Meeting 40% Carbon Emissions Reductions by 2020

Version 2.1 FINAL REPORT

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Abbreviations/Terms of Reference

BRE	Building Research Establishment
BAU	Business as usual
C & I	Commercial and industrial
CHP	Combined heat and power
CO_2	Carbon dioxide
CRC	Carbon Reduction Commitment
DECC	Department for Energy and Climate Change
DfT	Department for Transport
EU	European union
FiT	Feed in Tariff
FOE	Friends of the Earth
GLA	Greater London Authority
GWh	Gigawatt hours
kg	Kilograms
km^2	Square kilometres
ktpa	Kilo tonnes per annum
kW	Kilowatt
kWe	Kilowatts electrical
kWh	Kilowatt-hour
LCCA	London Climate Change Agency
LCTP	Low Carbon Transition Plan
m^2	Square meters
MLSOA	Middle layer super output area
MRP	Maximum resource potentials
MW	Megawatt
MWe	Megawatt electrical
MWh	Megawatt–hour
NI	National Indicator
NO_x	Nitrous oxides
NPV	Net present value
PV	Photo voltaic
RHI	Renewable Heat Incentive
SME	Small and medium sized enterprise
UK	United Kingdom
VP	VantagePoint

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Executive Summary

This study was undertaken to provide the London Borough of Camden with an update to the 2007 Report 'Delivering a Low Carbon Camden' in light of:

- A need to assess the viability of achieving the Friends of the Earth (FOE) target of 40% reduction in carbon emissions by 2020 on a 2005 baseline
- Alternative methodological approaches to assessing reductions
- Progress since the original study, new reference data and policies.

This report is not intended to act as a detailed action plan for Camden, but instead it seeks to highlight the likely route to a low carbon Camden through analysis. A detailed action plan would need to follow.

This work has been undertaken using Carbon Descent's in-house carbon reduction scenario planning tool, VantagePoint (VP). This enables the creation of carbon reduction scenarios to help underpin the development of Climate Change Strategy. It allows the establishment of a target and can help to determine the best mix of measures to deliver the carbon dioxide (CO_2) reductions. A range of scenarios made up of generation, behaviour change, infrastructure and policy measures can be generated and compared.

The Camden context

Camden is an inner London borough covering 22 square kilometres with its southern end located in Central London and as such there are several factors that must be considered when selecting the most appropriate carbon reduction strategy for the borough to meet a 40% reduction target by 2020 on a 2005 baseline. The majority of carbon emissions (65.82%) in Camden are from the C&I(C&I) sector, followed by the domestic sector (24.07%), then the transport sector (10.11%). The high emissions from the C&I sector reflect the size of the economy in Camden, however, emissions from this sector are beyond the council's direct control. This presents a significant challenge to meeting a 40% carbon reduction target by 2020. Other challenges include:

- The high proportion of listed buildings and designated conservation areas in the borough making it difficult to retrofit energy efficiency measures due to strict planning restrictions
- The high land value and lack of space for installing large innovative technologies
- A growing population who need homes, jobs and access to transport.

Baseline and targets

The 40% carbon reduction target by 2020 is set against a baseline year of 2005 to ensure consistency with the methodology used for NI186 (per capita emissions in the local authority area, which forms part of Camden's Local Area Agreement). The most recent year for which actual carbon emission data is available from DECC is 2007, so this data has been used in VantagePoint and the first year in the model has been set to 2007. This year, 2010, has been set as an interim year in the model so that progress on reducing carbon emissions to date can be taken into consideration in the scenario. Other interim years have been set at 2013 and 2016, in line with the FOE study, and the percentage carbon reduction target increases linearly throughout the overall period reaching 40% by 2020 (from a 2005 baseline).

Business as usual growth

Business as usual (BAU) growth to 2020 has been estimated for each of the three sectors in the model: Domestic, Commercial & Industrial, and Transport. For the purposes of calculating BAU emissions, Camden have provided details on the projected growth in electricity demand, gas demand, and population from a recent study carried out jointly by URS Corporation and the London Borough of Camden entitled 'Camden Infrastructure Study: Utilities and Physical Infrastructure Needs Assessment' (completed in October 2009). Transport emissions growth has been calculated by scaling 2007 figures in line with Department for Transport (DfT) Regional Transport Forecasts for London.

Effect of grid factor

The choice of grid emissions factor, (the number of kilograms of CO_2 emitted per kWh of used electricity), used in the modelling has a significant impact on the overall results. The grid factor used in the final scenario modelled in VP for this study was calculated from the central projection of the likely grid mix in 2020 at 0.332 $kgCO_2$/kWh, published by DECC[1]. The study underpinning the FOE campaign to reduce emissions by 40% by 2020 uses an optimistic projection of a grid emissions factor of 0.216 $kgCO_2$/kWh by 2020. A report released by the Committee on Climate Change entitled 'Meeting Carbon Budgets – the need for a step change'[2] predicts a grid factor of approximately 0.400 $kgCO_2$/kWh. If the FOE grid factor is used, the scenario exceeds the carbon reduction target by 189 $ktCO_2$ per annum. If the Committee on Climate Change grid factor is used the scenario misses the target by 108 $ktCO_2$ per annum. This brief analysis demonstrates the crucial role of the grid factor in achieving the 40% reduction target by 2020. However the grid factor is a variable that is largely outside Camden's control which introduces a significant risk that the 40% reduction target will not be met.

Scenario setup

A scenario that meets the 40% reduction target by 2020 and the corresponding targets for the interim years was set up in VantagePoint using an iterative process to optimise the mix of carbon reduction measures that should be implemented in each time period.

Measures that are due to be implemented through current legislation or known government policy were defined in the scenario first. This included:

- The DECC projections for carbon reductions through greening the grid
- Reductions in road transport emissions through the Government target to increase the level of biofuels used in transport fuels to 10% by 2020
- The EU target to increase average new car efficiency to $95gCO_2$/km transport by 2020.

After applying these national measures, other measures were selected based on cost effective carbon savings and a realistic assessment of what is feasible for Camden with proven technologies being given priority in the early years. Several iterations of the scenario were modelled before the final optimised version that could meet the targets was selected.

In the final scenario:

- Loft and cavity wall insulation have been set to almost the full maximum resource potential (MRP) by 2020 as they have a big impact on carbon savings for a relatively low cost.
- Other building fabric improvements including internal and external solid wall insulation and double glazing have been installed to approximately half of their maximum potential as these can significantly reduce carbon emissions but are more expensive technologies to install and can be disruptive to the resident.
- Carbon reductions through behaviour change have been limited to 6% and may come about through measures such as the installation of smart meters in all homes.
- Carbon reduction measures in the C&I sector are limited to installing double glazing, installing energy efficient lighting, and behaviour change measures (again limited to 6%).
- Camden already plans to install 8.7MWe of CHP on buildings in the borough by 2014. The scenario reflects the relatively long lead in times required to implement CHP projects suggesting that 12MWe needs to be installed by 2013 ramping up rapidly to 120 MWe by 2020 to meet the targets.
- The scale of renewable technology potential has been established through an analysis of appropriate technologies and available space.
- Part of the reduction in transport emissions is accounted for by behaviour change measures that include a modal shift from cars to public transport, walking and cycling and measures such as eco-

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[1] DECC grid mix projections can be found in Annex D of the Energy and Emissions projections which can be downloaded at: www.decc.gov.uk/en/content/cms/statistics/projections/projections.aspx

[2] Grid factor is estimated from figure 4.1 on page 107 of the report entitled 'Meeting Carbon Budgets – the need for a step change' published by the Committee on Climate Change in October 2009 which can be accessed at: thecccdev.heymoscow.com/reports/progress-reports

driving techniques or better vehicle maintenance. Savings from this measure have been capped at 6% in line with other behaviour change measures.

Although Camden are currently unable to commit to installing biomass CHP in the borough due to air quality and supply chain issues, a small amount of biomass has been included in the scenario. The reason for this inclusion is that it is likely that the technology will advance sufficiently over the next few years to overcome the issues with NO_x and particulate emissions allowing Camden to invest in the measure. Whilst not an option for Camden at the current time, energy from waste or anaerobic digestion could be viable when waste contracts are renegotiated or renewed.

Results

Implementing the combined measures in the scenario will result in carbon savings of 750 ktpa of CO_2 by 2020, just above the target of 744 ktpa. 43% of the carbon savings come from the 'Green Grid' measure assuming that the grid mix predicted by DECC is realised in practice by 2020. CHP technologies account for 19% of the carbon savings in this scenario. Installing 120 MWe of CHP capacity within the next 10 years will require aggressive policy setting by Camden. The Council should rigorously enforce and extend existing planning policy making it a requirement for new commercial developments to install CHP infrastructure capable of supporting local heat networks beyond the site boundary and require all other developments to connect to a district heating network in the future. A further 16% of savings is made through the implementation of improvements to the building fabric of domestic buildings. The remaining 22% of carbon savings comes from the implementation of behaviour change measures, transport related measures and C&I measures.

The total capital cost of implementing the scenario is approximately £783.5 million over the period between 2007 and 2020 with the majority of the investment being made between 2010 and 2020. Capital costs for each measure are built in to VP and total capital costs are calculated when the scenario is run. It should be noted that the capital costs presented here are not solely attributable to the local authority but are a combination of all costs that will be distributed across all investors involved in implementing measures. The total capital costs will therefore be spread across the local authority, individual householders, landlords, and private sector investors.

Overall the scenario has a net present value (NPV) of £718.5 million by 2030. NPV is a measures of the profitability of the project taking into account all cashflows and the changing value of money over time. NPV calculations have been extended to 2030 to show the value of the scenario once all technologies have had a chance to pay for themselves through revenue generation. It should be noted that the NPV is significantly positive by 2030 showing that investing in carbon reduction technologies is profitable. Additionally with the exception of large gas CHP and double glazing most of the technologies in the scenario have a positive NPV showing that they are financially viable and could attract investment from the private sector if the corresponding payback periods are short enough. Those measures that have a negative NPV may require an additional incentive from a local authority to attract private sector investment. Large gas CHP has a negative NPV at 2030 mainly because the majority of the investment in large CHP happens in the final period between 2016 and 2020. Payback periods for CHP can be in the region of 10 to 15 years depending on the location and capacity so further time is needed to see the financial benefits associated with this measure. This supports the idea that aggressive policy setting will be required to quickly increase CHP capacity in Camden.

Conclusion

It is possible for the London Borough of Camden to meet a 40% reduction target on a 2005 baseline by 2020. Successfully meeting this target relies on several factors:

- The national grid mix changing over time to include more renewable and low carbon technologies achieving a grid emissions factor of 0.332 by 2020.
- The fast growth in CHP capacity in the borough up to a total of 120 MWe capacity. This is likely to be achieved through the aggressive enforcement of existing local and regional planning policy.
- Continuation of the implementation of cavity wall and loft insulation and extension of these schemes to include double glazing and solid wall insulation in the private sector. This is likely to require full engagement with the proposed 'Green Deal' finance models.

