Air Quality Neutral Planning Support Update:

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1 Introduction

Background to the Study

1.1 Air Quality Consultants Ltd, in association with ENVIRON UK Ltd, has been commissioned by the Greater London Authority (GLA) to provide support to the development of the Mayor's policy related to "air quality neutral" developments.

1.2 Air quality is frequently a material planning consideration for major developments in Greater London, and the planning process presents useful opportunities to reduce the impacts of the development and to work towards achieving the UK air quality objectives and the EU limit values. It also presents an opportunity to reduce exposure to "non-threshold" pollutants such as $PM_{2.5}$.

1.3 The air quality impact assessments generally undertaken for developments focus on the incremental change in local pollutant concentrations associated with the scheme. However, individual developments, even in Greater London, typically generate only small changes to pollutant concentrations, categorised as "Negligible" or "Slight Adverse" using the Institute of Air Quality Management (IAQM) and Environmental Protection UK (EPUK) significance criteria. In addition, the air quality assessments often focus on traffic-related impacts alone, and ignore emissions associated with the future operation of CHP/CCHP/boiler plant. Furthermore, the cumulative impacts of several developments are rarely characterised in any detail, leading to potential concerns with regard to a "creeping baseline".

1.4 London's air quality problems are primarily a result of a very large number of sources each contributing a small amount. In light of these issues, both the London Plan and the 2010 Mayor's Air Quality Strategy (MAQS) make reference to new developments being "air quality neutral". The London Plan states:

"Development proposals should be at least 'air quality neutral' and not lead to any further deterioration of existing poor air quality".

1.5 The MAQS includes a policy which states:

"New developments in London shall as a minimum be 'air quality neutral' through the adoption of best practice in the management and mitigation of emissions".

1.6 The GLA intends to develop the "air quality neutral" policy so as to include it within a 2013 revision to the Sustainable Design and Construction Supplementary Planning Guidance. This report represents the first step in the process.

Project Deliverables

1.7 The principal deliverables from the project are to provide:

- A summary report on “air quality neutral” which provides a comprehensive overview and advice on the policy, its application and viability, and which focuses on the costs of implementation, emissions reduction, and recommendations for implementation; and
- A guidance note on the application of the “air quality neutral” policy.

1.8 It should be noted that this report is intended to address the Air Quality Neutral policy in isolation, and cross-reference to the other Mayor’s policies will be considered in the 2013 Sustainable Design and Construction Supplementary Planning Guidance

2 Options for "Air Quality Neutral" Policy

2.1 An initial review of potential options for the "air quality neutral" policy has been carried out in order to identify the most viable approach.

Pollutants to be Included

2.2 Within Greater London, nitrogen dioxide and particulate matter (PM_{10} and $PM_{2.5}$) are the principal pollutants of concern, and there is thus a strong evidence base to focus on both NOx and particulate matter. In terms of particulate matter, either PM_{10} or $PM_{2.5}$, or both could be included. The following factors, however, suggest that it is best to focus on PM_{10}:

- If PM_{10} emissions are controlled, then, by definition, $PM_{2.5}$ will also be controlled (particulate matter emissions from combustion sources are predominantly in the $PM_{2.5}$ fraction); and
- There are, perhaps, greater obligations on the Mayor and London Boroughs to reduce PM_{10} emissions as there are more challenging EU limit values in place (the $PM_{2.5}$ limit value for 2015 is expected to be met across the UK without the need for further measures, and the exposure-reduction obligations are only set as national target values);

2.3 It is therefore proposed that the air quality neutral policy should focus on NOx and PM_{10} emissions, recognising that, by definition, this will control emissions of $PM_{2.5}$ to a large extent

2.4 Incorporation of carbon dioxide emissions into the air quality neutral policy has also been considered. There are important synergies between measures to drive local air quality and climate change improvements, as well as some potential conflicts. However, there is existing guidance in the GLA Energy Strategy and the current Sustainable Design and Construction SPG, and it is therefore not considered appropriate to incorporate additional targets for CO_2 emissions reduction into the air quality neutral guidance.

Source types

2.5 A wide range of sources could be incorporated within the air quality neutral guidance. However, the key elements are considered to be emissions from the energy sources used within the building, and emissions from the vehicles associated with the buildings use. These are therefore the focus of the guidance.

2.6 Emissions from demolition and construction activities could also be included in the air quality neutral guidance; however, these activities are temporary in nature and emissions are very difficult to quantify. These emissions can be controlled through the implementation of effective mitigation measures. Indeed, the GLA is currently preparing updated guidance on the control of emissions from construction sites. It is therefore not considered appropriate to include this sector within the air quality neutral guidance.

2.7 Data from the LAEI[1] indicates that shipping (ferries, cargo transport, marinas etc.) makes only a very minor contribution to NOx (0.2%) and PM (0.02%) emissions in London. It is therefore appropriate to exclude explicit consideration of this source within the air quality neutral guidance.

2.8 Finally, consideration has been given to industrial installations that fall under the Environmental Permitting Regulations (EPR). These are governed by existing legislation. The National Planning Policy Framework states that "*planning authorities should focus on whether the development is an acceptable use of the land, and the impact of the use, rather than the control of processes and emissions themselves where these are subject to approval under pollution control regimes*". Thus, where developments are controlled by EPR it would not be appropriate to enforce additional emissions legislation and these sources will not be included within the air quality neutral guidance.

Major Transport Infrastructure

2.9 Major transport infrastructure development, such as that proposed by TfL, is assessed using the Transport Advisory Guidance (TAG) methodology, which estimates changes to NOx and PM emissions, and then applies an economic valuation. It is therefore suggested that it would be inappropriate to apply the air quality neutral policy to these types of development.

Scale of Development

2.10 It is proposed that the air quality neutral policy would apply to all major developments (other than those excluded above) in Greater London; this will capture a very high percentage of development in London. These are defined within the London Plan as being developments:

- For 10 or more residential dwellings (or where the number is not given, an area of more than 0.5 ha); or
- For all other uses, where the floor space is 1,000 sq m or more (or the site area is 1 ha or more).

Options for Application

2.11 Two principal routes for applying an air quality neutral policy have been considered:

- A comparison of emissions from the proposed development with those associated with the previous use of the site; or
- The establishment of benchmarks for acceptable emissions from a particular development.

2.12 The former would allow neutrality to be established on a site-by-site basis, whilst the latter could provide a means of ensuring that London as a whole remains air quality neutral.

[1] The London Atmospheric Emissions Inventory (LAEI) is compiled by GLA and provides information on emissions from identifiable pollution sources in Greater London.

2.13 The residential, mixed-use, and commercial sectors probably account for the largest number of development proposals in London, and they are worthy of specific consideration with regard to potential options for the air quality neutral guidance.

2.14 A number of "development opportunities" need to be considered, which could involve:

- Greenfield land;
- Disused or derelict land (for e.g. more than 5 years);
- Replacement use (like-for-like);
- Replacement use (expanded in size); and
- Replacement use (change of land use).

2.15 For "replacement use", where the site is in existing use, or the previous use can be easily defined, it would be possible to estimate the previous building and transport-related emissions. An air quality neutral policy would then seek to ensure that emissions from the new development are no greater than the previous use. This could, in some cases, be achieved by on-site mitigation (low-NOx boilers, NOx/PM abatement etc.), travel plans etc., but in other cases, where the scale of development is dramatically increased, or the change in land use inevitably leads to greater emissions, "off-site" offsetting may be required.

