GLAECONOMICS

London's environmental effectiveness - an update:
Comparing London with other English regions

Transport for London

LONDON DEVELOPMENT AGENCY

MAYOR OF LONDON

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Greater London Authority
July 2008

Published by
Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA
www.london.gov.uk
enquiries **020 7983 4000**
minicom **020 7983 4458**

ISBN: **978-1-84781-183-7**

Cover photograph

This publication is printed on recycled paper

For more information about this publication, please contact:
GLA Economics
telephone 020 7983 4922
email glaeconomics@london.gov.uk

GLA Economics provides expert advice and analysis on London's economy and the economic issues facing the capital. Data and analysis from GLA Economics form a basis for the policy and investment decisions facing the Mayor of London and the GLA group. The unit is funded by the Greater London Authority, Transport for London and the London Development Agency.

Contents

Foreword

It is vital that we cherish our city – its parks, suburbs, streets and town centres – and strive to make it cleaner and greener. This report from GLA Economics provides a vital steer for GLA Group policy development in this key area.

It is clear that urban living is desirable for most people. Indeed over half of the world's population now lives in towns and cities. The urban form brings many advantages – a large number and range of jobs; more productive working; opportunities for efficient public transport networks; a wide range of activities to enjoy in our leisure time – and, as this report shows, urban living is also environmentally effective.

However, London faces many daunting environmental challenges that need to be addressed. I will make use of my planning powers to improve the quality of local environments in London and tackle problems such as poor air quality, noise pollution and lack of accessible open spaces. I am encouraging urban greening – street trees and green roofs, for example – to make places more pleasant and to help adapt to climate change.

London suffers from high congestion levels that are impacting on our air quality through higher emissions from slow moving traffic. To remedy this I am working with Transport for London to determine if we can re-phase traffic lights to help reduce congestion levels in our city. I am also keen to enable Londoners to move around the city by pedal power, so I have prioritised investment in making cycling a more appealing option and increasing the number of cycle parks available.

As shown in this report, Londoners are keen to protect their environment and one way that I will help them to do so is by improving the way London deals with its waste; encouraging minimisation, recycling and more sustainable disposal methods.

One of the greatest threats that we face is from climate change and I will seek to make London an example to the world as a sustainable, green city. I have agreed that we will seek to reduce London's CO_2 emissions by 60 per cent from their 1990 levels by 2025. London's financial services will play a key role in achieving this target through the financing of new environmental technologies, the trading of carbon permits and new insurance products adapted to meet the needs of a changing climate. London is also leading the way in developing innovative clean tech start-ups. I will support London businesses in this role by ensuring that London has the infrastructural investment required to help them prosper.

I welcome this report as a baseline for the GLA Group, to be used as a monitor of the overall effectiveness of my programmes to improve London's environmental performance.

Boris Johnson
Mayor of London

Executive summary

The environment and its management has become an increasingly important issue in recent years. This report adds to this debate by considering how cities both impact the environment and the economy. Economists think about these issues by considering trade-offs between costs and benefits and this is the approach we take here for London. We believe this is even more important in the context of the current climate of slowing economic growth and the credit crunch.

The widely held assumption that cities are 'dirty' is a risky assumption which needs to be challenged. This report undertakes that analysis by looking at environmental effectiveness in the capital's transport, its commerce and industry and its households. Certain phases of economic growth can certainly be associated with heavy environmental costs but not all phases of economic growth are the same. But have cities such as London simply exported their emissions to other economies with less environmental regulation? Decentralising London would risk many of the agglomeration or scale economies which cities achieve and, therefore, the challenge for environmental policy is to protect and improve the London environment and quality of life without undermining the economic strengths of the city.

Different segments of the UK population also have varying attitudes towards the environment as well as different behaviours regarding energy consumption. However, London's environmental market segmentation is very distinctive when compared with other English regions. In particular, the relatively 'environmentally disinterested segment' which dominates some of the northern regions in England, is especially small in the capital. This means that the capital is a great place in which to seek to change environmental behaviours.

Overall results in the report suggest a confirmation of the previous GLA Economics' report on the environmental effectiveness of London's findings. Again, it finds that London uses fewer resources per unit of output generated and degrades the environment less than other English regions. Once again, there is some support for the suggestion that if London's population were to be more evenly spread across England as a whole, the result could be less effective in environmental terms than the current distribution. This is because in London we have a dense concentration of economic activity and any negative environmental impacts tend to be confined to a small geographical area. It is also the result of London's high-load and integrated public transport network.

In fact London has one of the most extensive and multi-modal transport networks and has also experienced the lowest growth in traffic of any of the English regions. Londoners also take fewer trips on average than their regional counterparts. That does not mean that there are not local issues with air pollution and rates of respiratory disease demonstrate some evidence of this.

As the UK economy as a whole has shifted from manufacturing to services the energy intensity of UK commerce and industry has declined. The results of our analysis here suggest that London is by far the most energy effective of the English regions in terms of its commercial and industrial energy use. Furthermore, thanks to strong regulation, London performs well on the recycling of construction and commercial waste. However, the service economy is posing new challenges. Over the 1990s, trends in the energy efficiency of new products were not mirrored in energy usage in new offices – at least in part due to the increased use of air conditioning units. However, far more attention is

now being given to building design in London than was formerly the case and this is evident in the 'green roofing' of offices.

The analysis of London households focuses on three core areas: energy consumption, household waste and domestic CO_2 emissions. The capital's density of flats tends to mean that it performs relatively well regarding household energy consumption. This is likely to improve further as new housing stock designed to better energy efficiency standards gradually replaces older, less-efficient housing stock. London's performance on household CO_2 emissions is also generally favourable. However, London's record on domestic recycling is currently poor – far behind many other English regions and also poor when compared with some other global cities.

By examining New York this report also begins an international comparison which data limitations have so far prohibited. London and New York are similarly sized cities facing similar growth and comparable problems. The two cities' carbon emission performance and sectoral composition are similar as well – with the exception of a greater proportion of carbon emissions coming from households in London.

The analysis does not consider London's wider role in the environment, which is also important. GLA Economics' 'Current Issues Note 19: The role of London's financial services sector in mitigating and adapting to climate change' demonstrated London's importance to carbon trading markets, financing new environmental technologies and to innovative insurance solutions focused on the environment.

Introduction

The environment is a matter that concerns everyone. Most if not all of us think that reducing the human environmental footprint will benefit all species, including our own in the long term. Economists are also human but they tend to have a rather different take on these issues than others. Their training leads to a consideration of costs as well as benefits and to a consideration of time frames. Both of these considerations were evident in the work presented in the Stern report[1], and the conclusion reached in that report on the need and effectiveness of early action rested strongly on the concept of balancing costs and benefits and on the way in which the future is evaluated.

This report builds on that approach and broadens some of the concepts into looking at the spatial distribution of activity within as well as between countries. Other parts of the GLA already focus on the environmental impact of London's activities. This report takes a distinctive approach in asking what the costs and benefits of such impacts might be in relation to the economy.

One way of thinking about this is to look at the environmental impact in terms of wealth and output. We need to understand whether there are economic costs of reducing environmental disbenefits and what scale these might be.

This is a standard approach in economics but is not always properly used. Indeed, it does not stand in isolation. Rather, it complements the range of other perspectives available with a particular 'economic' angle. The approach lends itself better to some elements of the environment than to others. For example, whilst it is possible to attach values to a loss of biodiversity, we would prefer to leave such calculations to experts in the field. However, many other elements of the environment – including energy consumption, transport emissions and water consumption can be analysed very well within such a context.

Fundamental to our approach is a need to overcome the perception that cities are 'dirty' whilst rural areas are 'green'. GLA Economics argues that we need to look at both sides of the equation: it is right to examine environmental degradation but it is equally right to look at wealth generated. What emerges from the analysis that follows in this report is that a strong, dynamic and economically successful city can go hand-in-hand with environmental improvement.

Another way of thinking about this is to consider a thought experiment. There are currently 60.6 million people in the UK[2]. Around 80 per cent of them live in cities or major towns[3]. If this population were to be spread out evenly across the country, it would mean a density of only 7.8 inhabitants per hectare. At these densities, an active economy would require far more travel than currently. Moreover, if this travel were not available, then the economy would probably start to shrink as trade became more difficult.

This report seeks to examine some of these trade-offs as a contribution to the debate on how most effectively to react to existing and projected climate change. It is by no means a complete and comprehensive coverage of all such issues, and does not provide

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[1] Sir Nicholas Stern – Stern Review on the Economics of Climate Change. The full report can be downloaded from the HM Treasury website www.hm-treasury.gov.uk/independent_reviews/ stern_review_economics_climate_change/stern_review_Report.cfm

[2] ONS, mid-year population estimates, 2006.

[3] The Department for Environment, Food and Rural Affairs (Defra) defines urban areas as those with over 10,000 inhabitants.

an analysis of all the costs and benefits of environmental impact within cities. Nonetheless it provides a useful starting point in thinking about some aspects of cities that may not always be considered.

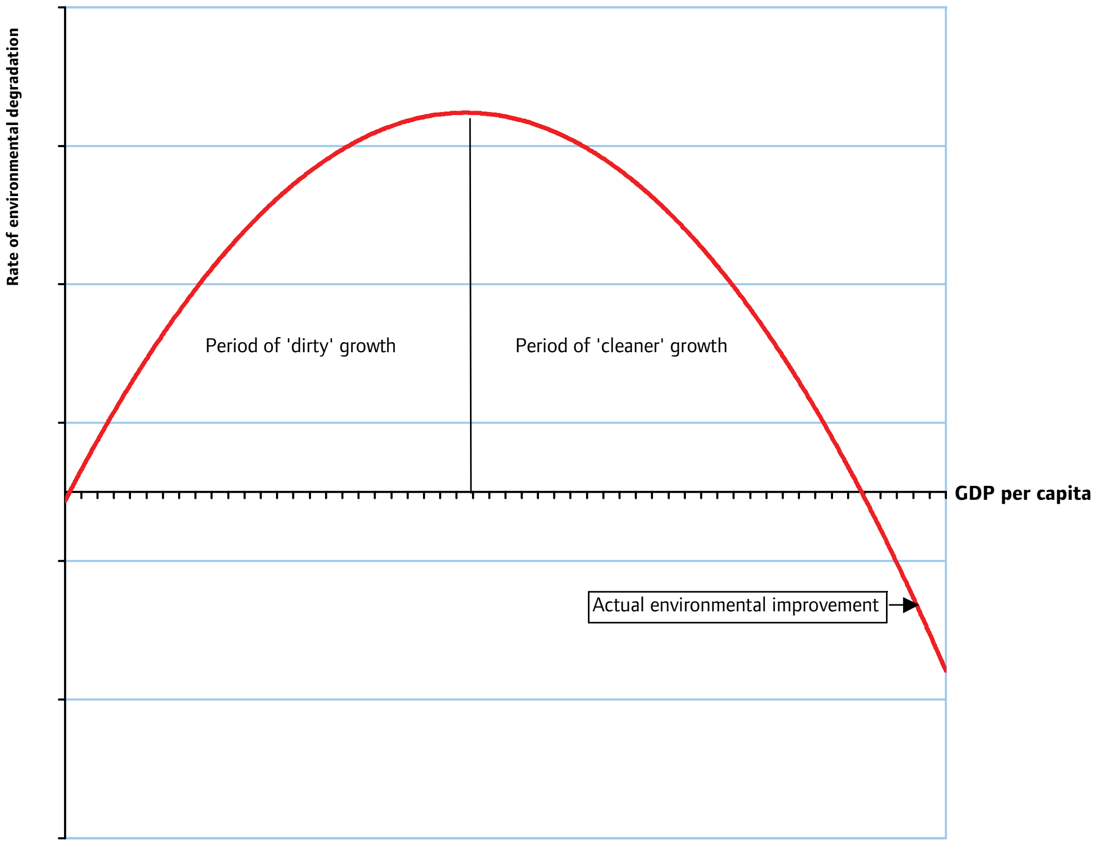
London's environment in the context of economic theory

The Environmental Kuznets Curve

Economic growth has traditionally been seen as having costs for the environment. However, not all phases of development of a country or a city have the same effects on the environment.

The Kuznets Curve[4] – originally designed for examining the effects of output growth on income inequalities – can be applied to the environment as well. In the early stages of growth an economy tends to focus on output *per se* without great regard for the environment. Environmental degradation accelerates over time until that economy arrives at a certain level of wealth. After that the rate of environmental degradation slows as growth becomes 'cleaner'.

Figure 0.1: Kuznets Environmental Curve relating GDP per capita to rates of environmental degradation



Source: Based on Kuznets (1955) / Panayotou (1993) / GLA Economics

Kuznets, S (1955) - Economic growth and income inequality. American Economic Review, 49: 1-28

Panayotou, T (1993) - Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working paper WP238 - Technology and employment programme, International Labour Ofice, Geneva.

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[4] Simon Kuznets won the Nobel Memorial Prize in 1971. Amongst his contributions to development economics was the realisation that developing countries today have different characteristics from those of the now developed economies during the Industrial Revolution.

The critical question is: what causes the turning point in the curve? There are several possible answers to this but they divide into 'market' and 'non-market' explanations. To start with the turning point could be driven by a shift in the sectoral composition of output. For example, most developed economies are now primarily service sector based and rely on imports for goods that require heavy manufacturing. The turning point could also be driven by the demands of members of that society demanding a better quality of environment, which might include phenomena such as 'green consumption'. Green consumption is where there are clear segments of the market in which consumers show a preference for 'greener' products driving 'green supply' by firms[5].

The other type of response is essentially 'non-market' in the form of regulation. Looking at the curve for emissions of sulphur dioxide (SO_2) in the UK, the 1956 Clean Air Act seems to mark the turning point although other pieces of legislation (such as the 1968 Clean Air Act or the Oslo Protocol) seem to have had far less obvious effect. Another possibility for the inflection in the curve is that it is driven by technological developments. These tend to mean that the same outputs can be generated using fewer inputs – including fewer energy inputs. Even if the turning point is in some way 'automatic', there may be policy interventions that could speed up when it takes place. Free market mechanisms will not lead to an optimum solution when the marginal benefits to the individual are widely different from the effect on society as a whole. This means that we have a situation where 'negative externalities' exist. The persistence of such negative externalities with regard to the environment leads to a logical rationale for public sector intervention. However, we also have to be careful about assuming that 'Government knows best' as well-meaning policy actions can have quite unintended detrimental consequences.

Of course, not all aspects of the economy behave in the same way as this model suggests. Emissions such as SO_2 seem to fit quite well with the Kuznets Environmental Curve, whilst some other environmental indicators, such as ecological footprint, do not[6]. In addition such models do not take account of the possibility that once certain thresholds are hit, some elements of environmental degradation may not actually be reversible[7].

Accepting that some components of the turning point might be driven by a combination of policy intervention and public demand, the two 'economic' drivers are technological change and sectoral composition of output. This poses some problems if our perspective is a global one.

Whilst London might well be on a downward section of the inverted 'U' curve, urban areas in the developing world may well be on the upwards section, particularly if they are focused on the manufacturing sector both for export markets and for a burgeoning domestic population. Since CO_2[8]-induced warming is a global phenomenon we should

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[5] For a brief overview of green production, green consumption and green supply, see 'Green cities: environmental challenges posed by urban growth' – M. E. Kahn (2005).

[6] Ecological footprints show a strong, positive correlation with average levels of wealth in an economy.

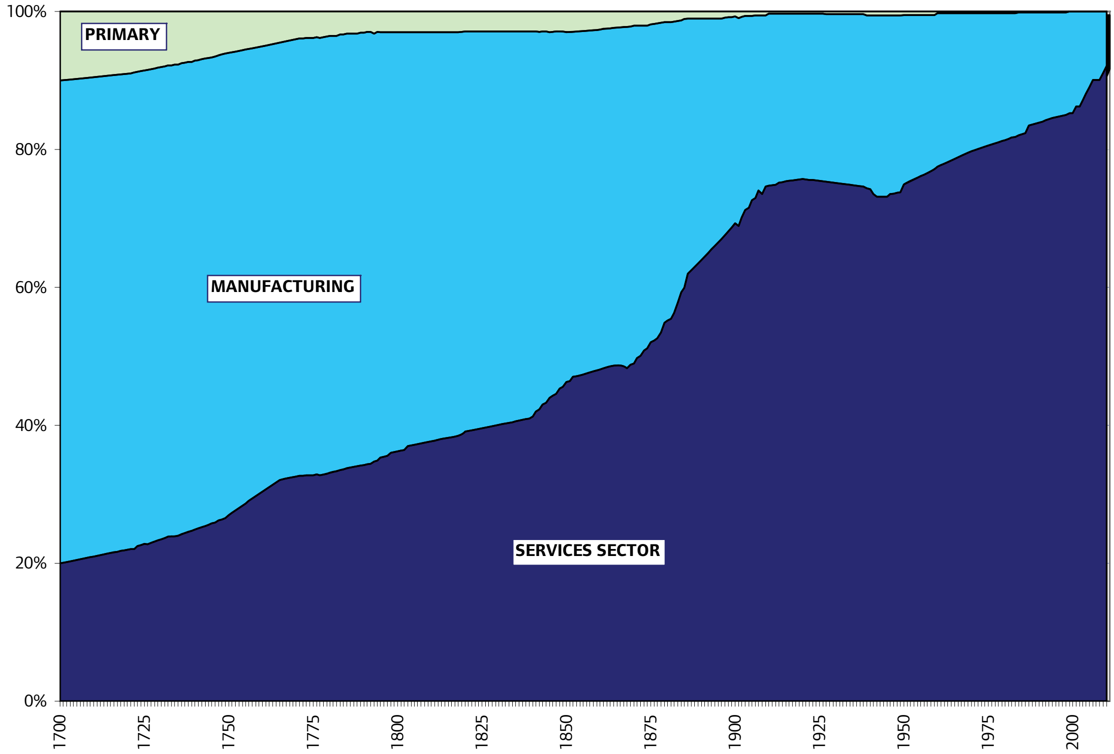
[7] Traditionally, such criticism tended to focus on issues such as biodiversity depletion. However, recent developments in climate science emphasise thresholds beyond which global warming might be 'irreversible' K. Baumert et al (1995) "Navigating the Numbers: Greenhouse Gas Data and International Climate Policy".

[8] Greenhouse gases are gases in the atmosphere that reduce the loss of heat into space thereby resulting in an increase in global temperatures. Other than carbon dioxide (CO_2) greenhouse gases include: methane (CH_4), nitrous oxide (N_2O), hydroflourocarbons and perflourocarbons and sulphur hexaflouride. Although these gases are emitted in lower quantities they can still have dramatic effects as they have higher 'global warming potentials' than CO_2. In addition water vapour plays an important part in the greenhouse effect.

be concerned about total emissions and not just about the country or city from which they are released. More optimistically, technological improvements should mean that those producers would manufacture more environmentally effectively than the UK did at the height of the Industrial Revolution. Set against that is the counter-argument that the world's population[9] has never been so great and many new people are now presented with the opportunity of being global consumers. In other words, unit environmental costs might be falling but total environmental costs could still be rising.

Figure 0.2 shows how Inner London's employment base has changed over the last 300 years with a critical switch of focus between manufacturing and tertiary industries taking place in the latter part of the nineteenth century.

Figure 0.2: 'Inner' London's changing employment composition[10] 1700-2008



Source: These trends have been estimated based on England and Wales Censuses and ONS Annual Business Inquiry (ABI) as well as 'A century of labour market change' (Labour Market Trends, ONS 2003) and 'The occupational structure of England 1750-1871 - some preliminary results' (Leigh Shaw-Taylor, Cambridge Group for the History of Population and Social Structure, Department of Geography, University of Cambridge). The last of these is not a paper as such but preliminary findings from an ongoing ESRC-supported study presented at Yale University in April 2005.

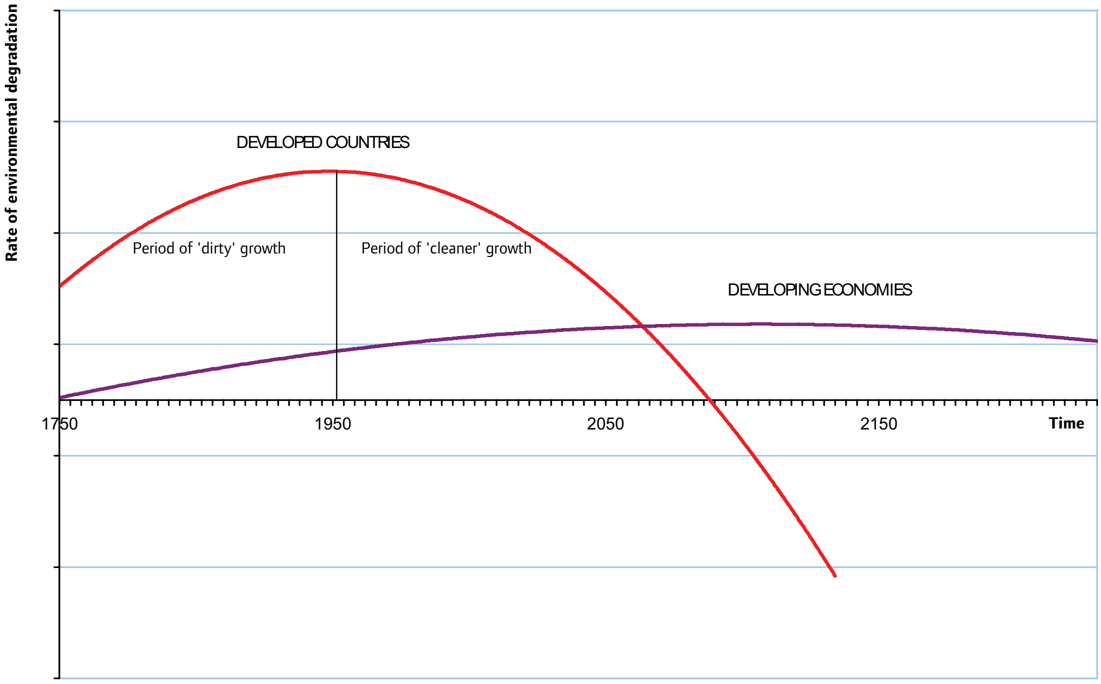
- Given the urban nature of London it is unsurprising that London has always had greater employment in the services sector and less employment in primary industries (farming, fishing, mining) than England as a whole.

[9] The US Census Bureau estimates global population at the time of going to print at 6.71 billion. Other estimates from the Office of Population Research at Princetown University and Worldometers suggest that world population as at July 2008 was around 6.68 billion. Global population did not arrive at the 2 billion mark until 1927 but by 1974 it had doubled to 4 billion. UN data suggest that it can be expected to hit 8 billion around 2024. Although the rate of increase has slowed markedly since 1963, peak global population at around 9.2 billion is not expected until the year 2075.

[10] By London here the old County of London (which existed from 1888 to the formation of the GLC in 1964) is implied. This is broadly the equivalent area to that covered by the former Inner London Education Authority (ILEA).

- Employment is shown, as it is easier to develop estimates than for output[11]. Nationally, manufacturing declined from 28 per cent of output in 1901 to 22 per cent of output in 2001 and has fallen further since.
- London's service sector first accounted for 50 per cent of employment in the early 1880s – earlier than in the rest of England.

Figure 0.3: Hypothetical Kuznets Environmental Curves for developed and developing countries under a scenario of improved production technologies



Source: Based on Kuznets (1955) / Panayotou (1993) / GLA Economics

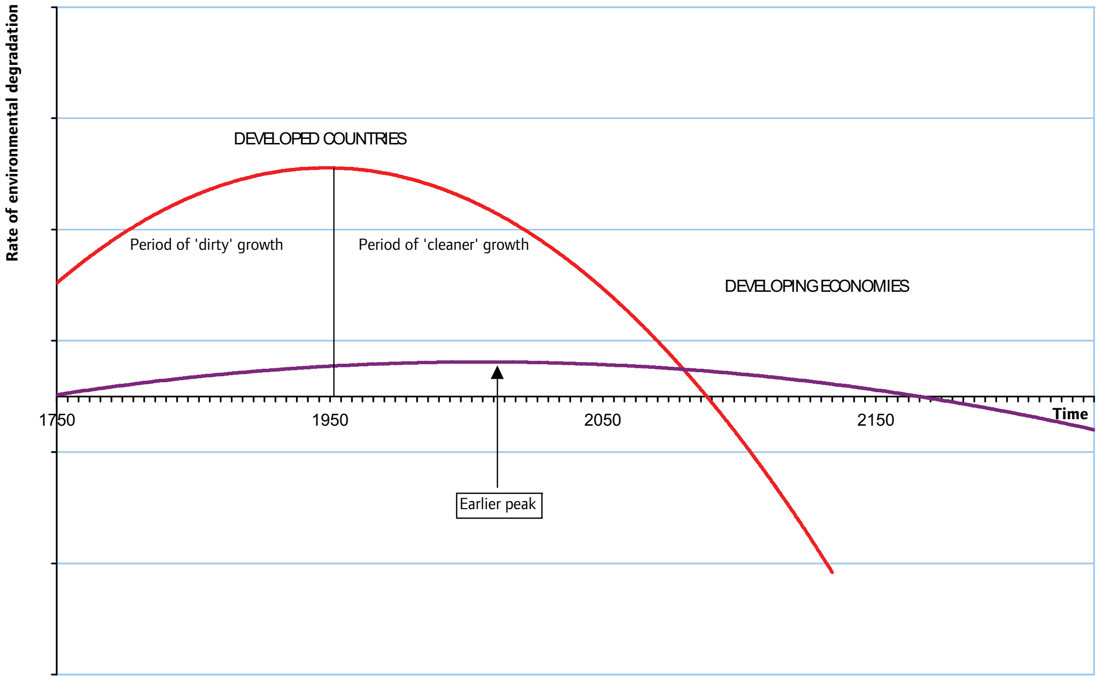
Kuznets, S (1955) - Economic growth and income inequality. American Economic Review, 49: 1-28

Panayotou, T (1993) - Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working paper WP238 - Technology and employment programme, International Labour Ofice, Geneva.

Another possibility for the turning point in the curve is that developing economies will have a stronger base of information about the consequences of a failure to reduce their rates of environmental degradation and will therefore have greater motivation to encourage – either through incentives or through regulation – an earlier peak in their Environmental Kuznets Curve. This would result in not only a lower curve but also one with a visible shift to the left. Representatives of the developed economies and cities within them could play a major role in this by demonstrating the importance of cleaner public transport systems, the opportunities for joint ventures in environmental technologies and the use of the most efficient available technologies.

[11] The employment structure of much of the nineteenth century can be estimated from job titles on the Censuses although this is subject to certain biases.

Figure 0.4: Hypothetical Kuznets Environmental Curves under a 'downward and to the left' scenario for the developing world



Source: Based on Kuznets (1955) / Panayotou (1993) / GLA Economics

Kuznets, S (1955) - Economic growth and income inequality. American Economic Review, 49: 1-28

Panayotou, T (1993) - Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working paper WP238 - Technology and employment programme, International Labour Ofice, Geneva.

Geography, responsibility and the pollution haven hypothesis

It is to be hoped that the Environmental Kuznets Curves for the rapidly developing economies are really being shifted downwards and to the left. London no longer has much manufacturing but Londoners – and people in other parts of the UK – continue to consume manufactured goods. In fact their consumption of manufactured goods has increased as real disposable incomes have increased[12]. The vast majority of these goods are now manufactured overseas, usually in lower cost locations and often in areas with weaker environmental protection. There are often additional energy inputs required as a result of longer distance transportation and in terms of lower levels of energy efficiency in foreign plants[13].

Recently, an additional influence has come through the Clean Development Mechanism (CDM) of the EU Emissions Trading Scheme (EU-ETS). The idea of the CDM is for greenhouse gas emissions to be cut most efficiently by focusing those reductions where costs are lower than in the industrialised countries. In fact CDM has been concentrated in a relatively small number of rapidly developing economies: nearly 70 per cent of reductions in greenhouse gases under CDM to date have taken place in China, India or

[12] Whilst real disposable incomes in the UK are being squeezed at the time of writing this report, longer-term forecasts are for the continued expansion of real disposable incomes.
[13] According to the OECD / IEA (2007), global industrial energy use has grown by 61 per cent between 1971 and 2004 with much of the change taking place in the rapidly developing economies – four fifths of growth being sourced to China. The adoption of advanced technologies already in commercial use could improve the energy efficiency of global manufacturing dramatically. Their findings demonstrate that the potential technical energy savings could be as high as 37 exajoules per year, equivalent to 900 million tonnes of oil.

Brazil. The record of CDM to date is difficult to assess, not least because of the problems associated with excessive payments for hydrofluorocarbon refrigerant reductions[14].

A wider issue remains which is often known as the 'pollution haven hypothesis'. Essentially this states that gains in sustainability in countries such as the UK are markedly overstated because their environmental degradation has simply been exported elsewhere. In fact the empirical evidence for this hypothesis is rather weak. Firms 'offshore' for all sorts of reasons and weak environmental regulation tends not to be one of the key factors in locational choice[15]. Relative wages are likely to be a stronger driving force, as 'dirty work' associated with dirty plants is usually low-paid work in developing countries, whereas in countries such as the UK it tends to attract a premium on account of only a small proportion of the workforce being willing to undertake such work. However, Kahn[16] shows that the embedded energy in imports into the United States has fallen dramatically and this suggests that these goods are being produced more energy-effectively, even with production located in other countries.

Of course, businesses from the developed world have the opportunity to promote 'better practice' in the developing world – both socially and environmentally. The public sector has a role to play through both ethical procurement and quality standard marks. However, London itself can play a very important role via investment funds.

Urbanisation, concentration and productivity

In the developed world around three quarters of the population now live in cities – and an even higher proportion in the Functional Urban Regions[17] of major cities. In the developing world, cities are growing at very rapid rates and not always with great attention to the environmental costs. Urbanisation has proved itself to be strongly associated with increased productivity and higher rates of economic growth. The challenge for policy makers is to find ways to make cities more sustainable without jeopardising the very rationale for cities. That may mean that some policies such as decentralisation are simply inappropriate. In fact what may be needed is greater concentration of economic activity, which at the same time as generating increased agglomeration benefits will also help to reduce the tendency for cities to sprawl out beyond their peripheries. This report will demonstrate how one city – London – by bringing people and businesses into close proximity to one another, generates agglomeration benefits that are not just economically effective, but environmentally effective as well.

None of this denies the fact that there are potential 'diseconomies' of scale in cities such as congestion, poor air quality, exacerbated property prices and pressures on public service provision. Cities do have to adapt to these challenges and adapt to the

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[14] Many non-Annex I countries with refrigerant producing plants (including China) were able to earn substantial amounts from CDM by 'scrubbing' a hydofluorocarbon, HFC-23, relatively cheaply. This meant that sometimes they were earning more through CDM than through the sale of their product. EU-ETS has subsequently acted against such schemes.

[15] See for example, T. Panayotou – 'Globalization and the environment', CID Working Paper 53, Harvard (2000).

[16] M.E. Kahn – ibid.

[17] The idea of Functional Urban Regions or FURs arose out of attempts to delimit European cities for the purpose of calculating economic indicators that would be comparable between 'city-regions'. This is often not the case if existing administrative boundaries are used since these are often based on historical boundaries or represent administrative compromises. The boundaries of FURs are drawn so as to emulate the boundaries of self-contained regional economies. An excellent case in point would be the NUTS 1 boundary of Greater London that takes no account of the substantial numbers of people who work in London, but who commute to work from outside the administrative boundary.

additional challenges posed by global climate change but removing the agglomeration benefits of London cannot be the answer to the environmental question. So, exactly what are these benefits from agglomeration and why do they matter?

Economies of scale and the environment

(Cities) *"can capitalise on economies of scale in developing 'green' investments, such as public transit, sewers and water systems… Nations that concentrate residents in mega-cities can reduce the average cost of providing such basic services to residents relative to nations where the population is scattered across many smaller cities."*[18]

The first group of benefits which are at risk from strategies advancing the decentralisation of (or from) London are the economies of scale that have provided London with the opportunity to develop the extensive, high-quality, relatively cheap public transport network. The efficiency of London's network is predicated upon London's high population densities. 'Decentralising' London would mean that many parts of the network would fail to maintain high load factors and simply become unviable – or require subsidy. An extreme form of the effects of low population densities can be seen in very rural areas of the UK. Bus services there are infrequent, destinations limited and costs often prohibitively expensive even when heavily subsidised by County Councils. Given the restricted public transport network, those who can afford to often then choose to travel by private car.

A decentralised London would also lose many other benefits of agglomeration[19]. Preferences exist over a wide variety of locational types for the phenomenon of co-location of specific economic activities. There are a number of explanations for this going back to the theories of Alfred Marshall (1842-1924)[20]. His work focused on access to raw materials and intermediate goods and the availability of labour. In effect, these are directly costed reductions in the costs of production. However, it also posited the idea that individuals might learn off one another creating 'spillover', precursing modern technology and skills transfer theory. As modern economics has developed, theories have been more careful to distinguish between 'localisation economies' (associated with an area's specialisation around a particular sector) and 'urbanisation economies' (dependent on urban thresholds of population and employment as well as the diversity of urban productive structure)[21]. This can mean that a city such as London can not only benefit from something in which it specialises – such as 'high level' financial services – but also from increased returns to scale in the majority of its sectors[22].

In the mid-1980s a series of economic models, which can be broadly grouped as 'endogenous growth models', challenged the received wisdom which suggested that scale economies ran out quite readily. Robert Lucas' model emphasised the importance of 'human capital' in endogenising growth[23]. Productivity gains in one firm spilled over into the economy as a whole. Similarly, the Romer model emphasised investment in

[18] Kahn, ibid.
[19] For an overview of the mechanisms of agglomeration, see Chapter 3 in 'Why distance doesn't die: agglomeration and its benefits' – Ormerod, Cook and Rosewell, Volterra Consulting / GLA Economics (2006)
[20] See A. Marshall – 'Principles of economics' (1890)
[21] See for example: 'Urban diversity and economic growth' – J Quigley, Journal of Economic Perspectives 12 127-138 (1998) and 'Agglomeration economies and industrial location: city-level evidence' – E. Viladecans-Marsal, Journal of Economic Geography 4 565-582 (2004).
[22] These specialisms, combined with opportunities for interaction, have also given London the scope to be a world leader in areas such as carbon trading and as an investment market for cutting-edge environmental technology financing.
[23] R. E. Lucas, 'On the mechanics of economic development', Journal of Monetary Economics, 22, 3-42.

'knowledge capital' generating new designs and new products and services[24]. Whilst the exact specifications of various endogenous growth models vary, many emphasise the importance of innovation in achieving sustainable growth.

At broadly the same time many commentators suggested that the rapidly expanding range of communications technology modes – especially those associated with computers and the Internet – would gradually put an end to the need for co-location – and, by implication, the need for cities[25]. Cities in Western Europe had been experiencing counterurbanisation since the beginning of the post-War period and it seemed to many that - whilst it might remain difficult for 'high level' businesses to thrive in very remote locations – sectors such as financial services might do as well in rural Dorset as in the City or Canary Wharf.

It is evident that this has not happened: cities have not died. In fact, the UK's 'high productivity' economic activity has become even more concentrated in the London area. Why? The fact that new Information and Communications Technology (ICT) has not created the 'footloose' spatial patterns that many envisaged does not mean that it has been space-neutral. Increased use of ICT has created greater opportunities for outsourcing and enabled the shortening of value chains by eliminating wholesale activities in particular places[26]. However, those commentators who argued that knowledge in the future would be transmitted through ICT were only focusing on knowledge that was easily codified. Other types of 'tacit' knowledge exist which are critical to innovation processes and which rely on observation, practice and active participation. Cities still favour the advancement and diffusion of these types of knowledge. Such types of knowledge are a resource, creating spillovers and increasing returns to scale in urban economies. Economies such as China are rapidly recognising that urbanisation is related closely to an economy being able to produce an increased amount of output for any given level of technology and resources[27].

None of this infers that for a city to be concerned about the environment is in any way negative. Indeed, other things being equal, congestion, high property costs, crime and the local environment are all factors which can limit the productive advantages and profitability of businesses and make cities less desirable places in which to live[28]. Therefore mitigation of such problems corresponds with the removal of various constraints on continued growth. They are, in effect, 'diseconomies of scale'. A city should only continue to grow if such diseconomies are outweighed by the benefits of further growth.

'Suburbanisation' versus 'densification'

Another aspect of this is ***how*** and ***where*** cities grow. A phenomenon of much of the early post-War period was suburbanisation and sprawl. 'Sprawl' tends to be used pejoratively with connotations of being irregular and unplanned. In fact most suburbanisation has been highly planned[29] from rehousing London's population after

[24] See Romer, 'Increasing returns and long-run growth', Journal of Political Economy, 94, 1002-1037 (1986) or Romer, 'Human capital and growth: theory and evidence', Carnegie-Rochester Conference Series on Public Policy, 32, 251-286 (1990).
[25] Some of these publications were aimed at a wide market such as Frances Cairncross' 'The death of distance: how the communications revolution is changing our lives' (2001).
[26] 'Death of distance and agglomeration forces of firms in the urban e-economy' – van Geenhuizen and Nijkamp.
[27] See 'Urbanisation and population relocation', Guanzhong James Wen.
[28] 'The effects of agglomeration on economic activity: the empirical evidence on mechanisms and magnitudes' – R. Crawford (2006).
[29] Particularly under the New Towns Act 1946, the Town and Country Planning Act 1947 and the proposals for London's Green Belt laid out by the Greater London Regional Planning Committee in 1935 and the Abercrombie Greater London Plan of 1944.

World War 2 to the New Towns and the Green Belt in response to many people's desire to live in lower density development and to increased car ownership.

One way of looking at the issues raised in this report is to ask whether large, dense cities are more environmentally effective than the centrifugal trends of dispersal of populations that seemed to be dominating during the 1970s. However, in reality the picture is more complicated than this. London has been gaining in population and increasing in density since the early 1990s but there has been no 'matching trade-off' in terms of a reduction in population in London's suburbanised 'commuter belt'. From New Towns such as Milton Keynes, Bracknell and Crawley to substantial 'M25 fringe' towns such as Slough and Thurrock to formerly very rural areas further out, such as East Cambridgeshire and the Test Valley, there has been population growth often at percentage rates higher than within London itself. Local air quality in such places is often substantially better than in London in spite of general reliance on private vehicle transport. We also need to keep in mind that such trends have been – and continue to be – a reflection of individual choices and aspirations which democracy aims to permit.

More recently the focus of planning guidance has been on concentrating development at increased densities in the central areas of cities – particularly around transport hubs – and on redeveloping Brownfield land.

The analysis that follows in this report examines London's environment from these perspectives. The environment poses many considerable challenges for London. However, one of the most complicated will be improving the urban environment without losing the gains London makes through concentration and co-location. The risk is that policies that inadvertently reduce economies of scale alter the balance between 'economies' and 'diseconomies' in cities in an unfavourable way. As a result, whilst the motivations are no doubt well intentioned, cities actually become less attractive places to live and do business. On the other hand, failing to respond to environmental problems increases the diseconomies and again makes cities less attractive. The real challenge must be to reduce the diseconomies whilst maintaining or increasing the benefits of agglomeration.

Therefore, the approach taken by this study is rather different from many other environmental reports[30]. It looks at both sides of the equation: the state of London's environment ***and*** the output achieved in London from the use of resources.

Environmental market segmentation

The third starting point for the study comes from the idea of market segmentation and the opportunity to apply this to the environment. This has been attempted by numerous studies and should help policy makers to identify target audiences for their key message. Here we start with studies at the EU level and work down towards London's local population. Important to our understanding of London is that, in terms of environmental attitudes it is neither similar to the UK as a whole nor to Europe as a whole.

[30] Some of these studies will be mentioned specifically later in this report.

Attitudes towards the environment in the UK and the EU

A special Eurobarometer survey published in March 2008 investigates attitudes of EU citizens towards the environment[31]. It parallels work undertaken in both 2004 and 2002. This shows that EU citizens attach great importance to the protection of the environment. Since 2004 climate change has become the single most cited environmental issue about which people are worried – named by 57 per cent of EU citizens as amongst their five foremost environmental concerns. In 2004 both water pollution and man-made disasters ranked higher.

However, the UK is not entirely typical of the aggregated EU picture. There are some 'external' reasons for this. For example, countries in the new member states of Eastern Europe often have very different views from those in Western Europe. However, there are some clear messages from the UK citizens' responses. UK 'distinctiveness' in terms of attitudes can be summarised as follows:

- A relatively high proportion of respondents in the UK associated urban pollution and climate change with the word 'environment' rather than with protecting nature or with pleasant landscapes.
- Climate change was the single most frequently cited 'worry', as it was in the EU as a whole, but air pollution, chemicals in products and growing levels of waste were all given higher levels of relative importance than in the EU as a whole.
- UK citizens tended to feel that 'quality of life' was less influenced by the environment than citizens of most other countries. However, the same pattern was also evident for economic and social factors.
- UK citizens tended to be slightly more likely to modify their behaviour by taking actions designed to reduce the environmental impacts of their consumption.
- The results were also consistent with the findings of other studies which suggest there is a belief that recycling is having a greater effect on reducing their environmental impact than it actually does.
- The willingness to purchase ecologically 'friendly' products for daily needs seemed to be markedly lower than for the EU as a whole. In fact the proportion of citizens citing this as one of their top three priorities was the lowest of any of the 27 member states.
- UK citizens were more aware that as individuals they could play a part in protecting the environment.
- There was a slightly lower degree of support for the 'polluter pays' principle in the UK than for the EU as a whole.
- By far the most distinctive aspect to the UK response was that a significantly lower proportion of citizens believed that decisions about protecting the environment should be made jointly at the EU level. However, the EU still had a narrow majority over decisions being made by national governments alone. However, when asked whether European environmental legislation was necessary, only 26 per cent said that they totally agreed with the statement compared to 40 per cent across the EU as a whole.
- UK citizens were also less keen that the EU should assist 'non-European' (i.e. non-EU) countries in improving their environments.

