# Delivering a Low Carbon Camden

## Carbon reduction scenarios to 2050

April 2007

Camden

SEA Sustainable Energy Action

Renue Renewable Energy in the Urban Environment

# Executive Summary

## Introduction

Climate change is now recognised as a very serious threat to mankind, and the need to act is recognised at an international, national and local level. This study builds on the existing Camden Climate Change Action Plan to provide a framework for reducing Camden's greenhouse gas emissions to 2050.

The aims of this study are to:

- Calculate the current annual $CO_2$ emissions from Camden to provide a **baseline** against which reductions will be measured
- Compile a list of **technologies and measures** that apply to the building and transport sectors and that can be used to reduce $CO_2$ emissions
- Define **constraints** on the technologies and measures such as maximum installed capacities
- Analyse various **scenarios** by using a model to alter the mix of the different technologies and measures to meet various $CO_2$ reduction targets
- Analyse the **financial and environmental implications** of the proposed scenarios
- Use the results of the scenario modelling to put forward recommendations for a $CO_2$ reduction target for the borough and suggest **actions** to implement the strategies envisaged by the scenarios

In essence, the scenario modelling provides a broad vision of how energy and transport provision might look in 2050. This will inform the decisions that are made in the coming years on policies that will impact on energy and transport in the borough. The actions suggested are possible first steps on this path.

## Camden

Although climate change is a global problem requiring global and national solutions, ultimately greenhouse gas emissions are the result of individual choices made at a local level. Local Authorities have considerable influence in spatial and transport planning and are ideally placed to provide community leadership on these issues.

Camden is an inner London borough with its southern end located in Central London and the Congestion Charging Zone (CCZ) border. The borough developed a climate change strategy for 2006 to 2009, which this work will build on.

Camden's waste strategy has already been set out in partnership with other local boroughs through the North London Waste Authority, and this should largely eliminate methane emissions from the landfill of Camden's waste.

Transport planning is conducted to a large extent regionally through Transport for London (TfL). However, the local authority can exert its influence on this sector through parking policies, requirements for travel plans and sustainable transport measures as part of the spatial planning process. Transport policy in Camden has already been put in place through the Local Implementation Plan (LIP) and the Green Transport Strategy. Camden has also been successful in reducing car use in the borough substantially in recent years. This study builds on that work.

The building sector and particularly space heating is an area where significant $CO_2$ savings can be made. Camden has direct control over some 33,000 dwellings in the Local Authority stock, as well as its own corporate buildings. It can also influence the 69,000 private dwellings through planning and building control and through other incentives. The greatest source of emissions is the commercial and industrial sector, and this is also the sector that is perhaps hardest for a local authority to influence. This strategy proposes a range of measures that can tackle this source of emissions, the most important of which is the installation of a borough wide heating network fuelled by CHP.

## Baseline $CO_2$ emissions and targets

Baseline emissions are based on direct emissions from fuel use in the borough. This includes emissions arising from the direct use of fuels such as gas and oil in buildings. It also includes emissions arising from the generation of electricity used in Camden even though the emissions are actually released at the point of generation. Finally it includes emissions from transport fuels for any journeys or parts of journeys that take place within the borough boundaries.

It should be noted that choices made in Camden can have implications for $CO_2$ emissions outside the borough. Examples of this include emissions associated with the manufacture of goods produced outside Camden but consumed in Camden, or transport emissions from journeys made by Camden residents outside the borough, notably from aviation. These are not included, but the implementation of a climate change strategy could have knock on effects elsewhere.

There are various sources of information on $CO_2$ emissions described in this report. The baseline emissions chosen for this study are as follows:

| Sector | Emissions (ktpa) | Emissions (%) |
|---|---|---|
| Domestic buildings | 538 | 30% |
| Non-domestic buildings | 1020 | 58% |
| Transport | 216 | 12% |
| **Total** | **1,774** | **100%** |

**Table 1: Baseline $CO_2$ emissions in Camden**

In addition, growth in the borough is expected to increase these emissions by 67 ktpa for dwellings, 15 ktpa for non-domestic buildings and 102 ktpa for transport if allowed to grow unconstrained. The scenarios therefore have to offset this growth in addition to the percentage of the baseline emissions that forms the reduction target.

Camden is considering targets to reduce $CO_2$ emissions by 60%, 80% and 90% by 2050. These correspond to reductions of 1,248 ktpa, 1,603 ktpa and 1,780 ktpa when the expected growth is accounted for.

## $CO_2$ Reduction Scenarios

The original aim of this study was to put forward scenarios to meet reduction targets of 60%, 80% and 90% against baseline emissions.

The scenarios model **technological solutions** that would enable Camden residents and businesses to continue to enjoy a lifestyle similar to the present, i.e. they would not be expected to use less heat or power or travel less. Rather, the methods of providing energy and transport would result in lower $CO_2$ emissions.

The scenarios rely on existing technology and fuels. They are also subject to various constraints. For example, maximum potentials have been estimated for the various technologies, heat cannot be exported and there are limitations on the supply of biomass fuel.

However, during the modelling process it was found that reaching higher targets through the measures included in the scenario modelling was very difficult. Therefore, the following scenarios are outlined in the report:

- **60% scenario:** This scenario meets a 60% reduction target within all the modelling constraints.
- **70% scenario:** This scenario meets a 70% reduction target, again relying on exceeding the local supply of biomass fuel. However in this scenario the imported biomass is at a more realistic level than for the 80% scenario.
- **80% scenario:** This scenario meets an 80% reduction target, but relies on the availability of significant quantities of biomass fuel that would have to be imported from other parts of the UK or abroad.
- **Maximum scenario:** This scenario demonstrates the limits of the technological solutions subject to all the modelling constraints including the use of only local biomass. Although this means that the scenario is not a realistic proposition, in particular relying on very ambitious changes in transportation, it shows that the limit of the model is a 70% reduction unless one of the constraints is broken.
- **Renewables and insulation scenario:** The previous scenarios all rely on a large district heating infrastructure with CHP power stations providing heat and power to the borough. This scenario examines what reduction is possible without a heat distribution network, by maximising energy efficiency and renewable measures. In this case, $CO_2$ reductions would be limited to around 25%.

A summary of the scenario results is shown here:

| Scenario | Name | Heat produced | Power produced | $CO_2$ Savings | Net Present Value | Capital Costs | % of borough heat demand met by heat network |
|---|---|---|---|---|---|---|---|
| | | MWh/y | MWh/y | Ktpa | £k | £k | % |
| 1 | 60% by 2050 | 3,209,124 | 2,818,273 | 1,329 | 799,901 | 937,990 | 92.2% |
| 2 | 70% by 2050 | 3,181,563 | 2,404,933 | 1,506 | 826,463 | 1,051,389 | 92.8% |
| 3 | 80% by 2050 | 3,212,876 | 2,026,076 | 1,686 | 733,081 | 1,561,314 | 93.7% |
| 4 | Maximum | 3,207,871 | 3,075,240 | 1,498 | 1,452,235 | 1,048,333 | 99.8% |
| 5 | Renewables and insulation | 1,295,624 | 652,820 | 528 | 355,850 | 537,850 | 0.0% |

**Table 2: Summary of $CO_2$ reduction scenarios**

## Conclusions

The following conclusions can be drawn based on the scenario modelling process:

1. Camden's existing target of a **60% reduction in $CO_2$ emissions** can be met through technological means in a financially viable way.
2. **Higher targets** would rely on either alternative technologies and fuels becoming available or on **significant behavioural change** to reduce demand. The most likely alternative fuel based on current technologies is biomass, and this study has shown that if biomass fuel supply is significantly increased in the UK a higher target of 70% could be met. Behavioural change is more difficult to enforce and has not been modelled in this report.
3. The use of **district heating and CHP technologies** is essential to meet the necessary $CO_2$ reduction targets. This must also be complemented by other efficiency measures and renewable energy technologies. CHP also offers advantages in terms of flexibility in switching to alternative fuels in the future.

This process leads to a vision of how energy and transport will be delivered by 2050, outlined below.

## The Vision

The strategies proposed here address a number of measures. The idea is to reduce energy demand, and simultaneously switch the supply to low carbon technologies.

This study illustrates that community heating (CH) and combined heat and power (CHP) provide the most cost-effective way for Camden to achieve its carbon reduction targets. The vision set out for Camden in this report is for a heating network served by a number of CHP based heat sources supplying a significant proportion of the borough. This is an ambitious, long term programme that requires careful planning now and sustained effort by LBC and its partners to achieve.

In addition to the heating network, a number of short term measures are proposed, many of which build on existing work already happening in the borough. These include the continuation and expansion of domestic energy efficiency schemes to ensure that all unfilled cavities and lofts are insulated. Non-domestic energy efficiency is also important, including measures such as commercial double glazing and more efficient lighting for offices and streetlights. The commercial and industrial sector will also be encouraged to undertake energy audits and offered assistance in improving energy efficiency.

In the short term CHP units will be encouraged in individual buildings, preparing these buildings for a heat network connection at a later date. Solar PV will also be encouraged in the early stages in both domestic and non-domestic settings, and an ambitious PV installation programme will be pursued as the technology becomes more cost effective in later years. Electricity-generating renewables complement the heat network, and PV is considered most appropriate for Camden, possibly alongside a small amount of wind power. A small number of other renewable installations will be put in place such as solar thermal and biomass boilers.

Similarly for transport, demand reduction is envisaged alongside a modal shift to more sustainable transport options. Private cars are responsible for the majority of transport emissions, and it is the aim of this strategy to expand on the reductions in private car use already achieved and encourage walking, cycling and public transport. Motorcycles and taxis are also carbon intensive modes, and strategies to reduce the use of these are also proposed. This will be complemented by reduced freight transport and efficiency improvements for all transport modes.

This vision implies a number of consequences in terms of carbon reduction targets, funding and financing, the planning framework, choices of technologies and the phasing of their implementation.

## Partnership working

The scenarios proposed in this study cut across all activities that happen within Camden's boundaries. The London Borough of Camden is uniquely positioned to lay out a framework for a transition to a low carbon borough and to lead in realising this vision by encouraging, demonstrating, catalysing and providing incentives.

Clearly the ambitious carbon reduction targets proposed here cannot be met without the co-operation of other partners. These will include regional authorities, neighbouring boroughs, local strategic partners, businesses and residents.

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# 1 Introduction

## 1.1 Current action in Camden

The London Borough of Camden is already working to reduce its climate change impact in a number of ways. The borough has a Climate Change Action Plan to 2009, which forms a base for the work proposed in this study for the period to 2050. The Climate Change Action Plan is summarised in Appendix B, but the key aims are:

- Adopt as a minimum targets from the Mayor's Energy Strategy and a 60% $CO_2$ reduction target by 2050
- Improve energy efficiency in buildings by 1.5% each year
- Install various renewable and low carbon technologies including one CHP unit in a Council building and at least 12 domestic solar thermal and PV installations
- Purchase 20% of the Council's electricity from renewable sources by 2010
- Reduce traffic levels by 15% on 2001 levels by 2011 and promote electric vehicles and cycling
- Support businesses to reduce their environmental impacts and carbon footprints
- Promote sustainability through Council procurement policies
- Use the planning system to reduce $CO_2$ emissions, including a 10% renewables requirement and minimum BREEAM and EcoHomes standards for major developments
- Support the principle of Contraction and Convergence and lobby central government
- Provide education and awareness raising on climate change
- Promote a debate on the practice and implications of adapting our listed and conservation area buildings to meet the demands of climate change.

## 1.2 Aims and objectives

The primary objective of this report is to calculate carbon reduction targets for Camden and to put forward a strategy for Camden to meet those targets, based on analysis of a range of scenarios. Interim targets (to 2012, 2026 and 2035) for these reductions have been proposed for Camden, based on reduction targets of 60%, 80% and 90% by 2050.

This report re-assesses the baseline on which the target is based and quantifies the target in absolute terms.

A model has been developed to analyse scenarios for a range of measures, and assess the costs, energy production and $CO_2$ emissions savings for each measure and for the scenarios overall.

Finally a range of policy measures and actions are proposed to enable and encourage the realisation of the proposed scenarios. These actions build on the existing Climate Change Action Plan (2006 to 2009) and other strategies such as the Green Transport Strategy. It is intended that the recommendations of this report are in addition to the work already being undertaken in this area in Camden.

Figure 1 shows the process of implementing a borough wide energy services strategy, as proposed in this report.

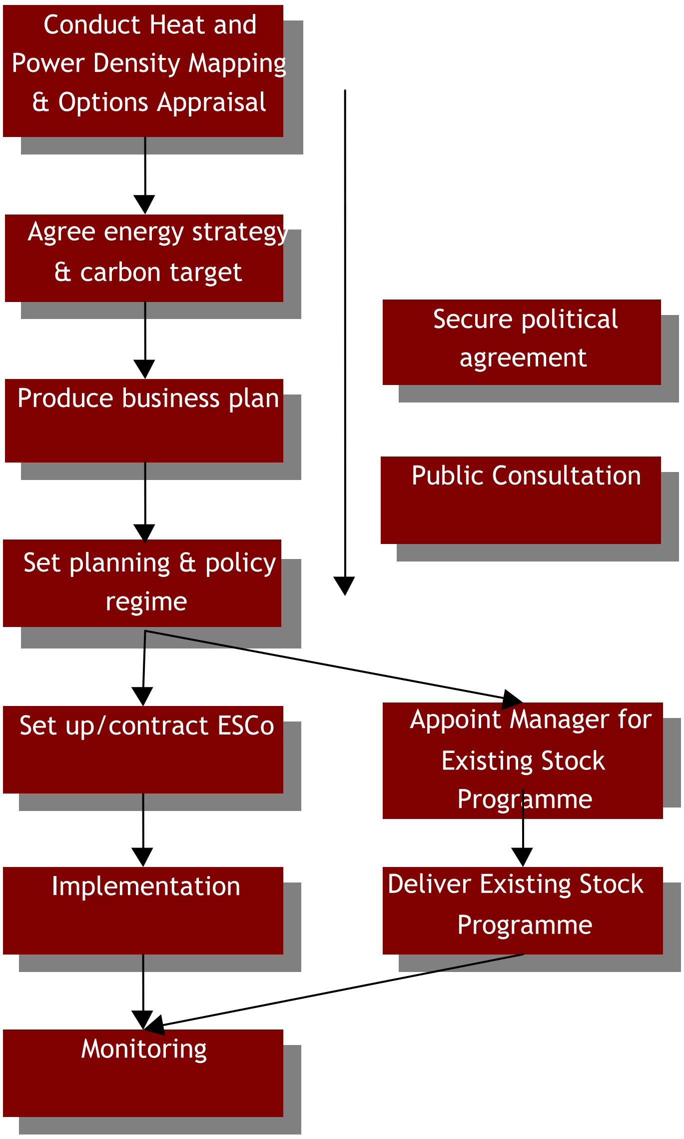


**Figure 1 Implementation of a borough wide energy services strategy**

## 1.3 Methodology

Figure 2 below gives an overview of the strategy development process. Each stage is described in more detail in the report.

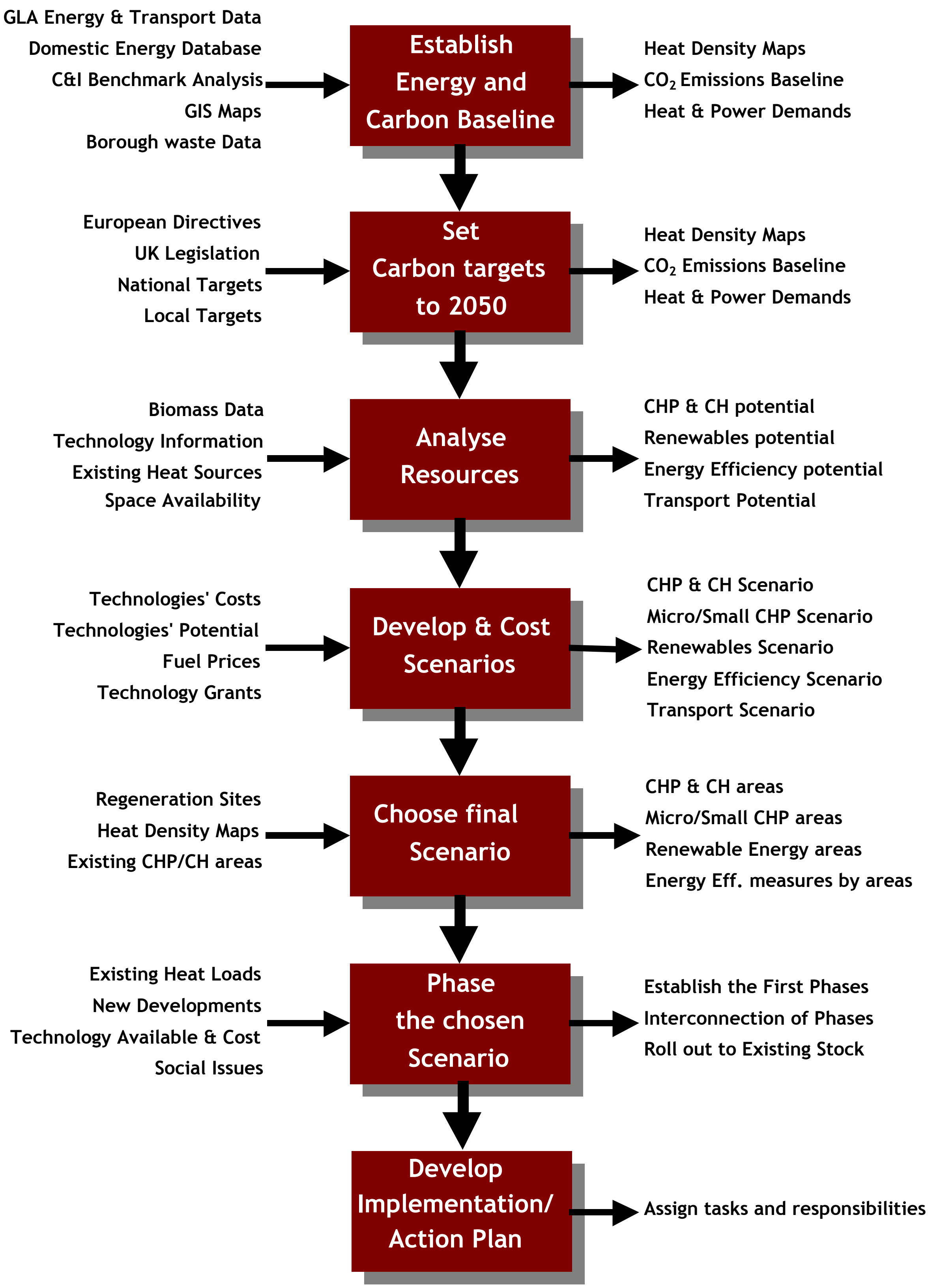


Figure 2 Methodology for strategy process

# 2 Existing Carbon Targets

## 2.1 Introduction

The section provides an overview of the carbon reduction targets that have already been set for London, including targets relating to renewable energy, energy generation, energy demand and distribution. All sectors are considered in the overview, including the transport, domestic and commercial sectors.

## 2.2 Measuring Carbon

Carbon accounting is a complex area. Human-induced climate change results from a whole host of interactions between a range of different greenhouse gases and pollutants released by our activities. The emissions from aviation, for example, are not purely from the $CO_2$ emissions that are released through the combustion of kerosene: there are also 'net radiative forcing' effects. These include the effect of the contrails and other effects produced by aircraft which are believed to increase the overall global warming impact of aviation by 2.7 times the direct $CO_2$ impact.[1]

Conventions for measuring carbon have tended to limit the inclusion of aviation fuel to landing and takeoff activities at airports within the city boundary. Other gases such as methane released from waste at landfill sites outside the borough can also be counted towards emissions targets.

For the purposes of this study, whilst these associated impacts should be born in mind when setting a target, for clarity and simplicity, in setting a building sector target we are purely counting $CO_2$ released through the direct combustion of fuels either in homes, businesses or public sector buildings in London and the electricity consumed in those buildings.

Where power generation is sited within London this becomes a more complex issue. All renewables and CHP generated power, where it is sold for Renewables Obligation Certificates (ROCs) will count towards the national target. We therefore propose that, to avoid double counting emissions reductions for electricity generated within London, we adopt a position that the current Building Regulations figure of $CO_2$ per kWh for electricity generation and displaced electricity generation is used and in taking forward projections into the future this is kept constant.

## 2.3 Existing Targets

### 2.3.1 The Royal Commission 2050 Target

The Royal Commission on Environmental Pollution (RCEP) report *Energy: the Changing Climate*[2] recommends a 60% reduction in greenhouse gas emissions by 2050 for the UK. This is based on stabilising atmospheric levels of $CO_2$ at 550ppm (parts per million). At the time of the report (2000) they stood at 370ppm (now 381ppm). This target has been adopted by the UK government as a long term goal, and the principle is supported by LBC as part of their Climate Change Action Plan (see Appendix B).

The RCEP also recommends setting per capita reduction targets based on 'contraction and convergence':

[1] Intergovernmental Panel on Climate Change www.grida.no/climate/ipcc/aviation/064.htm

[2] www.rcep.org.uk/pdf/summary.pdf

[2] www.rcep.org.uk/pdf/summary.pdf

[3] Climate Change and Carbon Dioxide Emissions Transport Sector, Draft Discussion Document, TFL, March 2006

> "The most promising, and just, basis for securing long-term agreement is to allocate emission rights to nations on a *per capita* basis - enshrining the idea that every human is entitled to release into the atmosphere the same quantity of greenhouse gases. But because of the very wide differences between *per capita* emission levels around the world, and because current global emissions are already above safe levels, there will have to be an adjustment period covering several decades in which nations' quotas converge on the same *per capita* level. This is the principle of contraction and convergence, which we support."

This principle has been adopted in Camden's existing climate action plan.

### 2.3.2 UK Emission Reduction Targets

The chart below summarises the overall targets that the UK currently aspires to. As the 2050 target is based on emission levels in 2000 rather than 1990, the overall target is actually 7% higher once set against 1990 levels[3] - a 7% reduction was achieved between 1990 and 2000.

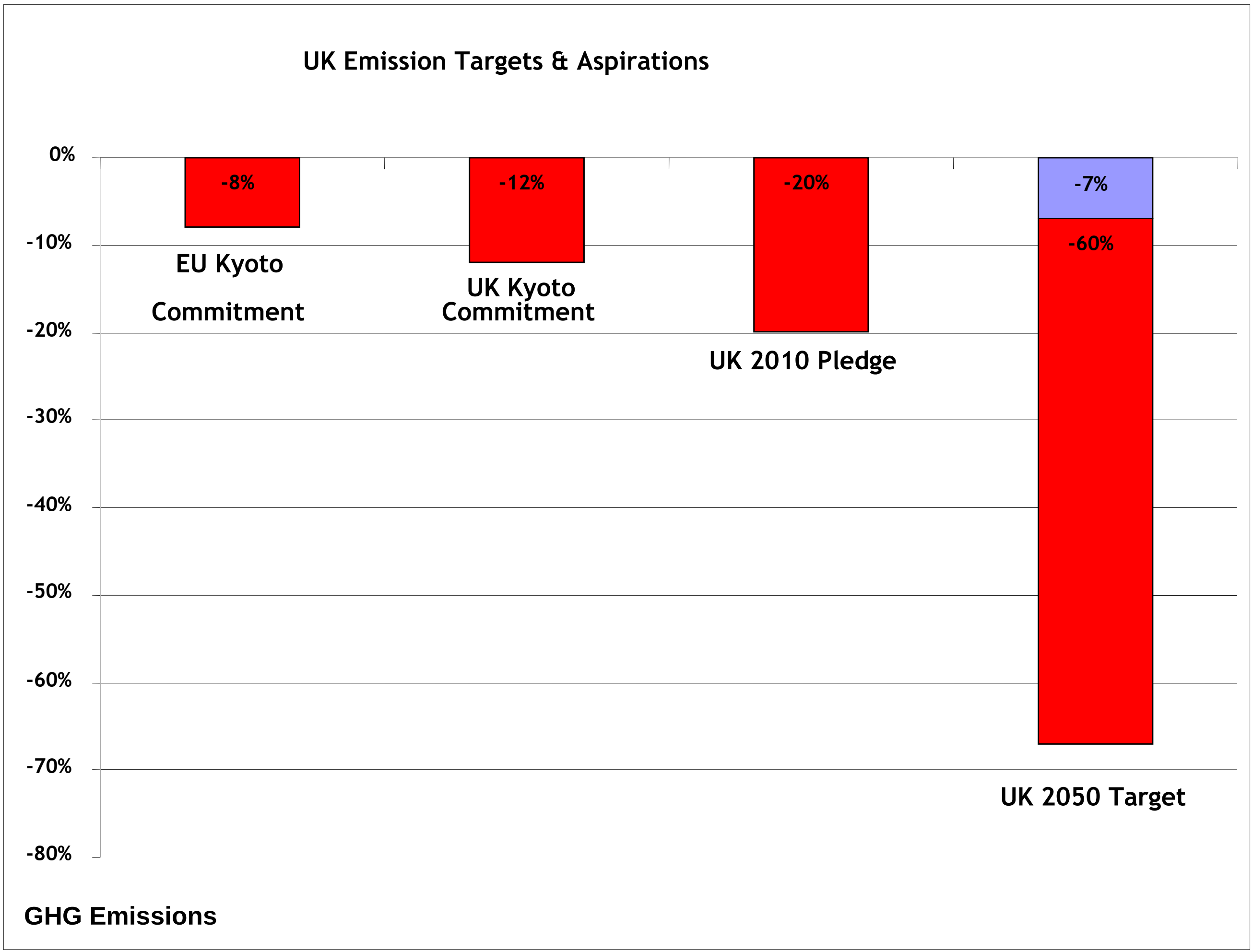


**Figure 3: UK Emission Reduction Targets and Aspirations against 1990 Baseline**

### 2.3.3 Targets in the Mayor's Energy Strategy

Policy 1 in the Mayor's Energy Strategy states:

> "The Mayor considers that London should take a proactive approach to ensure that it meets or exceeds its fair contribution to national targets for carbon dioxide emissions, renewable energy, combined heat and power, and eradicating fuel poverty."

[3] Climate Change and Carbon Dioxide Emissions Transport Sector, Draft Discussion Document, TFL, March 2006

Furthermore:

> "The Mayor supports the work of the Royal Commission on Environmental Pollution, and agrees with its conclusion that global atmospheric $CO_2$ concentration must not be allowed to exceed 550ppm. However, the choice of 550ppm as the upper limit will need to be kept under review."

The Mayor's Energy Strategy accepted the London Sustainable Development Commission's recommendations on targets. These were:

- 20% reduction on 1990 levels by 2010
- 60% reduction on 2000 levels by 2050

It is assumed that these refer to $CO_2$ emissions rather than the whole basket of greenhouse gas emissions which can be expressed as $CO_2$ equivalent.

### 2.3.4 Renewable Energy Targets

Targets were also set within the Mayor's energy strategy for specific technologies. These are set out in Proposal 6:

> "London should generate at least 665GWh of electricity and 280GWh of heat, from up to 40,000 renewable energy schemes by 2010. This would generate enough power for the equivalent of more than 100,000 homes and heat for more than 10,000 homes.
>
> To help achieve this, London should install at least 7,000 (or 15MW peak capacity) domestic photovoltaic installations; 250 (or 12MW peak capacity) photovoltaic applications on commercial and public buildings; six large wind turbines; 500 small wind generators associated with public or private sector buildings 25,000 domestic solar water heating schemes, 2,000 solar water heating schemes associated with swimming pools, and more anaerobic digestion plants with energy recovery and biomass-fuelled combined heat and power plants. London should then at least triple these technology capacities by 2020."

| Technology | Scale | 2010 | | | | 2020 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number installed | MWe | Elec GWh | Heat GWh | Number installed | MWe | Elec GWh | Heat GWh |
| **PV** | Domestic | 7,000 | 15 | 11 | | 21,000 | 45 | 34 | |
| **PV** | Large-scale | 250 | 12 | 9 | | 250 | 36 | 27 | |
| **Solar thermal** | Domestic | 25,000 | | | 35 | 75,000 | | | 105 |
| **Solar thermal** | Swimming pool | 2,000 | | | 21 | 6,000 | | | 63 |
| **Wind** | Small | 500 | 0.05 | 55 | | 1500 | 0.15 | 493 | |
| **Wind** | Large | 6 | 2 | 32 | | 18 | 6 | 284 | |
| **AD** | | | 5 | 40 | 40 | | 15 | 120 | 120 |
| **Biomass CHP** | | | 65 | 520 | 780 | | 195 | 1560 | 2340 |
| **Total** | | | | 667 | 876 | | | 2517 | 2628 |
| **Total Target** | | | | **665** | **280** | | | 1995 | 840 |

**Table 3: Minimum Targets for Renewable Energy in London (Mayor's Energy Strategy)**

As can be seen from the text from the Mayor's Strategy, not all of the targets were set out in detail for each technology but over-arching targets for heat and power generation were set. We have therefore made assumptions about the contribution from each technology. If Anaerobic Digestion (AD) and biomass CHP targets are both taken to be CHP, then meeting the electricity generation target of 665 GWh would result in the production of more than the target of 280 GWh of heat. The table below summarises the assumptions made in assessing the installed capacity required to meet the overall GWh targets.

| Technology | Scale | Output | Area | Load/ Capacity factor | Heat to power ratio |
|---|---|---|---|---|---|
| **PV** | Domestic | 750kWh/kWp/yr | | | |
| **PV** | Large-scale | 750kWh/kWp/yr | | | |
| **Solar thermal** | Domestic | 350kWh/m2/yr | 4m2 | | |
| **Solar thermal** | Swimming pool | 350kWh/m2/yr | 30m2 | | |
| **Wind** | Small | | | 25% | |
| **Wind** | Large | | | 30% | |
| **AD** | | | | 91.3% | 1:1 |
| **Biomass CHP** | | | | 91.3% | 3:2 |

**Table 4: Assumptions used for Renewable Target Calculations**

(8000hrs of operation was selected as an approximate figure which gave the load factor of 91.3% for AD and biomass CHP.)

### 2.3.5 Baseline Estimate in Mayor's Strategy

The current target for 2010 and 2050 for emissions reductions in London were set with 1990 and 2000 levels as a baseline respectively. These were estimated in the strategy as 45million tpa $CO_2$ for 1990 and approximately 42million tpa $CO_2$ for 2000, including the transport, domestic, commercial and industrial sectors.

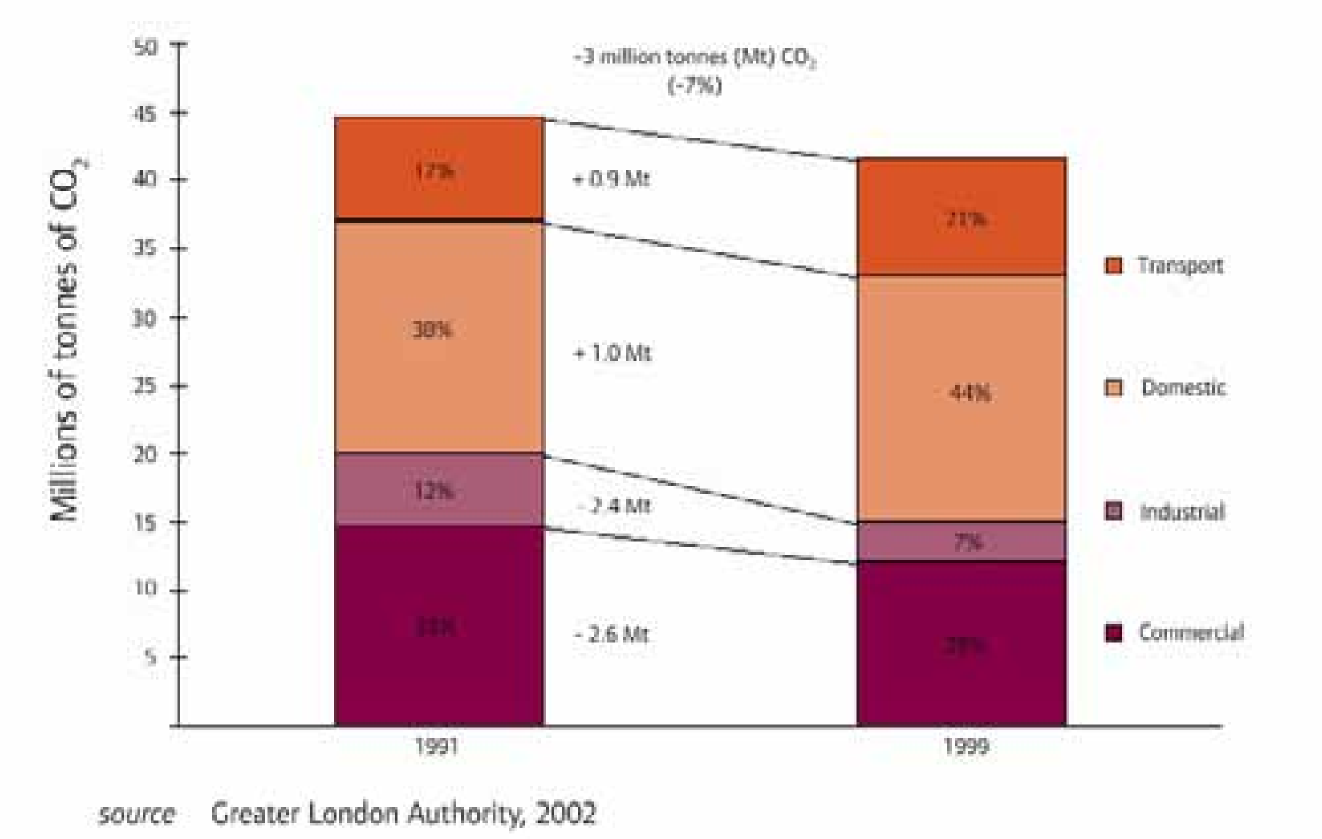


**Figure 4: Sectoral Carbon dioxide (CO2) emissions from London, 1991 and 1994**

## 2.4 The New Climate Science

The targets discussed above were set in a context of considerable uncertainty about the likely impact, scale and speed of climate change (the RCEP report was published in June 2000). Climate science has moved on significantly since then with many studies suggesting that the worst case scenarios are likely to have been closest to the correct predictions. There is also increasing evidence around a 'tipping point' where natural feedback mechanisms will lead to uncontrollable, irreversible and accelerated climate change. There is now a developing consensus that to avoid this, global temperature rises should not exceed 2°C. This target has been adopted by the EU Council:

> "The European Council acknowledges that climate change is likely to have major negative global, environmental, economic and social implications. It confirms that, with a view to achieving the ultimate objective of the UN Framework Convention on Climate Change, the global annual mean surface temperature increase should not exceed 2ºC above pre-industrial levels."

### 2.4.1 Royal Commission Response to Calls for Higher Targets

In the light of this new evidence, the Royal Commission have recently been asked to review their 60% reduction target. In a letter to the Treasury they state that:

> "Science is showing us ever more clearly that there will be serious impacts as a result of climate change, and this has prompted some to argue for stabilising $CO_2$ levels below the current UK/EU goal of 550 ppm. Recent evidence suggests this may be right at the upper limit of the likely prudent level, and that climate change could cause catastrophic and irreversible impacts, which will very difficult to predict or prepare for...

[4] Greater London Authority, Green Light to Clean Power, The Mayor's Energy Strategy, 2004

> ....Given the current uncertainties in models we cannot confidently unscramble the different dangers associated with 450, 550 or 650 ppm $CO_2$, although we know that each higher level will yield more problems from gradual climate change and increase the risk of dramatic and irreversible changes. However, the differences in emission scenarios over the next decade for the three $CO_2$ levels are not very great, and the crucial thing is to set a course for stabilisation now, otherwise all the targets will be unattainable. Thus we believe that the 550ppm $CO_2$ goal remains reasonable for now, being challenging yet attainable, and reducing the climate change impact far below business as usual levels. It could be kept under review to allow a move to a lower target if this becomes necessary."

### 2.4.2 What does a 2 degree limit mean?

According to the Potsdam Institute, this temperature limit leads to a requirement to stabilise atmospheric concentrations of greenhouse gases at less than 440 ppm $CO_2$ equivalent.

A report by Colin Forrest[5] explores the implications on targets for this level of atmospheric emissions:

> "we find that the current natural sinks for anthropogenic emissions, around 4 gigatonnes of carbon per year (or 4 GtC $a^{-1}$) will be reduced to around 2.7 GtC $a^{-1}$ in 2030. 2.7 GtC $a^{-1}$ therefore, is the amount of greenhouse gases we will be able to emit in 2030, without increasing atmospheric concentrations.
>
> When this global emission limit is shared out between the projected world population of 8.2 billion people, we get a per capita emission limit of 0.33 tonnes of carbon per year.
>
> In the UK we currently emit around 3 tonnes of carbon equivalent per person per year, so we will need to reduce our greenhouse gas emissions by 90%, compared with current levels, by 2030."[6]

Achieving an emission level per capita of 0.33 tonnes of carbon by 2030 is clearly a very ambitious target. As emissions levels are based on a per capita level this would need to allow for the projected increase in population.

### 2.4.3 The Tyndall Centre Target

Irrespective of what the overall targets are set at, there are also sound arguments that the building stock must make a higher contribution to these targets. A recent Tyndall Centre study made the claim that the rest of the economy would need to be carbon neutral to allow for the likely growth in aviation emissions.

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[5] www.climate-crisis.net/downloads/THE_CUTTING_EDGE_CLIMATE_SCIENCE_TO_APRIL_05.pdf

[6] The Forrest report uses Carbon rather than $CO_2$. The conversion factor is 3.67, i.e. 0.33 tonnes of carbon = 1.2 tonnes of $CO_2$.

# 3 Baseline Emissions

There are many different ways of assessing the baseline emissions and a range of different gases that could be included. This section provides a comparison of a number of different attempts to establish the baseline of greenhouse gas emissions for the London Borough of Camden and puts forward the best to be used for the purposes of this study. Figures below are expressed in carbon dioxide ($CO_2$) emissions rather than carbon (C) emissions and are generally stated in tonnes per annum (tpa) or kilotonnes per annum (ktpa).

## 3.1 ONS Household Emissions Report

An Office of National Statistics Report produced in 2004 examined the generation of greenhouse gases by UK households in 2001 and attributes them to the use of energy products, the use of transport and to the demand for goods and services. They include within the study remit carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride – so a larger range of greenhouse gases than the studies outlined below. Emissions from final demand for other goods and services include emissions embedded in imports of goods and services. Effectively this represents an "embodied" emissions approach seen from the household perspective.

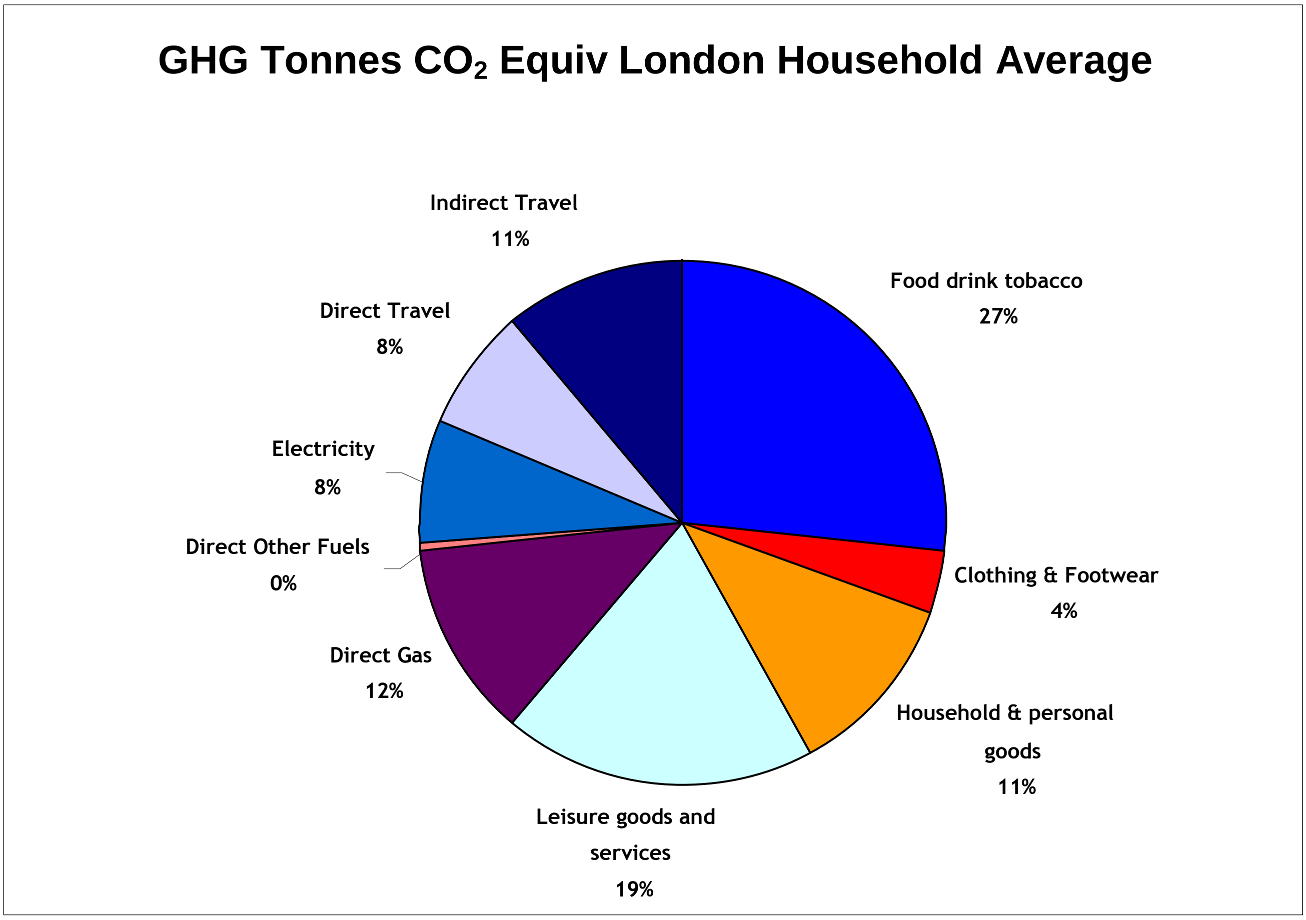


**Figure 5: Breakdown of London household emissions including indirect sources**

The report breaks down the figures regionally but not to the local authority so we have assumed the London figures are broadly representative of Camden. It can be seen that indirect emissions from goods and services accounts for some 60% of household emissions. This approach significantly increases the overall emissions that Camden is responsible for. This is because it includes transport outside of the borough (for instance air travel by residents) and the emissions associated with the import of goods and services.

