergy.at/en/downloads-publications/nox.html 8 papers on NO_x formation and reduction from biomass combustion</p> <p>Several of these papers are referenced in the IEA Bioenergy Task 32 Handbook on biomass combustion and co-firing</p>	

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Europe: Sweden

Title	Research Programme: Emissions and air pollution from combustion of biomass
Author(s)	Swedish national Energy Administration, EC DGET
<p>A programme of research funded under the Swedish Energy Programme as part of the EC DGET (Directorate General for Energy and Transport). Reports on the results of these programmes do not yet appear to be available.</p> <p>www.managenergy.net/products/R32.htm</p>	

IEA

Title	IEA International seminar on Aerosols in biomass combustion, Zurich
Author(s)	Various
Date Published	2001

Title	IEA International seminar on Aerosols in biomass combustion, Graz
Author(s)	Various
Date Published	March 2005
<p>Several useful presentations, including PM emissions in Austria 2000-2004 (J Schneider); Particle emissions from residential biofuel boilers and stoves (C Tullin); Exhaust gas cleaning for small wood fired appliances – recent progress and field test results (V Schmatloch); the last of which describes a small electrostatic precipitator for use in the flue of domestic scale boilers.</p> <p>www.ieabcc.nl/meetings/task32_Graz_aerosols/</p>	

Title	Aerosols in biomass combustion (expert workshop at Bioenergy 2007), Jyvaskyla
Author(s)	Various
Date Published	Sept 2007
<p>Several useful presentations, including Aerosol emissions from different modern Austrian small-scale biomass boilers (pellets, wood chips, log wood) (T Brunner); Cost of particle removal for 200 kW to 2 MW automatic wood combustion plants by ESP and fabric filter (T Nussbaumer); Novel small scale ESP concepts (S Gunczy) www.ieabcc.nl/meetings/task32_jyvaskyla_ws_aerosols/index.html</p>	

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Title	IEA Expert workshop on Next generation small scale biomass combustion technologies, Amsterdam,
Author(s)	Various
Date Published	October 2008
www.ieabcc.nl/meetings/task32_Amsterdam2008/SSC/index.html	

Title	Handbook on biomass combustion & co-firing
Author(s)	IEA Bioenergy Task 32
Date Published	Dec 2007
<p>A substantial (442 pages) book from IEA Bioenergy Task 32 on all aspects on biomass combustion, including a chapter on environmental impacts of biomass combustion, with 134 references, and one on ash characteristics and behaviour with 36 references</p> <p>In addition, a chapter on research and development needs and activities identifies technologies to reduce gaseous emissions, especially NO_x as of great importance (12 references to academic studies on NO_x emissions, including 2 by A Weissinger, et al. (1999 & 2002) on NO_x reduction by primary measures) and ash and aerosol related problems, including PM reduction technologies, with 46 references, including: I Obernberger, et al. (1999) "Formation, composition and particle size distribution of fly ashes from biomass combustion plants" in proceedings of the 4th Biomass Conference of the Americas.</p> <p>www.ieabcc.nl/handbook.html</p>	

Title	Particulate emissions from biomass combustion in IEA countries. A survey on measurements and emission factors
Author(s)	Nussbaumer, T, Czasch, C, Klippel, N, Johansson, N & Tullin, C For IEA Task 32
Date Published	Jan 2008
<p>Gives typical, best and worst emission figure for PM₁₀ or different combustions systems (including open fireplaces and wood stoves) for 8 European countries. Includes operational and design variations such as use with or without an accumulator tank, and updraft or downdraft log boilers.</p> <p>www.ieabcc.nl/publications/Nussbaumer_et_al_IEA_Report_PM10_Jan_2008.pdf</p> <p>Also presentation as part of IEA Expert workshop on Next generation small scale biomass combustion technologies, Amsterdam, October 2008</p> <p>www.ieabcc.nl/meetings/task32_Amsterdam2008/SSC/03%20Thomas%20Nussbaumer.pdf</p>	

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Worldwide: Canada

Title	Health Impacts of Biomass Air pollution
Author(s)	University of British Columbia
www.cher.ubc.ca/PDFs/biomass_air.pdf	

Title	Emissions from residential wood combustion
Author(s)	Preto, F
Part of IEA Workshop on recent developments in small scale combustion devices, Paris, France, October 2005 www.ieabcc.nl/meetings/task32_Paris_ssc/Preto.pdf	

Worldwide: USA

Title	Particulate control for biomass fired boilers
Author(s)	RA Mastropietro
Date Published	1996
A discussion of the development, use and performance of electrostatic precipitators (ESPs) in biomass combustion http://hamon-researchcottrell.com/HRCTechnicalLibrary/Particulate%20Control%20for%20Biomass%20Fired%20Boilers.pdf	

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Conclusions

The issue of biomass combustion, emissions and local air quality is clearly one that has been acknowledged in many countries around the world as one that needs to be addressed. Studies can be divided into a number of broad categories:

- those which address the fundamental efficiency of the boiler itself and the levels of emissions arising from the combustion process;
- developing end of flue abatement technologies;
- assessing the typical emissions arising from different types of biomass combustion appliance;
- modelling and impact assessment of different scenarios of biomass heat and power deployment;
- analyses of the potential health (and other) impacts of degradation of local air quality;
- advice on design, operation and deployment of biomass energy to minimise negative impacts.

While there is a large amount of information available, and major advances in the field of abatement technologies, particularly in regard to particulates, there is more work to do especially in regard to reducing NO_x levels. The modelling work has demonstrated that in non-urban areas it is possible to install large amounts of biomass heating without significant negative impact on local air quality, however deployment in cities, and especially where there are pre-existing air quality issues as a result of transport or industry, it is likely that best available technology, both in appliance design and abatement, will be necessary if biomass is to be deployed, and achieving acceptable NO_x emission levels, in particular, will clearly be challenging.