2.16 For greenfield developments, or brownfield developments on disused or derelict land (where the land has remained unused for many years), it would be extremely difficult, impractical or impossible to quantify emissions from previous use[2]. Possible options would be for the developer to:

- offset ALL of the emissions (as the previous use can only be quantified as zero); or
- compare the development emissions against a "benchmark" for the relevant land-use class, and offset all emissions exceeding the benchmark.

2.17 Taking the above into account, a number of options have been considered:

- **OPTION 1:** establish a benchmark for different land-use classes, expressed, for example, as kg pollutant/m^2/annum or vehicle trips/m^2. To achieve compliance with the air quality neutral policy, the development would need to demonstrate that the building and transport emissions would achieve the benchmark. If the benchmark cannot be achieved, then off-site offsetting could be used;

2 Examples include Battersea Power Station, where the site is being considered for mixed-residential use, but has remained unused for 30+ years, and is effectively a "greenfield" site.

- **OPTION 2:** would require that emissions from the new development do not exceed the previous use of the site[3]. If the emissions cannot be abated on-site, then off-site offsetting could be used;
- **OPTION 3:** a hybrid between Options 1 and 2, whereby a developer is required to meet the benchmark unless it can be explicitly demonstrated that emissions from the new development would not exceed the emissions from the previous use of the site; and
- **OPTION 4:** would require that all emissions from the new development are offset, treating "replacement use" identically to greenfield or derelict land use.

2.18 The advantages and disadvantages of each option are summarised in the table below.

Table 1: Advantages and Disadvantages of Each Option[1]

	Advantages	Disadvantages
Option 1	Sets a uniform standard for all new development. Does not require any knowledge of previous land use.	If benchmarking is based on, for example, 2010 emissions estimates, there would be a need for a regular review and update. Unless benchmarking is either supported by other measures to reduce emissions from individual sectors (e.g. standards for building plant and road transport), or somehow defined to offset net growth within London, there is the potential for emissions to increase.
Option 2	Sets an explicit air quality neutral standard for individual developments.	Requires knowledge of previous land use. Potentially leads to dual standards between "replacement use" and "derelict sites", whereby the former would only be required to offset the difference between new and previous, whereas the latter is required to offset all emissions. This may restrict development of "derelict" land.
Option 3	Sets a minimum standard for all developments, but allows the opportunity for individual developments to be tested against "air quality neutral".	Some developments could be allowed to exceed the benchmark if the previous site use had high emissions.
Option 4	Sets a uniform standard and does not require knowledge of previous use or benchmarking.	Requires offsetting of all emissions associated with the new development, and in many cases goes beyond "air quality neutral". May restrict new development in current economic climate.

1: the term "new development" also includes change of use and extension of use.

[3] Option 2 could not be applied to greenfield sites, or sites that have been derelict or disused for many years.

2.19 Taking all of the above issues into account, Option 1 is considered the most feasible approach for general application to the air quality neutral policy. It would be applied to both building and transport-related emissions.

2.20 A further issue is whether building and transport emissions should be treated together, i.e. combined, or treated separately. Issues are:

- Depending on how transport emissions are calculated they could substantially exceed building emissions, while only a small part of the transport emissions may be occurring in London (e.g. if total annual veh-km statistics are used[4]);
- Emissions from chimneys in buildings have a different impact from emissions at ground level.

2.21 It has been concluded that, in the first instance, emissions from buildings and transport should be treated separately, with the intent for each to attain "air quality neutral".

Mechanisms for Offsetting

2.22 In circumstances where the benchmark is exceeded, mitigation measures to reduce emissions may be applied on-site or off-site. Where this is not practical or desirable, some form of pollutant offsetting could be applied. One route would be to enforce the necessary "air quality neutral" measures via a Section 106 agreement or via the Community Infrastructure Levy (CIL). The potential use for the CIL is, however, restricted, in that even though the CIL will be used to fund infrastructure from April 2014 (earlier for London Boroughs that have adopted it), the charges will be determined by floor space alone, and it would not be possible to distinguish between developments that meet the benchmarks and those that do not.

2.23 Section 106 agreements are, however, still permitted for site-specific, non-infrastructure mitigation measures, without which a development should not be granted planning permission. Under this approach, there would effectively be a charge for each kg of pollutant emitted that is over and above the benchmark emission for that development.

Emission Standards

Boiler/CHP plant

2.24 A number of mandatory minimum standards are suggested that would be applied to certain aspects of developments, to run alongside the benchmarks. The approach would therefore be that:

- All developments would be required to comply with the mandatory emission standards; and
- All developments would also be required to comply with the benchmark emissions.

[4] As this would include veh-km undertaken outside of London

2.25 The current SPG on Sustainable Design and Construction includes guidance to ensure that building services plant has the lowest NOx emissions practicable. This is based on the technical guide for the Code for Sustainable Homes, which historically, had set five categories for NOx emissions from boilers. The SPG requires that where gas boilers are used in new buildings, as an *essential standard* they should have to meet a NOx3 rating. The *preferred standard* would be met with a boiler of NOx5 rating (i.e. with emissions <70mgNOx/kWh).

2.26 The NOx5 rating has now been split to introduce a new, lower rating of <40 mgNOx/kWh, which rewards the building with two points, as opposed to one. Guidance issued by DCLG[5] notes that individual gas boilers with NOx emissions lower than 40 mg/kWh are now standard for many developers and hence no extra cost is incurred. On this basis, the Mayor's essential standard should be revised to be <40mg/kWh for all developments.

2.27 GLA has also commissioned a report on emissions standards for CHP and biomass[6]. A tiered approach for applicable emissions standards has been recommended, depending on whether the development falls within the APEC-A (>5% below the air quality objective) or the APEC-B/APEC-C <5% below, or above the air quality objective) categories, as defined by the London Councils guidance. These proposed standards are summarised in Table 2 below.

5 DCLG (2010) Code for Sustainable Homes Cost Review, DCLG, London.

6 Biomass and CHP Emission Standards (2012) AMEC Environment & Infrastructure UK Limited.

Table 2: Suggested Emission Standards for Solid Fuel Biomass Boiler and CHP in Range 50kWth-20 MWth (AMEC, 2012)

Combustion Appliance	Pollutant	Emission Standard (mg/NM^3)	Indicative Emission Factor
APEC-A			
Spark ignition engine (natural gas/biogas)	NOx	250	0.7 g/kWh
Compression ignition engine (diesel/biodiesel)	NOx	400	1.1 g/kWh
Gas turbine	NOx	50	0.4 g/kWh
Solid biomass boiler	NOx PM	275 50	100g/GJ 20 g/GJ
APEC-B/APEC-C			
Spark ignition engine (natural gas/biogas)	NOx	150	0.3 g/kWh
Compression ignition engine (diesel/biodiesel)	NOx	400	1.1 g/kWh
Gas turbine	NOx	50	0.4 g/kWh
Solid biomass boiler	NOx PM	180 15	70 g/GJ 6 g/GJ

Motor Vehicles

2.28 Emission standards are applied to all new motor vehicles. These are set by the European Union and incorporated into the UK Road Vehicles (Construction and Use) Regulations. They are commonly referred to as Euro standards, with light duty vehicles referred to using Arabic numerals and heavy duty vehicles using Roman numerals. These standards are tightened over time, with current sales being of Euro 5 and Euro V vehicles, with new Euro 6 and Euro VI vehicles being required at different stages between 2013 and 2015.

2.29 Requirements could be placed on new developments to only allow vehicles of certain standards to be used, but this could be difficult to achieve across the board. It is, nevertheless, considered appropriate to investigate the option of requiring all new developments that come into force after September 2015 to use only Heavy Duty Vehicles (including all vehicles operated by, or on behalf of the developer) that comply with the Euro VI standard.