The report states that London emits 77.2 million tonnes of $CO_2$, or 26.2 tonnes per household per year. At this rate, Camden's 93,993 households would be responsible for 2463 ktpa, considerably higher than the emissions predicted by the other models outlined below.

## 3.2 Regional Energy Consumption Statistics, DTI 2003

Estimates of total final energy consumption in 2003 published by the DTI for the first time in the December 2005 edition of Energy Trends. It includes gas consumption, road transport fuel and other fuel statistics at regional (NUTS1) and local (NUTS4) levels for 2003[7]. The information published for Camden by DTI is shown in Table 5.

| Fuel | Sector | Energy Consumption GWh |
|---|---|---:|
| Coal | Industry & Commercial | 0 |
| | Domestic | 0.5 |
| | Total | 0.5 |
| Manufactured fuels | Industry & Commercial | 0 |
| | Domestic | 1.5 |
| | Total | 1.5 |
| Petroleum products | Industry & Commercial | 49.9 |
| | Domestic | 13.9 |
| | Road transport | 978.2 |
| | Rail | 11.1 |
| | Total | 1053.2 |
| Natural gas | Industry & Commercial | 1131.4 |
| | Domestic | 728.8 |
| | Total | 1860.1 |
| Electricity | Industry & Commercial | 1342.1 |
| | Domestic | 361.1 |
| | Total | 1703.2 |
| Renewables & Waste | Total | 8.1 |
| **Total** | | **4,626.7** |

**Table 5: Total Energy Consumption for Camden, DTI 2003**

The data provided for electricity consumption is classified as experimental and has now been released for 2003, 2004 and 2005. The transport figures were provided for the DTI by Netcen. Netcen runs the National Atmospheric Emissions Inventory (NAEI) which is used by government departments, local authorities, regulators and industry.

By using the above data in conjunction with $CO_2$ emission factors for the different fuels, it was possible to estimate the $CO_2$ emissions for the Borough, as shown in the next table.

[7] www.dti.gov.uk/energy/statistics/regional/index.html accessed January 2007

| Fuel / Sector | Domestic ktpa | Industry & Commercial ktpa | Transport ktpa | Total ktpa |
|---|---|---|---|---|
| Coal | 0.17 | 0 | 0 | 0.17 |
| Petroleum Products | 4.03 | 14.47 | 242.38 | 260.88 |
| Gas | 138.47 | 214.97 | 0 | 353.42 |
| Electricity | 152.38 | 566.37 | 0 | 718.75 |
| **Total** | **295.05** | **795.81** | **286.90** | **1333.21** |

**Table 6: $CO_2$ emissions by fuel & sector for Camden, DTI 2003**

The DTI have subsequently published gas and road transport fuel consumption data for 2004, and electricity consumption data for 2004 and 2005. These are summarised in the following tables. Note that there have been changes in the methodology used to compile these datasets, and that some of the change seen in consumption levels could be a result of these changes.

| Year | | Domestic | Commercial and Industrial | Total |
|---|---|---|---|---|
| 2003 | Energy (GWh) | 729 | 1,131 | 1,860 |
| | $CO_2$ (ktpa) | 138 | 215 | 353 |
| 2004 | Energy (GWh) | 840 | 1,272 | 2,111 |
| | $CO_2$ (ktpa) | 160 | 242 | 401 |
| Percentage change 2003 to 2004 | | 15.20% | 12.40% | 13.50% |

**Table 7 Energy use and $CO_2$ emissions from gas consumption for Camden 2003 to 2004 (DTI)**

| Year | | Domestic | Commercial and Industrial | Total |
|---|---|---|---|---|
| 2003 | Energy (GWh) | 361 | 1,342 | 1,703 |
| | $CO_2$ (ktpa) | 152 | 566 | 719 |
| 2004 | Energy (GWh) | 349 | 1,435 | 1,784 |
| | $CO_2$ (ktpa) | 147 | 606 | 753 |
| 2005 | Energy (GWh) | 373 | 1,445 | 1,818 |
| | $CO_2$ (ktpa) | 157 | 610 | 767 |
| Percentage change 2003 to 2004 | | -3.26% | 6.93% | 4.77% |
| Percentage change 2004 to 2005 | | 6.75% | 0.71% | 1.89% |
| Percentage change 2003 to 2005 | | 3.27% | 7.68% | 6.75% |

**Table 8 Energy use and $CO_2$ emissions from electricity consumption for Camden 2003 to 2005 (DTI)**

| Year | Buses | Diesel Cars | Petrol Cars | Motor-cycles | HGV | Diesel LGV | Petrol LGV | Total |
|---|---|---|---|---|---|---|---|---|
| **Fuel use (thousands of tonnes)** | | | | | | | | |
| 2003 | 8.4 | 7.6 | 40.5 | 1.5 | 6.5 | 10.0 | 1.3 | 75.8 |
| 2004 | 7.9 | 7.8 | 38.0 | 1.3 | 6.7 | 10.0 | 1.2 | 72.9 |
| % change 2003 - 2004 | -5.28% | 2.70% | -6.27% | -13.44% | 3.06% | -0.04% | -11.71% | -3.87% |
| **$CO_2$ emissions (ktpa)** | | | | | | | | |
| 2003 | 26.6 | 24.2 | 127.2 | 4.6 | 20.7 | 31.5 | 4.1 | 238.9 |
| 2004 | 25.2 | 24.8 | 119.3 | 4.0 | 21.4 | 31.5 | 3.6 | 229.7 |
| % change 2003 - 2004 | -5.28% | 2.70% | -6.27% | -13.44% | 3.06% | -0.04% | -11.71% | -3.85% |

**Table 9 Road transport fuel consumption and $CO_2$ emissions for Camden 2003 to 2004 (DTI)**

## 3.3 Defra Local and Regional $CO_2$ Emissions Estimates for 2003

Published in 2005 and produced by Netcen, part of AEA Technology, which is an extension of the National Atmospheric Emissions Inventory (NAEI).

This work was made possible following the publication of new local gas, electricity and road transport fuel consumption estimates by DTI. The DTI electricity consumption data enabled Netcen to map for the first time carbon dioxide emissions from electricity generation to the point of consumption. This is a key difference to the data previously published by the NAEI where emissions have traditionally been attributed to the location of emission (e.g. at the power station locations).

The emissions from electricity consumption were estimated using an average UK factor in terms of kt $CO_2$ per GWh. This average allocates equal shares of coal, gas, oil and renewable powered generation to the electricity consumers and is derived from the UK inventory for 2003. The local $CO_2$ estimates presented in the report are split into three categories: domestic (including electricity use), industrial and commercial (not including power stations) and road transport. Natural (e.g. soils) and land use change emissions are also included in the Local Authority data. The remainder of the UK emissions such as off shore emissions from oil and gas extraction, fishing and coastal shipping, are reported as unallocated because these could not be spatially disaggregated to LA level.

This reporting structure is different from that used for reporting the UK total $CO_2$ emissions for Defra commitments under the UN Framework Convention on Climate Change (in the National Communication Format). The simplified structure has been adopted because of the aggregated nature of the data available from the DTI.

| Sector | $CO_2$ Emissions ktpa |
|---|---|
| Domestic | 345 |
| Industry & Commercial | 967 |
| Road Transport | 235 |
| Land Use Change | 0 |
| **Total** | **1547** |

**Table 10: $CO_2$ emissions by sector for Camden (Defra 2003)**

The DTI electricity consumption data used in this work is an experimental dataset published for the first time. Electricity used by railways is included in the Industrial and Commercial dataset from DTI. Because it is not possible to separate rail use of electricity from this data both diesel and electric emissions from the rail sector are allocated to commercial and industrial sector.

The gas data published by DTI provides estimates of gas consumption by the domestic sector and the industrial and commercial sector for each Local Authority in Great Britain, has been used for this report. The estimates have been compiled by DTI using data provided by National Grid Transco (NGT) at postcode sector level. DTI have allocated each postcode sector in the NGT dataset to one or more Local Authority (LA) area.

## 3.4 Defra Local and Regional $CO_2$ Emissions Estimates for 2004

Defra have recently (November 2006) published updated estimates of carbon dioxide emissions at Local Authority level. These are described as experimental, and not directly comparable with the 2003 data described above due to improvements in the raw data and modelling methods used.

The main changes over the 2003 dataset are:

- Energy sector emissions are re-allocated to end users. In 2003 this was only done for the electricity sector.
- Improved DTI electricity consumption data means that only 1.5% is unallocated to a Local Authority compared to 8% previously. Meter point locations have been more accurately allocated to LAs.
- Improved estimates of the distribution of solid and liquid fuels in the domestic sector.
- Improved estimates of emissions and removal of $CO_2$ due to land use, land use change and forestry (LULUCF).

| Sector | $CO_2$ Emissions ktpa |
|---|---:|
| Domestic | 332 |
| Industry & Commercial | 999 |
| Road Transport | 269 |
| Land Use Change | 1 |
| **Total** | **1602** |

**Table 11: $CO_2$ emissions by sector for Camden (Defra 2004)**

## 3.5 London Energy and $CO_2$ Emissions Inventory (LECI) 2003

Published by Mayor of London in June 2006, the LECI 2003 is an annually updated database of related electronic files that hold geographically referenced datasets of energy consumption (in kWh) and the resulting $CO_2$ emissions (in tonnes/year) for the Greater London area in 2003. The LECI 2003 was compiled and is maintained by the Greater London Authority (GLA) as part of the implementation of the London Mayor's Energy Strategy.

The LECI 2003 provides energy consumption and $CO_2$ emission estimates at both London borough and $1km^2$ levels for various energy/fuel categories and sectors. The energy consumption and $CO_2$ emissions were split into three broad sectors: domestic, commercial and industrial, and transport. The database was also divided in energy/fuel sources. The following table shows different sources for the datasets used within the LECI 2003.

| Energy/Fuel Source | Energy Fuel/Sector | Data Source |
|---|---|---|
| Electricity | Domestic / C&I | NAEI 2003/NETCEN and DTI |
| Gas | Domestic / C&I | LAEI 2003 (GLA 2006) |
| Oil | Domestic / C&I | NAEI 2003/NETCEN and DTI |
| Coal | Domestic / C&I | NAEI 2003/NETCEN and DTI |
| Renewables & Wastes | Domestic / C&I | NAEI 2003/NETCEN and DTI |
| CHP | Domestic / C&I | LAEI 2003 (GLA 2006) |
| Rails | Transport | LAEI 2003 (GLA 2006) |
| Road Transport | Transport | LAEI 2003 (GLA 2006) |
| Shipping | Transport | LAEI 2003 (GLA 2006) |
| Aviation | Transport | LAEI 2003 (GLA 2006) |

**Table 12: Sources, sectors and datasets used within LECI 2003**

The LECI 2003 was provided in a database form (Microsoft Access) by the Environment Group's Energy Team (GLA). Most of the data can be exported to Microsoft Excel and linked to GIS software. For more information about the methodology used, please refer to the LECI 2003 report.

The following table shows the energy consumption and $CO_2$ emissions extracted from the LECI 2003 database. According to this database, the 2003 $CO_2$ emissions for Greater London were 43,665 ktpa while for Camden they were 1,268 ktpa.

| | Domestic | | Commercial & Industrial | | Transport | | Total | |
|---|---|---|---|---|---|---|---|---|
| Energy/Fuel Source | Energy GWh | $CO_2$ ktpa | Energy GWh | $CO_2$ Ktpa | Energy GWh | $CO_2$ Ktpa | Energy GWh | $CO_2$ ktpa |
| Gas | 1035 | 194 | 1454 | 269 | 0 | 0 | 2489 | 463 |
| Electricity | 288 | 124 | 1059 | 487 | 0 | 0 | 1347 | 611 |
| Oil | 11 | 3 | 45 | 12 | 0 | 0 | 56 | 15 |
| Coal | 0.4 | 0.1 | 0 | 0 | 0 | 0 | 0.4 | 0.1 |
| Wastes & Renewables | 0 | 0 | 6 | 0 | 0 | 0 | 6 | 0 |
| Rail | 0 | 0 | 0 | 0 | 43 | 26 | 43 | 26 |
| Roads | 0 | 0 | 0 | 0 | 584 | 153 | 584 | 153 |
| Aviation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shipping | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Totals** | **1335** | **321** | **2564** | **768** | **626** | **178** | **4525** | **1268** |

**Table 13: LECI 2003 Energy Consumption and $CO_2$ emissions for Camden**

The energy consumption and $CO_2$ emissions shown in the LECI 2003 are classed as experimental by the GLA. However, this database seems to be the most comprehensive and refined to date for the Greater London area. This version corresponds to an improved version of the previous LECI 2000 database.

## 3.6 LECI 2003 - Modified

After analysing in detail the data obtained from LECI 2003, it was found that the way of assigning emissions to each Borough contains some inaccuracies. As mentioned earlier, London was divided in 1km$^2$ areas and each square was assigned to only one Borough. When a square falls between 2 Boroughs, the one that has the largest area of the square gets assigned all the energy use within that 1km$^2$. The grid squares included in LECI 2003 for Camden are shown green in Figure 6.

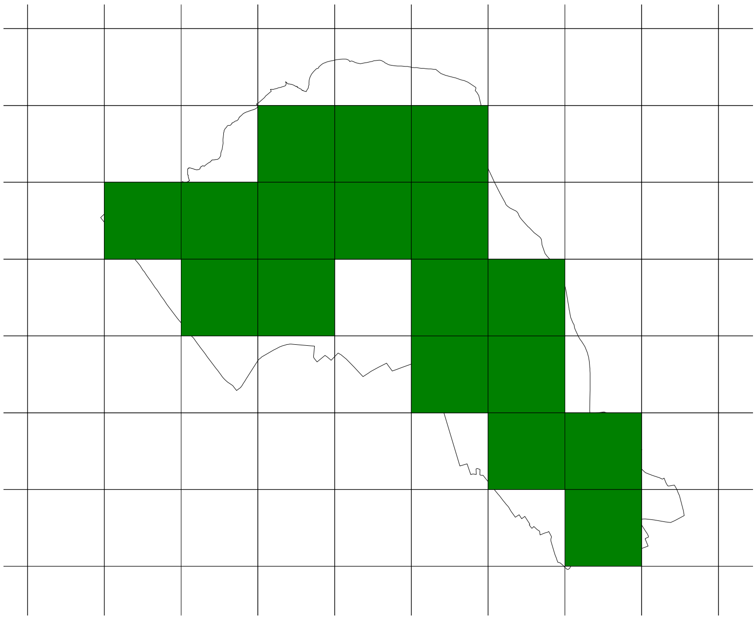

**Figure 6 Grid squares included in LECI**

It can be seen that in the case of Camden, most of the squares around the borough boundary are assigned to neighbouring boroughs. There is also one square in the middle of Camden that has been erroneously assigned to Lambeth. It would appear from this and from the Defra and DTI figures that the LECI estimate would be an underestimate. Figure 7 shows the areas of the grid squares that should be assigned to Camden.

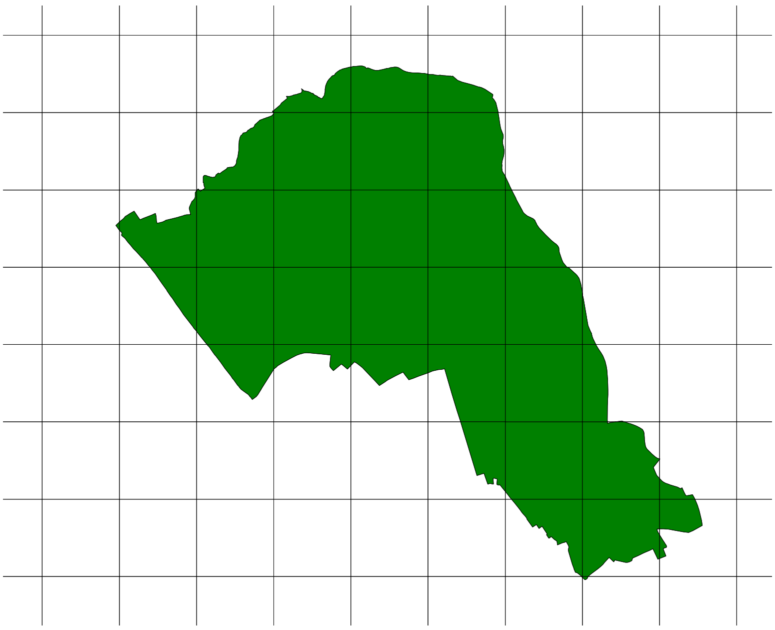

**Figure 7 Grid squares in Camden**

By calculating the area of each grid square within the Camden boundary and the $CO_2$ emissions from each grid square according to LECI 2003, it is possible to assign $CO_2$ emissions to each grid square shown in Figure 7 proportional to the area within Camden. Adding these values gives a more accurate estimate of the total emissions for Camden.

Furthermore, it was found that an out of date emissions factor for electricity was used for calculating train emissions. The current grid emissions factor was substituted and the $CO_2$ emissions recalculated for rail.

| | Domestic | | Commercial & Industrial | | Transport | | Total | |
|---|---|---|---|---|---|---|---|---|
| Energy/Fuel Source | Energy GWh | $CO_2$ ktpa | Energy GWh | $CO_2$ Ktpa | Energy GWh | $CO_2$ Ktpa | Energy GWh | $CO_2$ ktpa |
| Gas | 1377 | 258 | 1814 | 336 | 0 | 0 | 3191 | 594 |
| Electricity | 361 | 155 | 1422 | 654 | 0 | 0 | 1783 | 809 |
| Oil | 14 | 4 | 57 | 15 | 0 | 0 | 71 | 19 |
| Coal | 0.6 | 0.2 | 0 | 0 | 0 | 0 | 0.6 | 0.2 |
| CHP | 0 | 0 | 148 | 33 | 0 | 0 | 148 | 33 |
| Wastes & Renewables | 0 | 0 | 8 | 0 | 0 | 0 | 8 | 0 |
| Rail | 0 | 0 | 0 | 0 | 49 | 24 | 49 | 24 |
| Roads | 0 | 0 | 0 | 0 | 712 | 186 | 712 | 186 |
| Aviation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shipping | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Totals** | **1753** | **418** | **3449** | **1038** | **761** | **210** | **5963** | **1667** |

**Table 14 LECI 2003 Energy Consumption and $CO_2$ Emissions for Camden - Modified**

## 3.7 Road Transport Emissions

Camden has seen a reduction in car use in the borough, and consequently it might be necessary to adjust the emissions due to road transport. Table 9 shows that Defra estimate a 3.85% reduction in total road transport $CO_2$ emissions between 2003 and 2004, although emissions from some modes did increase.

### 3.7.1 Impact of Congestion Charging

A part of Camden falls within the congestion charging zone (CCZ), and this will have had an impact on traffic in the borough.

The LECI database for 2003 does make adjustments for the introduction of congestion charging in 2002, using the following percentage changes.

| Location | Motorcycles | Taxis | Cars | Buses | LGVs | HGVs |
|---|---|---|---|---|---|---|
| Congestion zone | 7.1 | 15.1 | -26.2 | 15.9 | -1.2 | -7.4 |
| Inner ring road | 43.3 | 15.1 | -8.7 | 21.9 | 16.3 | 5.6 |

**Table 15 Percentage changes applied to roads in LECI[8]**

[8] London Energy and $CO_2$ Emissions Inventory 2003 Methodology Manual, GLA, April 2006

### 3.7.2 Traffic counts in Camden

Camden have also carried out traffic counts regularly since 1995 using four screenlines (one running North – South and three running East – West). These have shown a 20% reduction in car use and 7% reduction in motor vehicles combined between 2001 and 2006. Taxis, motorcycles, buses and pedal cycles have all increased over this period. Data is available from LECI and Defra for 2003, so it is the change from this date that is relevant to this study.

| Vehicle type | Percentage change 2003 to 2006 |
|---|---|
| Pedal cycles | 68.1% |
| Motorcycles | 12.7% |
| Taxis | 15.5% |
| Light goods | 6.6% |
| Medium goods | -9.4% |
| Heavy goods | 50.4% |
| Buses and coaches | 33.1% |
| Cars | -4.1% |
| Total flow | 6.1% |
| Motor vehicles | 2.5% |

**Table 16 Change in traffic flow from 2003 to 2006**

If the percentage changes shown in Table 16 are applied to the emissions for each mode in each grid square from the LECI database, total road transport emissions actually increase slightly, from 186 ktpa to 192 ktpa.

This might appear to conflict with TfL claims of $CO_2$ reductions of around 20% in the CCZ. However, LECI 2003 had already taken into account the introduction of the charge. Furthermore, TfL modelling factors in improved efficiency due to changes in average speeds resulting from reduced congestion.

Finally, the changes in vehicle kilometres published by TfL do not show the same changes as the vehicle counts in Camden. This is to be expected because the methodology is different and the Camden study includes areas both within and outside the CCZ. Table 17 shows the changes in travel by different modes in the CCZ, with the observed changes in Camden shown alongside for comparison.

| Vehicle Type | Millions Vehicle km | | | | Percentage change 2003 to 2005 | Percentage changes observed in Camden | |
|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | | 2003 to 2005 | 2003 to 2006 |
| All vehicles | 1.64 | 1.45 | 1.38 | 1.4 | -3.45% | 2.53% | 0.76% |
| Four or more wheels | 1.44 | 1.23 | 1.16 | 1.16 | -5.69% | | |
| Potentially chargeable | 1.13 | 0.85 | 0.8 | 0.79 | -7.06% | | |
| - Cars and minicabs | 0.77 | 0.51 | 0.47 | 0.47 | -7.84% | -4.08% | -1.24% |
| - Vans | 0.29 | 0.27 | 0.26 | 0.25 | -7.41% | 6.63% | 2.81% |
| - Lorries and other | 0.07 | 0.07 | 0.06 | 0.07 | 0.00% | -2.14% | -8.36% |
| Non chargeable | 0.51 | 0.6 | 0.58 | 0.61 | 1.67% | | |
| - Licensed taxis | 0.26 | 0.31 | 0.29 | 0.3 | -3.23% | 15.51% | 3.75% |
| - Buses and coaches | 0.05 | 0.07 | 0.07 | 0.07 | 0.00% | 33.07% | 24.94% |
| - Powered two-wheelers | 0.13 | 0.14 | 0.13 | 0.13 | -7.14% | 12.73% | 3.69% |
| - Pedal cycles | 0.07 | 0.09 | 0.09 | 0.1 | 11.11% | 68.14% | 46.10% |

**Table 17 Changes in transport modes in CCZ**[9]

It can be clearly seen that Camden has experienced a great increase in vans, taxis, buses and motorcycles compared to the CCZ, and this has offset any carbon reduction resulting from the decrease in cars.

## 3.8 Gas Consumption Emissions

The gas consumption data used by the DTI (and in turn in the Defra and LECI datasets) does not provide a reliable split between domestic and commercial and industrial consumers. The gas industry uses an annual consumption of 73,200 kWh as the cut off point. This means that many small businesses are incorrectly classified as domestic consumers.

Furthermore, in a borough such as Camden with a large number of estates using community heating, it is likely that most of these estates will be above the 73,200 kWh threshold and will therefore be classified as commercial and industrial consumers.

Billing data from the last available year (2005 to 2006) suggests that the total gas consumption in these estates was 336 GWh with associated $CO_2$ emissions of 65 ktpa.

Unfortunately it is not possible to quantify the emissions from incorrectly identified small businesses. However, despite the uncertainty in the split, the total emissions from gas are accurate.

## 3.9 Baseline Emissions

In order to use the most up to date baseline emissions, the modified LECI data has been updated using the following methods:

- Gas and electricity consumption has been increased by the percentages calculated for the DTI datasets since 2003. The LECI data is based on the DTI figures, so this approach seems reasonable.

[9]Congestion Charging Impacts Monitoring - Fourth Annual Report, TfL, June 2006, http://www.tfl.gov.uk/tfl/cclondon/pdfs/FourthAnnualReportFinal.pdf - accessed 29th January 2006.

- Road transport emissions have been updated using Camden's screenline analysis data as described in section 3.7.2.
- The Domestic / Commercial and Industrial split has been adjusted for the estates with community heating by subtracting 336 GWh and 65 ktpa from the C & I energy consumption and $CO_2$ emissions respectively and adding the same amount to the domestic figures.

This means that the final baseline, as shown in Table 18 contains data from a range of years – gas from 2004, electricity from 2005, road transport from 2006 and all other data from 2003. These are the most recent years available for each set of data.

| | Domestic | | Commercial & Industrial | | Transport | | Total | |
|---|---|---|---|---|---|---|---|---|
| **Energy/Fuel Source** | Energy GWh | $CO_2$ ktpa | Energy GWh | $CO_2$ Ktpa | Energy GWh | $CO_2$ Ktpa | Energy GWh | $CO_2$ ktpa |
| Gas | 1884 | 355 | 1617 | 296 | 0 | 0 | 3501 | 651 |
| Electricity | 416 | 179 | 1469 | 676 | 0 | 0 | 1885 | 855 |
| Oil | 14 | 4 | 57 | 15 | 0 | 0 | 71 | 19 |
| Coal | 0.6 | 0.2 | 0 | 0 | 0 | 0 | 0.6 | 0.2 |
| CHP | 0 | 0 | 148 | 33 | 0 | 0 | 148 | 33 |
| Wastes & Renewables | 0 | 0 | 8 | 0 | 0 | 0 | 8 | 0 |
| Rail | 0 | 0 | 0 | 0 | 49 | 24 | 49 | 24 |
| Roads | 0 | 0 | 0 | 0 | 712 | 192 | 712 | 192 |
| Aviation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shipping | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Totals** | **2315** | **538** | **3299** | **1020** | **761** | **216** | **6375** | **1774** |

**Table 18 Camden baseline emissions**

## 3.10 Comparison of Models

| Model / $CO_2$ emissions ktpa | Domestic | C & I | Transport | Total |
|---|---|---|---|---|
| LECI 2003 (modified) | 538 | 1020 | 217 | 1776 |
| LECI 2003 | 386 | 703 | 178 | 1268 |
| Defra 2003 | 410 | 902 | 235 | 1547 |
| Defra 2004 | 397 | 934 | 262 | 1593 |
| DTI 2003 | 360 | 731 | 284 | 1375 |
| ONS 2001 | 461 | 1541 | 461 | 2463 |

**Table 19 $CO_2$ emissions by model**

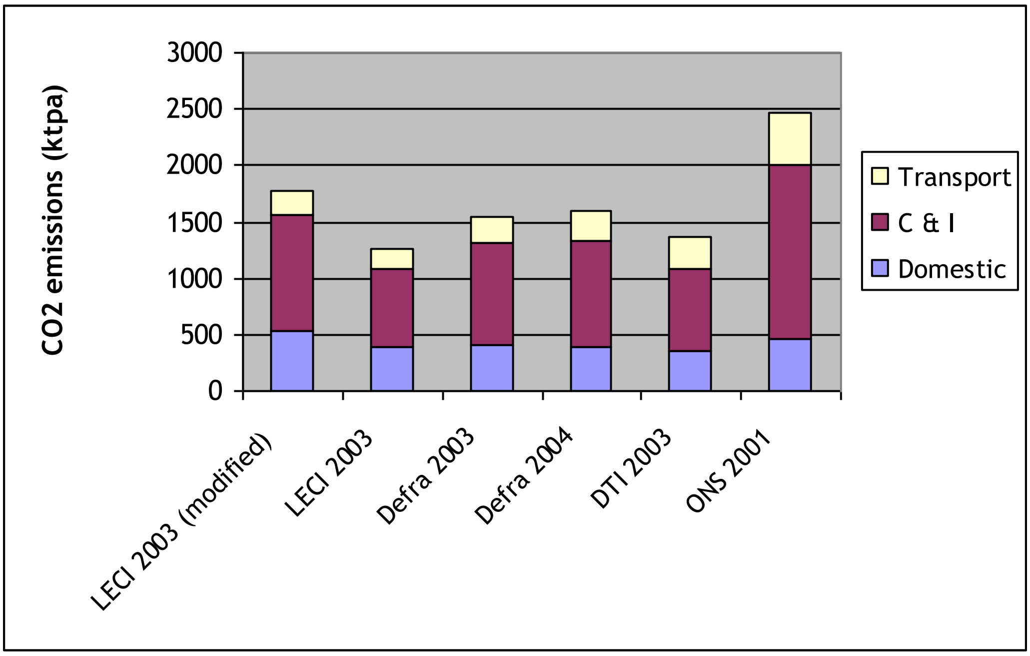


**Figure 8 $CO_2$ emissions for different models**

## 3.11 Transport Emissions Breakdown

According to the baseline emissions estimate, transport is responsible for 217 ktpa or 12% of total emissions from the borough. Of this, 89% is from road transport and 11% from rail transport. The road transport can be broken down further: 52% cars, 10% taxis, 9% buses and coaches, 13% LGVs, 15% HGVs and 1% motorcycles. Clearly private transport and particularly private cars have the greatest impact in terms of $CO_2$ emissions.

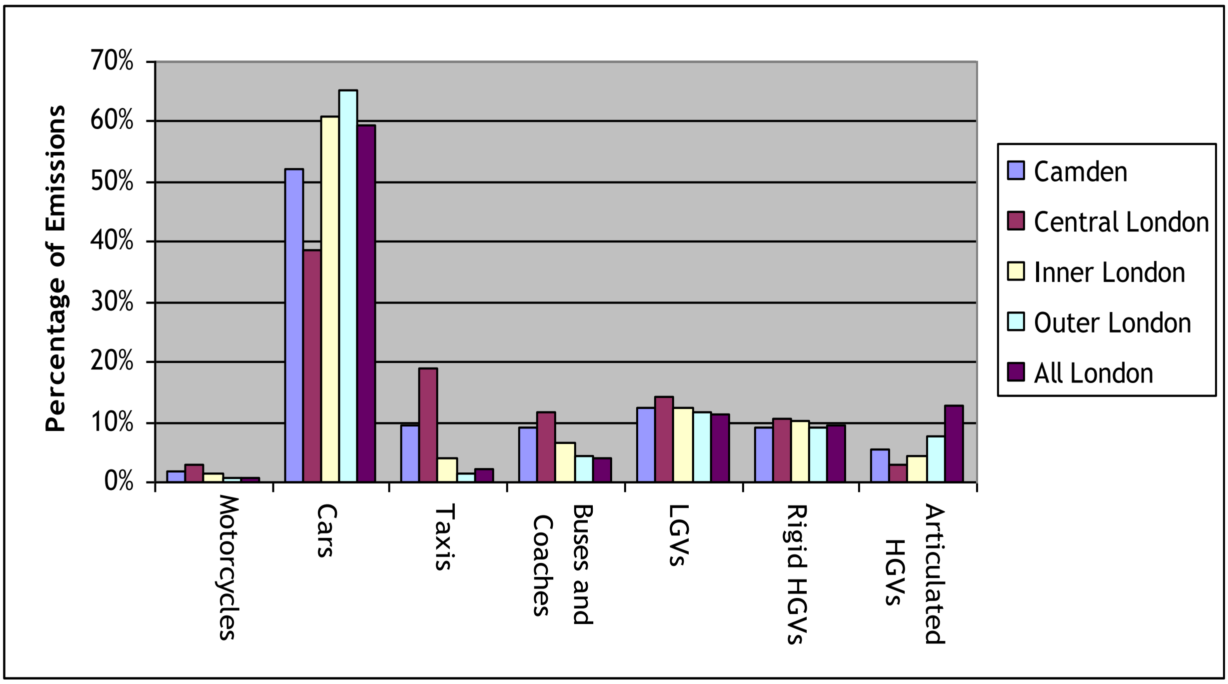


**Figure 9 Percentage of $CO_2$ emissions from road transport modes by region**

Figure 9 shows that generally emissions from Camden fall between those for central London and those for Inner London, as might be expected given Camden's location.

Overall Camden accounts for around 1.7% of London's transport emissions. Transport is responsible for 22% of all emissions in London as a whole, a much greater proportion than Camden's 12%.

#### 3.11.1 Growth in transport emissions

According to the London Plan[10], the population of the Central subregion (which includes Camden) is expected to grow from 1.52 million in 2001 to 1.73 million in 2016, an annual growth rate of 0.88%. Assuming that transport emissions grow at the same rate and this growth continues until 2050, transport emissions would increase by 1.9 ktpa each year, a total of 102 ktpa by 2050.

Effectively this assumes that as the population increases, each person travels the same amount using the same average mix of modes at the same efficiencies as the present time. This allows the scenario modelling to include any measures that would change this, and therefore avoid double counting.

### 3.12 Housing emissions breakdown




#### 3.12.1 Current emissions

Emissions from the domestic sector according to our baseline are 538 ktpa, 30% of the borough total.

The borough housing stock is broken down in Table 20 below. Emissions from LA stock are taken from Camden's NHER database. The emissions from private and RSL stock are taken from the 2004 housing stock condition survey. The breakdown in $CO_2$ emissions for private and RSL stock is not known, so the same per dwelling emission rate has been assumed for the purposes of this table.

| Tenure | Number of dwellings | $CO_2$ emissions (ktpa) | $CO_2$ emissions per dwelling (tpa)[11] |
|---|---:|---:|---:|
| Private stock | 51878(12) | 262 | 5.05 |
| RSL stock | 8850(13) | 45 | 5.05 |
| LA stock (leasehold) | 8434(14) | 33 | 3.91 |
| LA stock (tenanted) | 23694(15) | 92 | 3.88 |
| **Total** | **92856** | **432** | **4.65** |

**Table 20 Camden housing stock**

[10] London Plan Sub Regional Development Framework Central London, GLA, May 2006

[11] It is assumed that RSL and Private stock produce the same average $CO_2$ emissions per dwelling.

[12] Taken from Private Sector House Condition Survey 2004, http://www.camden.gov.uk/ccm/content/housing/information-on-private-sector-housing/private-sector-housing/private-sector-house-condition-survey-2004.en, less LA leasehold stock.

[13] Taken from Private Sector House Condition Survey 2004, http://www.camden.gov.uk/ccm/content/housing/information-on-private-sector-housing/private-sector-housing/private-sector-house-condition-survey-2004.en

[14] Taken from Camden NHER database.

[15] Taken from Camden NHER database.

Clearly this differs from the baseline figure of 538 ktpa for the domestic sector, or 5.79 tonnes $CO_2$ per dwelling. There are several reasons for this. The main one is that the $CO_2$ emissions from the stock condition data are based on SAP or NHER ratings whereas the LECI data is based on actual meter readings. While there is room for uncertainty in gathering this data, using metered consumption does take into account the behaviour of occupants and the use of small appliances. In addition, the LECI data has been updated to include gas data from 2004 and electricity data from 2005. The LA stock data was published in April 2006 and the private stock data in 2004, so the various estimates might be looking at different points in time.

For comparison, the average energy consumption for households in Greater London is 19617 kWh gas and 4301 kWh electricity, which equates to $CO_2$ emissions of 5.54 tpa per dwelling.

Table 20 is included to show a more detailed picture of the breakdown in emissions from housing.
The scenario model will use the modified LECI baseline figure of 538 ktpa because meter readings should be more accurate and some of the modelling also uses information on gas consumption which is taken from the LECI data.

### 3.12.2 Growth in domestic emissions

The London Plan[16] suggests that 595 new homes will be needed each year in Camden until 2016. Assuming that 61 homes are demolished each year, and that 95% of new homes are built to current building regulations standard and 5% to best practice standards, these new houses will contribute a further 1.5 ktpa each year.
If this rate continues to 2050, emissions from this sector will rise by 67 ktpa.

## 3.13 Commercial and Industrial Emissions

The commercial and industrial sector is responsible for 57% of Camden's total $CO_2$ emissions. This arises from energy use in non-domestic buildings. It is more difficult to provide a more detailed breakdown of emissions in this sector because of the wide variety of building types and their different patterns of energy use.

### 3.13.1 All bulk categories

Floor space statistics for Camden for April 2005 were taken from the National Statistics website[17].
Table 21 shows the definition used for the different sectors.

[16] London Plan Sub Regional Development Framework Central London, GLA, May 2006

[17] Neighbourhood Statistics (NeSS) on http://www.neighbourhood.statistics.gov.uk

| Type | Description |
|---|---|
| Retail premises | Premises that provide 'off-street' goods and services to the public. They include supermarkets, corner shops, local post offices, restaurant, cafes, launderettes and many others. Pubs are classed as non-bulk. |
| Offices | These include purpose-built office buildings, offices over shops, light storage facilities and light industrial activities. Larger banks, building societies and post offices containing substantial office space may be included in this class, rather than in the retail bulk class. |
| Factories | These range from small workshops to very large manufacturing units. Some industrial hereditaments where the rateable value is not primarily derived from floorspace (for example iron and steel plants) are classed as non-bulk. |
| Warehouses | These range from small storage units and depots to very large distribution warehouses. |

**Table 21 Commercial and Industrial Types**

Table 22 shows a summary of the commercial and industrial floor space by sector type for Camden as of April 2005. The most complex sector is that classed as 'Non-bulk' which is not shown in the table. This covers a whole range of building types from schools, leisure centres, libraries to pubs. Exact floor area is not known for this sector and only total numbers of buildings are known for London. The average floor area changes from year to year in this sector therefore produces quite a strong variation in total floorspace.

| Sector | Floorspace (thousands $m^2$) |
|---|---|
| Retail | 635 |
| Offices | 2186 |
| Factories | 184 |
| Warehouses | 245 |
| Other bulk classes | 51 |
| **Total** | **3301** |

**Table 22 Camden C & I Bulk Floorspace**

### 3.13.2 New build

The London Plan[18] suggests the following growth in Commercial and Industrial floorspace by 2016:

| Type | Floorspace growth by 2016 ($m^2$) | Floorspace growth per year ($m^2$) |
|---|---|---|
| Convenience goods | 8500 | 850 |
| Comparison goods | 12500 | 1250 |
| Offices | 0 | 0 |

**Table 23 Predicted C & I growth**

The GLA have since published employment projections for the borough, indicating that employment will grow by 67,000 jobs between 2006 and 2026. Assuming that 75% of these are office based and that each employee requires a minimum of 10m$^2$ of office space, 25,000m$^2$ of additional office floorspace will be required each year.

[18] The London Plan Sub Regional Development Framework North London, Mayor of London, May 2006

Using benchmarks for building types in these categories, it is estimated that the new growth each year will add 2.14 ktpa to Camden's emissions. If this rate continues to 2050 then Camden will emit a further 94 ktpa by this time.

## 3.14 Emissions from Waste



This section outlines a model to assess the baseline carbon emissions due to waste management in Camden, and the likely emissions from this sector into the future.

### 3.14.1 Emissions by waste management option

There have been three important studies estimating the carbon equivalent emissions due to waste management in recent years, commissioned by the United States Environmental Protection Agency (EPA), the European Union (EU) and the Waste and Resources Action Programme (WRAP). It is important to note that these are *$CO_2$ equivalents*, i.e. a mixture of greenhouse gases expressed as carbon dioxide. In the case of waste management the dominant greenhouse gas is methane from landfill sites, which has a climate change impact some 21 times stronger than carbon dioxide[19]. Waste management also results in emissions of $CO_2$, nitrous oxides and CFCs and their replacements, all with different climate change impacts.

Municipal waste management is an area where good data is available on the quantities of different types of waste going to each waste management option, because Local Authorities are required to report this information. Estimating waste arisings other than from households is more challenging, because the quantities and composition vary considerably for different types of business. However, commercial waste is similar in composition and quantity to municipal waste nationally.

A further problem is that the studies mentioned above assess greenhouse gas emissions from a waste generation standpoint. This means that emissions are zero at the point of waste generation, and emissions from that product's life cycle prior to it becoming waste are ignored. Since some waste management options, especially those involving materials recycling or energy recovery, displace materials or energy they can have a negative greenhouse gas flux. That is, there is a net emissions reduction from these options. This is shown in Table 24 below.

[19] AEA Technology for the European Commission, *Waste Management Options and Climate Change*, July 2001.

| Waste Management Option | | Greenhouse gas flux (kg $CO_2$ equivalent per tonne of waste) |
|---|---|---|
| Landfill | Best practice | 250 |
| | EU average | 699 |
| Incineration | Electricity only | -10 |
| | CHP | -348 |
| MBT | With landfill of rejects | -366 |
| | With incineration of rejects | -258 |
| Organics | Windrow composting | -12 |
| | In Vessel Composting | -10 |
| | Home Composting | -18 |
| | Anaerobic Digestion electricity only | -33 |
| | Anaerobic Digestion CHP | -58 |
| Recycling | Glass | -30 |
| | High Density Polyethylene | -41 |
| | Ferrous metal | -63 |
| | Textiles | -60 |
| | Aluminium | -95 |
| | Paper | -177 |
| | All materials | -467 |

**Table 24 Greenhouse gas flux for waste management options[20].**

### 3.14.2 Municipal Solid Waste

According to data provided by LB Camden, the borough produces a total of 75,570 tonnes of MSW.
The most recent figures (for 2005 to 2006) show a recycling rate of around 27%. The North London Waste Authority (NLWA) sends 44.75% of its waste to landfill and 34.35% for incineration, but these figures are not broken down by borough. Using these figures, the percentage of Camden's waste undergoing each treatment method has been estimated, as shown in Table 25.

| Waste treatment method | Percentage of waste treated (%) |
|---|---|
| Recycling | 22.24 |
| Composting | 4.90 |
| Incineration | 31.64 |
| Landfill | 41.22 |

**Table 25 Waste treatment methods in Camden**

[20] AEA Technology for the European Commission, *Waste Management Options and Climate Change*, July 2001.

Using the data from Table 24 and Table 25, the greenhouse gas emissions from waste management can be estimated. This analysis suggests that the landfilling of MSW from Camden results in the emission of 21,774 tpa ($CO_2$ equivalents), reducing to 13,645 tpa when the benefits from recycling and incineration are included.

The NLWA are proposing a strategy[21] whereby recycling rates will increase to 35% by 2010 and 45% by 2015. Edmonton incinerator will close in 2015, to be replaced by a new Energy from Waste (EfW) plant and a Mechanical and Biological (MBT) plant. As Table 24 shows, these treatment methods result in a negative net GHG flux mainly due to carbon sequestration and avoided energy and materials from the recycling and energy recovery elements of the processes. If these targets are met, the calculated carbon emissions from waste management would be negative. As mentioned above, it would be reasonable to count these negative emissions, or carbon savings, if the carbon emissions from the lifecycle of the products that make up the waste were also counted (see Section 3.1).

