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Energy Strategy

Willingham Terrace
Camden

On behalf of
Pocket Living

30/10/2013
Job Ref: 5225

Produced By	Position	Date
Vitaliy Troyan	Sustainability and Energy Consultant, Accredited SAP Assessor	30/10/2013
Avril Wheeler	Graduate Sustainability and Energy Assistant	

Approved By	Position	
Miranda Pennington	Partner, Licensed BREEAM, Code for Sustainable Homes and EcoHomes Assessor	30/10/2013

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metropolis green

Metropolis Green

4 Underwood Row
London N1 7LQ
T: 020 7324 2662
F: 020 7324 2663
E: info@metropolispd.com

Contacts:
Miranda Pennington Partner
Shaun Kelly Associate Partner

Metropolis Green LLP
Company No. OC331434

Planning

EXECUTIVE SUMMARY

I. This Energy Strategy has been prepared by Metropolis Green to accompany the planning application submitted to the London Borough of Camden by Pocket Living for the proposed development at Willingham Terrace.

II. This report has been prepared in line with the London Plan and London Borough of Camden Policy requirements, and follows the Mayor's 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 Willingham Terrace.

III. All energy and carbon figures have been calculated using Standard Assessment Procedure (SAP) 2009, which is used to demonstrate compliance with Building Regulations 2000, Approved Documents Part L 2010 edition and Code for Sustainable Homes requirements.

IV. The energy performance demonstrated in this report showed that the site can achieve a 43.8% total overall carbon reduction, with an average Dwelling Emission Rate (DER) over Target Emission Rate (TER) improvement of 40.8%. These achievements meet London Plan Policy 5.4 and London Borough of Camden Policy S7 for a 40% regulated carbon emission reduction improvement on 2010 Building Regulations. The DER/TER improvement achieved also exceeds the mandatory energy requirements of Code for Sustainable Homes Level 4, in line with London Borough of Camden Policy DP22 sustainable design standards.

V. London Plan Policy 5.7 and London Borough of Camden Policies SC13 and CPG3 target a 20% reduction in CO_2 emissions through the specification of on-site renewable technologies. Site analysis and calculations have determined photovoltaics (PVs) to be the most suitable renewable energy technology. A 32.8% carbon reduction has been shown to be achieved in this energy strategy through the specification of on-site PVs, exceeding policy requirements.

VI. The achievements demonstrated in this report are the result of the improvement of fabric and services to high energy efficiency standards, high efficiency gas boilers for the provision of space heating and domestic hot water (DHW), along with the specification of roof mounted PV panels and incorporation of passive design measures.

VII. Figures 1-3 below show an 'at a glance' summary of the 'Be Lean, Be Clean and Be Green' CO_2 reductions for the modelled solutions. A more detailed breakdown of emissions by category stage and emissions reductions for each stage of the 'energy hierarchy' can be found on page 37.

Figure 1: Regulated Carbon Emission Reductions

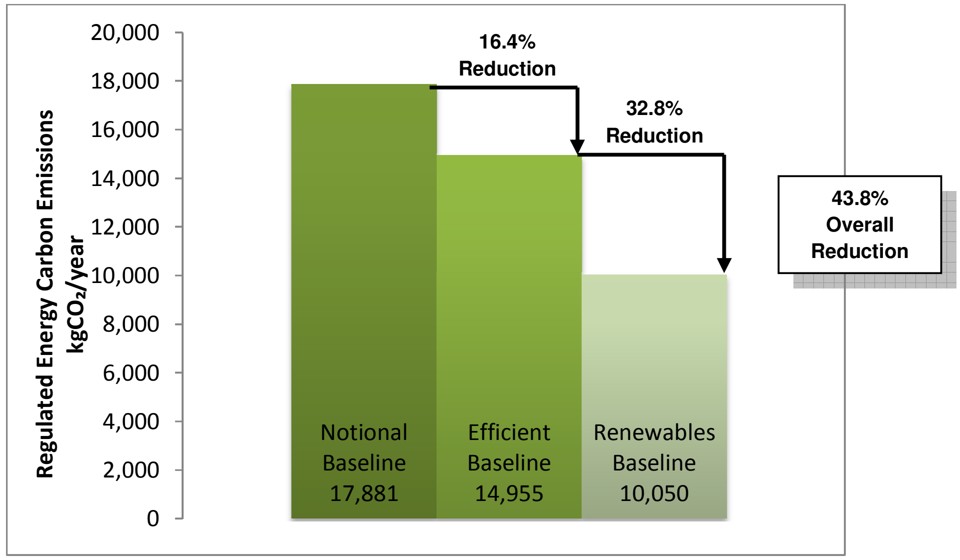


Figure 2: DER over TER improvement of the development

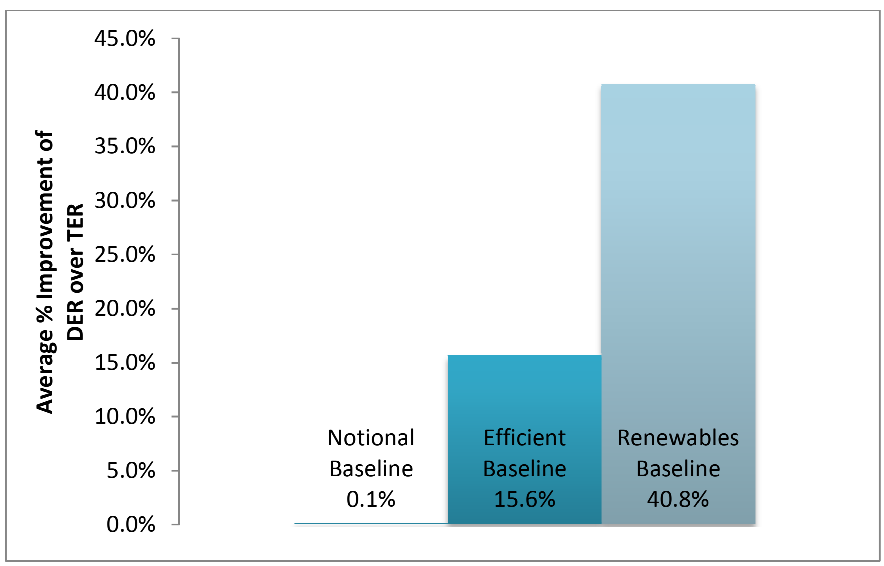
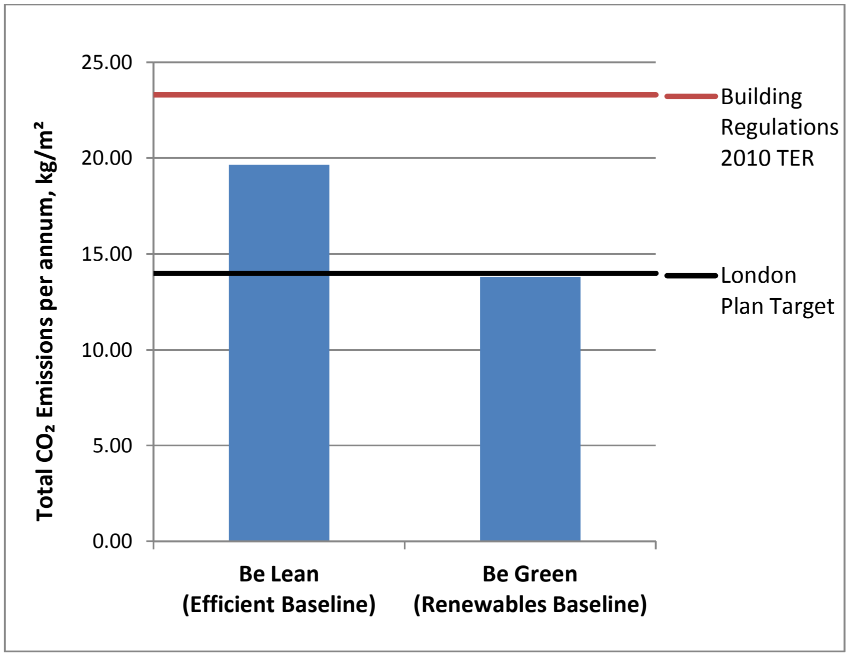