3 Benchmarking

3.1 The process used to identify suitable benchmarks for both building and transport-related emissions is set out below. As the benchmarks are founded on a variety of input assumptions, they will need to be reviewed and updated on a regular basis, ideally to coincide with updated versions of the LAEI.

Building Emissions Benchmarks

3.2 Two Building Emission Benchmarks (BEBs) have been defined, one for NOx and one for PM_{10}, for a series of land-use classes. The benchmarks are expressed in terms of g/m^2/annum. The gross floor area (GFA) is used to define the area. For developments classified as "one-off" (Sui Generis), it will be for the developer to provide convincing evidence that one of the derived BEBs should be used in those situations, or to provide an alternative approach.

3.3 The following information has been used in defining the benchmarks:

- fossil fuel energy density (kWh/m^2) for different land-use classes;
- percentage energy use for gas and oil, for domestic, commercial and industrial activities;
- local gas consumption data; and
- NOx and PM_{10} emission factors for gas and oil, for domestic and commercial/industrial use.

Fossil Fuel Energy Densities

3.4 The CDET[7] provides benchmark fossil fuel consumption (kWh/m^2) for a range of different building types. For the purpose of deriving the benchmarks, the 'typical' fossil fuel usage from this tool has been used.

3.5 The building categories defined in the CDET have been aggregated into various planning land-use classes. In cases where there is a range of fuel energy densities within the land-use class, the lowest fuel energy density has been selected. This is justified on the basis that some of the data within the CDET are relatively old, and modern buildings are more fuel efficient, and that this is in line with the concept of an air quality neutral policy. The following land-use classes have been considered[8]:

- Class A1 (Retail)
- Class A3 to Class A5 (Restaurants, drinking establishments, hot food takeaway)

7 Croydon Development Emissions Tool

8 Where land-use classes have been combined, this has been on the basis of similar fuel energy densities

- Class A2 and Class B1 (Financial/professional services/business)
- Class B2 to Class B7 (General industrial)
- Class B8 (Storage and distribution)
- Class C1 (Hotels)
- Class C2 (Residential institutions)
- Class C3 (Residential dwellings)
- Class D1 (a) (Medical and health services)
- Class D1 (b) (Crèche, day centres etc.)
- Class D1 (c-h) (Schools, libraries etc.)
- Class D2 (a-d) (Cinemas, concert halls etc.)
- Class D2 (e) (Swimming pools, gymnasium etc.)

Proportional Split of Fossil Fuel Use

3.6 The Department for Energy and Climate (DECC)[9] provides estimates of the energy consumption by fuel (gas, oil, solid fuel and electricity) and end use (domestic, service sector and industrial energy), see Table 3. For the purpose of deriving the benchmarks, the service data are referred to as commercial, and only the gas and oil data have been taken into account[10].

Table 3: Energy Consumption by Fuel Type (DECC)

	Usage (%)	
	Gas	**Oil**
Domestic	90.5	9.5
Commercial	88.0	12.0
Industrial	80.1	19.9

3.7 The CDET fossil fuel energy densities multiplied by the proportional split of fossil fuel use gives the anticipated use of each type of fuel from each land-use class.

Calibrating for London

3.8 The gas-use values determined using CDET and DECC data are not London-specific and do not differentiate between the different zones (i.e. the Central Activity Zone (CAZ) and Canary Wharf vs

9 DECC (2011) Special Feature – Estimates of Heat Use in the UK

10 Emissions from solid fuel combustion have not been taken into account. The widespread use of individual solid fuel appliances in new developments is unlikely. Emissions from biomass installations are controlled by additional guidance issued by GLA and by comparison with the PM_{10} benchmark.

the rest of London). Attempts have thus been made to tie these more closely to conditions in London and to these specific areas.

3.9 Information is available by area from the London Heat Map[11]. In order to populate the Heat Map, local authorities had been sent out questionnaires asking building operators to provide their energy use data; return rates were, however, low. For example, the City of London received data from only 1% of the organisations contacted. The majority of building-specific data within the London Heat Map were thus calculated using published national benchmarks (ultimately from the same sources as the CDET data). It is thus not considered appropriate to calibrate the benchmarks against data in the London Heat Map.

3.10 Location-specific gas consumption data are included within the LAEI and these have been used, where possible, to calibrate the benchmarks. The gas consumption data included in the LAEI are those recorded by DECC. DECC currently records these by Lower Layer Super Output Area (LSOA) for domestic usage and by Medium Super Output Area (MSOA) for commercial and industrial sectors.

London-wide Calibration Factors

Domestic

3.11 Aerial photography has been used to identify eleven LSOAs containing only residential properties; each within a different borough. Areas have been chosen where the number of storeys could be categorised easily. The total footprint of domestic buildings within each sample area has been taken from the London LSOA Atlas[12]. Building footprints have been multiplied by the estimated number of storeys to give an approximation of the GFA. This has then been used to calculate total gas usage following the CDET-derived approach described above.

3.12 The calculated gas usage has then been compared to the actual consumption of domestic gas as taken from the London LSOA Atlas[13]. The results are shown in Figure 1. There is a strong correlation between the two datasets, but the CDET-derived benchmarks consistently under-predict actual gas consumption. The average ratio of measured vs calculated gas consumption across the eleven LSOAs has thus been used to uplift the domestic benchmark (Table 4).

Other Land Uses

3.13 Deriving calibration factors requires the application of the uncalibrated gas consumption values to existing buildings. This, in turn, requires knowledge of the use class of existing buildings[14].

11 http://www.londonheatmap.org.uk/Content/home.aspx

12 http://data.london.gov.uk/visualisations/atlas/lsoa-atlas-2012/atlas.html

13 Which is currently based on the 2008 DECC data

14 It also requires gross internal areas for each building within an MSOA, which could be estimated by combining Ordnance Survey topography layer data with average building heights available for a relatively small fee from the London Building Heights database (http://www.findmaps.co.uk/packages/property/LondonBuildingHeights) .

Ordnance Survey Premium Address Point data have been analysed in detail. These data provide use classes for each address, but the information is incomplete for too many addresses (at least one address within in each MSOA) to allow the use of these data in isolation. In theory, it would be possible to supplement the land-use information by hand, by reading individual addresses, but the volume of data makes this approach impractical. It has not, therefore, been possible to calibrate the non-residential benchmarks.

Canary Wharf and the Central Area Zone (CAZ)

3.14 As explained above, the land-use classifications contained in Ordnance Survey Address Point data are insufficient to allow automated classification of building types across MSOAs. This prohibits specific calibrations being carried out for Canary Wharf and the CAZ using the data that are readily available.

