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Green

Energy Strategy

18-26 Hatton Wall

Camden

On behalf of Boultbee Brooks (Hatton Wall) Ltd

10/09/2014

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EXECUTIVE SUMMARY

I. This Energy Strategy has been prepared by Metropolis Green on behalf of Boultbee Brooks (Hatton Wall) Ltd in support of the full planning application for the proposed mixed use development at Hatton Wall which will deliver 7 new residential units and refurbished office space.

II. This report has been prepared in line with the London Plan and London Borough of Camden policy requirements, and follows the energy hierarchy: Be Lean, Be Clean, and Be Green. The report describes these policies, the calculation methodology used, and the measures taken to achieve policy requirements in the design of Hatton Wall.

III. All energy and carbon figures have been calculated using approved and Standard Assessment Procedure (SAP 2012) and SBEM software, which are used to demonstrate compliance with Building Regulations (2014 Addendum) and Code for Sustainable Homes requirements.

IV. The energy modelling demonstrates total regulated carbon emission reductions of 23.0% can be achieved for the proposed development.

V. The results of this energy strategy, in conjunction with the Code pre-assessment undertaken for this project, indicate that the development is on target to achieve the minimum energy requirements for Code Level 4 level.

VI. London Plan policy targets a 20% reduction in regulated carbon emissions through the specification of on-site renewable technologies. Site analysis and calculations have determined ASHP and photovoltaic panels (PV) to be the most suitable renewable energy technology. A 12.7% regulated carbon reduction has been shown to be achieved in this energy strategy through the application of onsite ASHP and PV, contributing to overall 7.3 tCO2/year reduction for the development.

VII. As part of the energy efficiency improvements, all practical measures have been implemented to minimise the risk of overheating. SAP 2012 /SBEM calculations have shown that the solar gain limits in summer have not been exceeded in the commercial or residential spaces.

VIII. The achievements demonstrated in this report are the result of high fabric performance, in combination with mechanical ventilation with heat recovery, ASHP and finally with roof mounted PV panels offsetting part of the building electricity consumption.

IX. Figures 1-4 below provide a summary of the 'Be Lean, Be Clean and Be Green' CO_2 reductions for the modelled solutions predicted for Hatton Wall.

Figure 1: Be Green – Regulated Carbon Emission Reductions

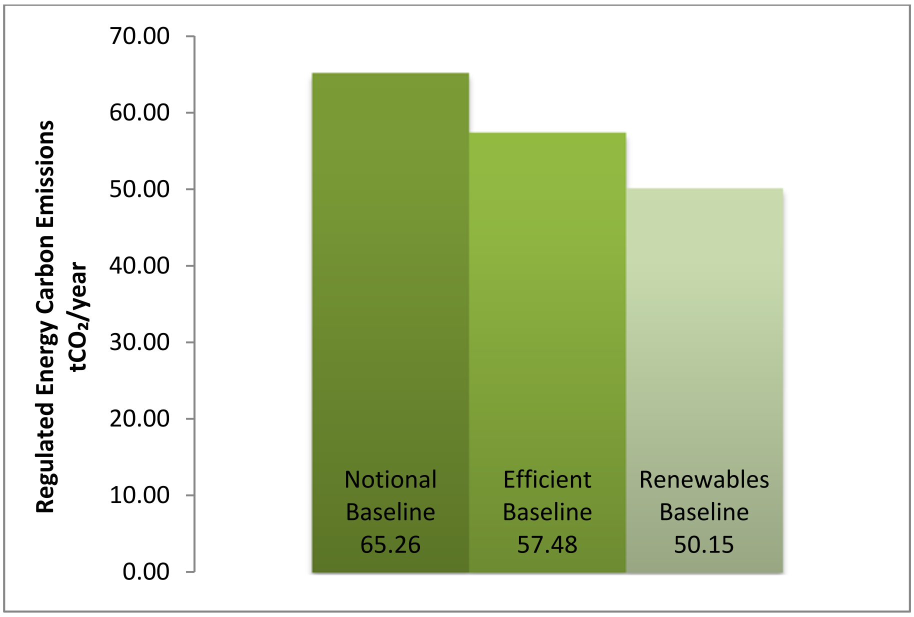


Figure 2: The Energy Hierarchy

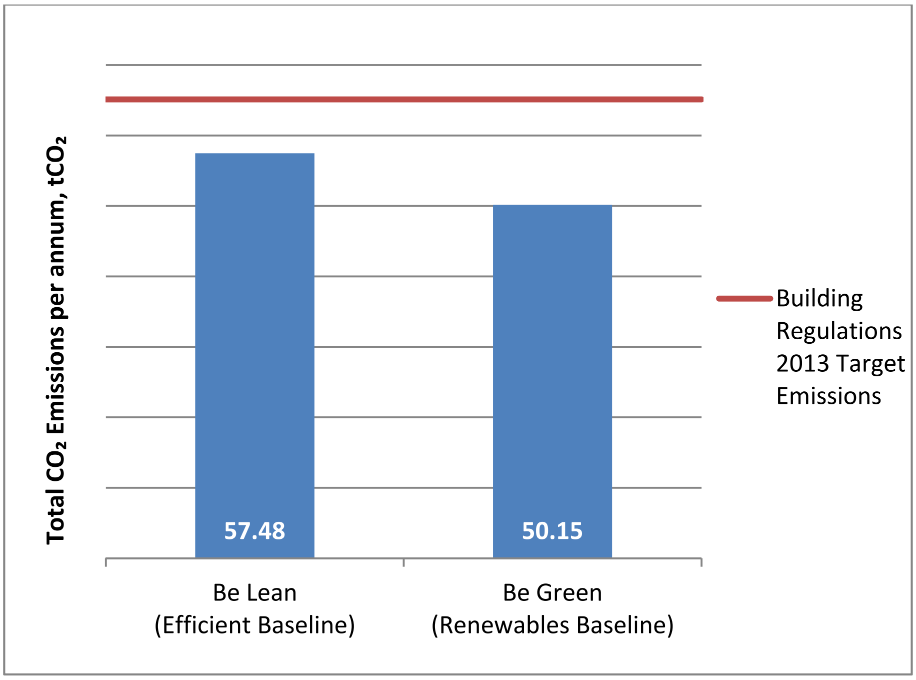


Figure 3: Residential, DER over TER Improvement

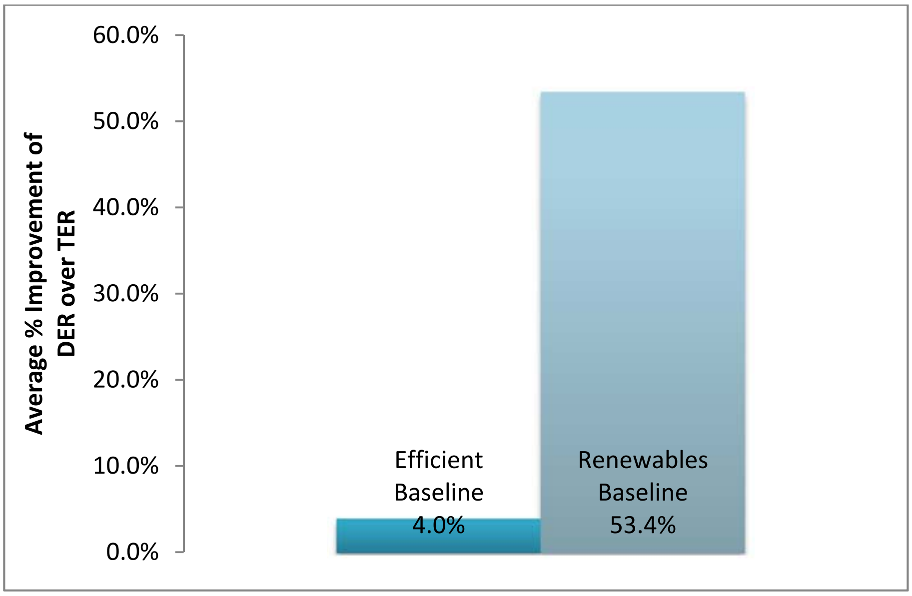
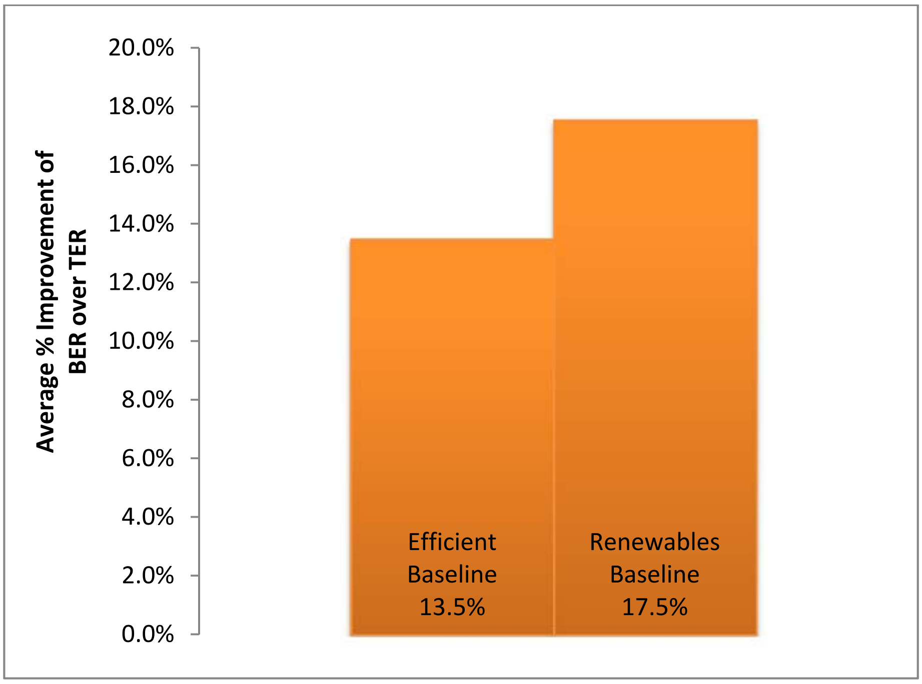


Figure 4: Commercial, BER over TER Improvement



CONTENTS

1.0 INTRODUCTION

1.1 This Energy Strategy has been prepared to accompany the detailed planning application for the development at Hatton Wall in the London Borough of Camden. The report demonstrates how the relevant planning policies with respect to energy will be achieved.

1.2 This Energy Strategy has considered the following key Planning Policies. Where these targets have not been met in full, justification has been provided:

- London Plan Policy 5.4 requirements for retrofitting of energy efficiency measures, decentralised energy and renewable energy opportunities.
- Investigation of decentralised energy use on site, in line with London Plan Policy 5.6 and London Borough of Camden CS13.
- London Plan Policy 5.7 requirements to achieve 20% carbon reduction through the specification of on-site renewable energy.
- London Borough of Camden Policy DP22:

  - New build housing to meet Code for Sustainable Homes Level 3 by 2010 and Code Level 4 by 2013 and encouraging Code Level 6 (zero carbon) by 2016;

- London Borough of Camden Section 9 of Camden Planning Guidance Sustainability (CPG3):

  - A new build dwelling will have to be designed in line with the Code for Sustainable Homes and achieve Level 4 between 2013 – 2015.