Figure 3: The Energy Hierarchy (Be Lean, Be Clean, Be Green) – DER



CONTENTS

1.0 INTRODUCTION AND DEVELOPMENT DESCRIPTION

1.1. This Energy Strategy has been prepared by Metropolis Green on behalf of Pocket Living to accompany the planning application for the proposed development at Willingham Terrace, in London Borough of Camden. This report demonstrates how the relevant planning policies with respect to energy will be achieved.

1.2. The developer, Pocket Living is a private company that specialises in developing affordable homes for first time buyers close to central London.

1.3. The application submission is for 22 no. one bed units in a 3-4 storey block with one staircase and a combination of internal and deck access circulation. The proposed building sits as two blocks separated by the core circulation zone.

1.4. The proposed development is located at Willingham Terrace, off Leighton Road in Camden. The site backs onto the rear gardens of 3-4 storey terraces to the north, east and south.

1.5. This Energy Strategy has been developed to ensure that the following key planning policies can be achieved and where these targets have not been met in full, justification has been provided:

- London Plan Policy 5.2 and London Borough of Camden Policy S7 requirements to achieve a 40% regulation carbon reduction improvement on 2010 Building Regulations.
- Investigation of decentralised energy use on site, in line with London Plan Policy 5.6 and London Borough of Camden Borough Policy CS13.
- London Plan Policy 5.7 and London Borough of Camden Policy SC13 and CPG3 requirements to achieve 20% carbon reduction through the specification of on-site renewable energy.
- Achievement of Code for Sustainable Homes Level 4 in line with London Borough of Camden Policy DP22 expected standards.

1.6. This report assesses the energy efficiency measures of the proposed scheme and the low carbon options for supplying energy to the site before examining the potential for renewable energy technologies to reduce carbon emissions of the development.

2.0 POLICY CONTEXT

2.0.1 The proposed development at Willingham Terrace must comply with a number of policies and regulations listed below, which require the calculation of energy demand and carbon emissions. The calculation of energy demand and carbon emissions for each of the policies/standards is slightly different; this is discussed in the following sections.

- Building Regulations
- Code for Sustainable Homes 2010
- London Plan and London Borough of Camden Policies

2.0.2 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 European Union (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.

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

2.1 NATIONAL POLICY

National Planning Policy Framework, March 2012

2.1.1 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.

2.1.2 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.

2.1.3 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 SDCS. 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);

2.1.4 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.

2.1.5 Meeting the challenge of climate change is addressed in section 10 of the NPPF, and paragraph 93 notes that 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.

2.1.6 Further to the above, paragraph 95 and 96

> 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.
>
> 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.

2.1.7 Paragraph 97 addresses renewable and low carbon energy and states:

> To help increase the use and supply of renewable and low carbon energy, local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:
>
> - have a positive strategy to promote energy from renewable and low carbon sources;
> - design their policies to maximise renewable and low carbon energy development while ensuring that adverse impacts are addressed satisfactorily, including cumulative landscape and visual impacts;
> - consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources;
> - support community-led initiatives for renewable and low carbon energy, including developments outside such areas being taken forward through neighbourhood planning; and
> - identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

2.1.8 Additionally paragraph 98 states that when determining planning applications, local planning authorities should:

> - not require applicants for energy development to demonstrate the overall need for renewable or low carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and
> - approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should also expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas.

2.2 BUILDING REGULATIONS

2.2.1 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.

2.2.2 The development at Willingham Terrace will be constructed to be compliant with Building Regulations which are current at the time of construction. Deregulatory changes to the current 2010 building regulations are expected in October 2013 and to come into force in April 2014. The relevant Approved Documents Part L1A “Conservation of fuel and power in new dwellings” provide guidance on ways of complying with the energy efficiency requirements.

2.2.3 The development has been assessed for Part L compliance using approved Government Standard Assessment Procedures for Energy Rating of Dwellings (SAP 2009).

2.3 LOCAL POLICY

2.3.1 Alongside the Mayor’s London Plan, London Borough of Camden has a number of policies dedicated to environmental protection and enhancement within their Core Strategy (CS), development policies and supplementary planning documents (SPDs).

London Borough Camden Borough, Camden Core Strategy 2010-2025, adopted November 2010

Policy CS13: Tackling climate change through promoting higher environmental standards

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

> **Reducing the effects of and adapting to climate change**
>
> The Council will require all development 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 occupation by:
>
> 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 buildings by implementing, in order, all of the elements of the following energy hierarchy:

1. ensuring developments use less energy,

2. making use of energy from efficient sources, such as the King’s Cross, Gower Street, Bloomsbury and proposed Euston Road decentralized energy networks;

3. generating renewable energy on-site; and

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

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

Local Energy Generation

The Council will promote local energy generation and networks by:

e) working with our partners and developers to implement local energy networks in the parts of Camden most likely to support them, i.e. in the vicinity of:

– housing estates with community heating or the 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;

– schools to be redeveloped as part of Building Schools for the Future programme;

– existing or approved combined heat and power/local energy networks;

and other locations where land ownership would facilitate their implementation.

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

London Borough of Camden, Camden Development Policies 2010-2025, adopted November 2010

Policy DP22: Promoting Sustainable Design and Construction

2.3.3 Policy DP22 of the Unitary Development Plan addresses sustainable assessments for proposed developments and states:

> 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 below, have been incorporated into the design and proposed implementation; 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 encouraging Code Level 6 (zero carbon) by 2016.;
>
> d) expecting developments (except new build) of 500 sq m of residential floorspace or above or 5 or more dwellings to achieve “very good” in EcoHomes assessments prior to 2013 and encouraging “excellent” from 2013;
>
> e) expecting non-domestic developments of 500sqm of floorspace or above to achieve “very good” in BREEAM assessments and “excellent” from 2016 and encouraging zero carbon from 2019.