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[31] Attitudes of European citizens towards the environment – Special Eurobaromoter 295 / Wave 68.2 (European Commission), March 2008. The survey was undertaken across 26 of the 27 member states during November and December 2007 and in Austria between November 2007 and January 2008. The 2007 work was based on a sample of more than 26,000 respondents across the EU with more than 1,300 of those being in the UK.

- They were also less keen to see the EU allocate more funds to the environment at the expense of other areas. However, 71 per cent of UK respondents still either 'totally agreed' or 'tended to agree' with the statement.
- Countries that in 2004 believed they had good access to information about the environment tended to see a rise in satisfaction about information. These countries included the UK and much of northwest Europe. Conversely many in the new member states and in the Mediterranean countries felt that access to information about the environment had declined since 2004.
- In the 2004 survey, environmental organisations were the most trusted source of information. In particular, people did not trust private companies for information but they were also sceptical about the role of local and regional government. That was even more the case in the UK.

Attitudes in England

Defra also conducts surveys on attitudes and behaviours towards the environment focusing solely on England. The 2007 survey[32] suggests that the public views the environment as the fourth most important issue of the day with which the UK Government should be dealing[33]. People seem to be aware that they are going to have to change some aspects of their lifestyles. Two thirds of people believe that humans are capable of finding ways to overcome global environmental problems but less than one in five respondents agreed that scientists would be able to find a solution to global warming without people having to make 'big changes' in their lifestyles. However, although 60 per cent of people believe many people will be able and willing to recycle more, less than one in five thinks many people will be willing to use their cars less or fly less, even though they recognise the impact of these activities on the environment.

The results of the survey are potentially contradictory when combined with the EU survey on potential purchases of environmentally friendly products. In the Defra survey 45 per cent suggested that they would be prepared to pay more for such products. However, in the EU survey only 12 per cent of UK citizens suggested that it should be amongst the top three national environmental priorities compared to 23 per cent across the EU. However, in the same EU survey, 23 per cent of UK citizens said that they had bought environmentally friendly products marked with an environmental label over the preceding month compared to only 17 per cent across the EU as a whole[34].

The environmentally disinterested segment

In the same Defra survey, around one in four people (in each case) agreed with the following statements:

- *I don't believe my behaviour and everyday lifestyle contribute to climate change.*
- *The environment is a low priority for me compared with a lot of other things in my life.*

The suggestion is that this one in four corresponds with a group within English society that is 'environmentally disinterested'. In fact, the first statement can be made independently without a major effect on attitudes to the environment as a whole. However, the one in four proportion does tie in relatively well with the most

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[32] Survey of public attitudes and behaviours toward the environment – Defra/National Statistics, August 2007.
[33] Ranked higher were crime, health and education.
[34] As well as slightly different question wording in the survey there is also the issue of 'Fair Trade' products which around 45 per cent of the Defra England sample made an effort to purchase.

disinterested segment of the attitudes matrix that is outlined in the next section of the report.

It may prove difficult to change the behaviours of those who make the environment a 'low priority'. However, there are still many areas in which knowledge, information and understanding are limited amongst far more environmentally interested segments of the population. For example, work by the Energy Savings Trust[35] has shown that eight out of ten people in Britain do not know what they are paying for their gas and electricity. That same study shows that around half would be interested in having a smart meter and would use it to attempt to monitor and reduce their consumption of energy.

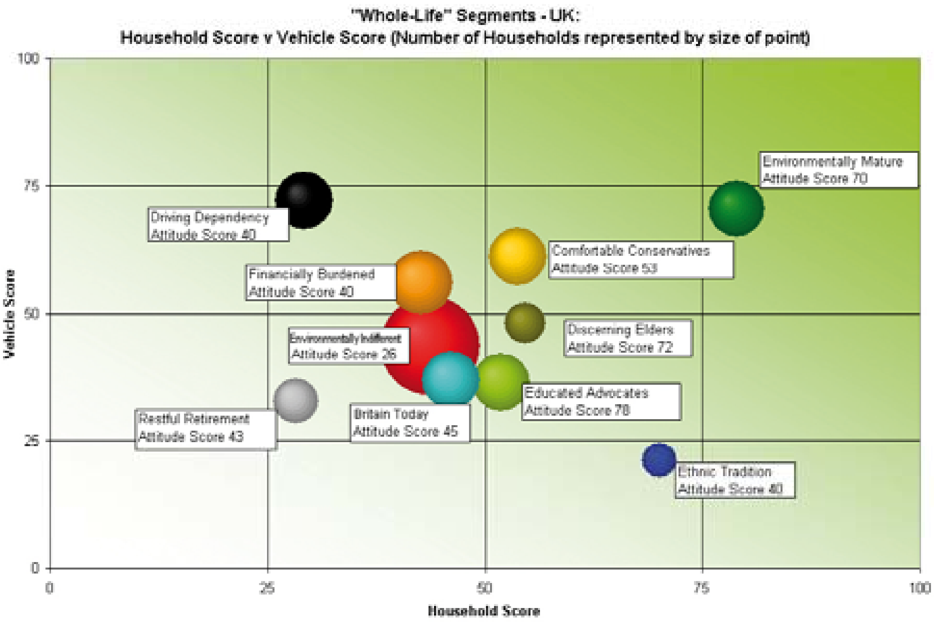
None of the above research brings to the fore one key aspect of the national picture: namely that the people who might be most interested in reducing their environmental impact are often those who currently have a high environmental impact generated by their affluent lifestyle.

A separate Defra report[36] pulls together evidence on public understanding, attitudes and behaviours; identifying behavioural goals and drawing conclusions on the potential for change across a range of behaviour groups. Defra uses different population segments (seven of them) with similar ideas behind them from 'positive greens' at one end and the 'honestly disengaged' and 'stalled starters' at the other. Segment '7', the honestly disengaged is not likely to adopt any of Defra's targets. Segment 1, the positive green segment, in contrast, is likely to find all bar one of the targets acceptable. In Defra's segmentation strategy the positive greens are identified not only as willing to do more but also as having the greatest potential to do more.

The EST market segmentation – a case study

The following analysis outlines a market segmentation created for the Energy Saving Trust that is being used by some parts of the London administration.

Figure 0.5: The EST market segmentation matrix



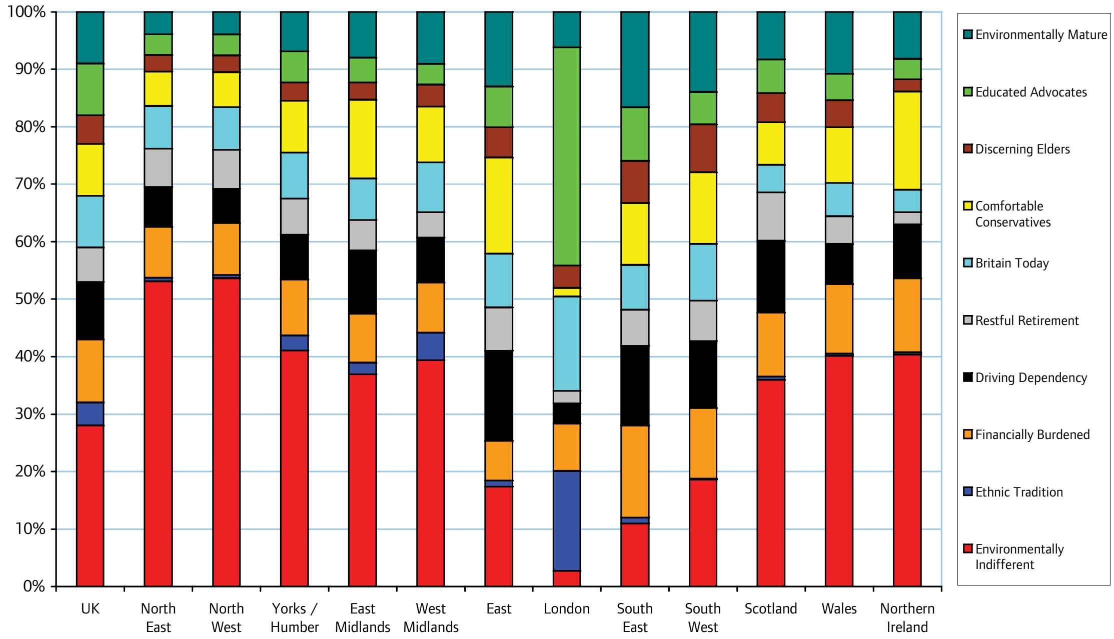
Source: EST

[35] EST – Green Barometer IV.
[36] A framework for pro-environmental behaviours – Defra, January 2008.

Like the Defra framework for pro-environmental behaviours, the market segmentation matrix[37] for the UK shows that groups who are most responsible for carbon emissions are also the most likely to be concerned about environmental issues. The matrix provides a useful guide for national policy. However, the individual regional pictures can be very different. Critical to the overall UK picture is a segment known as 'environmentally mature' (dark green). These are rich, affluent couples, living in large detached houses. They are big consumers of both household and vehicle energy but they are also well educated and understand the issues around climate change. At the other end of the scale are those who are 'environmentally indifferent' (red). These people are either poorer families or elderly couples living in local authority or ex-local authority accommodation. Their focus is on making ends meet and therefore they tend to have a low level of environmental concern.

However, neither of these two segments is a very large group in the composition of Greater London. The 'environmentally mature' are most significant in the South East where they constitute 16.6 per cent of population, whilst the 'environmentally indifferent' are the largest group in the regions of the North and Midlands, constituting around 53 per cent of the North East's and North West's demographic make-up[38].

Figure 0.6: Regional composition by EST environmental segment



Source: EST/Daily Telegraph

As can be seen in Figure 0.6, London shows particular concentrations of three groups relative to the other regions. The first of these is 'ethnic tradition' reflecting London's diverse ethnic mix[39]. Secondly, London has a relatively high share of 'Britain Today', a mid-market grouping with relatively little scope for reductions in CO_2. However, the third concentration is the key target in London: 'educated advocates' who are young urban professionals frequently in shared accommodation. One problem about this target group from a regional perspective is that it tends to be relatively mobile and a

[37] For the characteristics of each segment see Appendix 1.
[38] Note that some segments are more likely to live in larger households. Therefore, regional compositions differ by population and household structure. Both compositions are presented in Appendix 1.
[39] Typically, household size tends to be above average for this segment. This means that whilst vehicle energy use for the segment is low, household energy use is high. However, if the data were presented on a per capita basis, this would be unlikely to remain the case.

significant share of it will move out of London at some point to become 'environmentally mature'.

Whilst a key segment of the national strategy constitutes a particularly small proportion of Londoners, the fact that the environmentally disengaged constitute a very small proportion of Londoners – in contrast to their large share in some other regions – suggests that on the environmental front, things can be achieved most effectively in London. The fact that one of the city's most prominent advocate groups may tend to migrate away from London later in life can also be seen in a positive light; they will tend to be replaced by similar members of the segment whilst exporting positive messages to other regions – as well as to parts of the world outside the UK altogether.

Chapter 1: The basis for comparison

The following chapters update the information contained in GLA Economics' previous report on London's environmental effectiveness in the summer of 2005. That report broke new ground showing that the common portrayal of cities as being heavily polluted, dirty places where commerce and industry ensure that the demands of the environment are forced to take a back seat, is not an accurate description of the modern metropolis. On account of limited international data, it compared London with the eight other English regions and found the most environmentally effective of them to be the capital.

It was found that London used fewer resources and degraded the environment less than other regions. Therefore there was some support for the suggestion that had London's population been spread more evenly across England as a whole, the result would have been less effective in environmental terms. London's high level of productivity – which outstrips all the other eight regions – turned out to be effective not just in economic terms but also in environmental terms.

This report's primary objective is to update that study and to set it within a framework of economic theory but it also modifies the approach in some sections. In updating the information it does not pretend that there are not other approaches to assessing environmental effectiveness but this is the only current approach which takes account of the other side of the equation: namely, what output is produced from the depletion of environmental resources.[40]

London is England's most densely populated region at around 14 times the density of the average of the other eight English regions, and twelve times the density of England as a whole. A whole range of household and socio-demographic factors affect a region's environmental effectiveness and London is particularly atypical when compared to the other English regions.

City life is often associated with crowding, congestion and living in small spaces. This has an almost inevitable impact on air quality, water resources and energy consumption. Some health evidence also suggests that those living in urban areas suffer lower levels of health.

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[40] A recent study by Yale University, sponsored by European Commission and Columbia University, shows GDP to be the strongest single driver of environmental wellbeing globally.

Table 1.1: Key regional population, area and output statistics

	Population	Area	Density	GVA - workplace based
	2006 millions (ONS)	Million ha.	People per ha.	£ million (ONS provisional, 2006)
North East	2.56	0.87	2.94	38,788
North West	6.85	1.49	4.59	111,252
Yorkshire and the Humber	5.14	1.56	3.30	82,116
East Midlands	4.36	1.58	2.76	74,113
West Midlands	5.37	1.30	4.13	88,997
East of England	5.61	1.96	2.87	98,967
London	7.51	0.16	47.25	217,549
South East	8.24	1.94	4.24	167,356
South West	5.12	2.44	2.10	89,501
England	**50.76**	**13.29**	**3.82**	**968,639**

However, in many respects, cities can be – and are – environmentally effective. As this report will show, by putting people close together, waste, emissions and energy consumption are reduced in per capita and per unit of output terms. In April 2007, New York's Long-Term Planning and Sustainability Office released a greenhouse gas inventory suggesting that its carbon emissions were about 1 per cent of the total for the United States as a whole[41]. Given that the city is home to about 2.7 per cent of the total population of the US, this implies that it is nearly three times as environmentally effective as the US as a whole. New York's greenhouse gas inventory is examined towards the end of this report and it transpires that New York and London are similar in emissions terms.

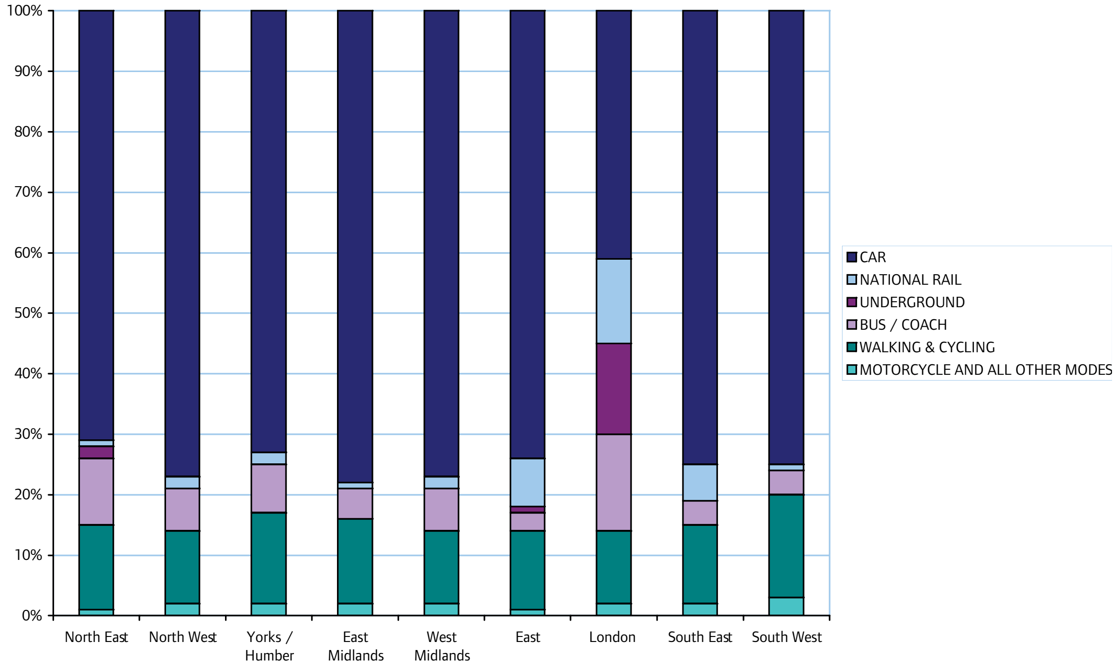
New York's key environmental strengths - and weaknesses – are similar to those of London. Like London, the city has an extensive metro and public transport network and the policy of mixed-use zoning helps encourage zero carbon modes of transport such as walking and cycling. The city is also facing the challenge of an increasing demographic base between now and 2030 of a similar proportion to that of London. New York's current population is around 8.2 million people and is expected to rise by one million by 2030.

In London, we have a dense concentration of economic activity and the negative environmental impacts are often confined to a relatively small geographical area. The trade-off between a poorer overall environmental quality in cities and an improved environment for the rest of the country needs to be taken into account, especially given that high levels of labour mobility ensure that only a small proportion of the city's population lives out its entire life in London. Obviously it is important that quality of life in London remains a key objective.

[41] The New York greenhouse gas inventory is examined in more detail in Chapter 5.

There are some areas in which, intuitively, London is likely to perform well. Even the relatively ill informed are now aware of the fact that high load public transport is more effective in environmental terms than single-occupancy car travel and London's modal patterns of travel are completely different from any of the other eight regions.

Figure 1.1: Transport mode for travel to work by region



Source: Department for Transport (DfT)

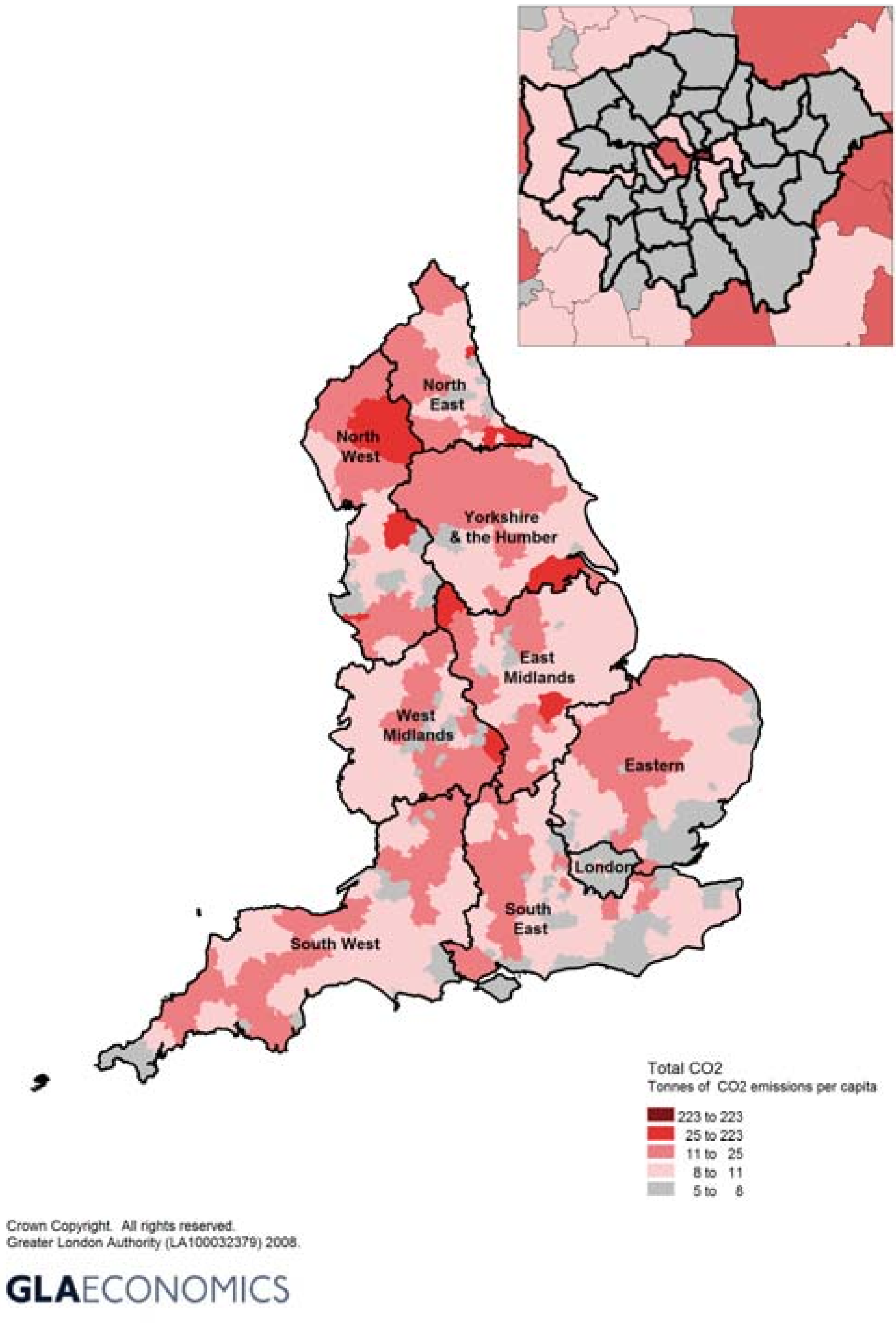
From here onwards the report follows a sequence as shown below:

- Chapter 2 addresses at the environmental effectiveness of transport. It shows that the perception of London as congested masks a strong performance in environmental terms.
- Chapter 3 looks at commerce and industry. The chapter demonstrates that the dominance of the service sector in the capital has pay-offs in terms of reduced energy consumption.
- Chapter 4 looks at households. London's domestic performance emerges as strong thanks in part to a high proportion of flats in the housing stock.
- Chapter 5 focusses on London and New York's greenhouse gas emissions.
- And Chapter 6 looks briefly at green space.

This update of the study (unlike the previous report) makes no attempt to produce some kind of 'composite' indicator assessing overall environmental effectiveness. Obviously, the results of such an indicator would vary according to the mix of variables. Therefore, in this update, the general findings are discussed in the conclusion (Chapter 7) together with some 'pros' and 'cons' of some of the alternative approaches that have been undertaken by other organisations in recent years. Finally, mention is made of other roles that a global city such as London plays with regard to the environmental agenda that are not currently covered by this update.

As the EU study mentioned earlier demonstrated, over the past few years, the issue of global climate change has become far more prominent. The Mayor of London, Boris Johnson, who is honorary Deputy Chair of the C40 group of major international cities committed to tackling climate change, has recognised the importance of cities in tackling carbon reductions: "Cities across the world share the common threat of climate change, and cities create most of the carbon emissions that are causing it, so it is vital we continue to work together to accelerate action on this issue"[42]. With CO_2 as the main gas driving anthropogenic climate change, the report also looks at carbon emissions by various sectors. Map 1.1 shows total carbon dioxide emissions by local area.

Map 1.1: Total CO_2 emissions by local authority



Source: Department for the Environment, Food and Rural Affairs (Defra)

[42] The Mayor of London, Boris Johnson, became honorary Deputy Chair of the C40 Large Cities Climate Initiative in an announcement from the C40 on 4th June 2008. At the same time, the C40 announced that the new Chair was to be Mayor of Toronto, David Miller. Consistent with the aims of the C40 there are new arrangements ensuring that the leadership of the Group is rotated. The C40 Secretariat continues to be based in London.

On account of the fact that in areas with high total CO_2 emissions per capita, the driver tends to be commercial and industrial emissions (as transport and household emissions tend to vary much less from one authority to another), total emissions and commercial and industrial emissions show very similar patterns. Data for commercial and industrial emissions only is presented in Map 3.1 and Map 3.2.

By far the highest level of emissions per capita is to be found in the City of London. This is not at all surprising and can be explained by the fact that, whilst there is an enormous concentration of economic activity in the 'square mile', very few people actually live there.

All of the remaining authorities with very high total emissions per capita have also been driven by their commercial and industrial emissions – although in nearly all cases this is not service-based activity as in the City but rather manufacturing. These other high total emissions per capita authorities are not concentrated in any one particular region but, as with the general distribution of the manufacturing sector in the UK, are concentrated mainly in the North and Midlands.

London's Boroughs nearly all perform well with the exception of Westminster. The logic behind the strong performance of the Boroughs is that they have high populations relative to the economic activity taking place within them. Many residents within them commute to either the City or the Borough of Westminster to work. The emissions map shows similar processes affecting Essex and parts of Sussex and the South Coast where there is also a high degree of outcommuting. This is less obvious in terms of emissions to the north and west of Greater London's boundary.

Other conurbations such as the Former Metropolitan Counties of Greater Manchester, Merseyside, West Yorkshire and the West Midlands also perform well.

Some of the London Boroughs are amongst the best performers in the country (Hackney, Lewisham, Waltham Forest) although this has to be set against the high emissions per capita profiles of Westminster and the City. Nevertheless, the trade-off between Central London's high emissions and the low emitting Boroughs seems to pay off. At a regional level London outperforms all other English regions. London emits 6.8 tonnes of CO_2 per capita compared to the national average of 8 tonnes per capita. The North East is the worst performer with 9 tonnes per capita, although this is most likely due to its low population density compared with other regions.

Chapter 2: Transport

This chapter examines the transport trends in the English regions. It looks at the interaction between transport and the environment and the resource usage of transport by primarily examining the CO_2 emissions associated with different modes of transport in each English region. In this chapter an attempt is made to assess the relative efficiency of transport options in London to discern if City transport is more environmentally effective than in other regions of England. The analysis also provides evidence of where improvements are needed in London's transport network.

Exclusion of aviation from this analysis

Aviation has been omitted from the present analysis primarily on the grounds that the GLA Group has very limited influence over airports – effectively limited to surface transport access. The Kyoto Protocol targets cover emissions from domestic flights but international aviation is currently excluded. The UK Government supports the EU proposal[43] to include international aviation in the third phase of the EU Emissions Trading Scheme (EU-ETS). Emissions from aviation currently account for around 3 per cent of total EU greenhouse gas emissions but – unlike most other sectors within emissions – they are increasing rapidly[44]. This implies an increasing share of total CO_2 emissions. According to Defra, total transport emissions were about 147 million tonnes of CO_2 ($MtCO_2$) in 2000[45]. In 2000 the National Environmental and Technology Centre (NETCEN) estimated that aviation (including freight) contributed 32.2 $MtCO_2$[46]. Civil aviation contributed about 30 $MtCO_2$ of the total or 8 million tonnes of carbon[47].

Therefore, the omission of this area from the analysis is not intended to imply that aircraft emissions are unimportant in their effects upon the environment as air travel is the most CO_2-intensive form of mainstream transport and aircraft also emit oxides of nitrogen, oxides of sulphur, particulates and hydrocarbons. Clearly, London Heathrow in particular is a major international air travel hub. However, another factor to consider is the difficulty in measuring air travel's contribution to climate change. At altitude there are additional global warming impacts from aviation. Radiative forcing means that other emissions associated with aviation, such as NOx and contrail formations provide additional global warming impacts that are over and above the impacts from CO_2 emissions. Therefore the global warming impact of aviation is significantly more than the CO_2 emissions from air travel. Department for Transport (DfT) publications such as the 'The future of air transport'[48] suggest that because of radiative forcing, the impact of aviation on global warming should be estimated as 2 to 4 times the CO_2 emissions from aviation. However, some aspects of aviation's contribution to climate change, including the role of contrails, remain relatively poorly understood.

The emission of CO_2 from an individual flight will actually depend on a large number of factors including distance travelled, weather, passenger and cargo loads, altitude and landing and take-off cycle ratios[49]. In addition there is still no internationally recognised

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[43] Directive 2003/87/EC to modify the EU-ETS statutes.
[44] K. Anderson et al (2006) Tyndall Centre Working Paper 84, "Growth scenarios for EU & UK aviation: contradictions with climate policy".
[45] DfT (2003), The Future of Air Transport
[46] DfT (2004), Aviation and Global Warming
[47] 1 tonne of carbon equals 3.67 tonnes of CO_2.
[48] DfT (2003), The Future of Air Transport
[49] The ratio between landing and take-off cycle and climb, cruise and descent cycle varies markedly between short-haul and long-haul flights, making short-haul flights more environmentally damaging than long-haul when analysed per mile travelled.

way of allocating aviation emissions to domestic sources. There are also significant data issues in apportioning emissions by countries and – more particularly - by English regions, especially as airports serving London spill over the boundaries of Greater London into neighbouring regions[50].

Surface transport

An efficient transport network is an integral part of a growing economy. London has one of the most extensive and multi-modal transport networks in the country. In the previous report, the efficiency of the transport sector in London was assessed against those of other English regions, by examining the per capita and per pound sterling of output emissions originating from transport in each region.

Transport emissions are correlated directly with distance travelled, thus Table 2.1 shows the changes in vehicle kilometres travelled in each region for the period 1995 to 2006.

Table 2.1: Vehicle kilometres (billions)

	1995	2006	% change 1995 – 2006 (rank)
North East	14.2	16.4	15% (3)
North West	39.6	45.7	15% (3)
Yorkshire and the Humber	28.2	33.0	17% (7)
East Midlands	27.1	31.9	18% (9)
West Midlands	34.2	39.2	15% (3)
East of England	38.6	43.7	13% (2)
Greater London	25.8	26.4	3% (1)
South East	61.7	70.7	15% (3)
South West	33.1	38.8	17% (7)

Source: Department for Transport (DfT), National road traffic survey

Just as in the previous report, London had the lowest growth in traffic in terms of vehicle kilometres driven. There was a 3 per cent growth in traffic on roads within London in contrast to an average increase of 16 per cent in all other regions over this period. Car ownership in London is low compared to other regions and public transport accounts for a higher proportion of journeys within the capital. Over the period 1995-1997 to 2004-2005[51], the number of cars per household in London stayed at roughly 0.8 per household. In all other regions, for the same period average car ownership jumped from 1.04 per household to 1.17 per household. The North East had the largest rise in car ownership going from 0.7 cars per household in 1995-1997 to 1.0 cars per household in 2004-2005.

Londoners also take fewer trips on average than their regional counterparts. In 2004/2005 Londoners took an average of 905 trips per annum. This is in contrast to, for example, the South West where an average resident undertook 1,096 trips. The average number of trips per person in all regions in 2004/2005 was 1,039 and in all regions excluding London the average number of trips taken was 1,056 (DfT)[52].

[50] For example, whilst City Airport is undisputedly within Greater London, a small part of Heathrow falls in the South East region, Gatwick is entirely within the South East and Luton and Stansted are both within the East of England.

[51] Combined years using National Travel Survey. All data are weighted and are therefore not directly comparable with previously published data based on unweighted figures.

[52] Modes of transport included are: walking, car driver, car passenger, other private, local bus and other public.

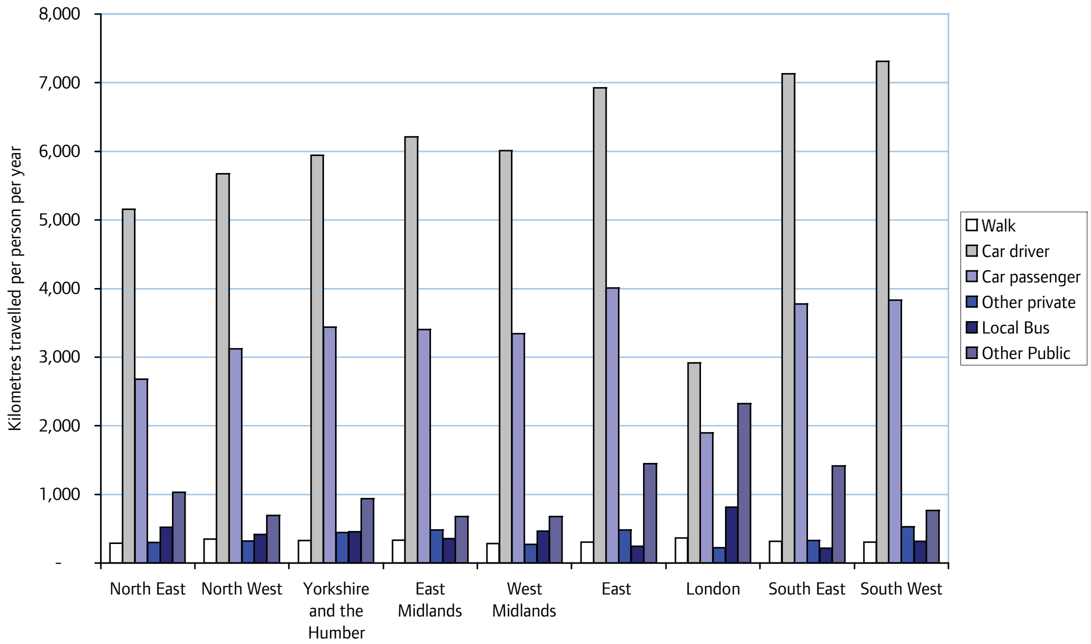
Fewer trips in London also equates to fewer miles travelled. Table 2.2 shows the average distance travelled for each resident in each of the nine English regions. In London the average distance travelled was 5,313 miles in 2004/2005 and in all regions excluding London the average distance travelled was 7,326 miles. When measured by miles travelled per annum, Londoners walk on average 17 per cent more than their regional counterparts. Londoners also travel by bus 118 per cent more and use other public transport 143 per cent more.

Table 2.2: Average kilometres travelled per person per year 2004/2005

	Walk	Car driver	Car passenger	Other private	Local Bus	Other Public	All Modes (ranking)
North East	293	5,158	2,681	301	521	1,033	9,989 (2)
North West	348	5,668	3,121	325	415	695	10,572 (3)
Yorkshire and the Humber	328	5,947	3,439	446	459	938	11,558 (6)
East Midlands	336	6,209	3,404	483	357	676	11,467 (5)
West Midlands	285	6,013	3,346	275	465	676	11,059 (4)
East	309	6,923	4,006	488	246	1,450	13,420 (9)
London	370	2,919	1,896	224	816	2,326	8,550 (1)
South East	320	7,131	3,774	328	219	1,415	13,187 (8)
South West	309	7,313	3,832	526	317	766	13,063 (7)

Source: DfT, National travel survey.

Figure 2.1: Modal patterns of transport (2004/2005)



Source: DfT

Calculating transport emissions

While transport provides many benefits in terms of accessibility, general improved mobility and commercial benefits, the provision of transport services does incur costs other than financial costs. Economists usually refer to these costs as 'external costs' and their impacts can have financial implications for individuals and the economy. The external costs linked with transport are associated with local and global impact emissions as well as congestion costs.

Estimating the emissions from transport requires the application of emission factors to all modes of transport. For the purpose of this report one emission, carbon dioxide (CO_2) with a globalised impact was estimated. For CO_2 emissions, DfT data on petrol and diesel consumption in each region were used as proxy variables to estimate road vehicle CO_2 emissions.

GLA Economics has not attempted to compare localised air quality emissions from transport in each region or international city since it is believed that these comparisons would be problematic given that health and environmental impacts differ by region, pollutant concentrations and population densities. The policy responses will vary according to each of these factors.

Transport CO_2 emissions

The DfT now publishes data on regional usage of petrol and diesel for all road vehicles. Using this data it is possible to estimate CO_2 emissions from fuel consumption. CO_2 data provided in Table 2.3 are proxy estimates since some vehicles use alternative fuels such as CNG[53] and LPG[54] which also lead to CO_2 emissions but are not included here. However, the data below are likely to be reasonable estimates since only a very small proportion of the vehicle fleet uses these alternative fuels.

Table 2.3: 2004 Transport CO_2 emissions (road vehicles) Thousand tonnes[55]

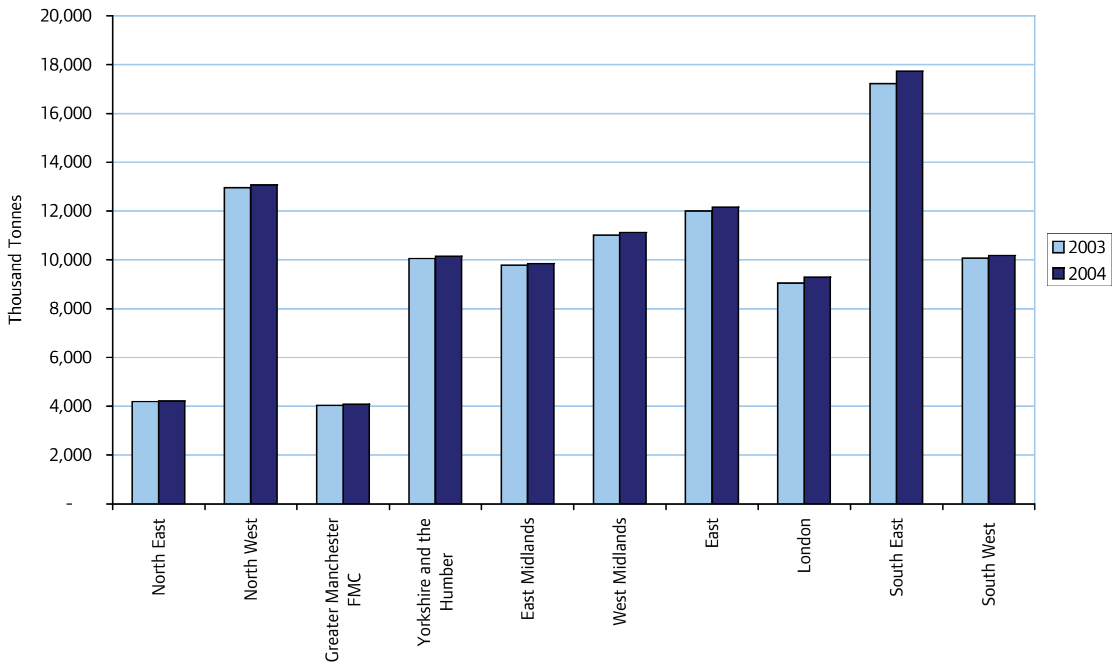
	Buses	Diesel Cars	Petrol Cars	Motor-cycles	HGV	Diesel LGV	Petrol LGV	Total
North East	273	504	2,076	10	708	581	56	4,209
North West	554	1,496	6,061	34	3,007	1,750	163	13,066
Greater Manchester FMC[56]	210	472	1,925	10	835	567	54	4,073
Yorkshire and the Humber	389	1,086	4,432	32	2,619	1,457	138	10,153
East Midlands	243	1,033	4,176	28	2,846	1,387	128	9,841
West Midlands	438	1,232	4,995	29	2,722	1,556	145	11,117
East of England	358	1,354	5,545	43	2,947	1,754	167	12,168
London	758	1,125	4,697	93	1,124	1,352	136	9,286
South East	478	2,167	8,832	66	3,435	2,514	237	17,728
South West	321	1,210	4,918	46	2,044	1,500	141	10,180

Source: Calculated from fuel usage data from DfT

[53] CNG stands for Compressed Natural Gas.
[54] LPG stands for Liquefied Petroleum Gas.
[55] 1 litre petrol = 2.3kg CO_2; 1 litre diesel = 2.63kg CO_2.
[56] FMC= Former Metropolitan County.

Table 2.3 shows the estimated road transport CO_2 emissions for all English regions and the Greater Manchester area in 2004[57]. London had the second lowest total road vehicle emissions when compared to other regions. The North East region had the lowest road vehicle CO_2 emission in 2004[58]. However, further analysis of the data reveals that London's buses emit the most CO_2 emissions. In fact buses in London emitted about 20 per cent of all bus CO_2 emissions in England. For all other vehicle categories, vehicles operating in London contributed approximately 10 per cent of the total except for motorcycles and HGVs where the share of emissions were 24 per cent and 5 per cent respectively for London.

Figure 2.2: Road vehicle CO_2 emissions



Source: DfT and GLA Economics

Analysing these data in per vehicle kilometre terms shows that London's emissions are higher than other regions. Also in 2004 it is only in London and the South East that CO_2 emissions per kilometre increase compared to 2003 (see Table 2.4).

Table 2.4: Road vehicle CO_2 emissions per vehicle kilometre

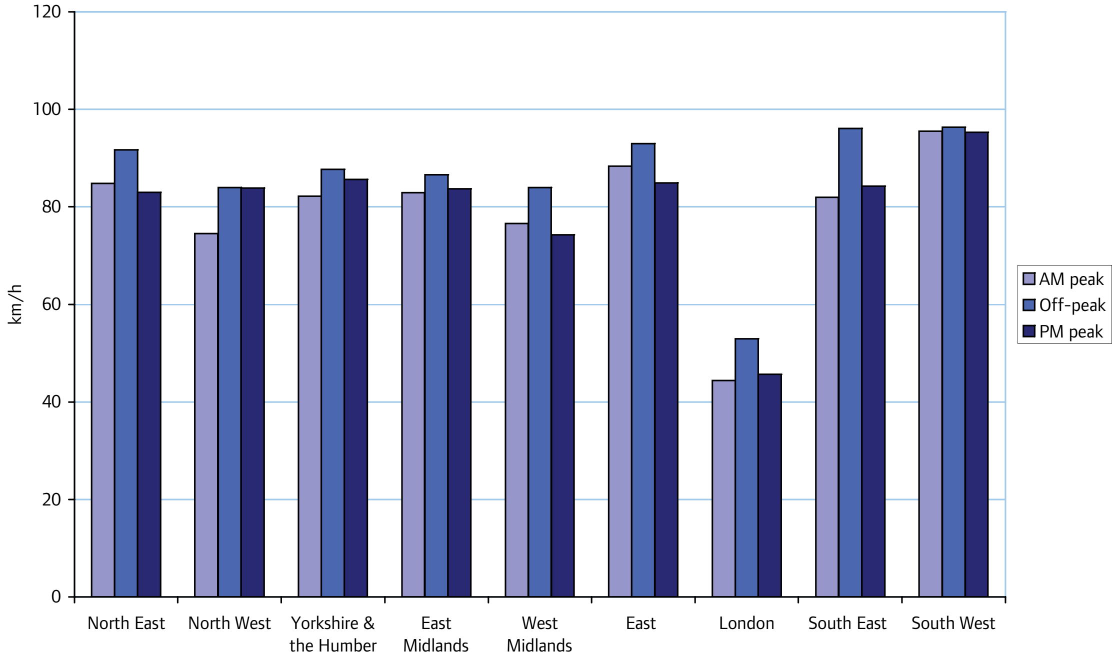
	2003	2004	Percentage change
North East	214	212	-1%
North West	234	231	-1%
Greater Manchester FMC	220	218	-1%
Yorkshire and the Humber	248	244	-1%
East Midlands	245	242	-1%
West Midlands	231	229	-1%
East	223	221	-1%
London	276	284	3%
South East	201	205	2%
South West	216	216	0%

Source: DfT

[57] Greater Manchester forms part of the North West region but data are sometimes available to specify it separately.
[58] Greater Manchester has the lowest emissions shown but is not considered a region.