There is a danger of double counting when undertaking these analyses. For example, incineration results in a net carbon benefit due to the displacement of conventional sources of energy. However, this strategy proposes the use of some of that energy from Edmonton, with associated reductions in carbon emissions. In the case of recycling, there is an energy saving from using recycled materials in place of virgin materials to manufacture new products resulting in a negative GHG flux for recycling options shown in Table 24. However, the baseline carbon emissions calculated in this strategy already account for energy used in the borough. If the recycling were taking place here in Camden, these energy savings would already have been counted. If the recycling takes place outside the borough's boundaries (as is probably the case) then a consistent approach would allow another local authority to count these carbon savings in their own area.

For these reasons, we recommend taking the landfill emissions figure of 21,774 tpa as a baseline. This represents approximately 1.2% of emissions from the borough. The quantity of waste landfilled and the resultant emissions can easily be monitored over time. In practice, Camden's waste strategy targets combined with the Landfill Directive (see Appendix B) and the reducing landfill capacity in the South East and East of England will almost certainly mean that emissions associated with the landfilling of waste will be close to zero by 2050.

### 3.14.3 Other forms of waste

Nationally, commercial waste consists of similar materials and is produced in similar quantities to municipal waste[22]. London produces 17 million tonnes of waste in total, made up of 4.4 million tonnes municipal waste, 6.4 million tonnes commercial and industrial and 6.1 million tonnes from construction and demolition[23].

The disposal of these other types of waste tends to be market led, and is generally not subject to statutory recycling rates except in the case of certain specific waste streams such as packaging, electrical equipment and end of life vehicles. However reduced landfill capacity, increased disposal cost, improved recycling technologies and corporate environmental responsibility concerns are likely to lead to a reduction in landfill rates in future years.

Furthermore, many of these waste streams do not contain putrescible waste that would result in methane emissions from landfill.

[21] North London Joint Waste Strategy, www.nlondon-waste.gov.uk/jointwastestrategy/, accessed 29/1/2007.

[22] www.wasteonline.org.uk/resources/InformationSheets/WasteAtWork.htm

[23] Rethinking Rubbish in London, GLA, 2003.

LBC collected 58,318 tonnes of commercial waste (including flytipped waste) in 2005/06, of which just 205 tonnes were recycled. This means that commercial waste and household waste collected by the borough were landfilled in similar quantities. It is likely that more commercial waste was generated and collected by private sector waste management companies, but the quantities are not known. However, we believe that it would be reasonable to assume that commercial waste in the borough contributes similar carbon emissions to municipal waste, 22,000 tpa, and that this will be close to zero by 2050.

# 4 Technology Review

In this section we include a brief overview of the various measures that are available to reduce carbon emissions, and included in the scenario models. A more detailed discussion is included in Appendix C.

## 4.1 CHP Overview

Several of the technologies in the model are Combined Heat and Power (CHP) technologies. Generally these are electricity generators where waste heat is recovered. This heat can be used locally for space heating or process use. CHP offers higher efficiencies than the combination of grid supplied electricity and local heat generation it replaces, because large power stations supplying the grid waste over half their input energy as heat.

The installed capacities of CHP technologies are described in terms of $MW_e$ (Megawatts electrical). This describes the electrical output of the plant operating at full load. The model then assumes a certain thermal (heat) output for each $MW_e$.

Large parts of Camden are designated Conservation Areas. CHP with a heat network could be an appropriate technology for these regions in particular because once installed, the network would have very little visual impact[24].

## 4.2 Biomass CHP

Biomass CHP can range in scale from several $kW_e$ upwards. There are Scandinavian plants of several $MW_e$. The scale envisaged in London is in the order of 1 to 30 $MW_e$.

[24] Since CH consists of underground pipes, the only visual impact is from the power plant itself. This could serve a conservation area but be located outside the designated area.

### 4.2.1 Technology

#### 4.2.1.1 Gas engines

Biomass can be converted into a gaseous fuel by means of *gasification* (a thermal decomposition process that involves heating the fuel in a limited oxygen environment) or *anaerobic digestion* (biological decomposition in the absence of oxygen). The resulting gas is then burnt in an internal combustion engine that drives an electrical generator. The waste heat from the engine is captured by heat exchangers.

#### 4.2.1.2 Diesel engines

Waste oil can be processed into biodiesel, and used in a diesel engine to produce heat and power.

#### 4.2.1.3 Steam turbines

Solid, liquid or gaseous biomass fuels can be used in a boiler to produce steam for a steam turbine driving a generator to produce electricity. Heat can be extracted from the steam after it has passed through the turbine.

#### 4.2.1.4 Stirling engines

Stirling engines are external combustion engines that offer higher theoretical maximum efficiencies and the potential to accept a wider range of fuels because the combustion occurs outside the cylinders.

### 4.2.2 Applicability

Biomass CHP is still a relatively immature technology, although it is used more in parts of Europe than in the UK. The technology is generally adapted from fossil fuel fired applications, and is therefore not completely new. CHP is the most efficient way to use a limited biomass resource.

There is an example of biomass CHP at BedZed, where a biogas CHP and wood gasifier were installed with a district heating network. This has not been successful due to noise complaints, which resulted in the unit being switched off at night.

Of course the technology is likely to improve in the future. However at present Camden might consider siting any biomass CHP plant away from dwellings, perhaps amongst commercial and industrial (C & I) buildings.

### 4.2.3 Cost effectiveness

Biomass CHP has higher capital costs than gas fired CHP (as much as five times more expensive initially). However, like all renewable energy technologies the price is expected to fall as the technology develops. Biomass fuel is slightly more expensive than mains gas, but cheaper than oil or stored gas.

CHP is generally cost effective in the right setting because the higher efficiencies mean that more revenue is gained for the same fuel cost compared to electricity only plant.

### 4.2.4 Potential

Biomass CHP is limited primarily by the available biomass resource. Estimates for biomass arising in London and within a 40 km radius of London have been made. Excluding recyclable wastes and sharing this resource by population amongst the London boroughs gives an estimated “fair share”, which in Camden is estimated to be 119 GWh / yr (see Appendix D). This equates to a maximum installed capacity of about 5.4 $MW_e$ for biomass CHP.

Biomass can be transported considerable distances by road, rail and waterways with a small $CO_2$ impact compared to the savings made by using biomass in place of fossil fuels. It is possible that biomass will be available in the future from other parts of the UK or even other countries with large biomass resources such as Scandinavia and Canada.

## 4.3 Large Gas CHP

### 4.3.1 Technology

Large gas CHP would be more like a centralised power station for a borough. There would most likely be one or more plant of over 100 $MW_e$. This would use a Combined Cycle Gas Turbine (CCGT), which offers higher electrical efficiencies. A CCGT uses a gas turbine engine to drive a generator to produce electricity. The high grade waste heat is then used to produce steam for a steam turbine that also drives an electrical generator. The low grade heat is then recovered to produce hot water for a community heating network. CHP on this scale would have the highest overall efficiencies (over 90%).

### 4.3.2 Applicability

The use of large gas CHP will depend on identifying suitable sites and the outcome of environmental impact assessments. This is discussed in Section 6.10.5.

### 4.3.3 Cost effectiveness

Large gas CHP is capital intensive, requiring the construction of the plant itself and a heat network to deliver heat to consumers. However, it has been shown to be cost effective by attracting revenue from electricity and heat. The economics of CHP are dependent on the difference in price between gas and electricity.

### 4.3.4 Potential

The use of large gas CHP is limited mainly by thermal demand. If customers are not available to use the heat, the plant effectively becomes a conventional power station.

## 4.4 Gas CHP - buildings

### 4.4.1 Technology

This technology describes gas fired CHP for individual buildings. These would normally use internal combustion engines and can range from around 30 $kW_e$ to 1 $MW_e$. It is envisaged that these would be used in larger buildings such as office blocks, blocks of flats, hospitals or educational establishments.

### 4.4.2 Applicability

The use of CHP is dependent on a suitable heat load being present in the building, so that the unit can run for at least half of the time. However it is an underused technology at present and there are many buildings where CHP would be suitable to meet at least part of the heat load. CHP can also be used with absorption chillers to provide cooling.

### 4.4.3 Cost effectiveness

As with all forms of CHP the technology has a high capital cost. However, in the right situation CHP in individual buildings can have payback periods of around 5 years. It is also possible to lease plant from manufacturers by entering into long term energy contracts with them.

### 4.4.4 Potential

The potential for building CHP is more limited than for CHP connected to district heating, because district heating can support small or intermittent heat loads as part of a network. It is envisaged that building CHP can be used initially to meet early carbon reduction targets and prepare large commercial heat users for connection to a heating network.

## 4.5 Domestic CHP

### 4.5.1 Technology

The scenario modelling includes two domestic scale CHP technologies; gas fired micro CHP units and fuel cell CHP units. These would be rated at around 1 kWe for a single household. Gas fired CHP units use Stirling engines to generate heat and power. Fuel cells are an alternative to combustion and work by chemically combining hydrogen and oxygen to produce heat and electricity. The advantages are that they are quieter, offer higher electrical efficiencies and do not produce any of the by-products of combustion such as nitrogen oxides. Although they might in the future use pure hydrogen as fuel, they would most likely use natural gas initially.

### 4.5.2 Applicability

Micro CHP units using Stirling engines are undergoing trials at the time of writing. Fuel cell units are expected to become commercially available in the next few years. It would be technically feasible to install these technologies in most dwellings. However, such heat generation technologies are not compatible with a community heating network.

### 4.5.3 Cost effectiveness

Again, these units have higher capital costs than individual boilers. Fuel cells are still very expensive as they are a developing technology. Early indications from Carbon Trust trials of micro CHP units suggest that some savings on fuel bills would be achieved.

### 4.5.4 Potential

In theory, a considerable number of dwellings in Camden could use micro CHP units in place of their individual boilers.

## 4.6 Heat from power station

### 4.6.1 Technology

Waste heat from existing power stations could be used in the region around the power station. This would require the adaptation of the power station to export heat and the provision of a heat network to distribute the heat to local residents and businesses. The installed capacity is rated in $MW_{th}$ (Megawatts thermal), as only heat is supplied. In Camden, we envisage connecting to Edmonton incinerator, an option that has been considered in the past.

### 4.6.2 Applicability

If a heat network is developed with sufficient demand, it might be more cost effective to connect an existing power station than to build new plant. However, Camden is some distance from the Edmonton incinerator, so if heat networks were developed closer to the plant, these might be preferred to those further away in Camden. Edmonton is due to be replaced by a new plant on the same site in 2015, which represents an opportunity to implement a CHP scheme.

### 4.6.3 Cost effectiveness

An incinerator such as Edmonton would lose some electrical efficiency by converting to CHP. They would also gain some heat sales revenue. However the biggest attraction at present is that incinerators operating as CHP plant can claim Renewable Obligation Certificates (ROCs) for the electricity they produce. These are of considerable value, and it could be in the operators' interest to subsidise the development of a heat network or the sale of heat in order to claim the ROCs.

### 4.6.4 Potential

The Edmonton power plant is rated at 32 $MW_e$ and is likely to be in the region of 20% to 25% efficient, in which case it must reject close to 100 $MW_{th}$. This is a considerable resource, and while the recoverable fraction is undoubtedly smaller than this, the use of this heat should be thoroughly investigated.

## 4.7 Solar PV

### 4.7.1 Technology

Solar PV panels convert light into electricity. Solar PV arrays are built up from individual panels. Our model envisages both domestic scale installations and larger installations, for example on flat roofs or the walls of office blocks. Capacities are expressed in terms of the number of dwellings for domestic installations, and in $MW_e$ for large scale installations. A fixed installation size (2.5 $kW_e$) is assumed for domestic installations. For PV the rated capacity is the peak output in ideal conditions.

### 4.7.2 Applicability

Solar PV is widely applicable. It can be installed successfully on any flat roof, or roofs that are within 90º of south. PV can also be used as a vertical cladding material, or installed on structures other than buildings such as bus shelters or road barriers. Being in the plane of the building surface it is mounted on means it is relatively unobtrusive.

### 4.7.3 Cost effectiveness

PV is currently a relatively expensive renewable energy technology, but the price is expected to fall rapidly to become cost effective by 2030.

### 4.7.4 Potential

It has been estimated that the building footprints for both domestic and non-domestic sectors are over 2.5 million $m^2$ each. If one quarter of this area can be used for PV installations, the potential exists for over 33,000 domestic installations and around 65 MW of commercial installations.

## 4.8 Wind power

### 4.8.1 Technology

Wind turbines employ a rotor to convert kinetic energy in the wind to electrical energy using a generator. The scenarios in this study consider three sizes of wind turbine:

- Domestic building mounted wind turbines, rated at 1 to 1.5 kW, with a rotor diameter of up to 2m
- Medium scale wind turbines. These are free standing machines and have been modelled as 50 kW turbines with a hub height of 30m and a rotor diameter of 15m
- Large scale wind turbines are also free standing, and would have a mast approximately 50m to 60m high and a rotor diameter of around 50m.

### 4.8.2 Applicability

The power available from the wind is proportional to the cube of the wind speed, so the location of wind turbines at sites with high wind speeds is critical. Turbines are also sensitive to turbulence, which will both reduce power output and increase wear on the machine. Urban environments generally have relatively low wind speeds and high turbulence. This is particularly true for building mounted wind turbines on low buildings such as houses. Some tall buildings such as tower blocks might be suitable for building mounted turbines. Medium and large scale wind turbines might be located in a few urban sites but are unlikely to match the performance of turbines in rural areas.

Wind speeds have been logged in Camden on the Town Hall roof and at a nature reserve at Camley Street on a single storey building. The Town Hall recorded an average wind speed of around 3.5 m/s between October 2005 and June 2006, while at Camley Street the average wind speed has varied between 1 m/s and 1.5 m/s since 1999. Both weather stations are in the south of the borough in the area around Kings Cross, but if these results are representative of the borough as a whole, then outputs from wind turbines are likely to be low.

Wind turbines also have a greater visual impact than many other renewables, and might be considered inappropriate in Camden's conservation areas and strategic views. Turbines do also produce some noise and building mounted examples also create vibrations that must be managed to avoid building damage and causing a nuisance for occupants.

### 4.8.3 Cost effectiveness

Wind power is one of the most cost effective renewables, provided a site is found with reasonable wind speeds.

### 4.8.4 Potential

The potential for wind in Camden is quite limited. It would probably be technically feasible to install a few thousand small turbines on the taller buildings in the borough, and either one or two large or several medium scale turbines on hills in parks in the north of the borough. However, it is expected that other low carbon technologies might be preferred to this option.

## 4.9 Solar thermal

### 4.9.1 Technology

Solar hot water systems use energy from sunlight to heat water using panels mounted on buildings. Solar hot water systems are usually used to provide domestic hot water only, and might be expected to meet about half of this demand for a typical dwelling. These systems generally require a thermal storage system.

### 4.9.2 Applicability

Solar hot water systems can be fitted to many properties with roofs facing within 90º of south, and not subject to significant over shading. Provision of thermal storage and access for pipework from the roof are also required. This means that many flats on lower floors might be unsuitable, as would properties without space for hot water cylinders. Installations of solar thermal systems might also be limited in conservation areas. Solar thermal systems are also not appropriate where district heating is available.

### 4.9.3 Cost effectiveness

Solar thermal systems do suffer from relatively long payback periods and cannot usually be justified for financial reasons alone. They are a relatively mature technology, and therefore are not expected to reduce in price as much as PV.

#### 4.9.4 Potential

It would in theory be possible to use solar hot water systems in a large number of properties in Camden. In practice, their use is likely to be limited to houses rather than flats in areas where a heat network is not going to be installed and where there is no adverse impact on designated areas.

## 4.10 Biomass boilers

### 4.10.1 Technology

Biomass boilers produce hot water for heating and domestic hot water by burning biomass fuels. The most common fuel is wood, usually in the form of woodchips or pellets (manufactured from sawdust). Capacities are expressed in terms of numbers of dwellings for domestic boilers and $MW_{th}$ for larger commercial installations. Biomass boilers can be very flexible with automated feeds, and modern models are very efficient and can be used in smoke control areas.

### 4.10.2 Applicability

Biomass boilers can be fitted in place of fossil fuel boilers in domestic and non-domestic buildings. The use of individual biomass boilers does not fit well with a heat network. In addition, these installations would require more space than equivalent gas boilers, particularly for fuel storage. They also require some more work on the part of the building operators or householders for example emptying ash and arranging fuel deliveries.

### 4.10.3 Cost effectiveness

Biomass boilers have higher capital costs than equivalent gas boilers, and fuel costs are also slightly higher than mains gas, although cheaper than fuel oil. However, biomass boilers are more cost effective than solar renewables.

### 4.10.4 Potential

The main limitations for biomass fuel are space for fuel storage and supply of fuel. The fuel supply from the London area would limit biomass boilers to about 17 $MW_{th}$ for commercial installations or about 7000 dwellings (see Appendix D) unless fuels are bought in from elsewhere.

Given the limited biomass fuel availability, it would be better used in more efficient CHP applications.

## 4.11 Ground source heat pumps

### 4.11.1 Technology

Ground source heat pumps transfer heat from the ground to heat water for space heating. The technology is essentially the same as a refrigerator or air conditioning unit, and uses electricity as an input fuel. The system consists of a *groundloop* (lengths of pipe containing water and antifreeze buried in the ground) and a *heat pump*. The water and antifreeze is circulated through the ground loop, extracting heat from the ground. The heat pump extracts this heat energy from the fluid and transfers it to low temperature hot water for space heating. This technology is interesting because it can deliver 3 to 4 units of thermal energy for every unit of input electrical energy. Capacity is expressed in terms of the number of dwellings with a heat pump installed.

### 4.11.2 Applicability

GSHPs require available land to bury the groundloop, which in most cases will mean this technology is limited to newbuild where the groundloop can be installed under the building. This technology is also not recommended where connection to a heat network is available. Once installed, GSHPs have the advantage of being small units above ground, quiet and require low maintenance.

### 4.11.3 Cost effectiveness

GSHPs are expensive to install, primarily due to the laying of a groundloop. Again, this is mitigated in newbuild applications where foundations are being dug anyway. Where electricity is the heating fuel and gas is unavailable, the high efficiencies mean that running costs are low. Where mains gas or a heat network is available, these are likely to be cheaper options.

### 4.11.4 Potential

GSHPs in Camden are likely to be limited to a relatively small number of newbuild projects.

## 4.12 Domestic insulation measures

### 4.12.1 Technology

There are four domestic insulation measures included in the scenarios, expressed in terms of the number of dwellings where the measure is implemented. The four are cavity wall insulation (filling empty wall cavities with insulating material), loft insulation (laying insulation between joists in the loft), double glazing and solid wall insulation (applying a layer of insulating material either internally or externally to a solid wall).

### 4.12.2 Applicability

Most dwellings can install loft insulation and double glazing, where this has not been done already. Wall insulation depends on the construction of the building and whether cavities are present. Double glazing and solid wall insulation might not be permitted in conservation areas. Double glazing has additional benefits such as noise attenuation.

### 4.12.3 Cost effectiveness

Loft and cavity wall insulation usually pay for themselves within a few years. Double glazing and solid wall insulation are much less cost effective in terms of energy saving alone.

#### 4.12.4 Potential

Stock condition surveys indicate the following potentials for energy efficiency measures:

| Measure | Potential (number of dwellings) |
|---|---|
| Cavity wall insulation | 23,170.0 |
| Loft insulation | 33,533.0 |
| Double glazing | 38,944.0 |
| Solid wall insulation | 59,994.0 |

**Table 26 Domestic energy efficiency potentials**

### 4.13 Commercial energy efficiency measures

#### 4.13.1 Technology

The non-domestic energy efficiency measures used in the scenarios are double glazing and improving the efficiency of lighting systems.

#### 4.13.2 Applicability

Many older commercial buildings do not meet current best practice and could be improved. Many non bulk premises are in older buildings.

#### 4.13.3 Cost effectiveness

Double glazing is relatively expensive, but could provide additional benefits such as noise attenuation. Energy efficient lighting can be cost effective, particularly where lighting needs replacement anyway.

#### 4.13.4 Potential

It has been estimated that around 90,000 $m^2$ of glazed area could be improved. The potential for improving lighting is estimated to be around 1.5 million $m^2$ floorspace, a little under half of the total floorspace in the borough.

### 4.14 Street lighting

#### 4.14.1 Technology

This measure models the replacement of street lighting bulbs with more efficient, lower powered versions. Efficiency can also be improved through better fittings.

#### 4.14.2 Applicability

It has been assumed that most, if not all, the street lights in Camden could be improved. Obviously lighting levels must be maintained to meet statutory requirements and safety considerations.

#### 4.14.3 Cost effectiveness

This measure is not particularly cost effective, and is best carried out when bulbs are due for replacement anyway.

## 4.15 Transport measures




### 4.15.1 Technologies

#### 4.15.1.1 Reduce passenger km

These options, measured in millions of passenger kilometres, are total reductions in the number of passenger km travelled by car, taxi or motorcycle in Camden. This might be achieved by reducing journey lengths, cutting the number of journeys or switching to walking or cycling.

#### 4.15.1.2 Reduce road freight t-km

This option is measured in millions of tonne kilometres, and represents a total reduction in freight transport in the borough. This could be achieved through more efficient logistics or sourcing local food.

#### 4.15.1.3 Reduce $CO_2$ emissions of fleet

There are six options for reducing the carbon dioxide emissions from vehicle types. These are reductions from the current baseline in the specific emission factors for cars ($gCO_2$ / pass-km), taxis ($gCO_2$ / pass-km), motorcycles ($gCO_2$ / pass-km), road freight ($gCO_2$ / t-km), passenger trains ($gCO_2$ / pass-km) and buses ($gCO_2$ / pass-km). There are various ways in which these emissions factors could be reduced including engine efficiency improvements, lightweighting, hybrid or electric engine technologies and substituting fossil fuels with biofuels.

#### 4.15.1.4 Modal shift – cars to public transport

These options, measured in millions of passenger kilometres, model a reduction in car, taxi and motorcycle passenger km and an equal increase in public transport passenger km, shared between buses and trains.

#### 4.15.1.5 Modal shift – freight from road to rail

This option, measured in millions of tonne kilometres, models a reduction in road freight tonne km and an equal increase in rail freight tonne km.

### 4.15.2 Applicability

All these measures are applicable anywhere to some extent, but this depends on how the measures are to be achieved and often on national or regional policies. Many of these measures are behavioural changes, which can be difficult to implement. These measures could have wider benefits such as reduced congestion, improved air quality and improved health of the population.

### 4.15.3 Cost effectiveness

The cost effectiveness of the transport measures depends on how they are achieved. Many transport measures save money with little or no capital outlay, such as driving a smaller car or using a bicycle. Supplying biofuels or changing freight logistics might incur high capital costs.

### 4.15.4 Potential

The potential to reduce the impact of transport, especially from the use of private cars, is high but difficult to realise. Appendix E shows the total distances travelled by each mode and the associated emissions factors.

# 5 Carbon scenarios

## 5.1 Introduction

The section of the report outlines four possible energy scenarios, which illustrate a mix of sustainable energy measures that attempt to meet the three targets of 60%, 80% and 90% $CO_2$ emissions reduction by 2050, e.g. a mix of energy efficiency, CHP & community heating, micro CHP, renewables and transport measures. A 90% target has not been possible to meet, and the four scenarios demonstrate how revised targets of 60%, 70% and 80% reductions could be met.

Associated costs and carbon savings for each measure are set out.

## 5.2 Business as usual

The first part of this work examines the likely changes to carbon emissions in the absence of any intervention, based on the growth of floor space in both the housing and non-residential sectors and growth in transport.

Note that predictions are not available to 2050, and the expected growth here has been extrapolated to 2050 based on shorter term predictions. Some of these figures might seem quite high. While there is a danger that high growth predictions could induce despair and make the costs of avoidance higher, it does serve to highlight the importance of managing growth. Furthermore, if these levels of growth turn out to be lower, the targets will be easier to meet. Therefore if a worst case scenario is planned for, the difficulty of meeting the challenges can only get easier.

The predictions also assume that current standards continue to be applied throughout the period to 2050. It is likely that standards will improve so that emissions from transport and buildings in the future will be lower than the present time. However, there is a danger of double counting because these improved future standards might be met using some of the measures proposed in the scenario. Using current standards for future growth allows these measures to be accounted for in the model, and higher standards can be seen as policies employed to achieve the target emissions reductions.

### 5.2.1 Trends in housing

Demolition and new build rates for housing are critical to this work. Carbon emissions of new homes will vary in a non-interventionist business as usual scenario according to the Building Regulations. For the purposes of this study the new 2006 Regulations have been used. Whilst it is known that the government intends to strengthen these regulations at regular intervals, Building Regulations currently exclude the majority of electricity use from their remit. Electricity can easily represent more than 50% of emissions. As appliance use is growing the assumption has been made that overall emissions remain unchanged to 2050.

Taking a typical new build property to be a mid floor flat of $87m^2$ gives $CO_2$ emissions of 2.3 tpa. The average household in Camden is estimated to be responsible for 5.3 tpa of $CO_2$. The net effect in terms of household emissions is that, in the absence of a more interventionist approach and without improvements beyond the 2006 Building Regulations, new-build housing could add up to 67 ktpa of $CO_2$ by 2050.

### 5.2.2 Trends in Commercial & Industrial

It has been estimated that approximately 21,000 $m^2$ of new retail floorspace in Camden would be built by 2016, and 500,000 $m^2$ of new office space by 2026. Using emission benchmarks for gas and grid electricity it was estimated from the above figures (extrapolated on linear basis from 2016 to 2050) that the net impact of commercial and industrial premises (bulk) could add in excess of 94 ktpa of $CO_2$ by 2050.

### 5.2.3 Trends in Transport

The population of the Central London region is expected to grow by around 14% by 2016[25]. This is equivalent to an annual increase of 0.88%. If it is assumed that this rate of population increase continues to 2050, and that emissions due to transport grow at the same rate in an unconstrained scenario, then the emissions from transport would increase by 102 ktpa by 2050.

## 5.3 A Target for 2050 Taking into Account Growth Rates

The preceding sections estimated the impact of growth in housing, non-residential buildings and transport to 2050. The final column in Table 27 below shows the impact of factoring in that growth. Reduction targets of 60%, 80% and 90% will require $CO_2$ to be reduced by 1248 ktpa, 1603 ktpa and 1781 ktpa respectively. These figures form the targets for all the energy scenarios work that follows. The table below shows the reduction targets for different years.

| | | $CO_2$ Emission Reduction Required | | |
|---|---|---|---|---|
| Target | Year | % | Excluding growth (ktpa) | Including growth (ktpa) |
| **60%** | 2012 | 7.0% | 124 | 158 |
| | 2026 | 26.5% | 470 | 585 |
| | 2035 | 39.1% | 693 | 862 |
| | 2050 | 60.0% | 1064 | 1327 |
| **80%** | 2012 | 9.3% | 165 | 199 |
| | 2026 | 35.3% | 627 | 742 |
| | 2035 | 52.1% | 924 | 1093 |
| | 2050 | 80.0% | 1419 | 1682 |
| **90%** | 2012 | 10.5% | 186 | 220 |
| | 2026 | 39.8% | 705 | 821 |
| | 2035 | 58.6% | 1040 | 1209 |
| | 2050 | 90.0% | 1597 | 1860 |

**Table 27: $CO_2$ Targets for 2012, 2026, 2035 and 2050**

## 5.4 Methodology and Model Description

In order to analyse the different scenarios, a model was devised in Microsoft Excel. Figure 10 shows a simplified flow diagram of the model. Once a scenario has been selected, the model estimates the heat and power displaced and calculates $CO_2$ savings. Using this information an economic analysis is carried out in order to estimate yearly cash flows which then allow the calculation of simple payback, net present value and internal rate of return.

Technical and financial parameters can be easily adjusted, which include $CO_2$ emission factors, fuel and electricity prices and financial incentives, among others. The information used for different technologies can also be easily adjusted.

[25] The London Plan Sub Regional Development Framework Central London, Mayor of London, May 2006

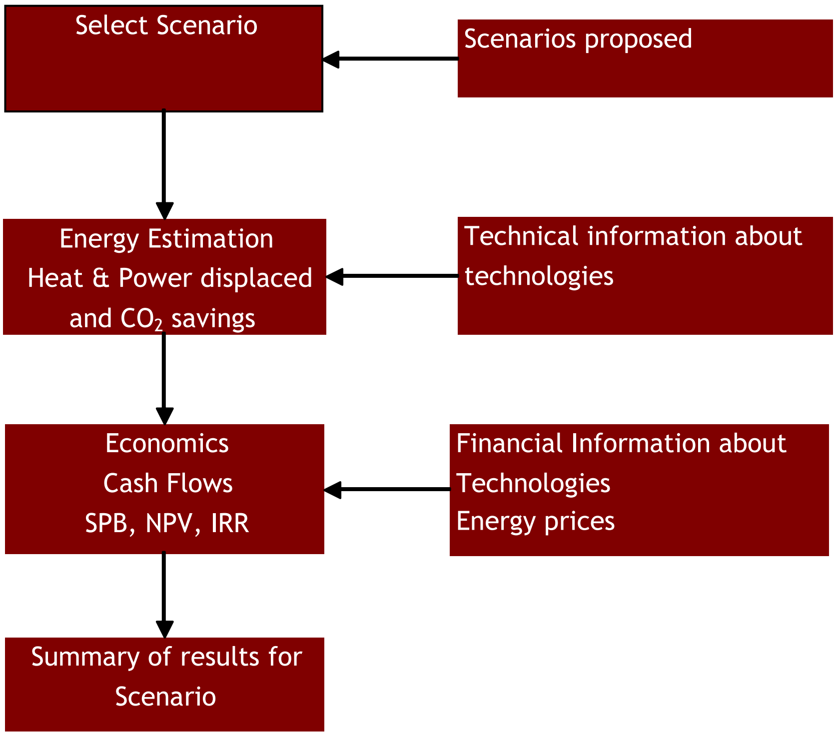


**Figure 10: Flow diagram of the model**

The following table shows the technologies that are included within the model and some comments about their potential in London and Camden.

| Technology | Description | Potential |
|---|---|---|
| 1. Renewable CHP | Includes a mixture of different biomass technologies, such as anaerobic digestion, gasification, steam turbines, biodiesel. This technology is measured in number of $MW_e$ installed. | It has been estimated that 200MWe of biomass CHP are required in London to comply with the Mayor's Energy Strategy |
| 2. Large Gas CHP | Large CHP plant that could be built within London, and connected to heating networks. This technology is measured in number of $MW_e$ installed. | The Carbon Trust estimates the UK CHP capacity at 18GWe, CHPA suggests 12GWe by 2020 |
| 3. Gas CHP - building | These are smaller CHP engines that would be building integrated. This technology is measured in number of $MW_e$ installed. | As above |
| 4. Heat from existing Power Stations | There are a number of power stations within London that reject heat to the atmosphere. This heat could be potentially used for heating and DHW purposes. | It has been estimated that the potential heat that could be exported from Edmonton power station is in the order of 25 $MW_{th}$. |
| 5. PV - domestic | Domestic systems of 2.5kWp are assumed per dwelling. This technology is measured in number of systems installed. | Mayor's Energy Strategy proposes no less than 100MWp for London |
| 6. PV- large | Commercial & industrial systems are measured in number of $MW_e$ installed. | As above |

| Technology | Description | Potential |
|---|---|---|
| 7. Wind - large | Large systems are measured in number of $MW_e$ installed. | Mayor's Energy Strategy proposes no less than $6MW_e$ |
| 8. Medium scale wind | This measure envisages freestanding wind turbines in the region of 50kW, which might be less visually intrusive than the large wind option. | Mayor's Energy Strategy proposes no less than $6MW_e$ |
| 9. Wind - domestic | Domestic systems of 1 $kW_e$ are assumed per dwelling. This technology is measured in number of systems installed. | Mayor's Energy Strategy proposes no less than $0.5MW_e$. There is some doubt as the effectiveness of this technology for urban houses, but turbines could be installed on tower blocks. |
| 10. Solar thermal | Domestic systems of $2.8kW_{th}$ are assumed per dwelling. This technology is measured in number of systems installed. | Mayor's Energy Strategy proposes no less than 75,000 domestic systems |
| 11. Biomass boilers Large | Commercial & industrial systems are measured in number of $MW_{th}$ installed. | There are no real targets for biomass boilers in London. |
| 12. Biomass boilers domestic | Domestic systems of $20kW_{th}$ are assumed per dwelling. This technology is measured in number of systems installed. | As above, but in this case they would be applicable to houses with space for fuel storage. |
| 13. Ground Source Heat Pumps | Domestic systems of $5kW_{th}$ are assumed per dwelling. This technology is measured in number of systems installed. | This is not considered to be a very cost effective measure and it would applicable only to new houses. |
| 14. Micro-CHP Stirling | Domestic systems of $1.2kW_e$ are assumed per dwelling. This technology is measured in number of systems installed. This technology is more appropriate for those areas where larger CHP systems are not favourable. | Defra proposes $0.5GW_e$ and EST $3.2GW_e$ by 2020 for the UK. CHPA estimates $1.5GW_e$ by 2020. |
| 15. Micro-CHP fuel cell | Domestic systems of $1kW_e$ are assumed per dwelling. This technology is measured in number of systems installed. | As above |
| 16. Cavity wall insulation | This is measured as the number of dwellings that could insulate the unfilled cavity wall. | It has been estimated that more than 25,000 homes have unfilled cavity walls in Camden. |
| 17. Loft insulation | This is measured as the number of dwellings that could insulate or increase the levels of insulation of the loft. | It has been estimated that more than 33,000 homes have low levels of loft insulation in Camden. |
| 18. Double glazing | This is measured as the number of dwellings that could replace single for double glazing. | It has been estimated that more than 38,000 homes could install double glazing in Camden. |
| 19. Solid wall insulation | This is measured as the number of dwellings that could insulate their solid walls. | It has been estimated that more than 59,000 homes have solid walls in Camden. |

| Technology | Description | Potential |
|---|---|---|
| 20. Double glazing - commercial | Measured in thousands of $m^2$ glazing area improved. For every 1000 $m^2$ of single glazing replaced by double glazing, approximately 35 tonnes of $CO_2$ per annum could be saved. | It is estimated that there are approximately 90,000 $m^2$ single glazing in the borough. |
| 21. Energy efficient lighting for non-domestic premises | Energy efficient lighting could save between 10 and 30 kWh/m2, depending on the type of lighting and type of premise. | It has been estimated that there are than 3,301,000 m2 of commercial & industrial premises. This figure does not include the non-bulk premises. |
| 22. Street lighting – efficient lamps | Replacing a 150W lamp with a 120W lamp could save approximately 100 kWh/yr | It has been estimated that there are around 10,000 street lights in Camden |
| 23. Reduce car passenger-km | Reduction measured in millions of passenger-kilometres | It has been estimated that around 800 million passenger-kilometres are travelled annually in cars in Camden |
| 24. Reduce road freight tonne-km | Reduction measured in millions of tonne-kilometres | It has been estimated that more than 360 million tonne-kilometres are travelled annually in Camden |
| 25. Reduce taxi passenger-km | Reduction measured in millions of tonne-kilometres | It has been estimated that around 75 million passenger-kilometres are travelled annually in taxis in Camden |
| 26. Reduce motorcycle passenger-km | Reduction measured in millions of tonne-kilometres | It has been estimated that around 30 million passenger-kilometres are travelled annually in motorcycles in Camden |
| 27. Reduce $CO_2$ emissions of fleet - cars | Reduction measured in $gCO_2$/pass-km. This could be by efficiency improvements or alternative fuels. | Current average is 124 $gCO_2$/pass-km |
| 28. Reduce $CO_2$ emissions of fleet - motorcycles | Reduction measured in $gCO_2$/pass-km. This could be by efficiency improvements or alternative fuels. | Current average is 125 $gCO_2$/pass-km |
| 29. Reduce $CO_2$ emissions of fleet - taxis | Reduction measured in $gCO_2$/pass-km. This could be by efficiency improvements or alternative fuels. | Current average is 248 $gCO_2$/pass-km |
| 30. Reduce $CO_2$ emissions of fleet - freight | Reduction measured in $gCO_2$/t-km | Current average is 142 $gCO_2$/t-km |
| 31. Reduce $CO_2$ emissions of fleet – buses | Reduction measured in $gCO_2$/pass-km. This could be by efficiency improvements or alternative fuels. | Current average is 103 $gCO_2$/pass-km |
| 32. Reduce $CO_2$ emissions of fleet – trains | Reduction measured in $gCO_2$/pass-km. This could be by efficiency improvements or alternative fuels. | Current average is 44 $gCO_2$/pass-km |

| Technology | Description | Potential |
|---|---|---|
| 33. Modal shift, cars to public transport | Measured in millions of passenger-kilometres. This assumes that the number of car passenger kilometres is reduced, and the same number of passenger-kilometres is added to the total for public transport, divided between trains and buses. | It has been estimated that around 800 million passenger-kilometres are travelled annually in cars in Camden |
| 34. Modal shift, motorcycles to public transport | Measured in millions of passenger-kilometres. This assumes that the number of motorcycle passenger kilometres is reduced, and the same number of passenger-kilometres is added to the total for public transport, divided between trains and buses. | It has been estimated that around 30 million passenger-kilometres are travelled annually in motorcycles in Camden |
| 35. Modal shift, taxis to public transport | Measured in millions of passenger-kilometres. This assumes that the number of taxi passenger kilometres is reduced, and the same number of passenger-kilometres is added to the total for public transport, divided between trains and buses. | It has been estimated that around 75 million passenger-kilometres are travelled annually in taxis in Camden |
| 36. Modal shift, freight road to rail | Measured in millions of tonne-kilometres. This assumes that the number of road freight tonne-kilometres is reduced, and the same number of tonne-kilometres is added to the total for rail freight. | It has been estimated that more than 360 million tonne-kilometres are travelled annually in Camden |

**Table 28: Technologies analysed within the model**

To model a scenario, the user has to enter the amount of technology that would be deployed by 2050. It is possible to model installing these technologies at different rates over time by entering installed capacities for the key interim years 2012, 2026 and 2035. Between these years, it is assumed that installed capacity increases yearly in a linear fashion. For example if 10$MW_e$ of CHP are proposed by 2012, 2$MW_e$ would be implemented every year (from 2007 to 2012). Detailed assumptions for the different technologies can be found in Appendix E. The following sections detail the scenario analysed and the results obtained.

The model also includes subsidies for certain technologies as a further option, such as ROCs, LECs, EECs, ETS and Social Cost of Carbon, which were described earlier in this report.

## 5.5 Scenario constraints

When generating potential scenarios, there are numerous constraints that affect the capacities of each technology that can be installed. The SEA model has automatic checks for these each time a scenario is analysed. The need to hit the target and keep within these constraints significantly limits the range of possible scenarios.

### 5.5.1 Maximum potentials

For each technology, a maximum potential has been identified and this maximum cannot be exceeded.

### 5.5.2 Biomass resource

As described in Appendix D, the biomass resource from within London and the surrounding area for the biomass technologies (CHP and boilers) is limited. The model has a warning if this resource is exceeded.

### 5.5.3 Thermal and power demand

The total thermal and power demands for Camden have been estimated at the key target dates, based on current consumption and expected growth from new build. These are shown in Table 29 below. The model calculates the total heat and power displaced by all the technologies in each scenario.

| Year | 2007 | 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Power demand (GWh/yr) | 1,885 | 1,917 | 2,007 | 2,065 | 2,162 |
| Thermal demand (GWh/yr) | 2,501 | 2,518 | 2,748 | 2,967 | 3,214 |

**Table 29 Thermal and power demand**

Power export is allowed, since the national grid system means that excess electricity can be sold to users outside the borough.

Heat export is not allowed, i.e. the heat displaced under any given scenario must not exceed the total thermal demand. This is because at present there is no way to export this heat out of the borough. Heat export might become possible in the future if neighbouring boroughs implement heat networks and these networks can be connected up.

### 5.5.4 Transport reduction and modal shift

The transport options include reductions in car, motorcycle and taxi passenger-kilometres and freight tonne-kilometres, and modal shifts from cars, motorcycles and taxis to public transport and from road freight to rail freight. The sum of the reduction and the modal shift cannot be greater than the total number of passenger-kilometres or tonne-kilometres travelled.

## 5.6 Proposed Scenarios

This section outlines the five scenarios meeting various targets with different constraints.

### 5.6.1 60% reduction by 2050

Table 30 shows a scenario to meet a 60% reduction target. This scenario uses no wind power or solid wall insulation and limited double glazing, so that there should be little impact on Camden's conservation areas. The scenario envisages an ambitious programme of insulation, with most available cavity wall and lofts insulated by 2050. A small number of small scale renewable thermal technologies and small scale CHP will be used early on, and continue to 2050. PV will be installed from the start, and installations of this technology will increase in the later periods as it becomes cost effective.

The scenario sees a significant installation of building scale CHP initially. This would reduce the emissions from the dominant C & I sector to meet the first interim target in 2012. This approach also prepares the larger heat users for community level CHP in later years. It is envisaged that by 2026, the development of a community heating network will be underway. One CCGT CHP plant will be operational, supplemented by some heat from Edmonton or another NLWA incinerator.

The transport measures in this scenario envisage relatively modest changes. Distances travelled, modal shifts and emission factors are all expected to reduce gradually by 10% to 20% by 2050.