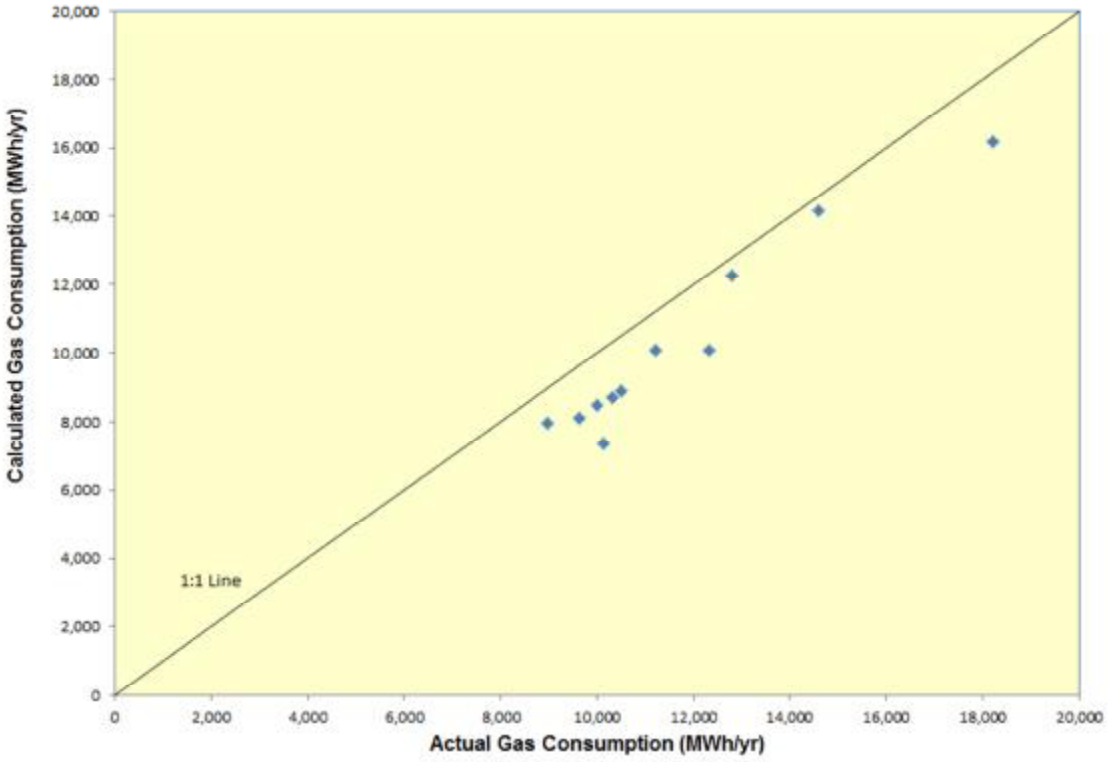

Figure 1 Calculated vs Actual Gas Consumption Data for Eleven Sample Residential Areas in London.

Table 4: Data Used to Calculate the London Specific Residential Calibration Factor

LSOA	Calculated Gas Consumption (MWh/yr)	Actual Gas Consumption (MWh/yr)	Factor
Croydon 035E	16,162	18,218	1.13
Ealing 035C	10,062	12,326	1.22
Redbridge 025C	8,694	10,323	1.19
Havering 021A	8,466	9,993	1.18
Bexley 025D	12,257	12,811	1.05
Bromley 013C	14,167	14,586	1.03
Lewisham 022B	8,893	10,513	1.18
Richmond Upon Thames 018C	10,091	11,223	1.11
Kingston Upon Thames	7,953	8,974	1.13
Brent 017D	7,354	10,146	1.38
Brent 016A	8,124	9,619	1.18
Average			**1.16**

Emission Factors

3.15 Emission factors for NOx and PM_{10} have been taken from the London Atmospheric Emission Inventory 2010 (See Table 5). Factors are provided for both gas (kg/kWh) and oil (tonnes/m^3); for oil it is necessary to covert the factor from tonnes/m^3 to kg/kWh. The emission factors for gas oil have been used for all oil use. For gas data, emission factors are provided for domestic and industrial-commercial; for oil just one emission factor is provided.

Table 5: LAEI 2008 NO_x and PM_{10} Emission Factors

	Gas (kg/kWh)		Oil (kg/kWh)	
	NO_x	PM_{10}	NO_x	PM_{10}
Domestic	0.0000785	0.00000181	0.000369	0.000080
Industrial/Commercial	0.000194	0.00000314	0.000369	0.000080

Deriving Benchmarks

3.16 To derive the benchmark for each of the land-use classes prescribed, the following steps have been taken:

1. The fuel energy density (from CDET) for the prescribed land-use class has been apportioned to the gas and oil estimate of energy consumption provided by DECC;

2. The gas consumption values for domestic dwellings have been uplifted by the calibration factor in Table 3; and

3. The energy demand data for gas and oil have then been used with the corresponding NO_x and PM_{10} emission factors for gas and oil to calculate an emission factor in kg/m^2. The totals from gas and oil have then been summed to create an overall emission factor to form the basis of the benchmarks.

Building Emissions Benchmarks

3.17 The derived BEBs for NOx and PM_{10} emissions are shown in Table 6.

Table 6: Building Emissions Benchmarks (BEBs)

Land Use Class	NOx (g/m^2)	PM_{10} (g/m^2)
Class A1	22.6	1.29
Class A3 - A5	75.2	4.32
Class A2 and Class B1	30.8	1.77
Class B2 - B7	36.6	2.95
Class B8	23.6	1.90
Class C1	70.9	4.07
Class C2[1]	68.5	5.97
Class C3[1]	26.2	2.28
D1 (a)	43.0	2.47
D1 (b)	75.0	4.30
Class D1 (c -h)	31.0	1.78
Class D2 (a-d)	90.3	5.18
Class D2 (e)	284	16.3

[1] These benchmarks have been calibrated for London.

3.18 BEBs have been defined on the basis of gas and oil combustion data. For practical reasons, it is not necessary for a developer to demonstrate compliance with the PM_{10} benchmark where gas is the only fuel used on site. It is intended that the PM_{10} benchmark will apply only where oil or solid fuel (including all biomass appliances) are used.

Transport Emissions Benchmarks

3.19 Two Transport Emissions Benchmarks (TEBs) have been defined, one for NOx and one for PM_{10}, for a series of land-use classes. For those land use types where a TEB has not been derived, it will be for the developer to select one of the TEBs derived for the nearest comparable category and

provide convincing evidence to justify the choice, or to suggest an alternative approach. Where a TEB has not been derived, it will be possible to demonstrate that a development would meet the benchmark if the scheme-generated trip rate for a particular land-use class is below the benchmark trip rate, but if it is above the benchmark trip rate it is not possible to calculate the excess emissions at this stage (see Section 4).

3.20 The benchmarks for residential dwelling are expressed in terms of g/dwelling/annum; those for all other developments expressed in terms of g/m^2/annum. The GFA should be used to define the area, consistent with the definition used for the BEB.

3.21 One aim in the development of the TEBs has been to make them specific to four areas of London, i.e. Canary Wharf, the CAZ, Inner London (outside Canary Wharf and the CAZ), and Outer London. However, it has not been possible to derive a specific TEB for Canary Wharf, and it is recommended that the CAZ TEBs are used for this area.

3.22 To derive the TEBs for cars the following information is required:

- Number of car trips associated with different types and sizes of development (i.e. trips/dwelling/annum or trips/m^2/annum);
- The typical distance travelled for each type of trip (i.e. km/trip); and
- The average emission per vehicle kilometre (i.e. g/km/annum).

3.23 Not all car traffic generated within London starts and finishes its journey within the GLA area and therefore there is an argument that “non-London traffic” should be discounted. However, in the derivation of the TEBs the average distance has been used to define the typical length of trips, which is, for all land uses, less than 10km (highest is 6.4 km for trips from Outer London to offices), and therefore the vast majority of the assigned trip length is likely to be within Greater London.

3.24 To develop TEBs for developments that generate significant goods vehicle traffic (e.g. retail and warehousing) similar trip length data would be required for freight transport. However, the typical distances travelled by goods vehicles originating in the three areas of London are not available, although national data are available (with a typical trip length of around 85 kilometres). HGV trip generation data are available for different land-use classes, but it was not possible to extract these data within the timescale of this study. Further work is therefore required to develop a TEB for land uses with significant HGV movements[15].