- Realisation of government targets and projections on the percentage of biofuels used in transport fuels and improvements in road transport efficiency together with an increase in the proportion of electric vehicles and a modal shift from cars to public transport, walking or cycling.
- Implementation of behaviour change measures to reduce demand electrical and thermal demand, the installation of small scale renewable such as domestic Photo Voltaic (PV) and the implementation of commercial energy efficiency measures.

1 Introduction

1.1 Background

The London Borough of Camden wishes to update the 2007 Report Delivering a Low Carbon Camden in light of:

- A need to assess the viability of achieving the FOE 40% by 2020 target
- Alternative methodological approaches to assessing reductions
- Progress since the original study, new reference data and policies.

This report is not intended to act as a detailed action plan for Camden, but instead it seeks to highlight the likely route to a low carbon Camden through analysis. A detailed action plan would need to follow.

The original report used an approach which was generally accepted at the time. The vision of the future put forward by the Greater London Authority (GLA) and London Climate Change Agency (LCCA) was one of decentralised heat and power almost to the exclusion of centralised systems. Since then the government's plans for greening the grid have become much clearer and alternative methodological approaches have been adopted particularly in the treatment of electricity generation.

This work has been undertaken using Carbon Descent's in-house carbon reduction scenario planning tool, VantagePoint. This enables the creation of carbon reduction scenarios to help underpin the development of Climate Change Strategy. It allows the establishment of a target and can help to determine the best mix of measures to deliver the CO_2 reductions. A range of scenarios made up of generation, behaviour change, infrastructure and policy measures can be generated and compared. The process allows the user to:

1. Select a local or regional authority; upload its profile from nationally verified statistics to populate the baseline emissions for year zero
2. Forecast emissions from population growth, rates of demolition, new build and transport statistics
3. Select a carbon reduction target for 2020
4. Analyse a mix of technologies and measures modelled for transport, domestic, commercial and industrial buildings to achieve the targets, tailor this mix of measures and save the scenario.

1.2 Robustness of the modelling

The data used by VantagePoint to calculate carbon savings, capital costs and NPVs is based on the most up to date reference data that is available from a range of sources including reports and statistics published by the Department for Energy and Climate Change (DECC) and the Carbon Trust. This reference data is updated regularly (at least annually) to ensure that the results of the modelling are as accurate as possible. A table showing a selection of reference data and the corresponding data sources is given in Appendix A. Where parameters have been calculated outside of VantagePoint, (for example, when calculating BAU emissions), source data has been taken from recently completed local studies provided by Camden. This ensures that the modelling is tailored to Camden's specific circumstances.

As VantagePoint makes use of the most recently available data from reliable data sources (such as DECC) and standard calculation methodologies the results from the model are as accurate as they can be at the time of writing. However, the model uses many parameters from different data sources – a significant number of which are themselves projections based on modelling – therefore, it is not possible to determine a specific figure for the margin of error associated with the results presented in this report. The robustness of the model is highly dependent on the robustness of the source data and in particular that of the projections that have been used to estimate how technology efficiencies, carbon emissions factors, and capital costs will change over the next 10 years. A list of the source data used by VantagePoint is available on request from Carbon Descent so that reference data can be checked independently if necessary.

1.3 The Camden context

Camden is an inner London borough covering 22 square kilometres with its southern end located in Central London. It has the seventh largest economy in the UK and is home to around 3% of the total population of London[3]. The local building stock, economy and the growing population present several challenges and opportunities that must be considered when selecting the most appropriate carbon reduction strategy for the borough and these are discussed in more detail below.

1.3.1 Distribution of carbon emissions by sector

Figure 1 shows the distribution of emissions in Camden by sector for 2007. It demonstrates that the majority of emissions (65.82%) in Camden are from the C&I sector, followed by the domestic sector (24.07%), then the transport sector (10.11%). The high emissions from the C&I sector reflect the size of the economy in Camden, however, emissions from this sector are beyond the council's direct control. This presents a significant challenge to meeting a 40% carbon reduction target by 2020 so innovative ways of engaging with and influencing businesses in the borough will be necessary.

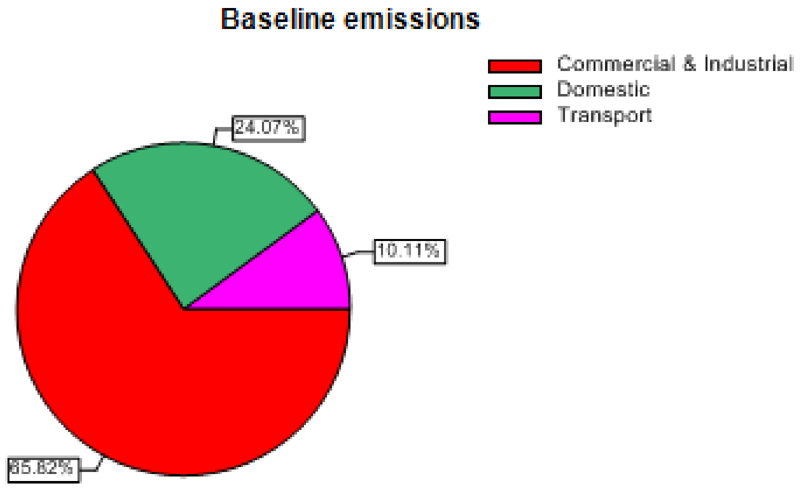

Figure 1: Distribution of emissions in Camden by sector in 2007

1.3.2 Building stock

Large reductions in the carbon emissions of the building sector can be made by retrofitting simple measures such as insulation or double glazing to existing buildings. However the building stock in Camden presents several challenges in achieving these savings:

- There are approximately 5,600 listed buildings in Camden, many of which will have solid walls. Listed status could mean that many simple energy saving measures cannot be installed at these sites because doing so may compromise particular architectural features that the listed status is intended to preserve.
- Over half the total land area in Camden has been designated as a conservation area. This means that there may be restrictions on carrying out work that would alter the external appearance of the buildings in these areas. As such some carbon reduction measures such as installing solid wall insulation, double glazing or domestic renewable technologies may be more costly than a standard installation or may be prohibited altogether by planning restrictions.

[3] www.camden.gov.uk/ccm/navigation/jobs-and-careers/about-camden/

- There are a high proportion of privately rented homes in Camden (23.46% compared to 14.34% across London and 8.80% nationally[4]). Private landlords are often reluctant to invest in installing carbon saving measures on rental properties because it is the tenant that benefits from lower fuel bills rather than the landlord. Camden may be able to influence private dwelling owners through planning and building control or other incentives.
- There is a high proportion of local authority owned housing stock in Camden (23.9% compared to 13.3% across London and 8.3% nationally[5]). Retrofitting the entire LA stock with carbon saving measures will require a large initial capital outlay, but since the Council has direct control over their own stock, significant carbon savings can be made in this sector.

1.3.3 Lack of space

As an inner city London borough, space in Camden is at a premium. Land values are high and there is little land area available to install large, innovative new technologies. For example, Camden is unlikely to be suitable for large wind turbine installations due to the high proportion of buildings in the area reducing the effective wind speeds in the area. Solar arrays are likely to be limited to those that can be installed on building roofs as there is no land area available to install large dedicated arrays for solar concentrator technology. Heat networks and CHP technology may be a more appropriate solution for Camden as they take up less space but can considerably reduce carbon emissions.

1.3.4 Growing population

The population in Camden is growing, with an expected 30,800 extra residents expected by 2026[6] all of whom will need homes, jobs and transport options. This growth in population could increase emissions from all sectors unless innovative ways of decarbonising each sector can be found.

[4,5] Taken from neighbourhood statistics for Camden which can be accessed at: www.neighbourhood.statistics.gov.uk/dissemination/

[6] Population figures taken from a recent study carried out jointly by URS Corporation and the London Borough of Camden. Growth figures provided by Camden are given in Appendix B

2 Methodology

2.1 Overview

A carbon emissions reduction scenario was developed using Carbon Descent's in-house climate change strategy modelling software, VantagePoint. The overall methodology applied to develop a carbon reduction scenario is broadly outlined in Figure 2 below.

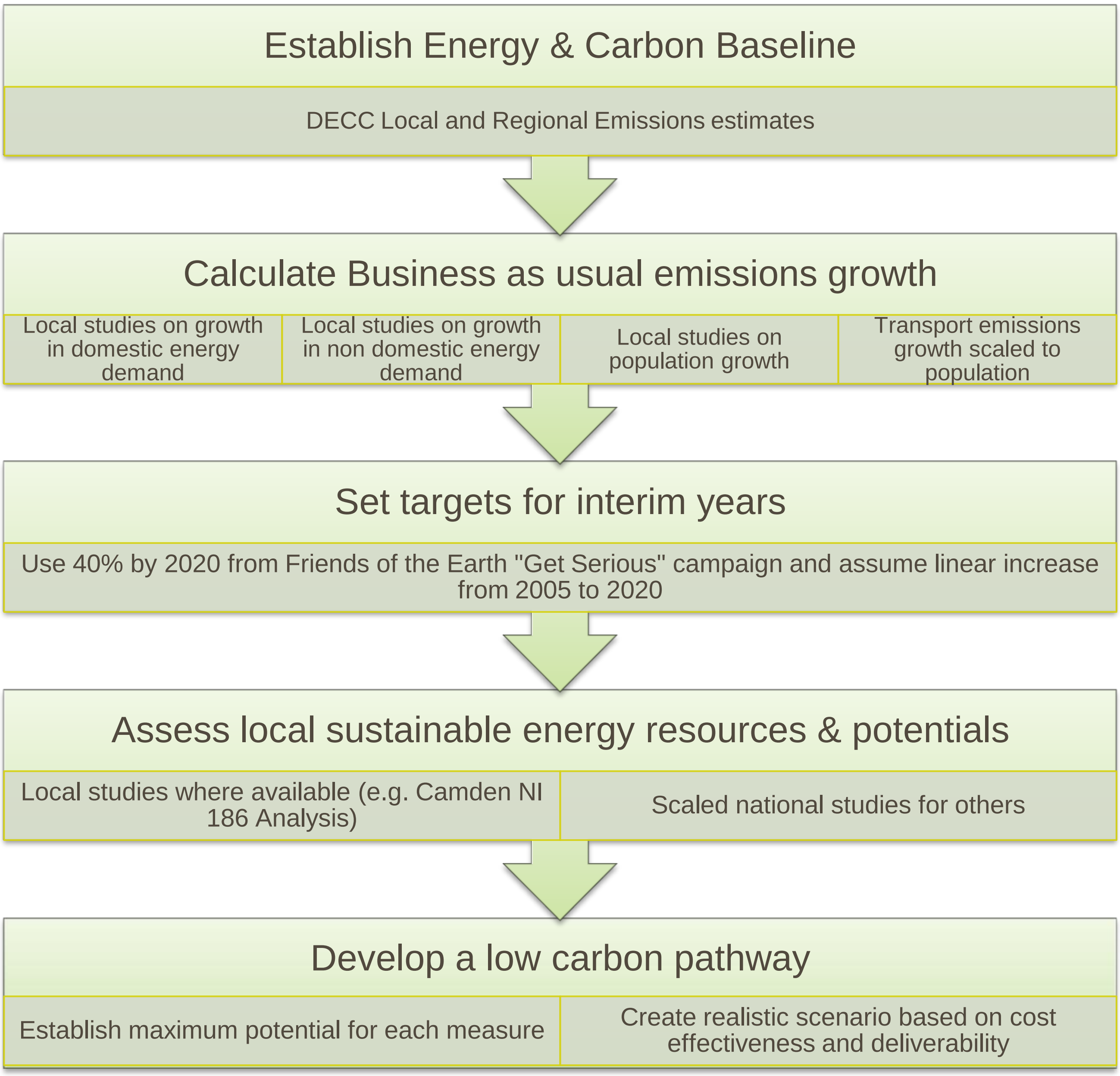

Figure 2: Modelling process

2.2 Assumptions & Methodology

2.2.1 Establishing the baseline & setting interim years

The 40% carbon reduction target by 2020 is set against a baseline year of 2005 to ensure consistency with the methodology used for NI186 (per capita emissions in the local authority area, which forms part of Camden's Local Area Agreement). It should be noted however that while NI186 is based on per capita emissions the FOE campaign to reduce emissions by 40% by 2020 on a 2005 baseline is based on absolute emissions in the area.