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| Technology | Units | 2012 | 2026 | 2035 | 2050 |
| Renewable CHP | $MW_e$ | 1 | 2 | 4 | 4 |
| Gas CHP - Large | $MW_e$ | 0 | 135 | 225 | 395 |
| Gas CHP - building | $MW_e$ | 32 | 35 | 20 | 5 |
| Heat from power station | $MW_{th}$ | 0 | 10 | 20 | 25 |
| PV - Domestic | Dwellings | 1000 | 3000 | 10000 | 28000 |
| PV- Large | $MW_e$ | 5 | 10 | 25 | 60 |
| Wind - large | $MW_e$ | 0 | 0 | 0 | 0 |
| Wind - medium | $MW_e$ | 0 | 0 | 0 | 0 |
| Wind - small | Dwellings | 0 | 0 | 0 | 0 |
| Solar thermal | Dwellings | 1000 | 1000 | 1000 | 1000 |
| Biomass boilers large | $MW_{th}$ | 3 | 3 | 3 | 3 |
| Biomass boilers small | Dwellings | 200 | 200 | 300 | 300 |
| GSHP | Dwellings | 100 | 200 | 300 | 300 |
| Micro-CHP Stirling | Dwellings | 100 | 200 | 300 | 300 |
| Micro-CHP fuel cell | Dwellings | 0 | 50 | 200 | 300 |
| Cavity wall ins | Dwellings | 10000 | 15000 | 20000 | 23000 |
| Loft insulation | Dwellings | 10000 | 15000 | 30000 | 33000 |
| Double glazing | Dwellings | 2000 | 5000 | 8000 | 10000 |
| Solid wall insulation | Dwellings | 0 | 0 | 0 | 0 |
| Energy Efficient Lighting | 000's $m^2$ | 200 | 400 | 700 | 1200 |
| Double Glazing - Commercial | 000's $m^2$ | 10 | 20 | 30 | 40 |
| Street Lighting - Efficient Lamps | Lamps | 1000 | 3000 | 5000 | 8000 |
| Reduce car passenger-km | million pass-km | 30 | 70 | 100 | 150 |
| Reduce motorcycle passenger-km | million pass-km | 2 | 4 | 5 | 6 |
| Reduce taxi passenger-km | million pass-km | 4 | 6 | 10 | 15 |
| Reduce road freight tonne-km | million t-km | 5 | 20 | 40 | 50 |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 10 | 15 | 20 | 25 |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 5 | 10 | 12 | 15 |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 10 | 20 | 30 | 40 |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 10 | 20 | 25 | 30 |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5 | 10 | 15 | 20 |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0 | 1 | 2 | 3 |
| Modal shift, cars to public transport | million pass-km | 15 | 50 | 75 | 120 |

| Technology | Units | Total capacity installed by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Modal shift, motorcycles to public transport | million pass-km | 2 | 4 | 5 | 6 |
| Modal shift, taxis to public transport | million pass-km | 3 | 10 | 12 | 15 |
| Modal shift, freight road to rail | million t-km | 5 | 20 | 25 | 30 |

**Table 30 Proposed scenario to meet a 60% reduction target**

Table 31 below shows the transport measures expressed as a percentage change from the current baseline. This is intended to provide a clearer understanding of the scale of the changes under the proposed scenario.

| Technology | Units | Percentage change by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Reduce car passenger-km | million pass-km | 4% | 9% | 12% | 19% |
| Reduce motorcycle passenger-km | million pass-km | 7% | 13% | 17% | 20% |
| Reduce taxi passenger-km | million pass-km | 5% | 8% | 13% | 20% |
| Reduce road freight tonne-km | million t-km | 1% | 5% | 11% | 14% |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 8% | 12% | 16% | 20% |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 4% | 8% | 10% | 12% |
| Reduce $CO_2$ emissions of fleet – taxis | $gCO_2$/pass-km | 4% | 8% | 12% | 16% |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 7% | 14% | 18% | 21% |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5% | 10% | 15% | 19% |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0% | 4% | 9% | 13% |
| Modal shift, cars to public transport | million pass-km | 2% | 6% | 9% | 15% |
| Modal shift, motorcycles to public transport | million pass-km | 7% | 13% | 17% | 20% |
| Modal shift, taxis to public transport | million pass-km | 4% | 13% | 16% | 20% |
| Modal shift, freight road to rail | million t-km | 1% | 5% | 7% | 8% |

**Table 31 Percentage changes in transport measures, 60% scenario**

Figure 11 shows the $CO_2$ savings by technology for the scenario. Clearly these are dominated by the CHP options, with the transport measures, PV and insulation options also making a smaller but useful contribution.

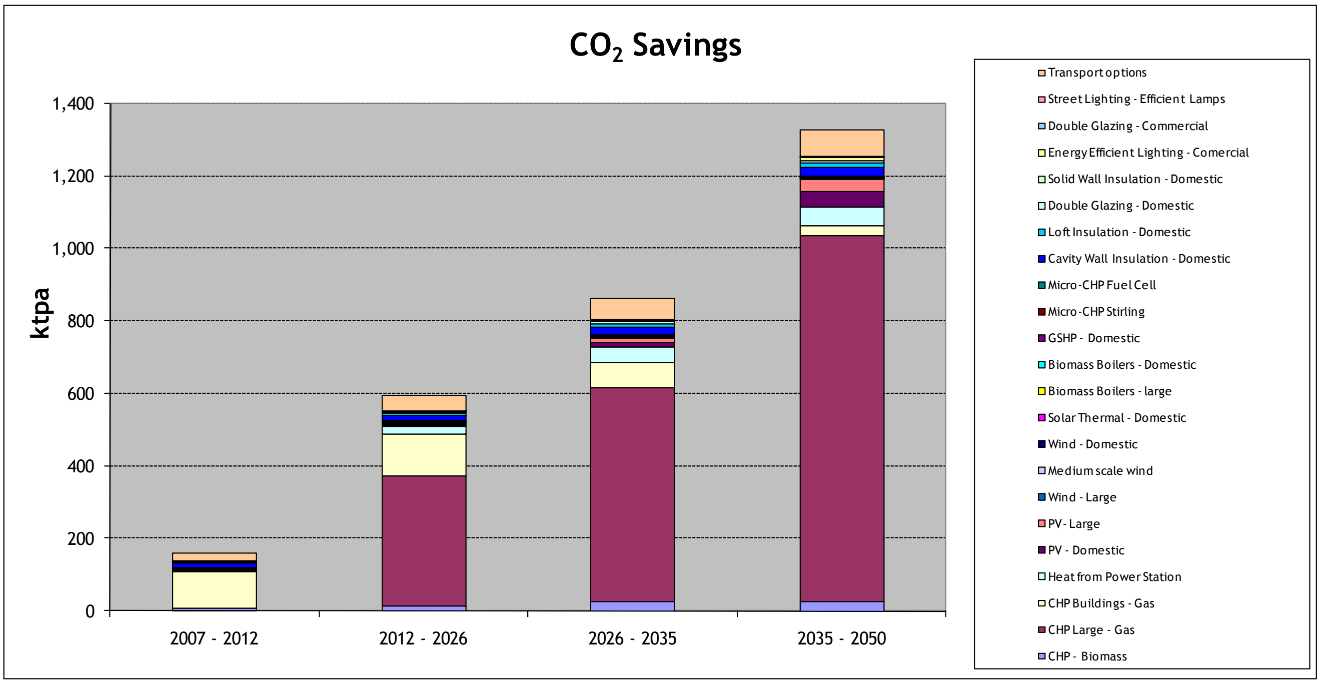


**Figure 11 $CO_2$ emissions savings, 60% scenario**

Figure 12 shows the capital costs by technology for the scenario. Again, the CHP options dominate, but this chart also shows that the CHP options make up a smaller proportion of the capital costs than of the $CO_2$ reductions.

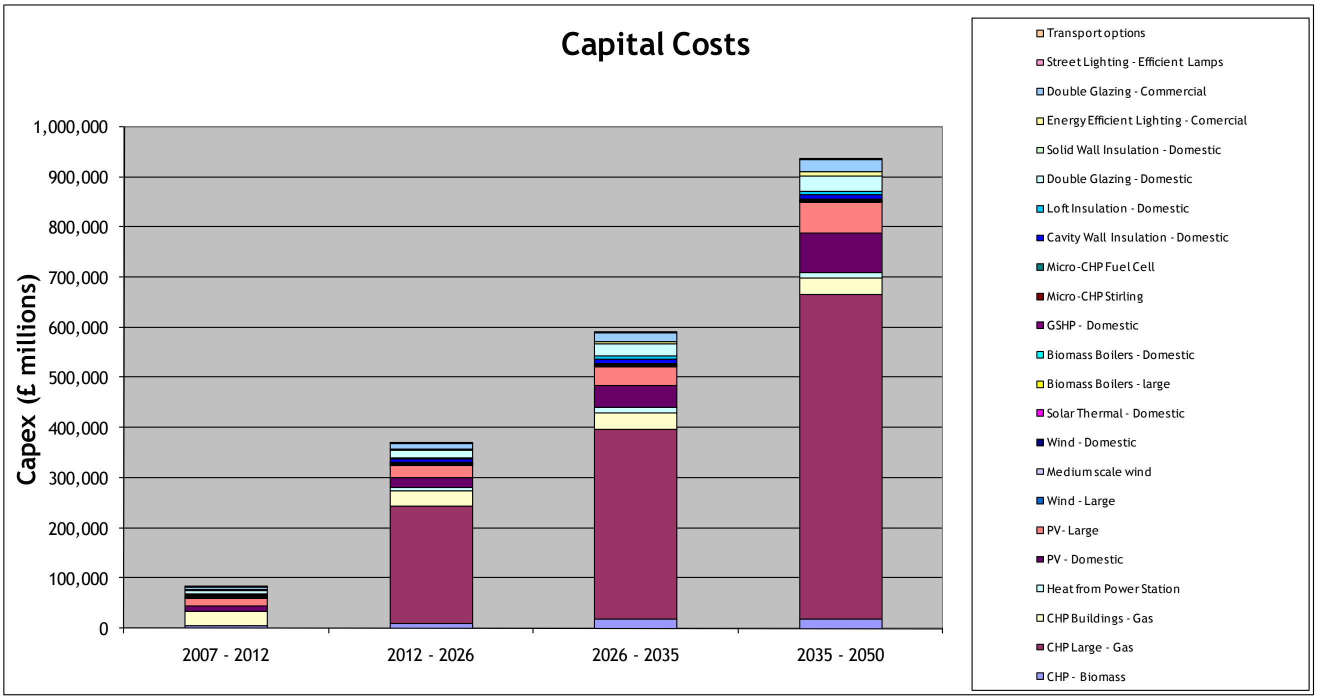


**Figure 12 Capital costs, 60% scenario**

Table 32 summarises the results of this scenario. This clearly shows that the CHP options give the greatest $CO_2$ saving and have a positive NPV. Loft insulation and cavity wall insulation are also financially attractive. The transport options also make a useful contribution to the targets and save considerable amounts of money by using less fuel. The scenario overall has a positive NPV.

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Renewable CHP | $MW_e$ | 4 | 46 | 24 | 25 | 19 | 4 |
| Gas CHP - Large | $MW_e$ | 395 | 2710 | 2595 | 1011 | 647 | 361 |
| Gas CHP - building | $MW_e$ | 5 | 47 | 39 | 28 | 32 | 130 |
| Heat from power station | $MW_{th}$ | 25 | 208 | 0 | 51 | 13 | -3 |
| PV - Dom | Dwellings | 28000 | 0 | 73 | 41 | 78 | -11 |
| PV- Large | $MW_e$ | 60 | 0 | 65 | 37 | 61 | -11 |
| Wind - large | $MW_e$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Wind - medium | $MW_e$ | 0 | 0 | 1 | 0 | 2 | -1 |
| Wind - small | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Solar thermal | Dwellings | 1000 | 0 | 0 | 0 | 0 | 0 |
| Biomass boilers large | $MW_{th}$ | 3 | 2 | 0 | 0 | 1 | -2 |
| Biomass boilers small | Dwellings | 300 | 18 | 0 | 5 | 1 | -2 |
| GSHP | Dwellings | 300 | 4 | 0 | 1 | 1 | -2 |
| Micro-CHP Stirling | Dwellings | 300 | 4 | 0 | 1 | 1 | -2 |
| Micro-CHP fuel cell | Dwellings | 300 | 6 | 1 | 1 | 1 | 0 |
| Cavity wall ins | Dwellings | 23000 | 1 | 1 | 0 | 1 | 0 |
| Loft insulation | Dwellings | 33000 | 95 | 0 | 25 | 9 | 23 |
| Double glazing | Dwellings | 10000 | 41 | 0 | 10 | 7 | 7 |
| Solid wall insulation | Dwellings | 0 | 21 | 0 | 5 | 30 | -18 |
| Energy Efficient Lighting | 000's $m^2$ | 1200 | 0 | 0 | 0 | 0 | 0 |
| Double Glazing - Commercial | 000's $m^2$ | 40 | 0 | 19 | 11 | 10 | 1 |
| Street Lighting - Efficient Lamps | Lamps | 8000 | 6 | 0 | 1 | 24 | -17 |
| Reduce car passenger-km | million pass-km | 150 | | | | | |
| Reduce motorcycle passenger-km | million pass-km | 6 | | | | | |
| Reduce taxi passenger-km | million pass-km | 15 | | | | | |
| Reduce road freight tonne-km | million t-km | 50 | 0 | 0 | 74 | ? | 343[26] |
| Reduce CO2 emissions of fleet - cars | gCO2/pass-km | 25 | | | | | |
| Reduce CO2 emissions of fleet - motorcycles | gCO2/pass-km | 15 | | | | | |
| Reduce CO2 emissions of fleet - taxis | gCO2/pass-km | 40 | | | | | |

[26] Note that this NPV is based on estimated fuel savings with zero capital cost.

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Reduce CO2 emissions of fleet - freight | gCO2/t-km | 30 | | | | | |
| Reduce CO2 emissions of fleet - buses | gCO2/pass-km | 20 | | | | | |
| Reduce CO2 emissions of fleet - trains | gCO2/pass-km | 3 | | | | | |
| Modal shift, cars to public transport | million pass-km | 120 | | | | | |
| Modal shift, motorcycles to public transport | million pass-km | 6 | | | | | |
| Modal shift, taxis to public transport | million pass-km | 15 | | | | | |
| Modal shift, freight road to rail | million t-km | 30 | | | | | |
| **Totals** | | | **3209** | **2818** | **1329** | **938** | **800** |

**Table 32 Summary of 60% scenario**

#### 5.6.1.1 Gas consumption

Figure 13 shows the total gas consumption under this scenario. This calculates the quantities of gas used locally by the technologies and the amount of gas required to supply grid electricity based on the current generating mix. Overall gas consumption remains relatively constant under this scenario, increasing by 2.7% between 2007 and 2050 despite an increase of 29% in thermal demand.

Note that although gas consumption rises slightly under this scenario, considerably more value is being obtained from the use of this gas. Firstly a considerably higher projected thermal demand is being met. Secondly, under this scenario the borough becomes a net exporter of electricity by 2050. In other words, the large CHP power stations are providing enough electricity to supply more than the borough requires and exporting excess to the grid. This displaces gas used in grid electricity generation, but also a considerable amount of coal fired and nuclear electricity generation.

In summary, current gas consumption meets the majority of the boroughs thermal demand, and generates a proportion of the grid electricity supplied to the borough. By 2050, 2.7% more gas will supply all of the borough's thermal demand (which is expected to have risen by 29%), all of the borough's electrical demand and export additional electricity to the national grid.

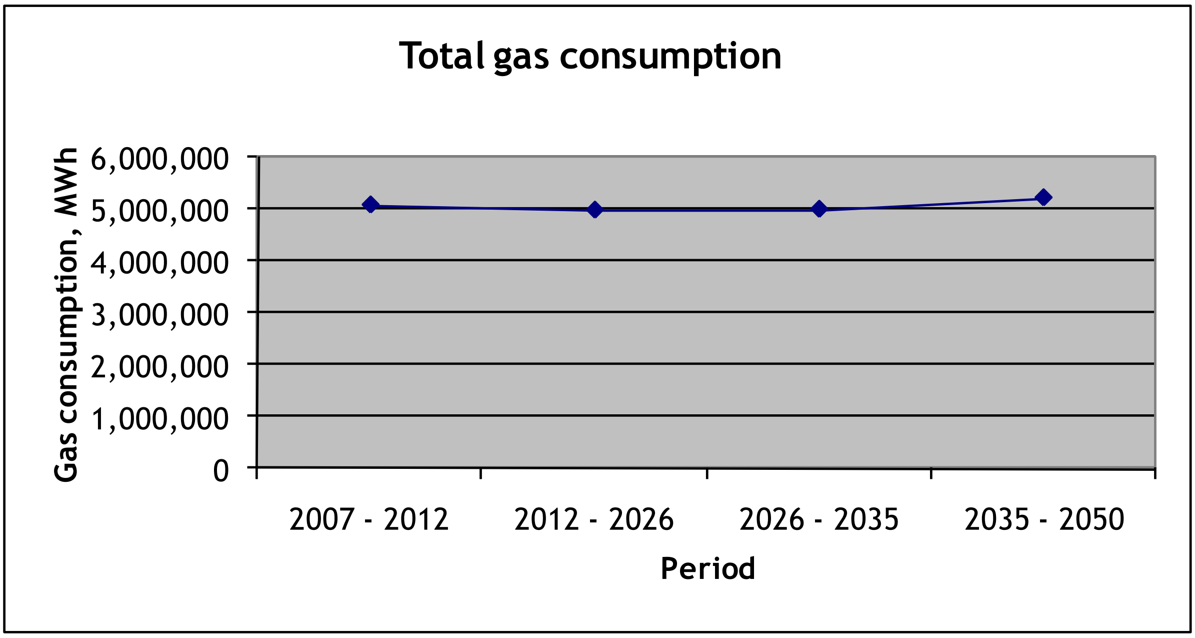


**Figure 13 Gas consumption, 60% scenario**

#### 5.6.1.2 Biomass consumption

Figure 14 shows that biomass consumption steadily increases until 2035 and levels off to stay below the available resource.

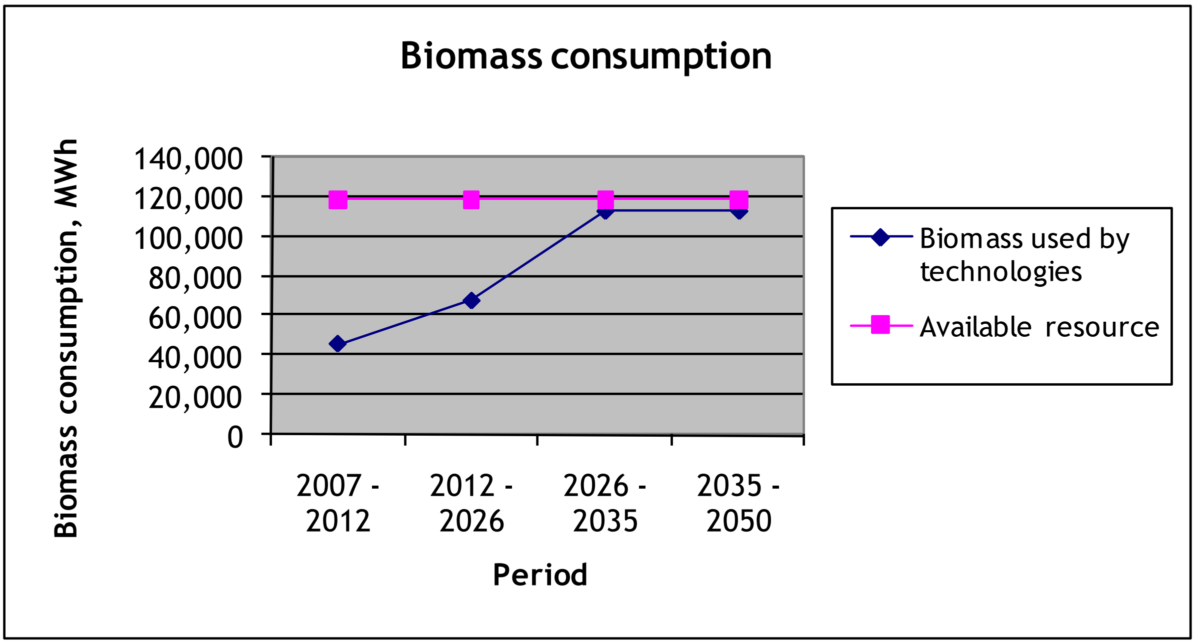


**Figure 14 Biomass consumption, 60% scenario**

### 5.6.2 80% reduction by 2050

In this scenario, the early periods are similar to the 60% scenario, dominated by building level CHP initially. To meet the higher early targets, more biomass boilers are installed. The transport measures are the same as for the 60% scenario.

The big difference here is the replacement of large scale gas CHP with biomass CHP in the final period to meet the higher target. Note that the combined capacity of biomass and large scale CHP is 305 $MW_e$ in 2035 and this reduces to 270 $MW_e$ in 2050. However, biomass CHP has a higher heat to electricity generation ratio than CCGT, so overall thermal production is actually higher in 2050.

This strategy clearly raises several issues. One advantage of a community heating approach is that it does allow the replacement of the central generation plant to accommodate different fuels in the future. However, in this scenario biomass consumption is considerably higher than the available resource from within London and the surrounding area (see Appendix D). Therefore large quantities of biomass would have to be imported from other parts of the UK or possibly from abroad. Biomass can be transported by road, rail and sea over considerable distances and still save $CO_2$.

Another major issue would be deliveries of fuel. It is unlikely that significant quantities would be stored on site in Camden, rather a steady stream of deliveries would be necessary. Biomass fuels vary considerably in density, but a report by the RCEP[27] gives an indication of the rate of deliveries required to sustain a 30 $MW_e$ biomass plant using different fuels. This is reproduced in Table 33 below, and multiplied up to 160 $MW_e$ as required by the scenario.

| Conversion method | Deliveries per day (assuming 120 $m^3$ truck volume) | | |
|---|---|---|---|
| | Wood chips | Straw bales | Miscanthus bales |
| Combustion, 30 $MW_e$ | 21 | 28 | 17 |
| Gasification, 30 $MW_e$ | 17 | 23 | 13 |
| Combustion, 160 $MW_e$ | 112 | 149 | 91 |
| Gasification, 160 $MW_e$ | 91 | 123 | 69 |

**Table 33 Biomass delivery rates, 80% scenario**

Another difference in this scenario is that wind energy is introduced on a small scale. This involves 5000 domestic scale turbines, several medium scale machines, and two large scale wind turbines. Some solid wall insulation is also included. It is envisaged that the 5000 small turbines would be installed on tower blocks. There are around 4,300 housing blocks in the borough, plus commercial buildings. Some of these will be unsuitable, but others could have several machines installed on the same building[28]. However, at the levels proposed, these measures are unlikely to impact significantly in conservation areas.

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| Technology | Units | 2012 | 2026 | 2035 | 2050 |
| Renewable CHP | $MW_e$ | 1 | 3 | 5 | 160 |
| Gas CHP - Large | $MW_e$ | 0 | 160 | 300 | 110 |
| Gas CHP - building | $MW_e$ | 40 | 50 | 16 | 10 |
| Heat from power station | $MW_{th}$ | 0 | 10 | 20 | 25 |
| PV - Domestic | Dwellings | 2000 | 10000 | 25000 | 33000 |
| PV- Large | $MW_e$ | 5 | 15 | 30 | 60 |
| Wind - large | $MW_e$ | 0 | 0 | 1 | 2 |
| Wind - medium | $MW_e$ | 1 | 1 | 1 | 1 |
| Wind - small | Dwellings | 500 | 1000 | 3000 | 5000 |

[27] *Biomass as a Renewable Energy Source*, RCEP, 2004.

[28] The offices of the London Climate Change Agency, for example has a 70 kW PV array and fourteen 1.5 kW wind turbines installed on one roof.

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| **Technology** | **Units** | **2012** | **2026** | **2035** | **2050** |
| Solar thermal | Dwellings | 500 | 1000 | 500 | 0 |
| Biomass boilers large | $MW_{th}$ | 12 | 6 | 1 | 0 |
| Biomass boilers small | Dwellings | 500 | 200 | 100 | 0 |
| GSHP | Dwellings | 100 | 100 | 100 | 0 |
| Micro-CHP Stirling | Dwellings | 100 | 100 | 100 | 0 |
| Micro-CHP fuel cell | Dwellings | 100 | 100 | 100 | 0 |
| Cavity wall ins | Dwellings | 5000 | 15000 | 20000 | 23000 |
| Loft insulation | Dwellings | 10000 | 20000 | 30000 | 33000 |
| Double glazing | Dwellings | 5000 | 20000 | 30000 | 36000 |
| Solid wall insulation | Dwellings | 0 | 0 | 1000 | 2000 |
| Energy Efficient Lighting | 000's $m^2$ | 300 | 900 | 1200 | 1400 |
| Double Glazing - Commercial | 000's $m^2$ | 10 | 40 | 60 | 60 |
| Street Lighting - Efficient Lamps | Lamps | 2000 | 6000 | 8000 | 9000 |
| Reduce car passenger-km | million pass-km | 30 | 70 | 100 | 150 |
| Reduce motorcycle passenger-km | million pass-km | 2 | 4 | 5 | 6 |
| Reduce taxi passenger-km | million pass-km | 4 | 6 | 10 | 15 |
| Reduce road freight tonne-km | million t-km | 5 | 20 | 40 | 50 |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 10 | 15 | 20 | 25 |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 5 | 10 | 12 | 15 |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 10 | 20 | 30 | 40 |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 10 | 20 | 25 | 30 |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5 | 10 | 15 | 20 |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0 | 1 | 2 | 3 |
| Modal shift, cars to public transport | million pass-km | 15 | 50 | 75 | 120 |
| Modal shift, motorcycles to public transport | million pass-km | 2 | 4 | 5 | 6 |
| Modal shift, taxis to public transport | million pass-km | 3 | 10 | 12 | 15 |
| Modal shift, freight road to rail | million t-km | 5 | 20 | 25 | 30 |

**Table 34 Proposed scenario to meet an 80% reduction target**

Table 35 below shows the transport measures expressed as a percentage change from the current baseline. This is intended to provide a clearer understanding of the scale of the changes under the proposed scenario.

| | | Percentage change by | | | |
|---|---|---|---|---|---|
| **Technology** | **Units** | **2012** | **2026** | **2035** | **2050** |
| Reduce car passenger-km | million pass-km | 4% | 9% | 12% | 19% |
| Reduce motorcycle passenger-km | million pass-km | 7% | 13% | 17% | 20% |
| Reduce taxi passenger-km | million pass-km | 5% | 8% | 13% | 20% |
| Reduce road freight tonne-km | million t-km | 1% | 5% | 11% | 14% |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 8% | 12% | 16% | 20% |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 4% | 8% | 10% | 12% |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 4% | 8% | 12% | 16% |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 7% | 14% | 18% | 21% |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5% | 10% | 15% | 19% |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0% | 4% | 9% | 13% |
| Modal shift, cars to public transport | million pass-km | 2% | 6% | 9% | 15% |
| Modal shift, motorcycles to public transport | million pass-km | 7% | 13% | 17% | 20% |
| Modal shift, taxis to public transport | million pass-km | 4% | 13% | 16% | 20% |
| Modal shift, freight road to rail | million t-km | 1% | 5% | 7% | 8% |

**Table 35 Percentage changes in transport measures, 80% scenario**

Figure 15 and Figure 16 show the $CO_2$ savings and capital costs for this scenario. As before, CHP makes the biggest contribution to the $CO_2$ reductions, and is relatively cheap compared to some of the other measures such as double glazing and PV. These charts clearly show the significant shift from gas to biomass CHP proposed here.

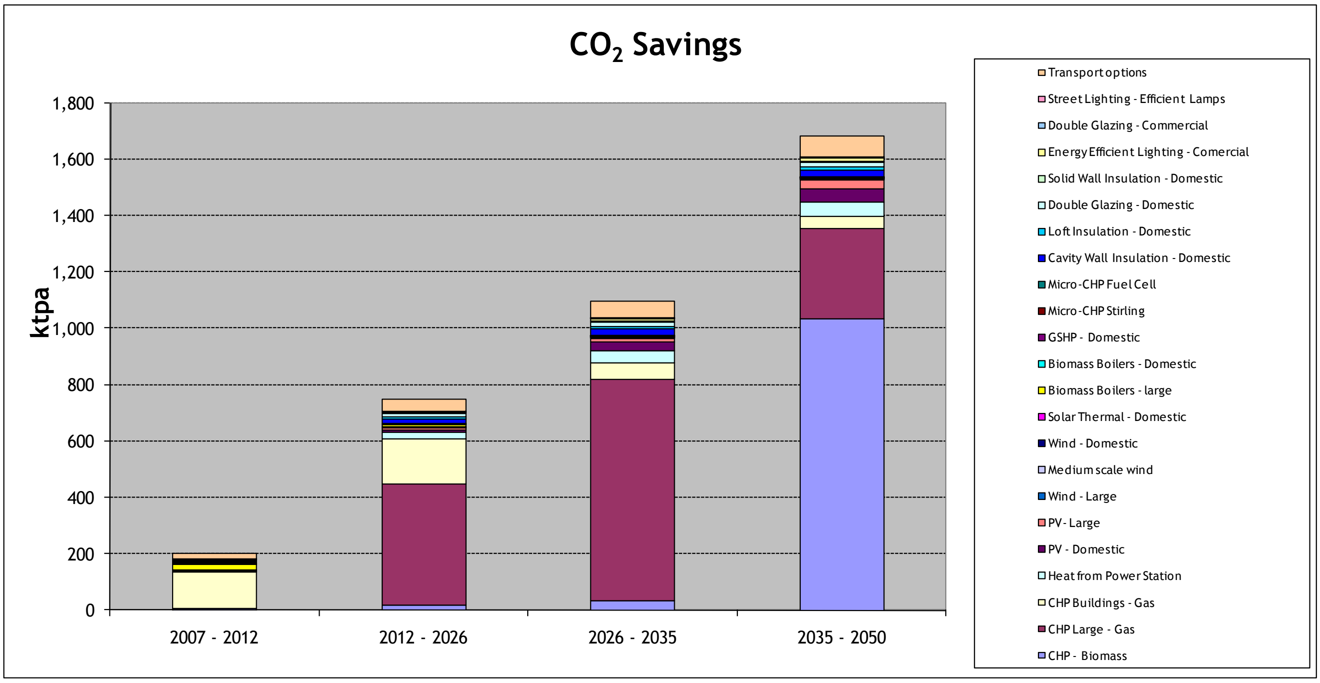


**Figure 15 $CO_2$ emissions savings, 80% scenario**

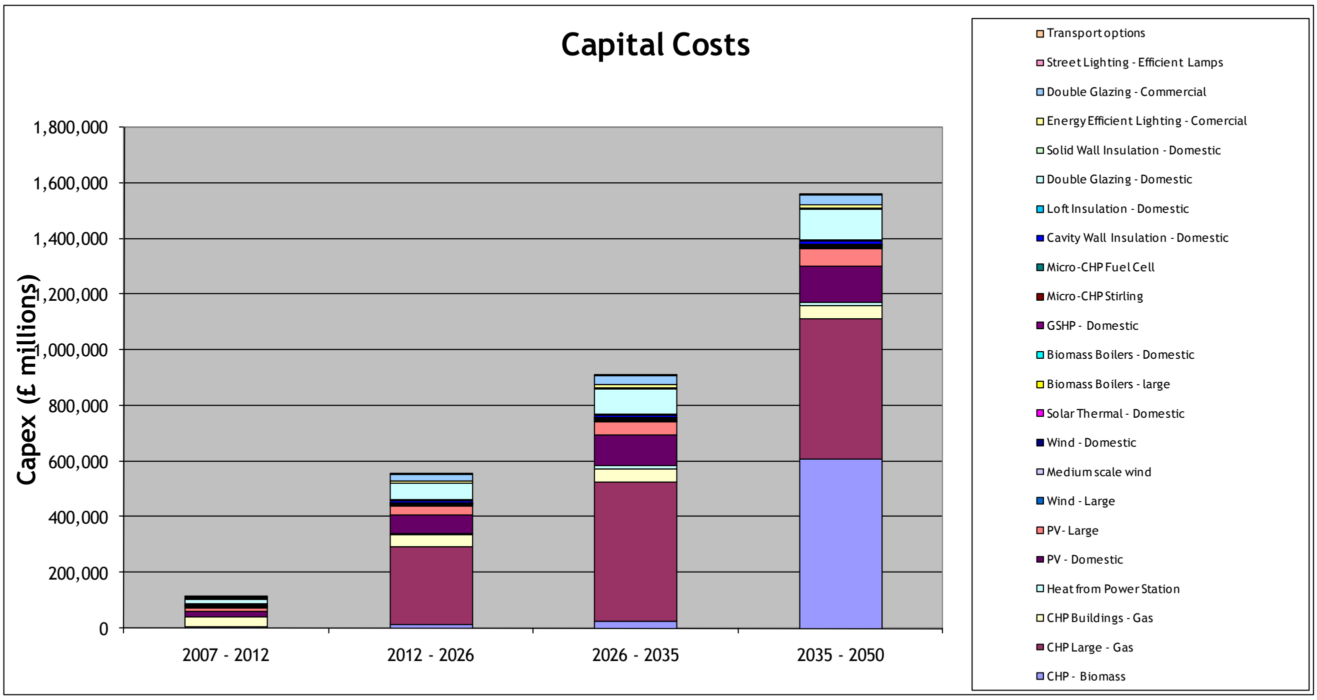


**Figure 16 Capital costs, 80% scenario**

Table 36 summarises the scenario. Again, it shows that CHP saves more $CO_2$ than other technologies. Gas fired CHP is financially viable. Biomass CHP has a negative NPV, but makes a huge contribution to $CO_2$ savings. Wind also has a positive NPV. The NPV for the scenario overall is positive.

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Renewable CHP | $MW_e$ | 160 | 1925 | 1048 | 1036 | 609 | -11 |
| Gas CHP - Large | $MW_e$ | 110 | 755 | 723 | 318 | 504 | 361 |
| Gas CHP - building | $MW_e$ | 10 | 95 | 79 | 45 | 46 | 162 |
| Heat from power station | $MW_{th}$ | 25 | 208 | 0 | 51 | 13 | -3 |
| PV - Dom | Dwellings | 33000 | 0 | 78 | 44 | 129 | -27 |
| PV- Large | $MW_e$ | 60 | 0 | 63 | 36 | 68 | -14 |
| Wind - large | $MW_e$ | 2 | 0 | 4 | 2 | 1 | 1 |
| Wind - medium | $MW_e$ | 1 | 0 | 1 | 1 | 3 | -1 |
| Wind - small | Dwellings | 5000 | 0 | 2 | 1 | 2 | 1 |
| Solar thermal | Dwellings | 0 | 0 | 6 | 3 | 4 | 1 |
| Biomass boilers large | $MW_{th}$ | 0 | 0 | 0 | 0 | 1 | -1 |
| Biomass boilers small | Dwellings | 0 | 0 | 0 | 2 | 2 | -7 |
| GSHP | Dwellings | 0 | 0 | 0 | 0 | 2 | -3 |
| Micro-CHP Stirling | Dwellings | 0 | 0 | 0 | 0 | 0 | -1 |
| Micro-CHP fuel cell | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Cavity wall ins | Dwellings | 23000 | 0 | 0 | 0 | 0 | -1 |

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Loft insulation | Dwellings | 33000 | 95 | 0 | 24 | 9 | 20 |
| Double glazing | Dwellings | 36000 | 41 | 0 | 10 | 7 | 7 |
| Solid wall insulation | Dwellings | 2000 | 74 | 0 | 19 | 108 | -65 |
| Energy Efficient Lighting | 000's $m^2$ | 1400 | 12 | 0 | 3 | 6 | -1 |
| Double Glazing - Commercial | 000's $m^2$ | 60 | 0 | 22 | 13 | 11 | 2 |
| Street Lighting - Efficient Lamps | Lamps | 9000 | 9 | 0 | 2 | 36 | -30 |
| Reduce car passenger-km | million pass-km | 150 | | | | | |
| Reduce motorcycle passenger-km | million pass-km | 6 | | | | | |
| Reduce taxi passenger-km | million pass-km | 15 | | | | | |
| Reduce road freight tonne-km | million t-km | 50 | | | | | |
| Reduce $CO_2$ emissions of fleet - cars | gCO2/pass-km | 25 | | | | | |
| Reduce $CO_2$ emissions of fleet - motorcycles | gCO2/pass-km | 15 | | | | | |
| Reduce $CO_2$ emissions of fleet - taxis | gCO2/pass-km | 40 | | | | | |
| Reduce $CO_2$ emissions of fleet - freight | gCO2/t-km | 30 | 0 | 0 | 74 | ? | 343 |
| Reduce $CO_2$ emissions of fleet - buses | gCO2/pass-km | 20 | | | | | |
| Reduce $CO_2$ emissions of fleet - trains | gCO2/pass-km | 3 | | | | | |
| Modal shift, cars to public transport | million pass-km | 120 | | | | | |
| Modal shift, motorcycles to public transport | million pass-km | 6 | | | | | |
| Modal shift, taxis to public transport | million pass-km | 15 | | | | | |
| Modal shift, freight road to rail | million t-km | 30 | | | | | |
| **Totals** | | | **3213** | **2026** | **1686** | **1561** | **733** |

**Table 36 Summary of 80% scenario**

#### 5.6.2.1 Gas consumption

Under this scenario gas consumption decreases slightly until 2035, and then reduces dramatically as biomass takes over.

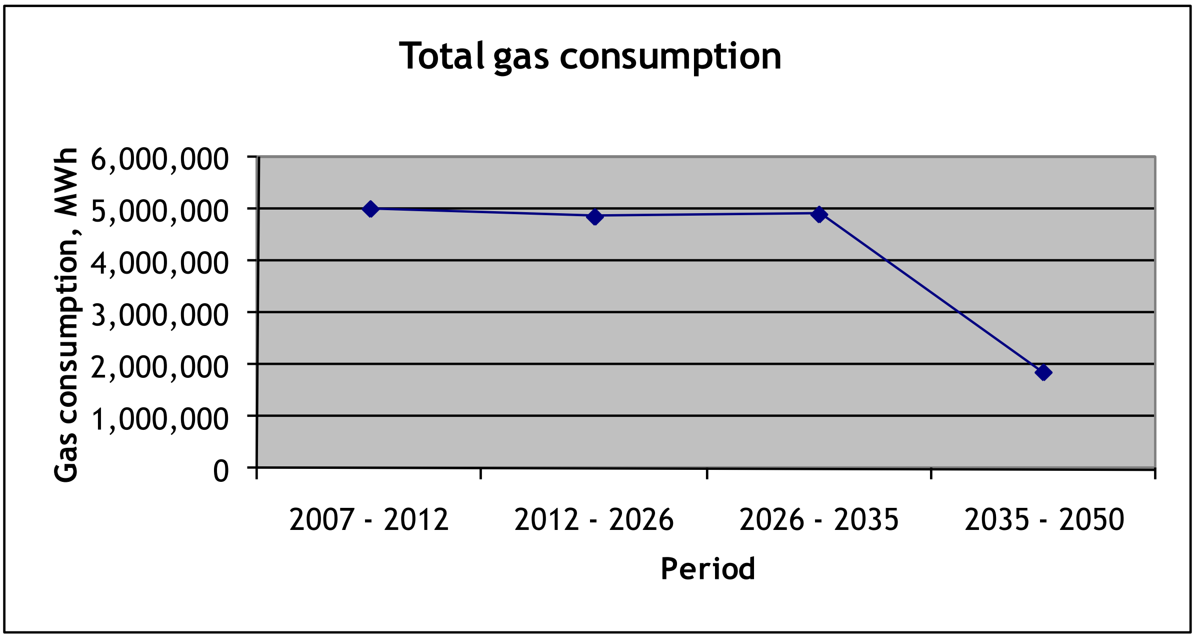


**Figure 17 Gas consumption, 80% scenario**

#### 5.6.2.2 Biomass consumption

Biomass consumption rises dramatically in the final period as it takes over from gas. Clearly the vast majority of this biomass would be imported from outside the London area.

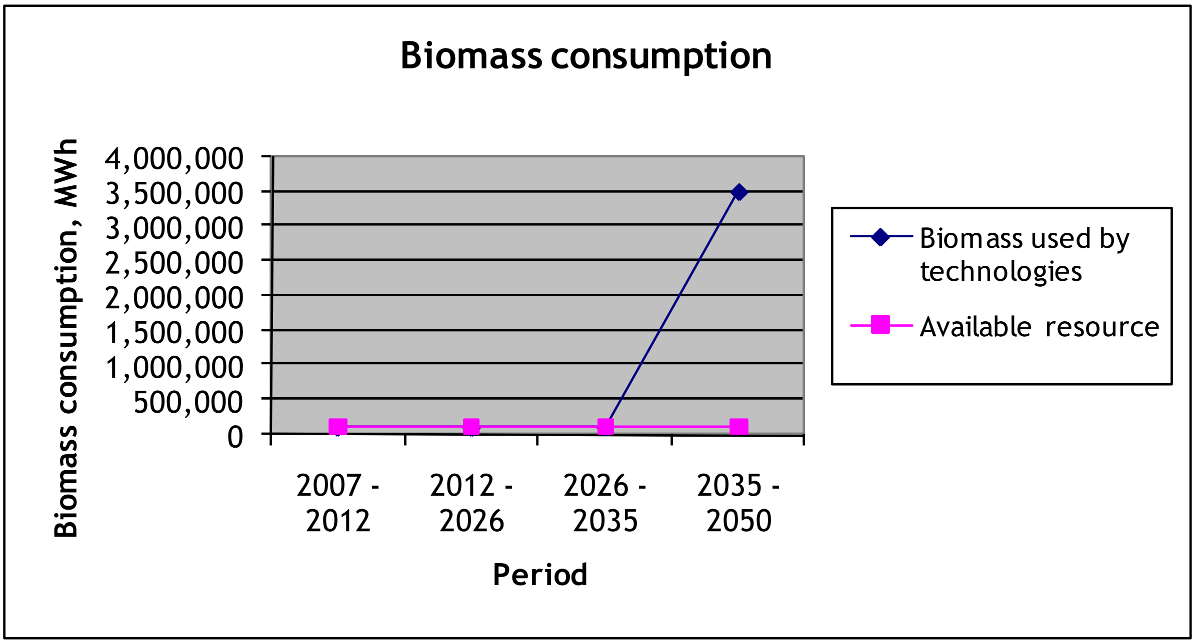


**Figure 18 Biomass consumption, 80% scenario**

### 5.6.3 Maximum reduction by 2050

This scenario shows the maximum $CO_2$ savings that can be achieved subject to certain constraints. In particular the biomass resource is not exceeded, and it is assumed that the programme of insulation measures would continue.

The scenario maximises all electricity generating measures, and minimises all heat generation so that CHP can be maximised.

This scenario proposes an unrealistic transport shift, with essentially no personal transport at all being used. 70% to 80% of all taxi, motorcycle and car journeys are avoided altogether, with most of the remainder being switched to public transport. Similarly freight journeys are reduced by 30% and a further 30% are switched from road to rail. Finally, efficiencies for all modes are improved dramatically.

The purpose of this is to show what target could be met in ideal conditions using the measures in the scenario model. This scenario falls 7 ktpa short of achieving a 70% reduction by 2050 (7 ktpa is less than 0.5% of the total $CO_2$ saving). In fact a 70% reduction can be achieved by reducing the levels of the insulation measures so that more CHP can be installed without rejecting heat. This is a counter-intuitive effect discussed further in Appendix C.