1.3 Appendix A of the report provides full details of national, regional, local policies and Building Regulations with regards to sustainability and energy conservation.

1.4 In line with the Mayor's energy hierarchy this report assesses the energy efficiency measures of the proposed scheme and the low carbon options for supplying energy to the development before examining the potential for renewable energy technologies to reduce carbon emissions.

2.0 SITE AND PROPOSED DEVELOPMENT

2.1 Site and Surrounding Area

2.1.1 The subject site is located in the southern part of the Borough, bordering Islington to the east and the City of London to the South. Leather Lane and Saffron Hill form the west and east boundaries of the Ely Estate, which was constructed in 1292 by the Bishop of Ely to house his Palace. This is the area currently known as Hatton Garden. The Church of St Ethedreda was part of this estate and still remains on Ely Place.

2.1.2 Hatton Wall is a typical street within the Hatton Garden area: narrow, with little space for cars and on a hill. Tall buildings front the pavement, and their mix includes a variety of periods, uses and styles.

2.2 Proposed Development

2.2.1 The proposals respect the mix of scales and characters in the Hatton Garden area, by providing a sympathetic refurbishment with contemporary extensions of the existing B1 space and the introduction of 7 residential dwellings in total, comprising of one, two and three bedroom flats with terraces.

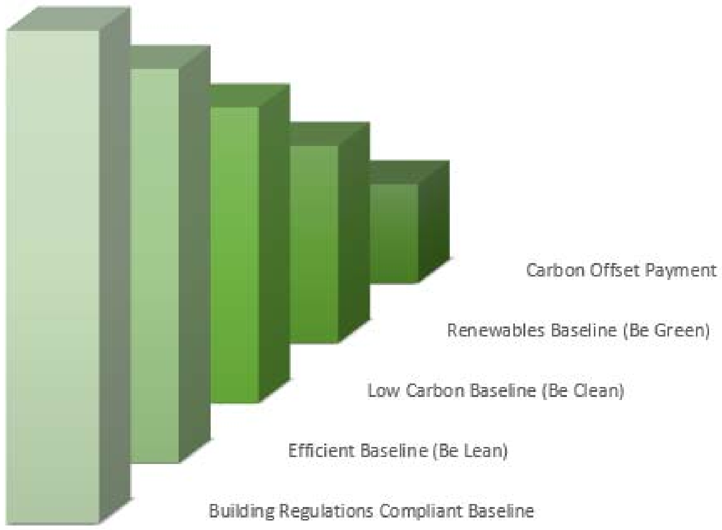
2.2.2 For more information regarding the design of the proposal, please refer to the drawings and the Design and Access Statement prepared by Gpad Architects.

Figure 5: Location Plan

3.0 METHODOLOGY

3.1 This document has been prepared in line with Energy Planning *GLA Guidance on preparing energy assessments (GLA, April 2014)*, and the methodology that has been applied is in line with the Mayor's energy hierarchy and national calculation methodologies. This is illustrated in Figure 6 below.

Figure 6: Energy Hierarchy



3.2 Please note that the calculations in this report are based on drawings and information provided pre-planning approval. These results are intended to provide initial assessment of the design to ensure that planning policies can be achieved at this site.

4.0 SITE ENERGY DEMAND AND NOTIONAL BASELINE

4.1 The London Plan promotes a 'regulated' energy approach to calculating the energy demand and carbon baseline of development. The baseline therefore includes the energy consumed in the operation of the space heating/cooling and hot water systems, ventilation, all internal lighting, and, reported separately is the energy demand and carbon dioxide emissions from cooking and all electrical appliances that are not covered by the Building Regulations, also called 'unregulated' energy.

4.2 The Notional Baseline for the Hatton Wall development has been modelled to comply with the current Building Regulations and the energy and carbon data has been determined using approved SAP/SBEM software.

4.3 Table 1 below provides the breakdown of the Notional Baseline results for the Wall development. Full detailed results providing the breakdown of the Notional Baseline can be found in Appendix C of this report.

Table 1 - Predicted Notional Baseline - Residential

Notional Baseline	
Regulated Carbon Emissions t/CO_2/yr	**65.1**
Un-Regulated Carbon Emssions t/CO_2/yr	**9.9**

Table 2 - Predicted Notional Baseline - Non-residential

Notional Baseline	
Regulated Carbon Emissions t/CO2/yr	**54.6**
Un-Regulated Carbon Emssions t/CO2/yr	**53.5**

5.0 ENERGY EFFICIENCY

5.1 The first stage in the energy hierarchy is to assess the energy performance of the building based on fabric and services improvements.

5.2 Metropolis Green have worked with Gpad Architects to determine the most efficient and feasible way to reduce the carbon emissions of the development through passive design measures. This strategy focusses on a high efficiency fabric performance specification.

5.3 Efficiency measures are considered to be the most sustainable approach to take in building design as the measures designed into the fabric of the building and the related carbon reductions will last the lifetime of the building and will outlast those of any renewables installed.

5.4 Minimising heat loss from the building fabric to avoid wasted energy is essential. Heat loss through walls, windows and surface areas of the building must be significantly lower than Building Regulations recommended values, requiring specification of building fabric with very low u-values. Heat loss through thermal bridges, where the continuity of insulation and/or the building envelope is broken, can be minimised through excellent workmanship and careful design, removal of unnecessary structural elements or insulation of structural elements.

5.5 Passive design measures such as building orientation, fabric performance, air tightness and natural ventilation will be optimised within the buildings on site to prevent overheating and avoid excessive requirements for heating and cooling.

Energy Efficiency Measures

5.6 The thermal performance of the building fabric for this baseline is significantly better than the limiting parameters of Building Regulations Part L, improving overall fabric efficiency and reducing carbon emissions for the residential and commercial parts of the development for the lifetime of the building.

5.7 Thermal bridging will be minimised in accordance with Accredited Construction Details and air permeability of 4 m3/hour/m2@50Pa is to be achieved for the residential and 5 m3/hour/m2@50Pa is to be achieved for the non-residential part.

5.8 Further energy efficiency measures include utilizing highly efficient condensing combi boilers and gas boilers to provide space heating and hot water generation during peak demand, along with energy saving heating control measures such as time and temperature zone control.

5.9 Ventilation to the apartments will be via natural means (openable windows and intermittent mechanical extract fans) to ensure adequate levels of ventilation and to contribute to maintaining thermal comfort levels. For the non-residential part ventilation will be through Mechanical Ventilation With Heat Recovery MVHR with 70% efficiency and 1.8 W/l s.

5.10 The design team have committed to exceeding the minimum low energy lighting requirements outlined in the Domestic Building Services Compliance Guide, with 100% low energy lighting for the residential spaces. For the non-residential spaces a lighting luminaire efficacy of 90 lm/W is to be implemented.

5.11 As a result of the above measures and improvements, a new energy baseline has been calculated and is referred to as the Efficient Baseline, completing the first stage of the energy hierarchy, to be lean and use energy efficiently. A summary of the Efficient Baseline, u-values and input parameters can be found in Table 8 of this report.

5.12 Further carbon reduction measures, such as application of low and zero carbon technologies will be investigated in the following chapters of the report.

Energy and CO_2 Reductions

5.13 The predicted regulated carbon emission reduction for the whole development delivered through the efficiency measures detailed above equates to 11.8%, with a reduction of 7.7 tCO_2/year.

5.14 Based on SAP calculations, improvements in the residential use obtains a 4.0% improvement of DER over TER as illustrated in Figure 8 below.

5.15 Based on SBEM calculations, improvements in the non-residential use obtains a 13.5% improvement of BER over TER as illustrated in Figure 9 below.

5.16 Table 3 below sets out energy and carbon emission results for the Residential Efficient Baseline.

5.17 Table 4 below sets out energy and carbon emission results for the Non-residential Efficient Baseline.

Table 3 - Efficient Baseline Energy and Carbon Emissions - Residential

Efficient Baseline	
Regulated Carbon Emissions tCO_2/yr	**57.5**
Un-Reg Carbon Emissions tCO_2/yr	**9.9**
% Improvement over Notional Baseline	**4%**

Table 4 - Efficient Baseline Energy and Carbon Emissions – Non-residential

Efficient Baseline	
Regulated Carbon Emissions tCO_2/yr	**47.4**
Un-Reg Carbon Emissions tCO_2/yr	**53.5**
% Improvement over Notional Baseline	**13.5%**