Emissions from motorways, aviation and embodied energy are not included in the NI186 local authority emissions and have therefore been excluded from this study.

The most recent year for which actual carbon emission data is available from DECC is 2007, so this data has been used in VP and the first year in the model has been set to 2007. This allows the changes in carbon emissions that occurred between 2005 and 2007 to be taken into account. As DECC figures show that absolute emissions in Camden increased between 2005 and 2007 (as shown in Table 1), the emissions reduction target for 2020 increases to 42.6% when based on 2007 emissions data.

This year, 2010, has been set as a key year in the model so that progress on reducing carbon emissions to date can be taken into consideration in the scenario. Other interim years have been set at 2013 and 2016, in line with the FOE study, and the percentage carbon reduction target increases linearly throughout the overall period as shown in Table 2.

Sector	Emissions in 2005 (ktpa)	Emissions in 2007 (ktpa)
Domestic	412.96	405.57
Commercial & Industrial	1,028.87	1,109.13
Transport	171.15	170.37
Total	**1,612.98**	**1,685.07**

Table 1: Sector emissions in 2005 and 2007

Key year	CO_2 reduction target %
2007	0.0%
2010	10.0%
2013	20.0%
2016	29.0%
2020	42.6%

Table 2: Carbon reduction target in each interim year using 2007 data as first year

2.2.2 Calculate business as usual (BAU) emissions

BAU growth to 2020 has been estimated for each of the three sectors in the model: Domestic, C&I, and Transport. For the purposes of calculating BAU emissions, Camden have provided details on the projected growth in electricity demand, gas demand, and population from a recent study carried out jointly by URS Corporation and the London Borough of Camden. Growth figures provided by Camden are given in Appendix B. The growth figures show the projected increase in gas and electricity demand in the Domestic and C&I sectors. These figures have been converted to show the corresponding annual increase in carbon emissions as a result of this demand increase for the period 2007-10, 2010-13, 2013-16 and 2016-20.

Transport emissions have been scaled from 2007 figures using DfT Regional Transport Forecasts for London[7]. These forecasts are based on road transport emissions in 2003 and include an estimate of the percentage

[7] The tables showing the Regional Traffic Forecasts 2008 can be accessed at: www.dft.gov.uk/pgr/economics/ntm/roadtransportforcasts08/

change in emissions in key years to 2025. The total annual business as usual growth broken down by sector is given in Table 3.

Period	Domestic annual emissions growth (ktpa)	C&I annual emissions growth (ktpa)	Transport annual emissions growth (ktpa)	Total for year (ktpa)
2007-2010	15.73	4.43	-1.53	18.64
2010-2013	11.65	9.08	1.67	22.39
2013-2016	12.02	10.46	0.89	23.37
2010-2020	13.79	12.34	0.13	26.26

Table 3: Business as usual increase in CO_2 emissions by sector

2.2.3 Absolute CO_2 target

To achieve a 40% reduction in CO_2 emissions on a 2005 baseline requires that Camden's annual emissions drop from their current level to no more than 968 ktpa in 2020. In 2007, annual CO_2 emissions were 1,685 ktpa but BAU growth will cause this to rise to 1,712 ktpa by 2020 assuming the projected growth figures are correct. In order to limit emissions to 968 ktpa in 2020, CO_2 emissions must therefore be reduced by 744 ktpa. This is the absolute carbon reduction target that has been used when calculating savings.

2.2.4 Analysis of maximum resource potentials (MRPs)

Before setting up scenarios in VP, the MRP for each carbon reduction measure is determined and entered into a table in the model. These MRPs are used as a check by VP to ensure that the subsequent scenario does not exceed the physical or technical limits for each measure. Setting the MRP value too high means that unrealistic scenarios can be generated; setting it too low might result in scenarios that are less effective in terms of CO_2 reductions or cost. For example, the MRP for installing cavity wall insulation is set at the number of unfilled cavity walls in the borough. VP ensures that the user is unable to include more cavity wall installations in the scenario than is physically possible.

As further examples, the MRP for solar thermal technology and solid wall insulation have been determined as follows:

- Solar thermal systems work most effectively where roofs face within 90° of due South and where there is no significant shading of the roof. The MRP for solar thermal for Camden has been estimated by determining the number of houses (excluding flats) in the local authority (from National Statistics data[8]), and assuming that a maximum of 25% of these houses will have unshaded south facing roofs suitable for solar thermal. When defining the scenario VP will prevent the user from entering a value that is higher than the MRP.
- A stock condition survey provided by Camden indicated that there are 59,994 homes in the borough that have uninsulated solid walls. This has been set as the MRP. The VP user can choose to insulate any number of homes up to the MRP when defining the scenario.

The purpose of the MRP analysis is to ensure that physical and technical limits are not exceeded however it is up to the user to ensure that the scenario developed is realistic in terms of deliverability within the timescales or

[8] www.statistics.gov.uk/

budget constraints. This must be considered when defining the scenario which is described in more detail in section 2.2.6.

The MRP in Camden for each carbon saving measure was estimated in a study carried out by Carbon Descent (known as SEA/RENUE at the time of writing) entitled ‘Delivering a Low Carbon Camden – Carbon Reduction Scenarios to 2050’. Since that study was completed, Carbon Descent updated the MRP for Camden in light of new data that has subsequently become available. These new figures are stated in a report entitled ‘Camden NI186 Analysis’. For the purposes of this project, the MRP have been taken from ‘Camden NI186 Analysis’ or ‘Delivering a Low Carbon Camden’ with the exception of biomass resource, community heating potential and transport measures which are described in more detail below. A table showing the maximum resource potentials that have been set in VantagePoint is given in Appendix C.

2.2.4.1 Biofuels resource

Camden does not currently support biomass installations due to air quality and supply chain reasons. Biomass which includes biogas and biodiesel as well as solid wood fuel, emits more NO_x and particulates when it burns and could negatively affect air quality in inner city areas like Camden. However it is anticipated that in the period between now and 2020 biomass installations such as biogas fired CHP, will become more common in the UK and will supply clean electricity to the grid. Increased uptake in these technologies is likely to lead to technology improvements which will reduce NO_x and particulate emissions to a level where Camden may be able to consider this technology. A small biomass resource has therefore been included to show how this technology could be used to reduce carbon emissions in Camden in future and to allow the necessary plans to be made should the technology become viable.

The available biomass resource has been estimated from nationally available biomass resource stated in the UK Biomass Strategy[9] and scaling this according to the population in Camden. The annual nationally available biomass resource is 54,216 GWh and 0.38% of the UK population live in Camden, making the available biomass resource 206.19 GWh per annum. It should be noted that this is an MRP and is used as a check to ensure that technical potentials are not exceeded. The user can set a realistic level of biomass use when defining the scenario.

2.2.4.2 CHP led community heating potential

The CHP community heating potential was set using Middle Layer Super Output Area (MLSOA) level energy consumption data for Camden. An MLSOA is a geographical area representing a minimum population of 5,000 and a mean population of 7,200. The community heating potential has been defined as the sum of the demand from those MLSOAs in Camden with an annual average thermal demand greater than 3,000 kW/km^2. The 3,000 kW/km^2 figure is a limit of economic viability used in the government’s consultation on the Heat and Energy Saving Strategy[10]. Using this limit of economic viability shows that a maximum of 96% of Camden’s overall thermal demand could be provided by using community heating. Again it must be stressed that this is a technical limit and non-technical risk factors such as finance, stakeholder resistance and procurement risks must be taken into consideration when defining the scenario to ensure that the final scenario is realistic. The figure calculated here is used by VP to ensure that the user does not exceed physical and technical limits when defining a scenario.

2.2.4.3 Transport

There are four transport related carbon reduction measures available in VP:

[9] UK Biomass Strategy, Department for Environment Food and Rural Affairs, May 2007. The report can be downloaded from http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/bioenergy/policy_strat/policy_strat.aspx

[10] “Heat and Energy Saving Strategy Consultation”, DECC, February 2009. The report can be downloaded from http://hes.decc.gov.uk/consultation/consultation_summary/index.html

- **Transport fuel use reduction by behaviour change** which covers carbon savings that result from a modal shift away from cars towards public transport and the increased use of eco-driving techniques. The MRP for this measure has been set at 40% in line with the 40:40:20 rule which states that 40% of car journeys could have been made by bike, foot or public transport without the need for changes to existing public services[11]. When the scenario is defined it is up to the user to specify a realistic percentage for the time frames in question but this can be set at up to 40%.

- **Road transport efficiency improvements** which relates to the EU efficiency target that requires all new cars to have emissions of 130gCO_2/km or less by 2015 and 95gCO_2/km or less by 2020. As this is now a legal requirement, this measure has been translated directly into the final scenario.

- **Replace road transport fuels with biofuels** which relates to the EU target requiring 10% of road transport fuel to come from biofuels by 2020. As this is now a specific target this has been translated directly into the final scenario.

- **Replace road transport fuels with electricity** which relates to the increased use of electric vehicles. There are few guideline on this so estimates in the scenario match those that were used in the original “Delivering a Low Carbon Camden” report.

2.2.5 Grid factor

The 2005 and 2007 grid emissions factors given by DECC are 0.534 and 0.527 kgCO_2/kWh respectively. There is much debate over what the national power demand is likely to be in future and what mix of technologies will be installed to meet the demand. What is certain is that as more large scale renewable and low carbon electricity generation technologies come online, the grid emissions factor will decrease making it easier to meet the carbon reduction targets. However the capacity of any potential low carbon energy generation technologies and the timeframe for installation is highly uncertain. As a result there are a range of grid emissions factor projections ranging from highly conservative to very optimistic.

The choice of grid factor used in the modelling has a significant impact on the overall results. The grid factor used in final scenario modelled in VP for this study was calculated from the central projection of the likely grid mix in 2020 published by DECC[12] at 0.332 kgCO_2/kWh as shown in Table 4. An overall carbon savings of 750 ktpa is achieved by the scenario and the results presented in section 3.2 show that this decarbonisation of the grid accounts for 43% of the total predicted carbon savings.