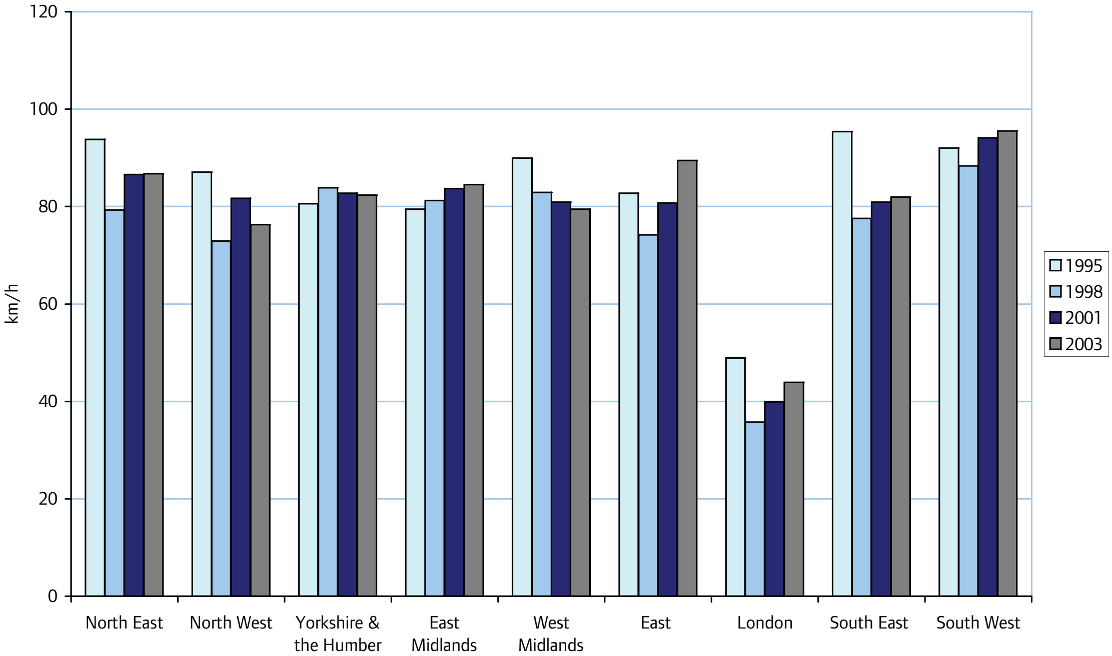
Why would vehicle CO_2 emissions/vkm be higher in London? This may be due in part to the lower average speeds in London and, in part, to the variation in speeds during a typical London journey. Vehicles have an optimum speed for fuel efficiency. At speeds that are too slow or too fast, the vehicle burns more fuel and hence emits more CO_2 per kilometre driven. Figure 2.3 shows the average trunk road traffic speeds for 2003. For all times of the day (AM peak, Off-peak and PM peak) speeds in London are much lower than in other regions, due to excessive congestion. It is therefore more likely that CO_2 emissions from road vehicles would be higher in London per vehicle kilometre.

Figure 2.3: Average trunk road traffic speed 2003



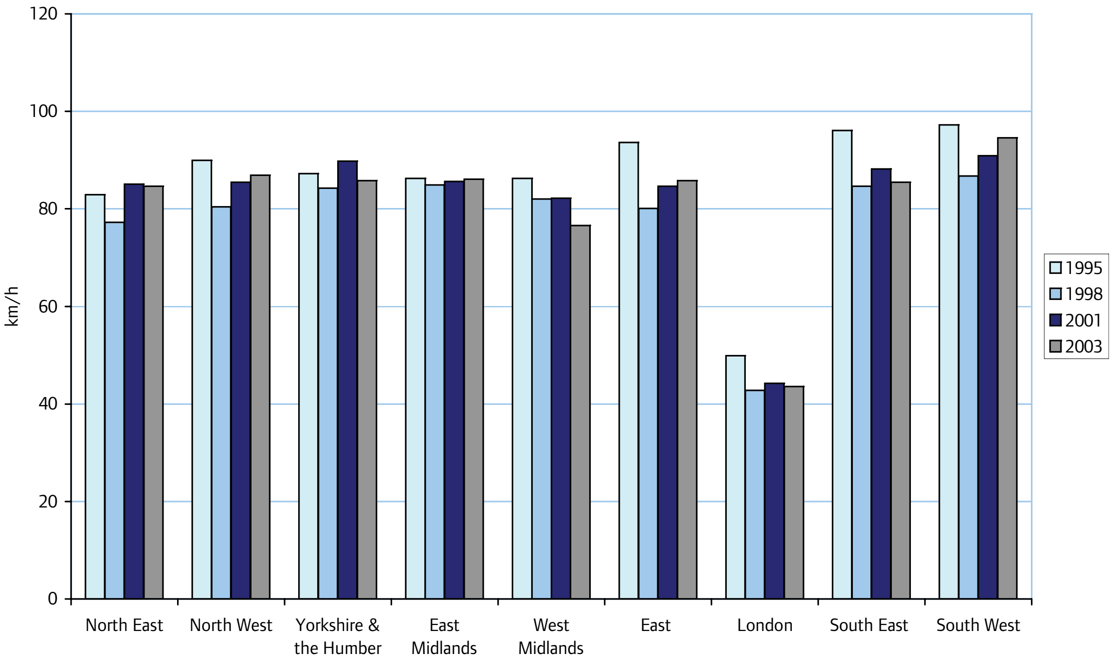
Source: DfT

Figure 2.4: Average trunk road speeds (AM peak) various years



Source: DfT

Figure 2.5: Average trunk road speeds (PM peak) various years



Source: DfT

Vehicle loads also have an impact on fuel consumption. Vehicles carrying a greater load will use more fuel to travel a specified distance than vehicles with lower loads. London buses travel more kilometres and carry more people than in other regions.

Further analysis of traffic speeds in London and other regions for the years 1995, 1998, 2001 and 2003 shows that for the AM-peak period (7:00am to 10:00am) in all regions except Yorkshire and the Humber, the East of England and the South West, traffic speeds were lower in 2003 than they were in 1995 (see Figure 2.4). London's traffic speeds during the morning peak time period in 2003 increased over the 1998 and 2001 levels but were still lower than the 1995 level. This increase in 2003 of London morning peak time traffic speeds may have resulted from the commencement of the congestion-charging zone in central London that began in February 2003. However, in 2003, traffic speeds in London during the evening peak time period (16:00 to 19:00) were lower than in previous years. From a policy perspective road vehicle speeds and hence fuel consumption would need to be examined to ensure that London's road vehicles can operate at a more efficient level and contribute further to the capital's CO_2 emission reduction targets.

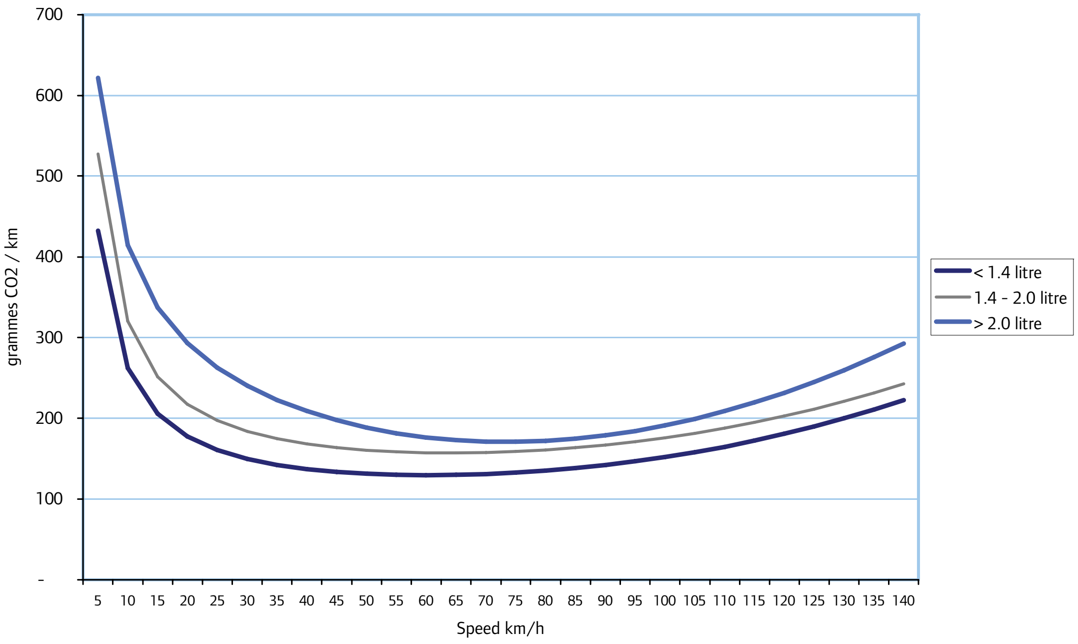
Figures 2.6 and 2.7 depict the CO_2 emissions associated with different speeds from a typical Euro II petrol car and Euro II bus respectively. The figures show that CO_2 emissions are high at slow speeds and then reduce as speed increase. Figure 2.6 shows that for different engine sizes of Euro II petrol cars, the lowest CO_2 emissions occur between 60km/h to 75 km/h. At speeds above these levels, CO_2 emissions begin to increase once more.

For Euro II buses (see Figure 2.7), CO_2 emissions are lowest at about 60km/h to 70 km/h and then begin to increase again. These graphs clearly show that there are optimum speeds for fuel efficiency and CO_2 emissions and that too low or too high speeds produce higher CO_2 emissions[59].

As a further comment on the road speed figures, it is suggested that driving patterns in London are characterised more by stop-start driving incidents that reduce the average speed throughout London to the levels shown in Figures 2.3, 2.4 and 2.5. Thus vehicles being driven on trunk roads within London during the PM peak time in 2003 are not necessarily moving along at constant speeds of about 44 km/h, but rather moving at varying speeds punctuated by "stop-start" intervals. The presence of traffic lights has an influence on this[60].

[59] "Too low" and "too high" refer to an optimum for reducing emissions. It is accepted that there are other influences – particularly health and safety – in setting maximum road speeds.
[60] GLA Economics is currently involved in a study measuring the economic impacts of traffic lights.

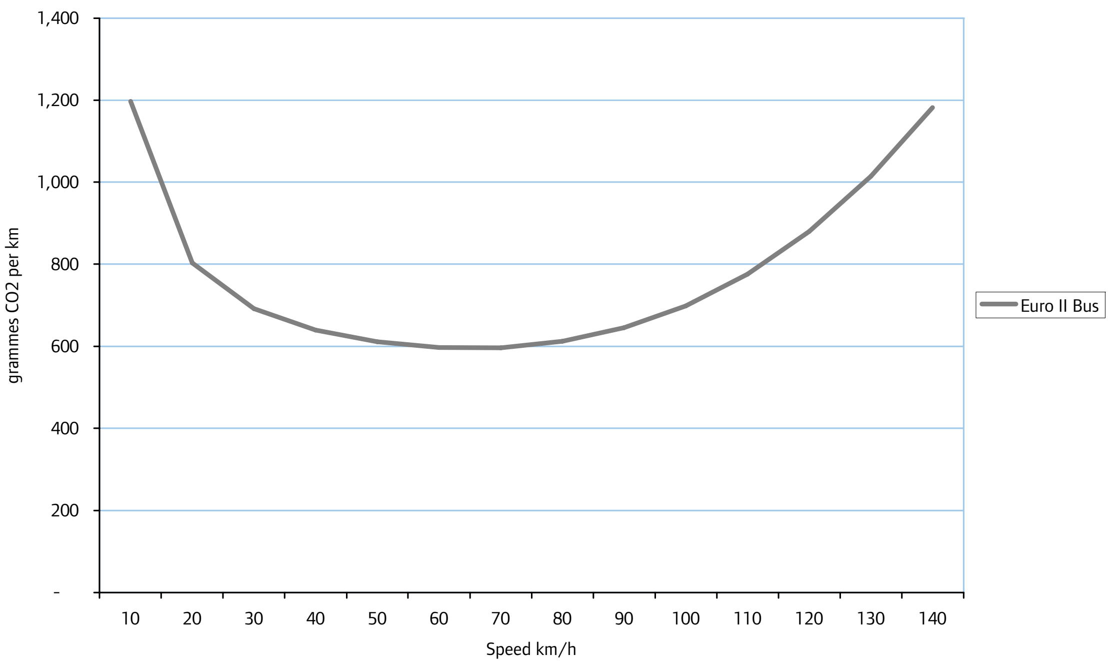
Figure 2.6: Average CO_2 speed emissions for Euro II petrol vehicles (by engine size)



Source: National Atmospheric Emissions Inventory (NAEI)

Note that CO_2 emissions refers to ultimate CO_2 emissions from all carbon emitted from the tailpipe as CO_2, CO, unburned hydrocarbons and particulate matter which ultimately have impacts on CO_2 levels.

Figure 2.7: Average CO_2 speed emissions for Euro II buses

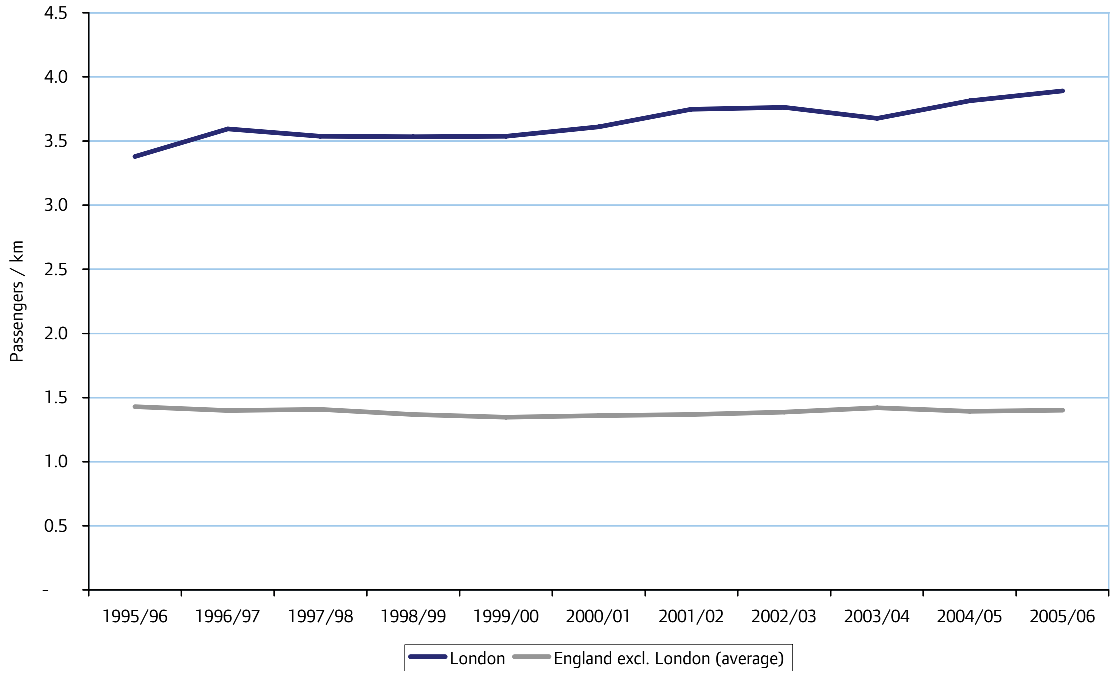


Source: NAEI

Note that CO_2 emissions refers to ultimate CO_2 emissions from all carbon emitted from the tailpipe as CO_2, CO, unburned hydrocarbons and particulate matter which ultimately have impacts on CO_2 levels

Higher loads and passenger numbers, particularly on London buses would also be a contributing factor to higher CO_2 emissions/vkm. However, once a 'per capita' approach is taken, these represent lower CO_2 emissions per passenger. Figure 2.8 shows average passengers per kilometre on buses within London and the rest of England for the period 1995/96 to 2005/06. If this is taken as an indicator of bus occupancy, bus occupancy is consistently over twice as high in London, averaging about 2.6 times the occupancy rate in the rest of England.

Figure 2.8: Average bus passengers per bus kilometre



Source: DfT

Higher loads lead to higher absolute fuel use and emissions. However, in terms of per passenger fuel use and emissions from buses the efficiency of London buses outstrips those operating in the rest of England. The high number of passengers using buses in London increases load and overall fuel use. However, fuel consumption and CO_2 efficiency per km and per passenger respectively are better in the capital than in the rest of England. More needs to be done to improve overall fuel consumption efficiency. However, the policy of getting more people to use buses and by extension public transport is the correct one since this improves relative efficiencies[61].

So are there environmental benefits from 'city type living' and hence high occupancy usage of public transport? Table 2.5, suggests 'yes' with regard to buses.

Table 2.5: 2004 Bus fuel consumption and CO_2 emissions

	Litres / km	g CO_2 / passenger
North East	0.73	1,259.4
North West	0.32	536.6
Yorkshire and the Humber	0.44	754.8
East Midlands	0.69	1,367.2
West Midlands	0.51	659.4
East of England	0.58	1,637.1
London	0.22	153.7
South East	0.44	936.7
South West	0.53	1,478.2

Source: DfT

[61] It is accepted that excessively high load factors have impacts on aspects other than fuel efficiency such as the quality of journey experience.

Productivity and population density is higher in London than in other regions and therefore one would expect that more goods would be transported in London and more people will be moving around per kilometre driven. It is therefore likely that in per capita terms, per passenger kilometre and per unit of output terms, CO_2 emissions will be lower. These issues will be examined in greater detail later in the chapter.

Box 1.1: London's Parc

A vehicle Parc is the collective noun for the mix of different vehicles on the road. Less than 2 per cent of cars on the road in London predate 1986. Around 11,000 cars on the road in London were originally registered in 1986. This number rises for each successive year of registration up until 2001. There are just under a quarter of a million cars on London's roads first registered in 2001. However, after 2001, there are fewer cars still running registered in each successive year until 2005[62]. The UK new car market has been easing since a 2003 peak at around 2.58 million and in 2006 fell back to 2.35 million – its lowest level since 2001[63].

London's Parc tends to be similar to the national picture but with minor, identifiable exceptions. On account of the fact that car ownership is relatively low in London compared to other regions of the country, those who do buy cars tend to buy newer and larger cars[64].

Combined, these data suggest that London's car stock on the road is not hugely different from other regions in terms of likely engine efficiency. If greater affluence in the region really reflects in newer and larger cars (and there is a strong case for purchasing smaller cars in an large urban environment such as London), improved engine efficiency in the last few years may counteract this[65]. Therefore, it seems fair to suggest that the main influences on fuel efficiency per mile in London when compared with other regions will be driving conditions, congestion and traffic lights rather than by differences in vehicle stock.

Improvements on engine technologies have led to improvements in the fuel efficiency of internal combustion engines. However, in some makes of car, this has been counteracted by a trend towards increased weight of car[66]. Therefore, although car fuel efficiency is improving, it is only doing so slowly. What is highly noticeable is the degree of variation in fuel efficiency within each class of car. Consequently, the EU Commissions has adopted a proposal to limit CO_2 emissions from cars[67] by charging manufacturers premiums if their average emission levels are above the limit value curve. In the UK, Vehicle Excise Duty has become increasingly 'banded' by fuel emissions[68].

[62] Source: Experian / DVLA.
[63] SMMT- The Society of Motor Manufacturers and Traders Ltd.
[64] This is in spite of the fact that urban driving may be more suited to smaller vehicles.
[65] However, both EU and UK regulation of carbon emissions from private vehicles encourages vehicle owners to buy new vehicles, thereby generating scrapping. Therefore, it is important to ensure that vehicles are disposed of/recycled in the most effective way possible. Every year, end of life vehicles generate between 8 and 9 million tonnes of waste in the Community which should be managed correctly. In 1997, the European Commission adopted a Proposal for a Directive which aims at making vehicle dismantling and recycling more environmentally friendly, sets clear quantified targets for reuse, recycling and recovery of vehicles and their components and encourages producers to manufacture new vehicles also with a view to their recyclability.

[66] See European Federation for Transport and Environment Report 2007.
[67] COM 2007 19.
[68] See http://www.vcacarfueldata.org.uk/

In London there are 2.4 million cars on the road with average CO_2 emissions of 178 grammes per kilometre[69]. This relatively high level of emissions is driven by the older stock of cars. Most cars produced today produce less CO_2 per kilometre with the exception of particularly heavy cars[70]. However, increased congestion also means raised CO_2 emissions.

One part of London's Parc, which is particularly subject to 'idling', is London's taxis. London taxis spend up to 40 per cent of their time waiting at taxi ranks, at traffic signals or waiting to pick up or drop off passengers. As part of its carbon reduction strategy, TfL's Public Carriage Office wants to work with motor manufacturers to develop taxis with reduced fuel consumption and emissions. Amongst these potential technologies examined might be 'micro-hybrid' technology where the engine cuts out automatically when the vehicle stops and re-starts when the accelerator is pressed[71]. This technology is already being used by many of the major car manufacturers and the company Ricardo exhibited the technology in taxis at the New York International Auto Show in 2007.

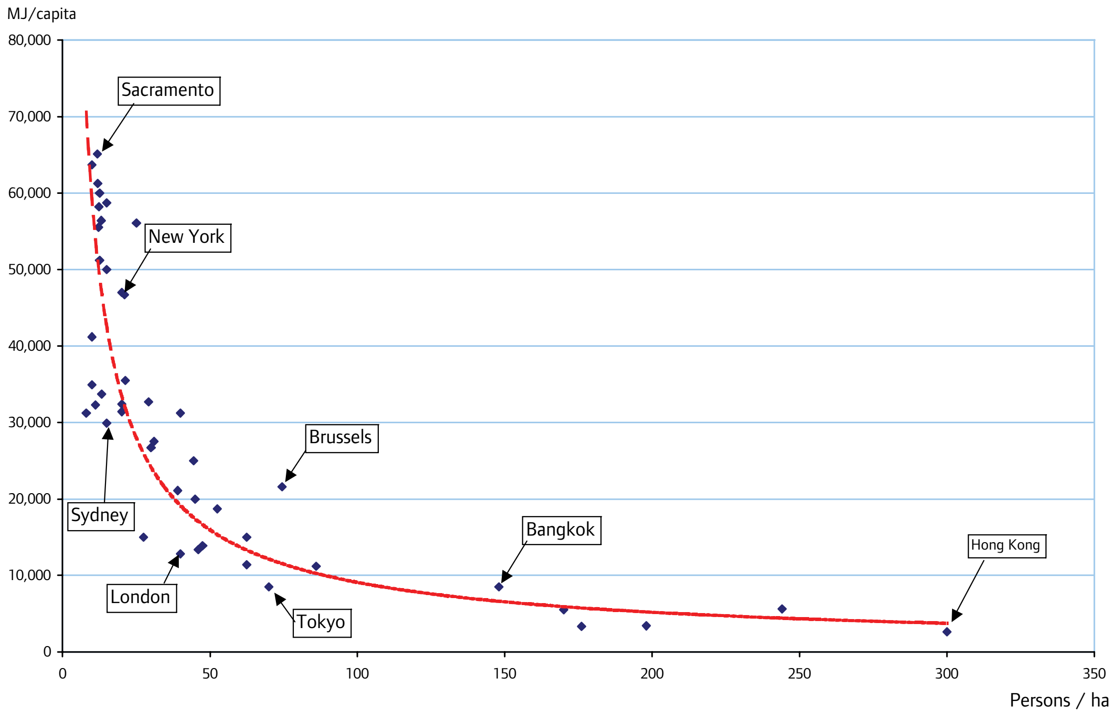
Box 2.2: Urban density and private fuel consumption

The advantages in terms of energy consumption of high urban densities have been demonstrated in a well-known graphic by Newman and Kenworthy, 1990[72].

This is reproduced here to demonstrate the variation in energy use in private passenger transport against population density in 1990[73]. The overall picture suggests that once urban densities hit a threshold of around 20 persons per hectare, private transport energy use per capita starts to fall rapidly. However, once a density of somewhere between 100 to 150 persons per hectare is achieved, the energy use benefits at the margin seem to become negligible. It should be pointed out that when the study was undertaken in 1990, only Asian cities had densities beyond this level.

[69] London Climate Change Action Plan.
[70] European Federation for Transport and Environment Report 2007.
[71] Transport for London Press Release – Mayor announces funding to help reduce carbon dioxide emissions from London taxis, 3 June 2008.
[72] Newman and Kenworthy, *Sustainability and cities: overcoming automobile dependence*, Island Press, 1999.
[73] Given current data availability, it is impossible to reproduce the relationship for a more current year.

Figure 2.9: Energy use per capita in private travel versus urban density in global cities



Source: Newman and Kenworthy

A closer examination of the relationship shows that it is the ***type*** of city that is important. Some low density US cities (such as Sacramento, Portland, Houston and San Diego) are based on a type of suburbanisation where the affluent live in relatively large spaces with large gardens but rely on private transport and the city's road network to access work and services nearer the centre of the city.

Most Western European cities (including London) occupy a 'mid point' position between the low density suburbanised cities and Asian cities such as Seoul, Bangkok and Hong Kong.

Those cities to the 'origin side' of the hyperbole had private transport energy consumption per capita at a lower level than would have been expected on the basis of their densities. For example, London's density in 1990 might have implied anticipated consumption of around 20 MJ per capita (compared to an actual figure of around 12 MJ). In contrast, Brussels' density might have implied consumption of around 11MJ as opposed to the much higher actual figure of around 21 MJ.

Newman and Kenworthy also found support for the hypothesis that urban density was positively associated with the proportion accessing their place of work by walking or cycling. The relationship might have been even stronger had the sample of cities used been drawn entirely from the developed, Western nations.

It should also be noted that Newman and Kenworthy's study was undertaken at a time when many European cities – London included – had experienced several decades of post-War declines in urban densities. For example, Amsterdam's density nearly halved over the period 1960-1990. In many European cities - again including London - such trends have now been reversed[74].

[74] London's population started to rise again in the early 1990s and has since risen by around 800,000.

London Underground CO_2 emissions

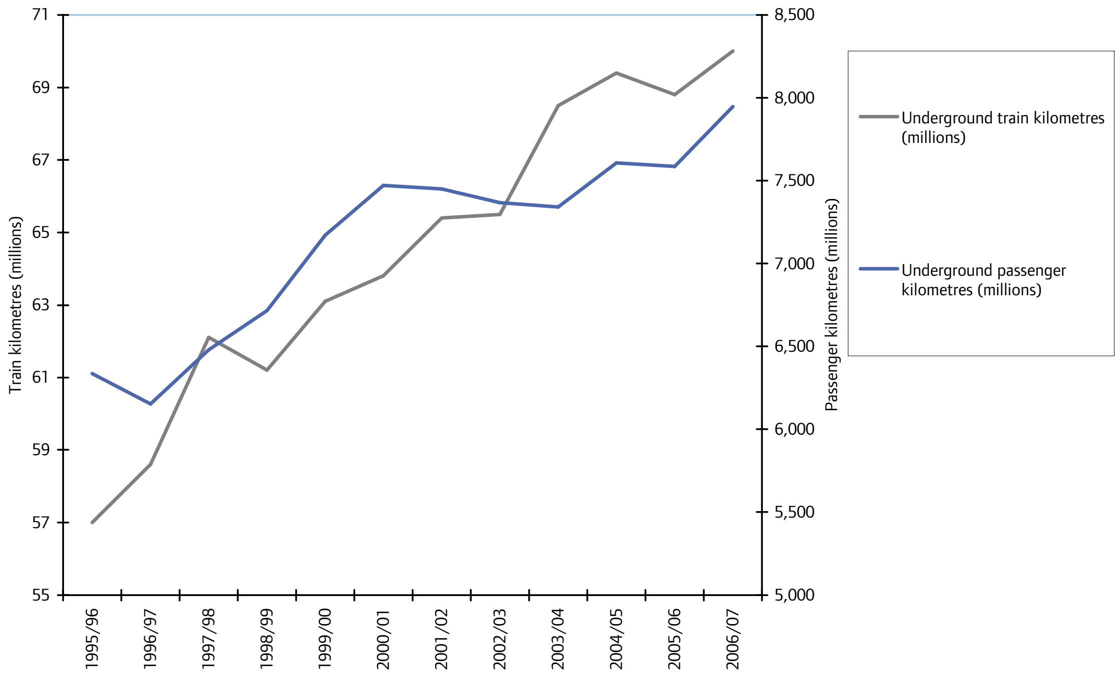
London's underground rail network transports millions of passengers throughout the city on a daily basis. The number of passenger journeys has been increasing steadily over the last decade. In 1995/96 the number of passenger journeys on the London Underground network was 784 million and this increased to 971 million in 2005/06, a 24 per cent increase. The London Underground's vast network of track, frequent services and accessible stations mean that it is an important part of the capital's transport system and allows Londoners and visitors to get around the city without relying on private vehicles. London's 408km of track is only about 40 per cent of New York's total mass transit track. However, the London Underground is used more intensively. GLA Economics' calculations estimate that there are currently around 2.5 million passenger journeys for every kilometre of track on the Underground. In comparison, the New York Mass Transit estimates that there are around 1.4 million passenger journeys per kilometre of track on its network.

London's CO_2 emissions per passenger kilometre are lower mainly because of the Underground and bus network. Figure 2.10 shows total London Underground train kilometres and passenger kilometres for 1995/96 to 2006/07. These indicators show growth in use of the Underground network.

TfL has estimated that the Underground network was responsible for 432,695 tonnes of CO_2 in 2004/05 and 431,279 tonnes of CO_2 emissions in 2005/06. In terms of passenger kilometres, the CO_2 emissions for each year were 56.7g per pkm and 57.0 g per pkm in 2004/05 and 2005/06 respectively. If these data are compared to calculations of bus CO_2 emissions per passenger kilometre of 96.2 g per pkm in 2004/05 and 102.6 g per pkm in 2005/06 then, in terms of CO_2 emissions, travelling by London Underground for the same distance (on average) would produce fewer greenhouse gas emissions than travelling by bus. These two major passenger transport networks in London (Underground and bus networks) allow London residents, commuters and visitors to travel within the capital relatively environmentally efficiently[75].

[75] Measured as grams of CO_2 emissions per passenger km.

Figure 2.10: London Underground operations 1995/06 – 2006/07



Source: TfL

Air quality indicators of transport

Almost all forms of transport used today emit significant amounts of pollutants that impact negatively on local air quality[76]. Two major pollutants that affect local air quality are particulate matter and nitrogen oxides (NO_X). However, it was decided not to estimate air quality impacts from transport for this report, since the impacts differ due to many factors including: population densities, atmospheric conditions and emission concentrations. That is not to deny the important impact transport modes have upon local air quality.

Box 2.3: Assessing the interaction between transport emissions and health

Source: Lung and Asthma Information Agency, University of London (www.laia.ac.uk)

While the environmental analysis of transport in this report focuses on transport's impact on the global environment, there are also interactions between transport emissions and the health of people who inhale these emissions. Epidemiological data suggests that respiratory diseases are exacerbated by exposure to emissions such as particulates and nitrogen oxides that emanate from many sources including transport. Maddison et al (1996[77]) explain that a cocktail of pollutants emitted from vehicle exhaust pipes form concentrations in the atmosphere and subsequently cause damage to human health usually in the form of respiratory disease incidents including asthma. Assessing the impact of transport emission on human health is not a new methodology but usually involves the use of dose-response functions that relate emission concentrations, the dose to human health impacts, and, finally, the response. Maddison et al (1996) estimated that in the UK for the year 1993 total external health costs from transport emissions ranged from £10.6 billion to £32 billion.

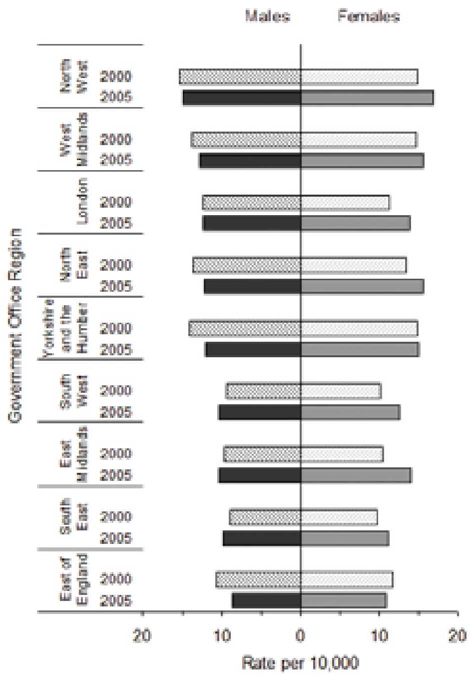
[76] Excludes cycles.

[77] Maddison D, Johansson O, Litman T and Pearce (1996) Blueprint 5: The True Cost of Road Transport Earthscan, London.

Although the appropriate data for the correct analysis was unavailable some initial data on asthma, a major respiratory disease, which may be exacerbated by the inhalation of pollutants from vehicle emissions, is presented below. Figure 2.11 shows asthma-related hospital admissions in English Government Office Regions for the years 2000 and 2005. It shows hospital admissions for both male and female patients per 10,000 of the population.

According to the Lung and Asthma Information Agency (LAIA) admission rates are affected by a range of factors including population age structure, prevalence and medical care factors. Therefore knowing what proportion of admissions may have been affected by exhaust pollutant inhalation would be useful research for the future.

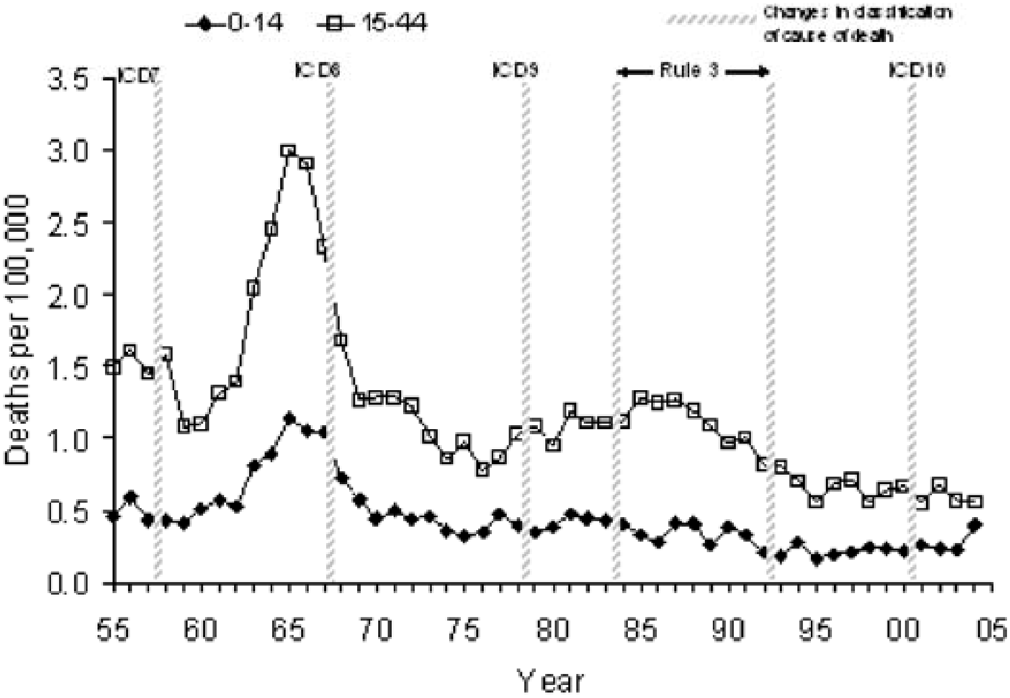
Figure 2.11: Asthma admission rates for English regions in 2000 and 2005



Source: HES and LAIA

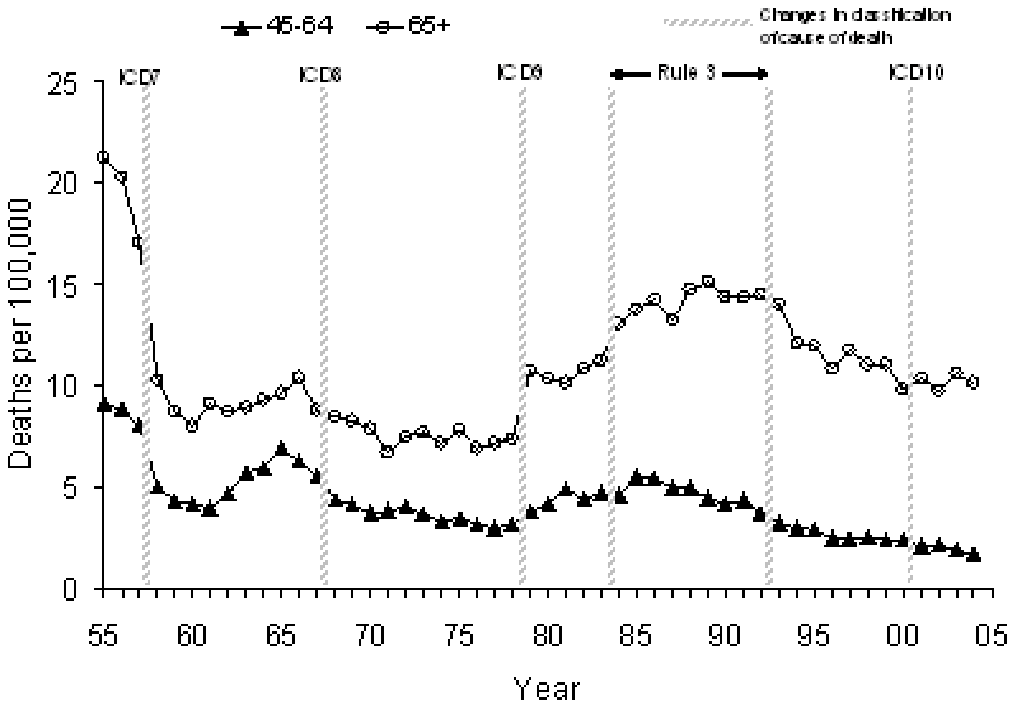
Mortality rates for respiratory diseases would also be useful data upon which the health impacts of vehicular emissions could be assessed. This data is not available regionally but at a national level and the following charts provide data of mortality rates for asthma for England and Wales for the period 1955 to 2004. Two waves of mortality can be clearly discerned in all age groups, the first in the 1960s and the second from the 1970s to the end of the 1980s. Since then there appears to be a reduction in asthma related deaths and we may attribute this to cleaner local air, which was affected by many policies including the removal of leaded petrol from the vehicle fuel market as well as stepped reductions in emissions from vehicle exhausts. However, it is unclear what proportion of the reduction in asthma mortality is related to cleaner emissions from exhausts and what reductions occurred in London since this type of analysis does not exist.

Figure 2.12a: Age-specific mortality rates for asthma – children and young adults, England and Wales, 1955-2004



Source: LAIA

Figure 2.12b: Age-specific mortality rates for asthma – adults, England and Wales, 1955-2004



Source: LAIA

Some additional data related to asthma in 2006 is presented below for comparison.

Table 2.6a: Emergency admissions rate per 10,000 in 2006

Country	Sex	Age						
		All ages	0-4	5-14	15-44	45-64	65-74	75+
England	M	12	59	27	6	6	6	9
England	F	14	31	17	12	11	12	14
England	M&F	13	45	22	9	8	9	12
Wales	M	13	71	28	6	7	9	9
Wales	F	16	38	18	14	13	12	21
Wales	M&F	15	55	23	10	10	10	16
Scotland	M	12	55	30	6	7	6	6
Scotland	F	15	28	21	15	12	9	9
Scotland	M&F	13	42	26	11	10	8	8
Northern Ireland	M	11	59	24	4	4	6	6
Northern Ireland	F	12	30	17	9	11	11	12
Northern Ireland	M&F	12	45	20	7	7	8	10
UK	M	12	59	27	6	6	6	8
UK	F	14	31	18	13	11	12	14
UK Total	M&F	13	45	23	9	9	9	12

Source: LAIA

Table 2.6b: Number of admissions in 2006

Country	Sex	Age						
		All ages	0-4	5-14	15-44	45-64	65-74	75+
England	M	29,852	8,867	8,400	6,553	3,499	1,243	1,290
England	F	35,448	4,471	5,146	12,923	6,953	2,613	3,342
England	M&F	65,300	13,338	13,546	19,476	10,452	3,856	4,632
Wales	M	1,945	581	523	366	277	113	85
Wales	F	2,444	295	312	818	526	173	320
Wales	M&F	4,389	876	835	1,184	803	286	405
Scotland	M	2,954	751	909	644	438	124	88
Scotland	F	3,906	368	615	1,621	848	225	229
Scotland	M&F	6,860	1,119	1,524	2,265	1,286	349	317
Northern Ireland	M	928	339	293	165	71	34	26
Northern Ireland	F	1,084	165	202	341	219	75	82
Northern Ireland	M&F	2,012	504	495	506	290	109	108
UK	M	35,679	10,538	10,125	7,728	4,285	1,514	1,489
UK	F	42,882	5,299	6,275	15,703	8,546	3,086	3,973
UK Total	M&F	78,561	15,837	16,400	23,431	12,831	4,600	5,462

Source: LAIA

Table 2.6c: Mortality per million in 2006

Country	Sex	Age					
		All ages	0-14	15-44	45-64	65-74	75+
England & Wales	M	12	5	4	36	18	79
England & Wales	F	28	2	4	46	35	208
England & Wales	M&F	20	3	4	42	27	158
Scotland	M	11					100
Scotland	F	20					128
Scotland	M&F	16		4	9	31	118
Northern Ireland	M	14					147
Northern Ireland	F	26					174
Northern Ireland	M&F	20					164
UK	M	12	5	4	11	19	83
UK	F	28	3	4	16	35	200
UK Total	M&F	20	4	4	14	27	155

Source: LAIA

The mortality rates have not been calculated for some sex/age sub-groups in Scotland and Northern Ireland due to small numbers.