Number of Trips

3.25 TRAVL (Trip Rate Assessment Valid for London) is a unique, multi-modal trip generation database designed specifically for use in the capital. It is used by planners working on projects across

[15] Although a TEB for land use developments with significant HGV movements has not been derived, an emissions standard related to Euro VI has been recommended.

Greater London to estimate the effect of proposed changes in land use on transport patterns and, in particular, on the amount of road traffic in an area.

3.26 From the TRAVL database it is possible to obtain average car-trip generation rates per dwelling for residential developments and trip generation rates for all vehicles, for each of the other broad land-use categories. Whilst there are some data for other goods vehicles (OGVs), the number of sites where information has been collected is very low, and the data were not considered to be sufficiently robust at this time.

3.27 Information on average trip rates was extracted from the TRAVL database by MVA Consultancy (which manages the database on behalf of London Councils). Data over the period 2000-2012 have been used in the development of indicative TEBs.

3.28 Trip data for retail, residential and office development, which are considered to be the major land-use classes that will be covered by the air quality neutral benchmarks are shown in Table 7.

Table 7: Average Number of Trips per Annum for Different Development Categories

Land use	Number of Trips (trips/m^2/annum)		
	CAZ	Inner	Outer
Retail (A1)	43	100	131
Office (B1)*	1	4	18
	Number of Trips (trips/dwelling/annum)		
Residential (C3)	129	407	386

Trip Length (km)

3.29 The London Travel Demand Surveys[16] (LTDS) provide information on trips originating and ending in CAZ, Inner and Outer London and outside London (known as CIOX data). These include data on the land use of trip destinations and the length of these trips in km.

3.30 Data for ten land-use types are available as follows, with the associated land-use category in brackets:

- Residential (C3/C4);
- Office (B1);
- Factory / Warehouse (B2/B8);
- School/college/university (i.e. education) (D1);
- Shop/ shopping area/centre (i.e. retail) (A1/A2);

[16] The data for the London Travel Demand Survey 07-08 to 09/10 has been used

- Public buildings (D2);
- Open spaces (Sui Generis) ;
- Health services (D1);
- Place of worship (D1); and
- Other.

3.31 Data are not provided for all land-use classes, and it is necessary to use surrogate TEBs for these land uses.

3.32 Table 8 provides the average (arithmetic mean) journey lengths for residential, office and retail developments derived from the LTDS.

Table 8: Average Distance Travelled by Car per Trip

Land use	Distance (km)		
	CAZ	Inner	Outer
Retail (A1)	9.3	5.9	5.4
Office (B1)*	3.0	7.7	10.8
Residential (C3)*	4.3	3.7	11.4
*Based on the LTDS destination. Note these distances are based on a straight line between the origin and destination of a trip, not the actual trip lengths.			

3.33 By combining the trip generation (Table 7) with the trip distance (Table 8) the average distance travelled per annum can be derived (Table 9).

Table 9: Average Distance Driven (km) per Annum for Different Development Categories.

Land use	Distance (km/m^2/annum)		
	CAZ	Inner	Outer
Retail (A1)	400	590	707
Office (B1)	3.0	30.8	194
	Distance (km/dwelling/annum)		
Residential (C3)	555	1,506	4,400

Emissions per vehicle kilometre

3.34 The final step is to combine the average distance driven (Table 9) with the average emissions rates for cars, in g/veh-km, for CAZ, Inner and Outer London per vehicle-km from the LAEI, taking

account of the driving conditions (i.e. average speeds) in each of the areas (Table 10), to give the TEBs for the different land-use categories and areas of London (Table 11).

Table 10: Emission Factors

Pollutant	g/vehicle-km		
	CAZ	Inner	Outer
NOx	0.4224	0.370	0.353
PM_{10}	0.0733	0.0665	0.0606

Table 11: Transport Emissions Benchmarks (TEBs)

Land use			
	CAZ	**Inner**	**Outer**
NOx (g/m^2/annum)			
Retail (A1)	169	219	249
Office (B1)	1.27	11.4	68.5
NOx (g/dwelling/annum)			
Residential (C3)	234	558	1553
PM_{10} (g/m^2/annum)			
Retail (A1)	29.3	39.3	42.9
Office (B1)	0.22	2.05	11.8
PM_{10} (g/dwelling/annum)			
Residential (C3,C4)	40.7	100	267

3.35 The TEBs are based on a limited range of land-use categories to match the LTDS data as closely as possible. Table 12 shows those land-use categories for which it has been possible to produce a specific TEB and those for which it has not been possible. Where a specific TEB is not provided, a recommended approach is provided where possible.

Table 12: Transport Emissions Benchmark (TEB) approach for each Land-use Category

Land use category	Subcategory	TEB	Notes
Retail	A1 Shops	Yes	Requires further work on HGVs.
	A2 Financial /professional services A3 Restaurants/cafes A4 Drinking establishments A5 Hot food takeaways	Yes	Developments will often be under the size criteria for the AQN policy. If part of a mixed use development, the A1 TEB should apply.
Commercial	B1 Business	Yes	TEB developed, assuming office use.
	B2 General industrial	No	Noted that industry requiring an Environment Permit is excluded from the Air Quality Neutral policy.
	B8 Storage and distribution	No	Further work required to develop the TEB for HDVs and extracting LTDS trip lengths for cars.
Living accommodation	C3 Dwelling houses C4 Houses in multiple occupation	Yes	Residential TEB developed
	C1 Hotels	No	There are no data on trip lengths, and therefore a TEB cannot be derived.
	C2 Residential Institutions Excluding hospitals	No	Includes wide range of land uses - care homes, boarding schools, residential colleges, training centres, prisons, military barracks etc. C3/C4 TEB may be applied.
	C2 Hospitals	No	There are no data on trip lengths, and therefore a TEB cannot be derived.
Institutional	D1 Non-residential institutions	No	Includes clinics, health centres, crèches, schools, art galleries, museums, libraries, places of worship etc. Trip length data available for education, health services and places of work, Too diverse land use class to have a generic D1 TEB.
Leisure	D2 Assembly and Leisure	No	Trip length data only available for public buildings. No data for other buildings within this category Therefore a generic D2 TEB cannot be derived.
Other	Sui Generis	No	

3.36 There are also non-road traffic transport emissions that have not been included e.g. for railways and aircraft. There is no appropriate means of setting a benchmark for rail, and this would be best promulgated by a GLA policy to only permit new rail infrastructure to be based on electric locomotives. In the case of aircraft, it would be possible to establish a benchmark for operations with the LTO cycle, but the responsibility for mitigation/offsetting could not reasonably lie with the airport operator, as they have very limited control over what aircraft are used by the airlines. The only mechanism for allocating responsibility to the individual airlines would be via the landing charges, but this system is strictly controlled by the Civil Aviation Authority, and it is highly unlikely that it could be adapted to support an Air Quality Neutral policy.

4 Guidance on Application

4.1 This section sets out the input parameters and steps required to apply the air quality neutral policy. In summary the benchmarks for a particular development are identified, and the emissions for this development are then compared with the benchmark emissions. Where the benchmark is exceeded then action is required, either locally or by way of off-setting. The Building Emissions and Transport Emissions for a development are calculated separately, and not combined.