London Borough of Camden Borough, Camden Planning Guidance, adopted September 2013

2.3.4 The Camden Planning Guidance CPG document is intended to: provide guidance to developers, on ways of meeting local planning policies aimed at securing more sustainable development in Camden.

CPG3: Sustainability

Renewable Energy:

All developments are to target at least a 20% reduction in carbon dioxide emissions through the installation of on-site renewable energy technologies.

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.

2.4 CODE FOR SUSTAINABLE HOMES (NOVEMBER 2010)

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

2.4.2 Credits are awarded based on the percentage improvement of the DER score over the TER as calculated by the SAP Assessments.

2.4.3 The required percentage improvement of DER over TER increases with each Code Level, as illustrated by Table 1 below. It should be noted that Part L compliance 2010 is roughly equivalent to an improvement of 25% over Part L compliance 2006

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

Criteria		
% Improvement 2010 DER/TER*1	Credits*2	Mandatory Requirements
≥ 8%	1	
≥ 16%	2	
≥ 25%	**3**	**Level 4**
≥ 36%	4	
≥ 47%	5	
≥ 59%	6	
≥ 72%	7	
≥ 85%	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 2010 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.

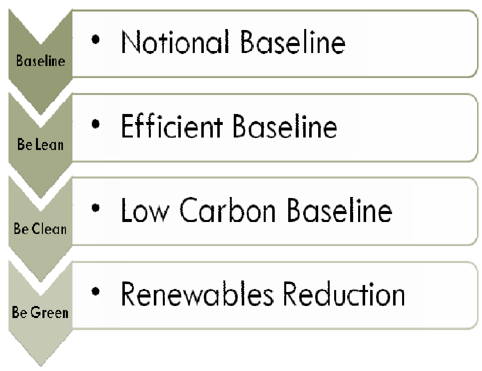
2.4.4 The SAP worksheets indicating the DER are necessary evidence for the Code Assessment to prove that this criterion has been met.

2.4.5 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.

3.0 METHODOLOGY

3.0.1. This document has been prepared in line with *GLA Guidance on preparing energy Assessments* (GLA, Sept 2011), the methodology that has been applied to this energy strategy is in line with the Mayor's energy hierarchy of Be Lean and use energy efficiently, Be Clean and supply low carbon energy efficiently and Be Green and produce renewable energy. This is illustrated in Figure 4 below.

Figure 4: Energy Hierarchy



3.0.2. The Notional Baseline and associated carbon emissions for the proposed development at Willingham Terrace have been calculated using SAP, the approved national calculation methodologies for the purpose of compliance with Building Regulations Part 1A for domestic buildings.

3.0.3. The Mayor's energy hierarchy requires that energy efficiency should be maximised in the first instance. Energy efficiency of buildings can be improved by increasing the levels of insulation and air-tightness in order to reduce heat losses; the Building Regulations specify minimum standards in this respect. A range of options have been considered including high thermal performance fabric and high efficiency heating equipment, which combined reduce energy demand and carbon emissions of the development. From this a new energy consumption and carbon baseline is calculated and referred to as the Efficient Baseline.

3.0.4. The energy hierarchy methodology, London Plan and London Borough of Camden require that all new developments consider decentralised energy generation technology and communal heating systems. CHP, communal heating and hot water systems are examined in terms of their suitability for the site, the impact of these technologies is assessed and a new baseline calculated which reduces the CO_2 emissions of the Efficient Baseline further and it is referred to as the Low Carbon Baseline.

3.0.5. The reduction in carbon emissions from on-site renewables must then be investigated. This includes a feasibility appraisal of each of the approved renewable energy technologies in terms of their contribution to meeting the carbon reduction. The most feasible and suitable technology is applied and carbon emissions reduction calculated, this is referred to as the Renewables Baseline.

3.0.6. 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 & NOTIONAL BASELINE

4.0.1 The London Plan promotes a ‘whole energy’ approach to calculating the energy demand and carbon baseline of the development. The whole energy includes the regulated energy consumed in the operation of the space heating/cooling, hot water systems, ventilation, all internal lighting and unregulated energy of cooling and electrical appliances.

4.0.2 The development at Willingham Terrace has been modelled to comply with the current Approved Document Part L1B (2010 edition) Building Regulations 2000 and Metropolis Green has determined the energy and carbon data using approved SAP software. Full detailed results are provided in Appendix B of this report.

4.0.3 Table 2 below provides a breakdown of the energy demand for the development. The Notional Baseline represents a Part L compliant building using the minimal allowable systems, fabric efficiency required for compliance and is shown graphically in Table 2 below. The input parameters used can be ground in Table 3.

4.0.4 At this stage, no energy efficiency measures have been applied to this baseline. Improving the energy performance of the building is the next step, detailed in Section 5.0.

Table 2: Predicted Notional Baseline

Notional Baseline	
Space Heating Energy kWh/yr	26,398
DHW Energy kWh/yr	38,819
Cooling kWh/yr	0
Lighting Energy kWh/yr	5,100
Aux Energy kWh/yr	4,510
Un-Reg Energy kWh/yr	36,372
Regulated Carbon Emissions $kgCO_2/yr$	**17,881**
DER over TER Improvement	0.01%