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| Technology | Units | 2012 | 2026 | 2035 | 2050 |
| Renewable CHP | $MW_e$ | 1 | 2 | 3 | 5 |
| Gas CHP - Large | $MW_e$ | 0 | 170 | 340 | 436 |
| Gas CHP - building | $MW_e$ | 50 | 60 | 20 | 0 |
| Heat from power station | $MW_{th}$ | 0 | 0 | 0 | 0 |
| PV - Domestic | Dwellings | 2000 | 5000 | 15000 | 33000 |
| PV- Large | $MW_e$ | 5 | 20 | 45 | 60 |
| Wind - large | $MW_e$ | 0 | 0 | 1 | 2 |
| Wind - medium | $MW_e$ | 0 | 1 | 1 | 1 |
| Wind - small | Dwellings | 0 | 1000 | 3000 | 5000 |
| Solar thermal | Dwellings | 200 | 100 | 0 | 0 |
| Biomass boilers large | MWth | 2 | 10 | 2 | 0 |
| Biomass boilers small | Dwellings | 200 | 200 | 200 | 0 |
| GSHP | Dwellings | 0 | 0 | 0 | 0 |
| Micro-CHP Stirling | Dwellings | 0 | 0 | 0 | 0 |
| Micro-CHP fuel cell | Dwellings | 0 | 0 | 0 | 0 |
| Cavity wall ins | Dwellings | 5000 | 10000 | 15000 | 23170 |
| Loft insulation | Dwellings | 5000 | 15000 | 20000 | 33533 |
| Double glazing | Dwellings | 500 | 5000 | 8000 | 10000 |
| Solid wall insulation | Dwellings | 0 | 0 | 0 | 0 |
| Energy Efficient Lighting | 000's $m^2$ | 200 | 800 | 1200 | 1500 |
| Double Glazing - Commercial | 000's $m^2$ | 0 | 0 | 0 | 0 |
| Street Lighting - Efficient Lamps | Lamps | 1000 | 4000 | 7000 | 9865 |

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| **Technology** | **Units** | **2012** | **2026** | **2035** | **2050** |
| Reduce car passenger-km | million pass-km | 50 | 300 | 500 | 646 |
| Reduce motorcycle passenger-km | million pass-km | 4 | 15 | 20 | 24 |
| Reduce taxi passenger-km | million pass-km | 10 | 35 | 50 | 60 |
| Reduce road freight tonne-km | million t-km | 15 | 50 | 80 | 111 |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 15 | 50 | 70 | 87 |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 5 | 40 | 50 | 63 |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 10 | 80 | 130 | 174 |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 10 | 40 | 60 | 100 |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5 | 35 | 50 | 72 |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 2 | 5 | 7 | 9 |
| Modal shift, cars to public transport | million pass-km | 20 | 70 | 120 | 150 |
| Modal shift, motorcycles to public transport | million pass-km | 1 | 4 | 5 | 6 |
| Modal shift, taxis to public transport | million pass-km | 2 | 7 | 8 | 10 |
| Modal shift, freight road to rail | million t-km | 15 | 50 | 80 | 111 |

**Table 37 Proposed scenario to maximise $CO_2$ savings**

Table 38 below shows the transport measures expressed as a percentage change from the current baseline. This is intended to provide a clearer understanding of the scale of the changes under the proposed scenario. Note that in this case, these changes are not being put forward as a genuine proposal to be achieved in reality.

| | | Percentage change by | | | |
|---|---|---|---|---|---|
| **Technology** | **Units** | **2012** | **2026** | **2035** | **2050** |
| Reduce car passenger-km | million pass-km | 6% | 37% | 62% | 80% |
| Reduce motorcycle passenger-km | million pass-km | 13% | 50% | 66% | 80% |
| Reduce taxi passenger-km | million pass-km | 13% | 47% | 67% | 80% |
| Reduce road freight tonne-km | million t-km | 4% | 14% | 22% | 30% |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 12% | 40% | 56% | 70% |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 4% | 32% | 40% | 50% |
| Reduce $CO_2$ emissions of fleet – taxis | $gCO_2$/pass-km | 4% | 32% | 52% | 70% |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 7% | 28% | 42% | 70% |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5% | 34% | 49% | 70% |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 9% | 22% | 30% | 39% |
| Modal shift, cars to public transport | million pass-km | 2% | 9% | 15% | 19% |
| Modal shift, motorcycles to public transport | million pass-km | 3% | 13% | 17% | 20% |
| Modal shift, taxis to public transport | million pass-km | 3% | 9% | 11% | 13% |

| Technology | Units | Percentage change by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Modal shift, freight road to rail | million t-km | 4% | 14% | 22% | 30% |

**Table 38 Percentage changes in transport measures, maximum scenario**

The $CO_2$ savings and capital costs for this scenario are show in Figure 19 and Figure 20 below.

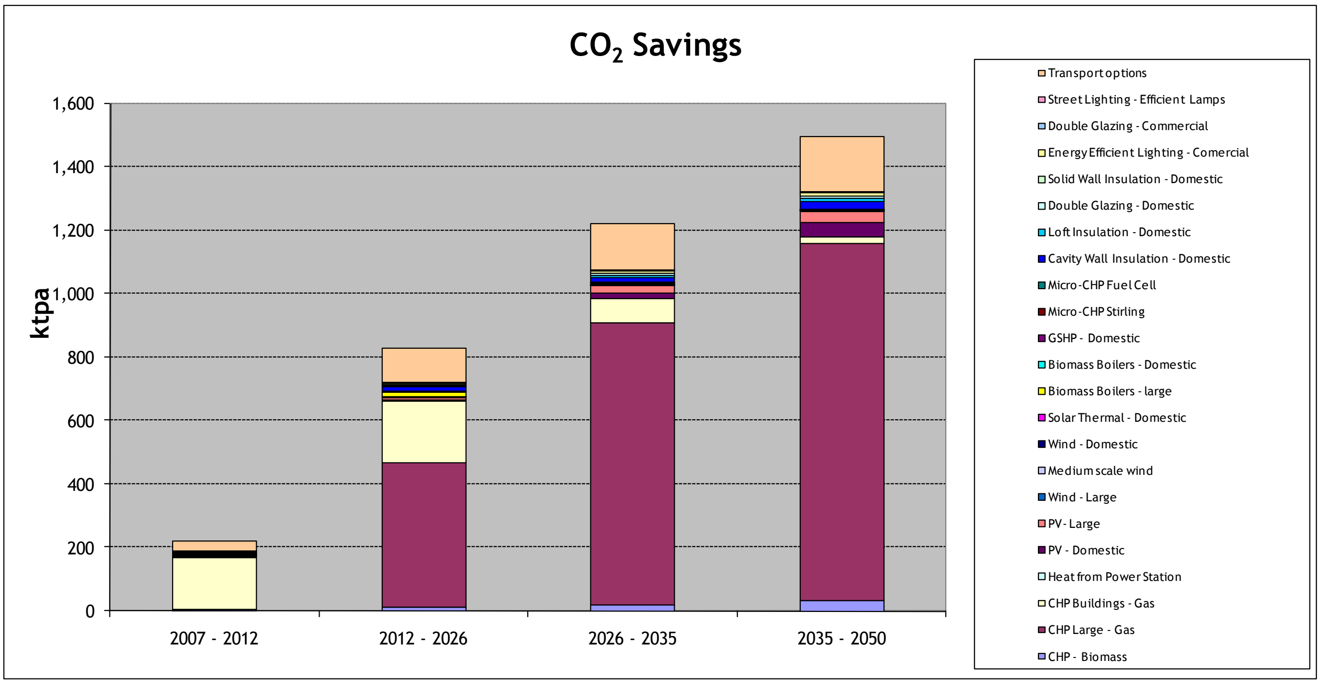


**Figure 19 $CO_2$ savings, maximum scenario**

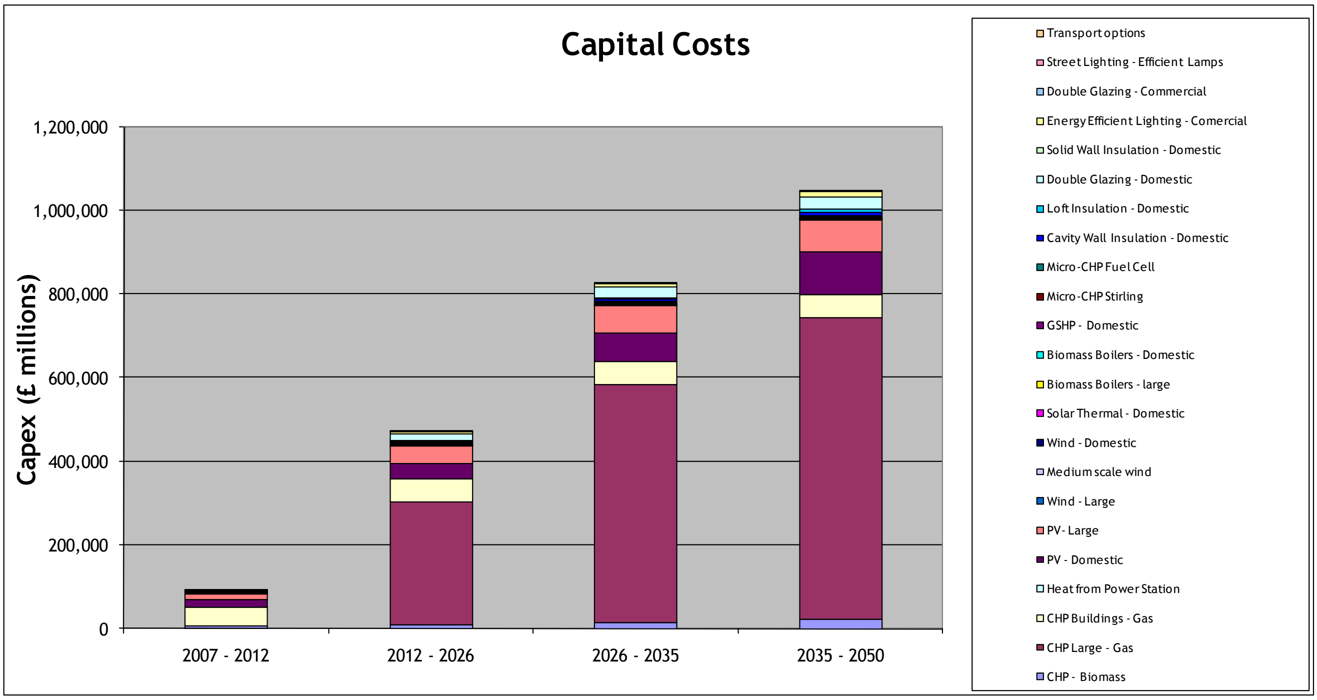


**Figure 20 Capital costs, maximum scenario**

The results for this scenario are summarised in Table 39 below.

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Renewable CHP | $MW_e$ | 5 | 58 | 31 | 32 | 22 | 3 |
| Gas CHP - Large | $MW_e$ | 436 | 2992 | 2865 | 1127 | 721 | 496 |
| Gas CHP - building | $MW_e$ | 0 | 0 | 0 | 21 | 55 | 191 |
| Heat from power station | $MW_{th}$ | 0 | 0 | 0 | 0 | 0 | 0 |
| PV - Dom | Dwellings | 33000 | 0 | 84 | 47 | 103 | -19 |
| PV- Large | $MW_e$ | 60 | 0 | 59 | 34 | 77 | -16 |
| Wind - large | $MW_e$ | 2 | 0 | 4 | 2 | 1 | 1 |
| Wind - medium | $MW_e$ | 1 | 0 | 1 | 1 | 3 | -1 |
| Wind - small | Dwellings | 5000 | 0 | 2 | 1 | 1 | 1 |
| Solar thermal | Dwellings | 0 | 0 | 6 | 3 | 4 | 1 |
| Biomass boilers large | $MW_{th}$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Biomass boilers small | Dwellings | 0 | 0 | 0 | 1 | 2 | -4 |
| GSHP | Dwellings | 0 | 0 | 0 | 0 | 1 | -2 |
| Micro-CHP Stirling | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Micro-CHP fuel cell | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Cavity wall ins | Dwellings | 23170 | 0 | 0 | 0 | 0 | 0 |
| Loft insulation | Dwellings | 33533 | 96 | 0 | 24 | 9 | 15 |
| Double glazing | Dwellings | 10000 | 41 | 0 | 10 | 7 | 5 |
| Solid wall insulation | Dwellings | 0 | 21 | 0 | 5 | 30 | -17 |
| Energy Efficient Lighting | 000's $m^2$ | 1500 | 0 | 0 | 0 | 0 | 0 |
| Double Glazing - Commercial | 000's $m^2$ | 0 | 0 | 24 | 14 | 12 | 1 |
| Street Lighting - Efficient Lamps | Lamps | 9865 | 0 | 0 | 0 | 0 | 0 |
| Reduce car passenger-km | million pass-km | 646 | | | | | |
| Reduce motorcycle passenger-km | million pass-km | 24 | 0 | 0 | 175 | ? | 797 |
| Reduce taxi passenger-km | million pass-km | 60 | | | | | |
| Reduce road freight tonne-km | million t-km | 111 | | | | | |
| Reduce $CO_2$ emissions of fleet - cars | gCO2/pass-km | 87 | | | | | |
| Reduce $CO_2$ emissions of fleet - motorcycles | gCO2/pass-km | 63 | | | | | |
| Reduce $CO_2$ emissions of fleet - taxis | gCO2/pass-km | 174 | | | | | |
| Reduce $CO_2$ emissions of fleet - freight | gCO2/t-km | 100 | | | | | |

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Reduce $CO_2$ emissions of fleet - buses | gCO2/pass-km | 72 | | | | | |
| Reduce $CO_2$ emissions of fleet - trains | gCO2/pass-km | 9 | | | | | |
| Modal shift, cars to public transport | million pass-km | 150 | | | | | |
| Modal shift, motorcycles to public transport | million pass-km | 6 | | | | | |
| Modal shift, taxis to public transport | million pass-km | 10 | | | | | |
| Modal shift, freight road to rail | million t-km | 111 | | | | | |
| **Totals** | | | **3208** | **3075** | **1498** | **1048** | **1452** |

**Table 39 Summary of maximum scenario**

#### 5.6.3.1 Gas consumption

Gas consumption increase steadily under this scenario, finishing around 7% higher by 2050 despite an increase in thermal demand of 29%.

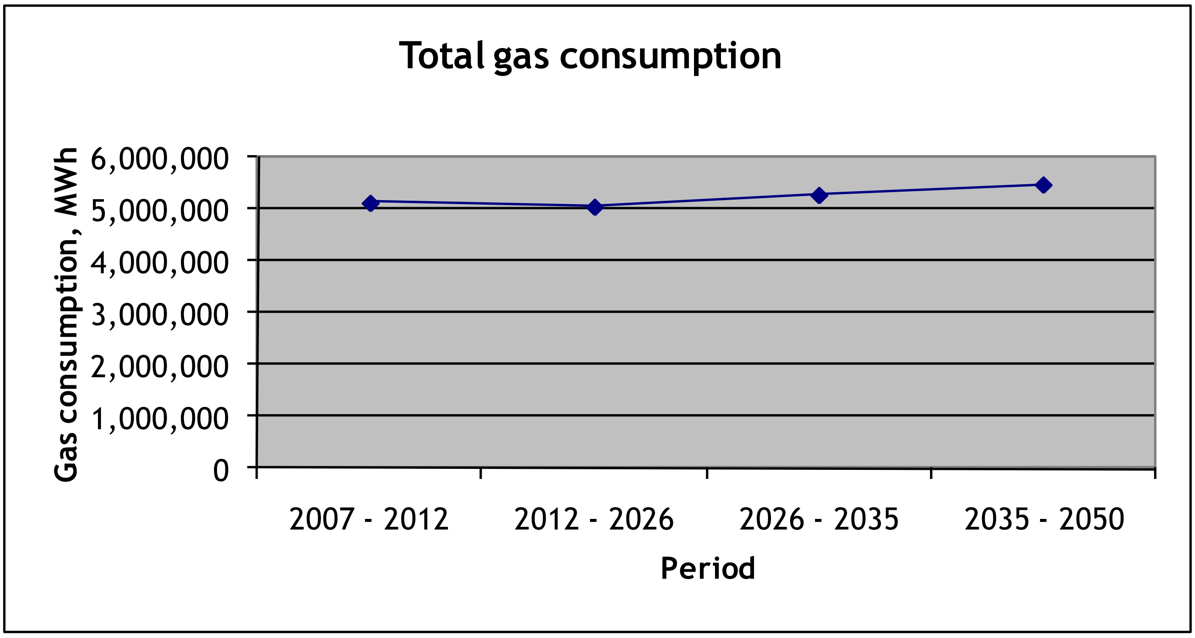


**Figure 21 Gas consumption, maximum scenario**

#### 5.6.3.2 Biomass consumption

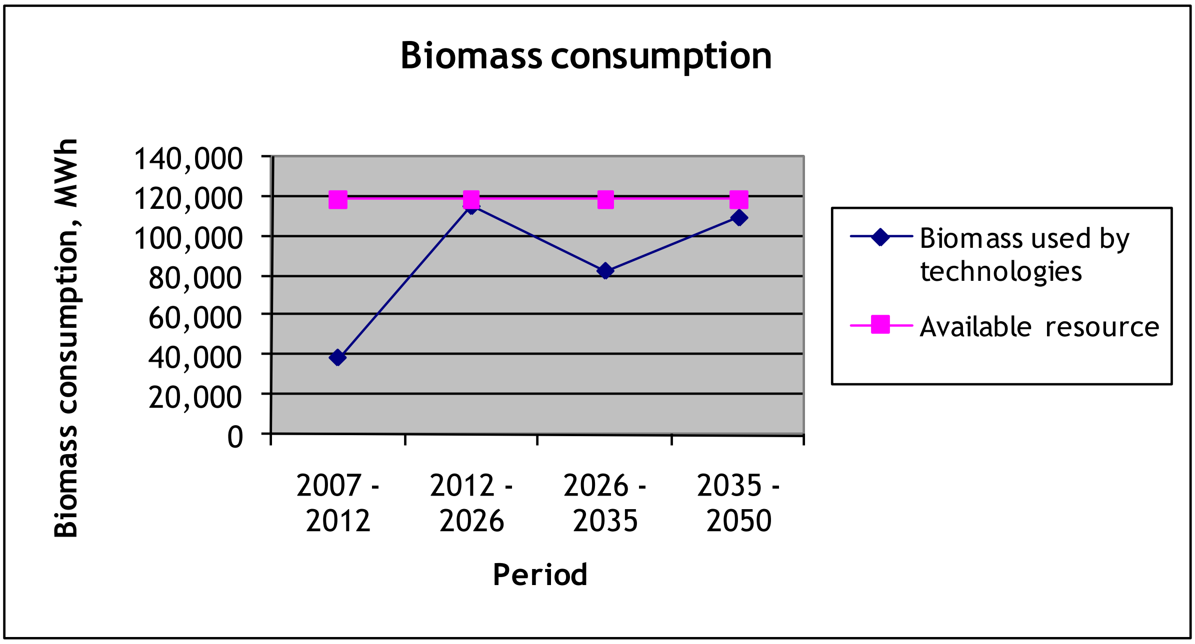


**Figure 22 Biomass consumption, maximum scenario**

### 5.6.4 70% reduction scenario

Given the results of the previous scenarios, it could be useful to examine a 70% target where more a more realistic transport scenario is envisaged and imported biomass is used for CHP but at a lower level than for the 80% scenario.

Based on the data used for the 80% scenario in Table 33, the number of daily deliveries required for 24 MWe biomass CHP in 2035 and 87 MWe in 2050 under this scenario are shown in Table 40 below.

| Conversion method | Deliveries per day (assuming 120 $m^3$ truck volume) | | |
|---|---|---|---|
| | Wood chips | Straw bales | Miscanthus bales |
| Combustion, 24 $MW_e$ | 17 | 22 | 14 |
| Gasification, 24 $MW_e$ | 14 | 18 | 10 |
| Combustion, 87 $MW_e$ | 61 | 81 | 49 |
| Gasification, 87 $MW_e$ | 49 | 67 | 38 |

**Table 40 Biomass delivery rates, 70% scenario**

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| Technology | Units | 2012 | 2026 | 2035 | 2050 |
| Renewable CHP | $MW_e$ | 1 | 4 | 24 | 87 |
| Gas CHP - Large | $MW_e$ | 0 | 132 | 225 | 250 |
| Gas CHP - building | $MW_e$ | 37 | 55 | 20 | 5 |
| Heat from power station | $MW_{th}$ | 0 | 10 | 20 | 25 |
| PV - Domestic | Dwellings | 1000 | 3000 | 10000 | 28000 |

| Technology | Units | Total capacity installed by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| PV- Large | $MW_e$ | 5 | 10 | 25 | 60 |
| Wind - large | $MW_e$ | 0 | 0 | 0 | 0 |
| Wind - medium | $MW_e$ | 0 | 0 | 0 | 0 |
| Wind - small | Dwellings | 0 | 0 | 0 | 0 |
| Solar thermal | Dwellings | 1000 | 1000 | 1000 | 1000 |
| Biomass boilers large | MWth | 5 | 5 | 3 | 0 |
| Biomass boilers small | Dwellings | 500 | 500 | 100 | 0 |
| GSHP | Dwellings | 100 | 200 | 200 | 0 |
| Micro-CHP Stirling | Dwellings | 100 | 200 | 300 | 300 |
| Micro-CHP fuel cell | Dwellings | 0 | 50 | 200 | 300 |
| Cavity wall ins | Dwellings | 10000 | 15000 | 20000 | 23000 |
| Loft insulation | Dwellings | 10000 | 15000 | 30000 | 33000 |
| Double glazing | Dwellings | 2000 | 5000 | 8000 | 10000 |
| Solid wall insulation | Dwellings | 0 | 0 | 0 | 0 |
| Energy Efficient Lighting | 000's $m^2$ | 200 | 400 | 700 | 1200 |
| Double Glazing - Commercial | 000's $m^2$ | 10 | 20 | 30 | 40 |
| Street Lighting - Efficient Lamps | Lamps | 1000 | 3000 | 5000 | 8000 |
| Reduce car passenger-km | million pass-km | 30 | 70 | 100 | 150 |
| Reduce motorcycle passenger-km | million pass-km | 2 | 4 | 5 | 6 |
| Reduce taxi passenger-km | million pass-km | 4 | 6 | 10 | 15 |
| Reduce road freight tonne-km | million t-km | 5 | 20 | 40 | 50 |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 10 | 15 | 20 | 25 |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 5 | 10 | 12 | 15 |
| Reduce $CO_2$ emissions of fleet – taxis | $gCO_2$/pass-km | 10 | 20 | 30 | 40 |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 10 | 20 | 25 | 30 |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5 | 10 | 15 | 20 |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0 | 1 | 2 | 3 |
| Modal shift, cars to public transport | million pass-km | 15 | 50 | 75 | 120 |
| Modal shift, motorcycles to public transport | million pass-km | 2 | 4 | 5 | 6 |
| Modal shift, taxis to public transport | million pass-km | 3 | 10 | 12 | 15 |
| Modal shift, freight road to rail | million t-km | 5 | 20 | 25 | 30 |

**Table 41 proposed scenario to meet a 70% reduction target**

Table 42 below shows the transport measures expressed as a percentage change from the current baseline. This is intended to provide a clearer understanding of the scale of the changes under the proposed scenario.

| Technology | Units | Percentage change by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Reduce car passenger-km | million pass-km | 4% | 9% | 12% | 19% |
| Reduce motorcycle passenger-km | million pass-km | 7% | 13% | 17% | 20% |
| Reduce taxi passenger-km | million pass-km | 5% | 8% | 13% | 20% |
| Reduce road freight tonne-km | million t-km | 1% | 5% | 11% | 14% |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 8% | 12% | 16% | 20% |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 4% | 8% | 10% | 12% |
| Reduce $CO_2$ emissions of fleet – taxis | $gCO_2$/pass-km | 4% | 8% | 12% | 16% |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 7% | 14% | 18% | 21% |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5% | 10% | 15% | 19% |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0% | 4% | 9% | 13% |
| Modal shift, cars to public transport | million pass-km | 2% | 6% | 9% | 15% |
| Modal shift, motorcycles to public transport | million pass-km | 7% | 13% | 17% | 20% |
| Modal shift, taxis to public transport | million pass-km | 4% | 13% | 16% | 20% |
| Modal shift, freight road to rail | million t-km | 1% | 5% | 7% | 8% |

**Table 42 Percentage changes in transport measures, 70% scenario**

The CO2 reductions and capital costs for this scenario are shown in Figure 23 and Figure 24 below.

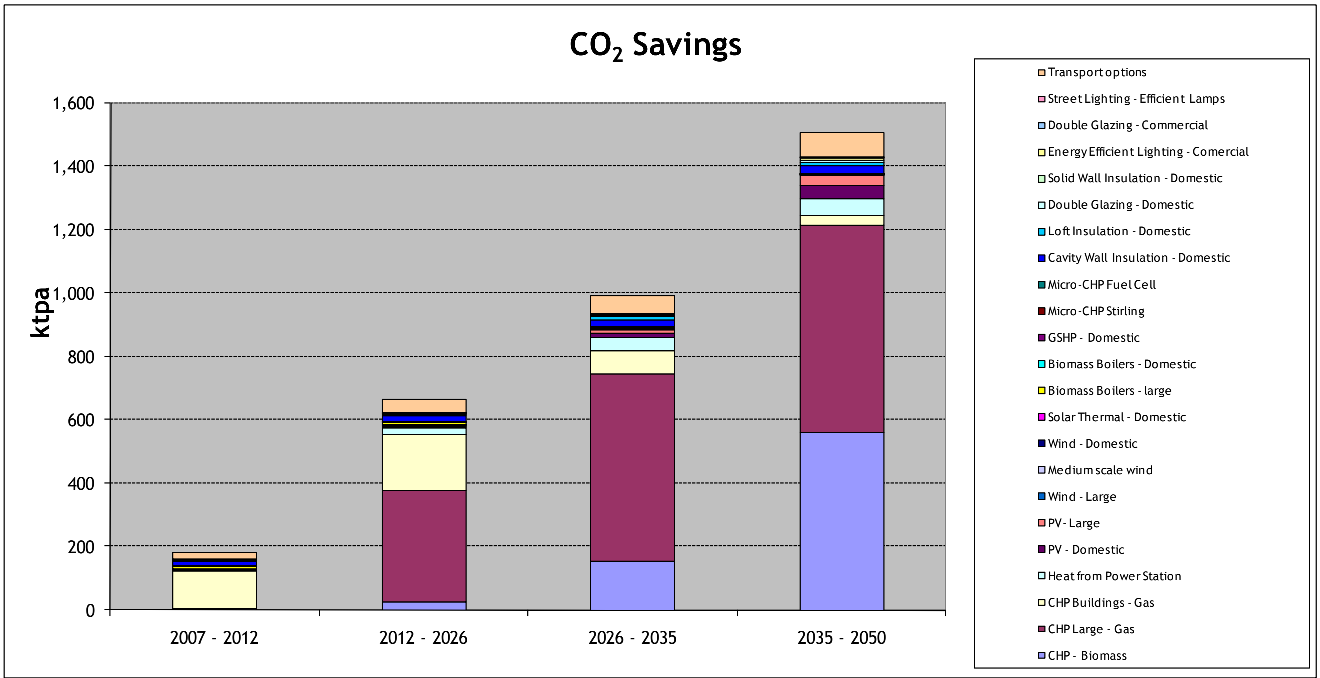


**Figure 23 $CO_2$ emissions savings, 70% scenario**

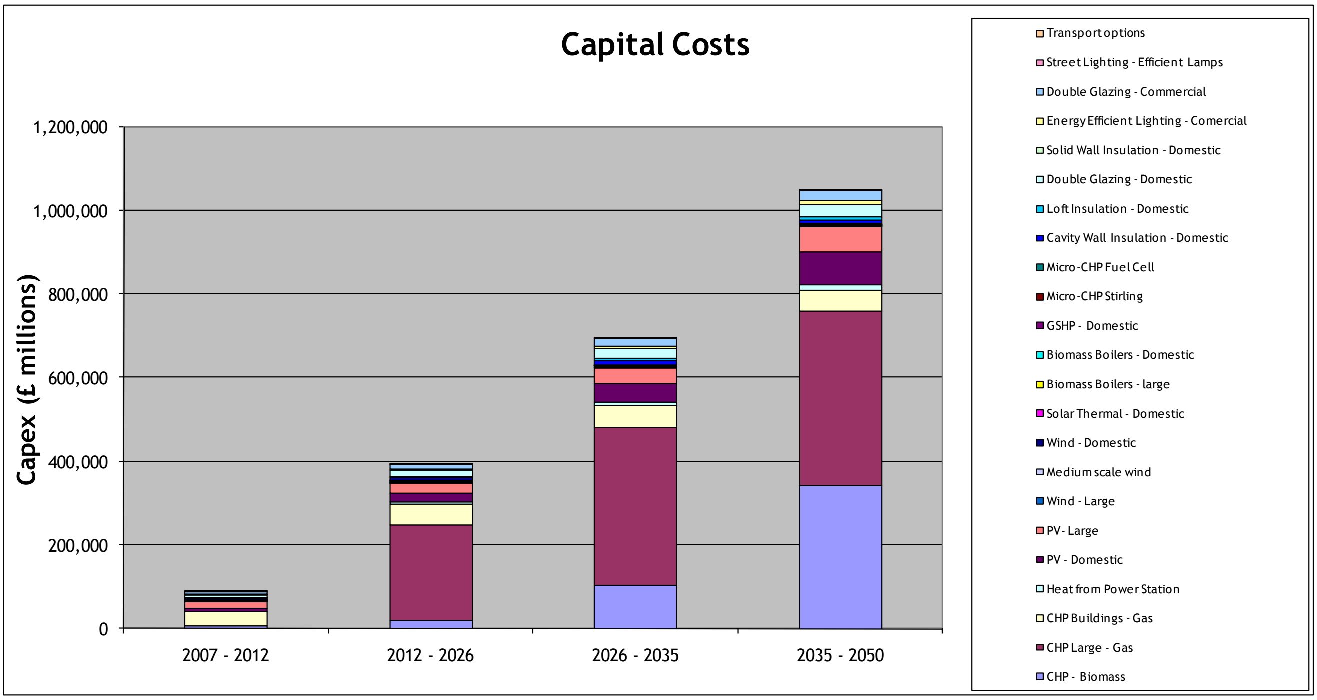


**Figure 24 Capital costs, 70% scenario**

The results for the 70% scenario are summarised in Table 43 below.

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Renewable CHP | $MW_e$ | 87 | 1040 | 563 | 562 | 342 | 14 |
| Gas CHP - Large | $MW_e$ | 250 | 1716 | 1643 | 653 | 418 | 343 |
| Gas CHP - building | $MW_e$ | 5 | 47 | 39 | 32 | 50 | 166 |
| Heat from power station | $MW_{th}$ | 25 | 208 | 0 | 51 | 13 | -3 |
| PV - Dom | Dwellings | 28000 | 0 | 73 | 41 | 78 | -11 |
| PV- Large | $MW_e$ | 60 | 0 | 65 | 37 | 61 | -11 |
| Wind - large | $MW_e$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Wind - medium | $MW_e$ | 0 | 0 | 1 | 0 | 2 | -1 |
| Wind - small | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Solar thermal | Dwellings | 1000 | 0 | 0 | 0 | 0 | 0 |
| Biomass boilers large | $MW_{th}$ | 0 | 2 | 0 | 0 | 1 | -2 |
| Biomass boilers small | Dwellings | 0 | 0 | 0 | 1 | 1 | -4 |
| GSHP | Dwellings | 0 | 0 | 0 | 0 | 2 | -3 |
| Micro-CHP Stirling | Dwellings | 300 | 0 | 0 | 0 | 1 | -1 |
| Micro-CHP fuel cell | Dwellings | 300 | 6 | 1 | 1 | 1 | 0 |
| Cavity wall ins | Dwellings | 23000 | 1 | 1 | 0 | 1 | 0 |
| Loft insulation | Dwellings | 33000 | 95 | 0 | 25 | 9 | 23 |

<table>
<tr><th rowspan="2">Technology</th><th rowspan="2">Units</th><th>Installed capacity</th><th>Heat</th><th>Power</th><th>$CO_2$ savings</th><th>Capital cost</th><th>NPV</th></tr>
<tr><th>By 2050</th><th>GWh/y</th><th>GWh/y</th><th>Ktpa</th><th>£m</th><th>£m</th></tr>
<tr><td>Double glazing</td><td>Dwellings</td><td>10000</td><td>41</td><td>0</td><td>10</td><td>7</td><td>7</td></tr>
<tr><td>Solid wall insulation</td><td>Dwellings</td><td>0</td><td>21</td><td>0</td><td>5</td><td>30</td><td>-18</td></tr>
<tr><td>Energy Efficient Lighting</td><td>000's $m^2$</td><td>1200</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Double Glazing - Commercial</td><td>000's $m^2$</td><td>40</td><td>0</td><td>19</td><td>11</td><td>10</td><td>1</td></tr>
<tr><td>Street Lighting - Efficient Lamps</td><td>Lamps</td><td>8000</td><td>6</td><td>0</td><td>1</td><td>24</td><td>-17</td></tr>
<tr><td>Reduce car passenger-km</td><td>million pass-km</td><td>150</td><td rowspan="14">0</td><td rowspan="14">0</td><td rowspan="14">74</td><td rowspan="14">?</td><td rowspan="14">343</td></tr>
<tr><td>Reduce motorcycle passenger-km</td><td>million pass-km</td><td>6</td></tr>
<tr><td>Reduce taxi passenger-km</td><td>million pass-km</td><td>15</td></tr>
<tr><td>Reduce road freight tonne-km</td><td>million t-km</td><td>50</td></tr>
<tr><td>Reduce $CO_2$ emissions of fleet - cars</td><td>gCO2/pass-km</td><td>25</td></tr>
<tr><td>Reduce $CO_2$ emissions of fleet - motorcycles</td><td>gCO2/pass-km</td><td>15</td></tr>
<tr><td>Reduce $CO_2$ emissions of fleet - taxis</td><td>gCO2/pass-km</td><td>40</td></tr>
<tr><td>Reduce $CO_2$ emissions of fleet - freight</td><td>gCO2/t-km</td><td>30</td></tr>
<tr><td>Reduce $CO_2$ emissions of fleet - buses</td><td>gCO2/pass-km</td><td>20</td></tr>
<tr><td>Reduce $CO_2$ emissions of fleet - trains</td><td>gCO2/pass-km</td><td>3</td></tr>
<tr><td>Modal shift, cars to public transport</td><td>million pass-km</td><td>120</td></tr>
<tr><td>Modal shift, motorcycles to public transport</td><td>million pass-km</td><td>6</td></tr>
<tr><td>Modal shift, taxis to public transport</td><td>million pass-km</td><td>15</td></tr>
<tr><td>Modal shift, freight road to rail</td><td>million t-km</td><td>30</td></tr>
<tr><td>Totals</td><td></td><td></td><td>3182</td><td>2405</td><td>1506</td><td>1051</td><td>826</td></tr>
</table>

**Table 43 Summary of 70% scenario**

#### 5.6.4.1 Gas consumption

Under this scenario overall gas consumption reduces and the rate of reduction increases over time.

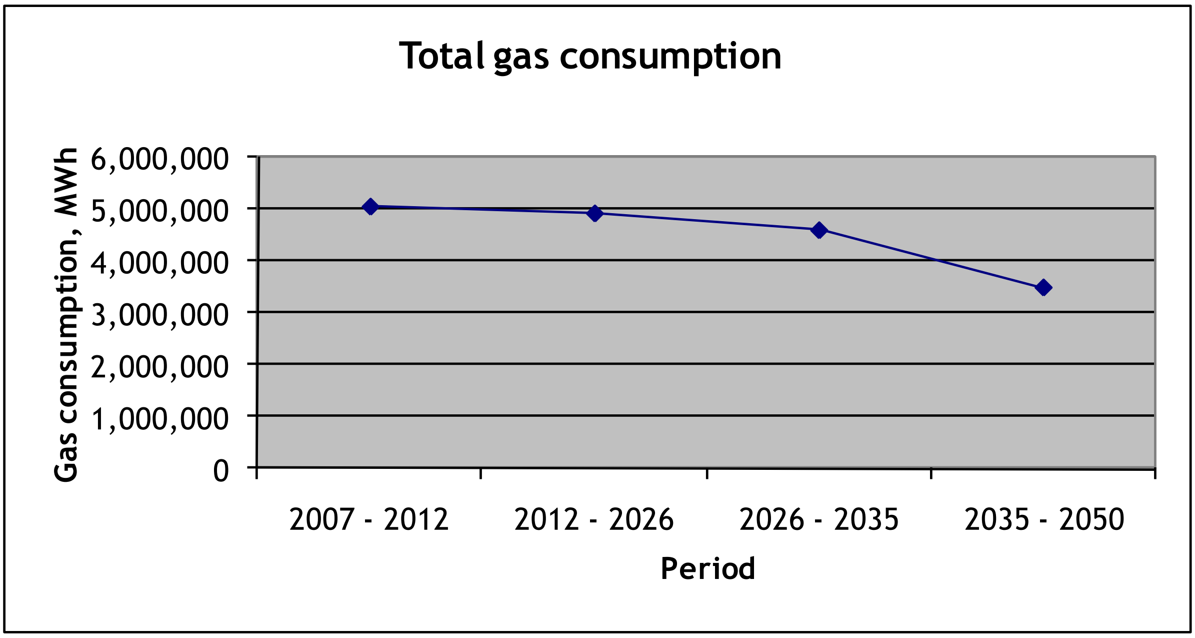


**Figure 25 Gas consumption, 70% scenario**

#### 5.6.4.2 Biomass consumption

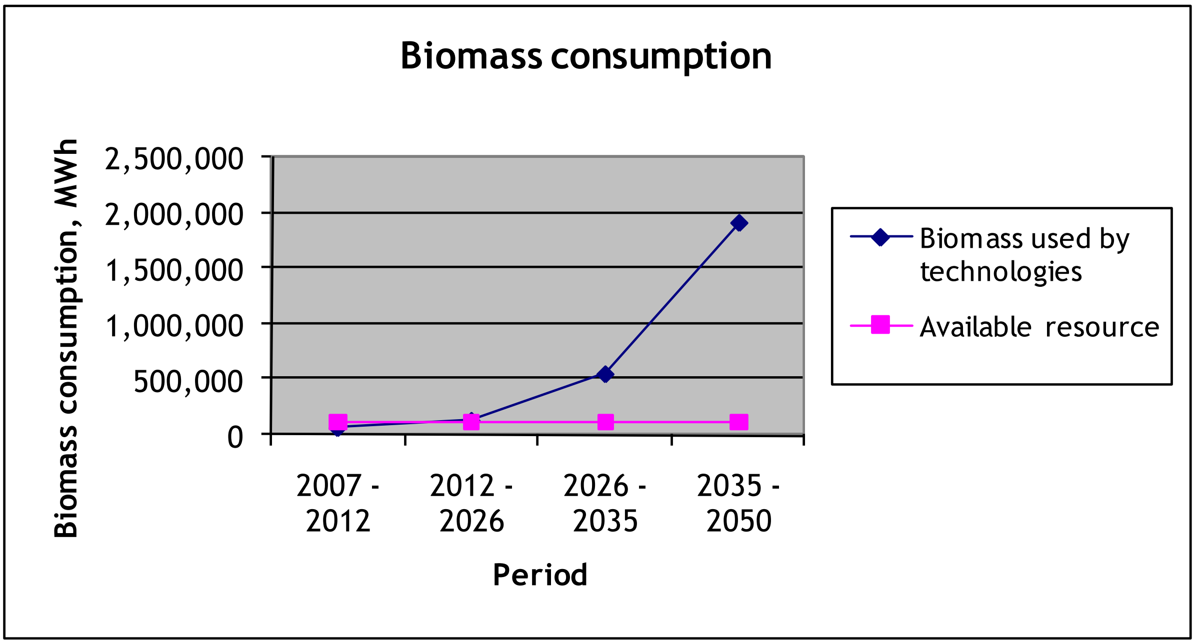


**Figure 26 Biomass consumption, 70% scenario**

### 5.6.5 Renewables and insulation scenario

This scenario is designed to investigate the potential for $CO_2$ reductions without the use of district heating. It therefore seeks to maximise renewable energy generation and energy efficiency measures, but uses no large scale CHP and also cannot take waste heat from an existing power station.

CHP in individual buildings is allowed, but would be limited to sites where there is a sufficient heat load such as large commercial buildings, hospitals or the local authority housing estates currently using community heating systems.

This scenario envisages approximately 50,000 domestic renewable energy installations. This is a high level given that the total housing stock consists of under 93,000 dwellings and not all of these will be suitable for renewable energy installations due to issues such as space and orientation.

In addition, high levels of domestic renewables and solid wall insulation would have a significant visual impact in the borough.