The study underpinning the FOE campaign to reduce emissions by 40% by 2020 uses an optimistic projection of grid emissions factor of 0.216 kgCO_2/kWh by 2020. If this grid factor is used in the VP scenario whist all other parameters are kept constant the scenario achieves a carbon saving of 933 ktpa exceeding the carbon reduction target by 189 ktpa and accounting for 56% of the total carbon savings achieved by the scenario.

A report released by the Committee on Climate Change entitled ‘Meeting Carbon Budgets – the need for a step change’[13] predicts a grid factor of approximately 0.40 kgCO_2/kWh. Using this grid factor in the VP scenario whilst all other parameters are kept constant achieves a carbon saving of 636 ktpa, missing the target by 108 ktpa and accounting for 31% of the total carbon savings achieved by the scenario.

[11] Lyn Sloman, Carsick, Green Books, Dartington, 2006

[12] DECC grid mix projections can be found in Annex D of the Energy and Emissions projections which can be downloaded at: www.decc.gov.uk/en/content/cms/statistics/projections/projections.aspx

[13] Grid factor is estimated from figure 4.1 on page 107 of the report entitled “Meeting Carbon Budgets – the need for a step change” published by the Committee on Climate Change in October 2009 which can be accessed at: thecccdev.heymoscow.com/reports/progress-reports

This brief analysis demonstrates the crucial role of the grid factor in achieving the 40% reduction target by 2020. Should the grid factor remain above 0.332 $kgCO_2/kWh$, it is likely that Camden will not achieve the target by 2020 even if all the other measures in the scenario are successfully implemented. The reliance on a variable that is largely outside Camden's control introduces a significant risk that the target will not be met.

Year	Grid Emissions Factor ($kgCO_2/kWh$)
2005	0.534
2007	0.527
2010	0.470
2020	0.332

Table 4: Grid emissions factors for key years

2.2.6 Defining the 40% reduction scenario

The final stage of the modelling process is the development of a scenario that meets the 40% reduction target by 2020 and the corresponding targets for the interim years. This is done by defining in VP which measures will be implemented during each specific time period and in what quantities. The MRPs that were set in section 2.2.4 prevent the development of an unrealistic scenario by ensuring that the technical and physical limits of each measure are not exceeded, however it is up to the user to ensure that the resulting scenario is realistic from a deliverability point of view. For example, although the carbon reductions that can be achieved by cavity wall insulation are limited by the number of cavity walls in the borough that can be filled it would be unrealistic to expect them all to be filled within the next 3 years. A phased approach has therefore been taken for most measures.

In this case the scenario has been built by first defining measures that are due to be implemented through current legislation or known government policy. This includes:

- The DECC projections for carbon reductions through greening the grid. The 'Green Grid' measure models the impact of the predicted reduction in grid carbon emissions factor. The installation of large scale renewable and low carbon technologies such as large wind turbines and CHPs will contribute to this reduction in grid emissions factor due to the electricity generated by this technology being exported to the grid. To avoid double counting, carbon savings from the electricity generated by CHP have not been included in the scenario since their impact is already covered through the 'Green Grid' measure.[14]
- Reductions in road transport emissions through the Government target to increase the level of biofuels used in transport fuels to 10% by 2020
- The EU target to increase average new car efficiency to $95gCO_2/km$ transport by 2020.

After applying these national measures, other measures have been selected based on cost effective carbon savings and a realistic assessment of what is feasible with proven technologies being given priority in the early years. Insulation of domestic properties has been prioritised in the early years as these are proven technologies that are known to result in large carbon savings and relatively short payback periods (up to 7 years in most cases). The amount of CHP installed in the borough has been limited in early years but ramped up in the later periods to reflect the long lead in times that are often associated with these projects.

There is a degree of uncertainty in using this methodology as it relies on national measures being implemented as planned and national targets being met which are outside of Camden's control. As a result, there is a risk that the target will be missed if, for example the grid does not decarbonise as quickly as the DECC projection

[14] NB. Because of the way VP does its calculations, the "Green Grid" measure in VP has been defined such that 1 unit of green grid installed equates to 100,000 MWh of electricity saved. The value entered into the scenario for this measure has been calculated by taking the predicted grid factor and back calculating the energy/CO_2 saved as a result of achieving this grid emissions factor.

shows. However, this approach does provide an indication of the level of intervention that may be required by the Council to influence other sectors to reduce their carbon emissions by sufficient levels to meet the 40% by 2020 target.

3 Scenario and results

3.1 Mix of technologies in final scenario

The scenario described in Table 5 summarises the measures that have been included in the final scenario and their respective installed capacities for each of the key years. This mix of measures would allow Camden to meet the 40% reduction in emissions on a 2005 baseline by the end of 2020 provided a number of key risks and barriers, some of which are outside Camden's direct control, can be overcome. The interim targets outlined in Table 2 are also met using this mix of technologies.

Measure	Units	2007-10	2010-13	2013-16	2010-20
CHP Biomass	MWe	0	0	3	5
CHP Large gas	MWe	0	6	28	95
CHP Buildings gas	MWe	0	6	10	20
PV Domestic	Homes	0	5,000	8,000	10,000
PV Non domestic	MWe	0	5	10	15
Wind medium	MWe	0	0	0	1
Solar thermal domestic	Homes	0	5,000	8,000	10,000
Ground source heat pump domestic	Homes	0	10	60	100
Cavity wall insulation domestic	Homes	2,190	16,000	19,000	24,000
Loft insulation domestic	Homes	550	11,000	13,000	15,000
Double glazing domestic	Homes	0	13,000	16,000	20,000
Solid wall insulation domestic	Homes	0	20,000	25,000	35,000
Energy efficient lighting commercial	000's m^2	0	1,000	1,300	1,500
Double glazing commercial	000's m^2	0	10	35	40
Street lighting efficient lamps	Lamps	0	4,000	7,000	9,865
Domestic fuel reduction by behavioural change	%	0	3	4.5	6
Domestic electricity use reduction by behavioural change	%	0	3	4.5	6
Non-domestic fuel reduction by behavioural change	%	0	3	4.5	6
Non-domestic electricity use reduction by behavioural change	%	0	3	4.5	6
Transport fuel use reduction by behavioural change	%	0	3	4.5	6
Road transport efficiency improvements	%	1.7	4.6	9	18.8
Replace road transport fuels with biofuels	000's litres	2,298	3,667	5,056	6,894
Replace road transport fuels with electricity	000's litres	0	75	150	217
Green grid	Units	1.59	4.04	6.48	9.742

Table 5: Final scenario

The particular mix of measures outlined in Table 5 has been determined by following the method outlined in section 2.2.6 and applying an iterative process to optimise the scenario. As detailed in section 2.2.4 VP allows a capacity to be entered for each measure up to (but not exceeding) the MRP. A detailed assessment of MRP was undertaken during the original 'Delivering a Low Carbon Camden' study and many of these potentials have been carried forward into this work.

The first stage of scenario definition was to enter estimates of the likely installed capacity of each measure in each key year. National measures that will be implemented as a result of legislation or government targets such as greening the grid and transport efficiency improvements were entered directly into the scenario. At this stage, none of the other measures were set to the MRP but a realistic figure of likely installation capacities was entered to define the scenario. This first estimate was based on what is known about likely installation rates in the borough. Once all measures had been defined, the model was run and the results showed the level of carbon reductions that the specified technology mix would achieve. The mix of measures was then changed to take into account the level of further reductions necessary, the available resource, and the relative carbon savings of each measure and the model was run again. This process was repeated until a realistic scenario was developed that does not exceed the MRPs and meets the carbon reduction targets in each period. The result of applying this method is an optimised scenario detailing the capacity of each measure that should be implemented during each period.

The rationale that has been applied to select the particular mix of measures detailed in Table 5 is as follows:

- Loft and cavity wall insulation have been set to almost the full MRP by 2020 as they have a big impact on carbon savings for a relatively low cost. As the MRPs for these measures were taken from Camden's own stock condition surveys it has been assumed that the number of cavity walls that cannot be filled due to in fill rubble or cavities that are narrower than 50mm has already been taken into account. Most installations take place in the earlier period as these are proven technologies with relatively short lead in times for implementation.
- Other building fabric improvements including internal and external solid wall insulation and double glazing have been installed to approximately half of their maximum potential as these can significantly reduce carbon emissions but are more expensive technologies to install and can be disruptive to the resident.
- Carbon reductions through behaviour change have been limited to 6% and may come about through measures such as the installation of smart meters in all homes. This was a scheme supported by the previous Government in the UK Low Carbon Transition Plan[15] and the replacement programme was due to be completed by 2020. Although the MRP of behaviour change measures is much higher, the capacity in the final scenario has been limited because long term reductions through behaviour change are difficult to achieve.
- Carbon reduction measures in the C&I sector are limited to installing double glazing, installing energy efficient lighting, and behaviour change measures (again limited to 6%). The capacities of these measures in the scenario are well below the MRPs based on the assumption that whilst larger businesses that are obligated under the Carbon Reduction Commitment (CRC) are likely to act to reduce carbon emissions, small and medium size enterprise (SMEs) have less incentive and less resources to invest in implementing these measures. As a large proportion of businesses in Camden are likely to be SMEs, the capacity for carbon reductions from the C&I sector is therefore expected to be limited.
- Camden already plans to install 8.7MWe of CHP on buildings in the borough by 2014. The scenario reflects the relatively long lead in times required to implement CHP projects suggesting that 12MWe needs to be installed by 2013 ramping up rapidly to 120 MWe by 2020 to meet the targets. The capacity split across large gas CHP, building CHP and biomass CHP with the biomass technologies beginning to come online during the period 2013-16. Although this is a large increase in capacity over a

[15] "The UK Low Carbon Transition Plan, National strategy for climate and energy", DECC, 15th July 2009. This report can be downloaded from http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/lc_trans_plan/lc_trans_plan.aspx

relatively short time frame, CHP technically lends itself well to implementation in Camden due to the high heat demand densities and hence the ability to set up heat networks. As shown in section 2.2.4.2 there is the potential in Camden to provide 96% of the borough's heat demand via heat networks as most of the MLSOA areas show a heat demand density of greater than 3,000 kWh/km^2, the limit proposed by DECC for economic viability of heat networks. In the scenario presented here 20% of the borough's heat demand is provided by CHP led heat networks. Several practical deliverability issues will need to be overcome to achieve this level of community heating in Camden. Most notably, such schemes will depend on engaging with multiple stakeholders which is time consuming and costly.