Figure 7: Be Lean – Predicted Efficient Baseline, Regulated Carbon Emissions

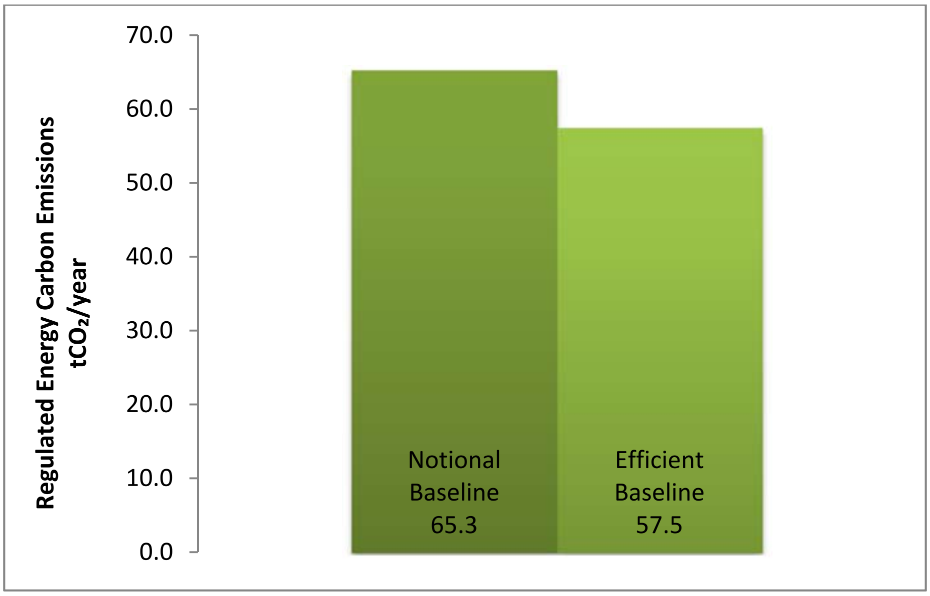


Figure 8: Residential Efficient Baseline DER over TER Improvement

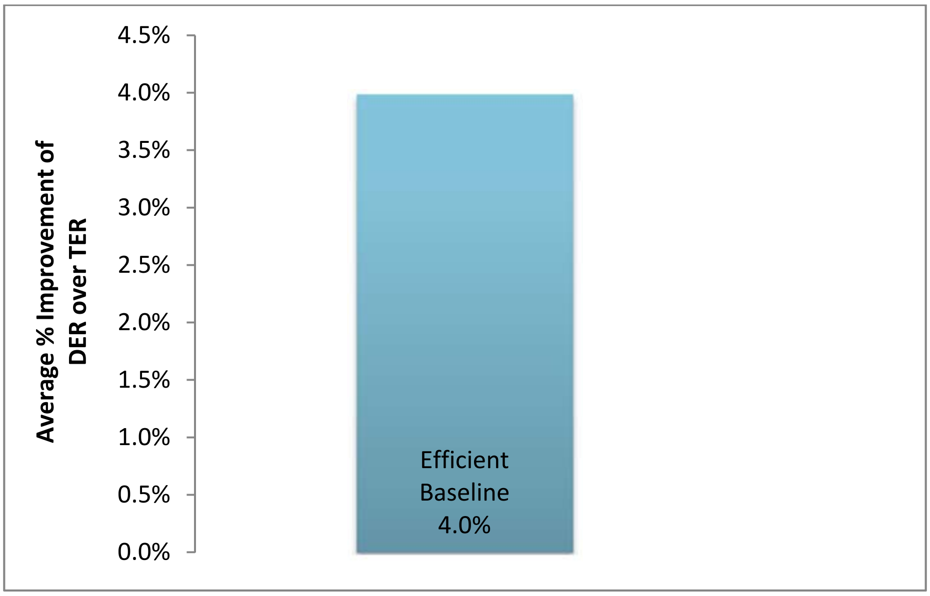
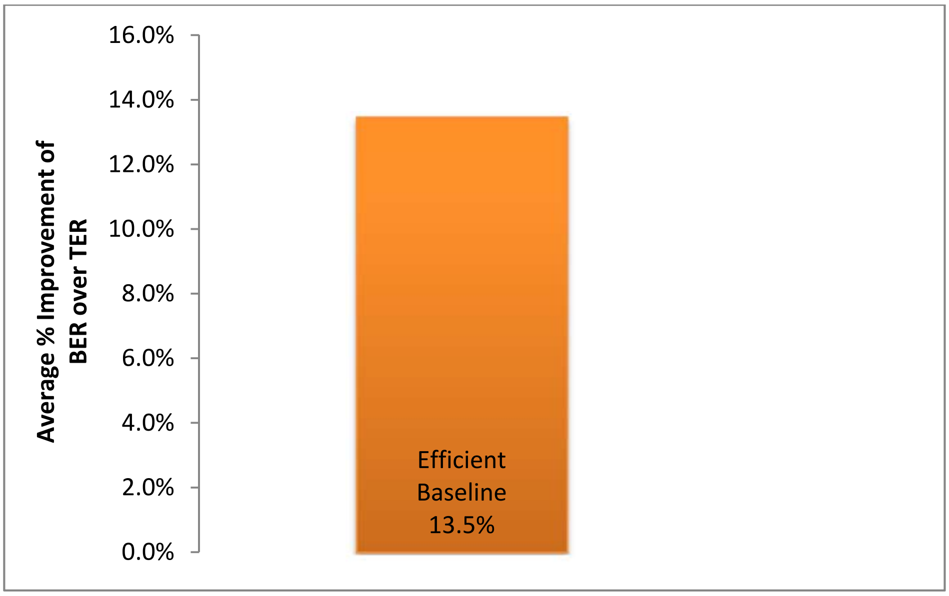


Figure 9: Non-residential Efficient Baseline BER over TER Improvement



6.0 OVERHEATING AND COOLING

6.1 Through the application of passive design and low energy measures the design team have worked to ensure that the risk of summer overheating and reliance on mechanical cooling is minimised in line with the 'cooling hierarchy' and London Plan Policy 5.9.

6.2 The orientation of the buildings is constrained by the site location, neighbouring buildings and street orientation. Although, careful design along with low u-value glazing allows for a balance between beneficial solar gain and possible overheating.

6.3 Good natural day lighting within the development at Wall will create significant benefits in terms of reduced electrical use for lighting, solar gains to reduce winter heating consumption and a healthier, more pleasant environment.

6.4 Internal heat generation due to solar gain has been minimised through energy efficient design, reducing the building summer overheating risk. A combination of high levels of fabric performance and insulation has been implemented, resulting in low u-values.

6.5 Natural ventilation is provided to all residential apartments through fully openable windows to allow for occupant control of temperature, to reduce the risk of summer overheating.

6.6 Mechanical ventilation with heat recovery is provided to the non-residential spaces to reduce the risk of summer overheating.

6.7 User comfort cooling is to be provided throughout the development via Air Source Heat Pump - ASHP. Cooling for the non-residential part will be delivered via Heat pump with SEER 7.0; Cooling for the residential part will be delivered via an A rated system with variable speed compressor.

6.8 SAP Appendix P, Assessment of Internal Temperature in Summer, for the residential spaces shows that the threshold of internal mean temperatures has not been exceeded on the hottest summer days. Therefore all dwellings on site satisfy Criterion 3 requirements of Building Regulations Part L.

7.0 COMMUNAL HEATING, COMBINED HEAT & POWER

7.1 The second stage in the Mayor's energy hierarchy is to investigate the application of CHP to produce energy more efficiently with the aim of reducing the carbon baseline further.

7.2 The Mayor requires that all new developments consider CHP, a decentralised energy generation technology, before renewables are applied to the site. Building up a network of mini-power stations that are far more efficient than traditional centralised power stations is an important part of the Mayor's overall strategy to move London towards its long term carbon reduction targets.

7.3 CHP is an engine which produces electricity. The process of creating the electricity produces heat as a by-product. Heat can be easily stored in a thermal storage tank and distributed across the site to provide for hot water and heating demands.

7.4 The Mayor's energy hierarchy and the London Plan Policy 5.6 require all major developments to demonstrate that the proposed energy systems have been selected in accordance with the following hierarchy:

- Connection to existing heating or cooling networks
- Site wide CHP network
- Communal heating and cooling.

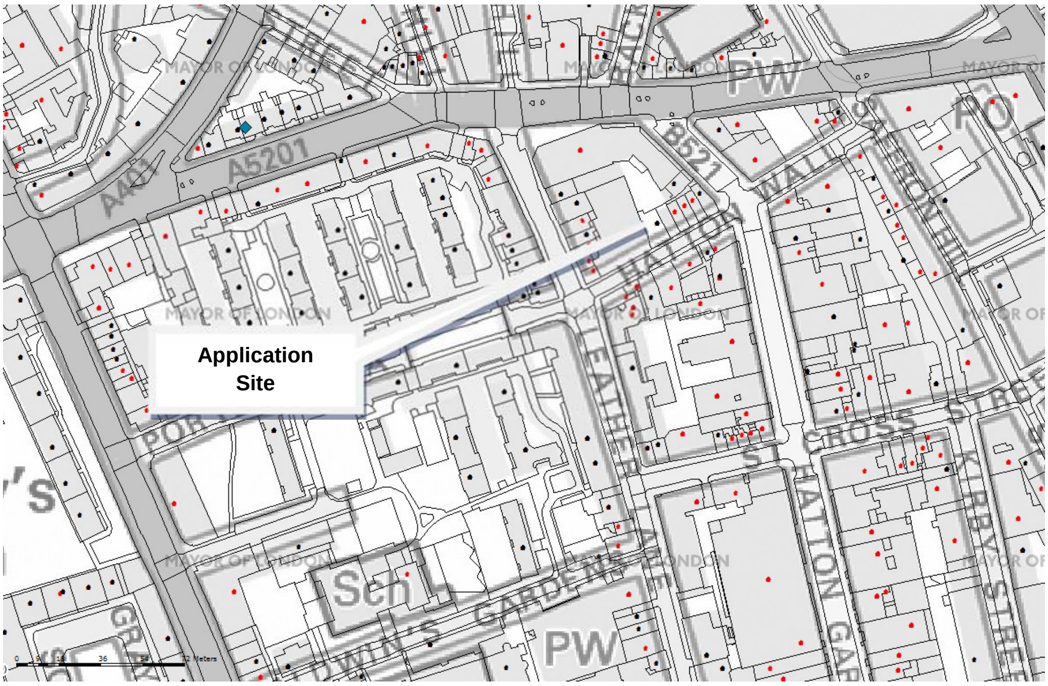
Local Connection

7.5 An investigation of the area was undertaken using the London Heat Map tool to determine opportunities to connect to existing heat infrastructure.

Research has concluded that there is not currently any opportunity to connect to a local heat network or CHP.

7.6 Investigation into existing heat networks in the area using the London Heat Map have shown that there are not any functioning or proposed CHP installations or heat networks within a 500m radius of the site (Figure 10). Therefore it has been determined that a connection to these kind of facilities is not feasible.

Figure 10: London Heat Map Indicating CHP Sites and District Heat Networks



Feasibility

7.7 A communal CHP solution has been investigated and found not to be the optimal technology for the new development due to the size and layout of the site providing limited space for CHP plant and related infrastructure, and contributing to a higher associated cost for the infrastructure with long payback periods. If specified, the CHP would have to run with a frequent on-off cycle, which would significantly reduce the efficiency and availability of the system and increase the maintenance requirements.

7.8 It has been established that the specification of an ASHP to provide space heating and DHW together with the fabric improvements discussed in previous section delivers the optimal carbon reductions in the most cost effective way.

8.0 RENEWABLE ENERGY

8.1 The third stage of the energy hierarchy refers to the production of renewable energy, which relates to London Plan Policy 5.7.

8.2 Each of the approved renewable energy technologies have been appraised, examining the suitability to the site and potential for delivering CO_2 reductions. The general feasibility of the technologies which were discounted is discussed in Appendix B in order to determine the most suitable solution for the site.

8.3 London Plan approved renewable energy technologies include:

- Photovoltaics
- Solar Water systems
- Biomass Heating
- Ground Sourced Heating / Cooling
- Wind

8.4 The choice of technology will be dependent upon a range of factors including: orientation, height, window size, surrounding buildings and environment, site size and layout, geology, conservation and biodiversity.

8.5 Site analysis and calculations have shown that shown that a combination of PV and an ASHP is the most suitable renewable energy technology for the site; reducing the Renewables Baseline to 50.2 tCO_2/year by a predicted 7.3 tCO_2/year from the Efficient Baseline of 57.5 tCO_2/year.

8.6 The following section sets out the energy and carbon reductions achievable and the feasibility and applicability of the application of PV panels and ASHP to the proposal.

8.1 PHOTOVOLTAICS AND ASHP

8.1.1 Photovoltaic systems convert solar energy directly into electricity through semiconductor cells. The panels generate electricity from both direct light and diffuse light. Photovoltaic panels can either be mounted external to the building or be integrated into the building cladding (known as Building Integrated Photovoltaic or BIPV).

8.1.2 In addition to the PV system, an air source heat pump (ASHP) will provide space heating and DHW to the residential units as well as space heating and DHW to the non-residential spaces.

8.1.3 PV panels and ASHP are the most feasible option for this site, offering the greatest CO_2 reduction in the space available.