Transport measures are at the same levels as for the 60% scenario.

| | | Total capacity installed by | | | |
|---|---|---|---|---|---|
| **Technology** | **Units** | **2012** | **2026** | **2035** | **2050** |
| Renewable CHP | $MW_e$ | 0 | 0 | 0 | 0 |
| Gas CHP - Large | $MW_e$ | 0 | 0 | 0 | 0 |
| Gas CHP - building | $MW_e$ | 10 | 20 | 40 | 60 |
| Heat from power station | $MW_{th}$ | 0 | 0 | 0 | 0 |
| PV - Domestic | Dwellings | 2000 | 5000 | 15000 | 33000 |
| PV- Large | $MW_e$ | 5 | 20 | 45 | 60 |
| Wind - large | $MW_e$ | 0 | 0 | 1 | 2 |
| Wind - medium | $MW_e$ | 0 | 1 | 1 | 1 |
| Wind - small | Dwellings | 0 | 1000 | 3000 | 5000 |
| Solar thermal | Dwellings | 200 | 1000 | 3500 | 5000 |
| Biomass boilers large | $MW_{th}$ | 2 | 10 | 20 | 25 |
| Biomass boilers small | Dwellings | 200 | 500 | 1000 | 1500 |
| GSHP | Dwellings | 100 | 1000 | 3000 | 5000 |
| Micro-CHP Stirling | Dwellings | 0 | 0 | 0 | 0 |
| Micro-CHP fuel cell | Dwellings | 0 | 0 | 0 | 0 |
| Cavity wall ins | Dwellings | 5000 | 10000 | 15000 | 23170 |
| Loft insulation | Dwellings | 5000 | 15000 | 20000 | 33533 |
| Double glazing | Dwellings | 500 | 5000 | 8000 | 10000 |
| Solid wall insulation | Dwellings | 1000 | 10000 | 30000 | 50000 |
| Energy Efficient Lighting | 000's $m^2$ | 200 | 800 | 1200 | 1500 |
| Double Glazing - Commercial | 000's $m^2$ | 5 | 20 | 50 | 90 |
| Street Lighting - Efficient Lamps | Lamps | 1000 | 4000 | 7000 | 9865 |
| Reduce car passenger-km | million pass-km | 30 | 70 | 100 | 150 |
| Reduce motorcycle passenger-km | million pass-km | 2 | 4 | 5 | 6 |
| Reduce taxi passenger-km | million pass-km | 4 | 6 | 10 | 15 |

| Technology | Units | Total capacity installed by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Reduce road freight tonne-km | million t-km | 5 | 20 | 40 | 50 |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 10 | 15 | 20 | 25 |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 5 | 10 | 12 | 15 |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 10 | 20 | 30 | 40 |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 10 | 20 | 25 | 30 |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5 | 10 | 15 | 20 |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0 | 1 | 2 | 3 |
| Modal shift, cars to public transport | million pass-km | 15 | 50 | 75 | 120 |
| Modal shift, motorcycles to public transport | million pass-km | 2 | 4 | 5 | 6 |
| Modal shift, taxis to public transport | million pass-km | 3 | 10 | 12 | 15 |
| Modal shift, freight road to rail | million t-km | 5 | 20 | 25 | 30 |

**Table 44 Proposed scenario without district heating**

Table 45 below shows the transport measures expressed as a percentage change from the current baseline. This is intended to provide a clearer understanding of the scale of the changes under the proposed scenario.

| Technology | Units | Percentage change by 2012 | 2026 | 2035 | 2050 |
|---|---|---|---|---|---|
| Reduce car passenger-km | million pass-km | 4% | 9% | 12% | 19% |
| Reduce motorcycle passenger-km | million pass-km | 7% | 13% | 17% | 20% |
| Reduce taxi passenger-km | million pass-km | 5% | 8% | 13% | 20% |
| Reduce road freight tonne-km | million t-km | 1% | 5% | 11% | 14% |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 8% | 12% | 16% | 20% |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 4% | 8% | 10% | 12% |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 4% | 8% | 12% | 16% |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 7% | 14% | 18% | 21% |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 5% | 10% | 15% | 19% |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 0% | 4% | 9% | 13% |
| Modal shift, cars to public transport | million pass-km | 2% | 6% | 9% | 15% |
| Modal shift, motorcycles to public transport | million pass-km | 7% | 13% | 17% | 20% |
| Modal shift, taxis to public transport | million pass-km | 4% | 13% | 16% | 20% |
| Modal shift, freight road to rail | million t-km | 1% | 5% | 7% | 8% |

**Table 45 Percentage changes in transport measures, renewables and insulation scenario**

Figure 27 shows the $CO_2$ savings by technology for the scenario. The total $CO_2$ reduction is 528 ktpa by 2050, a reduction of just 25%. The biggest reductions are from building CHP, PV, biomass boilers, solid wall insulation and transport measures.

It is possible to achieve slightly higher $CO_2$ reductions by introducing CHP in individual dwellings. However, since the model was created there have been some setbacks in the development of these technologies and their use has been avoided in the scenarios on the basis that it is not a proven technology. In any case, the savings would be small, an extra 15 ktpa from installing 10,000 systems.

Maximising the transport measures to the levels shown in the maximum scenario would increase savings to approximately 650 ktpa. However as discussed previously this is not put forward as a realistic scenario.

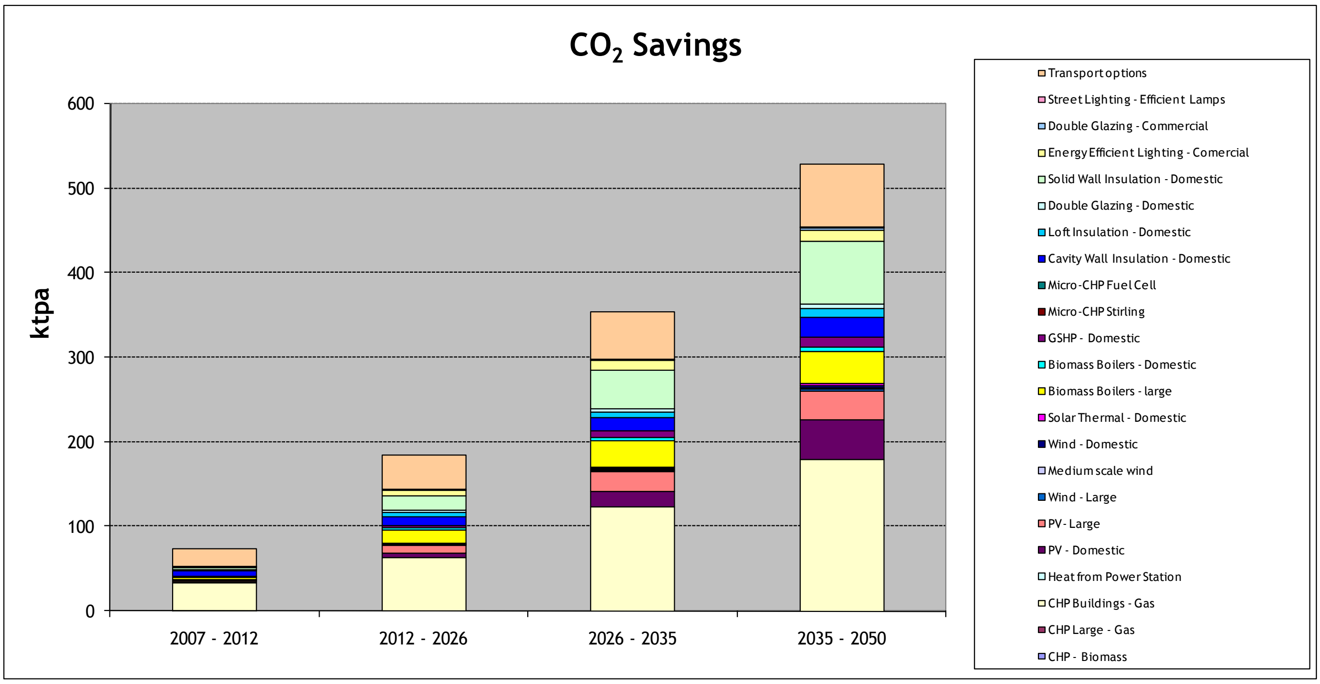


**Figure 27 $CO_2$ emissions savings, renewables and insulation scenario**

Figure 28 shows the capital costs by technology for the scenario. The highest capital costs are for solid wall insulation, PV, double glazing and building CHP.

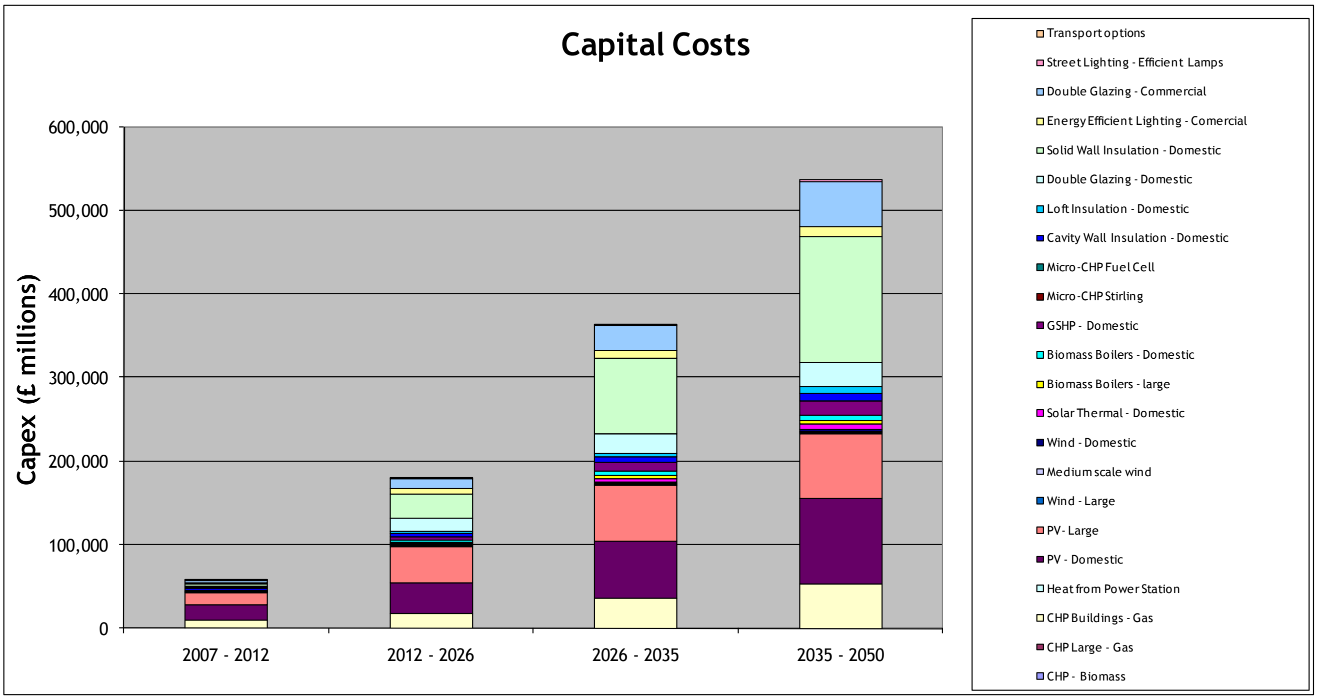


**Figure 28 Capital costs, renewables and insulation scenario**

Table 46 summarises the results of this scenario. It can be seen that building CHP and the transport measures make the biggest contributions to the positive NPV. Loft insulation and cavity wall insulation are also financially attractive. However, without the savings in fuel from the transport measures, the scenario only just has a positive NPV. Since no capital cost is assumed for the transport measures, the financial viability of this scenario is questionable.

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Renewable CHP | $MW_e$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas CHP - Large | $MW_e$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas CHP - building | $MW_e$ | 60 | 568 | 473 | 179 | 53 | 119 |
| Heat from power station | $MW_{th}$ | 0 | 0 | 0 | 0 | 0 | 0 |
| PV – Dom | Dwellings | 33000 | 0 | 84 | 47 | 103 | -19 |
| PV- Large | $MW_e$ | 60 | 0 | 59 | 34 | 77 | -16 |
| Wind - large | $MW_e$ | 2 | 0 | 4 | 2 | 1 | 1 |
| Wind - medium | $MW_e$ | 1 | 0 | 2 | 1 | 1 | 1 |
| Wind - small | Dwellings | 5000 | 0 | 6 | 3 | 4 | 1 |
| Solar thermal | Dwellings | 5000 | 8 | 0 | 2 | 5 | -3 |
| Biomass boilers large | $MW_{th}$ | 25 | 153 | 0 | 38 | 5 | -9 |
| Biomass boilers small | Dwellings | 1500 | 22 | 0 | 5 | 7 | -5 |
| GSHP | Dwellings | 5000 | 66 | 0 | 12 | 17 | -15 |
| Micro-CHP Stirling | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Micro-CHP fuel cell | Dwellings | 0 | 0 | 0 | 0 | 0 | 0 |
| Cavity wall ins | Dwellings | 23170 | 96 | 0 | 24 | 9 | 15 |
| Loft insulation | Dwellings | 33533 | 41 | 0 | 10 | 7 | 5 |
| Double glazing | Dwellings | 10000 | 21 | 0 | 5 | 30 | -17 |
| Solid wall insulation | Dwellings | 50000 | 309 | 0 | 74 | 150 | -20 |
| Energy Efficient Lighting | 000's $m^2$ | 1500 | 0 | 24 | 14 | 12 | 1 |
| Double Glazing - Commercial | 000's $m^2$ | 90 | 12 | 0 | 3 | 54 | -27 |
| Street Lighting - Efficient Lamps | Lamps | 9865 | 0 | 1 | 1 | 3 | -1 |
| Reduce car passenger-km | million pass-km | 150 | | | | | |
| Reduce motorcycle passenger-km | million pass-km | 6 | | | | | |
| Reduce taxi passenger-km | million pass-km | 15 | 0 | 0 | 74 | ? | 343 |
| Reduce road freight tonne-km | million t-km | 50 | | | | | |
| Reduce CO2 emissions of fleet - cars | gCO2/pass-km | 25 | | | | | |

| Technology | Units | Installed capacity | Heat | Power | $CO_2$ savings | Capital cost | NPV |
|---|---|---|---|---|---|---|---|
| | | By 2050 | GWh/y | GWh/y | Ktpa | £m | £m |
| Reduce CO2 emissions of fleet - motorcycles | gCO2/pass-km | 15 | | | | | |
| Reduce CO2 emissions of fleet - taxis | gCO2/pass-km | 40 | | | | | |
| Reduce CO2 emissions of fleet - freight | gCO2/t-km | 30 | | | | | |
| Reduce CO2 emissions of fleet - buses | gCO2/pass-km | 20 | | | | | |
| Reduce CO2 emissions of fleet - trains | gCO2/pass-km | 3 | | | | | |
| Modal shift, cars to public transport | million pass-km | 120 | | | | | |
| Modal shift, motorcycles to public transport | million pass-km | 6 | | | | | |
| Modal shift, taxis to public transport | million pass-km | 15 | | | | | |
| Modal shift, freight road to rail | million t-km | 30 | | | | | |
| **Totals** | | | **1296** | **653** | **528** | **538** | **356** |

**Table 46 Summary of renewables and insulation scenario**

### 5.6.5.1 Gas consumption

Figure 29 shows the total gas consumption under this scenario. Gas consumption reduces under this scenario because of local energy efficiency measures and some displacement through the use of renewables. However, note that under this scenario the majority of electricity demand is still supplied by the national grid, so this scenario would still rely on a considerable amount of electricity generated in coal or nuclear power stations.

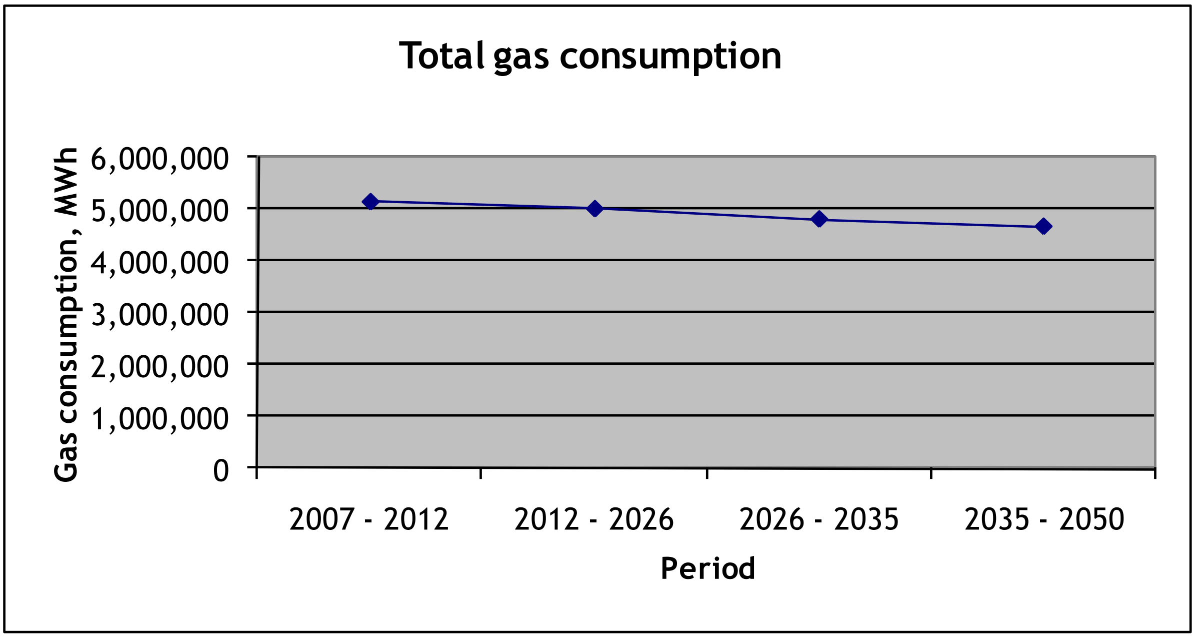


**Figure 29 Gas consumption, renewables and insulation scenario**

#### 5.6.5.2 Biomass consumption

Figure 30 shows that biomass consumption steadily increases to 2050 and does increase beyond the available resource from within London, although by an amount that would be feasible to supply. In this scenario where consumers have individual biomass boilers there would be little control over biomass supply because each customer could choose to buy fuel from any supplier. This is in contrast to other scenarios where biomass is used in large CHP plant where the local authority could influence procurement through its ESCo.

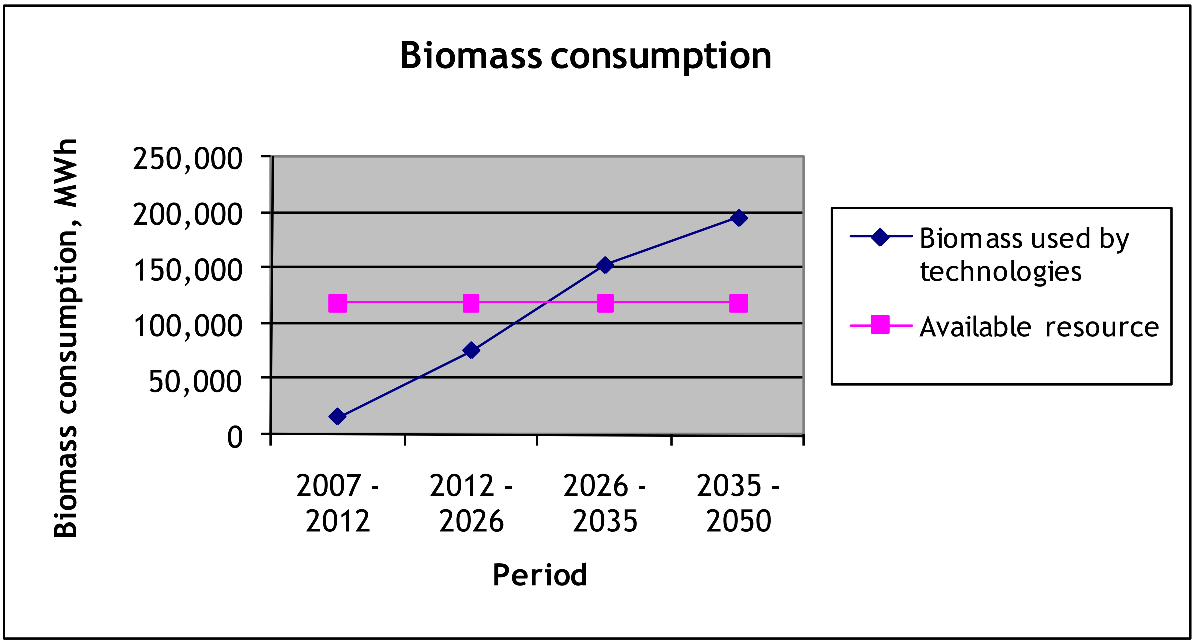


**Figure 30 Biomass consumption, renewables and insulation scenario**

## 5.7 Comparison of scenarios

This section shows a comparison of the five scenarios proposed.

The maximum scenario proposes an unrealistic transport scenario, which gives a high NPV because the model assumes no capital cost for transport measures but this scenario would result in significant fuel savings. It also displaces more heat and power than the other scenarios.

The renewables and insulation scenario generates considerably less heat and power than the other scenarios. Capital costs are lower because no CHP is installed, but this also results in a lower NPV and much lower $CO_2$ savings than the other scenarios. This clearly demonstrates that higher $CO_2$ reduction targets can only be met by the extensive use of district heating and CHP technologies unless significant lifestyle changes are made.

The 60%, 70% and 80% scenarios have increasing capital costs but comparable NPVs, of which the best is for the 70% scenario. All three displace similar quantities of heat but decreasing quantities of power. This is because biomass CHP has a higher heat to power generation ratio compared to gas CCGT.

| Scenario | Name | Heat | Power | $CO_2$ Savings | Net Present Value | Capital Costs | % of borough heat demand met by CH |
|---|---|---|---|---|---|---|---|
| | | MWh/y | MWh/y | Ktpa | £k | £k | % |
| 1 | 60% by 2050 | 3,209,124 | 2,818,273 | 1,329 | 799,901 | 937,990 | 92.2% |
| 2 | 70% by 2050 | 3,181,563 | 2,404,933 | 1,506 | 826,463 | 1,051,389 | 92.8% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 80% by 2050 | 3,212,876 | 2,026,076 | 1,686 | 733,081 | 1,561,314 | 93.7% |
| 4 | Maximum | 3,207,871 | 3,075,240 | 1,498 | 1,452,235 | 1,048,333 | 99.8% |
| 5 | Renewables and insulation | 1,295,624 | 652,820 | 528 | 355,850 | 537,850 | 0.00% |

**Table 47 Summary of scenarios**

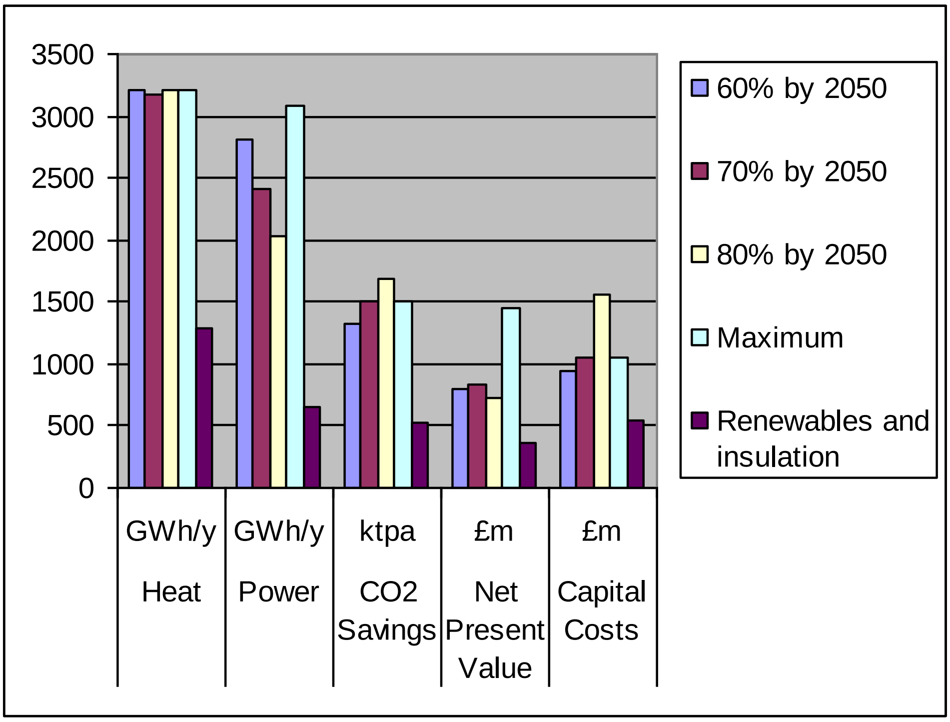


**Figure 31 Summary of scenarios**

## 5.8 Meeting higher targets

This analysis has shown that a target of 60% can be met using the measures proposed in this scenario model. Higher targets of 70% or 80% could also be met, but these scenarios rely on sourcing large quantities of non local biomass. It has not been possible to demonstrate meeting a 90% reduction target.

There are of course other ways to reduce emissions that are not included in the scenario measures. These might enable higher targets to be met.

### 5.8.1 Demand reduction

The scenario modelling assumes a constant demand for heat and power, plus additional demand due to growth in the borough. Some measures reduce this demand, such as insulation or energy efficient lighting. There are various other ways in which demand could be reduced.

Counter-intuitively, reducing thermal demand when CHP with community heating is available might not actually reduce $CO_2$ emissions as discussed in Appendix C.

#### 5.8.1.1 Domestic sector

Measures not included in the scenario modelling that could reduce energy demand include draft proofing, floor insulation, hot water tank and pipe work insulation and low energy light bulbs.

In addition, there are behavioural changes that can save energy such as simply turning down the heating. Reducing electricity demand would be of particular benefit by for example switching off appliances on stand by, using more efficient appliances or just using less electrical appliances altogether. These kind of behavioural changes are obviously difficult to plan for or enforce. They are most likely to come about through increased energy prices, personal carbon allowances or national or EU legislation to influence the efficiency of appliances.

#### 5.8.1.2 Non Domestic sector

Non domestic buildings are much more variable than dwellings in their hours of use, occupancy rates, internal heating gains, temperature requirements etc. This makes it much more difficult to generalise about energy efficiency measures in the same way as for housing. In particular, typical payback times and $CO_2$ savings will vary by building type and activity.

However, the following lists indicate some of the measures that might be appropriate to improve energy efficiency in commercial buildings.

##### *5.8.1.2.1 Insulation*

- Roof insulation or insulated suspended ceilings
- Wall insulation – cavity fill, external insulation or internal dry lining
- Floor insulation on exposed ground floors or where upper floors overhang untreated space

##### *5.8.1.2.2 Draught proofing*

- Consider adding draught lobbies and / or fast acting automatic doors to busy entrances
- Install draught stripping on doors and windows
- Ensure doors and windows fit tightly in their frames, close securely and any gaps are sealed

##### *5.8.1.2.3 Overheating*

Overheating is often a major problem in commercial buildings, and one that could get worse as climate change leads to hotter summers.

- Fit external shading
- Use internal blinds or blinds between glazing panes if fitting new windows
- Use coated glazing to reduce solar heat gains

##### *5.8.1.2.4 Heating and cooling controls*

Heating and cooling controls need to be designed so that the heating or cooling is not on when or where it is not needed, is not providing excessive output and so that any faults can be quickly detected.

This might involve zoning, using time controls and using thermostatic controls.

##### *5.8.1.2.5 Lighting controls*

Lighting is often the single biggest energy user in commercial buildings. Lighting energy use can be reduced by choosing the most efficient lamps and fittings and by appropriate controls such as occupancy sensors and illuminance sensors with auto dimming.

##### *5.8.1.2.6 Efficient plant*

Replacing old heating and cooling plant with the most efficient modern versions could significantly reduce fuel consumption and therefore $CO_2$ emissions.

##### *5.8.1.2.7 Absorption cooling*

It is possible to use heat from CHP to provide cooling using absorption chillers. This could be done by distributing chilled water as well as hot water in a centralised system. Alternatively, absorption chillers could use the hot water locally to provide cooling.

This measure has not been included in the model for various reasons. One is that since most cooling uses electricity as a fuel, it is difficult to estimate cooling loads as this cannot be disaggregated from total electricity consumption data.

In addition, the carbon benefits of absorption cooling are not clear cut. The Coefficient of Performance (COP) of a typical air conditioning system is around 2.5, i.e. for each unit of electricity input 2.5 units heat are removed. For absorption cooling, the COP is around 0.9, i.e. each unit of heat input provides 0.9 units of cooling. For a CCGT operating at 45% electrical efficiency and 45% thermal efficiency, it could be more efficient to use electricity to provide cooling due to the higher COP. Where electrical efficiencies are lower, for example in waste incinerators, the situation could be reversed. Absorption cooling can certainly improve the economics of CHP, and could be beneficial where the waste heat has no other use and displaces existing cooling load.

Cooling demands might also be expected to increase due to future climate change, adding another level of complexity to the problem.

### 5.8.2 Changes in growth forecasts

The scenario modelling has adopted the approach of assuming relatively high growth rates in the borough. These are based on shorter term projections and extrapolated to 2050, which might turn out to be unrealistic. An alternative assumption would be to use the London Plan projections to 2026 and then assume no growth or reduced growth from 2026 to 2050. This would make a target of 70% more achievable.

### 5.8.3 Grid electricity

National government and EU renewable energy targets should mean that significantly more grid electricity is supplied through renewables by 2050. This would reduce the $CO_2$ emissions factor for grid electricity. There are several reasons why it is problematic to factor this in to the model. One is that it is very difficult to predict future emissions factors. More importantly, there is currently a different emissions factor for displaced electricity than for delivered electricity giving local generators a credit for displacing central fossil fuel generation. The scenarios presented here are net power exporters by 2050 and the credit would also reduce if the grid mixed changed to a lower carbon mix.

## 5.9 Security of fuel supply

Examining energy scenarios as far into the future as 2050 can raise concerns about the security of fuel supplies. It is well known that North Sea gas supplies are diminishing and that the UK is expected to import more gas in the near future to meet rising demand. Since demand is rising across the world, there is likely to be increasing pressure on supplies of all fuels as time goes on.

Clearly there is considerable uncertainty in future energy supplies and we cannot know whether the fuels needed under the proposed scenarios will be available over such long timescales. In preparing this report we have examined technologies and fuels that are currently available.

Fuel supply issues are a national problem that cannot be dealt with at borough level. Obviously Camden has no local fuel reserves and will rely on fuel imports of some kind.

Despite the uncertainty, the scenarios proposed do offer some potential to address security of supply.

Firstly, the scenarios proposed would mean that gas is used considerably more efficiently than at present. Clearly this could help reduce the impact of fuel shortages and allow for more time to develop alternatives.

Secondly, CHP with district heating is inherently more flexible in terms of choice of fuels. It would be considerably less disruptive to modify or replace one central power station than many thousands of individual boilers, since the heat distribution infrastructure can remain in place whatever fuel is chosen to supply the heat. The current approach of distributing natural gas to buildings means that the fuel distribution infrastructure is likely to require replacement in the event of a move away from gas to alternative fuels.

## 5.10 Biomass fuel

The possible use of large quantities of biomass fuel raises several issues. One of these is the problem of storage or deliveries, which has been addressed in the discussions of the individual scenarios. The issues of transport distances, air quality and fuel availability are discussed briefly here.

### 5.10.1 Air quality

This report necessarily focuses on $CO_2$ emissions rather than any other pollutants. Of course the combustion of any fuel produces various emissions to atmosphere such as nitrogen oxides, carbon monoxide and particulate matter.

Natural gas is a particularly clean fuel, so replacing it with biomass fuel could potentially affect air quality. The RCEP state that biomass plant can be designed to meet any relevant legislation. It is certainly possible to use gas cleanup technologies on large plant to meet pollution control regulations and on a smaller scale, boilers are available that are authorised for use in smoke control areas. However, it is acknowledged that locating biomass plant in areas of poor air quality could exacerbate existing problems. This is a potential danger since these scenarios do propose moving power stations into Greater London in order to make use of the waste heat.

This is an area that would require further investigation. In particular, the scenario model could in principle be adapted to use emissions factors for pollutants other than $CO_2$. This would enable the air quality for the whole scenario to be examined. It is possible that emissions from one source might be offset by a reduction in emissions due to another measure in the scenario.

The use of large biomass CHP rather than smaller plant in individual buildings also offers potential advantages in terms of air quality. One is that large CHP plant could potentially be located towards the edge of Greater London and serve more than one borough, rather than be located within Camden itself. Another is that a large power station is more likely to employ sophisticated exhaust gas cleaning equipment.

### 5.10.2 Transport

Based on data from the report by the RCEP[29], it is possible to calculate the $CO_2$ impact of the transport of biomass. Table 48 below shows the distance that biomass could be transported while limiting the transport emissions to 5% of the saving in $CO_2$ as a result of using the biomass to displace gas.

| Transport mode | Distance (km) |
|---|---|
| Road | 180 - 275 |
| Rail | 1000 - 1750 |
| Sea | 2050 - 4100 |
| Waterways | 750 - 2250 |

**Table 48 Transport distances for biomass**

[29] *Biomass as a Renewable Energy Source*, RCEP, 2004.

Clearly it is possible to transport biomass from much of the UK by road to London, or from abroad using rail or sea, and still consider it a low carbon fuel.

### 5.10.3 Fuel availability

The RCEP report[30] examines targets for biomass generation of up to 16 GW by 2050 for the whole of the UK, which would supply 12% of primary energy demand and require 32% of UK agricultural holdings to be used for fuel crops. This is clearly an ambitious target, but is potentially feasible. Land could be used that is not currently required for food production, but there could be conflicts between this aim and the provision of biofuels for transport.

Dividing 16 GW into fair shares by population would suggest 2 GW for London and 60 MW for Camden. This is close to the figure proposed for the 70% scenario. It seems that the 70% scenario could be realistic though ambitious but the 80% scenario is probably not realistic.

The availability of large quantities of biomass fuel will depend on national policies and possibly foreign imports. These might be beyond the control of an individual borough.

[30] *Biomass as a Renewable Energy Source*, RCEP, 2004.

# 6 Implementation

## 6.1 Introduction

This chapter outlines some of the measures that Camden can take to achieve its $CO_2$ emission reduction targets. Obviously not all the actions that need to happen are entirely within the control of the local authority. However, there is still a lot that LBC can achieve.

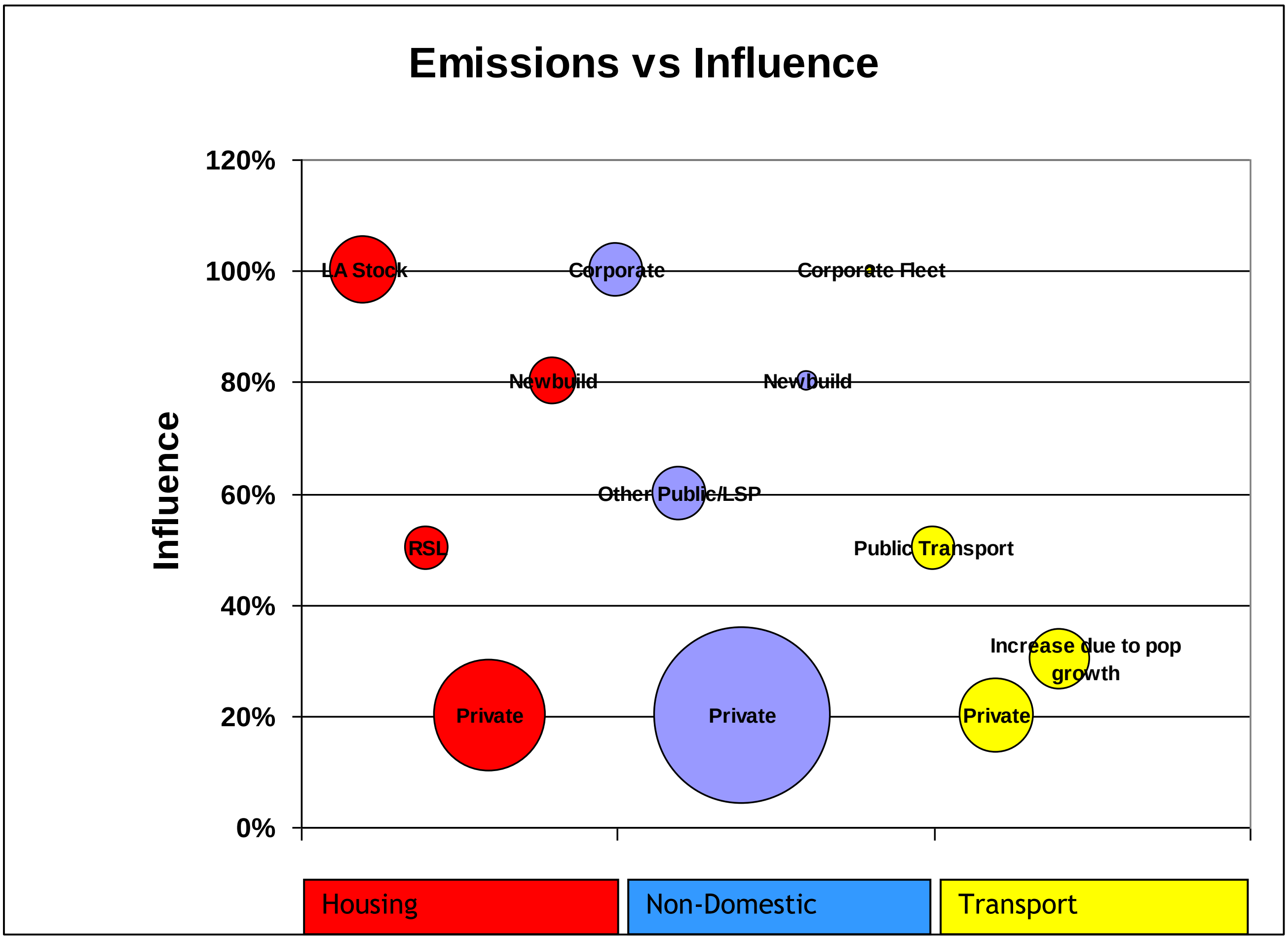


**Figure 32: Influence vs. Emissions**

Figure 32 indicates the amount of influence the borough has over various sectors, measured on a percentage scale. The size of the circles is proportional to the annual emissions produced by that sector.

At first glance it might be noted that there appears to be an inverse relationship between emissions and influence. However, there is no sector that LBC cannot exert at least some influence on. Those sectors where influence is estimated at 50% or above do represent a significant proportion of the total emissions.

This also illustrates the importance of leading by example and partnership working. By engaging partners in each of the sectors shown here, their influence can be added to the mix and more can be achieved. If the borough can achieve significant reductions in its own corporate emissions, then even though these emissions are relatively small, it will set an example that will filter down to other businesses and residents in the borough. Local Authorities can also set an example upwards, to central government. This is important, because central government can exert a significant influence on all sectors.

## 6.2 Leading by example

LBC must reduce its own corporate emissions as part of implementing this strategy. For transport, the recommended measures are outlined in the transport section below. Similarly, many of the building sector measures apply to the council stock.

The key measures for LBC building sector corporate emissions are:

- Undertake an energy audit of the council stock and implement any feasible energy efficiency measures.
- Install at least one visible renewable energy or low carbon technology installation on a council building or council land soon after the adoption of the strategy. A biomass boiler, large building CHP or large PV array would be suitable technologies.
- Advertise the work that the council is doing on its buildings and transport to reduce emissions.

## 6.3 Setting the Planning Framework

A few years ago, the idea that the planning system could be used to determine the energy performance of buildings would have seemed improbable. Tentative wording in planning guidance to 'encourage' developers to orientate buildings to maximise winter solar gains or to 'consider' higher energy efficiency standards were widespread but had limited effect. The national Building Regulations set the framework for the energy standards and developers tended to build to meet the minimum standards.

Then the introduction by the London Borough of Merton of a requirement for 10% of energy requirements to be supplied by on-site renewables opened up a whole possibility of using the planning system. Now 25% of UK local authorities have a 10% on site renewables requirement and this is also included in the London Plan.

In implementing this strategy Camden needs to think carefully about how the planning system will interact with, regional planning frameworks, national Building Regulations and the use of combined heat and power and community heating.

### 6.3.1 10% renewables requirement

ACTION PLAN NUMBERS 2, 3

Camden has a policy of requiring all major developments in the borough to supply 10% of their energy from on-site renewables, laid out in the UDP and Climate Change Strategy 2006 to 2009. This strategy envisages a heat network supplying over 90% of the boroughs thermal demand and therefore connecting to a large number of the buildings in Camden. As discussed in Appendix C, it does not make sense to supply renewable heat where community heating is available. It is therefore recommended that in areas where a heat network will be developed, the 10% requirement should be restricted to electricity generating technologies.

The 10% requirement could be improved to encourage electrical technologies by changing the requirement to a carbon based rule. That is, renewables should be installed such that carbon dioxide emissions are reduced by 10% (as opposed to supplying 10% of the energy). This is because electricity has a higher carbon emission factor than heat from gas. Therefore to reduce $CO_2$ emissions by 10% using a renewable electricity installation would require a smaller installed capacity than meeting 10% of the energy requirement.

At present, the 10% rule applies only to major developments. It should be made mandatory for all developments to increase the uptake of renewables.

Finally, the percentage required should be increased over time. There should not be a long delay in increasing to 20% and beyond.

### 6.3.2 Low carbon buildings

ACTION PLAN NUMBERS 10,12

Camden should adopt a policy requiring all building work subject to building regulations to exceed building regulations carbon targets by 40%.

In areas where a heat network will be available, new buildings and major refurbishments should be required to be made ready for community heating connection.

## 6.4 Encourage development of a heat network

ACTION PLAN NUMBERS 4, 5, 6, 14

This strategy illustrates that a community heating network supplied by CHP will be essential for Camden to meet its targets in a cost effective way. This will deliver the majority of the $CO_2$ reduction necessary. An outline of how this might be started is given in this report. The next steps are:

- Commission a study to investigate the setting up of a community heating network and associated CHP power station(s). This will need to look at phasing and pipe routes. It will also need to determine the appropriate size, type and location of power stations
- Work with partners including the existing local power stations, particularly Edmonton, and neighbouring boroughs to establish connections to these
- Identify businesses and local strategic partner sites (such as hospitals) with high heat loads and involve them in the scheme
- Set up an ESCo as a vehicle for supplying the infrastructure for the community heating scheme
- Begin development of the network, especially where regeneration is happening anyway

## 6.5 Encouraging large scale renewable energy installations

ACTION PLAN NUMBERS 1, 7, 8, 15

This strategy has identified two important renewable energy technologies that will operate on a larger scale than individual buildings. These are biomass CHP (using the heat network) and solar PV. Wind turbines might also be used to meet higher targets in the future.

Some biomass boiler installations are envisaged to meet short term targets, to be phased out and replaced by CHP in the future.

Biomass CHP represents the most efficient means of using a limited biomass resource, and is a useful lower carbon supplement to the main gas CHP generation. If larger quantities of biomass become available, biomass CHP could become the principal energy technology in the borough.

Solar PV is expensive at the moment, but is expected to fall in price in the future, particularly in the last period analysed here (2035 to 2050). It is a technology that is long lasting with low maintenance. It is also unobtrusive and there are a lot of existing surfaces especially roofs where it could be easily fitted.