- The installation of renewable technologies has been limited in this scenario due to concerns over feasibility. Domestic wind installations have been ruled out of this scenario due to the low wind speeds expected in a heavily built up area like Camden. Similarly, large wind turbines have been ruled out due to the lack of space and likely planning restrictions. Only 1 MW of medium sized wind technology has been allowed for here as it is thought that there may be a handful of suitable sites in the borough for showcase projects. Installations of PV on domestic properties are assumed to gain in popularity due to the recently announced Feed in Tariff (FiT), and the same level of domestic solar thermal installations is assumed as it is a more affordable technology. The planned introduction of the Renewable Heat Incentive (RHI) will be critical in incentivising the uptake of this measure.
- Part of the reduction in transport emissions is accounted for by behaviour change measures that include a modal shift from cars to public transport, walking and cycling and measures such as eco-driving techniques or better vehicle maintenance. Savings from this measure have been capped at 6% in line with other behaviour change measures. Road transport efficiency improvements have been calculated by assuming that the target of 130 g/km by 2015 and 95 g/km by 2020 for new cars will be achieved and that cars are replaced on average every 14 years. It has been assumed that target of 10% of road transport fuels to come from biofuels by 2020 will be achieved. A small saving through switching to electric vehicles has been assumed in line with the assumptions in the original 'Delivering a Low Carbon Camden' study.

3.1.1 The use of biomass CHP

Although Camden are currently unable to commit to installing biomass CHP in the borough due to air quality and supply chain issues a small amount of biomass has been included in the scenario. The reason for this inclusion is that it is likely that the technology will advance sufficiently over the next few years to overcome the issues with NO_x and particulate emissions allowing Camden to invest in the measure. Including a small amount of biomass in the scenario will allow Camden to prepare for a potential installation should it become technically viable over the coming years and investigate what other internal planning, legal and financial issues may need to be overcome to allow an installation to occur. Biomass CHP has been selected in this scenario rather than biomass boilers as CHP technology is far more efficient and has a bigger impact on reducing carbon emissions.

There are currently no available biomass resources in Camden so any biomass used in the borough would have to be brought in from another local authority. This increases the overall carbon emissions associated with the technology due to transport considerations and therefore reduces the effectiveness as a carbon reduction measure. Whilst not an option for Camden at the current time, energy from waste or anaerobic digestion could be viable when waste contracts are renegotiated or renewed.

3.1.2 Risk assessment

There are a number of factors that could prevent Camden from implementing this mix of measures to achieve a 40% reduction in carbon emissions by 2020:

- The dependency on a range of initiatives being implemented under the Low Carbon Transition Plan (LCTP). The LCTP outlined a range of measures that would allow the UK to meet nationally agreed carbon targets. These include measures such as installing smart meters, upgrading the building fabric of existing homes and incentivising the business sector to invest in reducing their carbon emissions. If these measures are implemented as outlined in the LCTP, they will have an impact on reducing emissions on a local authority level. Changes to the LCTP or national programmes that are planned but not implemented could prevent Camden from reaching the target.

- The recent change of government has introduced a level of uncertainty within local authorities particularly around finance. Budget cuts may mean that there is little capital available to invest in carbon reduction initiatives in the immediate future.
- The modelling shows that 43% of carbon reductions are achieved through a reduction in the carbon intensity of the grid. The grid factor is outside the control of Camden. If the capacity of low carbon electricity generation technologies does not increase as projected by DECC, the projected grid emissions factor will not be achieved and as a result there is a risk that Camden will not meet the 40% reduction target by 2020.
- The proposed level of CHP installation is a particular risk due to the large capacity of the system. This introduces a high level of uncertainty due to procurement issues and the complexity of delivering a scheme that requires the cooperation of multiple stakeholders.
- External solid wall insulation is difficult to implement in Camden due to the large number of listed buildings and designated conservation areas. Planning policy currently favours the preservation of heritage assets which could prevent installation of solid wall insulation to the levels set in the scenario. Internal solid wall insulation could be investigated as an alternative but this could lead to higher cost and a more disruptive installation process
- Camden has no direct influence over the C&I sector, yet this sector accounts for the largest proportion of emissions in the borough. Although the scenario presented here does not rely heavily on participation from the business sector, methods of incentivising them to reduce carbon emissions should be developed to ensure targets can be met. This presents an opportunity to further reduce emissions if engagement with the C&I sector could be achieved.

3.2 Analysis of results

3.2.1 Meeting the carbon reductions

Table 6 gives a summary of the results of the modelling using the scenario defined in Table 5 in terms of the actual CO_2 savings achieved against the target. The scenario meets the carbon reduction target for all key years except 2010 as shown by the row highlighted in pink in Table 6. To meet the overall carbon reduction target of 40% by 2020 on a 2005 baseline, Camden must reduce annual CO_2 emissions by 744 ktpa. The scenario defined in Table 5 results in a reduction in annual CO_2 emissions of 750 ktpa demonstrating that the target can be met if the described mix of measures is implemented in the specified capacities and within the specified timeframes.

Year	Target CO_2 savings (ktpa)	Total CO_2 savings from scenario (ktpa)
2007-10	187	82
2010-13	359	360
2013-16	512	534
2016-20	744	750

Table 6: Comparison of actual carbon savings achieved by the scenario with target

Table 5 shows that the capacity of measures installed in the period 2007-10 is small. These figures have been provided by Camden to reflect known upgrades to building stock. The green grid and road transport efficiency improvements have been extrapolated from the overall targets to indicate the level of savings that should be achieved in 2010 assuming that the UK is on track to meeting these targets. The small number of measures installed to date accounts for the inability of the scenario to meet the 10% reduction target in 2010. However the scenario does not take into account any upgrades to building stock undertaken by private home owners in the borough or measures taken by the C&I sector as there is no record of these improvements within Camden. The actual savings in 2010 may therefore be higher than predicted by this scenario.

Table 7 and Figure 3 show the carbon reductions associated with each measure in the final scenario.

Implementing the measures in the scenario will result in carbon savings of 750 ktpa of CO_2 by 2020, just above the target of 744 ktpa. 43% of the carbon savings come from the “Green Grid” measure assuming that the grid mix predicted by DECC is realised in practice by 2020. In order for this to happen, the capacity of renewable and low carbon technologies connected to the grid must increase in line with DECC projections and to some extent this relies on local authorities being willing to allow such technologies to be installed in their boroughs. The large proportion of savings from the green grid measure reduces the amount of local action required to meet the target, but presents a risk because in the event that the grid factor does not decrease by as much as predicted, the target could easily be missed. This makes it even more important for Camden to invest in and promote the other measures detailed in the scenario.

CHP technologies account for 19% of the carbon savings in this scenario. Installing 120 MWe of CHP capacity, within the next 10 years will require aggressive policy setting by Camden. 8.7 MWe of capacity has already been identified and, subject to agreement from the developers of a key building in the Euston Road area, is due to go online by 2014. A heat mapping study has already helped Camden to identify other areas that would benefit from CHP with district heating schemes and CHP growth areas identified in Gospel Oak and the Euston Road corridor should remain the key area of focus. Camden should rigorously enforce and extend existing planning policy making it a requirement for new commercial developments to install CHP capacity capable of supporting local heat networks beyond the site boundary and require all other developments to connect to a district heating network in the future. The Euston Road corridor represents a critical CHP opportunity because the energy balance between Camden housing and proposed commercial development is likely to result in financially viable projects.

A further 16% of savings is made through the implementation of improvements to the building fabric of domestic buildings. Since there are well established cavity wall and loft insulation schemes, the scenario allows for all cavity walls and lofts in Camden to be insulated by 2020. Camden may wish to consider further schemes that will encourage uptake of solid wall insulation and double glazing in domestic properties. As the Council own 23.9% of the housing stock in Camden, they have direct control of the emissions from these buildings and can greatly reduce carbon emissions by upgrading the stock with retrofitted energy efficiency measures.

The remaining 22% of carbon savings comes from the implementation of behaviour change measures, transport related measures and C&I measures. The C&I sector is particularly difficult to tackle as the Council have no direct control over this sector, but schemes to help or encourage businesses implement energy saving measures could significantly impact on borough carbon emissions because of the high proportion of C&I emissions in Camden. The scenario clearly indicates the areas where Camden will need to apply aggressive policies in order to meet the target and those areas where existing policies can be developed.

Measure	Installed Capacity in 2020 Units	 Capacity	2020 Carbon Savings (ktpa)	2020 Carbon Savings (%)	2020 Net Present Value (k£)	2030 Net Present Value (k£)	Estimate of simple payback (years)
CHP Biomass	MWe	5	17.95	2.4%	6,486	59,527	5 to 10
CHP Large gas	MWe	95	89.36	11.9%	-168,517	-43,194	5 to 10
CHP Buildings gas	MWe	20	37.01	4.9%	3,522	43,787	5 to 10
PV Domestic	Homes	10,000	7.02	0.9%	-5,031	38,658	8 to 12
PV Non domestic	MWe	15	4.23	0.6%	-34,063	-20,296	8 to 12
Wind medium	MWe	1	0.44	0.1%	-1,989	-1,500	10 to 15
Solar thermal domestic	Homes	10,000	3.61	0.5%	-24,590	-15,168	10 to 12
Ground source heat pump domestic	Homes	100	0.08	0.0%	-536	-628	20
Cavity wall insulation domestic	Homes	24,000	14.38	1.9%	12,870	29,444	2 to 5
Loft insulation domestic	Homes	15,000	5.23	0.7%	4,393	10,660	2 to 5
Double glazing domestic	Homes	20,000	13.15	1.8%	-41,541	-13,821	30
Solid wall insulation domestic	Homes	35,000	83.68	11.1%	7,788	113,896	18 to 20
Energy efficient lighting commercial	000's m^2	1,500	7.97	1.1%	-15,918	1,654	1 to 5
Double glazing commercial	000's m^2	40	0.49	0.1%	-13,011	-12,256	30
Street lighting efficient lamps	Lamps	9,865	0.71	0.1%	-1,564	-4	10
Domestic fuel reduction by behavioural change	%	6	16.97	2.3%	19,349	45,312	0
Domestic electricity use reduction by behavioural change	%	6	37.66	5.0%	80,013	180,175	0
Non-domestic fuel reduction by behavioural change	%	6	22.39	3.0%	18,810	52,961	0
Non-domestic electricity use reduction by behavioural change	%	6	8.95	1.2%	14,687	34,422	0
Transport fuel use reduction by behavioural change	%	6	11.05	1.5%	25,225	56,042	0
Road transport efficiency improvements	%	18.8	35.47	4.7%	61,954	160,840	0

Measure	Installed Capacity in 2020 Units	Capacity	2020 Carbon Savings (ktpa)	2020 Carbon Savings (%)	2020 Net Present Value (k£)	2030 Net Present Value (k£)	Estimate of simple payback (years)
Replace road transport fuels with biofuels	000's litres	6,894	8.67	1.2%	-2,712	-3,639	0
Replace road transport fuels with electricity	000's litres	217	0.34	0.0%	731	1,703	0
Green grid	Units	9.742	323.43	43.0%	-	-	0
Total	**-**	**-**	**750.25**	**100%**	**-53,642**	**718,572**	