Table 2.6d: Numbers of deaths in 2006

Country	Sex	Age					
		All ages	0-14	15-44	45-64	65-74	75+
England & Wales	M	309	22	43	77	39	128
England & Wales	F	773	11	42	108	81	531
England & Wales	M&F	1,082	33	85	185	120	659
Scotland	M	28	2	5	3	4	14
Scotland	F	54	1	3	9	10	31
Scotland	M&F	82	3	8	12	14	45
Northern Ireland	M	12	2	2	0	2	6
Northern Ireland	F	23	2	1	6	2	12
Northern Ireland	M&F	35	4	3	6	4	18
UK	M	349	26	50	80	45	148
UK	F	850	14	46	123	93	574
UK Total	M&F	1,199	40	96	203	138	722

Source: LAIA

Per capita and per output measures of transport's environmental impact

So far this chapter has examined the physical quantities of pollutants being emitted from transport within London and the rest of England. However, the question that arose before is still pertinent: does 'city type living' and activities associated with city living benefit the environment through greater efficiency? Is it possible that emissions or resource usage per unit of output or per capita are less in cities? GLA Economics' first report on the environmental effectiveness of London published in 2005 showed that this was true for London. However, some critics have argued that measuring environmental performance in this way concealed the real costs associated with city living, namely: resident health costs associated with emissions, the magnitude of global emissions from cities and some amenity losses. However, the conclusion of this report highlights where further policies are required to help improve the environmental efficiency of London.

Per capita measures of transport emissions

Regional road vehicle CO_2 emissions were divided by the total population of each region. The calculations for 2004 (see Table 2.7) show that London's road vehicle emissions per capita were 1,256.7kg of CO_2. This was the lowest of all regions.

Table 2.7: 2004 road vehicles kg of CO_2 emission per capita

	Buses	Cars	Motor cycles	HGV and LGV	Total
North East	107.4	1,015.1	4.1	529.2	1,655.8
North West	81.2	1,108.2	5.0	721.5	1,915.9
Yorkshire and the Humber	76.8	1,089.6	6.2	832.2	2,004.9
East Midlands	56.5	1,213.7	6.6	1,016.3	2,293.1
West Midlands	82.3	1,168.9	5.5	830.4	2,087.1
East of England	65.0	1,251.9	7.8	883.3	2,207.9
London	102.6	787.9	12.6	353.5	1,256.7
South East	58.8	1,353.7	8.1	761.3	2,181.9
South West	63.6	1,215.6	9.2	730.9	2,019.2

Source: DfT

Calculating the per capita emissions by vehicle type reveals that London's CO_2 emissions are higher for some vehicle classes. Bus CO_2 emissions per capita are higher in London than in other regions (except the North East) due to less bus usage in other regions. Further action could be taken on improving the fuel efficiency of London's buses, either through the use of alternative fuel buses, or reducing congestion on London's roads to allow London's buses to operate at a speed that is more conducive to greater fuel efficiency. Motorcycle CO_2 emissions are also highest in London at roughly 12.6 kg per capita. This is mainly due to the fact that there are many more motorcycles operating in London than in other regions.

For cars, HGVs and LGVs, CO_2 emissions per capita are less in London. Emissions from cars, HGVs and LGVs account for about 91 per cent of all road vehicle emissions in London. These statistics show that on a per capita basis, emissions from cars and goods vehicles are relatively efficient in London.

The total transport emissions of CO_2 for each region is taken as road vehicle emissions plus emissions from the London Underground for the London region. Some emissions have been excluded such as those associated with trams and rail services, since reliable estimates could not be calculated.

Total transport CO_2 emissions for 2004 in each region are shown in Table 2.8. It is worth noting that the methodology used to calculate CO_2 emissions from road transport differs from that of the previous report. In the previous report emission factors per kilometre were used to estimate CO_2 emissions from transport. However in this report

CO_2 emissions are calculated from fuel usage. Therefore the transport CO_2 estimates in this report are not comparable to those in the 2005 report.

Table 2.8: Transport CO_2 emissions 2004 including London Underground (thousand tonnes, unless stated otherwise)

	Road Vehicles	London Underground	Total CO_2 emissions	Tonnes per capita
North East	4,209		4,209	1.66 (2)
North West	13,066		13,066	1.92 (3)
Yorkshire and Humber	10,153		10,153	2.00 (4)
East Midlands	9,841		9,841	2.29 (9)
West Midlands	11,117		11,117	2.09 (6)
East of England	12,168		12,168	2.21 (8)
London	9,286	433	9,719	1.32 (1)
South East	17,728		17,728	2.18 (7)
South West	10,180		10,180	2.02 (5)

Source: DfT, GLA Economics and TfL

Per unit of output measures of CO_2 emissions

The second component of the comparative analysis involves comparing transport emissions per unit of output and London comes out best of all English regions. The rationale for doing this is to show that economic activity does have environmental consequences, but there may be some type of social-economic frameworks that provide the best outcome in terms of output and emissions. Some types of economic activities, which are important for human welfare, are best suited to situations where agglomeration benefits exist. In these types of situations, environmental impacts may be less than if the economic activities were dispersed. The report does not attempt to compare localised air emission impacts across regions or international cities, since the environmental/health impacts of emissions such as NOx[78] and PM[79] are local and depend significantly on local conditions as well as pollutant concentrations and population densities. Instead the report refers mainly to transport efficiency as measured by CO_2 emissions.

The CO_2 emissions shown in Table 2.9 are identical to those in Table 2.8 but have been divided by the Gross Value Added (GVA) of each region.

[78] Nitrogen oxides. A generic term that includes nitric oxide, nitrogen dioxide, nitrous oxide, dinitrogen trioxide, dinitrogen tetroxide and dinitrogen pentoxide. In the presence of excess oxygen, nitric oxide will be converted to nitrogen dioxide.
[79] Particulate Matter. These are fine suspended particles usually categorised according to their size. The exact composition usually varies by source.

Table 2.9: 2004 Transport CO_2 emissions per £ billion GVA

	CO_2 emissions (thousand tonnes)	CO_2 Tonnes/£ billion of GVA
North East	4,209	122.3
North West	13,066	127.6
Yorkshire and Humber	10,153	134.9
East Midlands	9,841	145.0
West Midlands	11,117	136.0
East of England	12,168	135.0
London	9,719	49.8
South East	17,728	118.2
South West	10,180	125.2

Source: DfT, GLA Economics

Transport summary

- In Central London car traffic levels are down – almost certainly as a result of the Congestion Charge. Levels in Inner London (which excludes the Central London area under this definition) have only grown by about 1 per cent over a decade.
- London has the lowest road vehicles emissions per capita.
- London has the lowest CO_2 emissions per £ billion GVA.
- London has the highest CO_2 emissions per vehicle kilometre out of all the regions. This is mainly due to the lower average speeds in London due to congestion.

Chapter 3: Commercial and industrial sector

The commercial and industrial sector accounts for a third of the UK's energy consumption. London – with a high proportion of services than the UK as a whole – is likely to be significantly different from the remainder of the country. Although the commercial and industrial sector has become less energy-intensive, part of this has been driven by the offshoring of manufacturing.

Until recently, service sector energy consumption has received relatively little attention. In particular, ICT is consuming a growing share of office energy. Offices also contribute to the capital's Urban Heat Island effect. However, far more attention is now being given to the environmental design of office buildings.

On commercial, industrial and demolition waste, London's performance – which has been driven by regulation – is strong.

Differences between manufacturing sector and service sector energy use

One third of total energy use in the UK is accounted for by the commercial and industrial sector. However, the picture in London is likely to be significantly different as London's manufacturing sector is relatively small – accounting for less than 6 per cent of GVA as opposed to more than 13 per cent in the UK as a whole. Twenty-one per cent of all UK energy use is accounted for by the manufacturing sector and it accounts for nearly three quarters of all commercial and industrial energy use (73 per cent).

In contrast, the service sector accounts for only around one quarter of commercial and industrial energy use at some 17,000 tonnes of oil equivalent per annum. The remainder is accounted for by agriculture – another very small sector in London – and the construction industry.

Around 44 per cent of the service sector's energy mix is natural gas, 28 per cent electricity and 28 per cent from petroleum sources. Within manufacturing there is a wider mix of sources including higher proportions from coal and other sources such as manufactured red fuel; the rebated fuel used in agricultural operations.

The trend in UK commercial and industrial energy use

Received wisdom holds that as the economy grows and economic activities expand, energy consumption increases. Whilst it is true that overall energy consumption in the UK is rising, commercial and industrial energy use as a share of total energy use has fallen. In fact the services share is rising but industrial use has fallen both in proportionate and actual terms.

It is relatively standard practice to speak of the energy-intensity of the economy in terms of the 'energy ratio' between energy consumption as numerator and economic output as denominator. The UK's recent historical experience suggests that the energy ratio has fallen by about 2 per cent per annum as GDP has tended to increase more rapidly than energy consumption[80].

[80] This trend has resulted in the UK having one of the lowest energy instensities in the world. In contrast, amongst the BRIC economies only Brazil has a relatively low energy intensity. China and Russia use around three times as much oil equivalent to produce a dollar of GDP than the UK. The US is also significantly more energy-intensive than the UK.

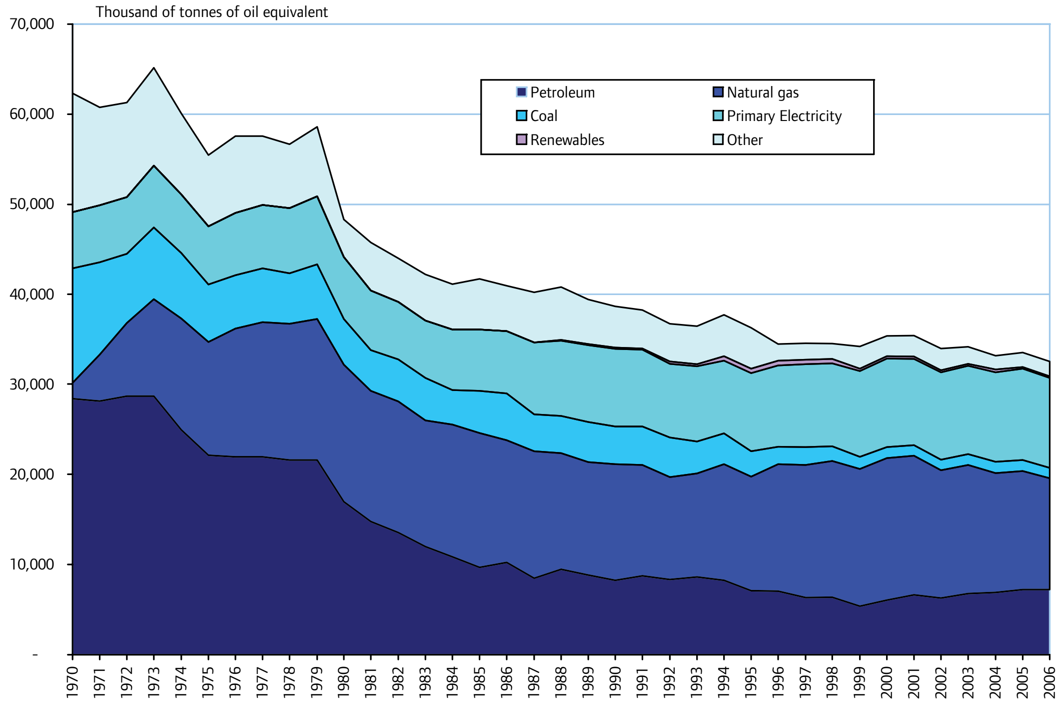
The downward trend in energy intensity can be explained by a wide variety of factors. However, it is the decline in industrial energy use which has been the strongest driver. Industrial energy use per unit of output generated by the whole economy has more than halved over the last 30 years. Within the industrial sector itself there are at least three important, separate but interlinked drivers for this trend:

1. A decline in the relative importance of energy-intensive industries in the UK economy;
2. Some industrial uses, such as space heating, not being scale-linked with levels of industrial output;
3. Improvements in the energy efficiencies of many industrial processes, particularly in energy-intensive industries where energy is a major input cost.

It should be no surprise that commercial and industrial energy use has fallen sharply over the last 40 years. Not only has there been a shift from the manufacturing to the service sector in the UK economy but the internal composition of manufacturing has changed. 'Heavy' industrial manufacturing such as iron and steel, vehicle manufacture and textiles production has declined in the UK and relocated to cheaper locations elsewhere in the world. That element of manufacturing that has remained in the UK has tended to have a higher value added focus. In addition, the UK – along with other economies in Western Europe and North America – has adopted the most energy efficient technologies for manufacturing available, especially since the energy price hikes of the 1970s[81]. That does not imply that there are not still some energy-intensive manufacturing sectors, which remain significant consumers of energy. For example, chemicals manufacture accounts for nearly 9 per cent of all commercial and industrial energy use in the UK. When only industrial energy consumption is examined for the UK the marked decrease in energy use is very clear. However, it can also be seen that the rate of decrease in industrial energy consumption has been far slower over the last 10 to 15 years than it was during the 1970s and 1980s[82].

[81] Current energy price increases should help push this trend further.
[82] This almost certainly reflects a changing mix of the aforementioned drivers.

Figure 3.1: UK industrial energy consumption 1970 to 2006

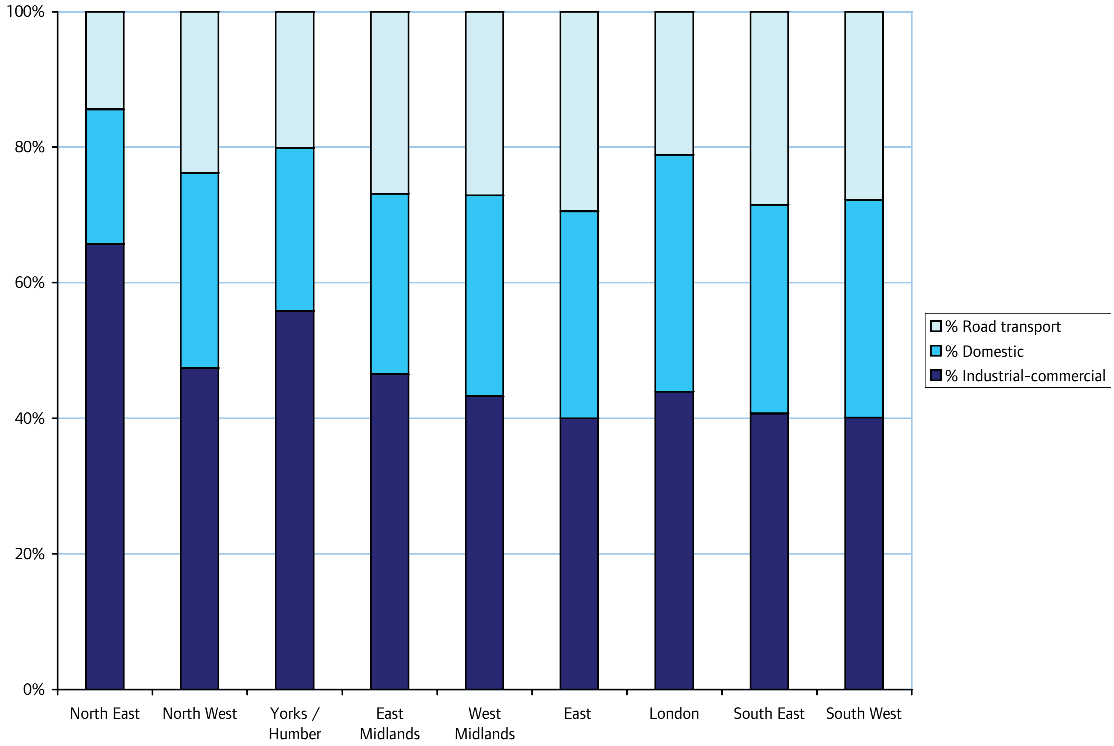


Source: BERR

In London, the shift away from manufacturing to services has been even more pronounced. Even the statistic of 5.6 per cent of London's GVA being sourced to manufacturing[83] probably slightly overestimates the manufacturing sector's presence in the capital[84]. This is on account of the 'headquarters effect' whereby a manufacturing organisation, which is engaged in manufacturing elsewhere, has its headquarters in London where employees are engaged in roles which, by and large, have more in common with the service sector. However according to NATCEN, the proportion of total CO_2 emissions accounted for by commerce and industry in London is almost identical as for the UK as a whole at just under 44 per cent (see Figure 3.2).[85]

[83] Source: Experian Regional Planning Service; estimates for 2007.
[84] Manufacturing accounts for 4.8 per cent of Greater London's workplace-based employment (source ABI).
[85] This is a slightly higher proportion than that identified by the GLA's own database, LECI, and used by the Mayor's Climate Change Action Plan.

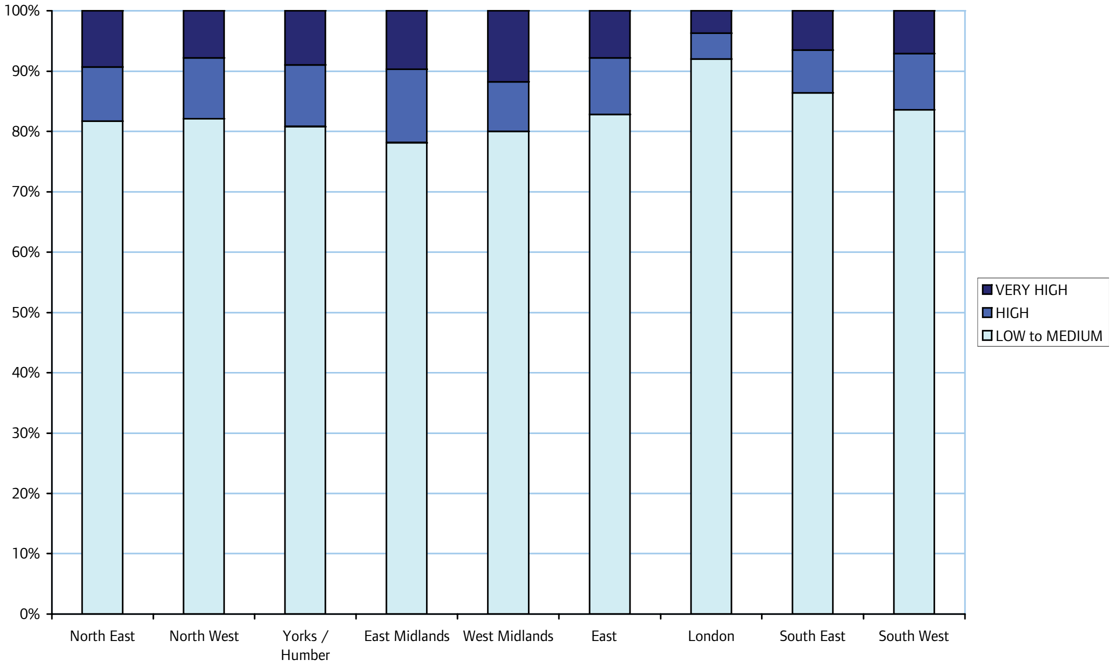
Figure 3.2: Proportion of CO_2 emissions accounted for by different sources, by region



Source: NATCEN

Figure 3.3 shows the proportion of each region's employment in sectors associated with high and very high energy consumption.

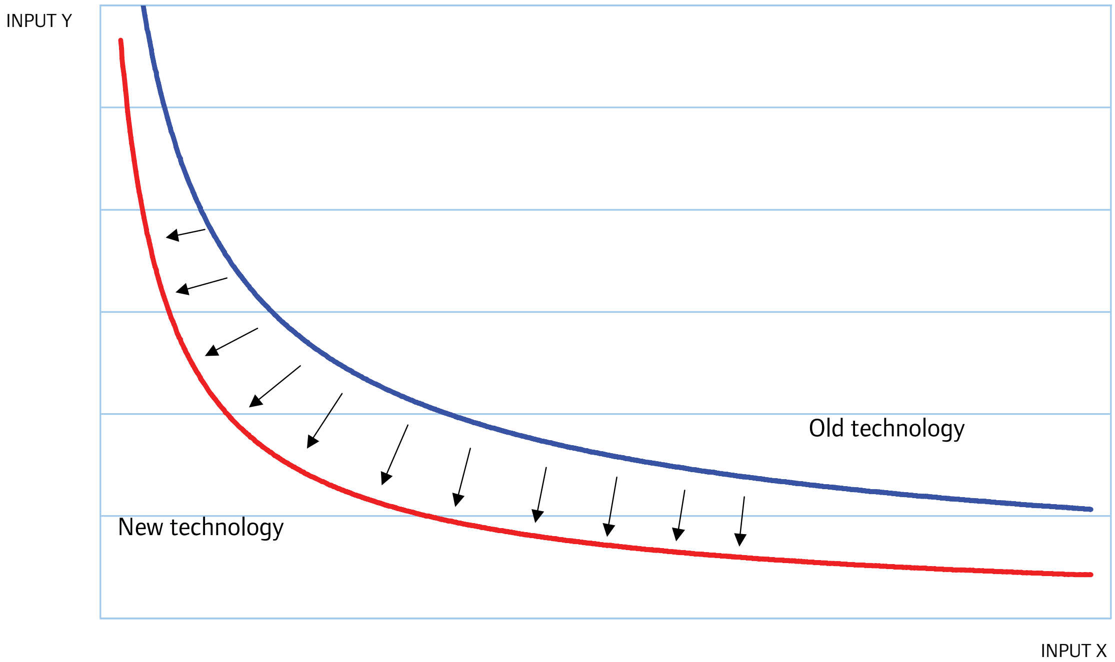
Figure 3.3: Proportion of employees employed in high-energy intensity sectors, by region



Source: Annual Business Inquiry (ABI), (2005)

Technical innovation also allows the same goods and services to be produced with less energy and/or other inputs. In economic terms, the isoquant of the original production method is shifted towards the origin enabling the same product to be produced with fewer inputs[86]. Figure 3.4 shows two inputs, X and Y. One of these inputs might be energy. New technology tends to mean that the production process becomes more energy efficient, shifting the whole production curve towards the origin. The reduction of energy consumption per unit of output produced will almost certainly mean reduced CO_2 and pollutant emissions per unit of output.

Figure 3.4: Effect of a shift in technology on efficiency of production



Source: GLA Economics

Geography versus responsibility in the analysis of London's energy use

Londoners – and people in other parts of the UK – continue to consume manufactured goods. In fact their consumption of manufactured goods has increased as personal disposable incomes have increased. However, the vast majority of these goods are now manufactured overseas, usually in lower cost locations. There are often additional energy inputs required as a result of longer distance transport and in terms of lower levels of energy efficiency in foreign plants[87]. Therefore it is possible that lower emissions data for the UK might actually hide higher total emissions globally created by a comparable level of demand in London[88]. However, there is also the possibility that this aspect of globalisation might encourage developing countries to adopt the most

[86] An isoquant, (shown in Figure 3.4 by an individual line), represents all the different ratio of inputs that produce the same level of output.
[87] According to the OECD / IEA (2007), global industrial energy use grew by 61 per cent between 1971 and 2004 with much of the change taking place in the rapidly developing economies – four fifths of growth being sourced to China. The adoption of advanced technologies already in commercial use could improve the energy efficiency of global manufacturing dramatically. Their findings demonstrate that the potential technical energy savings could be as high as 37 exajoules per year, equivalent to 900 million tonnes of oil equivalent.
[88] One other implication which is often overlooked is that the rapidly developing economies are considerably less efficient in their energy resource efficiency than the UK. Given that global growth is likely to be driven by the developing economies over the next few decades, this implies that growth will also be less resource efficient – although the developing economies can be expected to improve their resource efficiencies. Another implication is that it will put inflationary pressures on prices and partially offset global energy efficiency gains made in recent years.

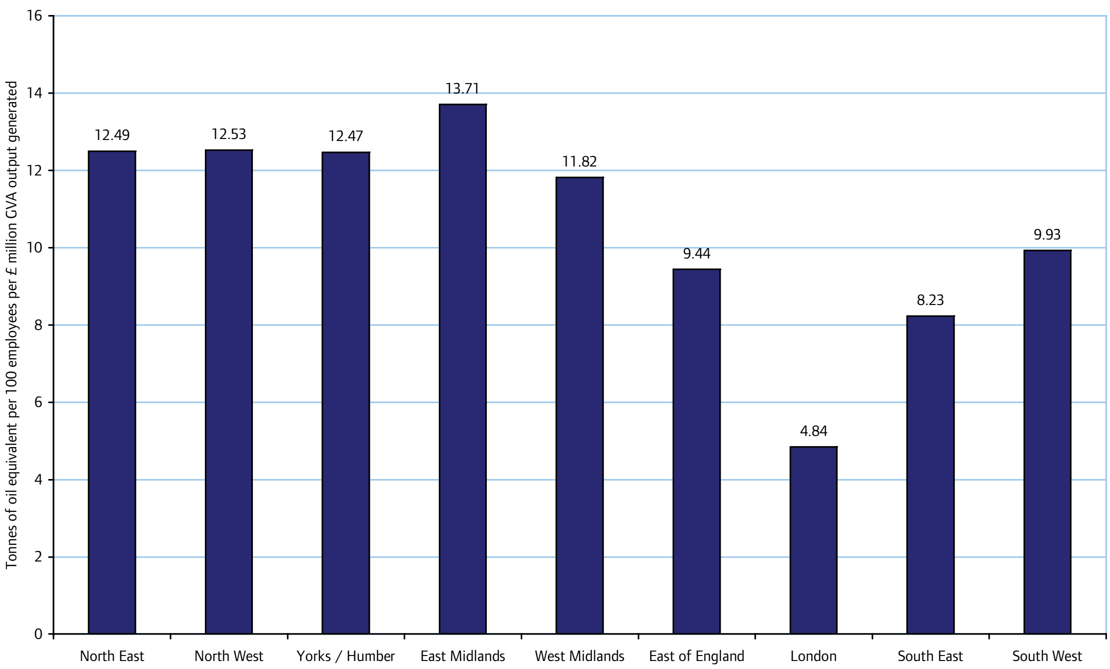
environmentally effective technologies – particularly if this process takes place within the context of schemes such as the Clean Development Mechanism (CDM)[89].

Modelling commercial and industrial energy use by region

Using data from BERR[90] on commercial, agricultural and manufacturing energy use by sector, national levels of energy use per 100,000 employees were established. This was then modelled to regions on the basis of the industrial structure of employment and GVA output. In effect, this produces GVA-weighted individual energy use per employee in the commercial and industrial sector. This is measured in tonnes of oil equivalent of energy per 100 workplace-based employees in a region per £1 million of GVA output generated.

The results suggest that London is by far the most energy effective of the English regions. However regions in the south of England generally perform well on account of the generally low presence of heavy manufacturing sectors such as chemicals and metals manufacture. There is a general uniformity in the performance of all of the northern regions and the West Midlands. On this analysis the East Midlands would appear to be the least environmentally effective region in terms of energy efficiency.

Figure 3.5: Energy efficiency per 100 employees per unit of output generated



Source: GLA Economics derived from BERR data

This methodology produces results that would seem to be broadly consistent with experimental data produced by the DTI. The Energy White Paper in 2003[91] emphasised

[89] The CDM mechanism under the Kyoto Protocol allows developed economies (Annex I Countries) to invest in projects reducing emissions in the developing world as an alternative to higher cost per unit reductions within their own economies. This reduces the cost of global greenhouse gas emission cuts. However, the mechanism's critics argue that there is 'deadweight' in CDM i.e. many of the projects would have been undertaken anyway and emissions reductions generated by such projects tend to be over-estimated.

[90] In June 2007, Gordon Brown announced, in a written ministerial statement, the creation of a new ministry: the Department for Business, Enterprise and Regulatory Reform (BERR). BERR has effectively replaced the DTI.

[91] Our energy future – creating a low carbon economy.

the importance of local and regional energy decisions and this led to a drive towards improved regional and local data on energy consumption. The data commented upon below are based on 2003/2004 data and measured in kilowatt hours (kWh) per employee. The DTI data do not cover all industrial and commercial consumption of gas and electricity but have enabled regional, local authority and NUTS 3[92] area comparisons to be made.

For gas consumption by the industrial and commercial sector, the study finds that London was a relatively low commercial consumer of natural gas although none of the individual Boroughs fell within the lowest ten consuming local authorities nationally.

For electricity, the highest total industrial / commercial consumption per meter point was for Wales and the lowest was for the South West. On this measure the City of London fared rather badly according to the DTI data.

The DTI has therefore been able to produce some estimates of total energy consumption by the industrial and commercial sector. These estimates suggest that London, the South East and the South West have broadly similar results and rank as the most energy efficient regions. When the analysis is extended to the NUTS 3 level the four lowest consumers are all within London's functional urban region (FUR)[93] and are:

- Surrey
- Outer London (South)
- Brighton & Hove
- Inner London (East)

Obviously, a number of factors may distort the DTI's findings. These factors include the location of particularly energy-intensive manufacturing plant (for example, Neath Port Talbot's rank on electricity is driven by the Corus steelworks there) and commuting patterns – authorities with a higher number of working age residents than employees will tend to fare badly (e.g. Rutland, Thurrock, New Forest). It is also worth noting that the DTI does not cover **all** commercial consumption of gas and electricity.

In summary, London performs relatively well mainly on account of its industrial structure and concentrations in the service sector rather than in manufacturing.

Commercial and industrial emissions of CO_2

CO_2 data from Defra have been initially denominated by local authority populations. Defra has not undertaken this approach itself – presumably because population is not the best denominator as ideally, the denominator should reflect output. However, other alternatives such as local GVA are also very distorted as a result of commuting patterns and therefore population has been used for the sake of simplicity. One by-product of this decision was that the City of London emerges as the worst performer nationally as emissions from its dense cluster of offices are relatively high whilst very few people actually live there. It does constitute a rather extreme example.

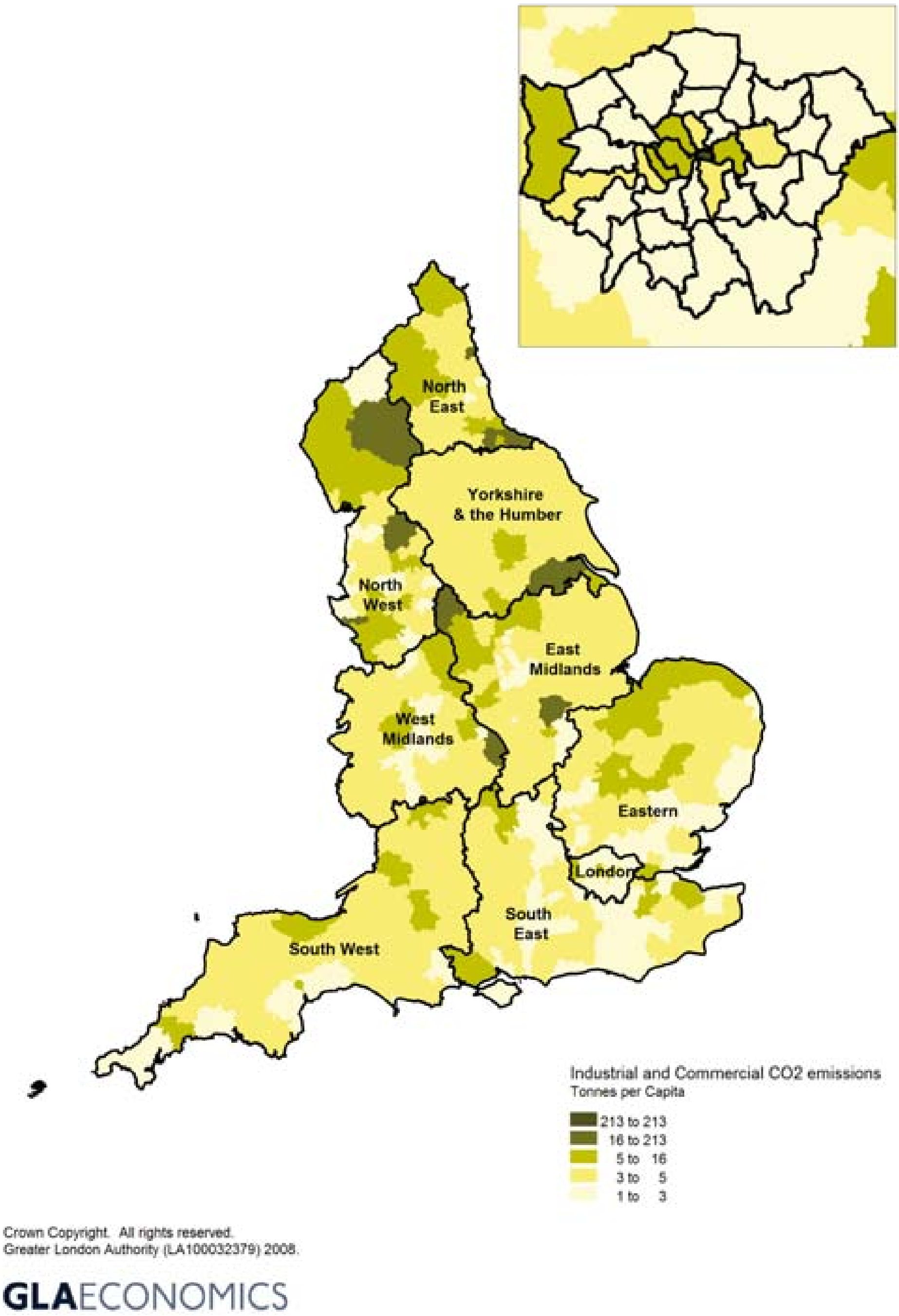
[92] The Nomenclature of Territorial Units for Statistics (NUTS) in the United Kingdom is a subdivision of the UK devised by Eurostat. NUTS 3 corresponds broadly to administrative counties and Unitary Authorities. However, the situation is different in the larger urban conurbations and London is divided into five NUTS 3 regions: Inner London West, Inner London East, Outer London East and North East, Outer London South, and Outer London West and North West.
[93] This is an approximation of London's self-contained regional economy. The London FUR contains large tracts well outside the GLA boundary.

However, it is also the case that on this measure London has many of the best performing authorities. Of the 12 best performing authorities, eight are London Boroughs and the Greater London area as a whole performs well.

Other than the City of London, none of the worst performers are within the Greater London area as they tend to be authorities in which large industrial plant is concentrated (Redcar & Cleveland, Neath Port Talbot, North Lincolnshire or Wansbeck).

There is a longer-term worry for London though. At present, only around 6 per cent of commercial CO_2 emissions can be sourced to cooling. However, with increased temperatures, due to global warming and the urban heat island effect, there is a risk that cooling could become a greater source of energy demand than the heating of office buildings.

Map 3.1: Industrial and commercial CO_2 emissions per capita



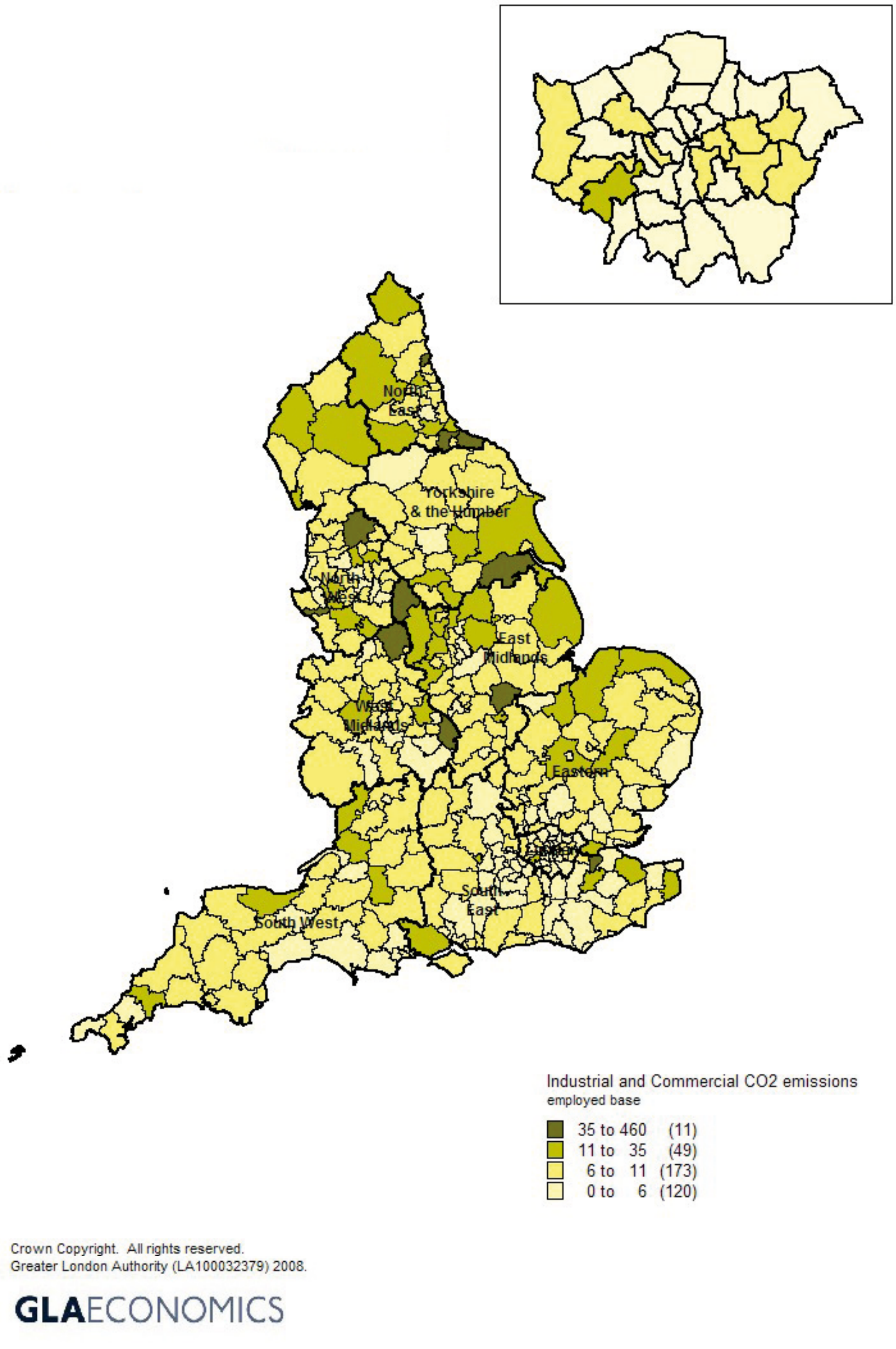
Source: Defra

In 2005, at a regional level, London's commercial and industrial sector emitted 2.9 tonnes of CO_2 per capita compared to the national average of 3.24 tonnes. The only region to perform better was the South East at 2.8 tonnes of CO_2 per capita.

The analysis of industrial and commercial CO_2 emissions by local authority was then repeated using the employment base rather than population as the denominator. This should be more closely related to output although the denominator will fail to account for differences in the productivity of workers. This is likely to mean that London's environmental performance is being underestimated on this indicator.

However, London's performance is still very strong. As expected the main change to result from the switching of denominators is that the City ceases to be the worst performer and now shows a strong environmental performance since its employment base is high. The change of denominator does not affect the relative performance of other authorities dramatically.

Map 3.2: Industrial and commercial CO_2 by employed base



Source: Defra and ONS

Service sector energy inefficiency

Historically, energy consumption in the service sector has received only limited attention from official statistics. Traditionally, the sector's energy use was aggregated into 'other final users' meaning that its rapid rate of growth was partially obscured by the decline in agricultural energy use.

During much of the 1990s, the trend towards increased energy efficiency in new products was not followed in new offices. One key contributor to this was the increased use of air conditioning in offices. This remains an issue and it is likely that in the future space cooling in UK offices will be a greater consumer of energy than space heating. Nevertheless, tighter building regulations have impacted on new offices. However, these have largely left the existing stock unaffected and significant barriers to retrofitting exist – particularly in the form of split incentives between developers, management companies and tenants.

Although the service sector uses far less energy per unit of output than the manufacturing sector, in a service-based economy such as the capital it is essential that buildings and ICT systems are as environmentally effective as possible. ICT, in particular, consumes a growing proportion of office-related energy and ICT now accounts for around one tenth of UK electricity consumption.

Around two thirds of energy is actually lost in power generation and transmission (the vast majority in generation). However, even when energy supply arrives in an office, typical computers and servers do not use it particularly efficiently. Around 45 per cent of energy used by computers and servers is actually being used to maintain internal temperatures whilst nearly a further 10 per cent is being used for converting AC power supply to DC.

Closely linked to IT systems is the concept of the 'intelligent office'. Green building innovation was actually flourishing as early as the 1970s, a by-product of the systems and controls used to optimise manufacturing plant process performance. However, three decades on a new generation of businesses is seeking out intelligent offices to satisfy both their own business needs and their environmentally aware consumers. These solutions include ideas such as Web-enabled tenancy where Facilities Management can be housed off-site.