Applying the Building Emissions Benchmark (BEB)

4.2 The required input data to calculate the Building Related Emissions are summarised in Box 1.

Box 1: Data Requirements for Building Related Emissions

For each land-use category:

- Gross Floor Area (m^2) of development
- On-site emissions of NOx associated with building use (kg/annum) calculated from energy use (kWh/annum) and default or site specific emission factors (kg/kWh)
- On-site emissions of PM_{10} associated with oil or solid fuel use (kg/annum) calculated from energy use (kWh/annum) and default or site specific emission factors (kg/kWh)

4.3 The estimated on-site emissions of NOx and PM_{10} associated with the building use can be calculated either a) from estimates of fossil fuel consumption per annum, using the default emissions factors in Box 2 unless the developer can justify the use of alternatives, or b) from knowledge of the emissions standards that would apply to the combustion sources (e.g. for boilers, CHP plant etc.). PM_{10} emissions need only be considered for oil and solid fuel use. Where emissions from mixed-use developments are associated with a single point of release (e.g. an on-site energy centre) the emissions should be assigned to each land-use class based on the proportion of GFA.

Box 2: Default Emissions Factors (2010 LAEI)

Gas

- Domestic: 0.0000785 kgNOx/kWh
- Industrial/commercial: 0.000194 kgNOx/kWh

Oil

- Domestic: 0.000369 kgNOx/kWh; 0.000080 kgPM_{10}/kWh
- Industrial/commercial: 0.000369 kgNOx/kWh; 0.000080 kgPM_{10}/kWh

4.4 The calculation for comparison of the Building Related Emissions with the BEB is shown in Box 3.

Box 3: Comparison of Building Related Emissions with the BEB emissions for the Development

- Calculate the NOx and (if oil/solid-fuel used) PM_{10} emissions (kg/annum) for each land use class and sum to give Total Building Emissions for the development.
- Calculate the BEB emissions for the development using the annual emission rates set out in Table 6 (kg/annum).Subtract the BEB from the Total Building Emission.
- If the outcome is negative, the building emissions are within the benchmark. If the outcome is positive, on or off-site mitigation or offsetting will be required.

Applying the Transport Emissions Benchmark

4.5 The required input data to calculate the TEB are summarised in Box 4.

Box 4: Data Requirements for Transport Related Emissions

For each land-use category, obtain:

- Gross Floor Area (m^2) of development (A1-A5, B1)
- Number of dwellings (C3,C4)
- Development trip rate (trips/dwelling/annum, or trips/m^2/annum) – normally found in the Transport Assessment
- Average distance travelled (km) for each land-use class – see Table 8
- Emissions of NOx and PM_{10} per kilometre as shown in Table 10 (unless there are measures in place to ensure that the emissions per kilometre will be less than the average (e.g. if the development will be restricted through a planning condition to vehicles meeting the most recent EU emissions (Euro) standards), in which case these development specific emission factors can be used.

4.6 The calculation for comparison of the Transport Related Emissions with the TEB is shown in Box 5.

Box 5: Comparison of Transport Related Emissions with the TEB Emissions for the Development

- Calculate the NOx and PM_{10} emissions (kg/annum) for each land use class and sum to give Total Transport Emissions for the development
- Calculate the TEB emissions for the development using the values in Table 11. Subtract the TEB from the Total Transport Emission.
- If the outcome is negative, the transport emissions are within the benchmark. If the outcome is positive, on or off-site mitigation or offsetting will be required.

4.7 Total Transport Emissions cannot be calculated for car-free' developments, but it will be crucial that the developer provides evidence that users of the proposed development will not use off-site parking.

4.8 Developments that incorporate a car club can ignore the emissions from the car club vehicles, as their use should discourage the use of private motorised transport. Trips associated with the use of electric vehicles can also be disregarded.

4.9 Where a specific TEB has not been calculated, it will be possible to shown that a development would meet the benchmark if the scheme-generated trip rate for a particular land-use class does not exceed the benchmark trip rate, derived from TRAVL, as shown in Appendix A1. If the scheme-generated trip rate exceeds the benchmark trip rate, it is not possible at this stage to derive the excess emissions, and it will be for the developer to suggest an alternative approach.

5 Application of the Air Quality Neutral Guidance

5.1 An evaluation of the Guidance as set out in Section 4 has been carried out using a number of case studies, based on recently completed applications. These have been selected to represent the most common types of development in Greater London, i.e. residential, mixed-use and retail, and are shown in Appendix A2.

5.2 It has not been possible to fully apply the Guidance in many of the case studies due to the absence of readily available information for air quality assessments carried out to date. The exercise has, however, highlighted a number of matters that will need to be addressed::

- Emissions associated with the operation of the building are rarely (if ever) collated for the air quality assessment, unless an energy centre (or some form of centralised boiler plant/CHP/biomass scheme) is included within the proposals;
- Where emissions from CHP/biomass plant are provided, they often reflect emissions limits as opposed to actual operational emissions;
- Where Transport Assessments are completed, information on trip rates is commonly provided, but generally only for the AM and PM peak periods. These would need to be factored up to provide annual trips. This can be based on the same conversion factors used to derive AADT data from peak hours.

5.3 For on-site abatement of building emissions, costs for abatement technologies for biomass and CHP plant have been derived from the AMEC report. For off-site abatement, consideration could be given to either published marginal abatement costs (MAC) or damage costs. The former relate specifically to the costs of abating emissions, while the latter relate to the environmental damage associated with the emissions; consequently the damage costs for PM_{10} are several orders of magnitude higher than for NOx.

5.4 The average national shadow price for NOx abatement has been derived within a study published by Defra[17], and has been incorporated into a consultation document related to the Transport Advisory Guidance (TAG), published by DfT[18]. This consultation document suggests that a hybrid approach be adopted with air quality impacts valued using the MAC methodology for NOx emissions, and the damage cost approach for PM_{10} concentrations. In areas where the EU limit value for nitrogen dioxide is exceeded, a MAC value of £29,000 per tonne of NOx is recommended. The air quality neutral approach is based on emissions, and not concentrations: the damage costs for PM are shown in Table 17.

[17] Defra (2011) A Low Emissions Zone framework for inclusion in the Time Extension Notification for compliance with the EU limit value for NO2. IA No: Defra1341

[18] TAG Unit 3.3.3C: The local air quality sub-objective. Available at www.dft.gov.uk/webtag/documents/expert/unit3.3.3c.php

Table 17: Damage costs (per tonne)

	Central estimate[1,2]	Low central range	High central range
PM transport average	£52,298	£40,948	£59,430
PM transport Central London	£239,008	£187,132	£271,599
PM transport Inner London	£245,806	£192,456	£279,288
PM transport Outer London	£160,558	£125,711	£182,453

1 Range always to be quoted

2 Data derived from Defra Table 1 ICGB, Air quality damage costs in 2009 prices, uprated by GDP deflator for 2011 (2.60%), 2012 (2.50% estimated) and 2013 (2.50% estimated).

5.5 A strict comparison with the recommended CHP and biomass emission standards is not straightforward, as these are related to the AMEC categories. For the purpose of this study the more stringent standards applicable to the APEC-B/APEC-C categories were assumed to apply throughout.

6 Recommendations for Further Work

6.1 The development of the Air Quality Neutral guidance would benefit from additional work that it was not possible to complete within the timescale allotted for the study. Recommendations for further work are summarised below.

Transport Emission Benchmarks

6.2 For residential land use, the LTDS destination data have been used, but the outcome may differ if origin data were assumed. Using the destination data is correct for the other land uses.

6.3 Only the residential, office and retail LTDS LDV data have been analysed, and additional assessment should be carried out for the other LTDS trip purpose land uses. The LTDS land uses are factory/warehouse (B2/B8); education (D1), public buildings (D2), health services (D1), places of worship (D1) and other.

6.4 An analysis of the HGV data for retail should be carried out, and other land uses where it may be significant, e.g. warehousing (B8) and industry (B2).

The LAEI data should be examined to decide whether or not to use the LDV or just the car emission data. The LGV component of LDV data is unlikely to be significant but it should be checked.