Table 7: Carbon reductions, net present value and simple payback by measure

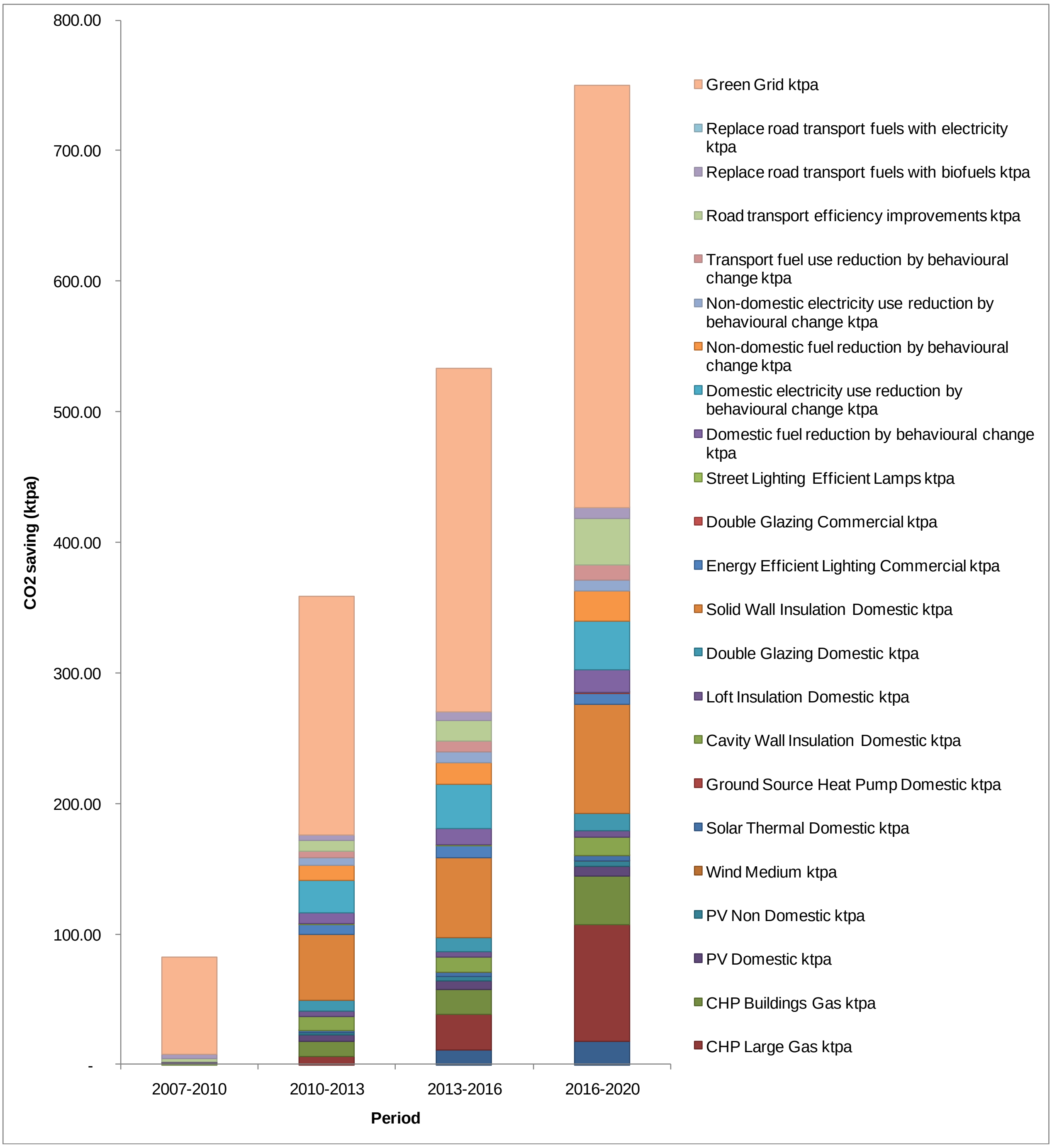

Figure 3: Chart showing scenario CO_2 savings by measure[16]

[16] Corresponding data table for Figure 3 is given in Appendix D

3.2.2 Financial analysis of scenario

The total capital cost of implementing the scenario is approximately £783.5 million over the period between 2007 and 2020 with the majority of the investment being made between 2010 and 2020 as shown in Table 8. Capital costs for each measure are built in to VP and total capital costs are calculated when the scenario is run. VP uses the most up to date reference data available for capital costs. Reference data is updated regularly (at least annually) from reliable sources such as the Carbon Trust and Building Research Establishment (BRE). The calculation takes into account the capital required to purchase equipment and the installation costs but in most cases does not cover the cost of any associated design or management activities.

It should be noted that the capital costs presented in Table 8 are not solely attributable to the local authority but are a combination of all costs that will be distributed across all investors involved in implementing measures. The total capital costs will therefore be spread across the local authority, individual householders, landlords, and private sector investors. It is beyond the scope of this report to distinguish between investments required by the various groups.

Measure	Units	2007-2010	2010-2013	2013-2016	2016-2020
CHP Biomass	£k	-	-	17,325	11,550
CHP Large gas	£k	-	18,204	66,748	203,278
CHP Buildings gas	£k	-	5,184	3,456	8,640
PV Domestic	£k	-	31,688	19,013	12,675
PV Non domestic	£k	-	20,000	20,000	20,000
Wind medium	£k	-	-	-	3,000
Solar thermal domestic	£k	-	20,000	12,000	8,000
Ground source heat pump domestic	£k	-	60	300	240
Cavity wall insulation domestic	£k	832	5,249	1,140	1,901
Loft insulation domestic	£k	157	2,991	572	572
Double glazing domestic	£k	-	52,000	12,000	16,000
Solid wall insulation domestic	£k	-	75,000	18,750	37,500
Energy efficient lighting commercial	£k	-	25,000	7,500	5,000
Double glazing commercial	£k	-	4,200	10,500	2,100
Street lighting efficient lamps	£k	-	1,360	1,020	974
Domestic fuel reduction by behavioural change	£k	-	-	-	-
Domestic electricity use reduction by behavioural change	£k	-	-	-	-
Non-domestic fuel reduction by behavioural change	£k	-	-	-	-
Non-domestic electricity use reduction by behavioural change	£k	-	-	-	-
Transport fuel use reduction by behavioural change	£k	-	-	-	-
Road transport efficiency improvements	£k	-	-	-	-
Replace road transport fuels with biofuels	£k	-	-	-	-
Replace road transport fuels with electricity	£k	-	-	-	-

Measure	Units	2007-2010	2010-2013	2013-2016	2016-2020
Green Grid	£k	-	-	-	-
Total	**£k**	**990**	**260,935**	**190,324**	**331,430**

Table 8: Capital costs of scenario in each period

Table 7 and Figure 4 show the net present value (NPV) of each measure in 2020. NPV is a measure of the profitability of a project. It takes into account the initial investment cost, the operating costs, and annual revenues generated from the project and takes into account the time value of money by applying a discount factor to any future revenues or expenditure. In general this means that if the NPV of a given measure is positive at the end of a period, the project will have made a profit, whilst a negative NPV indicates a loss. The recently announce government Feed in Tariff (FiT) effects the profitability of renewable electricity generation technologies that qualify for the scheme such as PV and wind turbines. The electricity sale price for these technologies has been updated in VP to account for the additional revenue generated by the FiT to give a broad estimate of their impact.

To show a more accurate representation of the NPV of the scenario the NPV calculations have been extended for a further 10 years to 2030 to show the value of the scenario once all technologies have had a chance to pay for themselves through revenue generation. The result is shown in Table 7. It should be noted that the NPV is significantly positive by 2030 showing that investing in carbon reduction technologies is profitable. Additionally with the exception of most of the technologies in the scenario have a positive NPV showing that they are financially viable and could attract investment from the private sector if the corresponding payback periods are short enough. An estimate of the typical simple payback periods that can be expected for each technology is given in the final column of Table 7.

Double glazing measures still have a negative NPV after 2030 because the capital costs are proportionally very high compared to the annual savings made, as pay back periods can be as long as 30 years. Despite the introduction of the FiT, non domestic PV installations still have a negative NPV after 2030. This is likely to be because the level of the FiT is lower for larger installations but the capital costs associated with installation are still high despite the larger capacity of the system. Large gas fired CHP also remains non profitable after 2030, mainly because the majority of the investment in large CHP happens in the final period between 2016 and 2020. Payback periods for CHP can be in the region of 10 to 15 years depending on the location and capacity so further time is needed to see the financial benefits associated with this measure. Those measures that have a negative NPV may require an additional incentive from a local authority to attract private sector investment. This supports the idea that aggressive policy setting will be required to quickly increase CHP capacity in Camden.

It is important to note that it is beyond the scope of this report to distinguish between investment that must be made by local authorities and those that are made by private investors, business, other groups or home-owners. This means that the total costs associated with the scenario are not the total cost to the London Borough of Camden but the cumulative total costs that will be borne by all investors across the borough. Similarly, any profits or revenues are spread across all investors.

The total capital cost of implementing the scenario is £783.5 million and overall the scenario has an NPV of £718.5 million by 2030. The main measure that Camden should urgently focus on is promoting the installation of CHP in the borough. This is an area that the Council can influence and will have a big impact on reducing carbon emissions. It is essential that steps are taken now to encourage the growth of Camden’s heat network in order to meet the necessary capacity by 2020. It is unlikely that private developers will invest in this technology without significant pressure from the local authority because of the high capital costs associated with the installation and the perceived negative image of CHP among key stakeholders. Without planning requirements to enforce the installation of CHP and heat networks on new developments, it is unlikely that CHP capacity in Camden will be built quickly enough to meet the 40% reduction target by 2020.

A second area that Camden should focus on is building on their early success at retrofitting loft and cavity wall insulation. These measures should be rolled out across local authority stock as quickly as possible and the scheme extended to include solid wall insulation on older properties. Due to the number of listed buildings and area of the borough that is designated as a conservation area internal solid wall insulation should be considered, despite the higher cost and more difficult installation process. Insulation measures are well proven technologies and the payback periods are relatively short making them financially viable. Camden should also use their experiences to persuade private householders and landlords to install the same measures. The feasibility of a 'Green Deal' scheme should be investigated as a means of helping householders to finance upgrades to the building fabric of their home.