Openness about office energy performance has improved in recent years with many businesses now reporting their environmental performance in the knowledge that it can influence their attractiveness to potential investors. Since April 2006 all London Stock Exchange listed companies have been required to include any environmental issues of importance affecting their business performance in their Annual Report and Accounts.

The capital's urban heat island

In addition, London's dense concentration of offices is a major contributor to the capital's problems with the urban heat island effect. This is the phenomenon whereby London's night time temperatures can be up to five degrees Celsius higher than at Wisley in Surrey. The causes of the urban heat island are actually multiple but several involve commercial offices. The main driver is believed to be comparatively warm buildings blocking the 'sky view' to the cooler night-time sky resulting in cities retaining heat at night whilst rural areas tend to lose heat more rapidly. However, office buildings are also part of how urban development alters thermal bulk and radiative properties of surfaces. Basically, materials commonly used in cities tend to absorb rather than reflect heat. Of course, tall buildings greatly increase the total surface area which can be heated – the so-called 'canyon effect'[94]. Finally, some outputs from offices such as waste heat from air cooling systems can also exacerbate the urban heat island.

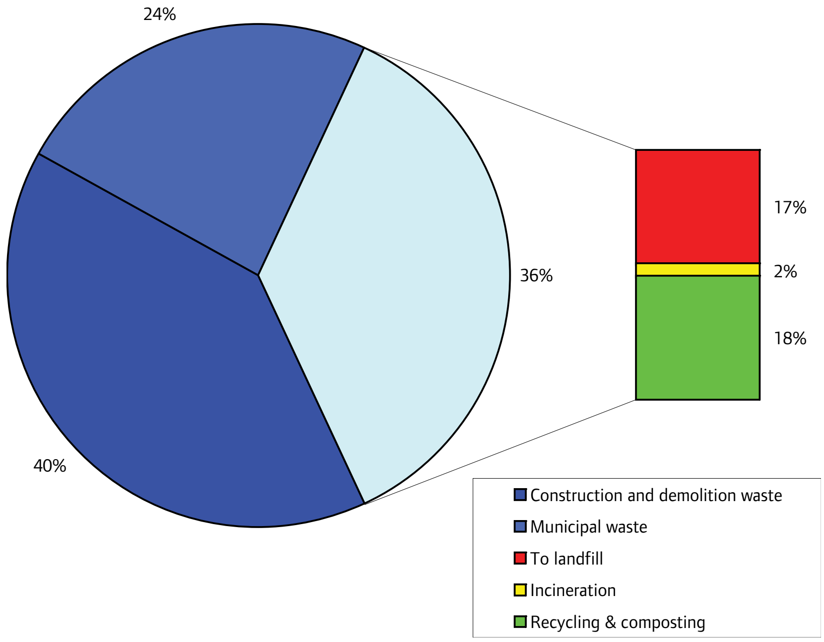
The effects of the urban heat island should not be underestimated. During hot summers London's urban heat island effect will impact directly on the health and welfare of Londoners. However, the urban heat island hypothesis is not without critics, the most notable being Peterson who has argued that the perceived effect is a result of biases in the datasets[95].

Commercial, industrial and construction sector wastes

The last GLA Economics report on environmental effectiveness concentrated on municipal waste. However, London produces over 18 million tonnes of waste every year of which under a quarter is municipal waste. 76 per cent of waste generated in the capital is either commercial and industrial waste or construction and demolition waste. Total waste in London is forecast to increase to 24 million tonnes by 2020.

By 2020 London hopes to be meeting its self-sustainability target of treating 85 per cent of waste generated in London within London 'in some way'. That is a tough target. However, both commercial and industrial waste and construction and demolition waste have much higher recycling and composting rates[96] than the municipal sector – which is discussed in Chapter 4.

Figure 3.6: Commercial and industrial waste (pale blue segment) in London as a proportion of total waste

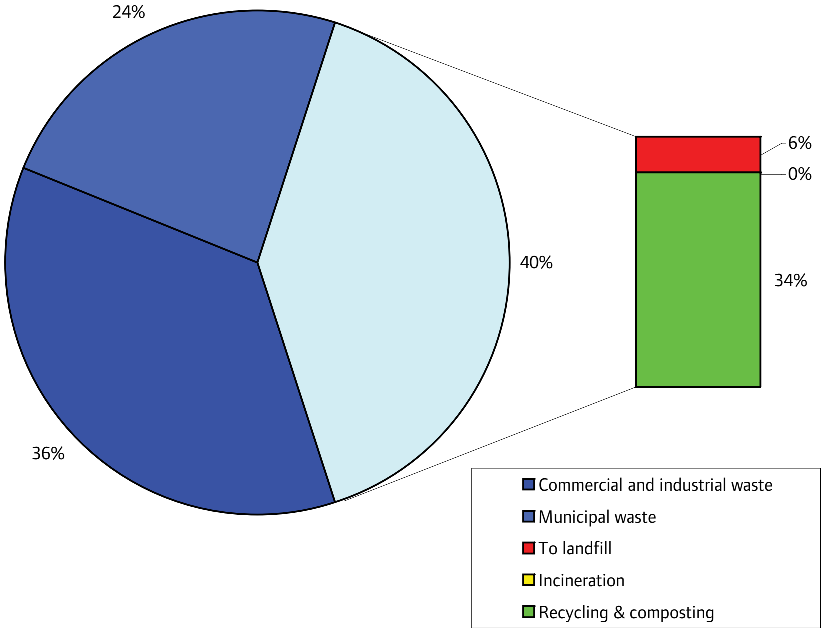


Source: London Plan Waste Alterations, December 2006 / London Remade

[94] However, tall buildings can play a part in strengthening agglomeration benefits. Obviously, they are controversial in terms of their impact on the urban skyline.
[95] See Thomas C Peterson – Assessment of urban versus rural *in situ* surface temperature in the contiguous United States; no differences found (Journal of Climate, Vol. 16 Issue 18).
[96] The Landfill Directive of October 2007 ensures that waste can be traced back to source and companies fined. From September 2008 UK businesses are also likely to become subject to the Batteries Directive. The new legal obligations will mean stricter rules on recycling and recovery as well as improvements to the environmental performance of all batteries. Currently the UK has a good track record on the recycling of lead acid batteries but only 3 per cent of portable waste batteries are currently recycled and this needs to increase to 25 per cent by 2012 and 45 per cent by 2016.

- Commercial and industrial waste accounts for 36 per cent of all London's waste.
- Around half of that is already recycled or composted, equivalent to over 3 million tonnes of waste.

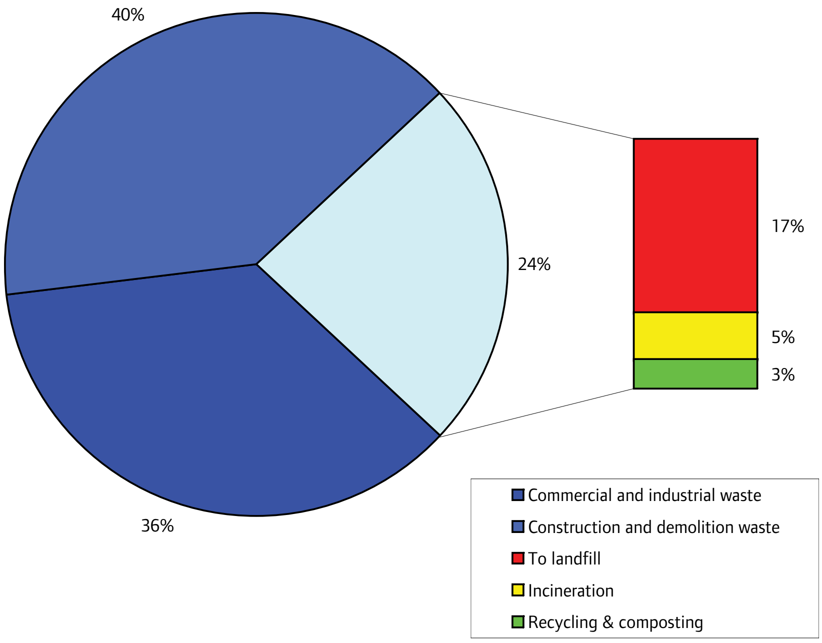
Figure 3.7: Construction and demolition waste (pale blue segment) in London as a proportion of total waste



Source: London Plan Waste Alterations, December 2006 / London Remade

- Construction and demolition waste accounts for 40 per cent of all London's waste.
- However, the vast majority (around 85 per cent) is already recycled or composted.
- Almost none of it is incinerated.
- A particular problem is wood recycling as it is often contaminated with glues, metals, resins or preservatives. A small amount of contaminant may actually render a whole consignment of waste wood unusable.

Figure 3.8: Municipal waste (pale blue segment) in London as a proportion of total waste



Source: London Plan Waste Alterations, December 2006 / London Remade

Note: Further details of municipal waste recycling can be found in Chapter 4

- Municipal waste accounts for just under a quarter of London's waste.
- It is the most discussed segment of the capital's waste and this report deals with it separately under the households chapter.
- The majority (seven tenths) of municipal waste from London goes to landfill – often to sites beyond the Greater London boundary.

Meeting London's targets on the recycling of waste by 2020

As can be seen from the pie charts above, the commercial and industrial sector and the construction sector in London already have a good record on recycling. However, London has set itself a tough target for dealing with its own waste and this raises major challenges. It is estimated[97] that around 300 additional treatment plants will be needed in London to meet waste targets, requiring an investment of around £2 billion. These required facilities include a whole range of facility types from materials recovery to gasification[98], anaerobic digestion[99] and mechanical biological treatment (MBT)[100].

However, London is already being highly innovative in moving towards these targets. Some Boroughs are operating systems of shared waste management plans in order to

[97] London Plan Waste Alterations 2006

[98] Gasification converts carbon-based materials to syngas via high temperatures and a controlled oxygen input.

[99] Anaerobic digestion – often shortened to AD – is a treatment which composts waste in the absence of oxygen resulting in a biogas that can then be used to generate heat and electricity. The organic matter is broken down by bacteria in a controlled version of what happens at a landfill site where methane is released. AD actually takes place in several phases: hydrolysis, acidogenesis, acetogenesis and methanogenesis.

[100] MBT plants combine a mechanical sorting facility with biological processes such as anaerobic digestion or composting to process both commercial and industrial waste and mixed household waste.

specialise. Closed Loop at Dagenham, which has been backed by the London Development Agency, is the UK's first PET[101] recycling plant. The plant will convert 35,000 tonnes per year of plastics from drinks bottles and cosmetics into packaging – equivalent to 910 million bottles a year[102].

Within recycling the fastest growing materials stream is electronic and electrical equipment, known as WEEE[103]. The EU WEEE Directive came into force in England and Wales in January 2007[104]. If all separately collected WEEE in London were to be recycled the total mass of recovered material would be around 132,000 tonnes per annum[105] with more than half of this as ferrous material.

Improving the sustainability of office buildings

Far more attention is now being given to office building design than was formerly the case. For example, a number of buildings at Canary Wharf now have *Sedum* based 'green' or 'living' roofs. Barclays in the Canary Wharf development actually has the highest living roof in the world[106]. Such roofs are actually a rather traditional design for roofing buildings with the 'pitched sod' variety having been used extensively in Viking structures and still being evident today in Iceland and the Faroe Islands. Modern green roofing began in Germany during the 1960s and has since spread to a wide range of countries as diverse as the United States and Egypt.

Not only do green roofs absorb heavy rainfall, reducing surface runoff at ground level and thereby reducing flood-risk, they can also be extremely valuable in terms of biodiversity[107]. Once greened the roof can store as much as 70 per cent of rainfall, gradually releasing moisture back into the atmosphere via transpiration. They can also have a small impact on the improved filtering of pollutants in the city and can play a part in reducing the scale of the urban heat island effect. On lower level office buildings green roofs can have amenity value to office workers and improve the view from surrounding buildings. The latter was a key driver in the design for FC4 at 20 Cabot Square. 'Extensive' (as opposed to 'intensive') roofs can be very low (but not usually zero) maintenance and can be established on a very thin layer of specially formulated compost. Furthermore, provided structural standards are met, green roofs can usually be retrofitted onto existing office structures.

However, as yet there are no specific standards for green roofing in the UK so architects wishing to incorporate them into their office designs usually have to start from scratch which raises the initial, up-front costs of the building. Increasing the costs of design and construction of office buildings inevitably means passing such costs on. In a market where commercial property rents have fallen considerably over the past year this can create difficulties in letting offices. However, a properly designed, efficient, green building should be no more expensive in its design and construction than any other office.

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[101] Polyethylene terephthalate – a thermoplastic resin with molecular formula $(C_{10}H_8O_4)_n$ belonging to the polyester family.
[102] Source: McLaren Eco-Projects website
[103] Electrical and electronic waste is also the fastest growing waste stream in the UK as a whole. Around 1.8 million tonnes are generated each year.
[104] Statutory Instrument 2006 No. 3315 and 2007 No. 3454.
[105] Source: London Remade.
[106] The Barclays roof at 160 meters was designed specifically with nature conservation objectives in mind – in particular to attract the black redstart (Phoenicunus ochruros) of which there are less than 100 breeding pairs in the UK according to the RSPB.
[107] See, for example: Tecticolous invertebrates: a preliminary investigation of the invertebrate fauna on green roofs in urban London – English Nature, 2002.

Clearly, in the longer term sustainable office design offers cost savings. Poorly designed offices cost the occupants in terms of higher energy costs and may have less obvious costs such as higher rates of absenteeism. Research by the international architects, Gensler[108], has suggested that not only are unsustainable offices raising energy bills by as much as 27 per cent, they may also be reducing productivity as well. However, energy costs do not typically form a large proportion of a business' total costs and that means they are unlikely to give them much attention. However, recent increases in energy prices may push energy savings and efficiency up the corporate agenda. A more direct problem is 'split incentives'. Property developers will not usually go beyond the demands of statutory legislation in green building design and it will not be them who get the benefits of increased energy efficiency. Potential occupants may well want better energy efficiency but wield very little influence in the design of office buildings.

Commercial and industrial sector summary

- Overall London's energy consumption compared to other English regions in this sector is relatively good mainly on account of its industrial structure and concentrations in the service sector rather than in manufacturing.
- Using Defra data, CO_2 emissions for this sector denominated by the local employment base show that London has many of the best performing authorities.
- In 2005, at a regional level, London's commercial and industrial sector emitted 2.9 tonnes of CO_2 per capita compared to the national average of 3.24 tonnes.

[108] Faulty Towers: is the British office sustainable? (2006).

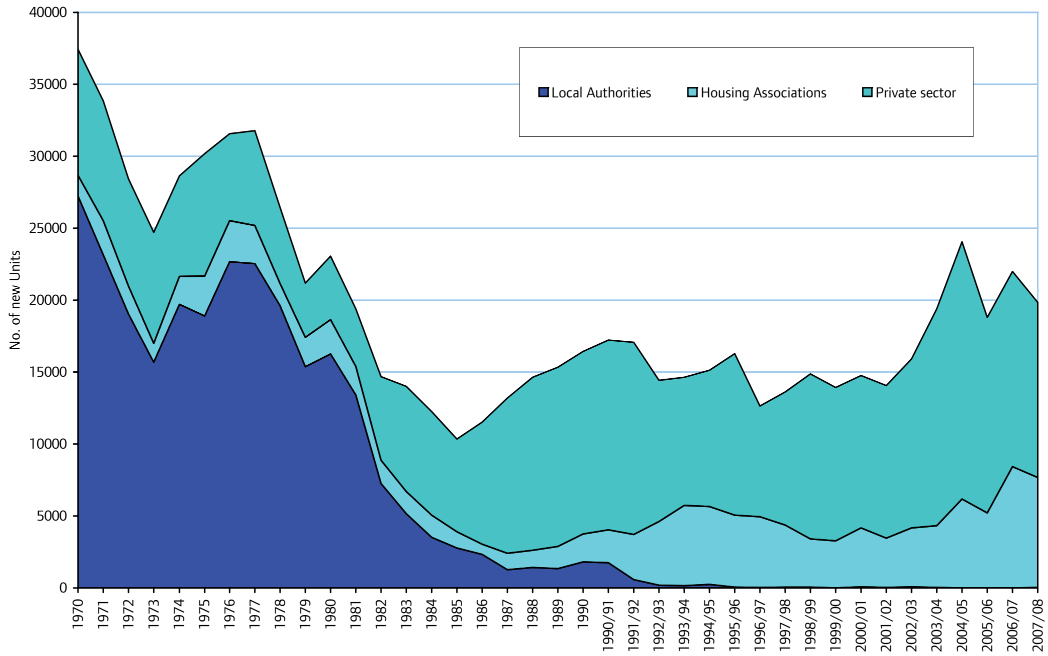
Chapter 4: Households

The analysis of London households focuses on three areas: energy consumption, household waste and domestic CO_2 emissions. Also included in this chapter is a brief summary of river water quality. London's density of flats tends to mean that it performs well on energy consumption – although there are also some signs that poverty in parts of east London may also be a driver for this. However, this density of flats has also been used as a traditional explanatory factor for London's poor recycling record.

London is the fastest growing capital city in Europe, with projected growth of around a million households over the next 20 years[109]. New housing built in the future to meet these needs will be far more environmentally effective than the current housing stock by being designed to use less energy, being better insulated and in some cases completely carbon-neutral[110]. However in order to improve the environmental performance of London's homes now, and hence tackle climate change and fuel poverty, it is necessary to track the environmental effectiveness of households against a number of key environmental indicators such as energy consumption, waste, water consumption and carbon emissions.

London's housing stock is skewed in terms of age towards older housing. Fifty eight per cent of residential property units in the capital were built prior to 1945[111] compared to only 39 per cent across England as a whole[112]. In contrast, with lower completions over the 1980s and 1990s – particularly Local Authority housing completions as shown in Figure 4.1, only 11 per cent of London's housing stock is post-1980, compared to 19 per cent nationally. This reflects in London's average SAP rating being six points lower than nationally[113].

Figure 4.1: Permanent dwelling completions in Greater London



Source: Communities and Local Government (CLG)

[109] The Mayor's Draft Housing Strategy, July 2007.
[110] This will also have the socio-economic benefit of contributing to the alleviation of fuel poverty.
[111] London Household Survey, 2002.
[112] English House Condition Survey, 2001. The information collected by the English House Condition Survey (EHCS) is the main source of information on the condition and energy efficiency of housing in England.
[113] SAP is the Government's Standard Assessment Procedure for Energy Rating of Dwellings.

Home design

London's existing housing stock has significant disadvantages with much of it having been built in the nineteenth century. The implications of this are that much of the existing stock has solid brick walls that cannot be cavity insulated. Incentives to encourage people to better insulate their homes also run into problems in the private rented sector where the benefits would accrue to the tenant. The problem here is that the tenant is likely to have little long-term interest in the property in a market with high turnover whilst the landlord has no incentive to upgrade the property whilst receiving adequate rent from the tenant with the property in its existing condition.

These issues create real long-term problems for the capital's household energy efficiency as only around 1 per cent of the capital's housing stock is changed each year through new build. That means that the majority of 2050's housing stock in London is already with us and relies on retrofitting to improve environmental performance.

In the future homes are not only likely to be far more energy efficient, they are also likely to have better water efficiency performance, improved waste management during their construction phase and more efficient waste management whilst under occupation as well as being more resistant to floods and being better at utilising design to improve internal air quality and to adapt to a warming environment.

The Code for Sustainable Buildings (CSB) is an evolving voluntary scheme developed jointly by Government and industry. It seeks to develop an effective, practicable and marketable standard to which all sectors of the building industry can subscribe and which property buyers will expect. At present one major weakness of the CSB is that it does not take full account of the importance of design techniques such as passive shading in avoiding overheating.

The private sector is unlikely to adopt voluntarily any scheme that does not either save costs or is at least cost-neutral unless it can be proved to add value in terms of sales or margins. This emphasises the importance of having either financial or planning incentives in place for sustainable housing. An example of such an incentive was implemented by the (then) Chancellor of the Exchequer, Gordon Brown, in 2007 when stamp duty was scrapped for all zero-carbon new build accommodation units under £500,000 in value until the year 2012.

Household energy consumption

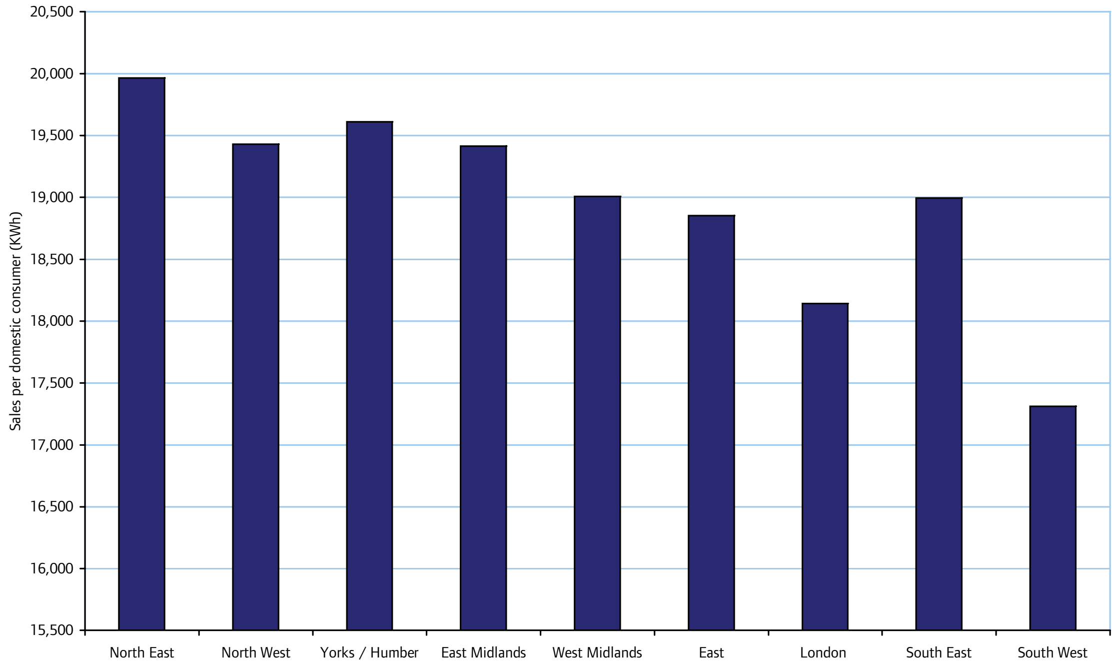
Across the whole of the UK domestic energy consumption makes up approximately 30 per cent of total energy consumption. This figure has changed very little over the past 25 years. However, what has changed is the end use of the energy within households. Although the percentage of domestic energy used on space heating has remained stable at around 60 per cent since 1970, the amount of total energy used for cooking has decreased by 36 per cent and energy used on lighting and appliances has increased by 150 per cent. While UK wide figures give an overall indication of energy use trends, this report is specifically about London. With that in mind, it is useful to see how London compares to the other English regions and the national average. Households use 40 per cent of the total energy consumption in London[114], a higher proportion than any other region. However this is due to the high population density of the region and when per capita figures are calculated London has the lowest domestic energy consumption figure

[114] Source: BERR. This figure is not directly comparable with the shares taken from other sources elsewhere in the report.

at 0.77 Toe (tonnes of oil equivalent) per capita, compared to an across region average of 0.83 Toe per capita[115].

The main energy sources for the majority of households are gas and electricity, and hence the rest of this section will focus on these specific energy sources. Gas sales to households in all regions were relatively stable during the period 2002 to 2005. In 2005 London households consumed approximately 52,600 GWh, far higher than the 39,500 GWh average across all regions. However, this high figure can be explained by London's large population. As Figure 4.2 indicates, London has the second lowest gas sales per capita figure compared to other regions at approximately 18,100 KWh per consumer. Household gas sales per domestic consumer fell in all regions during the period 2002 and 2005. In London sales per consumer fell by 7 per cent while sales in all other regions fell on average by 4 per cent.

Figure 4.2: Household gas sales per consumer for 2005

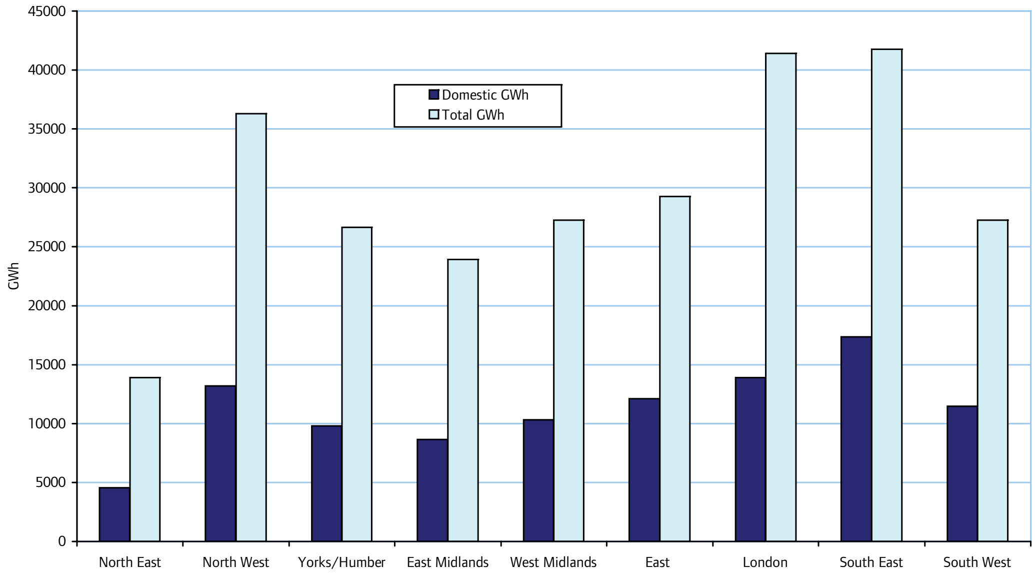


Source: BERR, regional energy consumption statistics

Households in London use about 34 per cent of total electricity distributed in the capital. The region with the highest household usage rates is the South East. London households use roughly 13,900 GWh of electricity; the highest, second only to the South East.

[115] All the statistics in this paragraph are derived from BERR energy consumption tables.

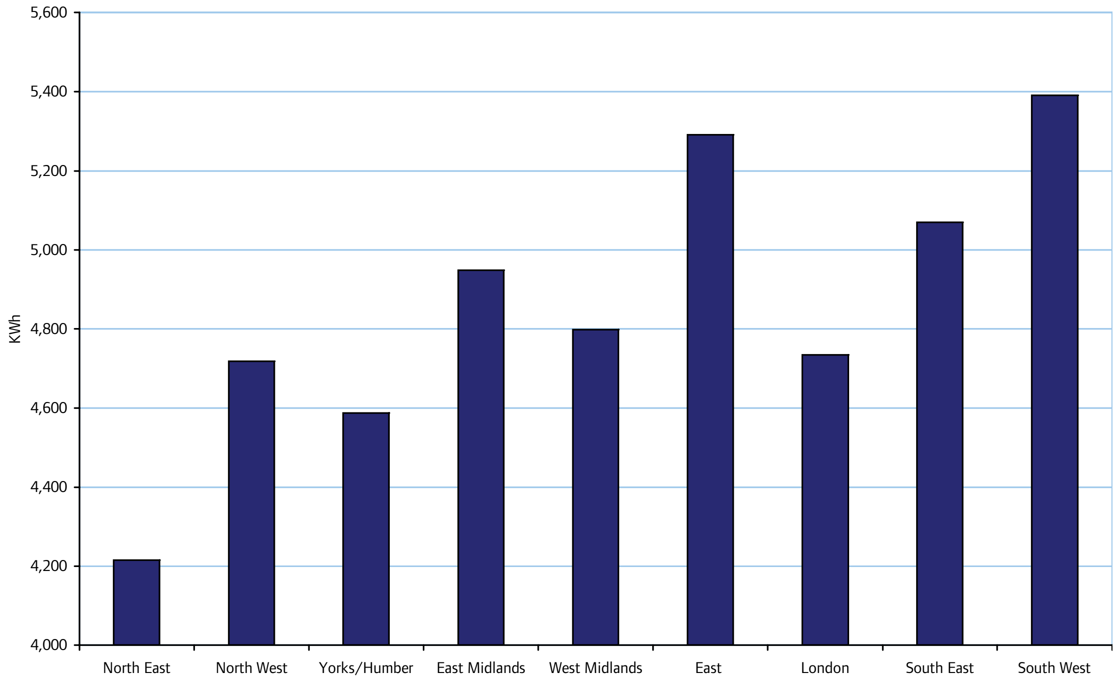
Figure 4.3: Total electricity consumption and household consumption, 2005 (GWh)



Source: BERR, regional energy consumption statistics

However per household statistics (see Figure 4.4) shows that average household electricity consumption in 2005 was around 4,850 KWh. London's household electricity consumption was slightly less than the average at around 4,750 KWh. It should be acknowledged that London generally has a higher than average number of single-person households, which may reflect the lower use per household figure[116].

Figure 4.4: Electricity consumption per household, 2005 (KWh)[117]



Source: BERR, regional energy consumption statistics

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[116] There could be all sorts of other influences here such as local climate, the effects of the urban heat island and varying attitudes to consumption.

[117] Note here that the methodology for the calculation of these data has been improved so that they are no longer comparable with the 2002 figures published in the last report.

Per GVA estimates for household energy use

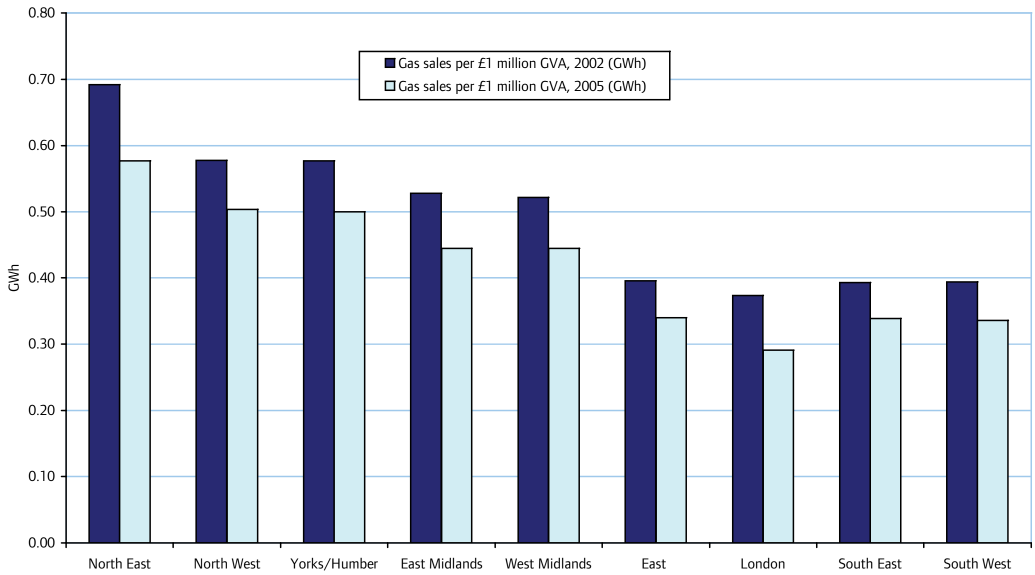
Another measure of comparing environmental effectiveness is to examine energy usage per unit of economic output. This is done by examining the estimated household electricity and gas consumption per £1million of GVA for all regions. These calculations have been made using the 2002 and 2005 regional gas and electricity sales statistics from BERR and the 2002 and 2005 GVA data from ONS. Estimates of regional GVA used in this section of the report are on a residence basis, so that the income of commuters is allocated to where they live rather than where they work. ONS produces two estimates of GVA for regions – a residence-based figure and a workplace-based figure.

As Figure 4.5 shows, domestic gas sales per unit of output measured by GVA fell in all English regions by an average of approximately 15 per cent from 2002 to 2005. London had the largest decrease in domestic gas sales per GVA. From 2002 to 2005 domestic gas sales per unit of output fell by 22 per cent in London.

Figure 4.6 shows that domestic electricity consumption per unit of output fell in every region except in the East, South East and the South West. On average per GVA domestic electricity consumption fell by 4 per cent. The largest percentage decreases occurred in the North East and London where per unit of output domestic electricity consumption fell by 19 per cent and 14 per cent respectively.

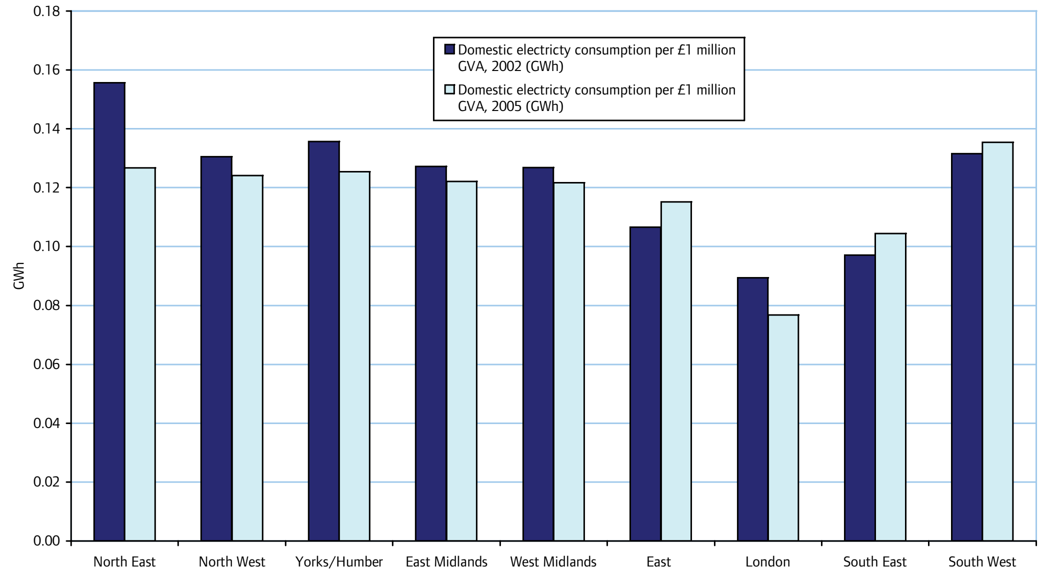
London performs well against other regions when using per GVA estimates indicating environmental effectiveness in the capital when looking at energy use and economic output.

Figure 4.5: Gas sales per £1 million of GVA, 2002 and 2005 (GWh)



Source: BERR, regional energy consumption statistics, ONS

Figure 4.6: Household electricity consumption per £1 million of GVA, 2002 and 2005 (GWh)



Source: BERR (regional energy consumption statistics), ONS

Total domestic gas and electricity use in London compared to other regions – an aggregate analysis

All the domestic energy use data has been reworked to examine whether London's ranking has been affected seriously by either its energy use mix or certain characteristics of its population structure. The methodologies used provide ten measures of total gas and electricity energy use in domestic households.

Initially, GLA Economics devised its own methodology to examine the majority of these indicators. However, for the majority of the KWh-based measures there was already a pre-existing DTI / BERR methodology which had been used to produce experimental data and, wherever possible, GLA Economics has followed their methodology.

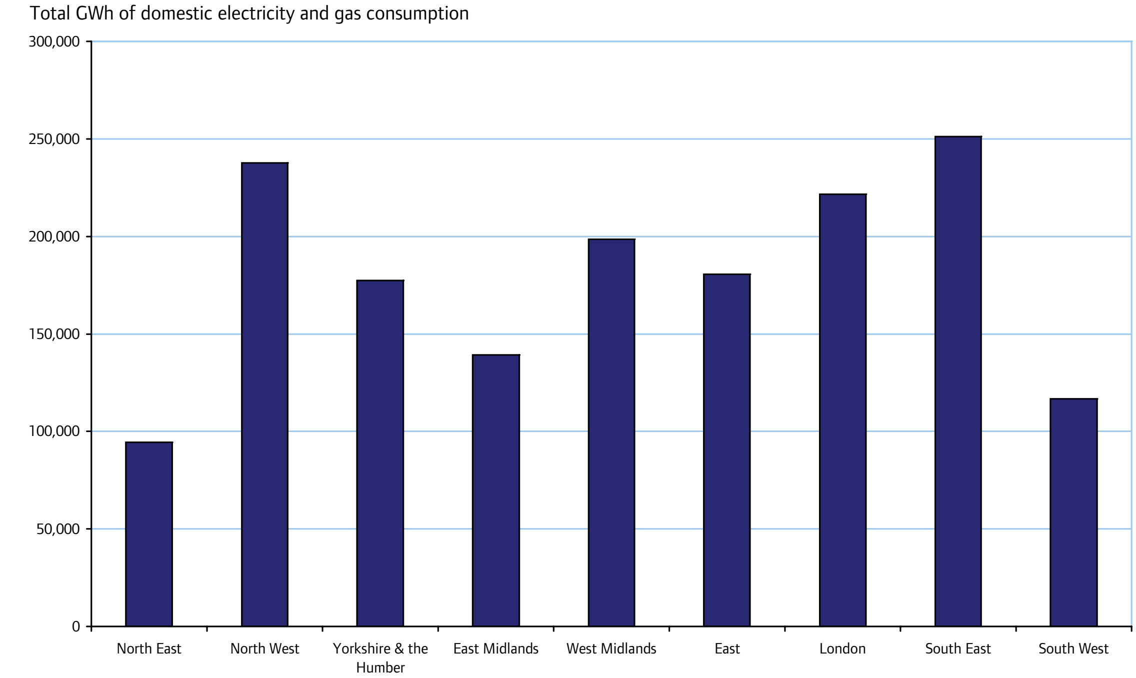
A – KWh basis

The first set of indicators simply aggregates KWh data for electricity and gas use and analyses the resultant data by a number of inter-related but distinct denominators.

1. **Total domestic gas and electricity consumption (GWh)**

In total terms London is the third largest consuming English region after the South East and North West. This indicator takes no account of the geographical, demographic or economic size of any of the regions. The smallest region, the North East, is the lowest consumer.

Figure 4.7: Total domestic gas and electricity consumption (GWh), 2005

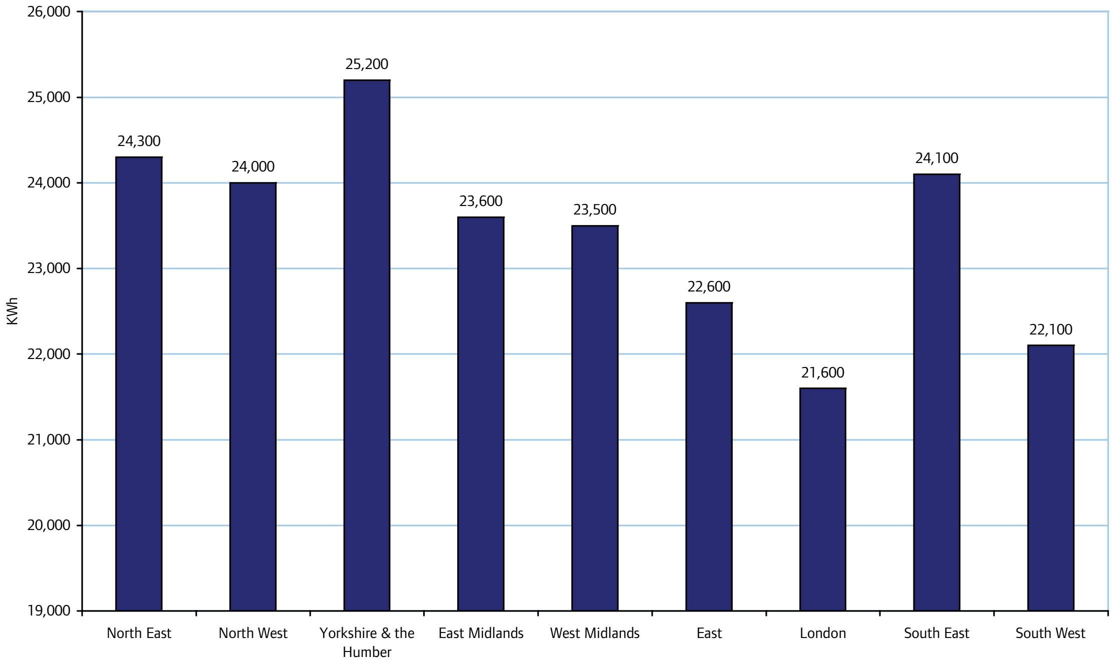


Source: DTI/BERR and GLA Economics

2. Domestic gas and electricity consumption per household (KWh)

London uses the least domestic energy on the per-household measure. Yorkshire and the Humber has the highest consumption – some 3,600 KWh more per household than London. The North East, North West and South East also have relatively high consumption on this measure. The South West is a relatively low consumer on this measure.