Figure 5: The Energy Hierarchy – Predicted Notional Baseline

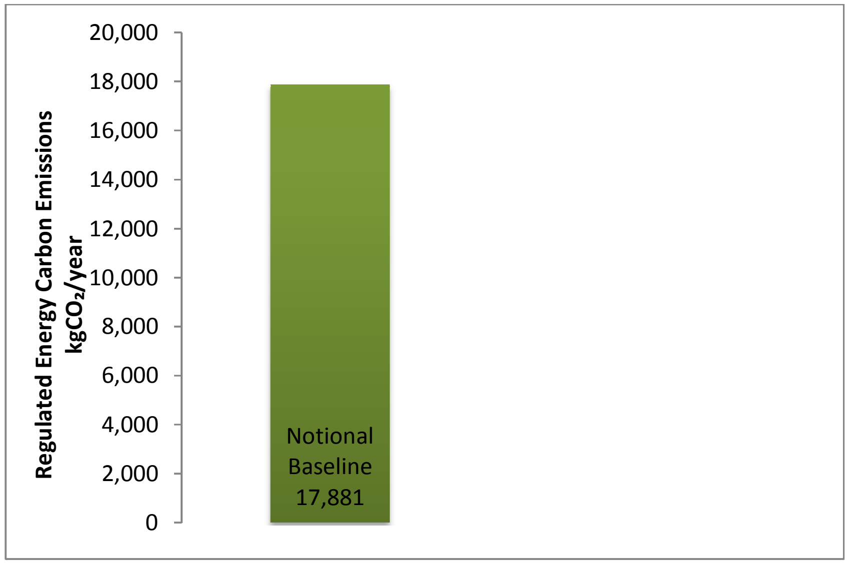
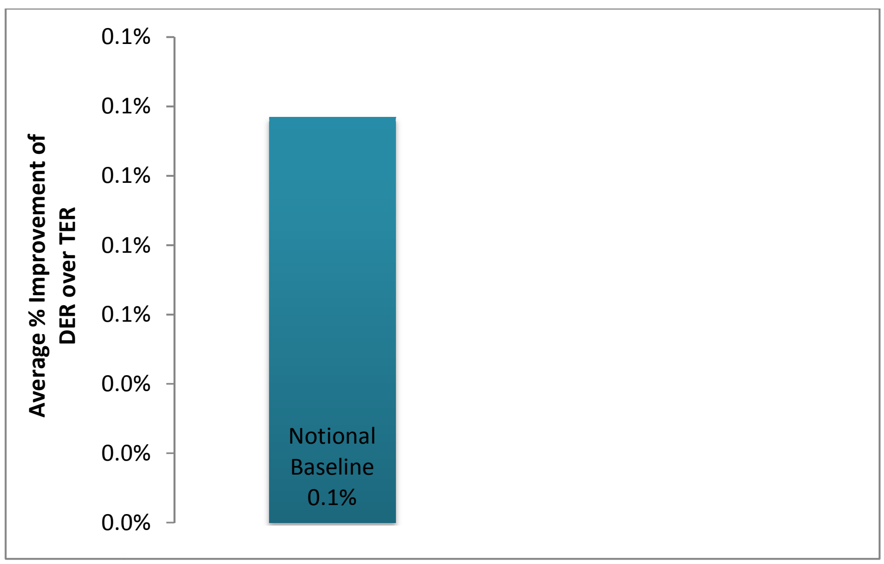


Figure 6: DER over TER improvement of the development



5.0 BE LEAN – ENERGY EFFICIENCY MEASURES

5.0.1 The first stage in the energy hierarchy is to determine the improvement in the energy performance of the building based on fabric and services specifications with improved energy efficiency.

5.0.2 Metropolis Green has been working with the project architects, HTA Design to determine the most efficient and feasible way to reduce the carbon emissions of the development.

5.0.3 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.

5.0.4 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.

5.0.5 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

5.0.6 Improving the fabric and services efficiency is the most effective way of reducing carbon emissions as these measures will last the lifetime of the building. Reducing the Notional Baseline in turn reduces the amount of low carbon and renewable energy technologies required to comply with regulations and policies, as well as lowering costs.

5.0.7 The U-values and input parameters that have been used to achieve the optimum improvement for the Efficient Baseline are shown in Table 3 below.

Table 3: Summary of Input Parameters for Notional and Efficient Baselines

	Notional Baseline	Efficient Baseline
External Wall U-value	0.23	0.16
Internal Heat Loss Wall U-value	0.21	0.21
Party-Wall U-value	0	0
Ground Floor / Basement Floor U-value	0.18	0.12
Roof U-value	0.17	0.13
Windows & Openings U-values	0.20	1.20
Building Regulations 2010 Accredited construction details	Yes (y-value=0.10)	Yes (y-value=0.10)
Thermal Mass Parameter	Medium (250 kJ/m2K)	Medium (250 kJ/m2K)
Air Permeability	5	5
DHW System	Instantaneous, gas combi boiler	Instantaneous, gas combi boiler
Water Consumption	125 litres per person per day or less	125 litres per person per day or less
Space Heating System	Gas combi boiler, efficiency 88%, time and temperature zone control	Gas combi boiler Vaillant EcoTec plus 824 (or similar), time and temperature zone control, weather compensator
Ventilation System	Mechanical extract ventilation, Vent Axia Sentinel Multivent (or similar)	Mechanical extract ventilation, Vent Axia Sentinel Multivent (or similar)
Energy Efficient Lighting	75%	100%

5.0.8 Thermal bridging will be minimised in accordance with Accredited Construction Details and air permeability of 5 m^3/hour/m^2 at 50Pa is to be achieved.

5.0.9 Fabric elements thermal performance for the development will be improved beyond the limiting parameters specified in Part L through use of high thermal performance insulation and low u-value double glazing. Thus, improving overall fabric efficiency and reducing carbon emissions for the development.

5.0.10 Further energy efficiency measures are also to be applied to space heating and hot water generation utilising high efficient Vaillant EcoTec Plus 824 (or similar) gas boilers fitted with flue gas heat recovery system (FGHRS) for domestic hot water and space heating. The FGHRS recovers waste heat from the boilers flue gases and uses it to preheat the boiler cold incoming water; thus less energy is needed to heat the water to the required temperature. Additional heating system control features were also included in modelling, such as zone controls, boiler interlock and weather compensation.

5.0.11 To ensure improved energy efficiency and maintain adequate air quality throughout the building it proposed that mechanical ventilation via a highly efficient mechanical extract ventilation system (MEV) has been specified for all apartments.

5.0.12 The design team have committed to going beyond the minimum low energy lighting requirements outlined in Domestic Building Services Compliance Guide and will specify 100% low energy space lighting for the development.

5.0.13 As a result of the measures and improvements listed above, a new energy demand and carbon baseline has been calculated from the Notional Baseline and is referred to as the Efficient Baseline. These results are detailed in Table 4 below.

5.0.14 This new Efficient Baseline completes the first stage of the energy hierarchy, to be lean and use energy efficiently, as illustrated in Figure 7 below.

Energy and CO_2 Reductions

5.0.15 The predicted regulated CO_2 reduction measured from the Notional Baseline and delivered through the efficiency measures equates to 2,927kgCO_2/year, or a 16.4% reduction.