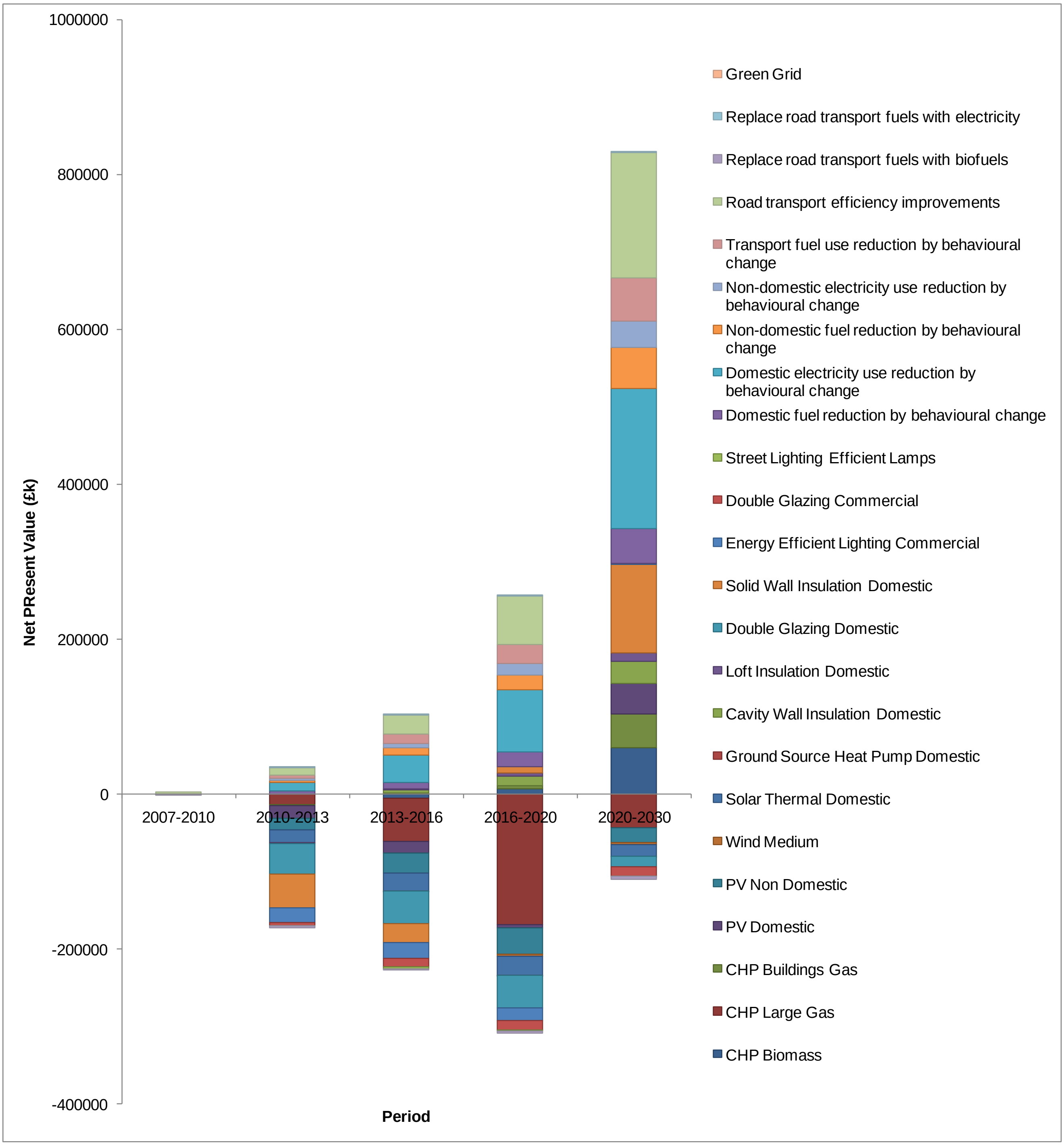

Figure 4: Net present value for scenario by measure[17]

[17] Corresponding data table for Figure 4 is given in Appendix D

4 Conclusion

It is possible for the London Borough of Camden to meet a 40% reduction target on a 2005 baseline by 2020. Successfully meeting this target relies on several factors:

- The national grid mix changing over time to include more renewable and low carbon technologies. This will result in a reducing grid emissions factor which will in turn provide 43% of the necessary emissions savings. This also represents the most significant risk to achieving the 40% target and necessarily means that Camden's ability to meet it is highly dependent on factors that are outside the council's control.
- The fast growth in CHP capacity in the borough up to a total of 120 MWe capacity. This is likely to be achieved through the aggressive enforcement of existing local and regional planning policy, potentially extending to a requirement for all new large scale developments in the borough in the vicinity of existing heat loads (such as Camden owned community heated housing estates) to be required where technically and commercial feasible to design and build CHP energy centres of sufficient size to meet the adjacent heat loads. This could achieve up to 19% of the total carbon savings required to meet the target.
- Continuation of the implementation of cavity wall and loft insulation and extension of these schemes to include double glazing and solid wall insulation in the private sector. This is likely to require full engagement with the proposed 'Green Deal' finance models. This could account for 15% of the necessary carbon savings.
- Realisation of government targets and projections on the percentage of biofuels used in transport fuels and improvements in road transport efficiency together with an increase in the proportion of electric vehicles and a modal shift from cars to public transport, walking or cycling. Transport related measures could account for 7% of the necessary carbon savings.
- The remaining 15% of emissions are to be met through behaviour change measures to reduce demand electrical and thermal demand, the installation of small scale renewable such as domestic PV and the implementation of commercial energy efficiency measures.

Since meeting the 40% target relies heavily on the grid emissions factor dropping to forecasted levels there is a risk that Camden will be unable to meet the target if these projections are not achieved. To mitigate this risk, Camden will need to prepare themselves by promoting the installation of all measures over which they have an influence. The biggest areas are likely to be installing CHP capacity and improving the building fabric of residential buildings. There are also opportunities in the C&I sector which makes up the largest proportion of emissions in the borough. The maximum potential carbon savings from this sector have not been fully exploited in this scenario indicating that there are other options available to Camden should the grid emissions factor projection prove to be unrealistic.

The overall NPV for the scenario is positive when it is extended out to 2030 to allow time for measures installed in the final years to pay for themselves. This indicates that investing in carbon reduction technologies is financially viable overall. Some technologies, including large gas CHP installations still have a negative NPV at 2030 but this is largely due to the large capacity increase that takes place in the final period of the scenario between 2016 and 2020. Private investors may be reluctant to invest in technologies that cannot pay for themselves within 10 years so additional policies and incentives will need to be set up to ensure that enough CHP capacity is built to meet the carbon reduction target.

In addition, the costs and revenues associated with this scenario are not specific to the London Borough of Camden, but are in fact a combination of all the stakeholders who may invest in the measures detailed here. This may include private investors, householders, businesses and other groups. As a result we recommend that Camden carry out specific feasibility studies for each measure that they are considering implementing to demonstrate the financial case for the London Borough of Camden.

Appendices

Appendix A: Reference data used in VantagePoint

VantagePoint uses a built in set of reference data when carrying out its internal calculations. A selection of reference data for individual measures, the source of the data and any assumptions made are presented in Table 9 and Table 10. The reference data is reviewed and updated regularly (at least annually) to ensure that the results from the modelling are as accurate as possible.

Measure	Measure power generated or displaced	Source	Date Sourced
CHP Biomass	6071 MWh/MW_e	*The Potential and Costs of District Heating Networks*, Pöyry/AECOM report for DECC, April 2009	December 2009
CHP Large gas	6071 MWh/MW_e	*The Potential and Costs of District Heating Networks*, Pöyry/AECOM report for DECC, April 2009	December 2009
CHP Buildings gas	5000 MWh/MW_e	*The Potential and Costs of District Heating Networks*, Pöyry/AECOM report for DECC, April 2009	December 2009
Energy efficient lighting commercial	16 MWh/000 m^2	*Carbon trust Guide ECG019 – Energy use in offices*	December 2009
PV Domestic	2.115 MWh/Home	*CERT illustrative mix* (available from www.opsi.gov.uk/si/si2008/em/uksiem_20080188_en.pdf)	December 2009
PV Non domestic	850 MWh/MW_e	*Design of Feed-in Tariffs for Sub-5MW Electricity in Great Britain*. Quantitative analysis for DECC, Final Report, July 2009, Element Energy	December 2009
Street lighting efficient lamps	0.216 MWh/Lamp	*Energy efficiency in street lighting*, March 2009, Northern Ireland Assembly (www.niassembly.gov.uk/io/research/2009/3009.pdf) Assumes consumption of 432 kWh per lamp prior to efficiency improvements (average per lamp annual consumption in Northern Ireland), and a saving of 50% due to efficiency improvements. 50% reduction in energy use was achieved in the Ann Arbor case study in this report converting to LEDs. 50% energy saving figure also agrees with figures quoted in the *Guide for energy efficient street lighting installations* www.e-streetlight.com/Documents/ Homepage /0_3%20Guide_For%20EE%20Street%20Lighting.pdf	December 2009
Wind domestic	0.877 MWh/Home	*CERT illustrative mix* www.opsi.gov.uk/si/si2008/em/uksiem_20080188_en.pdf	December 2009

Measure	Measure power generated or displaced	Source	Date Sourced
Wind large	2190 MWh/MW_e	*Design of Feed-in Tariffs for Sub-5MW Electricity in Great Britain*. Quantitative analysis for DECC, Final Report, July 2009, Element Energy. Assumes load factor of 0.25. Report has load factors ranging from 15% in 5.5m/s winds to 32% in >8m/s winds. Assumes that larger scale turbines will be installed at higher wind speeds.	December 2009
Wind medium	1314 MWh/MW_e	*Design of Feed-in Tariffs for Sub-5MW Electricity in Great Britain.* *Quantitative analysis for DECC, Final Report*, July 2009, Element Energy Assuming a turbine size of 15 to 50 kW, 15% load factor (rural, wind speed 5.5 to 6 m/s)	December 2009

Table 9: Power generated or displaced by measure

Measure	Heat produced/ displaced figure	Source	Date
Biomass boilers domestic	14.1 MWh/dwelling	Domestic heat demand from *Powering London into the 21st century*, March 2006, PB Power. www.london.gov.uk/mayor/environment/energy/docs/powering-london-21st-century.pdf	December 2009
Biomass boilers non domestic	5000 MWh/MW_{th}	Assumes 5,000 hours annual run time	December 2009
Cavity wall insulation domestic	3.012 MWh/yr	*CERT illustrative mix* www.opsi.gov.uk/si/si2008/em/uksiem_20080188_en.pdf	December 2009
Chp buildings gas	14641.7 MWh/MW_e	*The Potential and Costs of District Heating Networks*, Pöyry/AECOM report for DECC, April 2009	December 2009
Chp large gas	4721 MWh/MW_e	*The Potential and Costs of District Heating Networks*, Pöyry/AECOM report for DECC, April 2009	December 2009
Double glazing domestic	3.306 MWh/yr	*Reducing carbon emissions from the UK housing stock*, BRE for DEFRA, 2005. projects.bre.co.uk/PDF_files/BR480reducingCarbonEmissionsFromUKHousing.pdf	December 2009
Ground source heat pump domestic	13.14 MWh/dwelling	*The Potential and Costs of District Heating Networks*, Pöyry/AECOM report for DECC, April 2009	December 2009

Measure	Heat produced/ displaced figure	Source	Date
Loft insulation domestic	1.752 MWh/yr	*CERT illustrative mix* www.opsi.gov.uk/si/si2008/em/uksiem_20080188_en.pdf	December 2009
Solar thermal domestic	1.816 MWh/yr	Assuming 454 kWh/m^2 from *GLA Renewables toolkit for planners & developers* www.london.gov.uk/mayor/environment/energy/docs/renewables_toolkit.pdf	December 2009
Solid wall insulation domestic	12.018 MWh/yr	*CERT illustrative mix* www.opsi.gov.uk/si/si2008/em/uksiem_20080188_en.pdf Average of internal and external SWI	December 2009
Heat from power Station	6071 MWh/MWth	Annual average run hours for CCGT major power producers in the UK. Figure for 2008, *DUKES 2009*, Table 5.10 decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx	December 2009

Table 10: Measure heat produced / displaced

Appendix B: Growth data from Camden

The tables in this section have been taken from a joint analysis carried out by the London Borough of Camden and URS Corporation in October 2009. The study is entitled 'Camden Infrastructure Study: Utilities and Physical Infrastructure Needs Assessment' and is available for download at: www.camden.gov.uk/ccm/cms-service/download/asset?asset_id=2024157

	Anticipated increase by five year period and in total				
Measure	***2006-11***	***2012-16***	***2016-21***	***2021-26***	***Total***
Population	8,358	11,064	9,869	6,697	35,988
Dwellings	3,369	4,817	4,297	2,916	15,669
Office Space (m2)	46,324	163,680	202,408	202,408	614,820
Retail Space (m2)	6,620	14,782	15,282	10,282	46,965
Leisure Space (m2)	6,836	24,001	29,665	29,665	90,166

Source: Based on joint analysis by London Borough of Camden and URS Corporation.