Figure 4.8: Domestic gas and electricity consumption per household by region (KWh), 2005

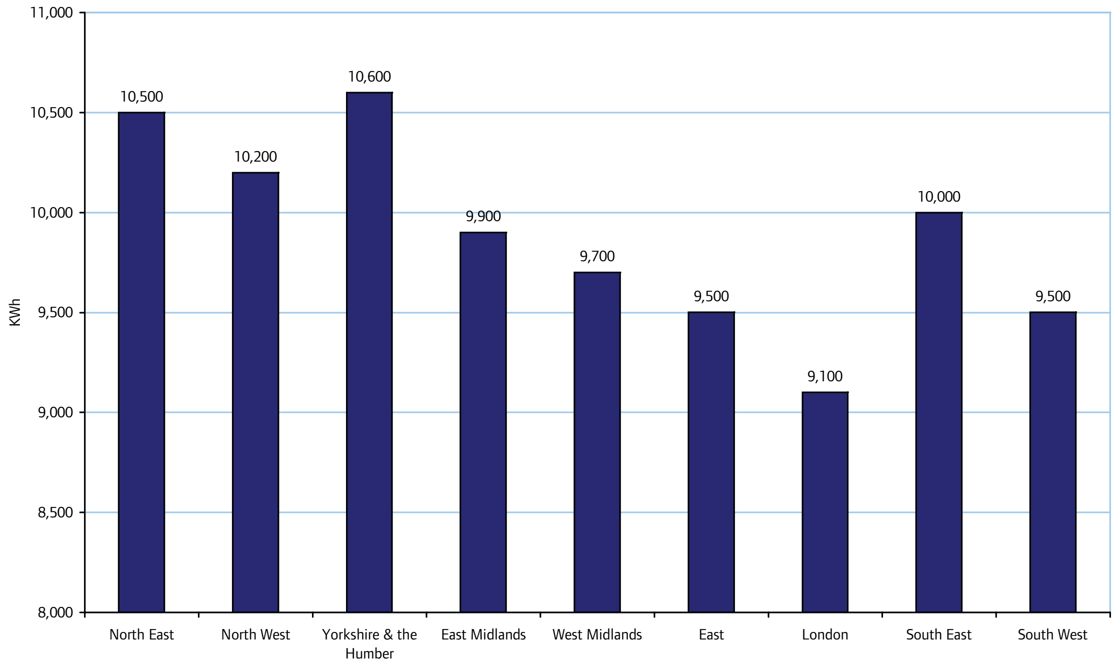


Source: DTI/BERR and GLA Economics

3. Domestic gas and electricity use per capita (KWh)

Again London has the lowest domestic energy consumption on a per head basis. Yorkshire and the Humber has the highest domestic energy consumption on this measure at some 1,500 KWh more per capita than London.

Figure 4.9: Domestic gas and electricity consumption per capita by region (KWh), 2005

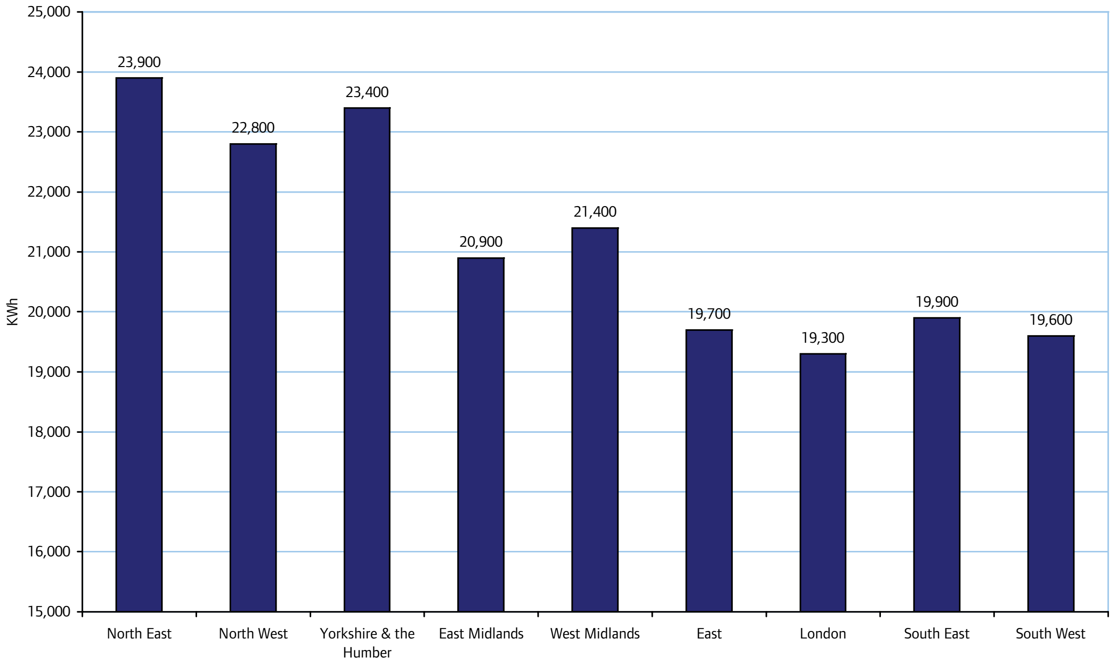


Source: DTI/BERR and GLA Economics

4. Domestic gas and electricity consumption per person in employment (KWh)

Domestic gas and electricity consumption data have also been analysed per person in employment. This has been undertaken on a residence basis and includes the self-employed as well as the employed. On this measure London again has the lowest consumption but three other regions – all of them in the south of England – are very similar. The North East has the highest consumption per person in employment. The results are influenced by rates of worklessness. With a lower level of worklessness London's result would have been even more energy efficient.

Figure 4.10: Domestic gas and electricity consumption per person in employment by region (KWh), 2005

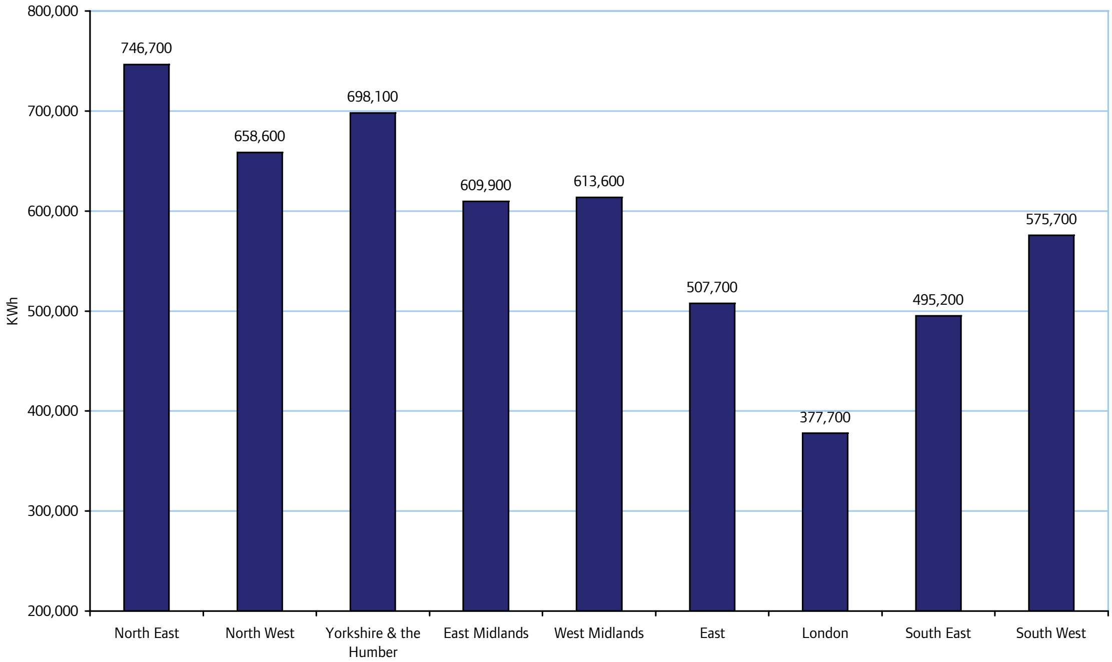


Source: DTI/BERR and GLA Economics

5. Domestic gas and electricity consumption per unit of residence-based GVA (KWh)

As might be expected on account of London's high productivity, it is on this measure that London performs best. No region comes close to London on this measure. However, it should be noted that output related to domestic energy consumption would not be a representative measure of resource efficiency which would in essence be driven by industrial and commercial consumption.

Figure 4.11: Domestic gas and electricity consumption per £1 million of GVA produced by region (KWh), 2005



Source: DTI/BERR and GLA Economics

B – Carbon dioxide emissions associated with domestic gas and electricity consumption

The second group of indicators concerns the carbon dioxide emissions generated by domestic gas and electricity consumption in London. This set of indicators is more complicated and can be more easily challenged on methodological grounds. The reason for this is that whilst 'gas' is just natural gas, household electricity is generated from a number of sources, some of which (for example, oil and coal) emit far more CO_2 than others (such as renewables and nuclear energy). The two main component sources in the UK are coal and gas which together account for just over 70 per cent with the majority of the remainder being nuclear. In contrast France generates most of its electricity from nuclear power with much of the rest coming from hydro. Clearly, different countries will therefore have different conversion factors. Furthermore, on account of the varying emission factors between components, one component source – namely coal – accounts for around 63 per cent of CO_2 emissions even though it is the source of only 34 per cent of the UK's electricity[118]. A further factor that needs to be considered is that the conversion factors change over time[119].

The conversion factors that have been used in this report are essentially consistent with those used in the UK Greenhouse Gas Inventory[120].

6. Total domestic gas and electricity consumption CO_2 emissions by region

The first graphic for this measure (Figure 4.12) takes no account of the size or population of a region; it merely shows the ***scale*** of energy use in domestic households by region. London is the second largest producer of CO_2 emissions from its domestic electricity and gas consumption but behind the South East. Unsurprisingly, as the smallest region in population terms, the North East accounts for the lowest total tonnage of CO_2.

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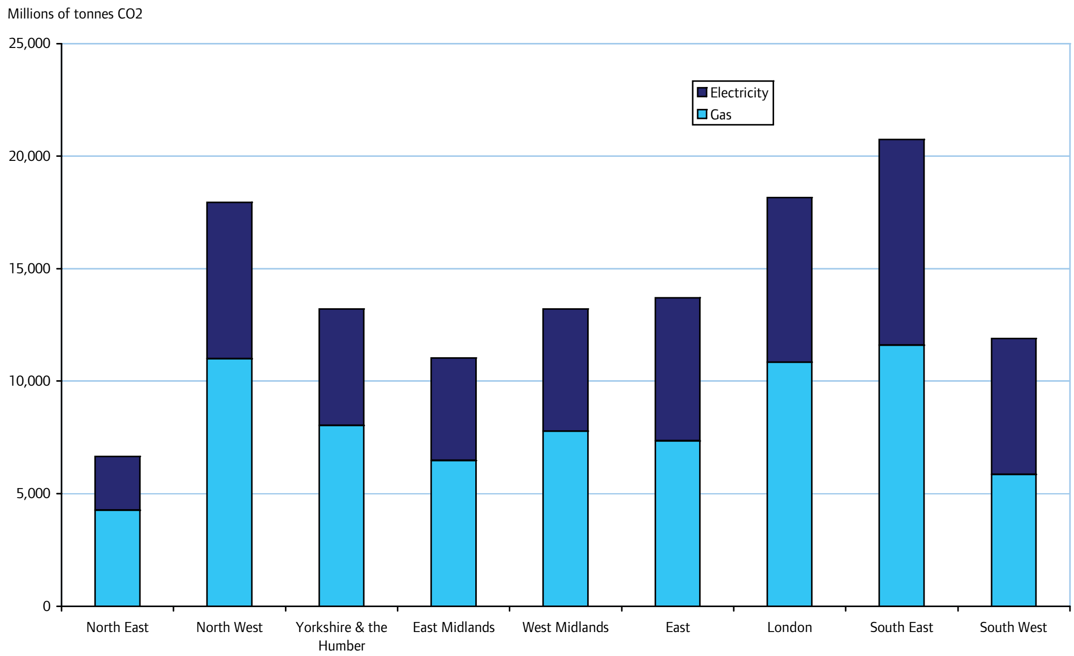
[118] GLA Economics calculation based on BERR data but with conversion factors that may not always be consistent with the UK Greenhouse Gas Inventory.
[119] The ones used in this piece of analysis all apply to 2005.
[120] UK Greenhouse Gas Inventory 2005, AEA Energy and Environment – published in the DTI Digest of UK Energy Statistics. Factors used in this GLA Economics report were 0.206 $kgCO_2/KWh$ for gas and 0.527 $kgCO_2/KWh$ for the combined mix of electricity.

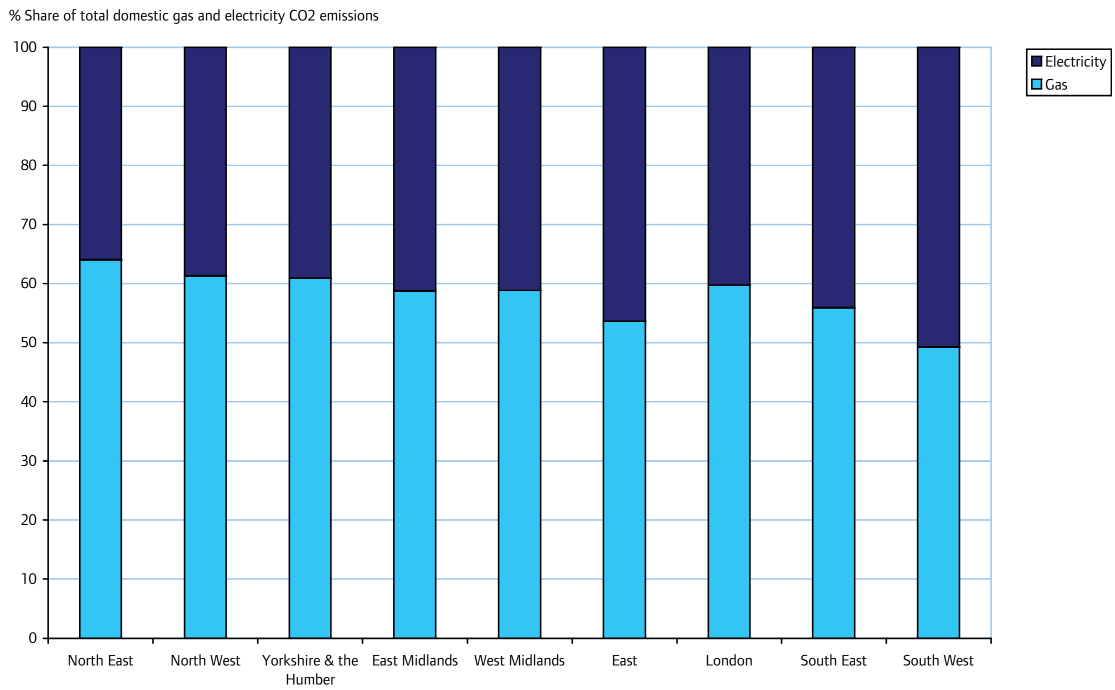
Figure 4.12: Millions of tonnes of CO_2 emissions generated by domestic gas and electricity consumption by region, 2005



Source: DTI/BERR and GLA Economics

The second graphic for this measure (Figure 4.13) shows that London is fairly typical in its share of emissions and even the regions at the extremes in terms of their energy use mix (the South West and North East) are not particularly removed from the overall picture for England as a whole.

Figure 4.13: Gas and electricity shares of total tonnage of CO_2 emissions generated by domestic gas and electricity consumption by region, 2005

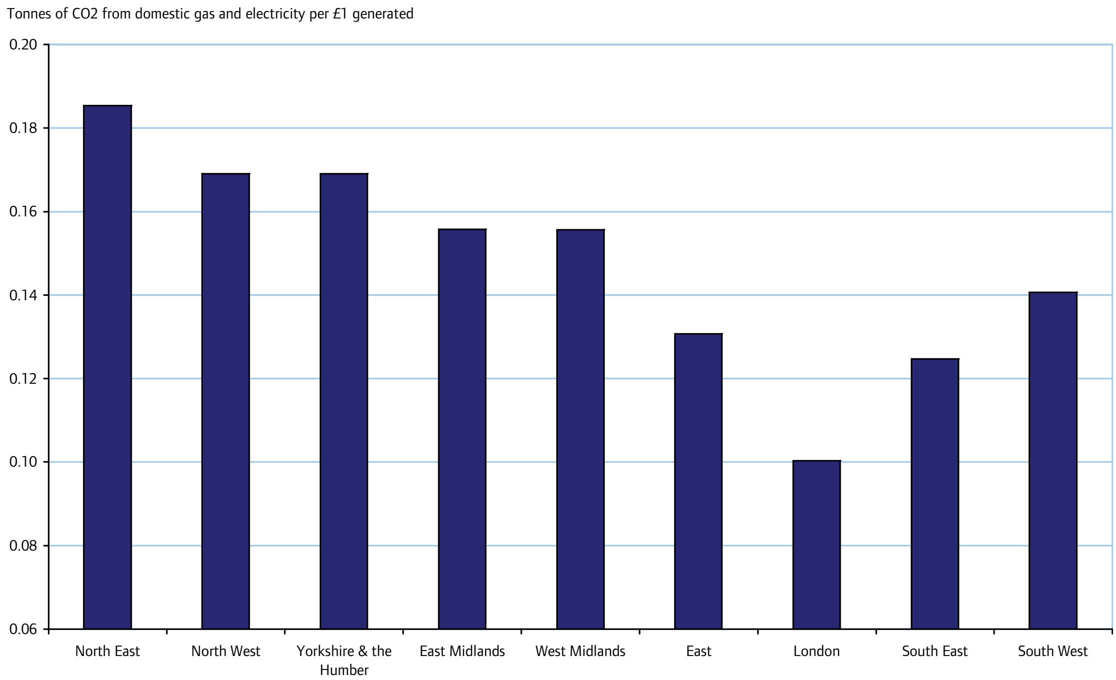


Source: DTI/BERR and GLA Economics

7. Domestic gas and electricity consumption CO_2 emissions per unit of output generated by region

On this indicator London is by far the best performer. Again, this is unsurprising given London's high level of output. Similarly, the North East emerges as the weakest region on this indicator on account of its relatively low levels of output. Generally, the regions in the south of England do relatively well on this indicator when compared with regions in the Midlands and those in the North of England.

Figure 4.14: Tonnes of CO_2 generated by domestic electricity and gas consumption per £1 of output generated, 2005

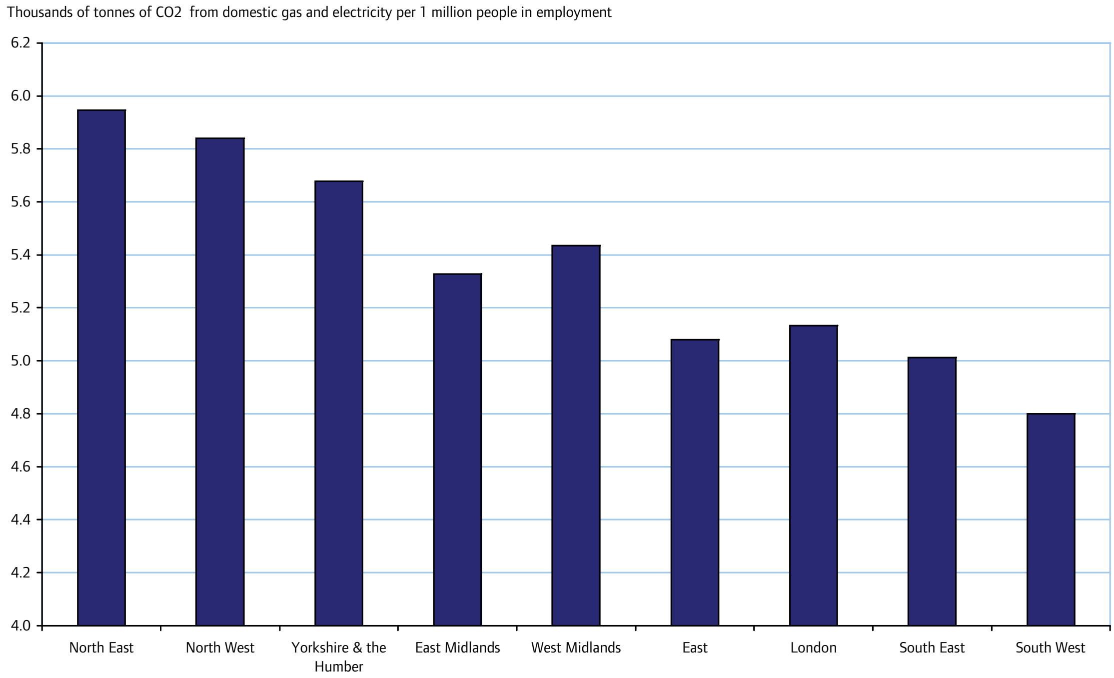


Source: DTI/BERR and GLA Economics

8. Domestic gas and electricity consumption CO_2 emissions per 1 million people in employment by region

Although London performs reasonably on this indicator, its high levels of worklessness mean that it is not the best performer. However, there remain clear divisions between London and the South on the one hand and the North on the other - with the East and West Midlands somewhere between the two. Again, it is important to realise that the employment data are on a resident basis and include the self-employed.

Figure 4.15: Thousands of tonnes of CO_2 generated by domestic electricity and gas consumption per one million of people in employment, 2005

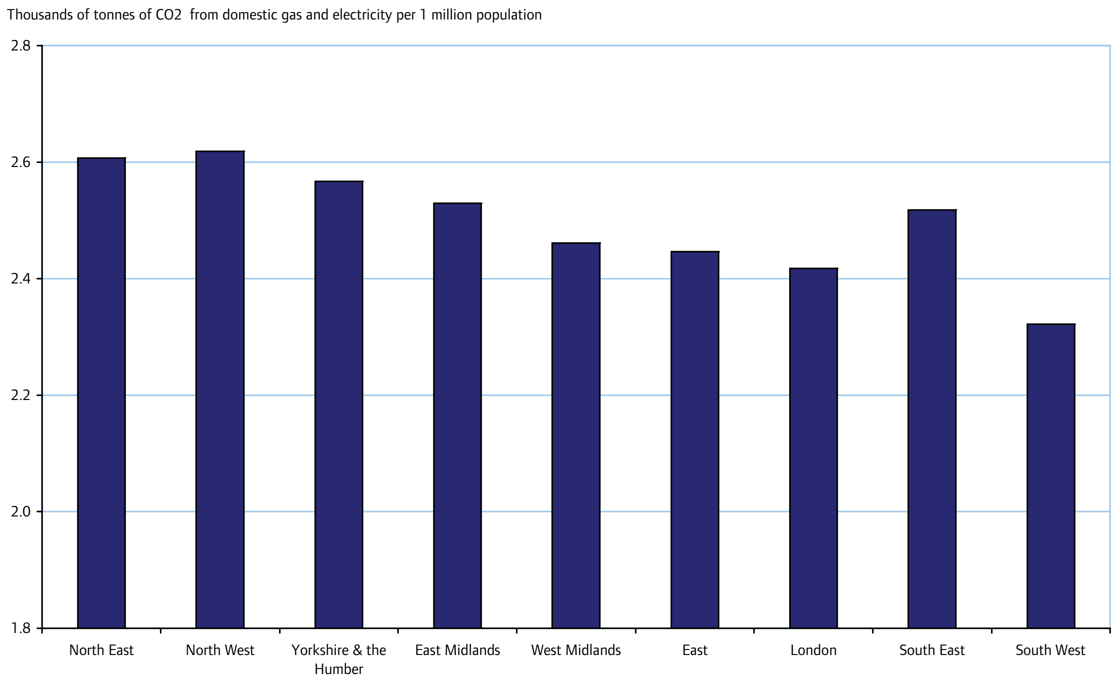


Source: DTI/BERR and GLA Economics

9. Domestic gas and electricity consumption CO_2 emissions per one million population by region

London is the second best performer on this indicator with the South West the best performer. This time the worst performer is actually the North West, although its CO_2 emissions per capita from domestic energy use are actually very similar to those of the North East. Amongst the southern regions, the South East stands out as being more similar to the East Midlands on this indicator.

Figure 4.16: Thousands of tonnes of CO_2 generated by domestic electricity and gas consumption per one million of population, 2005

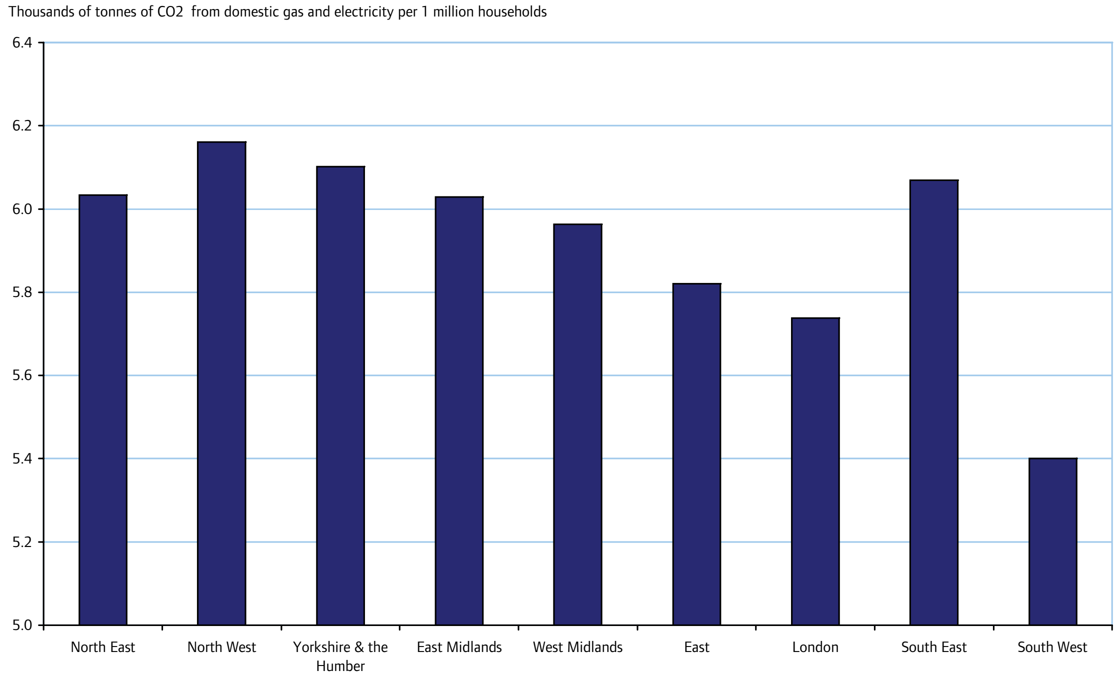


Source: DTI/BERR and GLA Economics

10. Domestic gas and electricity consumption CO_2 emissions per household by region

Again, London is the second best performer on this indicator and the patterns are broadly similar as for the population denominated indicator. The North West is the worst performer on this indicator although neither Yorkshire & the Humber nor the South East is dissimilar. The South West is again the best performer.

Figure 4.17: Thousands of tonnes of CO_2 generated by domestic electricity and gas consumption per one million households, 2005



Source: DTI/BERR and GLA Economics

Conclusion

Although London's total domestic energy use and associated carbon emissions are quite high, when examined denominated by population, number of households, employment or an output measure, London shows itself to be either the most environmentally effective performer or ***one of*** the most effective. This analysis also lends support to the contention that large cities may be more environmentally effective than their surrounding areas.

Table 4.1 represents a summary performance for London on these indicators where 1 denotes being the most environmentally effective region and 9 the least effective.

Table 4.1: Total domestic gas and electricity use in London – summary performance on indicators

Indicator	1	2	3	4	5	6	7	8	9	Best performing region
Total domestic gas and electricity consumption (KWh)							■			North East
Domestic gas and electricity consumption per household (KWh)	■									London
Domestic gas and electricity use per capita (KWh)	■									London
Domestic gas and electricity consumption per person in employment (KWh)	■									London
Domestic gas and electricity consumption per unit of GVA (KWh)	■									London
Total domestic gas and electricity consumption CO_2 emissions by region							■			North East
Domestic gas and electricity consumption CO_2 emissions per unit of output generated by region	■									London
Domestic gas and electricity consumption CO_2 emissions per 1 million people in employment by region				■						South West
Domestic gas and electricity consumption CO_2 emissions per 1 million population by region		■								South West
Domestic gas and electricity consumption CO_2 emissions per household by region		■								South West

Waste

Historically, London has relied on landfill sites for the disposal of its waste and it is still the case that the majority of London's waste ends up in landfill sites. Often these are located at a considerable distance from London – for example, much of London's waste ends up in places such as Warnham in West Sussex, Brogborough in Bedfordshire or Appleford in Oxfordshire. Landfill sites emit methane, a potent greenhouse gas with around 23 times the global warming potential of CO_2. Even putting this fact aside the estimated capacity for landfill in the South East and East of England regions is running out and the UK has to conform with the various EU directives on the subject – including the Landfill Directive[121]. In fact the UK needs to divert a higher proportion of waste from landfill on account of the more recent Packaging Directive and a new directive on electronic waste. There are two ways in which London can make progress on reducing the amount of waste going to landfill. Firstly, London can reduce its overall levels of waste. Secondly, it can increase rates of recycling and adopt more innovative means of disposal.

The amount of total waste produced in London each year has now fallen by 5 per cent on 2002/03 levels and the overall trend is now clearly down.

The concept of decoupling waste from economic growth

It is important to realise that recycling is, in effect, a 'tail pipe' solution; the real challenge must be to minimise levels of waste in the first place. Behind this is the idea of 'decoupling' waste from economic growth. This means breaking the existing links between the production and consumption of economic goods on the one hand, and the 'environmental bad' of waste on the other.

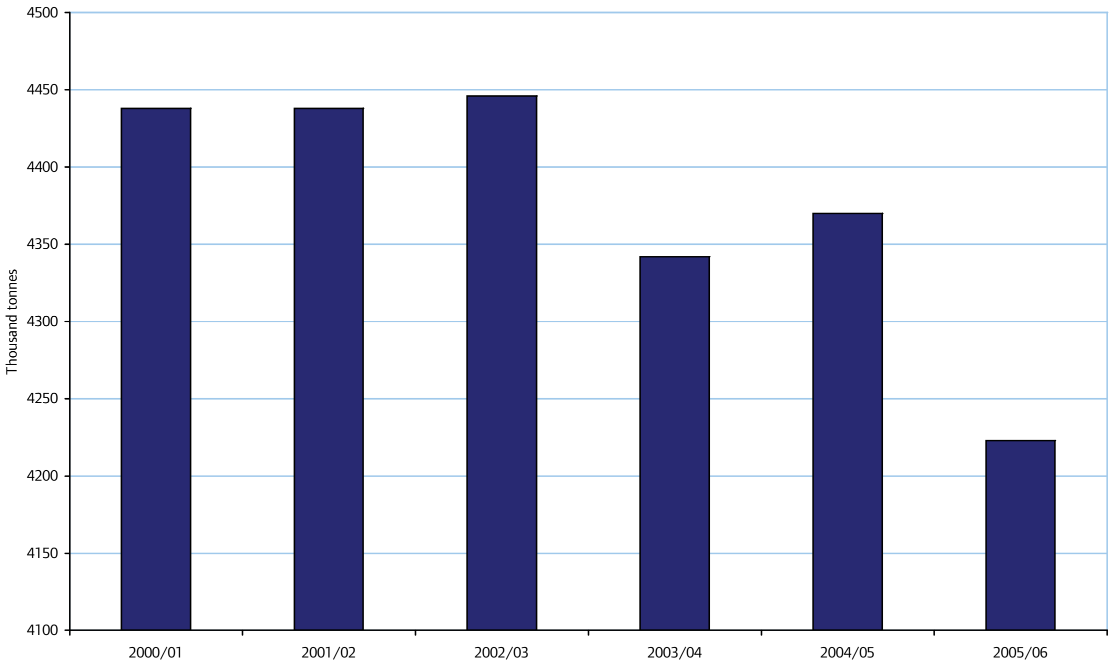
[121] The UK is subject to fines from the EU regarding landfill.

Clearly, decoupling can be ***relative*** (when waste levels continue to rise but at a slower rate than GDP) or ***absolute*** (where actual volumes of waste go into decline). The idea of decoupling fits well with the theory behind the 'downward section' of the Environmental Kuznets Curve. Whilst London has been successful in recent years in reducing waste output – in actual terms – the Swedish Environmental Advisory Council[122] suggests that when it comes to hazardous waste there is no tendency towards decreasing volumes either in the industrialised or in the developing nations. In fact, it concludes that they are increasing somewhat faster than GDP. Higher fees for waste disposal and 'producer responsibility' measures have not created the turning point in hazardous waste volumes.

Looking at waste as a whole, the European Environment Agency[123] is a little more optimistic. It is able to say that waste generation does seem to be falling in a number of EU member states although data limitations prevent a comprehensive analysis of most of the waste streams in Europe. Again, it is possible that many of the waste 'savings' have simply come from the "off-shoring" of manufacturing activity from the EU. Notably, whilst there has been a stabilisation of waste levels in many of the Western European member countries, there have also been notable increases amongst the new members states of the former Central and Eastern Europe.

Given London's high output of municipal solid waste, recycling is the main means by which the capital can reduce its contribution to landfill. The Mayor of London, Boris Johnson, opened a new Materials Recovery Facility (MRF) in Newham in June 2008. With an input capacity of up to 250,000 tonnes of dry recyclables per year, it is the largest undercover dry recyclables MRF in the capital.

Figure 4.18: Tonnes of waste in London (thousands)



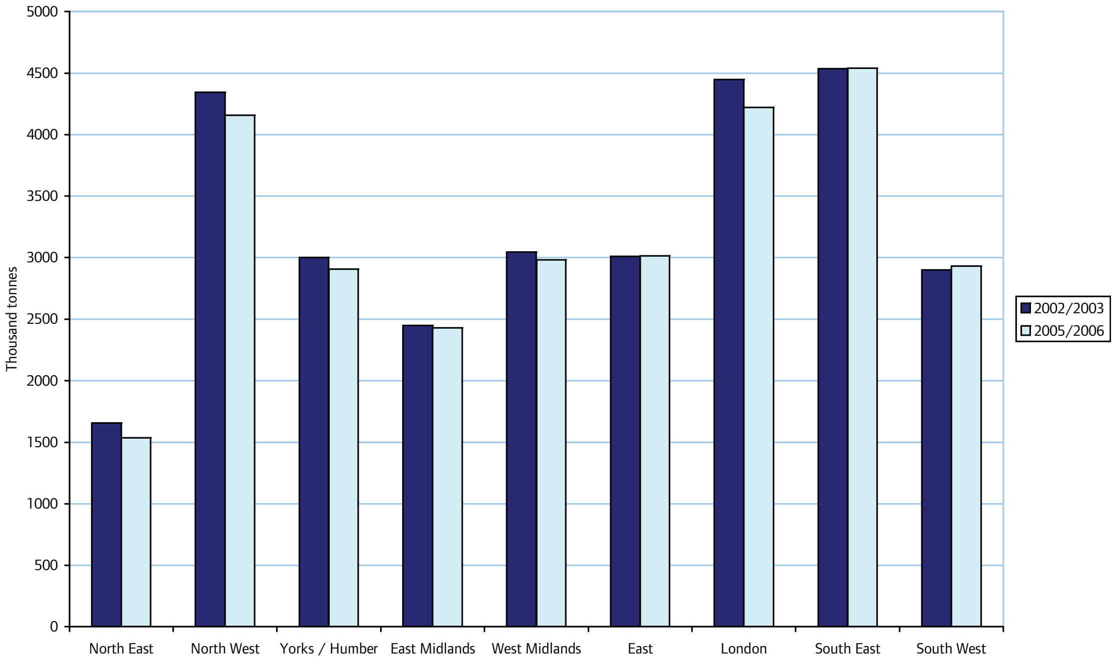
Source: Defra

[122] Decoupling – past trends and prospects for the future, SEAC.
[123] See http://themes.eea.eu.int/Environmental_issues/waste/indicators/generation/index_html.

Municipal Solid Waste Arisings

Municipal solid waste (MSW) is a broad term covering household waste and commercial wastes collected by either a local authority or an enterprise acting on that authority's behalf. This includes biodegradable waste and recyclable material as well as inert construction wastes and domestic hazardous wastes. The recycling of MSW is therefore a key component of modern waste management. It is also generally accepted to be a better solution than incineration as the latter produces greenhouse gases and may have negative health effects on account of carcinogens.[124]

Figure 4.19: Total MSW arisings

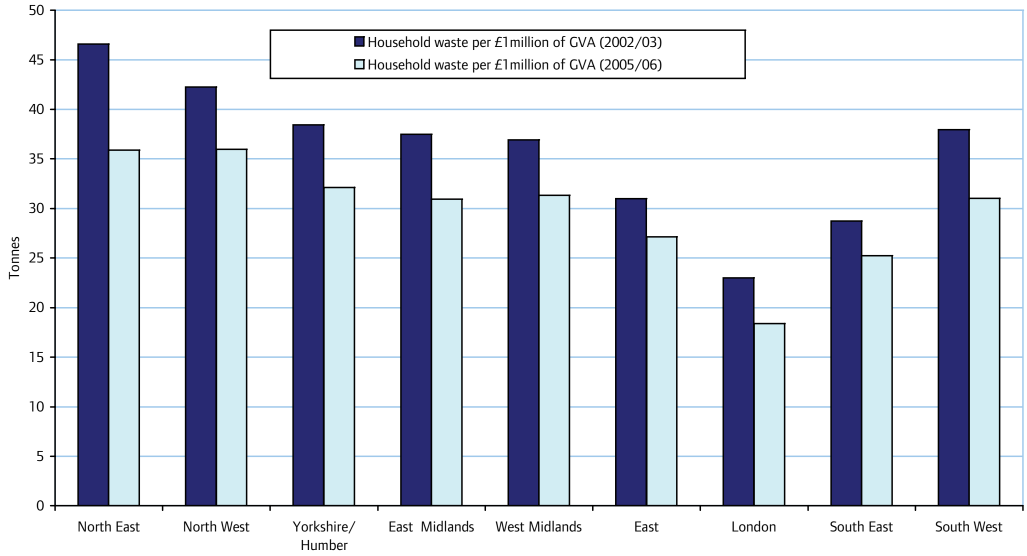


Source: Defra

Although London produces the second highest amount of MSW – some 4.2 million tonnes in 2005/06 (see Figure 4.19) – the capital does actually have a strong record on producing relatively low amounts of municipal waste when examined in the light of its economic output. The amount of municipal waste produced by unit of GVA has actually fallen in all regions since 2002/03 but the ranking between regions remains very similar with London being the best performer and the North West and the North East the worst. In 2005/06, London produced 18 tonnes per £1 million GVA compared to a national average of 30 tonnes (see Figure 4.20).

[124] Incinerators emit dioxins, particulate matter, sulphur dioxide and trace metals. Some of these metals are carcinogenic.

Figure 4.20: Household waste per £1 million of GVA

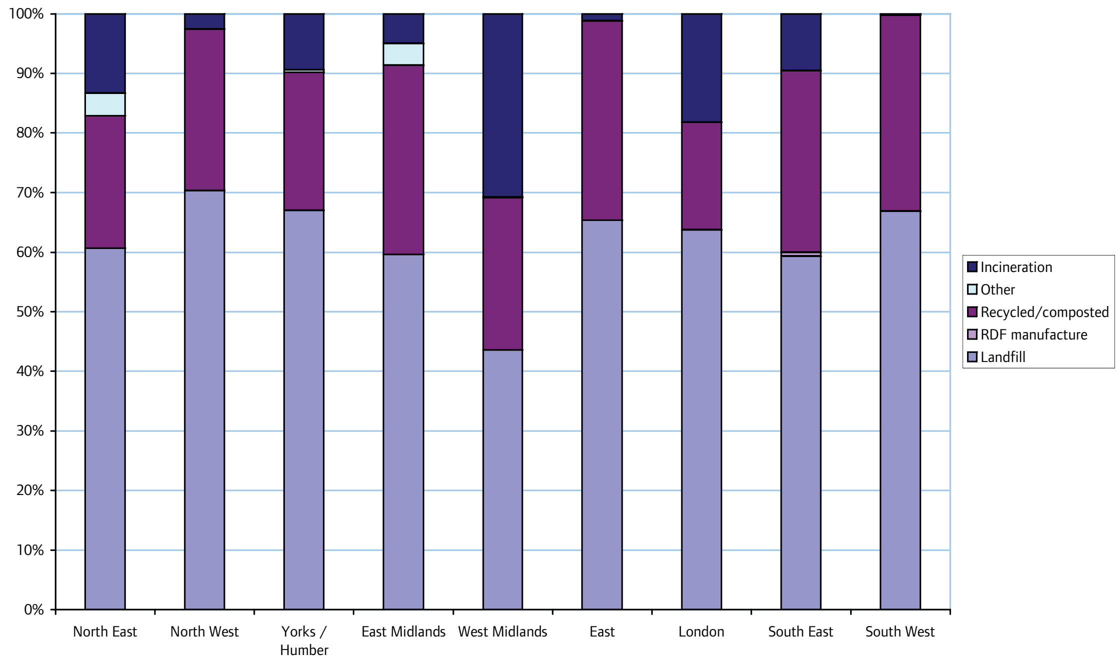


Source: Defra, ONS

Recycling

Recycling is a field in which traditionally London does not have a very strong record. Far higher rates of recycling have been achieved in some other large cities such as Berlin and Tokyo. Furthermore, city-level data often hides very marked disparities. Clarke and Maantay's work on New York reveals disparities in recycling rates in the city associated with differences in education, wealth, ethnic mix and single motherhood[125].