5.0.16 Based on SAP 2009 calculations the improvement of DER over TER at the development has increased from the Notional Baseline to 15.6%. (illustrated in Figure 8)

Table 4: Efficient Baseline Energy and Carbon Emissions

Efficient Baseline	
Space Heating Energy kWh/yr	23,199
DHW Energy kWh/yr	29,903
Cooling kWh/yr	0
Lighting Energy kWh/yr	4,079
Aux Energy kWh/yr	4,510
Un-Reg Energy kWh/yr	36,372
Regulated Carbon Emissions $kgCO_2/yr$	**14,955**
% Improvement over Notional Baseline	16.4%
DER over TER Improvement	15.6%

Figure 7: Be Lean – 0Efficient Baseline

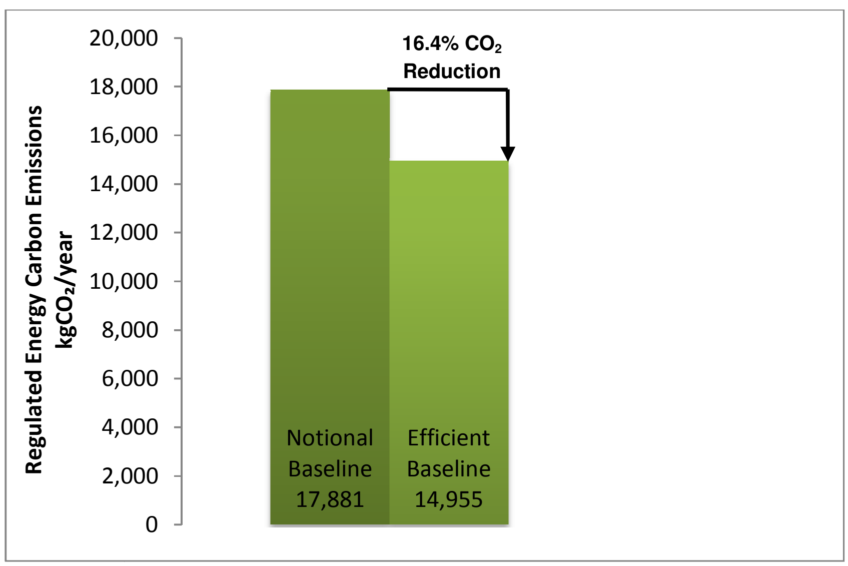
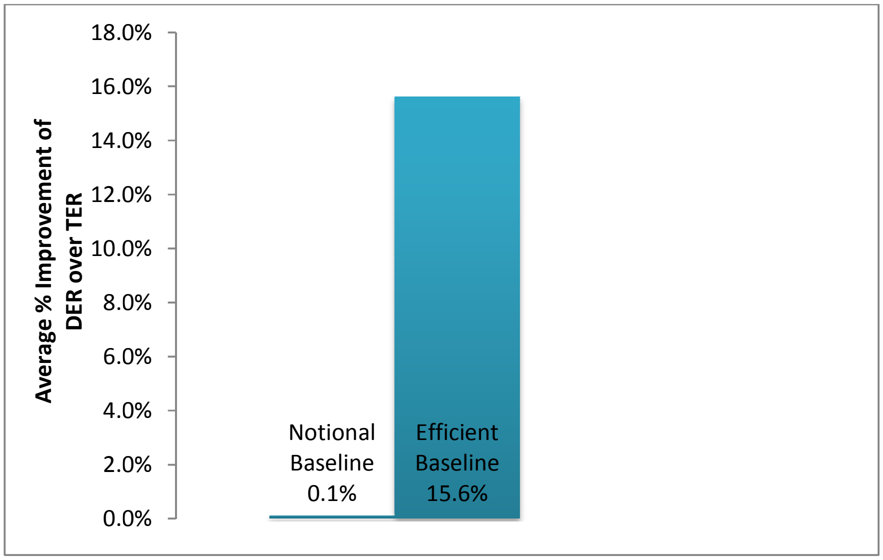


Figure 8: DER over TER improvement of the development



5.1. OVERHEATING AND COOLING

5.1.1 The design team have worked to ensure that the risk of summer overheating is minimised, prevent the need for mechanical ventilation systems in the development in line with the ‘cooling hierarchy’ and London Plan Policy 5.9. This is demonstrated through the application of passive design measures for the development.

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

5.1.3 Full floor to ceiling windows providing good natural daylight within the development at Willingham Terrace for a healthier, more pleasant environment and reduces the building electricity use for lighting. This improves the development’s carbon footprint.

5.1.4 In consideration of the building’s orientation and the site seasonal sun paths, the design of the building’s rear east elevation lightweight timber slat screens and windowless south elevation provides protection from excessive solar gains, reducing the summer overheating risk for the development.

5.1.5 The internal heat generation has been further minimised through a combination of high levels of air-tightness and energy efficient design, with high levels of fabric performance and insulation.

5.1.6 Natural ventilation and cooling is also provided to the apartments via openable windows allowing occupants to regulate and control the internal temperatures. Studies have shown that the ability to open windows enables occupants to cope with a wider range of temperatures, thus reducing reliance on mechanical systems. The careful design of spaces through room layout and shallow floor plans helps aids air flows for natural ventilation.

5.1.7 Following London Borough of Camden Policy DP22, the design elements of the (partial) brown roof and private gardens also play a role in providing natural cooling to the development. The green roof shades the building below from direct sunlight and reduces the surface temperature and surrounding air temperature through evaporation and transpiration.

5.1.8 The window frame architrave are to be reinforced to enable blinds to be fitted in all apartments, further improving thermal comfort and allowing occupants to control internal temperatures during the hot days of the year.

5.1.9 All practical measures in line with the ‘cooling hierarchy’ have been taken to minimise risks of overheating. Initial analysis based on SAP Appendix P: Assessment of Internal Temperature in Summer shows that threshold of internal mean temperatures have not been exceeded on the hottest summer days. All dwellings on site satisfy Criterion 3 requirements of Part L1A.

6.0 BE CLEAN – COMMUNAL HEATING AND COMBINED HEAT & POWER

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

6.0.2 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.

6.0.3 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 the hot water and heating demands of the site.

6.0.4 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.

6.0.5 The order of preference has been adhered to and as there is not an existing CHP distribution network in close proximity to the site it is not possible to implement the first option. (see Figure 9)

6.0.6 A preliminary study of the application of CHP to the site has been undertaken in order to assess if CHP is a suitable technology for the proposed scheme and to determine the level of CO_2 reduction that can be expected. This is an initial study to determine feasibility and CO_2 reductions.

6.0.7 The preliminary study of the application of CHP is based on a CHP engine providing space heating and DHW to the development with modulating output at varying efficiencies between 25% and 100% to account for peaks and troughs in hot water demand.

Feasibility

6.0.8 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 a 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.

6.0.9 It has been established that the specification of highly efficient individual gas boilers providing space heating and DHW together with the fabric improvements discussed in previous section delivers the optimal carbon reductions in the most cost effective way.

Local Connection

6.0.10 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.

6.0.11 Investigation into existing heat networks in the area using the London Heat Map have shown that there is no existing or proposed CHP installations in close proximity of the site. Hence connection to an existing CHP is not possible for the site. The London heat map (see (see Figure 9 below).

Figure 9 - London Heat Map Indicating CHP Sites and District Heat Networks

7.0 BE GREEN – RENEWABLE ENERGY TECHNOLOGY

7.0.1 The third stage of the energy hierarchy refers to the production of renewable energy, which relates to London Borough of Camden Policies SC13 and CPG3, and London Plan Policy 5.7.

7.0.2 Each of the approved renewable energy technologies have been appraised, examining the size and cost of each system required to maximise CO_2 reductions. The feasibility of each technology at the proposed site is also discussed in the following sections in order to determine the most suitable solution for the site.