A1 TRAVL Benchmark Trip Rates

A1.1 Benchmark trip rates for those land-use classes where it was not possible to derive trip lengths are shown in Table A1.1

Table A1.1: Average Number of Trips per Annum for Different Development Categories

Land use	Number of Trips (trips/m^2/annum)		
	CAZ	Inner	Outer
A3	153	137	170
A4	2.0	8.0	-
A5	-	32.4	590
B2	-	15.6	18.3
B8	-	5.5	6.5
C1	1.9	5.0	6.9
C2	-	3.8	19.5
D1	0.07	65.1	46.1
D2	5.0	22.5	49.0

A2 Case Studies

A2.1 In order to test the air quality neutral guidance, the proposed approach has been applied to a number of recently completed air quality assessments, selected to represent a range of different development types. In some cases, it has not been possible to fully test the guidance as insufficient data were presented in the Air Quality Assessment. However, this has highlighted the additional burden that would be required to undertake air quality assessments for new developments that incorporate an air quality neutral requirement.

1) A Large Mixed Residential Development

Available Information

A2.2 A mixed-use development for up to 240,000sqm of development, comprising:

- Class A1/A2 (Shops and Financial and Professional Services) up to 2,000 sq m;
- Class A3/A4 (Cafes/Restaurants and Drinking Establishments) up to 3,000 sq m;
- Class A5 (Hot Food Takeaways) up to 300 sq m;
- Class B1 (Business) up to 15,000 sq m;
- Class C1 (Hotels) up to 10,000 sq m;
- Class C3 (Dwelling Houses) up to 185,000 sq m;
- Class D1 (Non-Residential Institutions) up to 10,000 sq m;
- Class D2 (Leisure and Assembly) up to 15,000 sq m

A2.3 An Energy Centre comprising:

- 1 No. 1.6MWe gas-fired CHP plant
- 4 No. 2.6 MWth gas fired boilers (to comply with the Mayor's preferred standard of 70 mgNOx/kWh)
- The emissions from the Energy Centre are only presented in the ES in an aggregated format for CHP and boilers combined. However, based on a full load NOx emission rate of 1.4 g/sec, and a flow rate of 5.86 Nm^3/sec, a NOx concentration of approximately 238 mg/Nm^3 can be estimated.

A2.4 A Transport Assessment providing details of vehicular trips by land-use category, but only as "AM Peak" and "PM Peak" trips.

Application of Guidance

A2.5 The total annual building NOx emissions from the development can be calculated from the Energy Centre data, based on the stated operational load and an annual average emission rate of 0.55g/sec, equivalent to a **Total Building NOx Emission** of **17,345 kg/annum**.

A2.6 The **Total Benchmarked Building NOx Emission** is calculated from the land use categories and the BEBs, and is shown in Table A2.1.

Table A2.1: Calculation of Benchmarked NOx Emissions Using Building Emissions Benchmarks for each Land-Use Category

Land Use	GFA (m^2)	Building Emissions Benchmarks ($gNOx/m^2/annum$)	Benchmarked Emissions (kgNOx/annum)
A1	1,000	22.6	22.6
A2	1,000	30.8	30.8
A3	3000	75.2	226
A5	300	75.2	22.6
B1	15,000	30.8	462
C1	10,000	70.9	709
C3	185,000	26.2	4,847
D1	10,000	75.0	750
D2	15,000	90.3	1,355
Total Benchmarked Building Emissions			**8,424**

A2.7 The **Total Building NOx Emission** of **17,345 kg/annum** may be compared with the **Total Benchmarked Building NOx Emission** of **8,424 kg/annum**. As the building emission of NOx is higher than the benchmark, further action will be required to tackle the **8,921 kg/annum excess NOx emissions**, either by on-site measures or by off-setting.

A2.8 As stated above, it is not possible to strictly compare the performance of the CHP with the recommended GLA standard as the published emissions information is aggregated for CHP and boilers. If it is assumed that all emissions are related to the CHP, then compliance with the recommended standard (i.e. a reduction from 238 mg/Nm^3 to 100 mg/Nm^3) would reduce the **Total Building NOx Emission** to **7,287 kg/annum** which would be below the **Total Benchmarked Building NOx Emission**. Based on information within the AMEC report, the cost of SCR to achieve this reduction would be in the range of **£12,000 to £42,000** as an annualised cost.

A2.9 It has not been possible to test the Transport Emissions for this scheme against the Benchmarks as insufficient data are available.

2) A Retail Development

Available Information

A2.10 A Retail development comprising of 19,272 sqm GFA:

- Class A1 Foodstore and Retail (5,411 sqm);
- Hotel (Class C1) including bar (Class A4), café (Class A3), leisure use (Class D2) and restaurant (Class A3) totalling 2,945 sqm
- Office (Class b1) – 1,940 sqm.

A2.11 An Energy Centre comprising:

- 140kWe gassified wood pellet plant (stated NOx emission limit of 250 mg/Nm^3; PM_{10} emission 20 mg/Nm^3; mass flow 2028 m^3/h at 137 deg C; 6500 h/annum)

A2.12 The accompanying Transport Assessment was not provided and no comparison with the TEBs can be made.

Application of Guidance

A2.13 The total annual NOx and PM_{10} emissions from the development can be calculated from the Energy Centre data, based on 6,500 hours CHP operation, equivalent to **Total Building NOx emissions** of **2,194 kg/annum** and **Total Building PM_{10} Emissions** of **175.5 kg/annum**[19].

A2.14 The precise GFA of the different land-use classes was not provided, and has been estimated. The **Total Benchmarked Building NOx Emission** is calculated from the land use categories and the BEBs, and is shown in Table A2.2.

[19] These estimates are based on the emissions limits quoted for the plant. Actual operational emissions may be lower.

Table A2.2: Calculation of Benchmarked NOx Emissions using Building Emissions Benchmarks for each Land-Use Category

Land Use	GFA (m^2)	NOx		PM_{10}	
		Building Emissions Benchmark ($gNOx/m^2/annum$)	Benchmarked Emissions (kg/annum)	Building Emissions Benchmark ($gPM_{10}/m^2/annum$)	Benchmarked Emissions (kg/annum)
A1	5,411	22.6	122	1.29	6.98
C1	1,845	70.9	131	4.07	7.51
A4	100	75.2	7.52	4.32	0.432
A3	400	75.2	30.1	4.32	1.73
D2	400	90.3	36.1	5.18	2.07
A3	200	75.2	15.0	4.32	0.864
B1	1,940	30.8	59.8	1.77	3.43
Total Benchmarked Building Emission			**402**		**23.0**

A2.15 The **Total Building NOx Emission** of **2,194 kg/annum** may be compared with the **Total Benchmarked Building NOx Emission** of **402 kg/annum**. As the building emission of NOx is higher than the benchmark further action will be required to tackle the **1,792 kg/annum excess NOx emissions**, either by on-site measures or by off-setting. **Total Benchmarked Building PM_{10} Emission** of **23.0 kg/annum** may be compared with the **Total Building PM_{10} Emission** of **175.5 kg/annum**. As the building emission of PM_{10} is higher than the benchmark further action will be required to tackle the **152.5 kg/annum excess PM_{10} emissions**, either by on-site measures or by off-setting.

A2.16 The stated emissions of 250 $mgNOx/Nm^3$ and 20 $mgPM_{10}/Nm^3$ exceed the recommended GLA emissions standard for solid biomass boilers. If compliance were met, this would reduce the **Total Building NOx Emission** to **1,590 kg/annum** and the **Total Building PM_{10} Emission** to **131.6 kg/annum,** but emissions would still exceed the benchmarks. There appears to be no viable abatement that could be applied to small biomass boilers that would further reduce NOx emissions. Ceramic filters have a 99% reduction efficiency and would reduce PM_{10} emissions below the benchmark at an annualised cost of **£1,935**. The residual excess NOx emissions of 1,188 kg/annum would need to be offset.