Figure 4.21: Municipal waste disposal, 2005/06

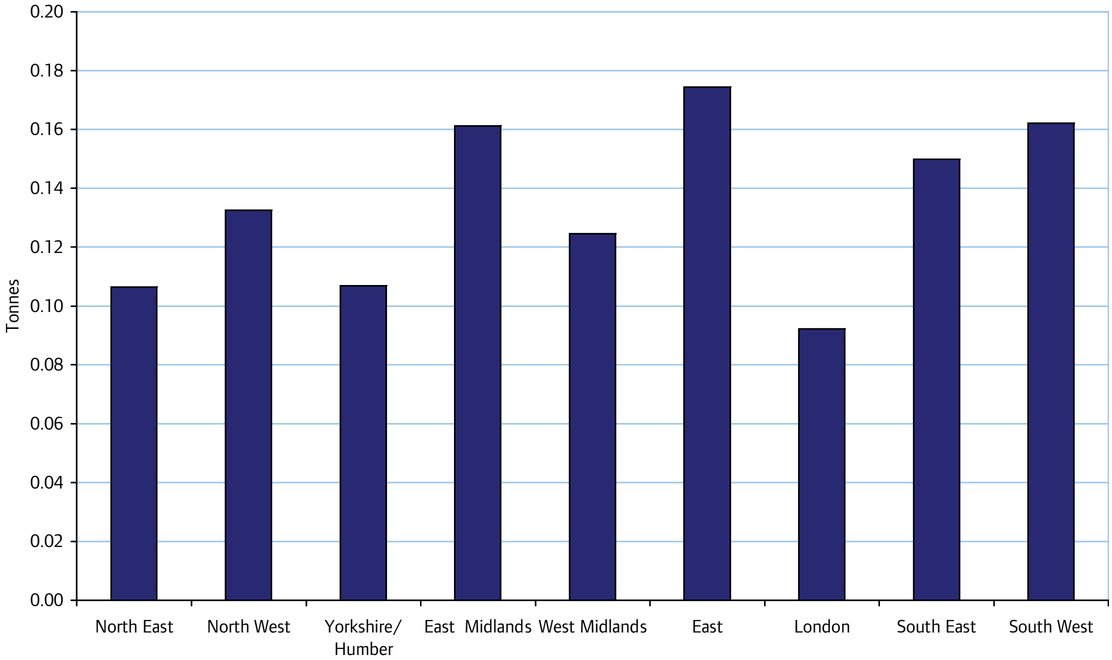


Source: Defra

[125] Optimising recycling in all New York City's neighbourhoods: using GIS to develop a REAP index for improved recycling education, awareness and participation.

Figure 4.21 shows in 2005/06 London recycled 18 per cent of it waste making it the worst performing region across the whole of England far behind the best performing regions, the East of England and the South West, who both recycled a third of their waste. In 2005/06 London recycled 687,000 tonnes of waste, less than the regional average of 755,000 tonnes.

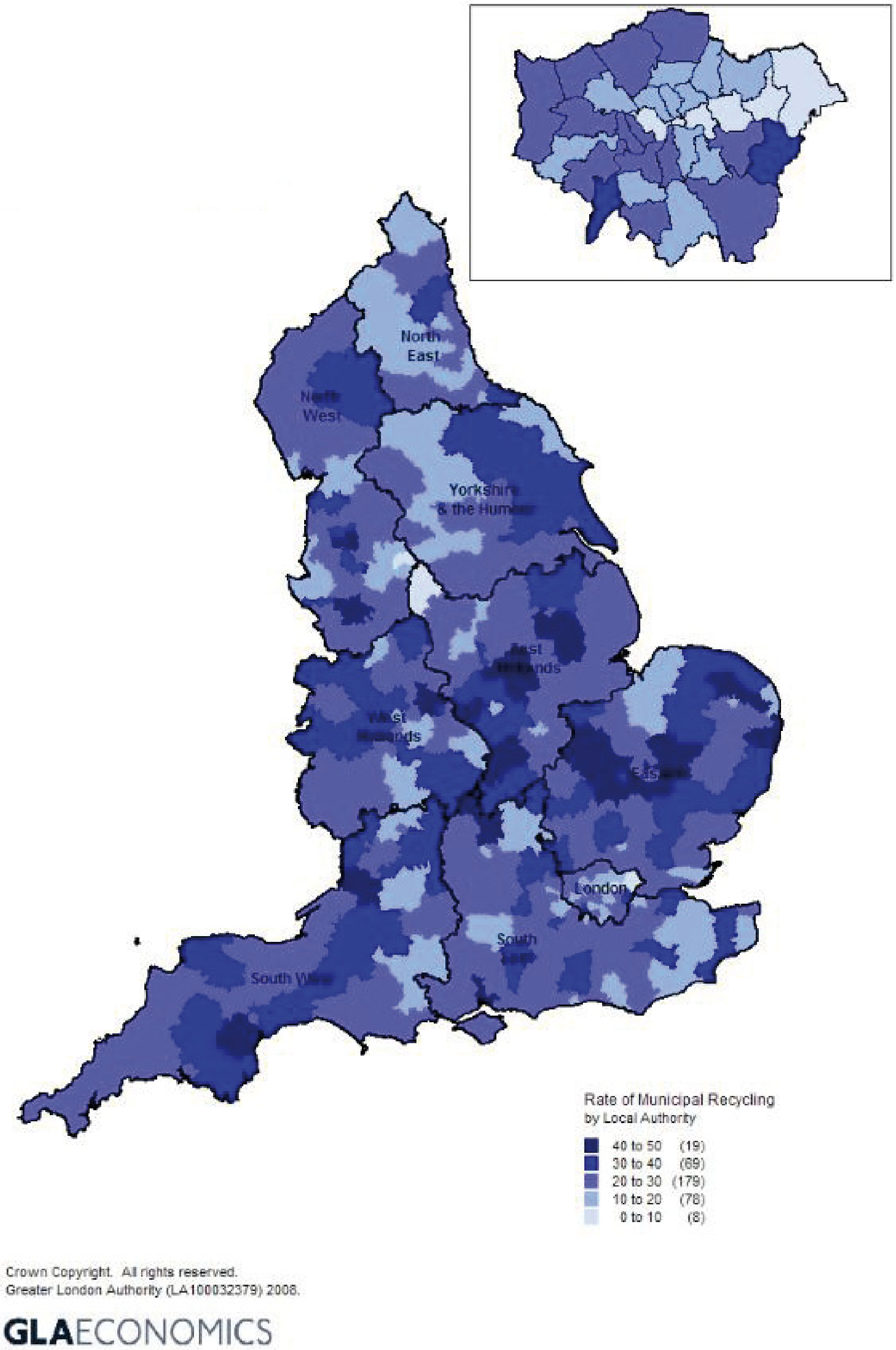
Figure 4.22: Tonnes of household MSW that are recycled per capita, 2005/06



Source: Defra, ONS Midyear population estimates 2005

Even though London is a large producer of MSW (see Figure 4.19), the tonnage of MSW recycled per capita is actually lower than in any other English region (see Figure 4.22).

Map 4.1: Municipal recycling rates[126]



Source: Defra

There may be many factors that affect municipal recycling rates other than the urban/rural split within authorities. Local authorities will all want to encourage recycling but both local policies and local obstacles to increased recycling will differ widely.

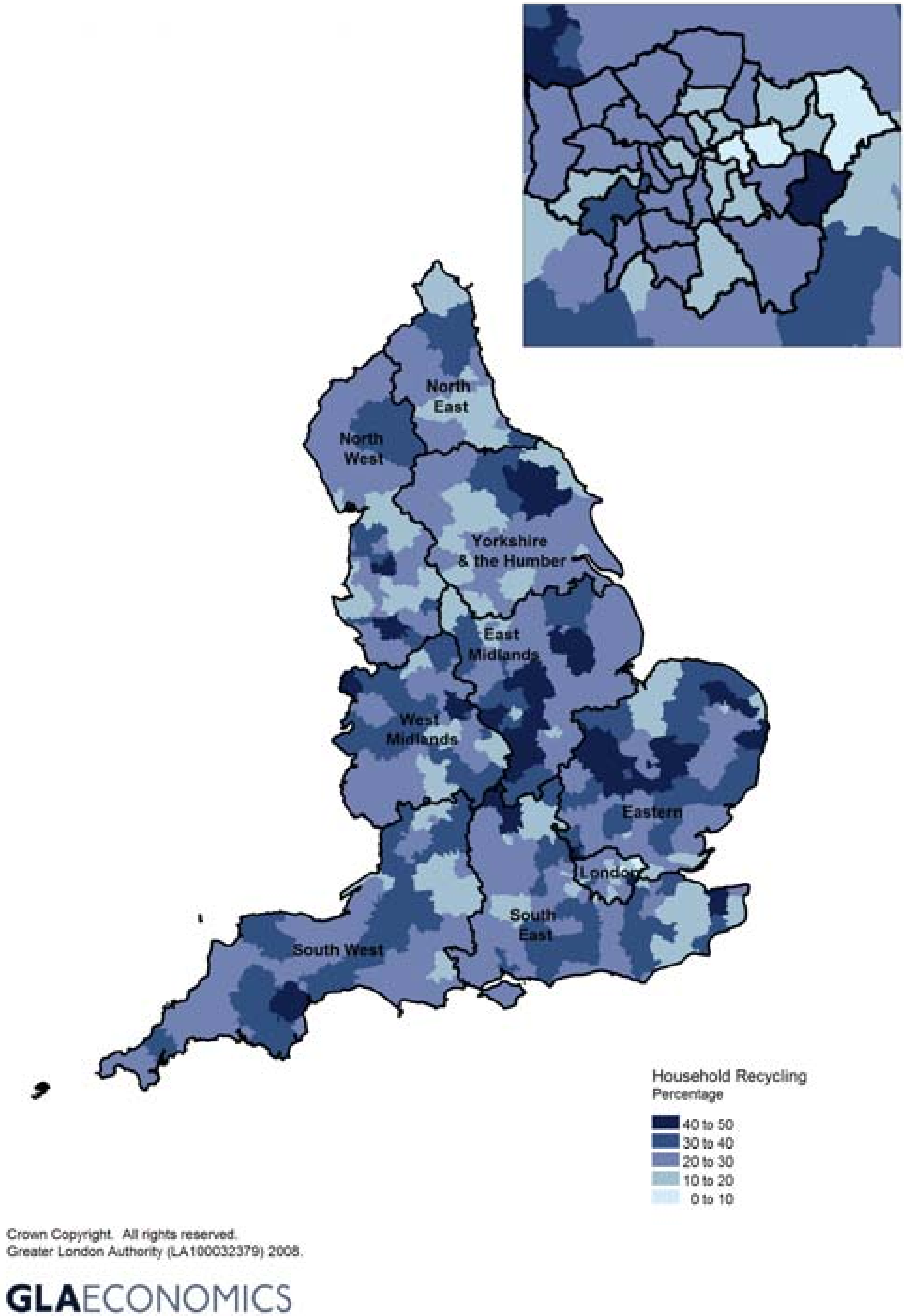
[126] Where possible these data have been drawn directly from Defra and relate to the year 2006. Data were not available for some authorities and in these instances results have been estimated from older data.

This is one indicator on which London as a whole has had a historically poor record. As things stand, this currently remains the case. Of all the authorities included in the analysis (**note**: data was not available at the time of writing for the latest year from ten authorities), Greater London's boundary contains many of the worst performing authorities.

It is well known that London faces specific issues on account of its high proportion of accommodation units that are flats. Recycling take-up tends to be far lower in flats. Many of the authorities in Inner London have high densities of flats, whilst many of the authorities in Outer London more closely resemble authorities in the South East of England and the East of England in their recycling behaviour. It is also the case that recycling rates in some other cities are far higher than for London.

Within England, the best performing authorities on this indicator tend to be some of the most rural. Nearly all regions outside London contain at least one example of an authority that has achieved a very high rate of municipal recycling. These include North Kesteven in the East Midlands, Huntingdonshire in the East of England, Teignbridge in the South West, Lichfield in the West Midlands and Chorley in the North West. However, it is authorities in parts of the East of England that seem to do particularly well – reflecting the high municipal recycling rate for that region as a whole.

Map 4.2: Household recycling rates



Source: Defra

London also performs poorly on the household-recycling indicator. One London Borough recycles only around six per cent of household waste whilst two authorities nationally (Ruschcliffe in Nottinghamshire and North Kesteven in Lincolnshire) have reached the 50 per cent mark[127] with a handful of other authorities, mainly concentrated in the East of England and East Midlands within site of that marker.

[127] Other authorities nationally have hit the 50 per cent mark in previous years.

Against the standard set by these authorities, London's performance can only be described as dismal. In fact three of the five worst performing authorities nationally are within the Greater London area. However, there is a notable exception within London in the form of Bexley Borough that recycles around 42 per cent of its household waste.

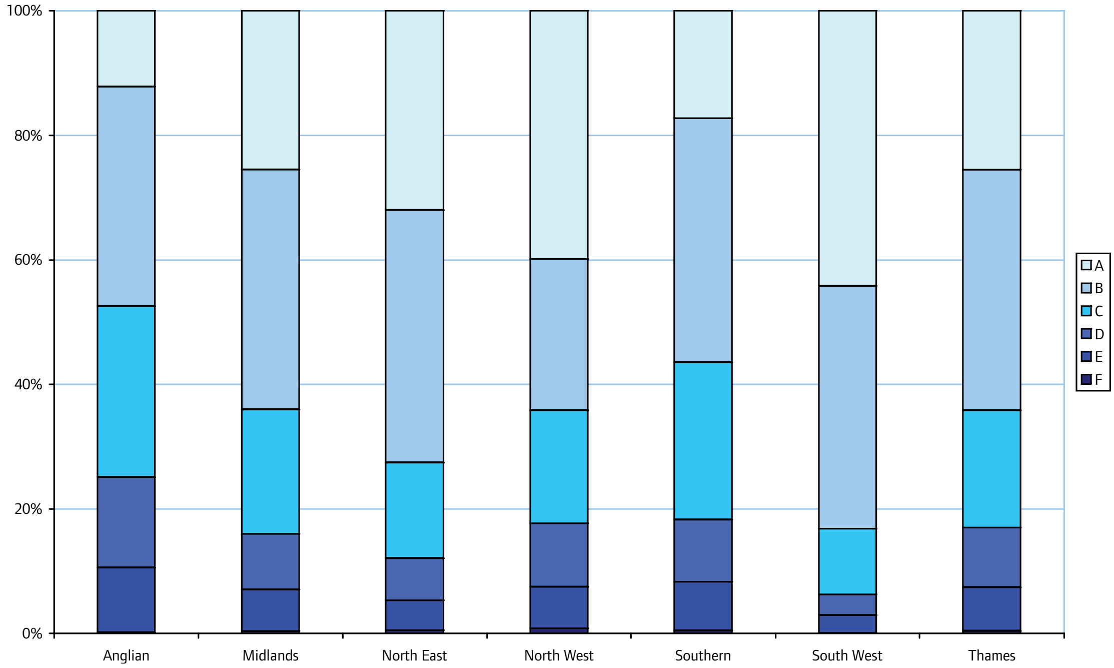
Water

Water presents a rather complicated picture for the London area, bearing no resemblance to regional or administrative boundaries. All of Greater London, bar a small proportion of Havering Borough falls within the Thames Water sewerage boundary but in terms of 'clean water' areas more than three quarters of Londoners are served by Thames Water whilst others fall under: Three Valleys Water; Essex and Suffolk; and Sutton and East Surrey Water. An additional complication is that Thames Water's area is not continuous with the majority of the area centred on Oxford but also including isolated areas of provision in Wiltshire and in the Godalming area of Surrey.

However, estimated water consumption in terms of litres per person per day in Thames Water's area has fallen more sharply than in any other region with the exception of Severn-Trent over the period 2000/01 to 2004/05 although nearly all of that reduction was in the first year of that period. On account of the fact that Thames Water covers such a large area, in 2005 Thames Water had the highest number of serious pollution incidents caused by a water company (25). However, when modified to account for the population base served, Thames Water's incidents were below average.

The Environment Agency uses boundaries based on catchment areas and watersheds to create seven water regions in England. General Quality Assessments (GQAs) for rivers on both biological and chemical quality show that the Thames region is about average in terms of river water quality. In chemical terms in 2006, 64 per cent of river length in the region was in the two highest quality categories ('A and B'). Although this is a markedly lower performance than in the best performing region (South West) where the comparable proportion was over 83 per cent, some regions such as Anglian (47 per cent) performed worse.

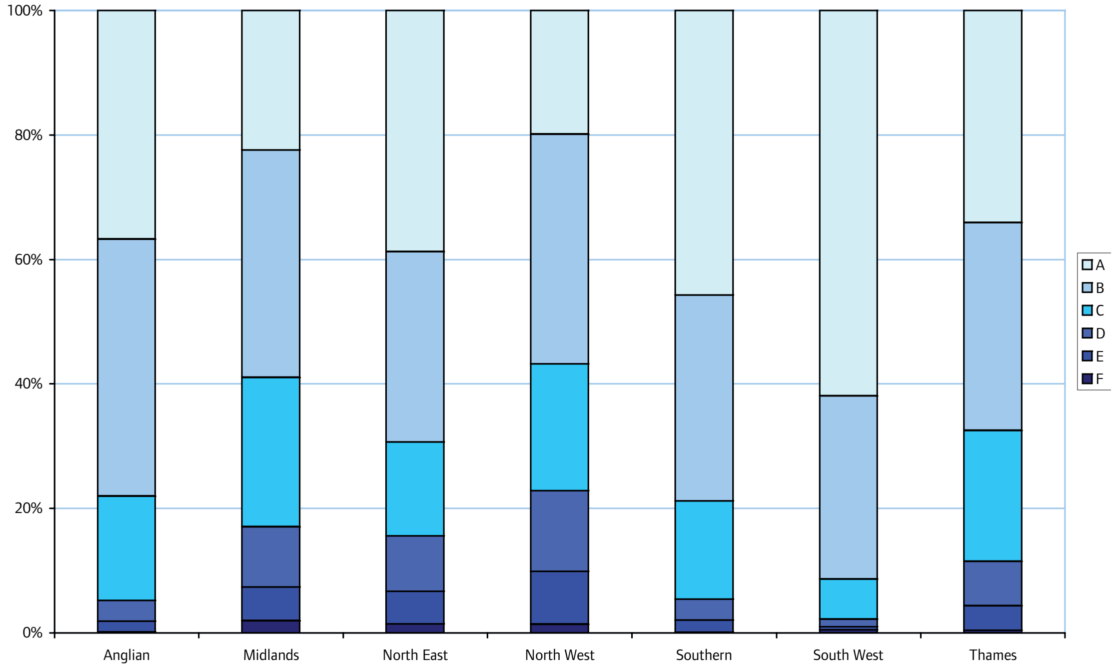
Figure 4.23: Chemical quality of river length by Environment Agency region, 2006[128]



Source: Environment Agency

In biological terms a different pattern emerges regionally, although Thames region was again around average (with 67 per cent of river length in the best two categories). The South West had the highest proportion of river length in categories A and B (91 per cent) and the North West the lowest (57 per cent).

Figure 4.24: Biological quality of river length by Environment Agency region, 2006



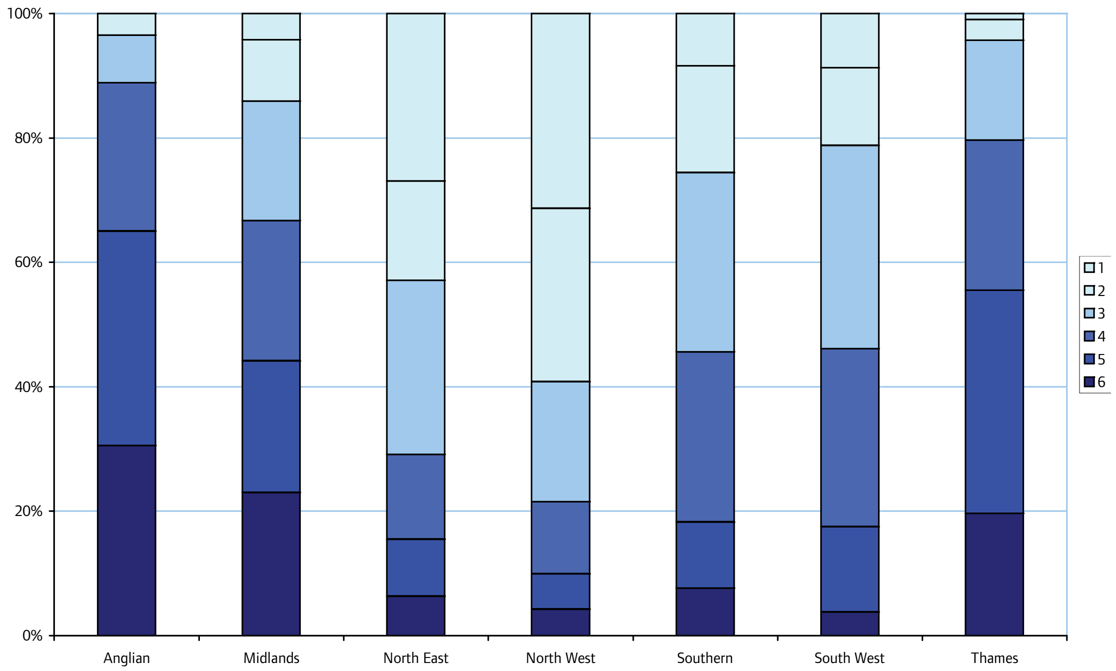
Source: Environment Agency

[128] For chemical and biological quality, A= highest quality and F= lowest quality.

The Environment Agency also publishes specific data on phosphates and nitrates based on three-year averages on which Figures 4.25 and 4.26 are based. Elevated levels of phosphates and nitrates in water can lead to eutrophication – a situation where algal growth becomes excessive. Phosphates enter rivers via runoff from agricultural fertilisers and from industrial and domestic water waste and from fabric washing. According to the Environment Agency, around 76 per cent of river length in the Thames, Anglia and Midlands regions combined had average phosphate levels in excess of the guideline value of 0.1 mgP/l[129]. In the UK the majority of nitrate enters the water system from agricultural sources. Nitrate pollution is of particular concern as it has to be removed from water prior to provision to households and can also cause methaemoglobinaemia in cattle stocks through very rapid concentration change in some crops such as oats[130].

Nitrate concentrations in the Thames do tend to be high relative to other regions – particularly when compared with the North West and North East. Nearly 56 per cent of river length in the Thames region is within the two highest concentration categories (6 and 5) – a lower proportion than the Anglian region, but still higher than elsewhere. In reality, London may bear less responsibility for this than parts of the region with more focus on agricultural activity.

Figure 4.25: Nitrate concentrations in rivers by Environment Agency region, 2006[131]

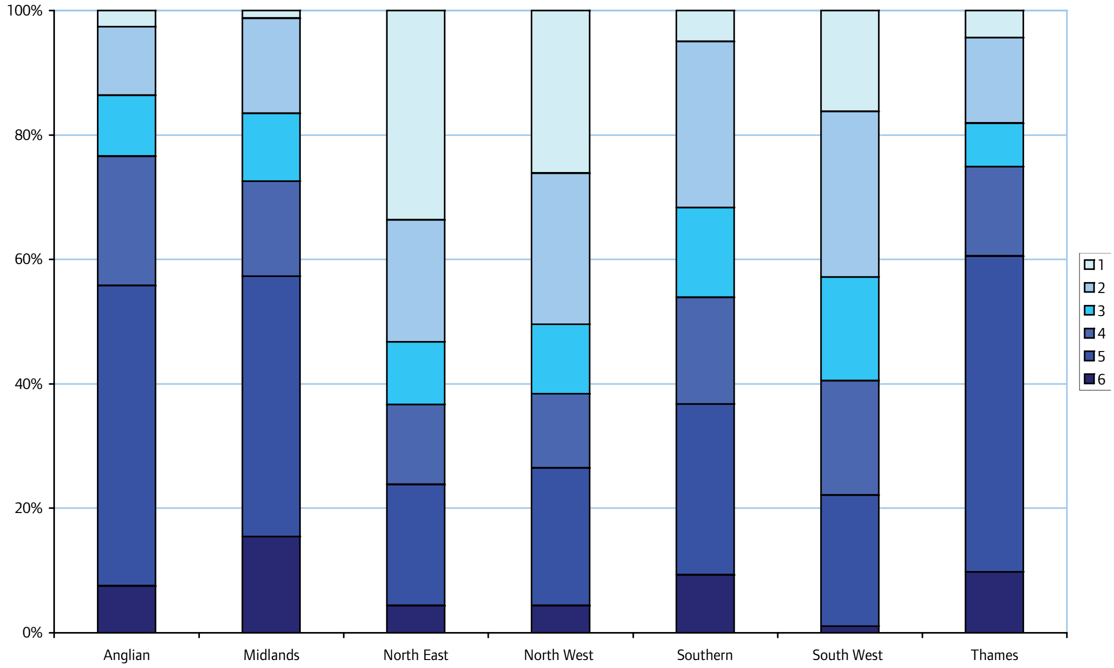


Source: Environment Agency

Phosphate concentrations also tend to be high with nearly 61 per cent of river length in the Thames region falling within the two highest concentration categories (6 and 5) compared with just 24 per cent in the North East. Thames' profile on phosphates has generally deteriorated in recent years. London cannot claim zero responsibility for phosphates as activities such as fabric washing are closely related to human population.

[129] milligrams per litre.
[130] Methaemoglobinaemia is a clinical condition which results in a reduced oxygen binding and carrying capacity. Numerous toxic agents can cause this form of excessive oxidisation.
[131] For nitrates and phosphates, 1= lowest concentration and 6= highest concentration (i.e. most polluted).

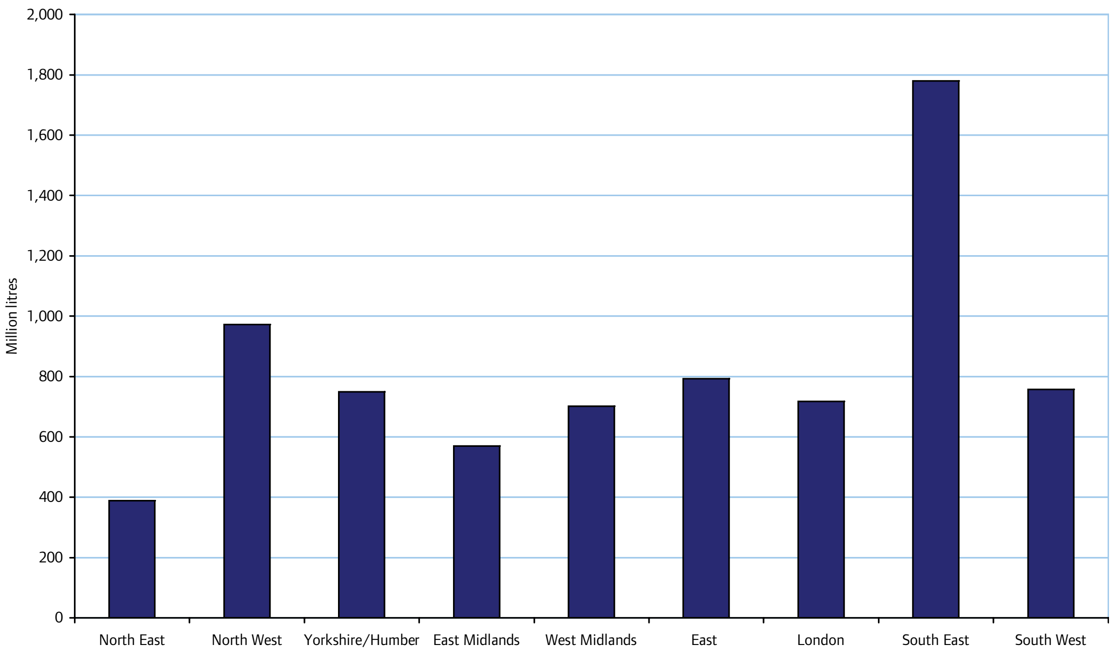
Figure 4.26: Phosphate concentrations in rivers by Environment Agency region, 2006



Source: Environment Agency

Given the complexities of boundaries, GLA Economics now believes that its methodology for the calculation of London's daily water consumption per capita in the previous report resulted in an overestimate. Figure 4.27 shows that London's total water consumption per day was approximately 720 million litres, considerably below the English average of 825 million litres.

Figure 4.27: Water consumption (millions litres per day), 2006



Source: ONS/Focus on London, GLA Economics

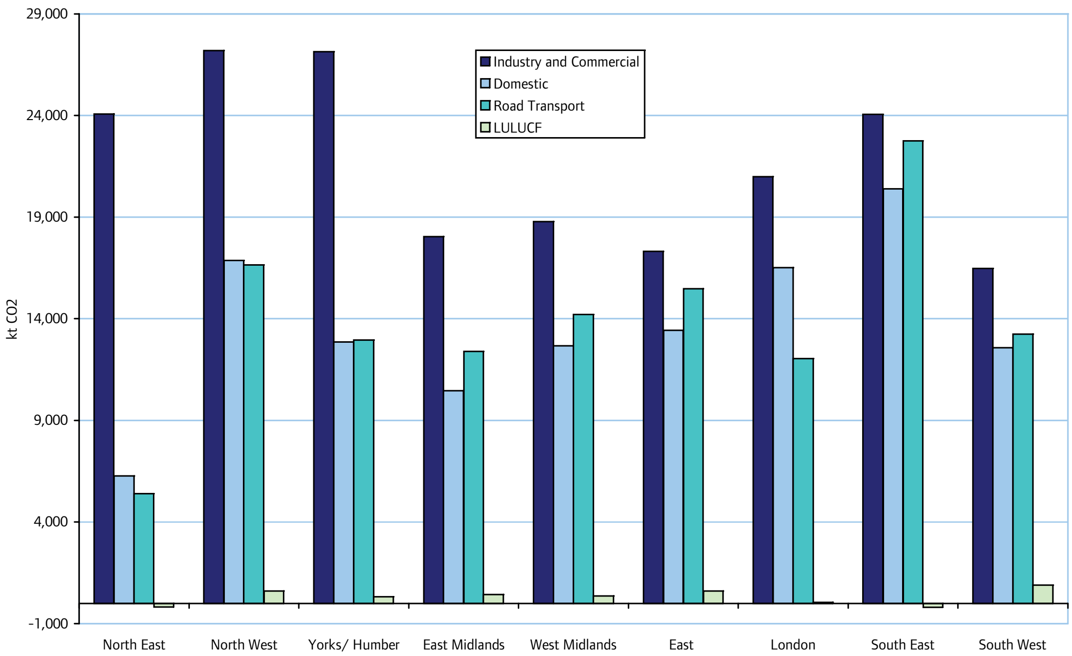
There remain considerable data issues for calculating water consumption in London. It must be emphasised that the calculation methodology used here remains experimental giving very crude approximations from weighted averages. The difficulty is due to regions that the Water Board uses not fitting with the conventional definition of English regions as highlighted at the beginning of this section.

Domestic CO_2 emissions

Carbon dioxide (CO_2) is the main gas believed to be responsible for climate change. The gas is a by-product produced in all sectors, but domestically it is emitted when energy is used to power, heat and light homes.

Figure 4.28 shows that for every region, without exception, industrial and commercial energy users emit the most CO_2. It should be noted that Land Use, Land-Use change and Forestry (LULUCF) is included as a separate, albeit small, category due to the potential for offsetting emissions, hence the graph indicates negative values for some regions. London households emit around 16,500 thousand tonnes of CO_2 each year. This is the third highest domestic CO_2 emitting region compared to an average of 13,500 thousand tonnes across all regions. Domestic emissions make up one third of total CO_2 emissions in London. The relatively high proportion of pre-1932 housing could explain London's high level of domestic CO_2 emissions, as older housing has solid walls and hence cannot be cavity wall insulated[132].

Figure 4.28: CO_2 emissions by region and energy user 2005



Source: 'Local and Regional CO_2 Emissions Estimates for 2005', produced by AEA Energy & Environment for Defra (see www.Defra.gov.uk/environment/statistics/globatmos/galocalghg.htm)

However, when looking at per capita figures, London outperforms all other regions for both total per capita CO_2 emissions and domestic per capita CO_2 emissions. This can be explained by a number of factors. Firstly, the high population density of the region means that per capita figures will be lower. Secondly the Urban Heat Island effect in the capital may contribute to lower energy consumption[133]. The final reason may be due to

[132] Prior to 1932, most new build was solid wall. The shift to cavity wall was a major improvement in domestic heat retention.
[133] Central London absorbs heat during the day and this raises night-time temperatures by several degrees above that in the surrounding areas.

fuel poverty[134]. The inability to afford to maintain comfortable heating standards afflicts around 300,000 households in London[135], and hence they consume much less gas and electricity. Table 4.2 shows per capita figures for CO_2 emissions for each region. This presentation of the data makes them less subject to distortion by the variability in total regional population figures.

Table 4.2: Per capita CO_2 emissions, 2005

Government Office Region	Per capita Total CO_2 (tonnes)	Domestic per capita CO_2 (tonnes)
North East	14.1	2.5
North West	9.1	2.5
Yorkshire and the Humber	10.7	2.6
East Midlands	9.9	2.5
West Midlands	8.7	2.4
East Midlands	8.7	2.5
London	6.9	2.3
South East	8.4	2.5
South West	8.8	2.6

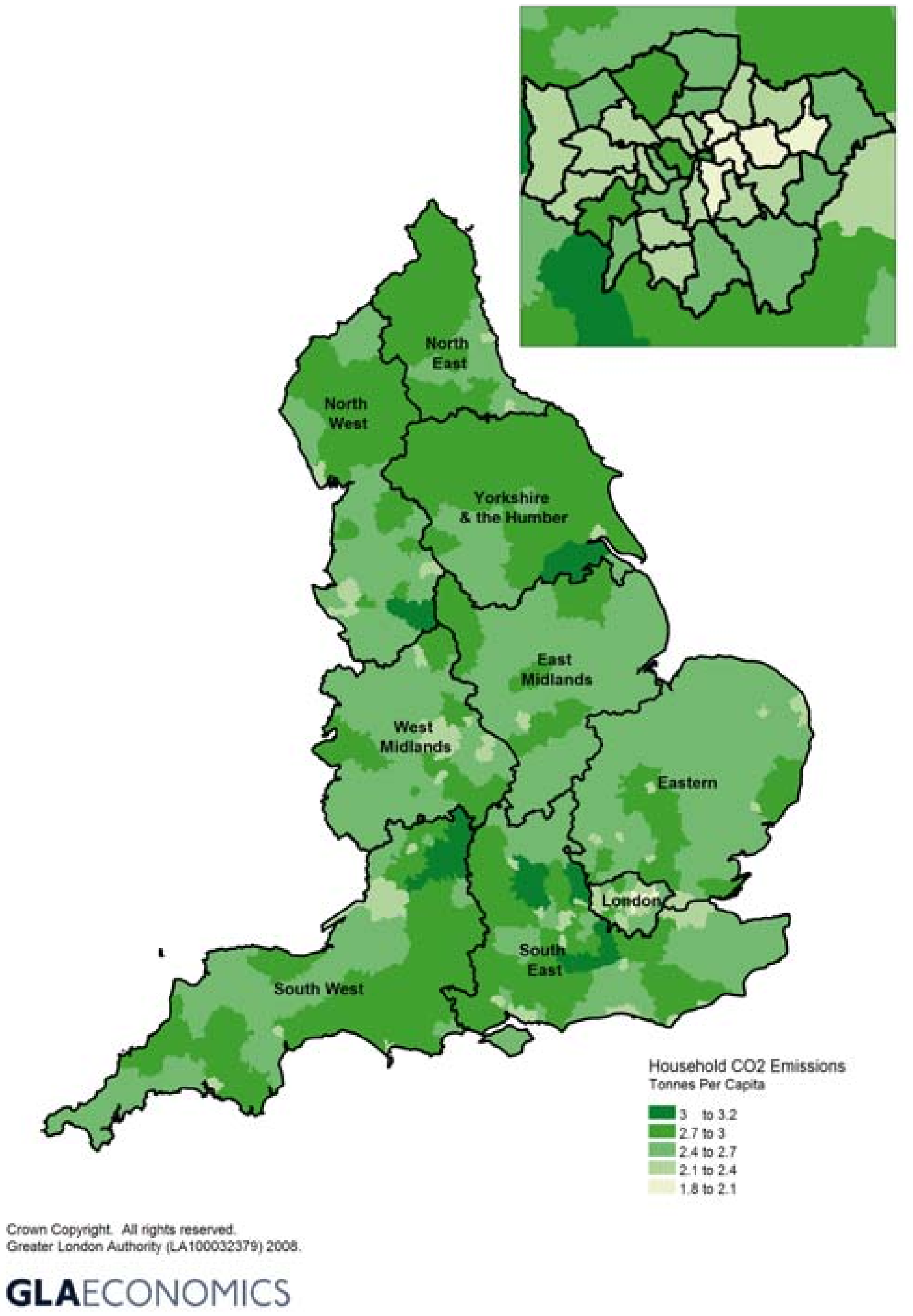
Source: 'Local and Regional CO_2 Emissions Estimates for 2005', produced by AEA Energy & Environment

Domestic household emissions data at the local authority level is not subject to the same presentational issues that the commercial and industrial emissions data was.

Some of the London Boroughs are the best performing of all local authorities – including all of the top five. One caveat needs to be issued here: amongst the best performers are London Boroughs such as Newham and Tower Hamlets which have high concentrations of disadvantaged people and people thought to be living in 'fuel poverty'. It may be that by attempting to save on energy bills, they are failing to maintain an acceptable domestic temperature. It is also possible that this result is driven primarily by a higher proportion of flats in the housing stock in these boroughs. However, suggestions of a 'trade-off' between the two policy arenas of poverty reduction and CO_2 emission reductions are misguided. By making heat retention improvements to existing housing stock, policy-makers can reduce both emissions and fuel poverty.

[134] Fuel poor households are defined as those that would need to spend more than 10 per cent of their income to maintain adequate warmth. At the time of writing, City Hall operates a slightly different definition which accounts for the higher housing costs in London than elsewhere in England.
[135] *Toward the Mayor's Energy Strategy* (Draft), GLA.

Map 4.3: Domestic CO_2 emissions per capita, 2005



Source: Defra

It is important to encourage the reduction of emissions of carbon dioxide from the domestic sector. However, it is also important from the perspective of this report to realise that the variation in per capita terms between the best performing local authorities and the weakest performing ones is relatively limited when compared to other components of total CO_2 emissions such as commercial and industrial.

However, it is clear that London performs very well on this indicator thanks to, at least in part, its much higher proportion of flats when compared to most of the rest of the country. It is also worth noting that much of the Thames Gateway area beyond the GLA boundary also performs relatively well and newbuild in these areas over the coming decade will continue to improve the area's performance in per capita terms. Many of England's other large urban areas can also be identified as strong performers - for example, Bristol, Birmingham and parts of Merseyside as well as spatially smaller cities such as Hull, Plymouth, Cambridge and Southampton.

Household summary

- London performs well against other regions when using per GVA estimates indicating environmental effectiveness in the capital when looking at energy use and economic output together.
- The amount of total waste produced in London has now fallen by 5 per cent on 2002/03 levels and the overall trend is clearly down.
- A major area for improvement is London's recycling rate. In 2005/06 London recycled 687,000 tonnes of waste, less than the national regional average of 755,000 tonnes.
- London's water performance presents a complex picture – largely on account of data and boundary difficulties.
- In absolute terms London's record on domestic CO_2 emissions looks poor. But examining a city's emissions without considering population is of little use. London actually has the lowest domestic CO_2 emissions per capita when compared to all other English regions.

Chapter 5: London and New York's greenhouse gas emissions – an initial comparison

In an era in which London and New York have emerged as the two strongest financial services centres in the world, the two cities are often compared. In addition both cities have recently given the environment a strong focus and, in particular, both have sought to present themselves as both leaders and innovators in the battle to mitigate anthropogenic climate change (known colloquially as 'global warming').

In 2007, New York City produced an Inventory of Greenhouse Gas Emissions as part of its participation in ICLEI – the Local Governments for Sustainability's Cities for Climate Protection Campaign. Mayor, Michael Bloomberg, described it as "a critical first step in reducing our contribution to global carbon dioxide levels. By identifying the largest sources of greenhouse gases … we can design our strategies for achieving our reduction target."[136]

As similarly sized cities, facing similar growth and similar problems (flood risk from climate change, the effects of increased temperatures on ground level ozone and consequent risks to air quality), it is perhaps unsurprising that in terms of greenhouse gas emissions London and New York turn out to be very similar indeed.

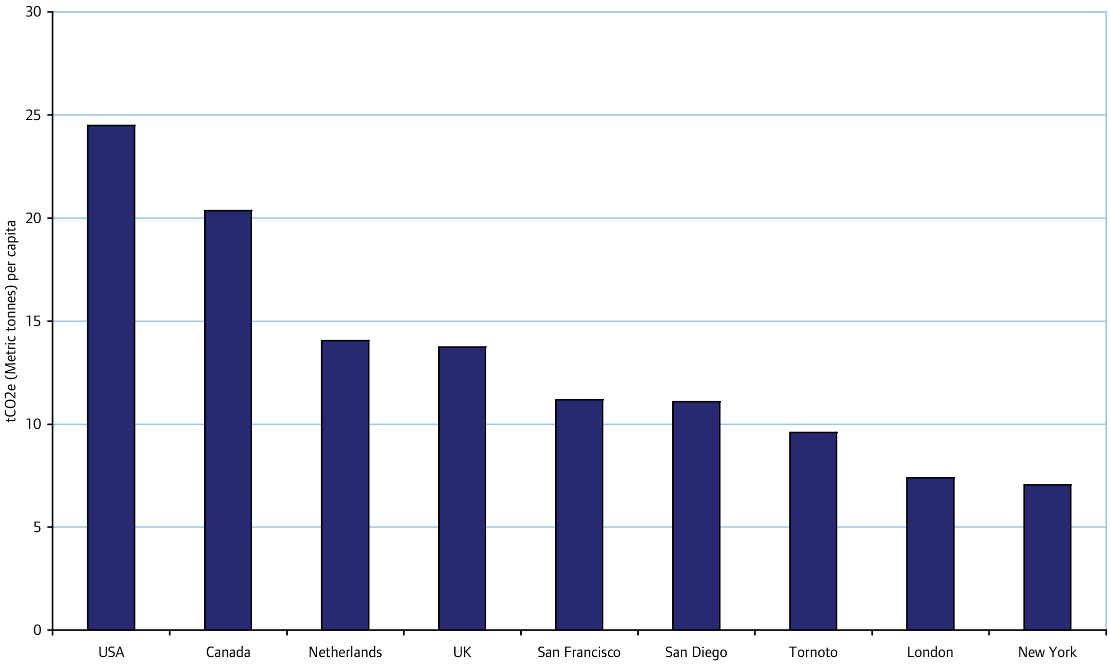
All the work on New York has been conducted in CO_2 equivalent units. CO_2e is a unit that allows emissions of different gases with varying global warming potentials (such as CO_2 itself, methane, nitrous oxide and perfluorocarbons or PFCs) to be summed together. For example, methane (CH_4) is a greenhouse gas with a global warming potential of around 23 times that of CO_2. That means that, averaged out of a century, each kilogram of methane warms the Earth's lower atmosphere 23 times as much as the same amount of CO_2. So, CO_2e is the amount of emissions of CO_2 that would cause the same amount of radiative forcing.