7.0.3 Energy Hierarchy approved renewable energy technologies include:

- Wind
- Photovoltaics
- Solar Hot Water Systems
- Biomass Heating / CHP
- Water / Ground Sourced Heating / Cooling

7.0.4 The choice of technology will be dependent upon a range of factors including: orientation, height of the building, surrounding buildings and environment, site size and layout, geology, conservation and biodiversity. (See Appendix A of the report for the full appraisable of renewable technologies for the development at Willingham Terrace)

7.0.5 Site analysis and calculations has shown that PVs are the most suitable renewable technology for the development to meet carbon reduction requirements; reducing the Renewables Baseline to10,050 $kgCO_2$/year by a predicted 4,904 $kgCO_2$/year from the Efficient Baseline of 14,955 $kgCO_2$/year.

7.0.6 A 32.8% CO_2 reduction can be attributed to PVs from the Efficient Baseline.

7.1 PHOTOVOLTAICS

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

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

Energy and CO_2 Reduction

7.1.3 The available roof space has been investigated and it has been determined that there is a sufficient space for a total of 36 PV panels and it is possible to offset the electrical consumption of the development by a total of 9,271kWh/year, hence lowering the carbon emissions of the development by 4,904kgCO_2/year from the Efficient Baseline.

7.1.4 Results of implementing the PVs at Willingham Terrace are summarised in Table 5 below. The proposed solution will deliver an overall 43.8% CO_2 reduction for the site as shown in Figure10, further increasing the DER over TER improvement of the development to 40.8% (Figure 12). These achievements enable the development to meet the mandatory Code Level 4 energy requirement and the London Plan Policy 5.7 and Tower Hamlets Policy SP11 requirements for a 40% on-site regulated carbon emission reduction.

7.1.5 A 32.8% CO_2 reduction can be attributed to PV from the Efficient Baseline exceeding the London Plan Policy 5.7 and London Borough of Camden Policies SC13 and CPG3 target for a 20% reduction in CO_2 emissions through the specification of on-site renewable technologies.

Table 5: Energy and Carbon Emissions with PV

Renewables Baseline	
Space Heating Energy kWh/yr	23,199
DHW Energy kWh/yr	29,903
Cooling kWh/yr	0
Lighting Energy kWh/yr	4,079
Aux Energy kWh/yr	4,510
Un-Reg Energy kWh/yr	36,372
Regulated Carbon Emissions $kgCO_2/yr$	**10,050**
% Improvement over Notional Baseline	32.8%
%Improvement over Efficient Baseline	43.8%
DER over TER % Improvement	40.8%

Figure 10: Be Green – Renewables Baseline

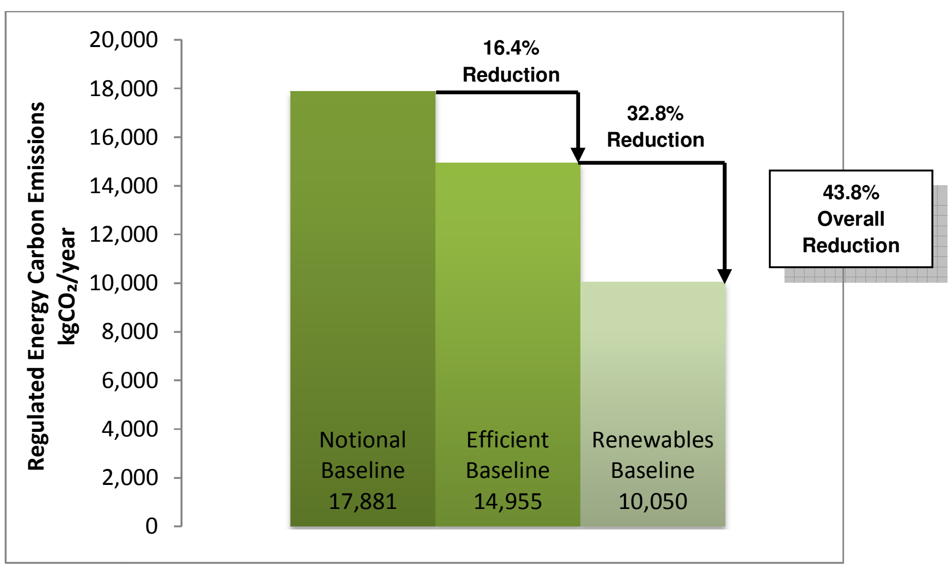
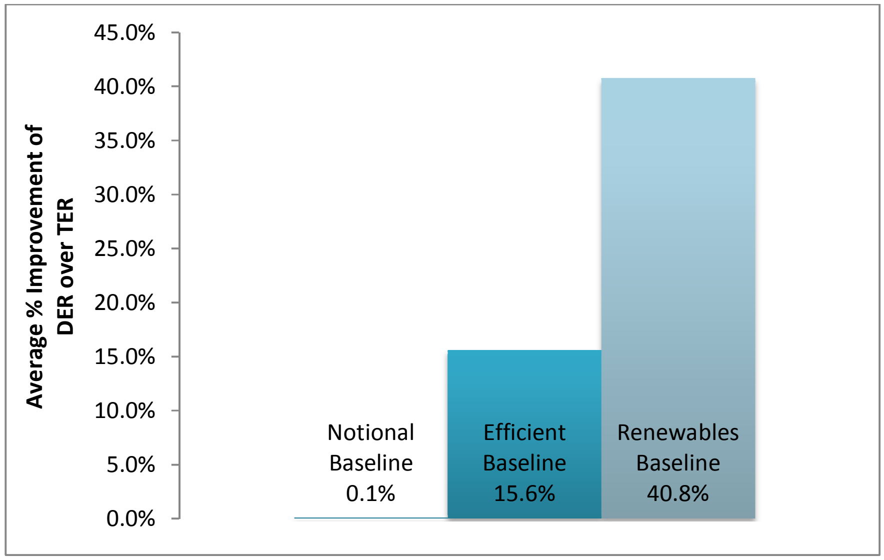


Figure 11: DER over TER improvement of the development



Plant Selection

7.1.6 Careful consideration has been given to maximising the use of PV on site to both provide renewable energy to the site and meet London Plan targets. Efforts have been made to minimised the visual impact of the PV panels and to ensure an appropriate placement for maximum output and increase efficiency of the system.

7.1.7 Orientation and layout of the PV panels on the available roof space has been carefully investigated. The roof plan sketch below, Figure 12, indicates the proposed PV arrangement layout for the building (please note the final layout is subject to specialist sub-contractor design and may differ from the proposed array illustrated). The modelled PV array was based on 36no. 300Wp mono-crystalline silicon PV panels, approximately ann overall 80m^2 area of PV.

7.1.8 As all panels will be situated on the roof of the building there is no extra land use associated with the technology.