Steps Camden can take to enable the development of these technologies are:

- Identify suitable sites in the borough for PV and biomass generation. These could be council or privately owned
- Identify transport routes for biomass imports into the borough. Preference should be given to water or rail transport over roads
- Establish an energy crop consortium, perhaps in the neighbouring counties of Buckinghamshire, Hertfordshire and Essex to secure supplies

## 6.6 Energy efficiency measures

### 6.6.1 Domestic

ACTION PLAN NUMBERS 23, 24, 25

The existing housing stock represents a significant proportion of emissions. Many existing houses are very inefficient, and much of the housing standing today will still be in use in 2050. This can be improved by changing the supply of energy as mentioned above. However it will also be necessary to improve the efficiency of the existing stock.

This strategy envisages that by 2050 nearly all feasible efficiency measures will have been carried out on the existing housing stock. This work has already started, but could be increased. Measures that could help include:

- Maintaining the database of housing stock condition to target energy efficiency measures. This should include all dwellings (LA stock, RSL stock and private houses)
- Offering additional grants or local tax incentives to householders for energy efficiency work
- Expand energy efficiency programme in LA stock
- Use influence to encourage RSLs and private householders to implement energy efficiency measures and to supply data. This could be through tax systems, preferred lists for RSLs, the planning system etc

### 6.6.2 Non-domestic

ACTION PLAN NUMBERS 13, 16, 17, 18, 20, 21, 22

As with housing, it is important to tackle energy efficiency in the non-domestic sector. Although the borough possibly has less influence on this sector, there are many measures that can easily be implemented and Camden must do all it can to encourage them to happen.

- A database should be developed and maintained of non-domestic building stock condition in order to target measures effectively.
- Businesses should be encouraged to complete energy audits. This could be a requirement under procurement rules for companies supplying the council. The borough could also facilitate audits of whole industrial estates.
- Explore the possibility of obtaining special dispensation to use local tax incentives to encourage businesses to improve energy efficiency.
- The council and local strategic partners should lead by example and publicise the work they are doing.
- An EPBD early implementation scheme could be encouraged, which requires energy auditing.

### 6.6.3 Cross cutting

ACTION PLAN NUMBER 11

It is recommended that a voluntary carbon trading scheme be introduced for householders and businesses in the borough. This would have several advantages:

- It would impose reduction targets (albeit voluntary) on scheme members, in line with (or exceeding) the strategy targets.
- It would enable useful monitoring of emissions from local businesses and residents.

- It would set a useful example for others to follow, and provide valuable information on the best ways to run such schemes.

## 6.7 Transport

Camden is recognised as a leading borough in sustainable transport and has achieved noticeable reductions in traffic volumes and carbon dioxide emissions from transport in the borough, at 12% of total emissions, are already much lower than the national or London average. Further reducing carbon dioxide emissions from transport in Camden will require a partnership approach with neighbouring boroughs, Transport for London and the rail companies. The figures for transport given in this chapter are those produced within the borough, but many of these emissions will be from vehicles which pass through the borough without stopping and are therefore less likely to be influenced by any measures put in place in Camden alone. Conversely many of the journeys made by Camden residents and workers will take place largely outside the borough and people within the borough will also generate considerable freight traffic both in the UK and overseas through their purchasing behaviour (see section 3.1).

Whilst most of the actions listed in the Action Plan are designed to be implemented by LBC they will be much more effective if similar measures are implemented in neighbouring boroughs and working closely with TfL and neighbouring boroughs will be crucial. It should also be remembered that reducing $CO_2$ emissions from transport is likely to bring other benefits such as reduced noise, improved air quality, better health (from more walking and cycling), social benefits (making streets a more pleasant place to be), safety improvements (less road casualties, reduced fear of crime) and local economic benefits (revitalising town centres and local shops).

## 6.8 Opportunities for reducing $CO_2$ emissions from transport in Camden

### 6.8.1 Within LBC

ACTION PLAN NUMBERS: 30

#### 6.8.1.1 Fleet

Camden's fleet uses 20,000l of diesel per week, 2000l of LPG and 2215l of petrol per week. This produces $CO_2$ emissions of 60.7 tonnes per week, or 3.15 ktpa. The LIP states that improvements to the fleet save an estimated 250 tonnes of $CO_2$ a year, largely through the use of more efficient vehicles and the 25 electric vehicles. LPG is widely used, but whilst it offers air quality benefits it has similar $CO_2$ emissions to diesel. Camden has set a target for a 10% reduction in CO2 emissions from its vehicle use which includes the fleet.

Despite good work to date it was suggested that Camden reviews its fleet to ensure that it is using the best mix of fuels to give a balance between air quality and climate change effects. Some possible measures would be:

- **Use a biodiesel blend** - by 2009 most diesel sold in the UK will contain 5% biodiesel but higher blends give better $CO_2$ savings (a 20% blend in the whole fleet would save approx 0.39ktpa $CO_2$). Biodiesel is relatively straightforward to introduce into fleets and can give considerable CO2 savings particularly if made from used cooking oil. However biodiesel offers less air quality savings than LPG and electric vehicles and there are some sustainability concerns regarding biodiesel made from palm oil and other crops grown overseas.
- **Use more alternatively fuelled vehicles** - Camden already uses considerable numbers of electric vehicles, but should continue to keep an eye on new developments in electric and hybrid vehicles which may make them suitable for further fleet uses.
- **Driver training** – improvements in driving technique have been shown to reduce fuel consumption by 5-25% (a saving of 157.7 to 788.8 tonnes $CO_2$ per annum).

- **Fleet review** – the most effective way to reduce $CO_2$ emissions from the fleet is to reduce the number of vehicles in the fleet. By regularly reviewing the number of and use of vehicles it may be possible to identify areas where vehicle usage can be reduced. The Energy Saving Trust can provide free advice to help start this process.
- **Always choose best in class vehicles** - for $CO_2$ emissions (those with the lowest g/km $CO_2$ emissions or with higher mpg), if this is implemented across all vehicles as they are replaced in the fleet this could produce considerable $CO_2$ emission reductions.

#### 6.8.1.2 Travel for work

Camden has had a travel plan since 1998 and has already considerably reduced car use to work amongst its employees and intends to reduce this further whilst promoting alternative modes especially cycling. Most common measures used in travel plans are already in place in Camden, but a couple of other measures which may be worth considering include:

- **Oyster cards for departments** – to encourage public transport use each department stocks several pre-loaded Oyster cards which staff can sign out to use for work journeys, this may be particularly relevant for departments with staff who drive to work.
- **Use of car clubs as pool vehicles** – Camden appears to mostly use electric vehicles as pool vehicles, whilst this is an excellent scheme at times conventionally fuelled vehicles may be needed therefore car club vehicles could be used as pool vehicles during the day and available to local residents at night.
- **Promoting home working** – to reduce travel to work and help cut congestion. Note that this measure could potentially result in an increase in $CO_2$ emissions from the home if, for example, heating is used more than it would have been if the resident were working in the office.

### 6.8.2 Within Camden

This section addresses how LBC can help further reduce $CO_2$ emissions from other transport in the borough for which it is not directly responsible. Camden has already made considerable progress in this area and many of the measures given in this section are already in progress in the borough. Perhaps one of the most important roles the borough can play is to demonstrate the success of its transport policies and thereby encouraging other boroughs to follow suit which should in turn further reduce traffic volumes in Camden.

The actions in this section are listed under the following hierarchy:

- Reduce travel
- Modal Shift
- More efficient vehicles
- Alternative fuels

Behaviour change through reduced travel and modal shift is more effective than more efficient vehicles and alternative fuels. This can be shown in the UK by the fact that cars have become considerably more efficient since the early 1990s, but the $CO_2$ savings made have been wiped out by the increased numbers of cars used and the distance driven. It is important to remember that whilst some of these actions will have small individual impacts on $CO_2$ emissions in the borough cumulatively they could lead to a real change in the way people travel in Camden.

Additionally any improvements to alternative modes of transport to the car will benefit the large number of Camden households without a car and help promote social inclusion.

#### 6.8.2.1 Reduce travel

ACTION PLAN NUMBERS: 28, 29

Reducing people’s need to travel without impacting on their standards of living, can be done through a range of methods including:

- integrating developments so people can shop and work locally
- promoting home deliveries
- improving local shopping centres and promoting these above ‘out of town’ style developments
- ensuring most people live within a walking distance of schools, health care facilities, banks, post offices and other services
- ensuring local employment opportunities
- consolidating freight deliveries
- promoting local entertainment and leisure facilities
- Travel plans for schools, residents and businesses can be useful in helping people identify areas where they can reduce travel
- Promoting home working

#### 6.8.2.2 Modal shift

ACTION PLAN NUMBERS: 28, 33, 36, 37, 39, 41, 46

When trying to encourage modal shift it is important to remember that most people will only change their travel behaviour if the alternatives give them some benefit over private car use such as a time or cost saving or health benefits. Camden has one of the lowest levels of car ownership in the country and states in its LIP that improving alternative modes benefits more of its population than improving car facilities. Actions for promoting specific alternative modes are given below, but some general actions to encourage people to change from the car to another mode include:

- **Awareness raising campaigns** as already carried out in Camden through Good Going and events such as car free day.
- **New developments** should be planned so that alternative modes are embedded from the start and are more attractive than private car use. Information on transport options could be supplied to all new households as changing transport behaviour is most easily achieved in conjunction with other changes in lifestyle. Section 106 money can be obtained from developers to fund transport measures within new developments. In addition it is important to follow up and ensure that developers have provided all the transport facilities promised. Again Camden has a high level of car free housing in the borough and should continue to implement this and demonstrate its success.
- **Travel plans** have an important role in promoting modal shift whether they are implemented for residents, schools or businesses.
- **Improving existing shops and services** so they have good access by all alternative forms of transport and ensuring that any new developments are fully accessible by public transport, walking and cycling is also critical.

#### 6.8.2.3 Promote walking

ACTION PLAN NUMBERS: 42

Walking is the cheapest and most environmentally friendly form of transport and is possible over at least short distances for almost everyone. Improving the pedestrian environment and increasing footfall provides a wide range of social and health benefits as well as reduced emissions of $CO_2$ and other pollutants.
When looking at ways to promote walking it is important to realise the reasons why people do not currently walk for short journeys. These might include perceived danger, unpleasant street environment, having to carry heavy shopping, lack of awareness of the time taken to walk short distances or a lack of fitness. Improvements can then be tailored to address these reasons.

The Mayor's Transport Strategy sets a target to increase walking trips by 10% per person/per year by 2015, Camden has a walking strategy to help implement this and is looking at ways in which walking trips can be more easily monitored.

Some ways in which walking can be promoted include:

- **Providing walking signs** to common destinations, these should give a walking time in minutes as most people find this easier to understand than distances.
- **Physical changes to the street** can help make walking a more pleasant environment; this includes pedestrian crossings in areas where people want to cross the road and well maintained pavements and street lighting. Home Zones and Naked Streets where road markings, bollards and railings are removed can help reduce traffic speeds and make pedestrians feel more secure.
- **Street audits** can be useful to look at the streetscape from a pedestrian's point of view and identify improvements to crossings and street furniture to make the street more pleasant to navigate. Street audits are particularly useful if carried out in conjunction with local businesses and residents so the views of those most likely to walk in the area are taken into account.
- **Guided walks** whether done for local history, leisure or health reasons can be a useful first step to encourage people to get out and explore their local area and they may help people realise how quick walking can be as a mode of transport.

#### 6.8.2.4 Promote cycling

ACTION PLAN NUMBERS: 31, 32, 45

Cycling is a quick and efficient carbon-free form of transport, but numerous barriers must be overcome before many people feel confident to take up cycling. Fear of traffic and safety concerns are probably the most common reasons cited for not cycling, but other problems include lack of access to a bike, lack of secure storage both at home, work/school and at shops and leisure facilities, concerns about getting wet or hot and sweaty can also put people off. However if these and other issues can be addressed cycling could become an important mode of transport in Camden.

The MTS sets a target of increasing cycling in London by 200% per person per year by 2020 which Camden is well on the way to achieving. Like walking cycling also brings health, air quality, noise and social benefits.

Cycling can be facilitated in many ways including:

- **Improving cycling infrastructure** – this includes signposting routes, cycle priority crossings and cycle racks in public places.
- **Cycle training** – Camden already offers subsidised cycle training to residents and this should be continued and expanded where possible. Cycle training is particularly useful to nervous cyclists or those who have not ridden a bike for many years. Innovative ways to promote this could be considered for example sending out leaflets when people renew their residents parking permits.

- **Cycle parking and bike security** is an important and often overlooked issue. Simple Sheffield type stands in public locations where bikes are only left for short times are relatively cheap to install and are suitable outside shops and services. For workplaces, public transport hubs and homes more secure parking is more appropriate. Good examples include the bike park at Finsbury Park station and secure cycle parking facilities Hackney Cycle Campaign has installed adjacent to some local authority flats. Cycle parking for households (especially flats) is particularly important as people won't go to the expense of purchasing a bike unless they have somewhere secure to store it. Whilst secure cycle parking can easily be installed in new developments and tends to be a requirement of planning permission it is important not to overlook existing households.
- **Promoting the benefits of cycling** and having free 'Dr Bikes' (where people can get their bikes fixed) and maps at community events is a straightforward way of encouraging cycling. The Good Going campaign and Camden Cycling Campaign can assist with this.
- **City bike clubs** have been successfully implemented in several European countries, these range from distinctive free bikes to cheap short term bike hire. These schemes can be expensive to implement particularly with regard to maintaining the bike and preventing theft. However they do provide an opportunity for people without bikes to have a go at cycling before purchasing a bike. This is something Camden is considering implementing and could be targeted at students, local businesses or tourists.

#### 6.8.2.5 Promote public transport

ACTION PLAN NUMBERS: 26, 35

Camden has excellent public transport links, although east-west routes in the north of the borough are less frequent. Public transport is the responsibility of TfL and the rail operating companies, but LBC can work with these bodies to ensure existing public transport is well utilised and can lobby for improved service levels and additional routes. Some specific actions which LBC can lead on to promote public transport use include:

- **Promotional campaigns** for existing public transport services, particularly those with spare capacity for example at off-peak times. This can be done in conjunction with TfL/rail operators and the Good Going campaign.
- **Lobby TfL** and the rail operators for improved services for example increased frequencies or new routes.
- **Ensure that buses are given priority** and bus lanes provided wherever possible; improve the waiting environment around bus stops and ensure correct information is available at bus stops. This will need to be done in conjunction with TfL.
- **Continue to lobby for new infrastructure** such as CrossRail and Cross River Tram.

#### 6.8.2.6 Reduce car ownership/use

ACTION PLAN NUMBERS: 47, 48

Private cars are the biggest transport contributors to $CO_2$ emissions in Camden. Whilst they do not emit $CO_2$ unless they are in use, reducing car ownership can help reduce car use as people who own cars tend to use them for the majority of journeys even if alternatives are available. Reducing car ownership can also help ease congestion problems caused by parking on the street and help make the streetscape more attractive.

44% of households in Camden have at least one car, this is lower than in the country as a whole (73% of households in England and Wales have at least one car) and the London average (63% of London households have at least one car). Whilst the percentage of households with cars has not changed much the numbers of cars have grown due to population growth. There are relatively low levels of households with more than one car in the borough.

As well as promoting alternative modes of transport as detailed above, LBC can influence levels of car ownership/use through its parking policy and through encouraging car clubs which may dissuade people from buying a car or replacing a second car. LBC can assist car club development by allocating on street parking spaces for car club vehicles and encouraging their inclusion in new developments.

### 6.8.2.7 Improve vehicle efficiency

ACTION PLAN NUMBERS: 27, 34, 40, 43, 44

As discussed in Appendix C, there are various ways in which the fuel efficiency of vehicles could be improved. Obviously the take up of more fuel efficient vehicles is largely influenced by fuel prices, vehicle manufacturers and national government policy, but there are some ways in which LBC can influence this at a local level:

- Camden is planning to **base the price of residents parking permits on the $CO_2$ emissions of their vehicles**. If people are therefore persuaded to move to a car in a lower band this could have a considerable $CO_2$ saving. It is important that over the years this policy is reviewed and if the majority of cars belong in the lowest permit band this band is further subdivided so only the most efficient cars pay the lowest rates.
- **Businesses with fleets tend to be more sensitive to fuel costs** than individuals and would be a good place to start when promoting more fuel efficient vehicles. There is a big difference in $CO_2$ emissions between similar size vehicles which often is not realised by purchasers. A publicity and awareness raising campaign could be run around this issue targeted at businesses first and then individuals.
- **Improved driving techniques can also considerably reduce $CO_2$ emissions**, LBC could help influence this by running an awareness campaign encouraging people to take steps such as switching off their engines when stationary or checking their tyre pressure regularly. If funding can be obtained, training for fleet and taxi drivers could be offered. Additionally LBC could lobby for fuel efficient driving to be included in the driving test to ensure all drivers are aware of the impacts of their driving style.
- **For freight vehicles increased delivery efficiency can greatly reduce $CO_2$ emissions**, this could entail encouraging local businesses to coordinate their deliveries (perhaps as part of a local travel plan group). Alternatively LBC and neighbouring boroughs could look into setting up a scheme similar to the London Construction Consolidation Centre in Bermondsey which has reduced $CO_2$ emissions from construction traffic by 73% and has also increased delivery accuracy.

### 6.8.2.8 Alternative fuels/vehicle technologies

ACTION PLAN NUMBERS: 38, 40

Alternative fuels/engine technologies for vehicles can reduce their $CO_2$ emissions, but this greatly depends on the fuel or technology used. Generally speaking diesel vehicles have lower $CO_2$ emissions than petrol and some alternative fuels/vehicle technologies currently available have similar $CO_2$ emissions to diesel and have lower $CO_2$ emissions than equivalent petrol cars. These include Bioethanol, LPG and petrol hybrids although these do all bring some air quality benefits.

Biodiesel, CNG and electric vehicles are considered to have lower $CO_2$ emissions than diesel vehicles. In the case of biofuels the source of the fuel is critical to the $CO_2$ savings, biofuels made from waste products being better than biofuels from virgin feedstock. Biodiesel made from palm oil grown on cleared rainforest land could even have higher $CO_2$ emissions than diesel and obviously brings other environmental and sustainability concerns.

The role LBC can play in promoting alternative fuels is fairly limited and largely revolves around promotion campaigns, encouraging petrol stations to stock alternative fuels and encouraging fleet managers and individuals to consider different fuels and vehicles. One step LBC is already taking to encourage the take up of electric vehicles is providing electric recharging points for vehicles both on street and in car parks. Currently people can only use electric vehicles if they have off-street parking, so by providing on-street charging points LBC could encourage the take up of these vehicles.

## 6.9 ESCos and Delivery

This section of the report examines what organisational structures and mechanisms might be used to develop the strategy, drawing on examples from elsewhere in the UK. It proposes establishing an ESCo to design, build, finance and operate the community heating network in Camden.

For more background information on ESCos is available through the London Energy Partnership[31].

### 6.9.1 Roles Required

The central element of the strategy is that a community heating network and a power station is required. The proposed scenario suggests that this would be a combination of new heat and power plant fed from gas and some biomass supplemented by heat from an existing power plant (e.g. Edmonton). There will also be a significant proportion of renewable energy systems required to meet the 10% requirement and there will be considerable activity in terms of retrofitting energy efficiency measures to existing stock.

#### 6.9.1.1 Power Plant Operator

There are various options considered for power plant in Camden, including:

- Biomass Power
- Solid Recovered Fuel (SRF) fuelled Plant
- A large CCGT power station

Whatever combination of technologies is eventually chosen, it is probable that partner organisations with experience of implementing these technologies will be required. These are likely to include manufacturers of these technologies.

#### 6.9.1.2 Heat Network

A plant of the scale envisaged is a specialist operation and is it not envisaged that the power plant operator would be vertically integrated i.e. that they would engage in selling heat (or power) directly to consumers. It is likely that a separate company will be required to operate and maintain a heat distribution network and sell heat onto consumers. This network will also need to be financed. This is the most complex area of development as there is so little UK experience of this on the scale envisaged here. It is here that is an ESCo will be required. The following sections explain the principles of an ESCo and put forward a possible model for Camden.

### 6.9.2 A Camden ESCo Model

The diagram below sets out the possible structure and role of a Camden ESCo. Essentially it would purchase heat from one or more possible heat utility companies. This could either be done directly or through a separate company in charge of operating a transmission network. In Copenhagen a consortium of boroughs and the city council have formed a company for this purpose. Heat would be sold on to local residents and businesses. Many of the ESCo responsibilities could be subcontracted in the short term but in the longer term the company could develop in-house capabilities to deliver project management, operation and maintenance and metering and billing. The ESCo would be responsible for the operation and maintenance of the local standby and peak load plant.

[31] Brodies LLP and SEA/RENUE, Guidance and Advice on Setting Up and Delivering an ESCo in London, LEP, awaiting publication.

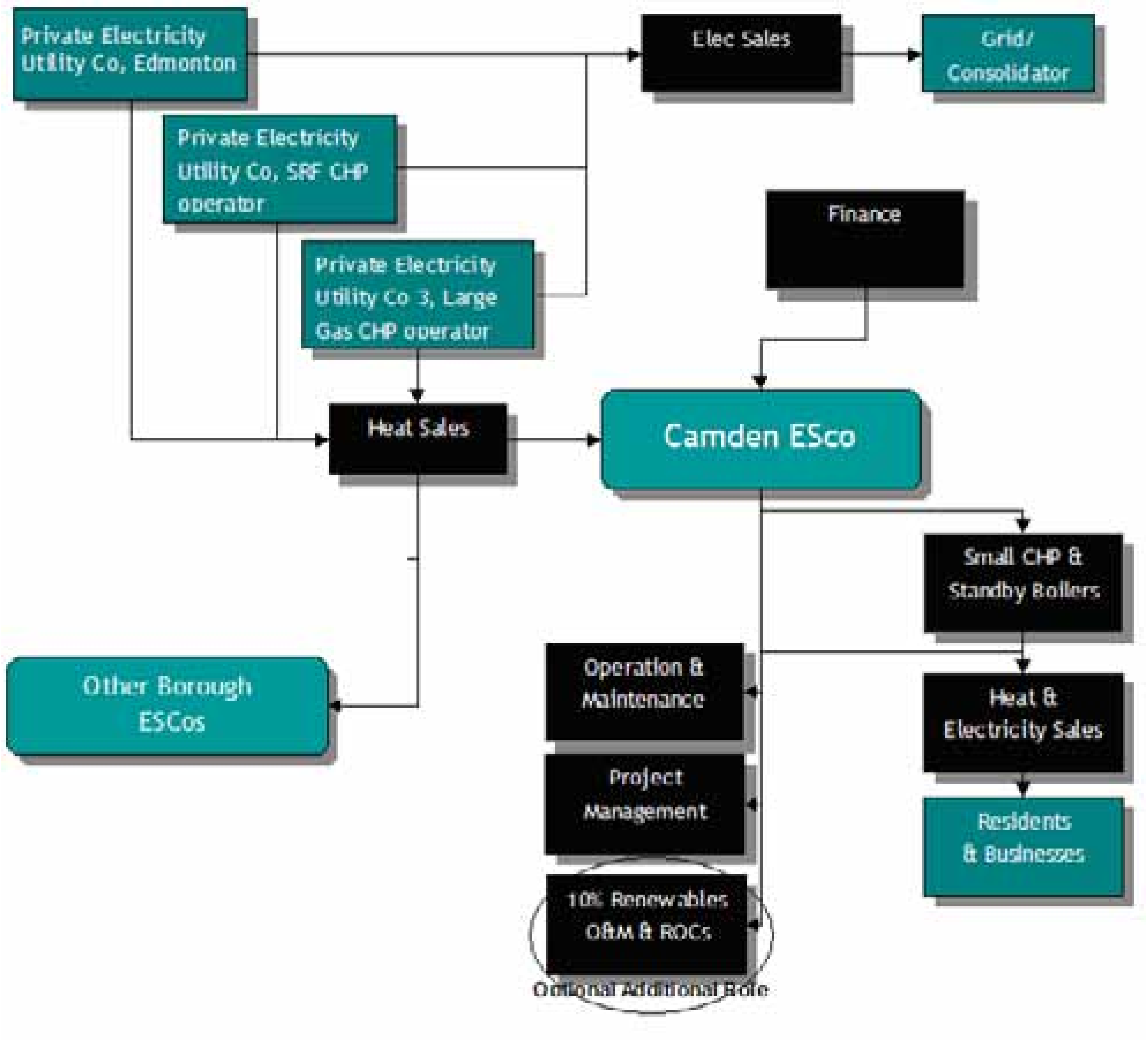


**Figure 33: ESCo Roles**

## 6.9.3 Possible ESCO Membership

If LBC chose to progress the option of a Camden ESCo on the model of Aberdeen or Southampton Millbrook there are a range possible organisations that could form the board of the ESCo besides LBC itself.

### 6.9.3.1 Housing Associations

Housing Associations have in other areas been responsible for the management and operation of community heating. The chief executive of a local Housing Association would bring business administration expertise to the board of an ESCo as well as representing local interests.

### 6.9.3.2 Industry Champions

There are a number of individuals who may wish to become involved in the delivery of a CHP based ESCo. In Southampton, Michael King from the CHPA who has considerable expertise in this area is a director on their board.

#### 6.9.3.3 Local strategic partners

Energy managers from local strategic partner organisations might wish to be involved. They could bring useful expertise and represent large potential customers, for example local hospitals.

#### 6.9.3.4 Residents' Associations

A representative from local residents' association would enable residents to have a say in charging mechanisms and the provision of a critical service.

### 6.9.4 Summary

The development of a heat network served by combined heat and power will require a delivery organisation. It is recommended that LBC set up an Energy Services Company (ESCo) or contract with an existing ESCo to deliver the construction, operation and maintenance of the system, as well as retail the heat. The terms of reference for the ESCo could also include the delivery of energy efficiency initiatives to the existing building stock and responsibility for claiming ROCs for the renewable energy systems installed as part of the 10% requirement within Camden. There are a number of successful models set out in this section that Camden could draw on to develop an ESCo.

## 6.10 Phasing of a heat network

This section gives an indication of how a heat network might be developed across the borough, based on thermal demand and the location of existing community heating schemes and regeneration areas.

### 6.10.1 Heat density maps

The following map shows gas density across Camden, which is taken as a proxy for thermal demand.

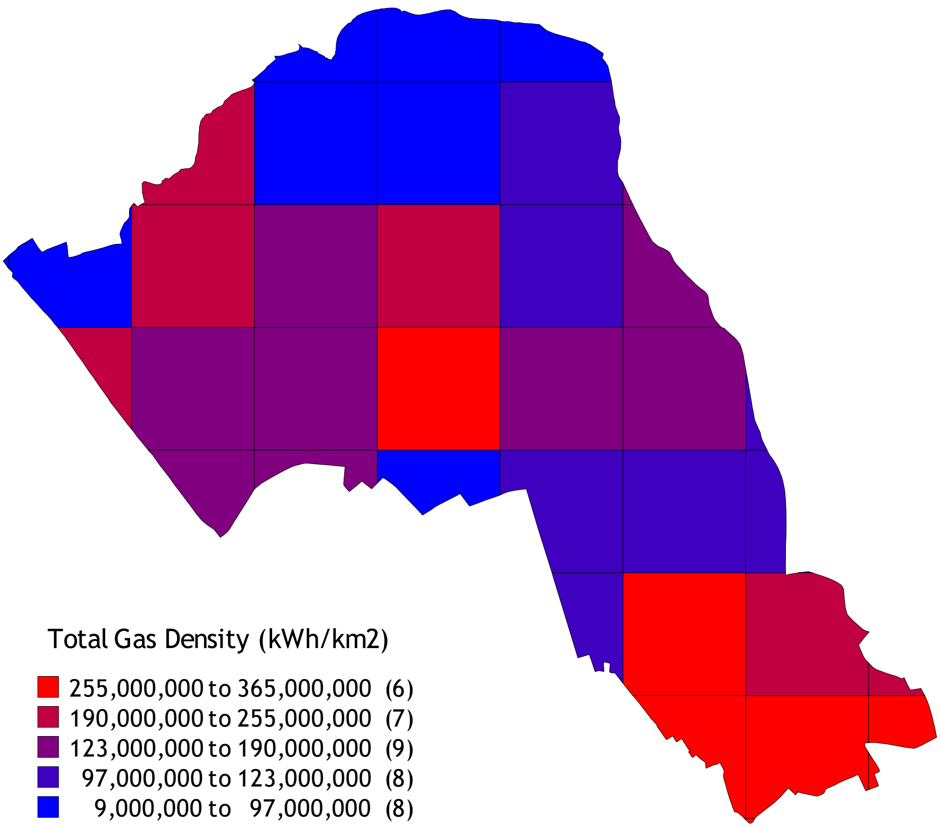


**Figure 34 Total gas density**

Gas densities are highest in the south and in the centre of the borough. This can be further broken to show gas density in the domestic and non-domestic sectors.

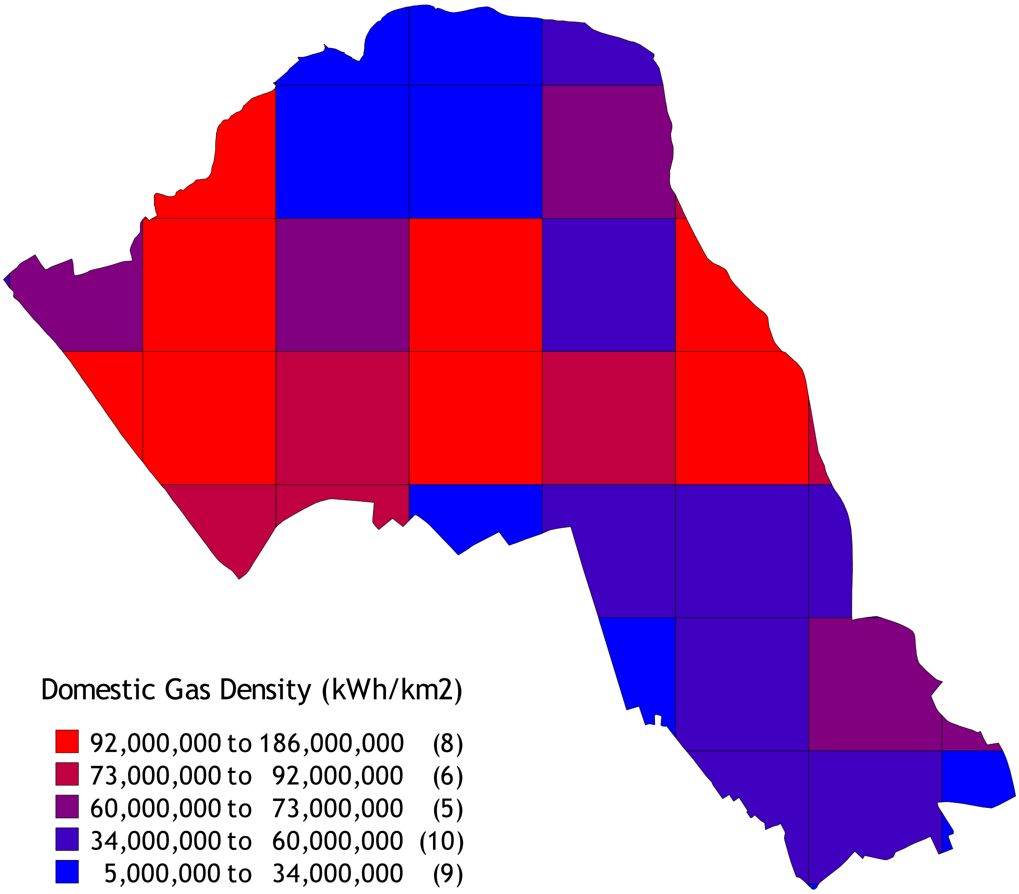


**Figure 35 Domestic gas density**

Domestic gas density is highest in a band running east to west across the middle of the borough.

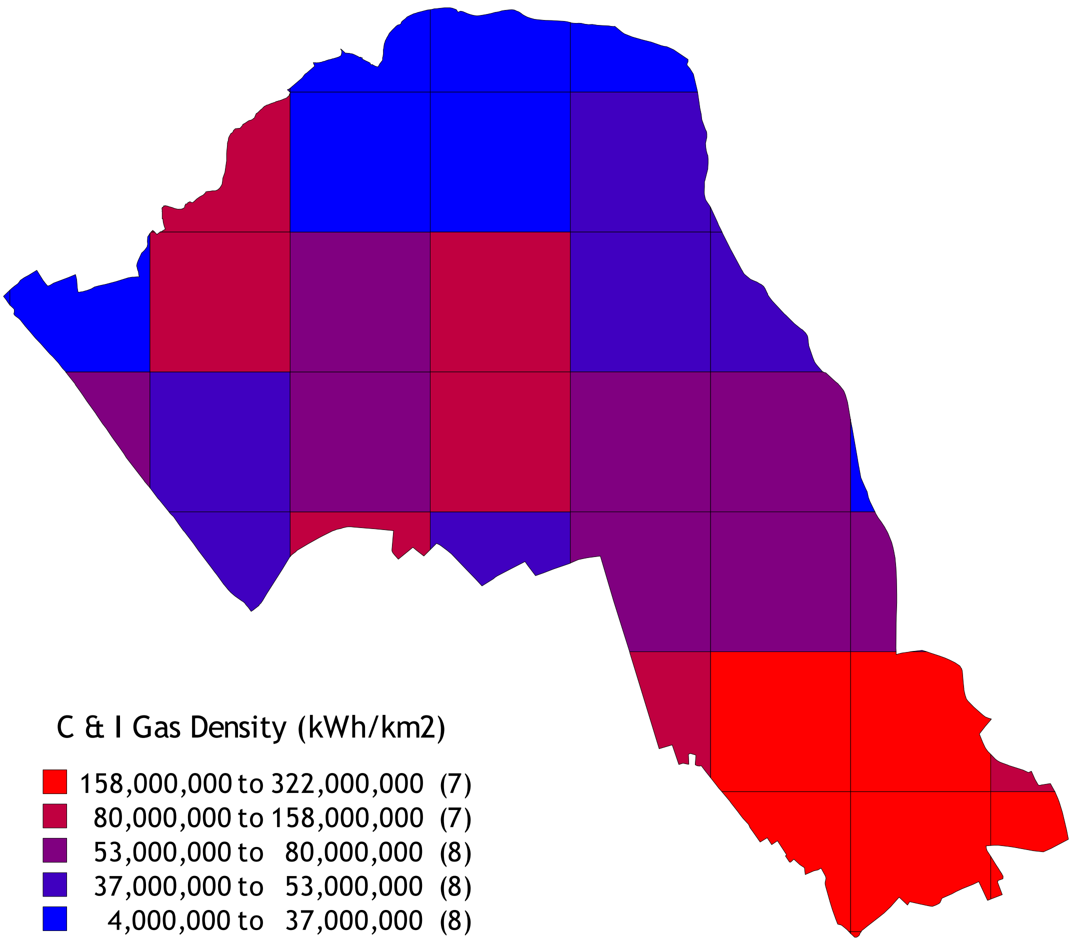


**Figure 36 Commercial and industrial gas density**

The non-domestic gas density is highest in the south of the borough, nearest to the centre of London.

### 6.10.2 Developing a heat network

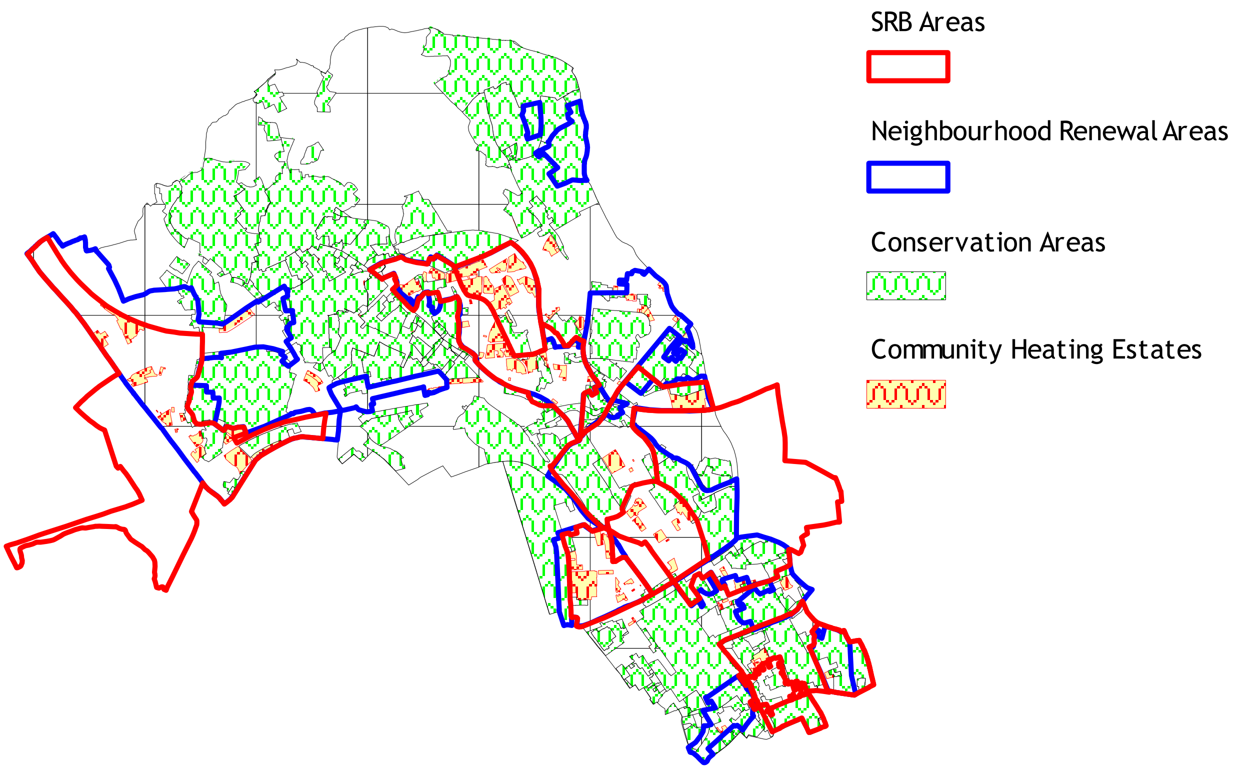


**Figure 37 CH estates, conservation areas and regeneration areas**

Figure 37 shows the locations of existing estates with community heating, conservation areas and regeneration areas (Neighbourhood Renewal and Single Regeneration Budget (SRB) areas).

- **Existing estates with community heating** are important because heat networks can be built around these sites without having to persuade potential customers of the benefits before a network is in place.
- **Conservation areas** lend themselves to community heating because, once installed, a heat network has no visual impact.
- **Regeneration areas** can also be used to kick-start a heat network, as installing a heat network can be less disruptive when work is already being done and connection to a heat network could be required in some cases.

Between them, these features cover a large proportion of the borough. However, the borough could be thought of as two zones in terms of developing a heat network.

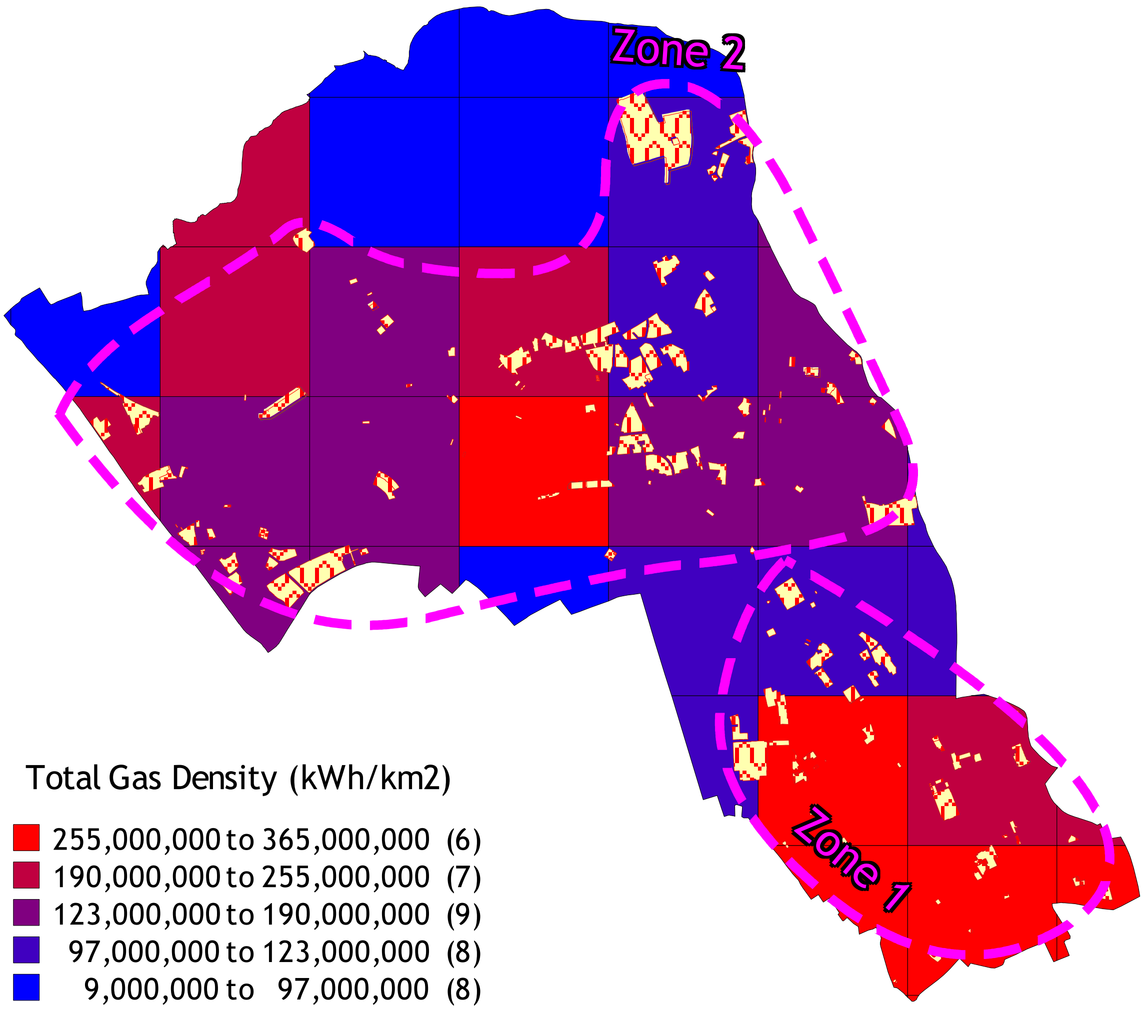


**Figure 38 Community heating zones**

Figure 38 shows the existing community heated estates overlaid on the total gas density map. Two zones are mapped here:

- **Zone 1** covers the area of highest thermal demand in the south of the borough. Most of this demand is from the non-domestic sector, but there are some existing CH schemes in this area.
- **Zone 2** covers a larger area in the centre of the borough where domestic gas demand is highest and where there are a number of existing CH schemes.