London's work for the Climate Change Action Plan[137] uses CO_2 only. This means that some adjustment needs to be made for other greenhouse gases, particularly methane. Methane is often associated with agricultural activities. For example, nearly four tenths of anthropogenic methane can be sourced to cattle stocks. Other anthropogenic sources include landfill sites, energy production, the treatment of waste and burning of biomass. In addition there are more 'natural' sources such as wetlands and volcanic activity.

Conversion from one to the other rests upon some assumptions which may affect the 'national level' data but are unlikely to have a major impact when comparing London and New York[138]. Analysis on the New York Inventory and the Mayor of London's Climate Change Action Plan suggests that London and New York are very similar, both in terms of total greenhouse gas emissions and in terms of per capita emissions. Furthermore, the results suggest that when compared with other North American cities and even with a densely populated European country (the Netherlands), London and New York are the best performers.

[136] Michael Bloomberg Foreword: *Inventory of New York City Greenhouse Gas Emissions (Apr 2007),* Mayor's Office of Operations, Office of Long-Term Planning and Sustainability.
[137] *Action Today to Protect Tomorrow,* Mayor of London, February 2007.
[138] New York's own report seems to have included London on CO_2 only. The 'scaling up' of London's emissions may result in a slight overestimate of London's greenhouse gas emissions.

Figure 5.1 Greenhouse gas emissions per capita in London and New York compared to other cities and countries[139]



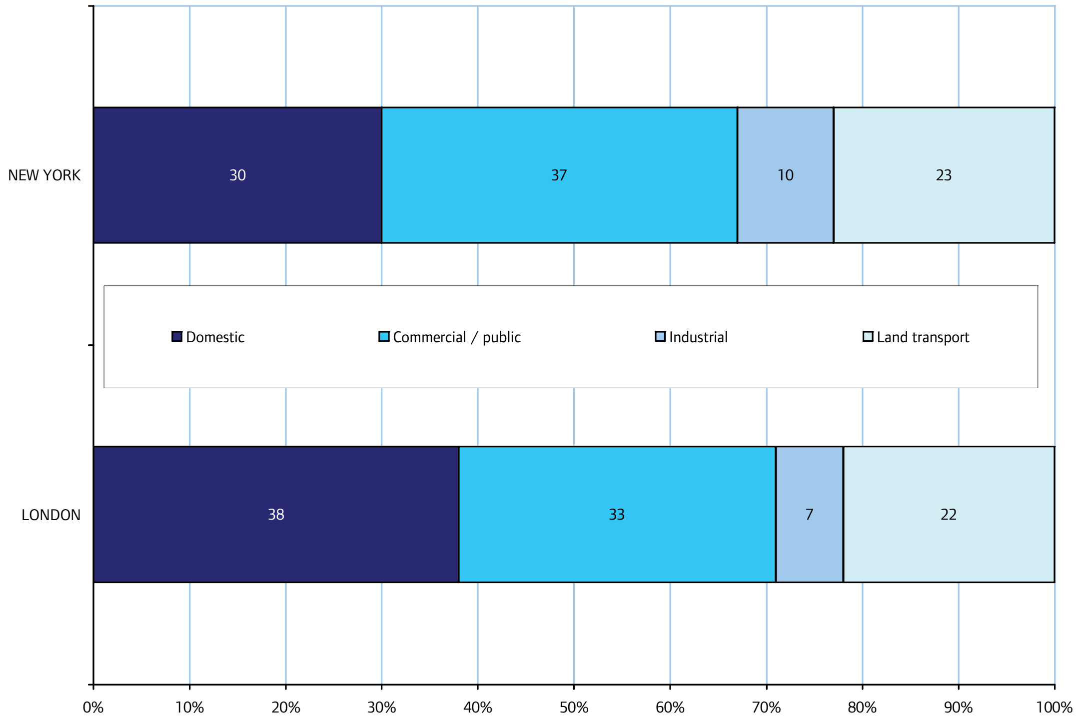
Sources: New York Greenhouse Gases Inventory, London Climate Change Action Plan, GLA Economics, International Energy Association, Carbon Trust

Although New York's CO_2 total emissions are at a level broadly comparable to those of some European countries such as the Republic of Ireland or Portugal, on a per capita basis they are low – less than one third of the level of the United States as a whole and significantly less than some other North American cities[140]. Furthermore, analysis of the composition of those emissions by source shows strong similarities between New York and London. New York's high density of building and the relatively small size of accommodation units means that less energy is required to heat each unit than in smaller cities in the United States when considered on a per capita basis.

Land transport accounts for around 13.6 million metric tonnes CO_2 equivalent of New York's emissions – which equates to 23 per cent of total emissions, a very similar proportion to that in London. Mass transit systems are believed to cover 40 per cent of all journeys whilst only resulting in 12 per cent of transport emissions and around 3 per cent of all emissions. In contrast, the comparable figures for cars and light vehicles suggest that 55 per cent of journeys are undertaken by road vehicles which are responsible for 78 per cent of transport emissions.

[139] Most emissions data used are 2005 or 2006. However national data for Canada and the Netherlands is 2003. London data have been based on the GLA's own database (LECI) modified to account for non-CO_2 greenhouse gases whilst the national UK figure has been supplied by the Carbon Trust.
[140] This needs to be qualified by the caveat that some countries in the Developing World have very low greenhouse gas emissions on a per capita basis.

Figure 5.2: Greenhouse gas emissions in London and New York – by sector source, 2006



Source: London Climate Change Action Plan, New York Greenhouse Gases Inventory

An even more recent study by the Brookings Institution[141] has identified Los Angeles to be a highly environmentally effective city in terms of traffic and household energy use in spite of the city's unfavourable image in environmental circles. Ironically, attempts by the city to improve environmental performance by building blocks of flats may have forced people who want to live in bungalows further inland, where temperatures are higher and more air conditioning is used.

[141] Reported in the Economist newspaper 31/05/08, p 58.

Chapter 6: Green space

In this report, only transport, the commercial and industrial sector and the domestic household sector have been examined. GLA Economics recognises that there is also a need to take account of green space. High density living creates a need to escape high density areas and there are real psychological and physiological risks of not being able to do so, although analysis of the relationship between urban density and health is complicated by other factors such as perceived quality of housing[142].

Measuring green space presents enormous definitional and boundary issues, particularly given that it is often the *quality* of green spaces that counts. This makes direct comparisons between different cities difficult and requires careful interpretations of the results of any such comparisons. In 1944 Abercrombie[143] set a quantitative open space standard of provision, the so-called 'four acre standard' at four acres[144] per 1,000 resident population. This is now seen to be unrealistically high for some inner areas of a modern city and the focus has shifted to providing the 'right kind of space'. In East London there are clearly opportunities for green space improvement. For example, the East London Green Grid aims to be an inter-linked network of multifunctional green spaces and rights of way to enhance East London in environmental terms. It also interacts with other networks of green grids beyond the Greater London boundary such as Kent Thames-side Green Grid.

GLA Economics' report in 2003, *Valuing greenness: green spaces, house prices and Londoner's priorities*[145], used hedonic pricing[146] and the 'willingness to pay' approach. Green spaces encourage healthy living and community development, are a source of education and promote recreation, tourism and biodiversity. If much of the health literature on green spaces is correct, then there is a link between green space and the physical and psychological health of city dwellers. Green space is also important in reducing flood risk as it counters high levels of surface run-off associated with many man-made materials in the urban environment. The GLA Economics' report found that a 1 per cent increase in green space resulted in a 0.3 to 0.5 per cent increase in average house prices, but was complicated by two conflicting preferences: one towards proximity to Central London and the other towards the greener spaces on London's periphery. London is already the most populous city in Europe and Europe's cities of comparable density (Brussels, Copenhagen, Paris) tend to be smaller.

More recent research by the Royal Institution of Chartered Surveyors (RICS) and the University of Aberdeen[147] across the UK as a whole shows that the overall premium for a property adjacent to a park ranges from 0.44 per cent to 19.97 per cent depending upon both house type and park type. However, there was actually found to be a negative premium for houses (as opposed to flats) – possibly on account of negative associations such as antisocial behaviour being associated with some parks.

London itself has relatively strong data on green space. The Green Belt within Greater London covers more than 86,000 acres, whilst metropolitan open land amounts to nearly 38,000 acres. This means that 31 per cent of Greater London is green space and

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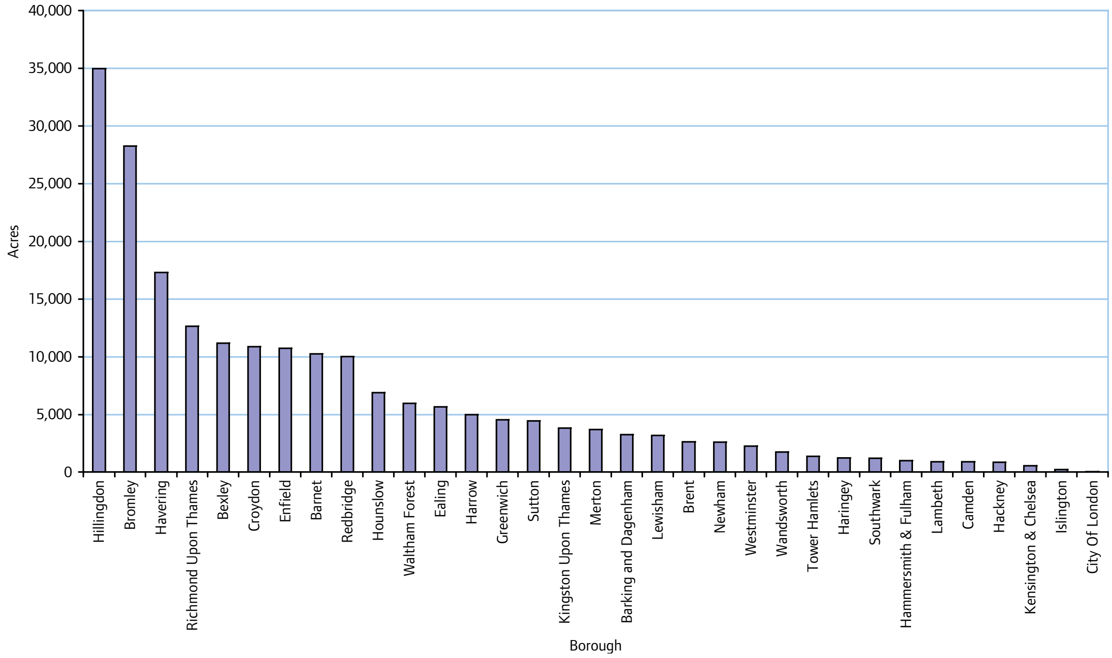
[142] See H.L. Freeman: *Mental health and the environment* (1985).
[143] Sir Patrick Abercrombie (1879 – 1957) was a town planner and trained architect and is best known for his replanning of London.
[144] 1 acre = 0.405 hectares.
[145] http://www.london.gov.uk/mayor/economic_unit/docs/valuing_greenness_report.pdf.
[146] Where a good is broken down into its composite characteristics and the contributory values of those components are assessed.
[147] *Urban parks, open space and residential property values*, July 2007.

that there is 16.3 acres per 1,000 resident population[148]. Even New York City ***as a whole*** meets the 'four acre standard'. The Centre for City Parks Excellence produced a figure of 4.6 acres for every 1,000 New Yorkers although direct comparability would obviously rest on the exact boundary drawn. Unfortunately, this lack of comparability is general. Outside the UK green space is defined differently and nearly all indicators will be influenced by boundary delimitation.

Much of London's green space is concentrated in the outermost Boroughs (such as Hillingdon, Bromley, Havering and Richmond), where population densities tend to be lowest. Parts of Inner London have relatively low levels of green space per head (for example Islington, Kensington & Chelsea and Hackney).

Figure 6.1: Green space per London Borough, 2005

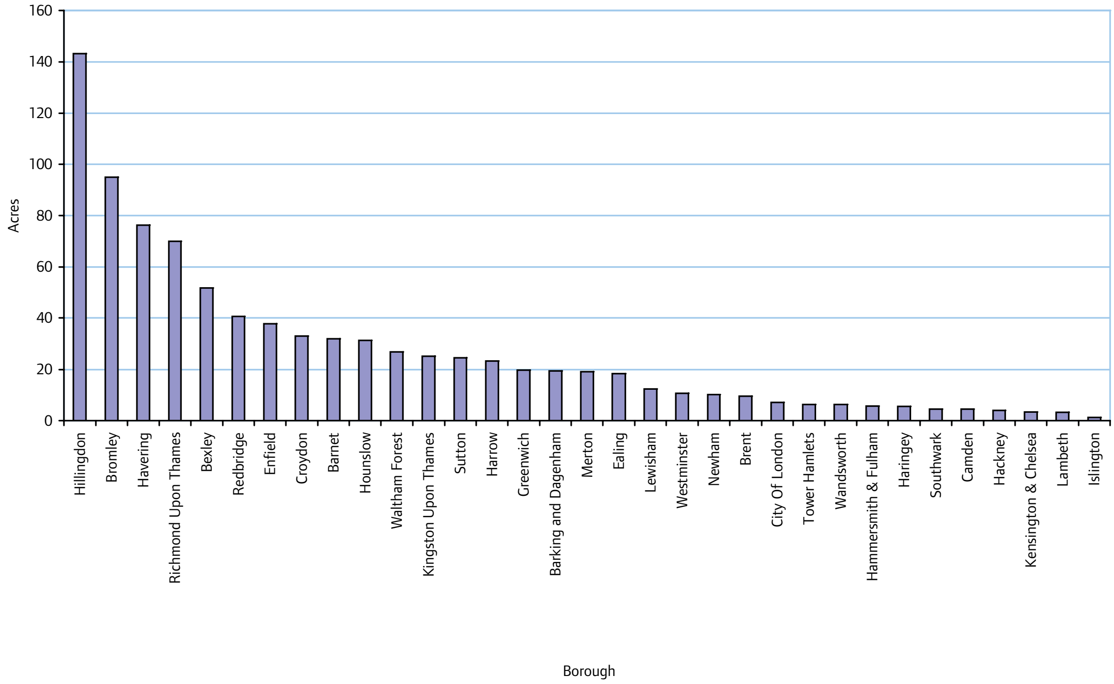


Source: Landmark Information Group/DMAG

As can be seen from Figure 6.1, it is likely that not every resident necessarily has access to the Abercrombie standard of green space[149]. For example, Hillingdon accounts for over 16 per cent of Greater London's green space yet has only 3.2 per cent of London's population.

[148] Source: Design for London.
[149] Green space here is defined as the sum of areas of natural or scientific interest, Metropolitan Open Land and Green Belt land.

Figure 6.2: Green space per 1,000 residents, 2005



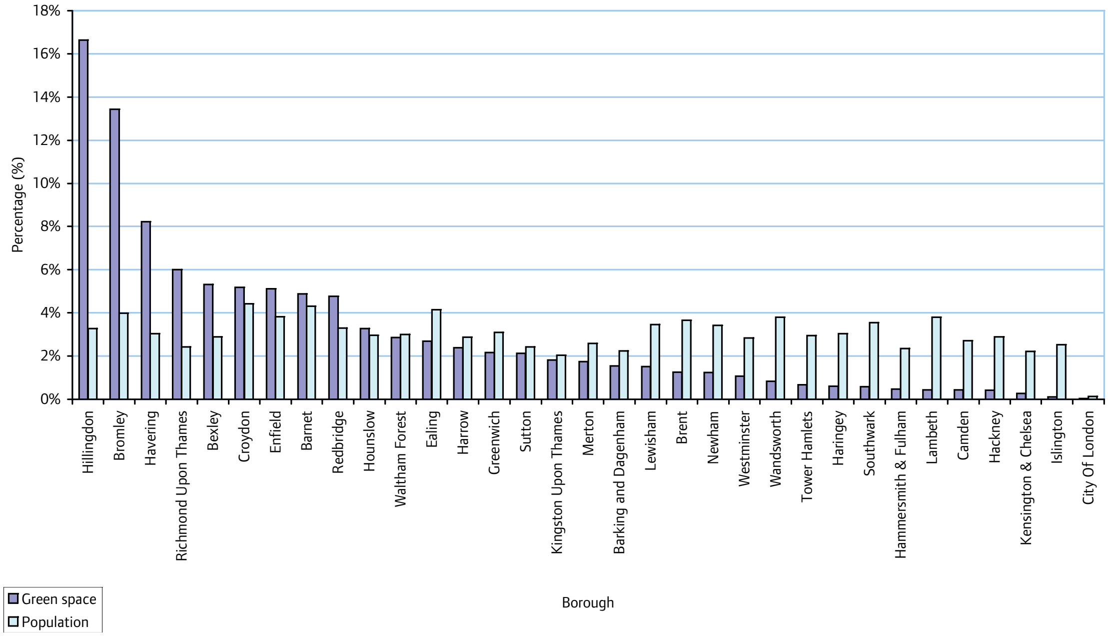
Source: Landmark Information Group/DMAG

When green space is divided by the number of residents it is possible to obtain a green space per capita value for each London borough. As can be seen, there is a great disparity in the distribution of green space available to London residents. Hillingdon, already cited as a particularly 'green' borough, has over 140 acres per 1,000 residents.

What cannot be identified from Figure 6.2 is the *quality* of green space available. Historically, green space provision in East London has been poor on account of patterns of industrial development. The East London Green Grid Primer[150] identifies 22 per cent of East London as deficient in Regional Parks with no Regional Park south of the Thames in the area. Nearly one third of urban land within East London does not have access to a Local Park of more than two hectares within 400 metres.

[150] See www.london.gov.uk/mayor/auu/docs/elgg-primer.pdf

Figure 6.3: Percentage share of green space and population by London Borough, 2005

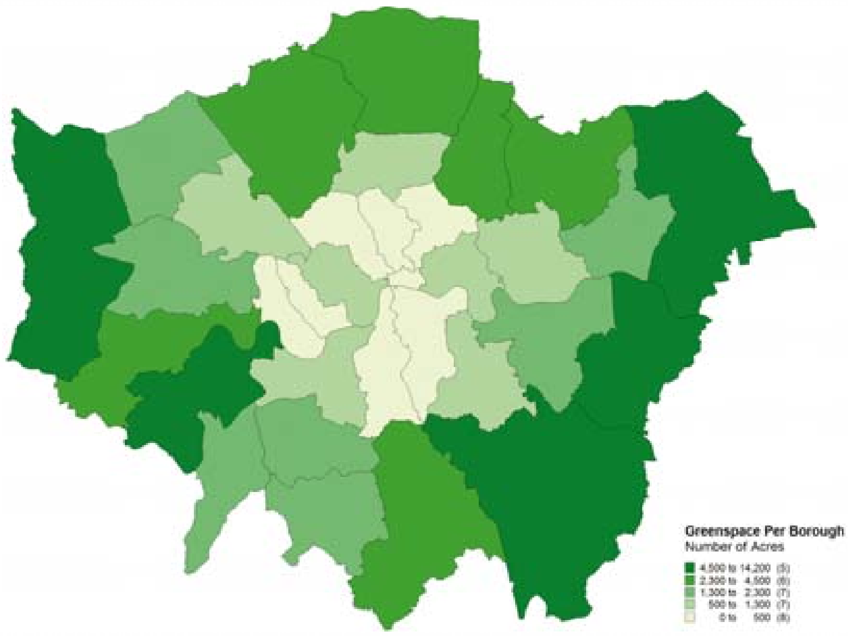


Source: Landmark Information Group/DMAG

Figure 6.3 shows that some inner boroughs have a clear 'deficit' of green space relative to their population. However, good transport links are likely to reduce the impact of lower green space availability, and many residents are likely to be willing to trade access to green space for the greater economic benefits of living nearer to Central London. Indeed, GLA Economics' 'Valuing Greenness' study showed that a specific segment of the population values access to Central London more highly than access to green space.

It is also true that green space within boroughs is concentrated in specific areas, rather than distributed evenly between wards, and so even the 'greenest' boroughs may contain residents without direct access to their share of green space.

Map 6.1: Distribution of green space by Borough, 2005



Source: Landmark Information Group/DMAG/GLA Economics

Note: 'green space' area is the sum of Metropolitan Open Land, green belt land and areas of scientific/natural interest

To some extent, London's policy of agglomeration has helped green space – or at least green space within the outer Boroughs. Office growth and employment development has been concentrated along a central axis along the Thames between the West End and Canary Wharf. Although population growth and new housing has tended to be diffuse rather than concentrated, the Green Belt areas on the peripheries of the outer London Boroughs have restricted housing growth on the edges of London allowing green space within the city to be undisturbed.

Chapter 7: Conclusion

Brief summary of findings – transport

Across England as a whole car ownership continues to rise in spite of record high petrol prices, increased vehicle licensing taxes and increased investment in public transport infrastructure. Against this, the fact that the fuel economy of vehicle engines has been continually improving over the last decade needs to be considered.

The picture in London is actually very different to the rest of the country. In Central London car traffic levels are down – almost certainly as a result of the Congestion Charge. Levels in Inner London (which excludes the Central London area under this definition) have only grown by about 1 per cent over a decade. Traffic levels in Outer London, whilst rising by about 6 per cent over ten years, have experienced relatively modest growth when compared to an England average of 12 per cent growth.

A study by the Commission for Integrated Transport found lower levels of car ownership in the UK than in France, Germany or Italy. In spite of this the number of licensed cars in Britain has grown from 21 million in 1997 to 26.5 million in 2004[151]. Car ownership in London is relatively low at roughly 0.8 cars per household compared to nearly 1.2 in many other English regions. Londoners make fewer car journeys and travel fewer miles. The National Travel Survey suggests that Londoners travel around 5,300 miles per person per year[152] of which only 1,800 miles were as the driver of a car – less than 'local bus' and 'other public' in aggregate (around 1,950 miles).

The fact that London's emissions of CO_2 per vehicle mile are high compared to other regions reflects the 'stop / start' nature of driving in the capital. This emphasises the continued importance of reducing congestion in the capital. It may also reflect differences in the age structure of the motor vehicle stock in the capital. However, it seems unlikely that differences in the age structure of vehicle stock in the capital are a significant driver.

The gap between average bus passenger load in London and the rest of England has widened in recent years to around 2.6 times. So, London's average bus load is now 260 per cent of the 'rest of England' average. This has the effect of reducing emissions per passenger in spite of the discomfort of overcrowding on some routes at peak times. Even more environmentally effective than London's bus network is the London Underground, producing only around 57g CO_2 per person per kilometre - a major advantage for London's environmental effectiveness and one that it shares with New York.

The second component of comparative analysis that was undertaken in regard to transport focused on transport emissions per unit of output generated. This analysis was limited to CO_2 emissions rather than including pollutants that tend only to affect local air quality such as nitrogen oxides[153] and particulates. Nevertheless, the results suggest that on a per unit of GVA basis, London is more than twice as environmentally effective as any other English region.

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[151] Are we there yet? A comparison of transport in Europe: Phase 1, CFIT, 2007.
[152] Note: this figure is limited to land surface transport modes.
[153] Although note that Nitrous Oxide is a greenhouse gas.

Brief summary of findings – commercial and industrial

According to NATCEN, the proportion of total CO_2 emissions accounted for by commerce and industry in London is similar to that for the UK as a whole at just under 44 per cent[154]. The shift away from manufacturing has helped London lower its commercial and industrial emissions. Much of this manufacturing has simply been offshored and demand from Londoners for manufactured goods has increased as personal disposable incomes have risen. It is arguable that on a global scale, mean environmental effectiveness may actually have been lowered on account of transitional economies having lower levels of environmental efficiency and weaker environmental legislation as well as the additional emissions generated from the increased transport of those goods.

An attempt at the simple modelling of commercial and industrial energy use by region was developed using data sourced from BERR on commercial, agricultural and manufacturing energy use by sector. The results suggested that most of the regions in the south of England performed effectively but that London was by far the most energy effective region.

One issue for London is that the fall in CO_2 emissions from the commercial and industrial sector, driven by the shift from manufacturing, will at some point come to an end. The rate of decrease in industrial energy consumption from the mid-1990s onwards has been markedly slower than it was during the 1970s and 1980s. The 5.6 per cent of output[155] estimate for manufacturing in London is boosted by a 'headquarters effect' which means that there is actually very little manufacturing left in London. This implies that further future savings in commercial and industrial emissions will have to come from elsewhere such as the improved energy efficiency of office buildings, behavioural changes of office staff and more efficient means of supplying energy to the commercial and industrial sector.

Brief summary of findings - households

The preceding analysis has again confirmed that the perception of London as 'environmentally degraded' or as simply antithetical towards the environment does not reflect a true picture of the city. In fact, when examined at a regional level, London demonstrates itself to be far more effective than most other English regions. It is because large cities – or rather, large, carefully planned cities – can utilise agglomeration benefits to capture significant advantages in terms of resource usage.

Furthermore, although London's forecast population and employment growth over the next two decades pose some real challenges for the capital, it will be able to take advantage of more stringent building regulations. This is likely to mean that household energy consumption per capita – already the lowest of any English region – is likely to improve at a faster rate than the majority of other regions[156].

Waste remains a controversial subject, as the UK needs to divert a proportion of waste from landfill either by simply creating less waste or by finding other ways to deal with it.

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[154] This compares with a proportion of 40 per cent (33 per cent commercial and 7 per cent industrial) used in the London Climate Change Action Plan derived from the London Energy and CO_2 Emissions Inventory (LECI) which has also been used in the comparisons with New York City.
[155] Source: Experian Regional Planning Service.
[156] Note here that the two neighbouring regions (the East of England and the South East) are also anticipated to see very rapid expansion in household numbers.

Nevertheless, the total amount of municipal waste produced by London does seem to be on a downward trend and, considering waste per unit of output produced, the capital is by far the most environmentally effective region in waste terms. However, it remains the case that, whilst London's performance benchmarked against other English regions may seem acceptable, when compared with some other global cities, London has room to improve on recycling rates.

Water presents a more complex picture – largely on account of data and boundary difficulties. However, the common perception of 'rural – good; urban – bad' needs to be addressed here as well because many of the most environmentally damaging pollutants in rivers can actually be sourced to the agricultural sector. Furthermore, new estimates of water consumption suggest that in terms of water efficiency the capital is performing relatively well. That does not downplay the risks that London faces both in terms of flood risk and in terms of a decrease in the water table.[157]

On domestic CO_2 emissions, London's record looks poor in terms of raw data. However, given that climate change is a global phenomenon, examining a city's emissions without denominating by population makes little sense. When examined on a per capita basis, London is again the best performing of all English regions.

A comparison with other studies

This report has taken one specific approach to evaluating environmental effectiveness. GLA Economics accepts that there are other, competing, approaches and that each of these has its advantages and disadvantages. The GLA itself has been involved with some of these.

The Chartered Institute of Wastes Management Environmental Body, CIWM (EB), commissioned a report from Best Foot Forward, the Oxford-based sustainability consultants in 2002. This – and many subsequent reports – took an approach generally known as 'ecological footprinting'. The benefits and disadvantages of such an approach have already been discussed in a separate GLA Economics publication, 'London's ecological footprint: A review', June 2003.

Ecological footprinting is really a subset of resource flow models that are focused on flows of resources within the whole economy rather than just the state of the localised environment[158]. The approach's roots go back to François Quesnay's 'tableau economique' in the eighteenth century and the arguments about the Earth's limited capacity to feed expanding populations put forward by Thomas Malthus in the first decades of the nineteenth century. Indeed, both Malthus and the modern footprinting approach are open to the same criticism: namely, that they fail to take account of the ability of societies to improve productivity and resource efficiency through technological innovation stimulated by economic growth – a process in which London plays a major role.

Whilst the Best Foot Forward report highlighted the resource and waste intensity of the London economy, it only examined one side of the equation as it failed to account for the productive outputs associated with the use of such resources. It is impossible to address the issues surrounding London's long-term sustainability without any reference to the economic and social implications of its wealth creation. By looking at London in

[157] Drier summers on account of climate change could result in the contraction of the London Clay, which underpins much of Greater London, the Thames Valley and Essex.

[158] The mass balance approach also forms part of the same suite of methodologies. Although different models have produced varying results, some, such as those used by Bioregional/WWF-UK, show the UK to be a "3 planet economy" using three times the resources of our share of the planet's carrying capacity.

isolation the report also failed to appreciate that the city's economic output provides benefits not only to London and surrounding areas, but also to the rest of the UK and the remainder of the world.

Cities provide agglomeration benefits by bringing people and industry together in densely-populated areas. Using mean bioproductivity[159] data disguises the reality that some areas are more productive than others. Therefore, it follows that in some parts of the world people may use less than the 'average' allocation of biocapacity[160]; in other places they will use more. It is intuitive that those using more should be encouraged to reduce their resource usage and flows but it seems very unlikely that all regions would eventually have the same resource use rates.

Another approach has been outside of the quantitative field altogether. For example, the Campaign to Protect Rural England (CPRE), Friends of the Earth (FoE) and WWF-UK commissioned Levvett-Therival to examine whether English Regional and Economic Spatial Strategies were likely to deliver environmental sustainability. The findings of the report were actually more critical of Central Government's overarching concern with the primacy of economic growth than of the individual regional strategies. However, the London Plan stood out as strong on road transport and building standards. It is important to realise that the focus was on aspirations (i.e. strategies) rather than on current performance but the report is typical of the general approach. The fact that London performed relatively poorly on biodiversity, water resources and CO_2 emissions is perhaps not surprising. No account is made for the fact that London is the only 'urban region' in the country, has 7½ million people in its boundaries (and far more within its Functional Urban region) and is by far the most productive of all English regions.

London's wider role in the environment

The report has not covered an important area that was touched on in GLA Economics' Current Issues Note 19[161]. However, it is further testimony to London's environmental credentials that it is involved heavily in the financing of new environmental technologies, the trading of carbon permits and new insurance products adapted to meet the needs of a changing climate. In some of these fields London is taking a globally pre-eminent role. For example, London's Alternative Investment Market (AIM) has earned the role as the dominant small-cap listing venue for Europe and has recently been competing with NASDAQ for the listing of Initial Public Offerings (IPOs) from the United States. Imperial Innovations has established a global reputation as an incubator for innovative cleantech start-ups and London has established a lead in European carbon trading with the majority of exchange-traded carbon on the EU-ETS system going through the European Climate Exchange (ECX). These are all activities that can only take place when a region has developed very high levels of agglomeration benefits – as in this case, of the financial services sector in London – and where the right skills base and infrastructure exists[162].

Cities and the future of the environment

If cities can be an environmentally effective means of organising people then there can be a degree of optimism about the future of the global environment. More than half of

[159] Bioproductivity: a unit of land's ability to produce biomass, whether animal, plant or microorganism, measured by weight of the organic matter.
[160] Biocapactiy: A measure of a unit of land's biological productivity. An aggregate of that land unit's ecosystems, whether natural or altered by human agency.
[161] The role of London's financial services sector in mitigating and adapting to climate change.
[162] A recent challenge to London comes in the form of Nymex's 'Green Exchange', which will trade in a variety of carbon financial instruments including EU-ETS emissions credits.

the world's population now lives in large urban areas. If these can follow London and make marked improvements in their environmental effectiveness, the traditional negative relationship between economic growth and environmental degradation might be effectively decoupled. Cities therefore provide the greatest opportunity to respond to both the environmental and economic challenges posed by the twenty first century.

That does not mean that cities perform well on all indicators and ways to address areas of environmental effectiveness where London performs below average need to be sought. These areas include:

- Issues regarding levels of waste and a historically poor performance on recycling;
- The use of renewable energy sources;
- The fuel efficiency of bus stock.

Table 7.1, based on a traffic light colour system, summarises London's performance on environmental effectiveness and highlights where improvements are still required. Green indicates a strong general performance, yellow indicates a situation where the results are less clear and red highlights indicators on which London still has considerable ground for improvement.

Table 7.1: Summary of London's performance on environmental effectiveness

Chapter	London's Environmental Effectiveness
Transport	• Lowest road vehicles emissions per capita. • Lowest CO_2 emissions per £billion GVA.
	• Low per passenger bus CO_2 emissions, due to more bus usage in London. Action required to improve the fuel efficiency of London's buses.
	• Highest CO_2 emissions per vehicle kilometre out of all the regions. This is mainly due to the lower average speeds in London due to congestion.
Commercial and Industry	• Most energy efficient per 100 employees per unit of output generated.
	• Relatively low commercial consumer of natural gas although none of the individual boroughs fell within the lowest 10 consuming local authorities.
Households	• Lowest Gas and Electricity consumption per £1 million of GVA. • Downward trend for the amount of total waste produced in London • Lowest domestic CO_2 emission per capita compared to all other regions.
	• Low recycling rate of just 18 per cent compared to national average of 27 per cent across all regions.

The fact that London does well on some environmental indicators and markedly less well on others reflects the applicability of the Kuznets Environmental Curve to some elements of the environmental agenda and not to others. In other words, some environmental improvements seem to be made as a result of the higher incomes achieved in cities, whilst some others (notably anything connected to the ecological footprint) do not.

That leaves us with the question about how best to tackle the environmental problems that remain. Creating incentives through pricing may be one route to influence certain types of behaviour but, unless they are truly revenue neutral, they may be unpopular. Of course, they may also have social and distributional implications. Less frequently considered is the trade-off between our own generations and future generations. Those alive today are less likely to see the benefits of reductions in carbon emissions, for example.

However, much of the remainder will have to be dealt with through innovation and generating new technologies. Having an innovation-driven programme for slowing down environmental degradation should mean that we maintain the freedoms to which we have become accustomed whilst not overestimating the utility of emissions reductions to future generations. We do not know how those people will value our sacrifices and, assuming that personal disposable incomes continue to rise in the longer term, they will have more wealth to spend on adaptation to a changed climate. It was seen earlier in this report that more efficient production techniques have had a profoundly positive impact on slowing down environmental degradation. Simply generating growth does not imply investment in innovation in cleaner technologies but London plays a profoundly important world role in this.

There is also a role here for the public sector. London has become Europe's centre for carbon permit trading but some of the credit for this is down to the public sector. Not only did the EU, an international institution, establish the EU-ETS, London's success is in some part predicated upon the DTI's experimental UK-ETS. Critics will argue that EU-ETS has not had a very significant effect on emissions but some of this criticism will not be applicable to Phase III of EU-ETS that the UK Government is pushing to be 100 per cent auctioned rather than allocated.

It is inevitable that some emissions will continue, regardless what policy makers do. The challenge is to get those emissions into the highest value uses.

Some final remarks

The studies behind this report have been a useful exercise in examining the environmental effectiveness of London. However, we are also aware that there remains some degree of need for methodological improvements. In addition, the analysis has raised concerns that, on some indicators, a clear and intuitive link has emerged between better environmental performance and low incomes – for example, in household carbon emissions in Inner East London. This suggests that on some indicators environmental effectiveness behaves in exactly the opposite way than the Environmental Kuznets Curve would suggest.

These findings relate to a broader issue of how London's policymakers can make the most use of the city's distinctive market segmentation matrix (see Appendix 1). The near absence of the 'environmentally indifferent' segment in the capital means that there is a genuine opportunity in London to lead the way on behavioural change with regard to the environment. The Energy Savings Trust has shown that there is a 'good correlation' between the segments and six levels of behavioural change. Certainly, the segments can be used for communication and targeted mailings but the degree of difference between London and the other English regions should imply that London policymakers can continue to develop a distinctive policy based on the modification of existing behaviours.

Appendix 1

The Energy Saving Trust (EST) segmentation matrix

This is a ten segment matrix developed from Experian's 61 MOSAIC types. These were devised by overlaying household and vehicle energy consumption and attitudinal data across types. From these ten segments, the EST has identified those it believes will have the highest returns in terms of carbon savings for targeted marketing activities. As with MOSAIC itself, the segmentation patterns are linked to postcodes so a very fine grain of detail can be achieved.

The full range of segments is given below with percentages applicable to the UK only. The percentages for London are very different and are illustrated in Fig 0.6. A higher attitudinal score means that there are potentially more positive attitudes towards the environment.

Environmentally mature

Attitudinal score 70
% Population 10.6
% Households 9.2
Characteristics: Affluent, well-educated couples with large homes. Very high vehicle and household energy consumption but potentially willing to change their behaviour, making them an important target category.

Educated advocates

Attitudinal score 78
% Population 8.4
% Households 9.2
Characteristics: Well-educated young couples and professionals sometimes in shared housing. Higher than average household energy consumption but relatively low vehicle energy consumption. An important target category as their lifestyles will develop towards larger homes and greater car ownership.

Discerning elders

Attitudinal score 72
% Population 4.8
% Households 4.8
Characteristics: Older people on the brink of retirement. Financial astuteness means they have usually succeeded in paying off their mortgages. Average vehicle energy consumption as car ownership tends to be relatively low but slightly above average household energy consumption.

Comfortable conservatives

Attitudinal score 53
% Population 10.5
% Households 9.2
Characteristics: Professional couples who dislike being pressured into lifestyle changes. Above average vehicle and household energy consumption. There is scope for reducing their emissions.

Britain today

Attitudinal score 45
% Population 8.5
% Households 9.2
Characteristics: Suburban couples whose values represent a cross-section of modern Britain. Lower than average energy consumption particularly in terms of vehicle use. Below average concern for environmental issues.

Restful retirement

Attitudinal score 43
% Population 4.9
% Households 5.9
Characteristics: Elderly couples and widows with low car ownership. Often keen to save energy as living on fixed income pensions. Low vehicle and household energy consumption.

Driving dependency

Attitudinal score 40
% Population 9.6
% Households 9.7
Characteristics: Young sharers or couples. Low household energy consumption but since cars are a lifeline to this group, vehicle energy consumption is very high. Household energy consumption is low as properties tend to be relatively new and well insulated.

Financially burdened

Attitudinal score 40
% Population 11.8
% Households 11.4
Characteristics: Families in large houses with high expenditure on everyday life. Higher than average vehicle energy consumption but lower than average household energy consumption.

Ethnic tradition

Attitudinal score 40
% Population 4.0
% Households 3.5
Characteristics: Traditional families with a focus on extended relationships. High household energy consumption driven by the large number of members within each household but very low vehicle energy consumption.

Environmentally indifferent

Attitudinal score 26
% Population 27.0
% Households 27.9
Characteristics: Poor families or elderly couples often living in local authority or ex-local authority housing. Vehicle ownership is low. Below average energy consumption both on the household (usually as a result of concern about bills rather than quality insulation) and vehicle scores but the most distinctive characteristic of this group is its lack of interest / disbelief in environmental issues.

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Chinese

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Vietnamese

Nếu bạn muốn có văn bản tài liệu này bằng ngôn ngữ của mình, hãy liên hệ theo số điện thoại hoặc địa chỉ dưới đây.

Greek

Αν θέλετε να αποκτήσετε αντίγραφο του παρόντος εγγράφου στη δική σας γλώσσα, παρακαλείστε να επικοινωνήσετε τηλεφωνικά στον αριθμό αυτό ή ταχυδρομικά στην παρακάτω διεύθυνση.

Turkish

Bu belgenin kendi dilinizde hazırlanmış bir nüshasını edinmek için, lütfen aşağıdaki telefon numarasını arayınız veya adrese başvurunuz.

Punjabi

ਜੇ ਤੁਹਾਨੂੰ ਇਸ ਦਸਤਾਵੇਜ਼ ਦੀ ਕਾਪੀ ਤੁਹਾਡੀ ਆਪਣੀ ਭਾਸ਼ਾ ਵਿਚ ਚਾਹੀਦੀ ਹੈ, ਤਾਂ ਹੇਠ ਲਿਖੇ ਨੰਬਰ 'ਤੇ ਫ਼ੋਨ ਕਰੋ ਜਾਂ ਹੇਠ ਲਿਖੇ ਪਤੇ 'ਤੇ ਰਾਬਤਾ ਕਰੋ:

Hindi

यदि आप इस दस्तावेज की प्रति अपनी भाषा में चाहते हैं, तो कृपया निम्नलिखित नंबर पर फोन करें अथवा नीचे दिये गये पते पर संपर्क करें

Bengali

আপনি যদি আপনার ভাষায় এই দলিলের প্রতিলিপি (কপি) চান, তা হলে নীচের ফোন্ নম্বরে বা ঠিকানায় অনুগ্রহ করে যোগাযোগ করুন।

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں چاهتے هیں، تو براہ کرم نیچے دئے گئے نمبر پر فون کریں یا دیئے گئے پتے پر رابطہ کریں

Arabic

إذا أردت نسخة من هذه الوثيقة بلغتك، يرجى الاتصال برقم الهاتف أو مراسلة العنوان أدناه

Gujarati

જો તમને આ દસ્તાવેજની નકલ તમારી ભાષામાં જોઈતી હોય તો, કૃપા કરી આપેલ નંબર ઉપર ફોન કરો અથવા નીચેના સરનામે સંપર્ક સાધો.

GLAECONOMICS

Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA

Tel: 020 7983 4922
Fax: 020 7983 4137
Minicom: 020 7983 4458
Email: glaeconomics@london.gov.uk

www.london.gov.uk/mayor/economic_unit

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