Table 11: Projected residential and commercial development growth, Camden 2006-26

Table 3-2: Future Electricity Demand in Camden's Growth Areas by Type of Development, 2006 to 2026

	kVA	*2006-2011*	*2011-2016*	*2016-2021*	*2021-2026*	*Total (2006-2026)*
Kings Cross	Residential	109	1,520	1,200	-	2,829
	Non-Residential	431	9,653	9,653	9,653	29,392
	Total	*540*	*11,173*	*10,853*	*9,653*	*32,221*
Euston	Residential	90	642	1,440	312	2,483
	Non-Residential	-	240	3,228	2,988	6,455
	Total	*90*	*882*	*4,668*	*3,300*	*8,938*
Tottenham Court Road	Residential	224	306	242	-	771
	Non-Residential	869	869	869	869	3,475
	Total	*1,093*	*1,174*	*1,110*	*869*	*4,246*
Holborn	Residential	-	72	-	-	72
	Non-Residential	579	579	579	579	2,317
	Total	*579*	*651*	*579*	*579*	*2,389*
West Hampstead Interchange	Residential	18	470	502	640	1,630
	Non-Residential	9	9	284	284	585
	Total	*26*	*479*	*786*	*924*	*2,215*
Other - South	Residential	2,310	2,736	1,880	2,107	9,034
	Non-Residential	2,072	2,072	2,072	2,072	8,286
	Total	*4,382*	*4,808*	*3,952*	*4,179*	*17,320*
Other - North East	Residential	2,008	1,277	1,040	1,064	5,389
	Non-Residential	136	616	424	184	1,361
	Total	*2,144*	*1,893*	*1,464*	*1,248*	*6,750*
Other - North West	Residential	1,064	685	571	542	2,862
	Non-Residential	160	160	160	160	641
	Total	*1,224*	*845*	*732*	*703*	*3,504*
Total	**Residential**	**5,822**	**7,707**	**6,875**	**4,666**	**25,070**
	Non-Residential	**4,256**	**14,199**	**17,269**	**16,789**	**52,513**
	Total	***10,079***	***21,906***	***24,144***	***21,455***	***77,583***

Source: URS calculations based on joint analysis by London Borough of Camden and URS Corporation.

Table 12: Future electricity demand in Camden's growth areas by type of development, 2006 to 2026

Table 3-3: Future Gas Demand in Camden's Growth Areas by Type of Development, 2006 to 2026

	m3/Hour	*2006-2011*	*2011-2016*	*2016-2021*	*2021-2026*	*Total (2006-2026)*
Kings Cross	Residential	55	772	609	-	1,436
	Non-Residential	36	271	271	271	849
	Total	*91*	*1,043*	*880*	*271*	*2,285*
Euston	Residential	45	326	731	158	1,261
	Non-Residential	-	20	109	89	217
	Total	*45*	*346*	*840*	*247*	*1,478*
Tottenham Court Road	Residential	114	155	123	-	392
	Non-Residential	24	24	24	24	98
	Total	*138*	*180*	*147*	*24*	*489*
Holborn	Residential	-	37	-	-	37
	Non-Residential	16	16	16	16	65
	Total	*16*	*53*	*16*	*16*	*102*
West Hampstead Interchange	Residential	9	239	255	325	828
	Non-Residential	1	1	8	8	17
	Total	*10*	*240*	*263*	*333*	*845*
Other - South	Residential	1,173	1,389	955	1,070	4,586
	Non-Residential	55	55	55	55	221
	Total	*1,228*	*1,444*	*1,010*	*1,125*	*4,807*
Other - North East	Residential	1,019	648	528	540	2,736
	Non-Residential	5	44	29	9	87
	Total	*1,024*	*693*	*557*	*549*	*2,823*
Other - North West	Residential	540	348	290	275	1,453
	Non-Residential	7	7	7	7	27
	Total	*547*	*354*	*297*	*282*	*1,481*
Total	**Residential**	**2,956**	**3,913**	**3,491**	**2,369**	**12,729**
	Non-Residential	**144**	**439**	**519**	**479**	**1,580**
	Total	***3,100***	***4,352***	***4,009***	***2,848***	***14,309***

Source: URS calculations based on joint analysis by London Borough of Camden and URS Corporation.

Table 13: Future gas demand by type of development, 2006 to 2026

Appendix C: Maximum resource potentials in Vantage Point

Maximum resource potentials have been determined using the methodology outlined in section 2.2.4 and are listed below in Table 14.

Measure	Unit	2005 - 2020
CHP Biomass	MWe	1,000.000
CHP Large gas	MWe	1,000.000
CHP Buildings gas	MWe	500.000
Heat from power station	MWth	0.000
PV Domestic	Homes	33,000.000
PV Non domestic	MWe	60.000
Wind large	MWe	2.000
Wind medium	MWe	1.000
Wind domestic	Homes	5,000.000
Solar thermal domestic	Homes	33,000.000
Biomass boilers domestic	Homes	30,000.000
Biomass boilers non domestic	MWe	50.000
Ground source heat pump domestic	Homes	5,000.000
Cavity wall insulation domestic	Homes	24,218.000
Loft insulation domestic	Homes	15,191.000
Double glazing domestic	Homes	38,944.000
Solid wall insulation domestic	Homes	59,994.000
Energy efficient lighting commercial	000's m^2	1,500.000
Double glazing commercial	000's m^2	90.000
Street lighting efficient lamps	Lamps	9,865.000
Domestic fuel reduction by behavioural change	%	80.000
Domestic electricity use reduction by behavioural change	%	80.000
Non-domestic fuel reduction by behavioural change	%	80.000
Non-domestic electricity use reduction by behavioural change	%	80.000
Transport fuel use reduction by behavioural change	%	40.000
Road transport efficiency improvements	%	40.000
Replace road transport fuels with biofuels	000's litres	10,000,000.000
Replace road transport fuels with electricity	000's litres	10,000,000.000
Green grid	Units	1,000.000
Air source heat pump domestic	Homes	1,000,000.000
Energy efficient appliances commercial	000's m^2	10,000,000.000

Table 14: Maximum potential by measure

Appendix D: Detailed carbon emissions and NPV by measure

Measure	Units	2007-2010	2010-2013	2013-2016	2016-2020
CHP Biomass	ktpa	-	-	11.10	17.95
CHP Large gas	ktpa	-	5.96	26.98	89.36
CHP Buildings gas	ktpa	-	11.72	18.95	37.01
PV Domestic	ktpa	-	4.78	6.87	7.02
PV Non domestic	ktpa	-	1.92	3.45	4.23
Wind medium	ktpa	-	-	-	0.44
Solar thermal domestic	ktpa	-	1.91	2.96	3.61
Ground source heat pump domestic	ktpa	-	0.00	0.03	0.08
Cavity wall insulation domestic	ktpa	1.44	10.12	11.66	14.38
Loft insulation domestic	ktpa	0.21	4.05	4.64	5.23
Double glazing domestic	ktpa	-	9.03	10.78	13.15
Solid wall insulation domestic	ktpa	-	50.49	61.22	83.68
Energy efficient lighting commercial	ktpa	-	7.23	8.44	7.97
Double glazing commercial	ktpa	-	0.13	0.44	0.49
Street lighting efficient lamps	ktpa	-	0.39	0.61	0.71
Domestic fuel reduction by behavioural change	ktpa	-	8.59	12.73	16.97
Domestic electricity use reduction by behavioural change	ktpa	-	24.58	33.72	37.66
Non-domestic fuel reduction by behavioural change	ktpa	-	11.33	16.79	22.39
Non-domestic electricity use reduction by behavioural change	ktpa	-	5.84	8.01	8.95
Transport fuel use reduction by behavioural change	ktpa	-	5.30	8.09	11.05
Road transport efficiency improvements	ktpa	2.81	7.93	16.13	35.47
Replace road transport fuels with biofuels	ktpa	2.89	4.61	6.36	8.67
Replace road transport fuels with electricity	ktpa	-	0.09	0.20	0.34
Green grid	ktpa	74.73	182.61	263.09	323.43
Total		**82.08**	**358.63**	**533.27**	**750.25**

Table 15: Carbon savings by measure for each period in the scenario

Measure	Units	2007-2010	2010-2013	2013-2016	2016-2020	2020-2030
CHP Biomass	£k	-	-	-5,974	6,486	59,527
CHP Large gas	£k	-	-13,335	-55,156	-168,517	-43,194
CHP Buildings gas	£k	-	-1,843	653	3,522	43,787
PV Domestic	£k	-	-16,706	-15,784	-5,031	38,658
PV Non domestic	£k	-	-14,607	-25,706	-34,063	-20,296
Wind medium	£k	-	-	-	-1,989	-1,500
Solar thermal domestic	£k	-	-15,947	-22,962	-24,590	-15,168
Ground source heat pump domestic	£k	-	-53	-309	-536	-628
Cavity wall insulation domestic	£k	-280	-557	4,554	12,870	29,444
Loft insulation domestic	£k	-71	-966	1,061	4,393	10,660
Double glazing domestic	£k	-	-40,015	-41,962	-41,541	-13,821
Solid wall insulation domestic	£k	-	-43,178	-24,199	7,788	113,896
Energy efficient lighting commercial	£k	-	-18,998	-20,146	-15,918	1,654
Double glazing commercial	£k	-	-3,589	-11,750	-13,011	-12,256
Street lighting efficient lamps	£k	-	-1,035	-1,518	-1,564	-4
Domestic fuel reduction by behavioural change	£k	-	3,150	8,871	19,349	45,312
Domestic electricity use reduction by behavioural change	£k	-	11,334	34,991	80,013	180,175
Non-domestic fuel reduction by behavioural change	£k	-	3,063	8,796	18,810	52,961
Non-domestic electricity use reduction by behavioural change	£k	-	2,078	6,417	14,687	34,422
Transport fuel use reduction by behavioural change	£k	-	4,094	11,771	25,225	56,042
Road transport efficiency improvements	£k	2,326	9,573	23,913	61,954	160,840
Replace road transport fuels with biofuels	£k	-1,247	-1,642	-2,304	-2,712	-3,639
Replace road transport fuels with electricity	£k	-	101	322	731	1,703
Green grid	£k	-	-	-	-	-
Total		**728**	**-139,076**	**-126,422**	**-53,642**	**718,572**

Table 16: NPV by measure for each period in the scenario