Energy and CO_2 Reduction

8.1.4 The available roof space has been investigated and it has been determined that there is a sufficient space for a total of 12 PV panels (54 m^2) with the potential to offset the electrical consumption of the development by a total of 3451.02 kWh/year. The combination of PV panels and ASHP implemented together is lowering the carbon emissions of the development by 7.3 tCO_2/year from the Efficient Baseline.

8.1.5 Results of implementing the PVs together with the ASHP at Hatton Wall are summarised in Table 5 below. The proposed solution will deliver an overall 23.0% CO_2 reduction for the site as shown in Figure 11. The DER over TER improvement of the development is 53.42% and is illustrated in Figure 12 below. For the commercial element of the development the BER over TER improvement is 17.5% and is illustrated in Figure 13 below.

8.1.6 The proposed PV and ASHP will deliver a 12.7% regulated carbon emission reduction for the site as shown in Figure 11, working towards the London Plan Policy 5.7 target for a 20% reduction in CO_2 emissions (where feasible) as a result of specification of onsite renewables.

Table 5 - Energy and Carbon Emissions with PV-Residential

Renewables Baseline	
Regulated Carbon Emissions tCO_2/yr	**50.2**
Un-Reg Carbon Emissions tCO_2/yr	**63.4**
% Improvement over Efficient Baseline	**12.7%**

Figure 11: Be Green – Predicted Renewables Baseline, Regulated Carbon Reduction

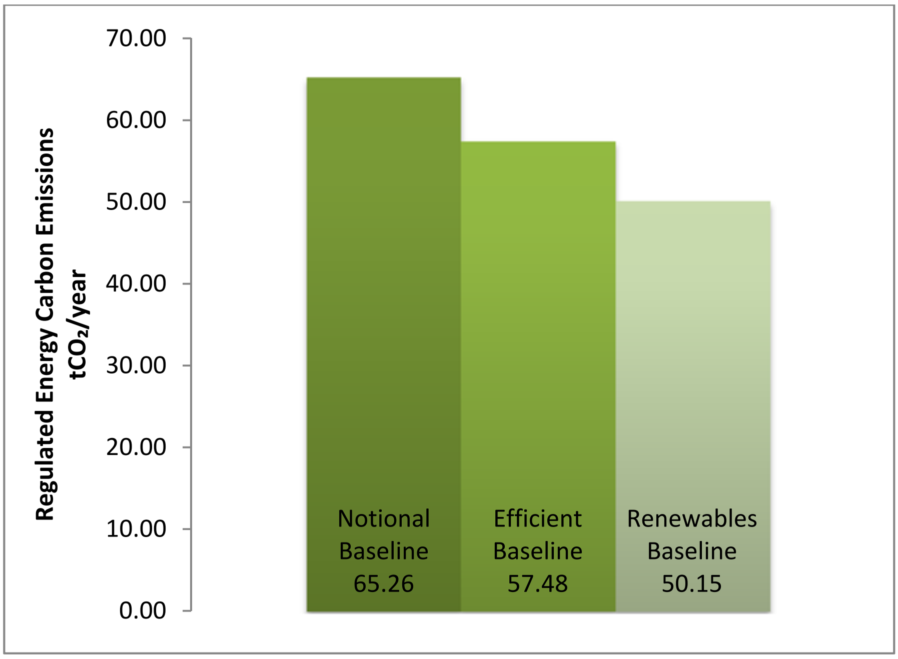


Figure 12: Residential DER over TER improvements of the development

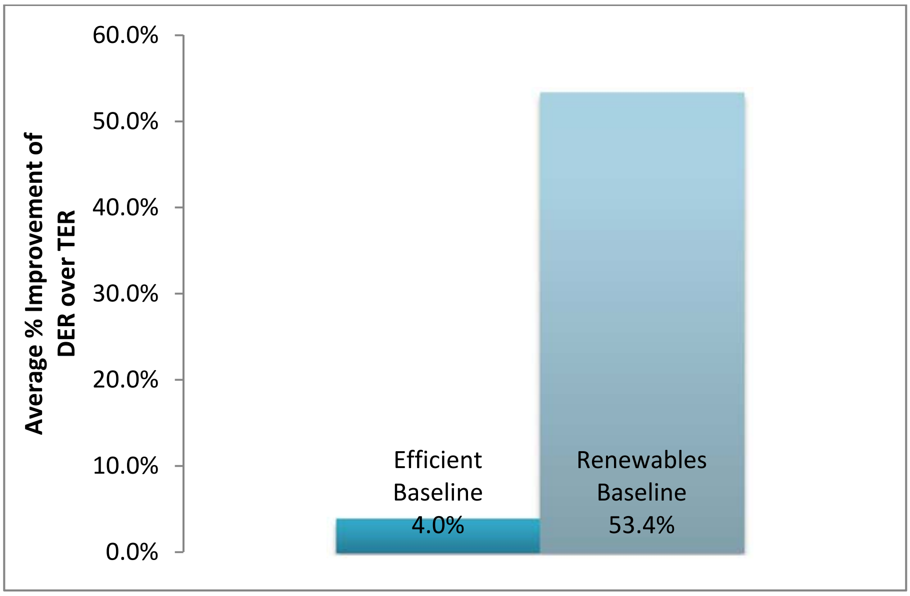
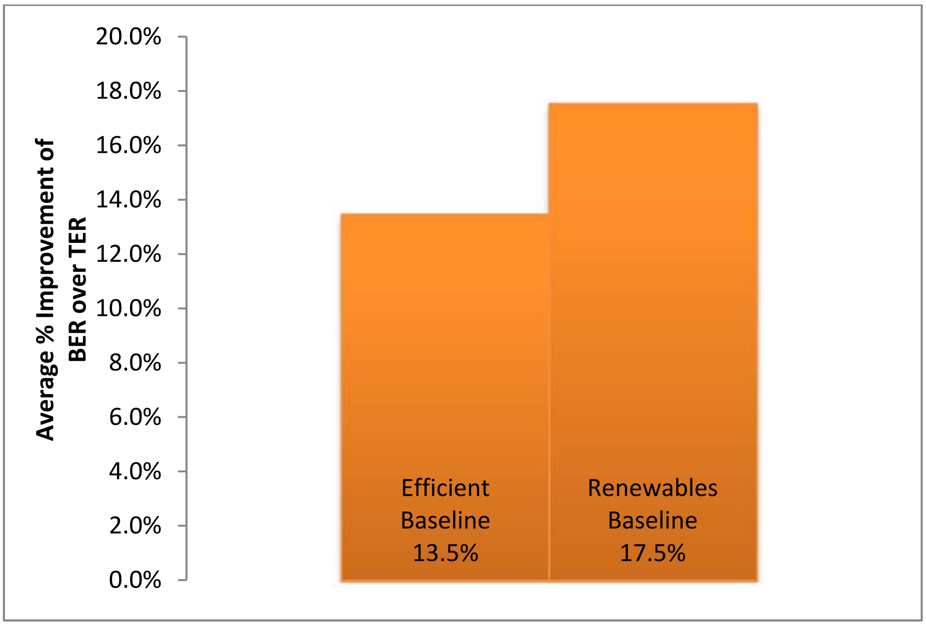


Figure 13: Non-Residential BER over TER improvements of the development



Plant Selection

8.1.7 Careful consideration has been given to maximising the use of PV to both provide renewable energy to the site and to meet London Plan Policy targets.

8.1.8 Attention has been given to the placement of PV panels in terms of orientation and angle for optimal performance output and to reduce their visual impact. The proposed array will be arranged with PV modules facing south and at a 30° angle for optimal performance. At less than 10°, the modules will not self-clean, invalidating their warranty.

8.1.9 The modules will also need to be spaced approximately 800mm apart to avoid overshadowing of neighbouring modules and to provide a safe walkway for maintenance access. If correctly installed, PV systems require minimal maintenance.

8.1.10 In addition, obstructions on the roof such as lift overruns and other plant must be avoided, again to ensure panels are not shaded at any time as this significantly reduces their output performance.

8.1.11 After careful investigation of the available roof space, it has been determined that there is enough available roof space for 12 (54 m^2) mono-crystalline silicon PV panels. Please note, the final layout is subject to specialist sub-contractor design and may differ from the proposed array illustrated.

8.1.12 As all panels will be situated on the roof of the building, there is no additional land use associated with this technology.

8.1.13 PV systems require an inverter which converts the low voltage direct current electricity produced by the array of panels into 230V 50/60Hz alternating current. Inverters along with the meters will be situated close to the panels either on the roof or in electrical cupboards within service risers.

Figure 14: Proposed Roof Plan with PV Layout

Capital and Life Cycle Costs

8.1.14 It is estimated that the total capital cost of the PV panels, including inverters, installation, miscellaneous electrical components etc., equates to approximately £13.159. This figure is indicative only and is based on a generic system price range provided by a single PV provider/installer. Final, actual costs will depend on detailed design of the PV array, ancillary equipment and site constraints and all prices are considered subject to change at any time due to market forces and are dependent on the supplier/installer. Once detailed designs have been prepared quotes should be obtained from PV suppliers/installers for accurate system costs.

Exporting Electricity

8.1.15 The annual income that can be generated by the PV panels includes a Feed-In Tariff (FIT) generation tariff rate of up to 15.44p/kWh (for more information please visit www.fitariffs.co.uk). Tariffs will be linked to the Retail Price Index (RPI) which ensures that each year they follow the rate of inflation. The rate payable is set at the year of entering the FIT and the entrance rate will reduce annually. In addition to the generation tariff a micro generation export rate of 4.5p/kWh for the electricity exported to the grid, this rate is payable by the electricity provider and will also be RPI linked. The electricity export rate is collected from electricity utility provider.

9.0 CONCLUSION

9.1 Following the energy hierarchy has enabled significant carbon reductions to be calculated for the proposed Wall development. A total overall carbon reduction of 15.0 tCO_2/year, equivalent to 23.0%, can be achieved through the energy strategy demonstrated in this report.

9.2 The results of this energy strategy, in conjunction with the Code pre assessment, indicates that the flats are on target to achieve Code Level 4.

9.3 The energy modelling demonstrates that the proposed Hatton Wall development can achieve an overall regulated carbon emission reduction of 23.0%. And achieves a DER over TER improvement of 53.42% for the residential spaces respectively.

9.4 In accordance with the London Plan and GLA guidance the baseline energy figures derived from SAP and SBEM calculations have been used including: space heating, DHW, cooling, lighting, pumps and fans. Separately, an un-regulated energy demand have also been reported. The proposed development at Hatton Wallis calculated to have regulated carbon emissions Notional Baseline of 65.1 tCO2/year.

9.5 In the first stage of the energy hierarchy (Be Lean), a 7.7 tCO_2/year carbon reduction associated with the proposed fabric and services energy efficiency measures has been predicted, equivalent to 11.8% reduction from the Notional to the Efficient Baseline. As a part of the energy efficiency improvements all practical measures have been implemented to minimise risks of overheating, and calculations have shown that the solar gain limits in summer have not been exceeded.