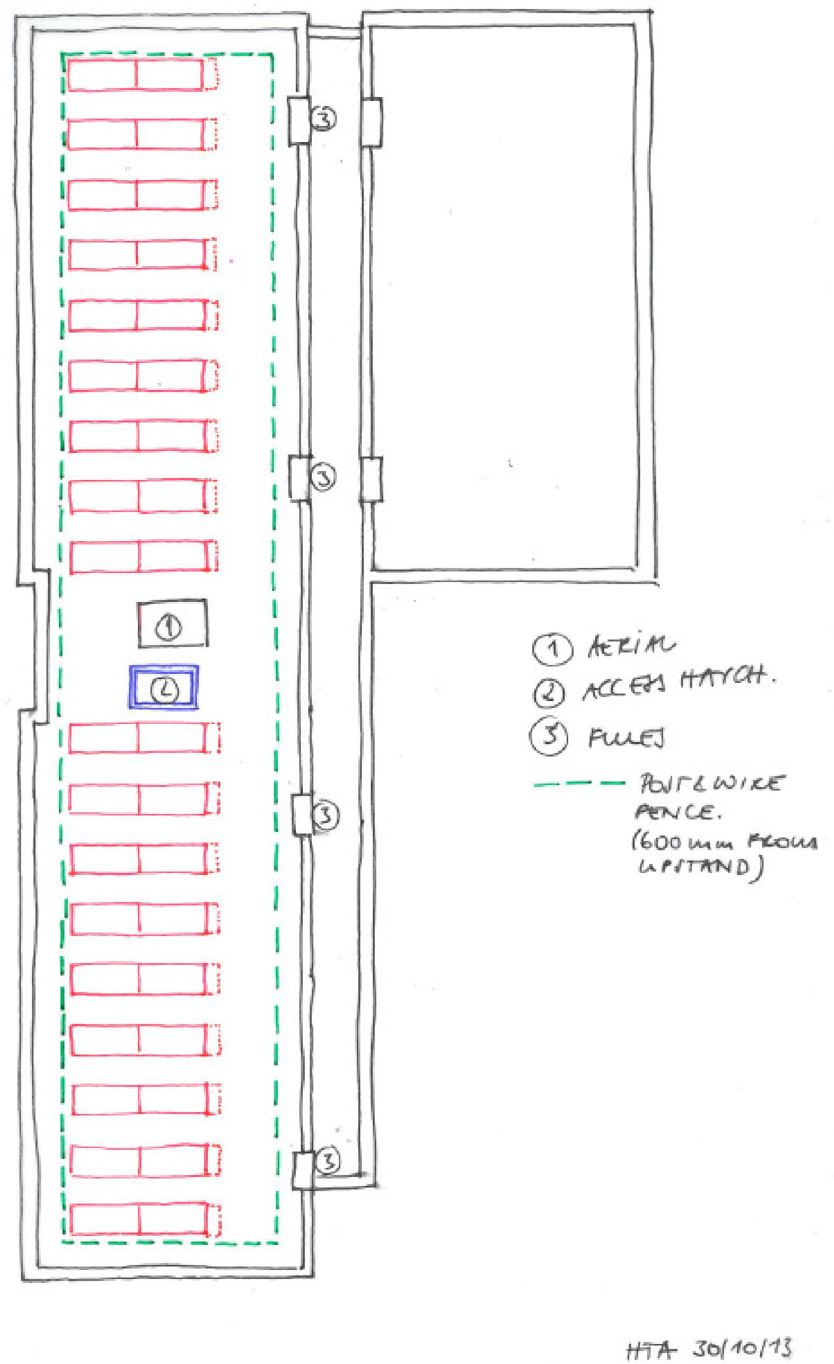
7.1.9 The modules should be installed tilted at an angle of 30° in order to maximise the PV output of the array. At less than 10° the modules will not self-clean, invalidating their warranty.

7.1.10 The modules will also need to be spaced at approximately 800mm apart to avoid overshadowing of neighbouring modules and to provide a walkway for safe installation and access.

7.1.11 PV systems require an inverter which converts the low voltage direct current electricity produced by the array of panels into 240V 50/60Hz alternating current. Inverters along with the meters will be housed inside the electrical services/meter cupboards.

7.1.12 PV systems require minimal maintenance, as long as the panels are installed at or above the recommended angle they will self-clean.

Figure 12: Indicative PV Panels Arrangement on Proposed Roof Layout



Capital and Life Cycle Costs

7.1.13 It is estimated that the total capital cost of the PV panels, including inverters, installation, miscellaneous electrical components etc., equates to approximately £21,600. Please note, all figures are indicative and based on a generic system price range provided by a single PV provider/installer. Metropolis Green takes no responsibility for the accuracy of these figures as final costs will depend on detailed design of the PV array, ancillary equipment and site constraints. All prices should be 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

7.1.14 The annual income that can be generated by the PV panels includes a Feed-In Tariff (FIT) generation tariff rate of up to 15.4p/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.

8.0 CONCLUSION

8.1 Following the energy hierarchy has enabled significant carbon reductions to be calculated for the proposed development at Willingham Terrace. The total overall carbon reduction is predicted to reach 43.8% as illustrated in Figure 13 below, with a DER over TER percentage improvement for the development of 40.8%.

8.2 The results of this energy strategy indicate that the development meets the mandatory energy requirements of London Borough of Camden Policy DP22 to achieve certification at Code Level 4. Figure 14 below demonstrates the average DER for all baselines. It should be noted that the average DER over TER improvement of 40.8%, is in line with the London Plan Policy 5.2 and London Borough of Camden Policy S7 requirements for a 40% reduction.

8.3 In accordance with the London Plan, 'whole energy' baseline figures derived from SAP 2009 calculations have been used in this energy strategy report, including: space heating, DHW, comfort cooling, lighting, pumps and fans and un-regulated energy. The proposed development at Willingham Terrace is calculated to have a Building Regulations 2010 compliant Notional Baseline of 17,881 kgCO_2/year.

8.4 In the first stage of the energy hierarchy (Be Lean), a 16.4% carbon reduction associated with the proposed fabric and services energy efficiency measures has been calculated; a reduction of 2,927 kgCO_2/year from the Notional to the Efficient Baseline. It should be noted that as a part of the energy efficiency improvements all practical measures have been investigated to minimise risks of overheating. Calculations have shown that the solar gain limits have not been exceeded and Criterion 3 of Building Regulations Part L document has been met.

8.5 For the second stage of the energy hierarchy (Be Clean) investigations in line with London Plan Policy 5.7 and London Borough of Camden Policy SC13, show that there are no local CHP plant installations or district heat networks nearby that the site can connect to. However, the policy's carbon reduction requirements have been met with implementation of highly efficient gas boilers for the site.

8.6 In the final stage of the energy hierarchy (Be Green), site analysis and calculations have determined PV to be the most suitable renewable energy technology for the site, providing a further 4,904 kgCO_2/year or 32.8% reduction through the implementation of 36 no. PV panels. This achievement exceeds the London Plan Policy 5.7 targeted 20% regulated carbon emission reductions through the specification of on-site renewable technologies.