The heat network can be developed initially in small sections to link up existing CH schemes in the two separate zones indicated here. At the same time, council policies will encourage private householders and businesses to join the network as it grows. Community heating will be included in all regeneration projects. It is envisaged that as the network develops, the sections will meet up and join together, to eventually create one borough wide heating scheme.

### 6.10.3 Strategic sites

There are a number of sites where a CHP plant might be located or heat networks might develop initially.

#### 6.10.3.1 Opportunity Areas and Areas for Intensification

The London Plan identifies opportunity areas and areas for intensification, and provides indicative employment capacity and minimum number of homes by 2026, as shown in Table 49.

From these figures, an estimate of the heat load as a result of the development can be made. This follows from the assumptions made for fuel use in new build housing and commercial property in order to estimate the likely growth in $CO_2$ emissions in the borough. These are shown in Table 50.

| Area | Indicative employemt capacity 2001 to 2026 | Minimum homes 2001 to 2026 |
|---|---|---|
| Kings Cross | 11400 | 2250 |
| Euston | 5000 | 3000 |
| Tottenham Court Road | 5000 | 1000 |
| West Hampstead Interchange | 500 | 2000 |
| Holborn | 2000 | 200 |

**Table 49 Opportunity areas and areas for intensification**

| Area | Estimated C & I heat load (MWh per year) | Estimated domestic heat load (MWh per year) | Estimated total heat load (MWh per year) |
|---|---|---|---|
| Kings Cross | 7,447 | 11,173 | 18,620 |
| Euston | 3,266 | 14,897 | 18,163 |
| Tottenham Court Road | 3,266 | 4,966 | 8,232 |
| West Hampstead Interchange | 327 | 9,931 | 10,258 |
| Holborn | 1,307 | 993 | 2,300 |

**Table 50 Estimated heat loads from new developments in opportunity areas**

In addition to these sites, LBC have identified the following sites with a medium to high pressure for change:

- Camden Town Tube Station
- Camden Town
- Swiss Cottage

### 6.10.4 Community heating clusters

Table 50 demonstrates that there is a key area of expected growth in thermal demand in the area of King's Cross and Euston regeneration areas, as these have the highest projected heat loads as a result of new development.

In fact, these regeneration areas are on the edges of an area with the highest thermal demand density in the borough. The region to the south of the grey line in Figure 39 has an estimated thermal demand of 757 GWh per annum, approximately 30% of the total for the borough. This is made up of 98 GWh / yr from the domestic sector and 660 GWh / yr from the non-domestic sector.

Using these figures and a knowledge of the total thermal demand, number of dwellings and total bulk floorspace in the borough, it can be calculated that this region in the south of the borough contains around 8286 dwellings (9% of the total for Camden) and 1,548,000 $m^2$ bulk floorspace[32] (46% of the total for Camden).

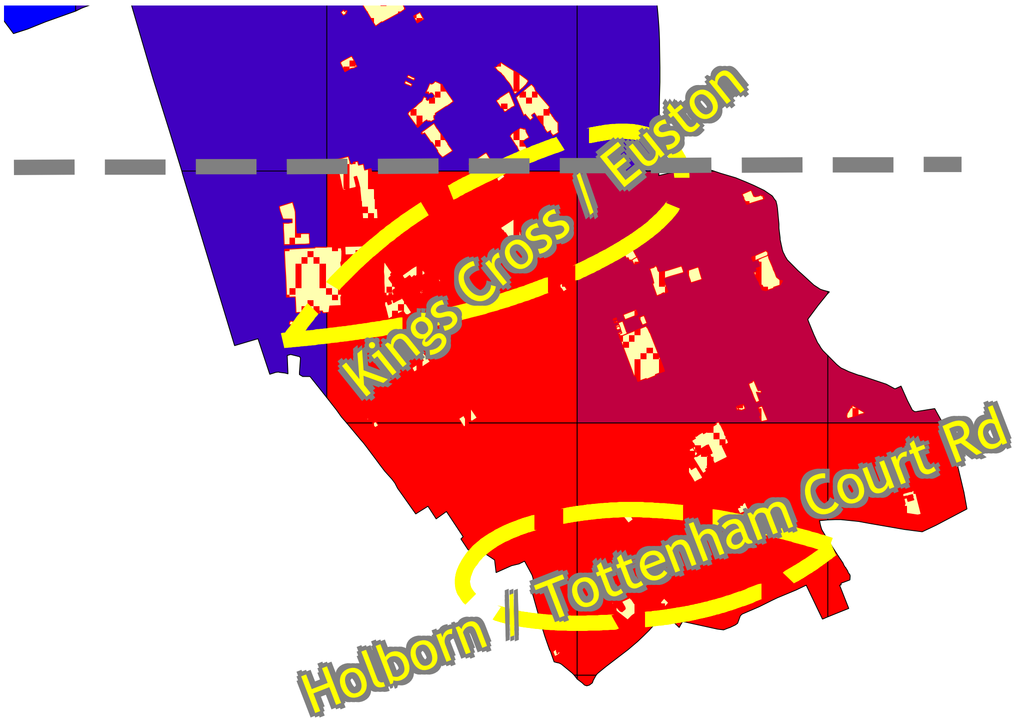


**Figure 39 Area around Kings Cross, Euston, Tottenham Court Road and Holborn**

Clearly targeting this area is critical to meeting the borough's $CO_2$ reduction targets. Table 47 shows that it would be impossible to implement the proposed scenarios without connecting at least some of this heat load to the network.

The first priority for setting up the heat network is to target the Kings Cross and Euston regeneration areas (the northern area shown in yellow in Figure 39). It is understood that an ESCo is expected to be in place for the Kings Cross development by the end of 2007. Figure 39 also shows that there are some existing estates with heat networks to the north of this region, and it would make sense to investigate connections to these areas.

A second heating network cluster can be developed as part of the Tottenham Court Road and Holborn developments (the southern area shown in yellow in Figure 39). This area in particular might be able to take advantage of heat loads in neighbouring boroughs as appropriate.

Once these two clusters are in place, the network can be spread out from these areas to encompass the region shown in Figure 39.

Two other good candidates for community heating clusters are in the region around the Swiss Cottage and West Hampstead Interchange regeneration areas, and an area with a concentration of existing community heating schemes to the north of Camden Town Tube. Camden Town and Camden Town Tube in particular are also areas set to undergo renewal.

[32] Note that that non bulk floorspace is an unknown quantity. It is implicitly assumed here that the borough ratio of bulk to non bulk floorspace is the same in this southern region as in the whole borough.

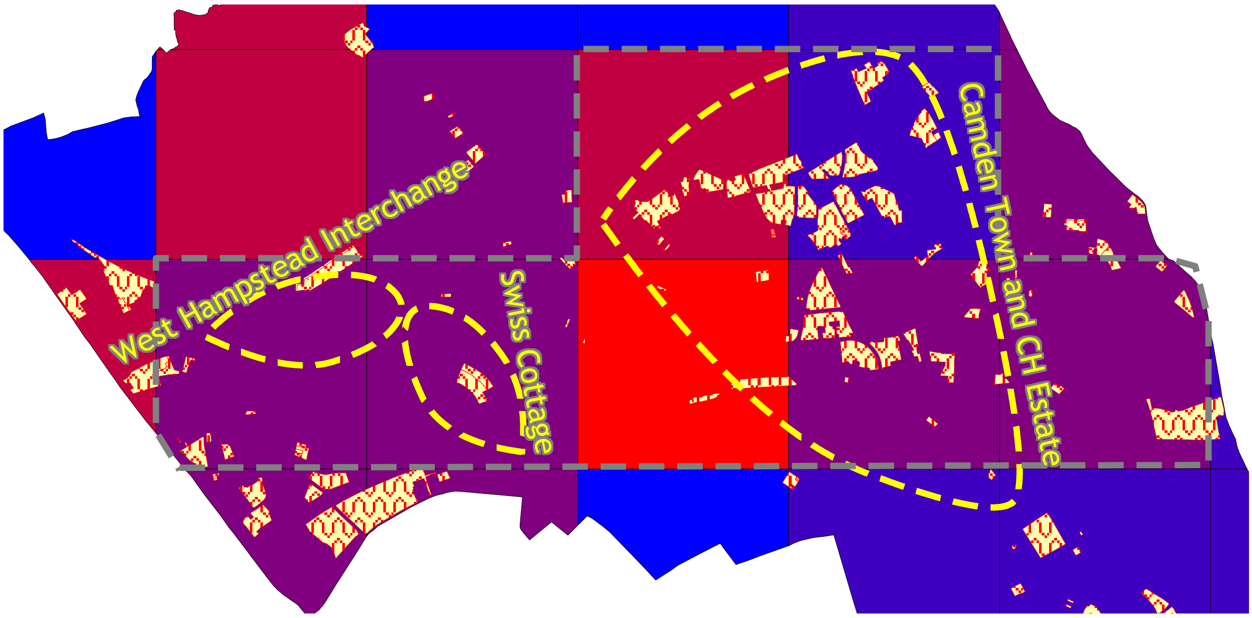


**Figure 40 Area around Swiss Cottage, West Hampstead Interchange and Camden Town**

The area enclosed by the dashed grey line in Figure 40 is also an area of concentrated heat demand. It is estimated that this region has a thermal demand of approximately 863 GWh / yr, nearly 35% of the total demand for the borough. Of this, 497 GWh / yr is domestic heating demand, and 367 GWh / yr non-domestic.

This equates to an estimated 42,167 dwellings (45% of all dwellings in the borough) and 860,000 $m^2$ bulk C & I floorspace (26% of the borough total).

Again, from these initial clusters the network can expand to link the two areas shown in Figure 40. There are also several existing community heated estates surrounding this region that could be linked up. Eventually the network could then spread south to join the network developing in the Kings Cross area.

### 6.10.5 CHP Plant

The scenarios envisage a total of between 270 $MW_e$ and 441 $MW_e$ of large scale CHP connected to a heat network installed by 2050. At this stage a location for such plant has yet to be identified, and there are several approaches to achieving this level of capacity:

- The total CHP capacity could be delivered by more than one plant. If biomass is to be used, clearly more than one plant would be required and these need not be on the same site. It is also possible that several smaller power stations could be used. This would mean that the capacity could be increased in two or more stages when the heat load connected to the network reaches a suitable level.
- If biomass use is limited, the main gas fired CHP could consist of one central plant.
- Some or all of the heat from CHP could be supplied from outside the borough if cross-borough heating networks are developed.

There are also different strategies for building capacity alongside the heat network. The large CHP plant can be built and run as a power plant, rejecting any excess heat while the heating network develops. Alternatively boilers could be employed to deliver heat while the network is constructed, at which point a large central CHP plant can be built.

#### 6.10.5.1 Land take

Barking Power Station, built in the early 1990's is a CCGT power plant rated at 1000 MW. This is made up of five 130 $MW_e$ gas turbines and two steam turbines rated at 140 $MW_e$ and 210 $MW_e$. This demonstrates the modular nature of the technology.

Although it is not a CHP plant, it is a good example of modern gas turbine technology within London and can therefore give a useful indication of the scale of development required in Camden.

The Barking site is 15.3 hectares, or 153 $m^2$ per $MW_e$. Assuming that the cooling system at Barking has a similar land take to a heat exchanger feeding a heat network, the following areas of land would be required under the three scenarios:

| Scenario | CHP installed capacity ($MW_e$) | Land take (Ha) |
|---|---|---|
| 60% by 2050 | 404 | 6.2 |
| 80% by 2050 | 525 | 8 |
| 90% by 2050 | 560 | 8.6 |

**Table 51 CHP plant land take**

An extension is being planned for Barking Power Station, which would add 470 $MW_e$ capacity but only take a further 3 Ha, so it might be possible to build the capacity required for Camden on a more compact site.

#### 6.10.5.2 Flue

The Chimney stack at Barking is 55m high. The height of a flue is determined primarily by local meterological conditions and the locations and heights of nearby buildings. It is therefore difficult to provide an indicative flue height for a plant in Camden.

### 6.10.6 ESCo

ESCo's are discussed in more detail in Section 6.9. Essentially there are two strategies for managing ESCo's alongside the development of clusters of heat networks. Either separate ESCo's can be set up for each cluster, or a borough wide ESCo could oversee all the developments. It might not be possible for LBC to force this issue.

It would certainly be advantageous for LBC to be a stakeholder in an ESCo or ESCo's to ensure the aims of its energy strategy are met. Having one borough wide company might make this easier, and would be able to guarantee the eventual interconnection of the various clusters. It is also important that the clusters are constructed so that they can be connected, i.e. that they operate at similar temperatures etc.

### 6.10.7 Summary

This study has identified two zones where heating network development should be targeted. There are five clusters within these zones that could provide good starting points for the development. The location of the CHP plant has not been identified at this stage, but would not necessarily have to be in one of the areas identified for the heating network.

The two zones indicated here represent around 65% of the total thermal demand for the borough. Supplying these areas alone would go a long way towards providing a borough wide heat network.

The clusters and zones also represent two different types of region. The southern area is based around regeneration areas, and the thermal demand is mainly from non-domestic property. This presents the challenge of persuading commercial customers to sign up for connection to a network. However, a large new thermal demand is set to be available as a result of regeneration, and it is here that an ESCo is already being created and that the local authority can have a strong influence.

The northern zone has a much higher domestic heat load, and there is an opportunity here to develop a network starting from existing estates with community heating, where the council again has an influence.

# 7 Action Plan

This section details a list of actions that could help to make the proposed scenarios a reality. In each case, the level of priority, timescale and approximate costs and $CO_2$ savings are indicated.

This list of actions is intended to provide a range of ideas for actions that could help achieve the scenarios proposed in this report. This does not commit LBC to any course of action, nor does it imply that completing all of the actions in the list will result in the scenarios becoming a reality.

The priority indicated is a judgement based on a number of factors such as impact on $CO_2$ emissions, necessary timescale or value as an example. The column labelled 'Applies to (scenario measure)' indicates the measure in the scenario that the action addresses. The marginal cost is based on an initial estimate of capital cost and staff time and is indicative only. Each action would be separately costed to provide an accurate figure. Note that this is not the same as the methodology used to calculate capital costs in the scenario modelling, and the sum of the costs here does not equal the total capital costs for the scenarios. An indication is given of the potential $CO_2$ saving that the action leads to. Where a figure is given, it is often taken from the maximum potential from the relevant measure in the three scenarios, and these figures would not be the result of the single action in isolation. Finally, the team(s) within LBC with responsibility for the action are listed, along with a suggestion of appropriate partner organisations. The Departments are abbreviated as follows:

| Department | Abbreviation |
|---|---|
| Culture and Environment | (C & E) |
| Housing and Adult Social Care | (HASC) |
| Finance | (F) |
| Corporate Strategy Unit | (CSU) |

In each case, the teams are listed after the abbreviation for the department to which they belong.

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| High | 1. Identify sites for central biomass and gas fired CHP generation | CROSS-CUTTING | Biomass CHP, Large Gas CHP | To be completed alongside heat network study | 10 to undertake study | Biomass and gas CHP could save over 2.5 ktpa per $MW_e$ installed capacity | (C & E) Forward Planning and (HASC) Energy & Sustainability | Landowners, ESCo |
| High | 2. Adapt 10% renewables policy to restrict it to electricity generating technologies where connection to heat network will be available | CROSS-CUTTING | PV, Wind, Biomass CHP, Large Gas CHP, Heat from Power Station | Immediate | 5 staff time to adapt policy | Electricity is more carbon intensive than gas, and this measure complements CHP, which leads to high $CO_2$ savings | (C & E) Urban Renewal, Forward Planning | |
| High | 3. Adapt 10% renewables policy so that it is based on a 10% $CO_2$ reduction rather than meeting 10% of the energy demand. Apply requirement to all developments irrespective of size. Increase requirement to 20% and beyond at the earliest opportunity | CROSS-CUTTING | PV, Wind, Biomass CHP, Large Gas CHP, Heat from Power Station | Immediate, then requirement increasing according to planning timetable | 5 staff time to adapt policy | | (C & E) Urban Renewal, Forward Planning | |
| High | 4. Set up ESCo | CROSS-CUTTING | Biomass CHP, Large Gas CHP, Heat from Power Station | Immediate to facilitate timely installation of heat network and renewables | 110 set up costs, then self financing | High - essential for delivering CHP and heating network, saving over 2.5 ktpa per $MW_e$ installed | (C & E) Planning, Forward Planning, Kings Cross and (HASC) Energy & Sustainability and (F) | Energy companies |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| High | 5. Commission CHP study to investigate pipe routes and connection to local power stations | CROSS-CUTTING | Biomass CHP, Large Gas CHP, Heat from Power Station | Immediate, to be completed while ESco is set up | 22.5 for study | High - essential for delivering CHP and heating network, saving over 2.5 ktpa per $MW_e$ installed. Connection to power station could save over 50 ktpa by 2050 | (C & E) Planning, Neighbourhood Renewal, Kings Cross, Forward Planning and (HASC) Energy & Sustainability | Consultants, ESCo, Power station operators |
| High | 6. Develop borough wide heating network | CROSS-CUTTING | Biomass CHP, Large Gas CHP, Heat from Power Station | Started as soon as possible following feasibility study. Continued expansion to 2050 | Up to 653,000 capital cost (90% scenario) | Heat network with CHP and heat from power station accounts for the majority of $CO_2$ savings under all scenarios. | (C & E) Planning, Engineering Service, Forward Planning, Urban Renewal and (HASC) Energy & Sustainablility | ESCo, neighbouring boroughs, power station operators |
| High | 7. Ensure that UDP/LDF contains transport and energy sustainability policies including relating to:<br>• Electric car/van charging points off-street<br>• Car free and car capped housing<br>• Green roofs<br>• Alternative energy initiatives<br>• Contributions to sustainable transport initiatives<br>• Sustainable servicing initiatives | CROSS-CUTTING | | Ongoing | 0 | High | (C & E) | Developers |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Medium | 8. Establish energy crop consortium in area outside London | CROSS-CUTTING | Biomass CHP, Biomass Boilers | Established between 2012 and 2026, alongside transport routes | 15.5 initial coordination, 15 pa ongoing coordinator salary | Biomass CHP could save over 6 ktpa per $MW_e$ installed. Biomass boilers could save 1.7 ktpa / $MW_{th}$ for commercial or 0.42 tpa / dwelling for domestic | (CSU), (C & E) | Farmers, ESCo |
| Medium | 9. Identify biomass transport routes into London | CROSS-CUTTING | Biomass CHP, Biomass Boilers | Routes to be established by 2026 | 10 for initial study | Biomass CHP could save over 6 ktpa per $MW_e$ installed. Biomass boilers could save 1.7 ktpa / $MW_{th}$ for commercial or 0.42 tpa / dwelling for domestic | (C & E) | Rivers authority, TfL, train operators |
| Medium | 10. Improve efficiency of street lighting | CROSS-CUTTING | Efficient Street Lighting | Tied in with existing timetables of work | 0 if bulbs need replacement anyway | Could save 66 kg $CO_2$ per bulb per year | (C & E) Street Environmental Services, Street Policy | |
| Medium | 11. All new buildings to be CHP ready | CROSS-CUTTING | Biomass CHP, Large Gas CHP, Heat from Power Station | Follows CHP study and ESco set up | 12.5 to amend policies | Biomass and gas CHP could save over 2.5 ktpa per $MW_e$ installed capacity | (C & E) Planning, Urban Renewal, Neighbourhood Renewal, Forward Planning | ESCo |
| Low | 12. Develop voluntary carbon trading schemes for public sector, individuals and business | CROSS-CUTTING | | Initial trial period, then ongoing | 22.5 to coordinate initial trial | Depends on targets | (C & E), (CSU) | London Boroughs, GLA, LSP, Businesses and Residents |
| Low | 13. Planning requirement to exceed building regulations by 40% on new build | CROSS-CUTTING | Energy efficiency and renewables | Implement following consultation period | 25 to amend policies | Could save 64 ktpa by 2050 (40% of projected new build emissions) | (C & E) Planning, Building Control, Forward Planning, Urban Renewal | Developers |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| High | 14. Identify large business heat users and install CHP, with a view to joining the heat network as it develops | COMMERCIAL AND INDUSTRIAL | Biomass CHP, Large Gas CHP, Heat from Power Station | Alongside CHP study and ESco set up. 30 MWe to 45 MWe building CHP installed by 2012 | 7.5 for initial study | Building CHP could save over 3 ktpa per $MW_e$ installed | (C & E) Business Development, Urban Renewal | Local business |
| High | 15. Identify business owned and other sites for large PV installations | COMMERCIAL AND INDUSTRIAL | Large PV | 5 MWe PV to be installed by 2012 | 7.5 for initial study | PV saves around 0.6 ktpa per $MW_p$ installed. | (C & E) Business Development, Urban Renewal | Local Business |
| Medium | 16. Develop and maintain a database of commercial and industrial property including energy efficiency measures | COMMERCIAL AND INDUSTRIAL | Energy efficiency and renewables in non-domestic buildings | Completed by 2012 | 15 Set up cost | Helps target energy efficiency measures | (C & E) Business Development, Information Technology | |
| Medium | 17. Introduce a scheme to provide advice and promote energy efficiency measures in non-domestic buildings | COMMERCIAL AND INDUSTRIAL | Energy efficiency and renewables in non-domestic buildings | Scheme introduced by 2012 | 35 per annum ongoing | Potentially high - C & I sector dominates emissions in Camden | (C & E) Environmental Health, Business Development | |
| Medium | 18. Include Local Strategic Partners in LA work | COMMERCIAL AND INDUSTRIAL | | LSP should be engaged as early as possible | 5 initial engagement | Potentially high - C & I sector dominates emissions in Camden | (CSU) | Police, Fire Service, PCT, UCL, Voluntary and Community Sector, Local Business |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Low | 19. Investigate pilot scheme to use business rates to provide tax incentives for businesses to implement energy efficiency measures or install renewables | COMMERCIAL AND INDUSTRIAL | | Policies set up by 2012 | 20 to establish trial | Potentially high - C & I sector dominates emissions in Camden | (F) Council Tax & Business Rates, (C & E) Business Development | Local businesses |
| Low | 20. Calculate corporate carbon footprint and display publicly | COMMERCIAL AND INDUSTRIAL | | Next two years | 10 study and marketing costs | Low, but important example setting | (C & E) Environmental Health, Property, Street Environmental Services | |
| Low | 21. Use procurement rules to encourage businesses to have energy audits and environmental policies | COMMERCIAL AND INDUSTRIAL | | Completed by 2012 | 10 to adapt policies | | (F) Procurement Strategy Unit, (C & E) Business Development, Environmental Health | Local Businesses |
| Low | 22. Establish EPBD early implementation scheme | COMMERCIAL AND INDUSTRIAL | | Immediate, before EPBD is implemented nationally | 12.5 to set up scheme, 1 per audit | Low | (C & E) Environmental Health, Business Development | |
| Low | 23. Work with whole industrial estates at once for energy auditing | COMMERCIAL AND INDUSTRIAL | | Completed by 2012 | 25 for a year long coordinator post | Potentially low to medium if recommended measures are implemented | (C & E) Planning, Business Development | Local business, NISP |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Medium | 24. Continue and expand domestic energy efficiency programmes in Council and private stock | DOMESTIC | | Ongoing | 15800 total capital costs for insulation measures to 2050, running costs part of ongoing EEAC work | Loft and cavity wall insulation could save up to 35 ktpa. | (HASC) Renewal, Planning and Performance, Procurement and Business Support, Energy & Sustainability, Housing Management, (C & E) Environmental Health | RSL's, EEAC |
| Medium | 25. Encourage RSL's, Homeowners and private landlords to improve energy efficiency and supply data | DOMESTIC | | Ongoing | 5 per annum coordination | Low to medium | (C & E), (HASC) Energy & Sustainability, Planning and Performance, Housing Management | RSL's |
| Medium | 26. Offer grants to private households for renewable energy and energy efficiency | DOMESTIC | | Ongoing | 12.5 Initial set up costs, running costs part of EEAC work, grant funds to be decided | Domestic PV could save 44 ktpa if installed to maximum potential. Other renewables would have lower impact. Does engage population | (C & E) Environmental Health, (HASC) Housing Management | EEAC |
| High | 27. Continue to work with TfL to improve public transport network - lobby for Crossrail, Cross River Tram and other infrastructure improvements | TRANSPORT | | Long term, but planning should start now | 90 per annum staff time | Short-term low, long-term high. Initially may even slightly increase CO2 emissions, but improved public transport could reduce car miles. | (C&E) Street Management, Street Policy, Transport Planning, Planning | TfL, rail operators |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| High | 28. Reduce impact of freight in Camden - through freight quality partnerships (FQPs), distribution hubs and improved vehicles and driving techniques | TRANSPORT | | Ongoing, starting immediately | 60 per annum staff costs to develop FQP. Distribution hub is unlikely to be within Camden due to land prices but purchase and set up likely to be well in excess of 1500 | Medium - FQP and promotion. Improving driving techniques can reduce fuel use by 5-15%<br>High – distribution hub. A centre in Bermondsey cut CO2 emissions by 73% in six months. | (C&E) Street Management, Street Policy, Transport Planning, Planning | LBC, TfL, freight operators, construction companies, adjacent boroughs |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Medium | 29. Continue to address school transport - parents, teachers and pupils. This could include:<br>• family/personal travel plans for families applying to schools where they live more than 1/4 mile away.<br>• School Travel Plan implementation of safety/walking/cycling measures<br>• Cycle training<br>• Pedestrian Skills/Kerbcraft training<br>• Promotional (Walk on Wednesdays)<br>• School buses | TRANSPORT | | Ongoing, starting immediately. | 70 per annum school travel planning; 100 pa personal travel planning<br><br>150 pa capital; 50 pa cycle training, 60 pa pedestrian skills/ kerbcraft training, 15 per annum promotional (Walk on Wednesdays); School buses 500 per annum estimated minimum. | Low - as car use to take children to school is already low in Camden. | (C&E) Street Policy, Street Management, Transport Planning, Planning | TfL, Schools, pupils, teachers and parents |
| Medium | 30. Reduce need for travel in Camden through measures such as promoting home deliveries and ensuring as many households as possible within walking distance of food shops. | TRANSPORT | | Ongoing | 35 per annum staff time to promote home deliveries<br><br>25 per annum promotional to residents | Low - Nationally home deliveries estimated to cut car mileage for shopping by 4% and Camden already has lower levels of car use than national average | (C&E) Street Policy, Street Management Transport Planning, Planning, Community Development and Regeneration | |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Medium | 31. Review LBC fleet and implement measures to reduce CO2 emissions further. | TRANSPORT | | | 5 for a small-scale fleet review. Capital funding then needed to implement measures | Low - as fleet is only a small proportion of overall Camden emissions. High impact within corporate emissions though. | Fleet Manager | |
| Medium | 32. Continue to improve cycling infrastructure - routes, signage, storage | TRANSPORT | | ongoing | Capital funding for measures, 400 per annum for larger LCN+ projects, 100 per annum for local projects | Medium - cycling has the potential to replace a considerable number of car journeys. | (C&E) Street Policy, Street Management, Engineering Service, Transport Planning, Planning | TfL, Camden Cycling Campaign |
| Medium | 33. Provide secure cycle parking for estates and households (especially flats) | TRANSPORT | | Start soon, tie in with existing timetable of works. | 30 per annum to find locations and install parking for about 60 bike | Low - in itself minimal impact, but could greatly increase levels of bike ownership and therefore use. | (HASC) Housing Management<br>(C&E) Street Policy, Street Management, Community Development and Regeneration | Residents associations, Camden Cycling Campaign, TfL |
| Medium | 34. Continue to raise awareness of travel, especially public transport, walking and cycling | TRANSPORT | | Immediate start, then ongoing | 70 staff time and publicity costs per annum | Low - Medium - depending on impact of campaign. | (C&E) Transport Planning, Planning, Street Policy, Street Management | good going, TfL |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Medium | 35. Look into ways to improve the efficiency of the taxi fleet for example: driver training, grants and advice on alternative fuels/more efficient vehicles, shared taxis. This should be led by TfL and the Public Carriage Office (PCO) | TRANSPORT | | Immediate and ongoing | 15 for a review of taxi fleet and recommendat-ions.<br>50 per annum grants towards driver training<br>10 per annum staff time and publicity costs | Medium to High - depending on impact of campaign and measures implemented. | (C&E) Transport Planning, Planning | TfL PCO, taxi and private hire drivers and companies |
| Medium | 36. Lobby for more East-West bus routes and increased frequency of existing routes | TRANSPORT | | Immediate | 35 staff time to coordinate with TfL and lobby | Medium - if more routes implemented | (C&E) Street Policy, Street Management, Transport Planning, Planning | TfL, local residents groups, schools, businesses |
| Medium | 37. Continue to encourage travel plans for business, tailor these to promote more walking and cycling by employees, through pool bike schemes and similar. Reduced taxi use. Include promotion of bicycle couriers and greener vehicles. | TRANSPORT | | | 80 per annum funding | Low to Medium - travel plans can reduce car use by 10-25% but this may be lower in Camden as car use already lower than average. | (C&E)Transport Planning, Planning, Business Support Unit, Business Development | TfL, businesses and organisations |
| Medium | 38. Encourage the formation of local travel plan groups for groups of smaller businesses in the same area, e.g. town centres or trading estates | TRANSPORT | | Scheme set up by 2010 | 60 per annum for staff post | Medium - by targeting smaller businesses, could impact on car use and deliveries. | (C&E)Transport Planning, Planning, Business Support Unit, Business Development, Town Centre Management | Local businesses and organisations, TfL |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Medium | 39. Deliver emissions based parking permits with annual review to ensure that the policy is delivering a shift to smaller engines/ less CO2 | TRANSPORT | | Medium term | 0 | Medium - more efficient vehicles could significantly reduce emissions.. | (C&E) Street Policy, Street Management, Transport Planning, Planning, Parking Services | neighbouring boroughs |
| Medium | 40. Consider charging for motorcycle parking in the borough and linked to this run a campaign focussed at motorbike users to promote Lower emission bikes (e.g. electric scooters), Highlight environmental and safety issues | TRANSPORT | | Medium Term | 30 for feasibility study of pros and cons of charging scheme. 40 per annum staff time and publicity | Low - unless implemented with neighbouring boroughs. | (C&E) Street Policy, Street Management, Parking Services, Transport Planning, Planning | neighbouring boroughs, motorcycle users groups, TfL |
| Medium | 41. Continue to improve pedestrian environment to promote walking | TRANSPORT | | Tie in with existing timetable of works. | 15 per street audit, 2.5 staff time to apply for funding to implement recommendations.<br><br>5000 maintenance per annum, 2500 capital scheme investment pa | Low to medium - depending on improvements and whether modal shift occurs | (C&E) Street Policy, Street Management, Transport Planning, Planning, Engineering Service, Town Centre Management | TfL, Living Streets, Local residents associations, schools, businesses |

| Priority | Action | Sector | Applies to (scenario measure) | Timescale | Marginal cost (£k) | $CO_2$ saving | Department / Team | Partners |
|---|---|---|---|---|---|---|---|---|
| Low | 42. Promote better driving techniques and greener cars and motorbikes to individuals in Camden | TRANSPORT | | Ongoing, starting immediately | 100 per annum staff time and publicity | Medium - 'eco-driving' can reduce emissions by 5-25%. | (C&E) Street Policy, Street Management, Transport Planning, Planning | Driving instructors, TfL |
| Low | 43. Run a campaign focussed at motorbike users to promote Lower emission bikes (e.g. electric scooters), Highlight environmental and safety issues | TRANSPORT | | Medium term | 10 per annum staff time and publicity | Low - as motorcycles small proportion of overall fleet. | (C&E) Street Policy, Street Management | Motorbike users groups, TfL |
| Low | 44. Set up city bike scheme or bike club, could be promoted to tourists, businesses, students and residents | TRANSPORT | | Scheme set up by 2010. | 350 for pilot project with WCC and Corporation 4000 capital costs of setting up. 10 ongoing staff support | Low to medium - dependent on whether modal shift occurs from cars. | (C&E) Transport Planning, Planning, Community Development and Regeneration | TfL, Camden Cycling Campaign |
| Low | 45. Continue to encourage car clubs especially those using greener vehicles. Consider using car clubs within LBC as pool cars and encourage other businesses to do likewise. | TRANSPORT | | Ongoing | 60 per annum staff costs | Low to Medium - depending on whether it impacts on overall levels of car ownership and use. | (C&E) Transport Planning, Planning | Car club operators |

**Table 52 Actions**

# 8 Conclusions

## 8.1 Baseline Emissions

This strategy has identified the baseline $CO_2$ emissions for the London Borough of Camden as 1774 ktpa. Of these 30% are from dwellings, 58% from non-domestic buildings and 12% from transport.

Growth in the borough is expected to increase these emissions by 67 ktpa for dwellings, 15 ktpa for non-domestic buildings and 102 ktpa for transport if allowed to grow unconstrained.

Camden is considering targets to reduce $CO_2$ emissions by 60%, 80% and 90% by 2050. These correspond to reductions of 1248 ktpa, 1603 ktpa and 1780 ktpa when the expected growth is accounted for.

## 8.2 Carbon Scenarios

SEA/RENUE has developed a model to analyse various combinations of several technologies that could supply energy, reduce demand or reduce transport emissions. The proposed scenario is subject to various constraints.

The model suggests a scenario that can meet a 60% target, and can be financially viable. Higher targets are more difficult to meet using the particular set of measures and constraints laid out in the model. Within the modelled measures and constraints, the maximum target that could be achieved would be a 70% reduction, but this would probably be unrealistic, especially in the case of the transport measures. Allowing biomass imports from further than 40 km outside London would enable higher targets of 70% or possibly 80% to be met.

The scenarios suggest a vision of how the borough might meet its energy and transport needs between now and 2050. The scenarios also include the interim years 2012, 2026 and 2035. This gives an indication of how the energy and transport mix might develop over time.

Table 53 shows how each of the five scenarios would look in 2050, and Table 54 summarises the results.

| Technology | Units | 60% by 2050 | 70% by 2050 | 80% by 2050 | Maximum | Renewables and insulation |
|---|---|---|---|---|---|---|
| Renewable CHP | $MW_e$ | 4 | 87 | 160 | 5 | 0 |
| Gas CHP - Large | $MW_e$ | 395 | 250 | 110 | 436 | 0 |
| Gas CHP - building | $MW_e$ | 5 | 5 | 10 | 0 | 60 |
| Heat from power station | $MW_{th}$ | 25 | 25 | 25 | 0 | 0 |
| PV - Domestic | Dwellings | 28000 | 28000 | 33000 | 33000 | 33000 |
| PV- Large | $MW_e$ | 60 | 60 | 60 | 60 | 60 |
| Wind - large | $MW_e$ | 0 | 0 | 2 | 2 | 2 |
| Wind - medium | $MW_e$ | 0 | 0 | 1 | 1 | 1 |
| Wind - small | Dwellings | 0 | 0 | 5000 | 5000 | 5000 |
| Solar thermal | Dwellings | 1000 | 1000 | 0 | 0 | 5000 |
| Biomass boilers large | $MW_{th}$ | 3 | 0 | 0 | 0 | 25 |
| Biomass boilers small | Dwellings | 300 | 0 | 0 | 0 | 1500 |
| GSHP | Dwellings | 300 | 0 | 0 | 0 | 5000 |

| Technology | Units | 60% by 2050 | 70% by 2050 | 80% by 2050 | Maximum | Renewables and insulation |
|---|---|---|---|---|---|---|
| Micro-CHP Stirling | Dwellings | 300 | 300 | 0 | 0 | 0 |
| Micro-CHP fuel cell | Dwellings | 300 | 300 | 0 | 0 | 0 |
| Cavity wall ins | Dwellings | 23000 | 23000 | 23000 | 23170 | 23170 |
| Loft insulation | Dwellings | 33000 | 33000 | 33000 | 33533 | 33533 |
| Double glazing | Dwellings | 10000 | 10000 | 36000 | 10000 | 10000 |
| Solid wall insulation | Dwellings | 0 | 0 | 2000 | 0 | 50000 |
| Energy Efficient Lighting | 000's $m^2$ | 1200 | 1200 | 1400 | 1500 | 1500 |
| Double Glazing - Commercial | 000's $m^2$ | 40 | 40 | 60 | 0 | 90 |
| Street Lighting - Efficient Lamps | Lamps | 8000 | 8000 | 9000 | 9865 | 9865 |
| Reduce car passenger-km | million pass-km | 150 | 150 | 150 | 646 | 150 |
| Reduce motorcycle passenger-km | million pass-km | 6 | 6 | 6 | 24 | 6 |
| Reduce taxi passenger-km | million pass-km | 15 | 15 | 15 | 60 | 15 |
| Reduce road freight tonne-km | million t-km | 50 | 50 | 50 | 111 | 50 |
| Reduce $CO_2$ emissions of fleet - cars | $gCO_2$/pass-km | 25 | 25 | 25 | 87 | 25 |
| Reduce $CO_2$ emissions of fleet - motorcycles | $gCO_2$/pass-km | 15 | 15 | 15 | 63 | 15 |
| Reduce $CO_2$ emissions of fleet - taxis | $gCO_2$/pass-km | 40 | 40 | 40 | 174 | 40 |
| Reduce $CO_2$ emissions of fleet - freight | $gCO_2$/t-km | 30 | 30 | 30 | 100 | 30 |
| Reduce $CO_2$ emissions of fleet - buses | $gCO_2$/pass-km | 20 | 20 | 20 | 72 | 20 |
| Reduce $CO_2$ emissions of fleet - trains | $gCO_2$/pass-km | 3 | 3 | 3 | 9 | 3 |
| Modal shift, cars to public transport | million pass-km | 120 | 120 | 120 | 150 | 120 |
| Modal shift, motorcycles to public transport | million pass-km | 6 | 6 | 6 | 6 | 6 |
| Modal shift, taxis to public transport | million pass-km | 15 | 15 | 15 | 10 | 15 |
| Modal shift, freight road to rail | million t-km | 30 | 30 | 30 | 111 | 30 |

**Table 53 Installed capacities by 2050 for the four scenarios**

| Scenario | Name | Heat | Power | $CO_2$ Savings | Net Present Value | Capital Costs | % of borough heat demand met by CH |
|---|---|---|---|---|---|---|---|
| | | MWh/y | MWh/y | Ktpa | £k | £k | % |
| 1 | 60% by 2050 | 3,209,124 | 2,818,273 | 1,329 | 799,901 | 937,990 | 92.2% |
| 2 | 70% by 2050 | 3,181,563 | 2,404,933 | 1,506 | 826,463 | 1,051,389 | 92.8% |
| 3 | 80% by 2050 | 3,212,876 | 2,026,076 | 1,686 | 733,081 | 1,561,314 | 93.7% |
| 4 | Maximum | 3,207,871 | 3,075,240 | 1,498 | 1,452,235 | 1,048,333 | 99.8% |
| 5 | Renewables and insulation | 1,295,624 | 652,820 | 528 | 355,850 | 537,850 | 0.00% |

**Table 54 Summary of scenarios**

## 8.3 Recommendation for a target

The choice of target is likely to depend on two critical factors. One is the desired $CO_2$ reduction and the second is the view taken on the choice of fuels.

The Climate Change Action Plan adopted a $CO_2$ reduction target of 60%. This work has shown that a 60% target can be achieved in Camden with existing technologies and is financially viable.

One of the advantages of community heating is that alternative generation plant can be plugged in to the heat network and electricity distribution infrastructure, so it is a more flexible strategy than using individual boilers. Achieving a higher target of 70% or 80% would require such a shift. At present, the most likely option would be biomass and this would need to come from outside London.

It could be argued that there is no reason why biomass shouldn't be an internationally traded commodity in the same way that oil and gas are today. Others would prefer biomass to be locally sourced. LB Camden would need to take a view on this issue before adopting a higher target.

Planning for a biomass fuelled system now might appear to be something of a risk, given that imported biomass fuels are not yet available in huge quantities. However, all fuels are subject to some uncertainty of future supplies including natural gas.

If Camden develops a borough wide heat network, and it does turn out that an international biomass trade develops so that biomass fuels do become readily available, then the borough will be in a good position to exploit these fuels.

This report has focused on technological solutions to maintain current levels of energy consumption. This approach is able to meet $CO_2$ reduction targets of at least 60% without the need for significant lifestyle changes. In order to meet higher targets, behavioural changes would be required to reduce energy demand.

## 8.4 The Vision

This strategy envisages a fundamental shift in the way energy is supplied in the borough. By 2050, much of Camden will be served by a community heating network distributing hot water to buildings. This will be supplied by CHP power stations using gas, biomass and wastes as fuels.

The CHP and heat network will supply most of the heat demand for the borough and meet the majority of the carbon reduction target, depending on the choice of scenario. It will also supply electricity to the borough and to the national grid.

The scenario modelling clearly shows that without district heating the potential for $CO_2$ reductions is severely limited.

This CHP will be complemented by a range of efficiency measures to reduce demand in both the domestic and non-domestic sectors. In addition, there will be several renewable energy installations in the borough, principally solar PV supplying renewable electricity.

In the transport sector, personal car transport use will have reduced by up to 60% as people switch to public transport and walking and cycling. Road freight will also be reduced by efficient logistics and a switch to rail. A combination of efficiency improvements and alternative fuels will have reduced the emissions per kilometre travelled for all modes of transport.

## 8.5 Implementation

Action must start now to implement the recommendations of this strategy. Camden will have to begin by leading by example and reducing its own corporate emissions. It will need to work with a wide range of partners to help reduce emissions further. It will have to use its influence and set a policy framework to ensure that the right choices are made early on.

A range of policy measures are recommended in this strategy document. In the short term, policies can be implemented to shape the longer term developments in transport and energy. Energy efficiency measures must continue to be installed throughout the existing building stock. The borough will also need to provide some renewable energy, probably biomass and PV, and CHP for individual buildings to meet short term targets.

The regeneration areas of Camden in the borough are also key. Large redevelopment projects can be used as a template for the whole borough.

This report also outlines the start of developing the bigger infrastructure projects that will be needed by 2050, particularly the heat network. Decisions made now will have an impact on energy use in the borough in 2050, and it is important to set the right policies now. This means formulating a detailed plan and setting up an ESCo to deliver the infrastructure.

The local authority is uniquely positioned to see the long term view and guide the borough towards its vision for 2050.