9.6 For the second stage in the hierarchy (Be Clean), investigations show that there is no opportunity to connect to a local CHP plant insulation or district heat network, and due to efficiency and space considerations communal CHP has been determined not be appropriate for this site.

9.7 In the final stage of the energy hierarchy (Be Green), site analysis and calculations have determined PV panels in combination with an ASHP to be the most suitable renewable energy technology for the site. Providing a further 12.7% regulated carbon emission reduction equivalent to 7.3 tCO_2/year through the application of 12 PV panels (54 m^2) and a Daikin Atherma ASHP.

9.8 Table 6 and Table 7 below provide a summary of the CO_2 emissions, and overall carbon reductions for the modelled baselines of the development at Hatton Wall. A summary of the u-values and input parameters that have been used to achieve the optimum improvements for the proposed development are shown in Table 8 below.

Figure 15: Be Green – Predicted Renewables Baseline, Regulated Carbon Reduction

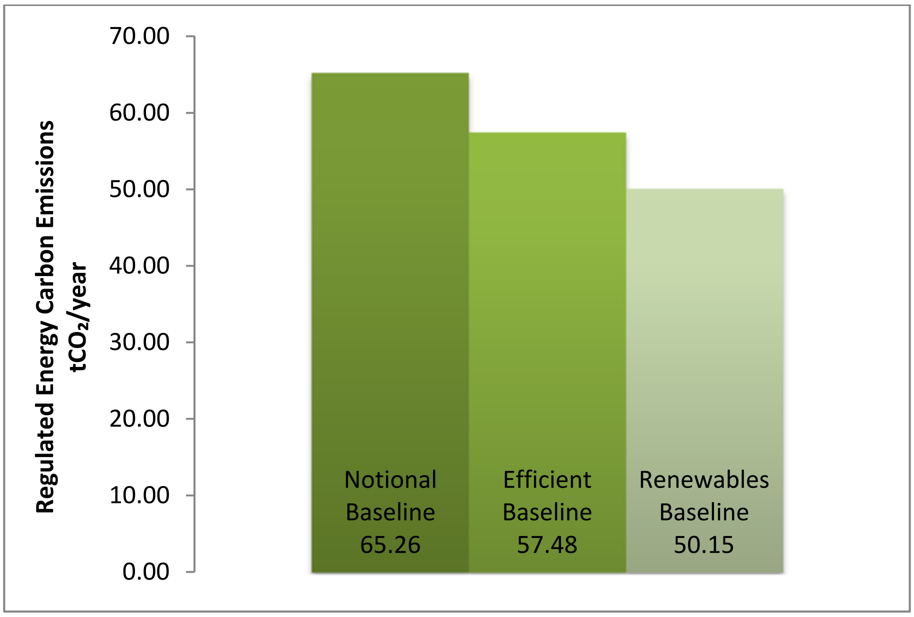


Figure 16: Residential DER over TER improvements of the development

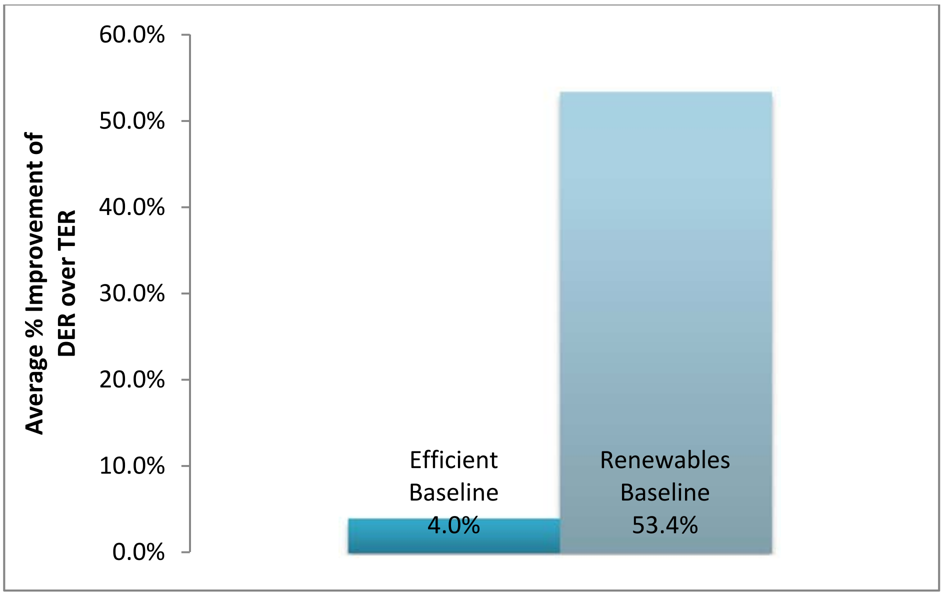


Figure 17: The Energy Hierarchy (Be Lean, Be Clean, Be Green)

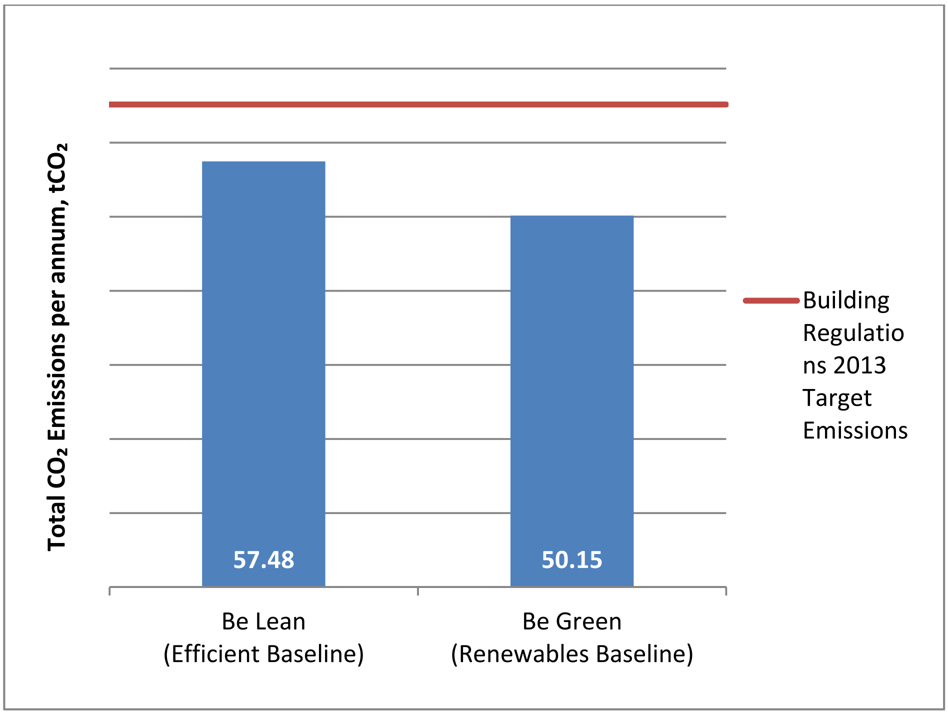


Table 6 - Carbon dioxide emissions after each stage of the Energy Hierarchy

	Carbon dioxide emissions (Tonnes CO2 per annum)	
	Regulated	Unregulated
Building Regulations 2013 Part L Compliant Development	65.1	63.4
After energy demand reduction	57.5	63.4
After renewable energy	50.2	63.4

Table 7 – Regulated Carbon dioxide emissions after each stage of the Energy Hierarchy

	Regulated Carbon dioxide savings	
	Tonnes CO_2 per annum	%
Savings from energy demand reduction	7.7	11.8%
Savings from renewable energy	7.3	12.7%
Total Cumulative Savings	**15.0**	**23.0%**

Table 8 – Summary of Input Parameters

Parameters	Notional Baseline	Efficient Baseline	Renewables Baseline
External Wall U-value (flats)	0.21	0.18	0.18
External Wall U-value (commercial retained)	1.6 (solid brick)	1.6 (solid brick)	1.6 (solid brick)
External Wall U-value (commercial new)	0.25	0.25	0.25
Internal heat loss walls U-value	0.21	0.18	0.18
Party-Wall U-value	0	0	0
Ground Floor / Exposed Floor U-value	0.20	0.20	0.20
Internal heat loss floor U-value (floor between flats and commercial)	0.20	0.20	0.20
Roof U-value	0.15	0.13	0.13
Windows and doors U-values	1.40	1.30	1.30
Thermal bridging (flats)	- Accredited construction details throughout - Lintels with Linear heat loss coefficient (Psi-value) of 0.05 W/mK (e.g. Keystone hi therm lintels) - Roof/wall junction psi-value 0.04 or lower	- Accredited construction details throughout - Lintels with Linear heat loss coefficient (Psi-value) of 0.05 W/mK (e.g. Keystone hi therm lintels) - Roof/wall junction psi-value 0.04 or lower	- Accredited construction details throughout - Lintels with Linear heat loss coefficient (Psi-value) of 0.05 W/mK (e.g. Keystone hi therm lintels) - Roof/wall junction psi-value 0.04 or lower
Thermal Mass Parameter	Medium (250 kJ/m2K)	Medium (250 kJ/m2K)	Medium (250 kJ/m2K)
Air Permeability (flats)	5	4	4
Air Permeability (commercial)	5	5	5

Space Heating System (flats)	Condensing combi boiler in each flat 89% SEDBUK 2009 efficiency, radiators, time and temperature zone control	Condensing combi boiler in each flat 89% SEDBUK 2009 efficiency, radiators, time and temperature zone control	ASHP Daikin Altherma ERLQ004CAV3 + EHBH04CA3V, underfloor heating, time and temperature zone control, weather compensator
DHW System (flats)	Condensing combi boiler in each flat 89% SEDBUK 2009 efficiency, radiators, time and temperature zone control	Condensing combi boiler in each flat 89% SEDBUK 2009 efficiency, radiators, time and temperature zone control	Indirect DHW cylinder "Gledhill Stainless Lite Heat Pump" fed from the ASHP
Ventilation System (flats)	Natural with intermittent mechanical extracts	Natural with intermittent mechanical extracts	Natural with intermittent mechanical extracts
Space Heating System (commercial)	Gas boiler, 95% seasonal efficiency	Gas boiler, 95% seasonal efficiency	ASHP, SCoP 5.0 (e.g. Mitsubishi City Multi VRF High CoP)
DHW System (commercial)	Gas boiler, 95% seasonal efficiency	Gas boiler, 95% seasonal efficiency	ASHP, SCoP 3.0
Ventilation System (commercial)	Offices: MVHR system with 70% efficiency and SFP 1.8 W/l.s or lower, demand control with CO2 sensors controlling fan speed Toilets and showers: Mechanical extract with SFP of 0.3 W/l.s or lower	Offices: MVHR system with 70% efficiency and SFP 1.8 W/l.s or lower, demand control with CO2 sensors controlling fan speed Toilets and showers: Mechanical extract with SFP of 0.3 W/l.s or lower	Offices: MVHR system with 70% efficiency and SFP 1.8 W/l.s or lower, demand control with CO2 sensors controlling fan speed Toilets and showers: Mechanical extract with SFP of 0.3 W/l.s or lower
Cooling (Commercial)	Heat pump SEER 7.0 (e.g. Mitsubishi City Multi VRF High CoP)	Heat pump SEER 7.0 (e.g. Mitsubishi City Multi VRF High CoP)	Heat pump SEER 7.0 (e.g. Mitsubishi City Multi VRF High CoP)
Cooling (flats)	A-rated system with variable speed compressor	A-rated system with variable speed compressor	A-rated system with variable speed compressor
Energy Efficient Lighting (flats)	100%	100%	100%
Lighting (commercial)	Luminaire efficacy 66 lm/W, metering with 'out of range' alarm, photoelectric dimming with constant illuminance control in offices, occupancy sensors in other areas	Luminaire efficacy 90 lm/W, metering with 'out of range' alarm, photoelectric dimming with constant illuminance control in offices, occupancy sensors in other areas	Luminaire efficacy 90 lm/W, metering with 'out of range' alarm, photoelectric dimming with constant illuminance control in offices, occupancy sensors in other areas