3) Student accommodation

Available Information

A2.17 Student accommodation comprising c14,700 sqm of C2 use. An energy centre comprising 3 No. gas-fired CHP units and 4 No. gas boilers. The calculated CHP NOx concentration from the data provided in the AQ assessment is 52 mg/Nm^3, which is well within the GLA recommended emission standard.

Application of Guidance

A2.18 The total annual NOx emissions from the development can be calculated from the Energy Centre data, based on 3,650 hours CHP operation and 8,760 hours gas boiler operation, equivalent to **Total Building NOx Emissions** of 2,194 kg/annum.

Table A2.3: Calculation of Benchmarked NOx Emissions using Building Emissions Benchmarks for each Land-Use Category

Land Use	GFA (m^2)	NOx	
		Building Emissions Benchmark ($gNOx/m^2/annum$)	Benchmarked Emissions (kg/annum)
C1	14,700	68.5	1,007
Total Benchmarked Building Emission			**1,007**

A2.1 The **Total Building NOx Emission** of **2,194 kg/annum** may be compared with the **Total Benchmarked Building NOx Emission** of **1,007 kg/annum**. As the building emission of NOx is higher than the benchmark, further action will be required to tackle the **excess NOx emissions**, either by on-site measures or by off-setting.

4) A Medium-Sized Mixed Use Development

Available Information

A2.2 A mixed-use development, comprising:

- Class A1 foodstore 3,543 sq m;
- Class A1 to A5 retail units 1,037 sq m;
- Class D1 neighbourhood unit 100 sq m;
- Class C1 (Hotel) 84 bedroom (assumed to be 1,200 sq m);

A2.3 An Energy Centre comprising:

- 1 No. 150kWe gas fired CHP

Application of Guidance

A2.4 The information provided within the Air Quality Assessment notes the NOx emission rate from the CHP to be 0.0269 g/sec, with a NOx concentration of 250 mg/Nm^3. The operating hours of the CHP are not provided and no annual estimate of NOx emissions is given, nor if any abatement was included. If it is assumed that the CHP operates for 6000 hours per annum, this equates to a **Total Building NOx Emission** of **581.0 kg/annum**.

Table A2.4: Calculation of Benchmarked NOx Emissions Using Building Emissions Benchmarks for each Land-Use Category

Land Use	GFA (m^2)	Building Emissions Benchmarks (gNOx/m^2/annum)	Benchmarked Emissions (kgNOx/annum)
A1	4,580	22.6	104
C1	1,200	70.9	85.1
D1	100	75.0	7.50
Total Benchmarked Building Emissions			**196**

A2.5 The **Total Building NOx Emission** of **581 kg/annum** may be compared with the **Total Benchmarked Building NOx Emission** of **196 kg/annum**. As the building emission of NOx is higher than the benchmark further action will be required to tackle the **385 kg/annum excess NOx emissions**, either by on-site measures or by off-setting.

A2.6 Compliance with the GLA recommended emissions standard would reduce the **Total Building NOx Emission** to 232 kg/annum, but would still exceed the benchmark. Based on data derived from the AMEC report, the NOx concentration from the CHP could be reduced to 50 mg/Nm^3 by fitting SCR. This would effectively reduce the **Total Building NOx Emission** to 116.2 kg/annum, which would be below the benchmark of 196 kg/annum. No further abatement would be required. The annualised cost of the SCR is £3,600.

5) Conversion of Office Building to Residential Use

Available Information

A2.7 Conversion of 7,700 sqm of office space to provide 154 residential units (C3) in Outer London. The Transport Assessment provided AM and PM peak trip rates of 77 and 37 movements respectively.

Application of Guidance

A2.8 The Transport Assessment does not provide any conversion rates for peak hour to average daily flows, and does not state which hours were assumed. In the absence of this information a conversion based on DfT national traffic distributions by time of day was used to estimate the number of daily trips as 689. Using the average distance per trip in Outer London of 11.4 km (from Table 9), gives a total of 7854.6 km/day, or 2,866,929 km/annum. Applying the default emissions factors from Table 10 generates a **Total Transport Emissions** of **1,012 kg NOx/ annum** and **174 kg PM_{10}/ annum**.

The **TEBs** for this development are derived from the data shown in Table 11, multiplied by the number of dwellings, i.e. (154*1,553) = **239 kg NOx/ annum** and (154*267) = **41.1 kg PM_{10}/ annum**. The Total Transport Emissions are thus higher than the benchmark emissions and mitigation would be required.

5) Redevelopment of Land to Mixed-Use

Available Information

A2.9 Mixed use development in the CAZ comprising:

- 363 residential units (Class C3)
- Health centre facility (Class D1) 1,265 sqm GFA
- Retail units (Classes A1, A2, A3 and A4) 2,195 sqm GFA
- Sports centre (Class D2) 5,312 sqm

Application of Guidance

A2.10 The Transport Assessment provides a summary of 2-way trips by mode for the 12 hour period 0700-1900 hrs. These have been converted to AADT figures by applying a factor of 1.45 (as recommended for inner London sites in LAQM.TG(09)). The retail and health centre elements were assumed to serve the local development, and thus generate no additional trips. The calculated AADT trips are:

- Residential C3 – 731 trips/day
- Sports centre (D2) – 187 trips/day

A2.11 The calculation is as follows:

Residential Use (C3)

- The total trips/annum = 731*365 = 266,815

- The NOx emission factor is 0.4224 g/veh-km (from Table 10) and thus the **Residential Transport NOx** Emission is (266,815*0.4224) = **112.7 kg/annum**.
- The PM_{10} emission factor is 0.0733 g/veh-km (from Table 10) and thus the **Residential Transport NOx** Emission is (266,815*0.0733) = **19.6 kg/annum**.

Sports Centre (D2)

- The total trips/annum = 187*365 = 68,255
- The NOx emission factor is 0.4224 g/veh-km (from Table 10) and thus the **D2 Transport NOx** Emission is (68,255*0.4224) = **28.8 kg/annum**.
- The PM_{10} emission factor is 0.0733 g/veh-km (from Table 10) and thus the **D2 Transport PM_{10}** Emission is (68,255*0.0733) = **5.0 kg/annum**.

Development Emissions

- The **Total Transport NOx Emission** is calculated by adding the numbers together, i.e. 112.7 + 28.8 = **141.5 kg/annum**
- The **Total Transport PM_{10} Emission** is calculated by adding the numbers together, i.e. 19.6 + 5.0 = **24.6 kg/annum**

A2.12 The **Residential Transport Benchmark** for the entire development can be calculated by multiplying the benchmarks in Table 11 by the number of properties: for NOx it is (234*363) = 84.9 kg/annum, and for PM_{10} (40.7*363) = 14.8 kg/annum. There is no benchmark for D2 land use specified, and the developer will need to provide evidence as to the most suitable approach to take. If the B1 benchmark is applied, the **D2 Transport NOx Benchmark** for the entire development is (1.27*5,312) = 6.7 kg/annum, and the **D2 Transport PM_{10} Benchmark** for the entire development is (0.22*5,312) = 1.2 kg/annum. The Total Transport Benchmarks are thus (84.9 + 6.7) = **91.6 kg/annum for NOx** and (14.8 + 1.2) = **16.0 kg/annum for PM_{10}**. The development emissions are above the TEBs and further mitigation would be required.