PV system (flats)	-	-	12 No PV panels at 0.333 kWp, facing south at 30 degrees with total output of 3.996 kWp

APPENDIX A – POLICY CONTEXT

A.0.1 The proposed development at Hatton Wall must comply with a number of the following policies, regulations and standards which require the calculation of energy demand and carbon emissions:

- Building Regulations (2014 Addendum)
- London Plan and London Borough of Camden
- Code for Sustainable Homes 2014

A.0.1 The calculations of energy demand and carbon emissions are slightly different for each of the policies/standards; this is discussed in the sections below.

A.0.2 Increased development of renewable energy resources and improvements in energy efficiency are vital to facilitating the delivery of the European, National, Regional and Local commitments on climate change. It is also worth noting that the EU has an ever increasing focus on carbon emissions and in February 2007, EU environment ministers agreed in principle to cut greenhouse gas emissions by 20% by 2020 based on 1990 levels.

A.0.3 The key documents of relevance to this development are highlighted below.

A.1 NATIONAL POLICY

A.1.1 Sustainable development is the core principle underpinning planning. At the heart of sustainable development is the simple idea of ensuring a better quality of life for everyone, now, and for future generations. A widely used definition was drawn up by the World Commission on Environment and Development in 1987: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

A.1.2 Planning has a key role to play in the creation of sustainable communities: communities that will stand the test of time, where people want to live, and which will enable people to meet their aspirations and potential.

National Planning Policy Framework

A.1.3 The National Planning Policy Framework (NPPF) was published in March 2012 and sets out the Government’s planning policies for England, and how these policies are expected to be applied. The policies in the document, taken as a whole, constitute the Government’s view of what sustainable development in England means in practice for the planning system.

A.1.4 Paragraph 14 of the NPPF states that:

> At the heart of the NPPF **is a presumption in favour of sustainable development**, which should be seen as a golden thread running through both plan-making and decision-taking. For **decision-taking** this means approving development proposals that accord with the development plan without delay.

A.1.5 The NPPF outlines a set of core land-use planning principles that should underpin both plan-making and decision-taking, three of which are particularly relevant to this Energy Strategy. Under paragraph 17, these principles are that planning should:

> - support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change, and encourage the reuse of existing resources, including conversion of existing buildings, and encourage the use of renewable resources (for example, by the development of renewable energy);
> - contribute to conserving and enhancing the natural environment and reducing pollution. Allocations of land for development should prefer land of lesser environmental value, where consistent with other policies in this Framework; and
> - encourage the effective use of land by reusing land that has been previously developed (brownfield land), provided that it is not of high environmental value.

A.1.6 Design is addressed in section 7 of the NPPF, and paragraph 56 states:

> The Government attaches great importance to the design of the built environment. Good design is a key aspect of sustainable development, is indivisible from good planning, and should contribute positively to making places better for people.

A.1.7 Meeting the challenge of climate change is addressed in section 10 of the NPPF, and paragraph 93 states: Planning plays a key role in helping shape places to secure radical reductions in greenhouse gas emissions, minimising vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of renewable and low carbon energy and associated infrastructure. This is central to the economic, social and environmental dimensions of sustainable development.

A.1.8 Further to the above, paragraph 95 addresses local plan-making and state:

> To support the move to a low carbon future, local planning authorities should:
>
> - plan for new development in locations and ways which reduce greenhouse gas emissions;
> - actively support energy efficiency improvements to existing buildings; and
> - when setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards.

A.1.9 Additionally, paragraph 96 discussed decision-taking and states that:

> In determining planning applications, local planning authorities should expect new development to:
>
> - comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and
>
> take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.

A.1.10 Lastly, it is important to note that paragraph 187 of the NPPF addresses decision-taking by local planning authorities with respect to development applications. This paragraph states that:

> Local planning authorities should look for solutions rather than problems, and decision-takers at every level should seek to approve applications for sustainable development where possible. Local planning authorities should work proactively with applicants to secure developments that improve the economic, social and environmental conditions of the area.

A.2 BUILDING REGULATIONS

A.2.1 Building Regulations exist to ensure the health, safety, welfare and convenience of people in and around buildings, and the energy efficiency of buildings. The regulations apply to most new buildings and many alterations of existing buildings in England and Wales, whether new residential, commercial or industrial.

A.2.2 The development at Hatton Wall will be constructed to be compliant with Building Regulations which are current at the time of construction.

A.2.3 The development has been assessed for Part L compliance using approved Government Standard Assessment Procedures for Energy Rating of Dwellings/Building (SAP software) and SBEM for the non-residential part of the building.

A.3 REGIONAL POLICY

A.3.1 The London Plan (2011) is the Spatial Development Strategy for London. Section 5 of the Plan covers the mitigation of, and adaptation to climate change and the management of natural resources. The London Plan supports the Mayor's Energy Strategy. The key policies regarding energy efficiency are summarised below.

Policy 5.4 - Retrofitting

Strategic

A. The environmental impact of existing urban areas should be reduced through policies and programmes that bring existing buildings up to the Mayor's standards on sustainable design and construction. In particular, programmes should reduce carbon dioxide emissions, improve the efficiency or resource use (such as water) and minimise the generation of pollution and waste from the existing building stock.

LDF preparation

B. Within LDFs boroughs should develop policies and proposals regarding the sustainable retrofitting of existing buildings. In particular they should identify opportunities for reducing carbon dioxide emissions from the existing building stock by identifying potential synergies between new developments and existing buildings through the retrofitting of energy efficiency measures, decentralised energy and renewable energy opportunities (see policies 5.5 and 5.7)

Policy 5.6 - Decentralised Energy in Development Proposals

Planning decisions

A. Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites.

B. Major development proposals should select energy systems in accordance with the following hierarchy:

1. Connection to existing heating or cooling networks
2. Site wide CHP network
3. Communal heating and cooling.

C. Potential opportunities to meet the first priority in this hierarchy are outlined in the London Heat Map tool. Where future network opportunities are identified, proposals should be designed to connect to these networks.

Policy 5.7 - Renewable Energy

Strategic

A. The Mayor seeks to increase the proportion of energy generated from renewable sources, and expects that the projections for installed renewable energy capacity outlined in the Climate Change Mitigation and Energy Strategy and in supplementary planning guidance will be achieved in London.

Planning decisions

B. Within the framework of the energy hierarchy (see Policy 5.2), major development proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible.

A.3.2 Section 5.42 of the London Plan states that:

Individual development proposals will also help to achieve these targets by applying the energy hierarchy in Policy 5.2. There is a presumption that all major development proposals will seek to reduce carbon dioxide emissions by at least 20 per cent through the use of on-site renewable energy generation wherever feasible.

Policy 5.9 – Overheating and Cooling

Strategic

A. The Mayor seeks to reduce the impact of the urban heat island effect in London and encourages the design of places and spaces to avoid overheating and excessive heat generation, and to reduce overheating due to the impacts of climate change and the urban heat island effect on an area wide basis.

Planning decisions

B. Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

1. minimise internal heat generation through energy efficient design
2. reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls
3. manage the heat within the building through exposed internal thermal mass and high ceilings
4. passive ventilation
5. mechanical ventilation
6. active cooling systems (ensuring they are the lowest carbon options).

C. Major development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and also meet its cooling needs. New development in London should also be designed to avoid the need for energy intensive air conditioning systems as much as possible. Further details and guidance regarding overheating and cooling are outlined in the London Climate Change Adaptation Strategy.

A.4 LOCAL POLICY

A.4.1 Alongside the Mayor's London Plan, the London Borough of Camden has a number of policies dedicated to environmental protection and enhancement within their Core Strategy adopted January 2011.

Camden Core Strategy 2010-2025

Policy SC13: Tackling Climate change through promoting higher environmental standards

A.4.2 Policy CS13 of the Core Strategy addresses sustainable development and is particularly relevant to this Energy Strategy. The policy states, in part:

Reducing the effect of and adapting to climate change

The Council will require all developments to take measures to minimise the effects of, and adapt to climate change and encourage all development to meet the highest feasible environmental standards that are financially viable during construction and occupations:

a. Ensuring patterns of land use that minimise the need to travel by car and help support local energy networks;

b. Promoting the efficient use of land and buildings;

c. Minimising carbon emissions from the redevelopment, construction and occupation of building by implementing, in order, all of the elements of the following energy hierarchy:

   - Ensuring developments use less energy,
   - Making use of energy from efficient sources, such as the King's Cross, Gower Street, Bloomsbury and proposed Euston Road decentralised energy networks:
   - Generating renewable energy on-site; and

d. Ensuring buildings and spaces are designed to cope with, minimise the effects of, climate change

The Council will have regard to the cost of installing measures to tackle climate changes as well as the cumulative future cost of delaying reductions in carbon dioxide emissions.

Local energy generation

The Council will promote local energy generation and networks:

e. Working with our partner and developers to implement local energy networks in the parts of Camden most likely to support them ie. In the vicinity of

   - Housing estates with community heating or potential for community heating and other uses with large heating loads;

- The growth areas of King's Cross, Euston: Tottenham Court Road; West Hampstead Interchange and Holborn;
- School to be redeveloped as part of Building Schools for the Future programme:
- Existing or approved combined heat and power/local energy networks (see Map 4); and other locations where land ownership would facilitate their implementation.

f. Protecting exiting local energy networks where possible (e.g at Gower Street and Bloomsbury) and safeguarding potential network routes (e.g. Euston Road);

Water and surface water flooding

We will make Camden a water efficient borough and minimise the potential for surface water flooding by:

g. Protecting our exiting drinking water and foul water infrastructure, including Barrow Hill reservoir, Hampstead heath reservoir, Highgate Reservoir and Kidderpore Reservoir;

h. Making sure development incorporates efficient water and foul water infrastructure;

i. Requiring development to avoid harm to water environment, water quality or drainage systems and prevents or mitigates local surface water and down-stream flooding, especially in areas up-hill from, and in, areas known to be at risk from surface water flooding such as South and West Hampstead, Gospel Oak and King's Cross (see Map 5).

Camden's carbon reduction measures

The Council will take a lead in tackling climate change by;

j. Taking measures to reduce its own carbon emissions;

k. Trialling new energy efficient technologies, where feasible; and

l. Raising awareness on mitigation and adaption measures.

Camden Development Policies 2010-2025

Policy DP22: Promoting sustainable design and construction

A.4.3 Policy DP22 of the Development Policies addresses sustainable development and is particularly relevant to this Energy Strategy. The policy states, in part:

> Reducing the effects of and adapting to climate change
>
> The Council will require development to incorporate sustainable design and construction measures. Schemes must:
>
> a. Demonstrate how sustainable development principles, including the relevant measures set out in paragraph 22.5 below, have been incorporated into the design and proposed implementations; and
>
> b. Incorporate green or brown roofs and green walls wherever suitable.
>
> The Council will promote and measure sustainable design and construction by:
>
> c. expecting new build housing to meet Code for Sustainable Homes Level 3 by 2010 and Code Level 4 by 2013 and encourage Code Level 6 (zero carbon) by 2016);
>
> d. expecting developments (except new build) of 500 sq m of residential floorspace or above or 5 more dwellings to achieve “very good” in EcoHomes assessments prior to 2013 and encourage “excellent” from 2013;
>
> e. expecting non-domestic developments of 500sqm of floorspace or above to achieve “very good” in BREEAM assessment and “excellent” from 2016 and encouraging zero carbon 2019.
>
> The Council will require development to be resilient to climate change by ensuring schemes include appropriate climate change adaptions measures, such as:
>
> a. summer shading and planting;
>
> b. limited water consumption;
>
> c. reducing air pollution; and
>
> d. not locating vulnerable uses in basements in flood-prone areas.

Camden Planning Guidance CPG3, 4th September 2013

Policy DP22: Promoting sustainable design and construction

A.4.4 The Core Strategy is supported by Supplementary Planning Documents (SPDs) which play an important role in planning decisions. SPDs provide detailed guidance on how planning strategy and policies will be implemented for specific topics, areas and sites.

A.4.5 CPG3 contains advice and guidance for developers on ways to achieve carbon reductions and more sustainable developments. It also highlights the Council's requirements and guidelines which support the relevant Local LDF policies, including CS13 and DP22 as noted above.

A.4.6 All new developments are to be designed to minimise carbon dioxide emissions by being as energy efficient as feasible and viable.

A.4.7 Where the New London Plan carbon reduction target in policy 5.2 cannot be met onsite, we may accept the provision of measures elsewhere in the borough or financial contribution which will used to secure delivery of carbon reduction measures elsewhere. This process is known as carbon offsetting.

A.4.8 All development are to target at least a 20% reduction in carbon dioxide emissions through the installation of on-site renewable energy technologies. Special consideration will be given to heritage buildings and features to ensure that their historic and architecture features are preserved.

A.4.9 When assessing the feasibility and viability of renewable energy technology, the Council will consider the overall cost of all the measures proposed and resulting carbon savings to ensure that the most cost effective carbon reduction technologies are implemented in line with the energy hierarchy.

A.4.10 A new building build dwelling will have to be designed in line with the Code for Sustainable Homes and will be expected to achieve 50% of the un-weighted credits in Energy, Water and Materials categories.

Time Period	Code Rating
2013-2015	Level 4
2016+	Level 6 'zero carbon'

A.5 CODE FOR SUSTAINABLE HOMES (2014)

A.5.1 As of May 2014, alterations were made to the Code in order to bring it in line with regulatory and national guidance changes which have occurred recently, in particular the introduction of Part L 2013 Building Regulations and SAP 2012 methodology. Standards have not changed.

A.5.2 No alterations have been made to the format and layout of the Code. In addition, the weightings and number of credits available for each Code category remain unchanged.

A.5.3 The element of the Code that deals with the calculation of energy and carbon dioxide emissions is the first Issue – ENE 1: Dwelling Emission Rate.

A.5.4 Credits are awarded based on the percentage improvement of the DER score over the TER as calculated by the SAP Assessments. The required percentage improvement of DER over TER increases with each Code Level, as illustrated by Table 9 below.

Table 9: Mandatory requirements for ENE 1 – Dwelling Emission Rate

Criteria		
% Improvement 2013 DER/TER England[1]	Credits*[2]	Mandatory Requirements
≥ 6%	1	
≥ 12%	2	
≥ 19%	**3**	**Level 4**
≥ 32%	4	
≥ 44%	5	
≥ 56%	6	
≥ 70%	7	
≥ 84%	8	
≥ 100%	**9**	**Level 5**
Zero Net CO_2 Emissions	**10**	**Level 6**
Default Cases		
None		

*1 Performance requirements are equivalent to those in previous scheme versions but are now measured using the AD L1A 2013 England TER as the baseline.

*2 Up to nine credits are awarded on a sliding scale. The scale is based on increments of 0.1 credits, distributed equally between the benchmarks defined in this table.

A.5.5 The SAP worksheets indicating the DER are necessary evidence for the Code Assessment to prove that this criterion has been met.

A.5.6 Credits are also available within the Code standard for carbon emission reduction through the use of low or zero carbon technologies in the ENE 7 issue. There is 1 credit available for carrying out a 10% reduction and 2 credits available for a 15% reduction. Credits are awarded based on the percentage reduction in total carbon emissions that result from using Low or Zero Carbon (LZC) Energy Technologies.

A.5.7 The proposed development at Hatton Wall is a mixed use development: part residential and part commercial. In order to demonstrate the ability to achieve certification at the desired level, a separate Code pre-assessment has been prepared is found as an Appendix to the Sustainability Statement produced by Metropolis Green.

APPENDIX B – OTHER APPRAISED RENEWABLE TECHNOLOGIES

B.1 WIND TURBINES

B.1.1 Wind is one of the most cost-effective methods or generating renewable electricity. However wind is more suited to low density areas where there is more space necessary for maintenance, less turbulent wind patterns, and they are less likely to be the cause of noise and vibration to nearby properties. High density areas are not ideal with current wind turbine technology.

Feasibility

B.1.2 Installation of wind turbines is neither feasible nor suitable for Hatton Wall. There are a number of concerns with wind turbines in an urban environment including; visual impact, noise, cost, maintenance and space. Although calculations for the modelled systems indicate that wind systems contribute to carbon reductions, it must be noted that under dense urban environments the energy outputs generated by wind turbines can be quite unpredictable. This is mainly due to the neighbouring buildings acting as obstructions causing turbulence to the incoming wind flow. The site would need to be evaluated appropriately (over a period of 12 months) using wind speed monitoring & recording devices in order to give an accurate prediction in terms of energy output derived by the real wind speed measurements recorded on site.

B.1.3 In addition to these concerns, the actual energy output of any turbines installed is likely to be much lower than the modelled outputs due to turbulence created in the urban environment.

B.1.4 Wind turbines have a long lifetime with relatively little maintenance required, and when considering life cycle costs, even with the feed in tariff and energy savings considered they have a longer payback time than other renewable technologies.

B.1.5 Therefore, wind turbines have been determined to be unsuitable for the development at Hatton Wall.

B.2 BIOMASS HEATING

B.2.1 Wood is the most commonly used form of biomass fuel, and can either be burned in solid fuel boilers for central heating applications, or for raising steam for power generation in large installations.

B.2.2 Typically, biomass installations are sized to meet a base heat load with peak load and load variations to be met from gas-fired boilers. Biomass boilers operate most efficiently and are therefore most cost effective when working continuously at full load, they do not respond well to rapidly fluctuating demand. When assessing the feasibility of a biomass installation, storage space and biomass delivery requirements need to be taken into account.

Feasibility

B.2.3 Although the calculations typically show that a biomass boiler could provide a higher level of carbon reductions than gas boilers, the main operational concerns are raised in relation to air quality, storage capacity and logistics of parking for delivery of wood pellets/chips etc.

B.2.4 Air quality is another major concern with biomass heating due to NOx (Nitrogen Oxides) and Particulate Matter (PM10) emissions.

B.2.5 The entire London Borough of Camden is designated as an Air Quality Management Area (AQMA), with current technology, biomass fuelled boiler may negatively impact on air quality which is deemed inappropriate in an Air Quality Management Area unless abatement technology can provide sufficient mitigation.

B.2.6 Biomass systems also require space for storage and delivery of fuel. Additionally, fuel delivery carries implications for parking, increased emissions and pressure from transport. In the context of the current layout, there is insufficient space able to be allocated for the biomass storage facility.

B.2.7 When considering life cycle costs, there are higher maintenance requirements than other forms of renewable energy, fuel costs are predicted to rise and the value of net lettable space required for storage must be considered.

B.2.8 When considering noise impact, the impact of fuel deliveries must be considered, otherwise, the impact is similar to conventional plant.

B.2.9 Therefore, it is determined that a biomass heating solution cannot be practically implemented and is not suitable for the development at Hatton Wall.

B.3 SOLAR THERMAL

B.3.1 Solar Thermal hot water heating systems harvest energy from the sun to heat water. The solar heating collectors are generally positioned on the roof of a building, they can also be wall mounted, although with reduced efficiency. A fluid within the panels, heats up by absorbing solar radiation. The fluid is then used to heat up new water which is stored in a separate water cylinder.

B.3.2 As an alternative to PVs, implementing Solar Hot Water (SHW) can deliver carbon saving to new hot water generation for space heating as well as for new hot water production.

Feasibility

B.3.3 Solar thermal water heating is a feasible solution for the development at Hatton Wall, however there is not space available that would be needed for hot water storage in the Pocket apartment layout and although solar thermal is a very efficient technology, it does not offset carbon emissions to the same extent as

PV as it offsets mains gas, which has lower carbon emissions than mains electricity, therefore PV is the preferred solar technology.

B.4 GROUND SOURCE HEAT PUMP (GSHP)

B.4.1 In the UK, soil temperatures stay at a constant temperature of around 11-12°C, throughout the year. Ground source heat pumps take this low temperature energy and concentrate it into more useful, higher temperatures, to provide space heating and water heating. The process is similar to that used in refrigerators. A fluid is circulated through pipes in the ground absorbing the heat from the soil, the fluid is passed through a heat exchanger in the pump which extracts the heat from the fluid and increases it via a compression cycle. This is then used to provide heating and heat new hot water.

Feasibility

B.4.2 It has been determined that connection to existing or installation of new Ground Source Heat Pump plant is not a feasible option for the Wall scheme. This is due to the large area required for boreholes exterior to the building.

B.4.3 Installation of a GSHP is one of the most costly options for this site and would require further detailed analysis of conflicts with existing systems, ground conditions and soil conductivity before determining whether or not the required levels of carbon savings could be achieved.

B.4.4 Land use, plant space and physical security for the ground collectors and the heat pump units also need to be taken into consideration. For horizontal collector systems, a potentially large area is required for the collector pipework. This area should be free of trees which will cause problems for installation of the pipework. It can be beneath the building but it is most effective in an open area. For borehole or vertical collectors, land requirements are reduced but still significant as the boreholes must be a minimum of five metres apart.

B.4.5 Noise impact of heat pumps is considered to be negligible although concerns have been raised where older systems are poorly maintained and become noisy.

B.4.6 Taking all of these considerations into account, it is judged that GSHP is not a suitable or affordable technology for Hatton Wall.

APPENDIX C – CALCULATION RESULTS

Notional Baseline

Residential														Electricity Offset	SAP 2012		Baseline CO_2 Emissions	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	Code Ene 7		% Improvement DER over TER
Floor	Unit	Dwelling Type	Floor area (m^2)	FEE ($kWh/m^2/yr$)	Space Heating from Boiler (Main 1) (kWh/an)	Space Heating (Main 2) (kWh/an)	Space Heating (Secondary) (kWh/an)	DHW from Boiler (kWh/an)	Cooling (kWh/an)	Lighting (kWh/an)	Aux (kWh/an)	Occupants	Un-Reg (kWh/an)	kWh/annum	TER	DER	$kgCO_2$/annum	$kgCO_2$/annum	$kgCO_2$/annum	Standard case emissions	Actual case emissions	
	Flat 1	Apt, mid tce	74	52.71	2,990			2,327	345	325	30		2,695	0	21.08	20.03	1,560	1,482	1,399			5.0%
	Flat 2	Apt, mid tce	70	38.58	1,930			2,288	227	311	30		2,586	0	18.07	17.52	1,265	1,226	1,342			3.0%
	Flat 3	Apt, mid tce	78	39.46	2,119			2,397	332	339	30		2,799	0	16.8	16.95	1,310	1,322	1,452			-0.9%
	Flat 4	Apt, mid tce	81	53.5	3,486			2,403	162	349	30		2,873	0	20.47	20.31	1,658	1,645	1,491			0.8%
	Flat 5	Apt, mid tce	51.5	63.58	2,572			1,952	212	238	30		2,035	0	22.46	24.09	1,157	1,241	1,056			-7.3%
	Flat 6	Apt, mid tce	57.2	62.24	2,813			2,053	205	261	30		2,211	0	21.91	23.37	1,253	1,337	1,147			-6.7%
	Flat 7	Apt, mid tce	140	49.82	5,599			2,626	529	487	30		3,897	0	16.73	16.32	2,342	2,285	2,023			2.5%
Total / Average	**55**		**551.7**	**50.43**	**21,508**	**0**	**0**	**16,047**	**2,012**	**2,309**	**210**	**0**	**19,095**	**0**	**19.11**	**19.10**	**10,545**	**10,538**	**9,910**	**0.00**	**0.00**	**0.1%**

Non-Residential													Electricity Offset	SBEM 2013		Baseline CO_2 Emissions	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	% Improvement BER over TER	% Improvement BER over TER
Floor	Description	Floor area (m2)	HLP	Space Heating (Main) (kWh/an)	Space Heating (Main 2) (kWh/an)	Space Heating (Secondary) (kWh/an)	DHW (kWh/an)	Cooling (SBEM) (kWh/an)	Lighting (kWh/an)	Aux (kWh/an)		Un-Reg (kWh/an)	kWh.annum	TER	BER	$kgCO_2$/annum	$kgCO_2$/annum	$kgCO_2$/annum		
	Non-residential	2621.54		17,976			39,904	14,590	52,774	13,746		103,120		20.87	20.83	54,718	54,598	53,519	0.2%	0.2%
Total / Average		2621.54		**17,976**	**0**	**0**	**39,904**	**14,590**	**52,774**	**13,746**		**103,120**	**0**	**20.87**	**20.83**	**54,718**	**54,598**	**53,519**	**0.2%**	**0.2%**

Efficient Baseline

Residential														SAP 2012		Baseline CO_2 Emissions	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	Code 2010 Ene 7		% Improvement DER over TER
Floor	Unit	Dwelling Type	Floor area (m^2)	FEE ($kWh/m^2/yr$)	Space Heating from Boiler (Main 1) (kWh/an)	Space Heating (Main 2) (kWh/an)	Space Heating (Secondary) (kWh/an)	DHW from Boiler (kWh/an)	Cooling (kWh/an)	Lighting (kWh/an)	Aux (kWh/an)	Occupants	Un-Reg (kWh/an)	TER	DER	$kgCO_2$/annum	$kgCO_2$/annum	$kgCO_2$/annum	Standard case emissions	Actual case emissions	
	Flat 1	Apt, mid tce	74	45.57	2,502			2,337	374	325	75		2,695	21.08	18.95	1,560	1,402	1,399			10.1%
	Flat 2	Apt, mid tce	70	34.16	1,660			2,296	244	311	75		2,586	18.07	17.03	1,265	1,192	1,342			5.8%
	Flat 3	Apt, mid tce	78	37.29	1,999			2,400	342	339	75		2,799	16.8	16.93	1,310	1,321	1,452			-0.8%
	Flat 4	Apt, mid tce	81	47.54	3,052			2,410	182	349	75		2,873	20.47	19.47	1,658	1,577	1,491			4.9%
	Flat 5	Apt, mid tce	51.5	58.97	2,373			1,956	224	238	75		2,035	22.46	23.75	1,157	1,223	1,056			-5.7%
	Flat 6	Apt, mid tce	57.2	55.36	2,509			2,058	223	261	75		2,211	21.91	22.68	1,253	1,297	1,147			-3.5%
	Flat 7	Apt, mid tce	140	42.89	4,677			2,637	582	487	75		3,897	16.73	15.09	2,342	2,113	2,023			9.8%
Total / Average	**54**	Apt, mid tce	**551.7**	**44.83**	**18,774**	**0**	**0**	**16,093**	**2,173**	**2,309**	**525**	**0**	**19,095**	**19.11**	**18.35**	**10,545**	**10,125**	**9,910**	**0.00**	**0.00**	**4.0%**

Non-Residential													SBEM 2013		Baseline CO_2 Emissions	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	% Improvement BER over TER	% Improvement BER over TER
Floor	Description	Floor area (m2)	HLP	Space Heating (Main) (kWh/an)	Space Heating (Main 2) (kWh/an)	Space Heating (Secondary) (kWh/an)	DHW (kWh/an)	Cooling (SBEM) (kWh/an)	Lighting (kWh/an)	Aux (kWh/an)		Un-Reg (kWh/an)	TER	BER	$kgCO_2$/annum	$kgCO_2$/annum	$kgCO_2$/annum		
	Non-residential	2621.54		19,617			39,904	13,375	39,343	13,746		103,120	**20.87**	**18.06**	**54,718**	**47,351**	**53,519**	13.5%	13.5%
Total / Average		2621.54		**19,617**	**0**	**0**	**39,904**	**13,375**	**39,343**	**13,746**		**103,120**	**20.87**	**18.06**	**54,718**	**47,351**	**53,519**	**13.46%**	13.5%

Renewables Baseline

Residential														PVs		SAP 2009		Baseline CO₂ Emissions	Regulated CO₂ Emissions	Unregulated CO₂ Emissions	Code 2014 Ene 7		% Improvement DER over TER	% Improvement over Standard Case SAP
Floor	Unit	Dwelling Type	Floor area (m^2)	FEE ($kWh/m^2/yr$)	Space Heating from Boiler (Main 1) (kWh/an)	Space Heating (Main 2) (kWh/an)	Space Heating (Secondary) (kWh/an)	DHW from Boiler (kWh/an)	Cooling (kWh/an)	Lighting (kWh/an)	Aux (kWh/an)	Occupants	Un-Reg (kWh/an)	PVs kWp	PVs Energy Offset	TER	DER	$kgCO_2$/annum	$kgCO_2$/annum	$kgCO_2$/annum	Standard case emissions	Actual case emissions		
	Flat 1	Apt, mid tce	74	45.6	629	0	0	1,172	0	325	0		2,695	0.536	-462.89	30.81	13.22	**2,280**	**979**	**1,399**	39.34	32.12	57.1%	18.3%
	Flat 2	Apt, mid tce	70	34.2	497	0	0	1,152	0	311	0		2,586	0.507	-437.87	26.23	12.95	**1,836**	**907**	**1,342**	37.61	32.13	50.6%	14.6%
	Flat 3	Apt, mid tce	78	37.3	520	0	0	1,191	0	339	0		2,799	0.565	-487.91	24.21	11.93	**1,888**	**931**	**1,452**	36.81	30.55	50.7%	17.0%
	Flat 4	Apt, mid tce	81	47.5	779	0	0	1,203	0	349	0		2,873	0.587	-506.68	29.79	13.24	**2,413**	**1,073**	**1,491**	39.07	31.65	55.5%	19.0%
	Flat 5	Apt, mid tce	51.5	59.0	772	0	0	1,041	0	238	0		2,035	0.373	-322.15	33.13	19.61	**1,706**	**1,010**	**1,056**	46.50	40.12	40.8%	13.7%
	Flat 6	Apt, mid tce	57.2	55.4	770	0	0	1,077	0	261	0		2,211	0.414	-357.80	32.17	17.92	**1,840**	**1,025**	**1,147**	44.69	37.98	44.3%	15.0%
	Flat 7	Apt, mid tce	140	42.9	1,141	0	0	1,297	0	487	0		3,897	1.014	-875.74	24.44	8.87	**3,422**	**1,242**	**2,023**	30.32	23.32	63.7%	23.1%
Total / Average		Apt, mid tce	**551.7**	**44.8**	**5,107.2**	**0**	**0**	**8,134**	**0**	**2,309**	**0**	**0**	**19,094.9**	**4.00**	**-3,451**	**27.89**	**12.99**	**15,385**	**7,166**	**9,910**	**38**	**30.95**	**53.4%**	**17.8%**

Non-Residential													PVs		SBEM 2013		Baseline CO₂ Emissions	Regulated CO₂ Emissions	Unregulated CO₂ Emissions	% Improvement BER over TER	% Improvement BER over TER
Floor	Description	Floor area (m2)	HLP	Space Heating (Main) (kWh/an)	Space Heating (Main 2) (kWh/an)	Space Heating (Secondary) (kWh/an)	DHW (kWh/an)	Cooling (SBEM) (kWh/an)	Lighting (kWh/an)	Aux (kWh/an)		Un-Reg (kWh/an)	PVs (kWp)	PVs Energy Offset	TER	BER	$kgCO_2$/annum	$kgCO_2$/annum	$kgCO_2$/annum		
	Non-residential	2621.54		3,728			12,636	13,375	39,343	13,746		103,120	0	0.00	**19.89**	**16.40**	**52,131**	**42,988**	**53,519**	17.5%	17.5%
Total / Average		2621.54		**3,728**	**0**	**0**	**12,636**	**13,375**	**39,343**	**13,746**		**103,120**	**0**	**0**	**19.89**	**16.40**	**52,131**	**42,988**	**53,519**	**17.5%**	**17.5%**