8.7 Table 6 below provides a summary of the energy demand, CO_2 emissions, improvements of DER over TER, and overall carbon reductions for the modelled baselines of the development at Willingham Terrace.

Table 6: Energy Hierarchy Summary

	Notional Baseline	Efficient Baseline	Renewables Baseline
Space Heating Energy kWh/yr	26,398	23,199	23,199
DHW Energy kWh/yr	38,819	29,903	29,903
Cooling kWh/yr	0	0	0
Lighting Energy kWh/yr	5,100	4,079	4,079
Aux Energy kWh/yr	4,510	4,510	4,510
Un-Regulated Energy kWh/yr	36,372	36,372	36,372
Regulated CO_2 Emissions $kgCO_2/yr$	**17,881**	**14,955**	**10,050**
Total Regulated CO_2 Reduction $kgCO_2/yr$	-	2,927	4,904
Percentage Regulated CO_2 Reduction		16.4%	7,831
Total Percentage Regulated CO_2 Reduction	-	16.4%	32.8%
DER over TER % Improvement	3.4%	15.6%	40.8%

Figure 13: Regulated Carbon Emission Reductions

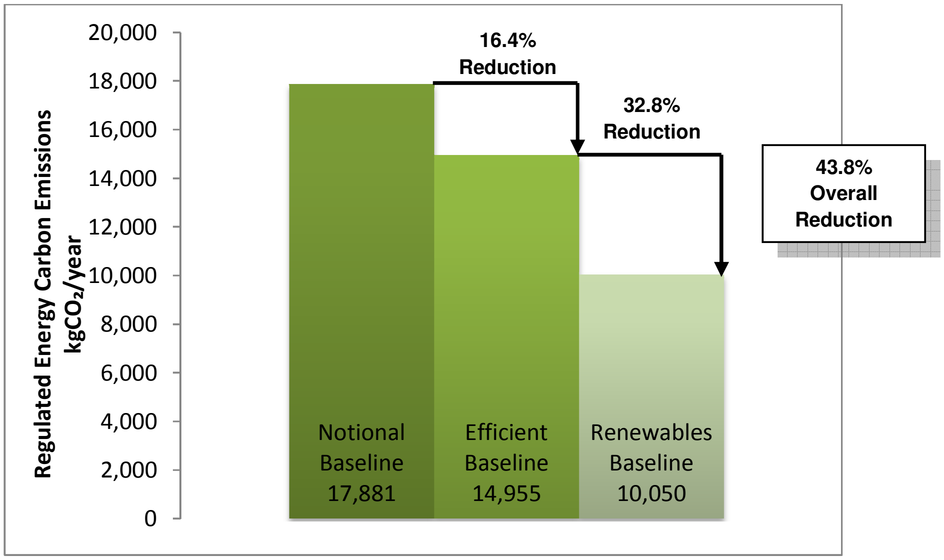


Figure 14: DER over TER improvement of the development

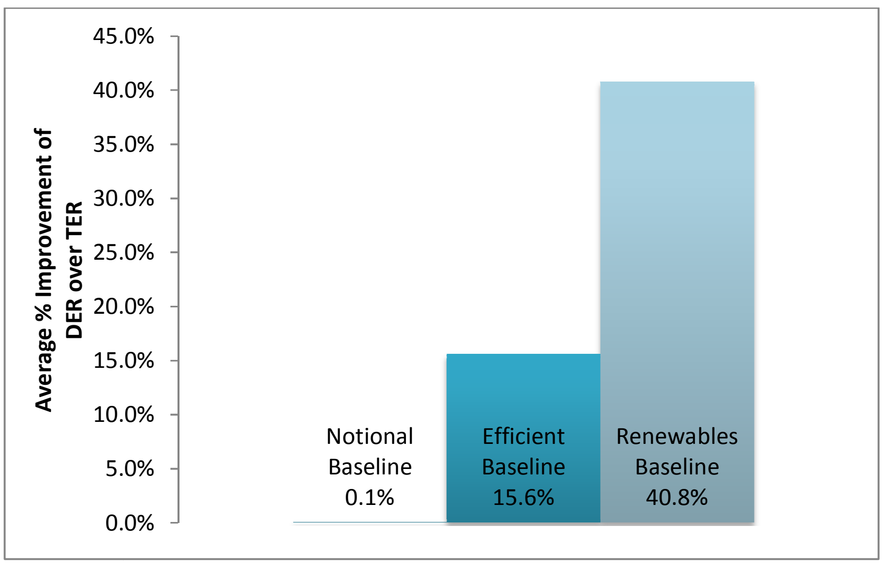
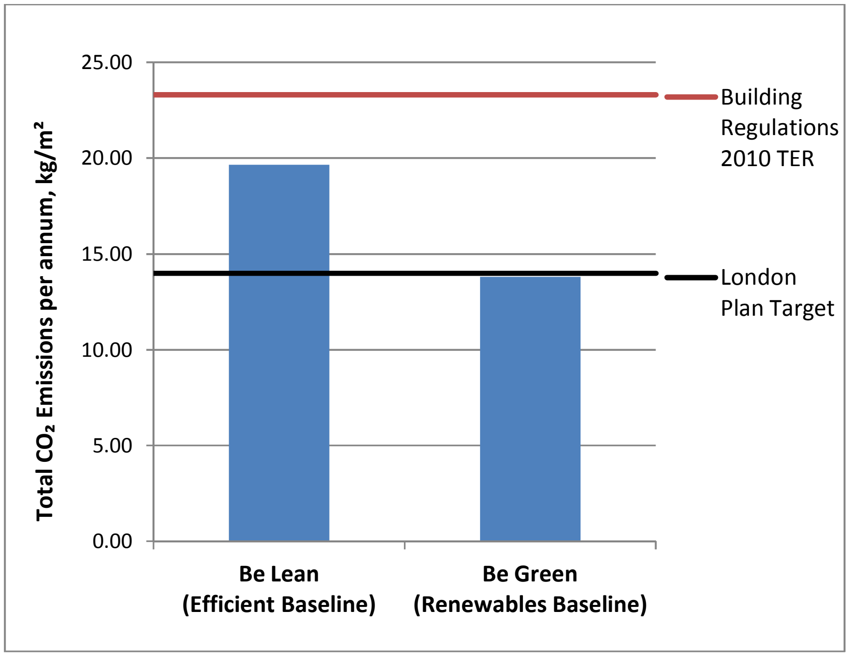


Figure 15: The Energy Hierarchy (Be Lean, Be Clean, Be Green) – DER



APPENDIX A – OTHER APPRAISED RENEWABLE TECHNOLOGIES

A.1 WIND TURBINES

A1.1 Wind is one of the most cost-effective methods of 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

A1.2 Modelling indicates wind turbines at this site will not able to achieve the level of carbon emission reductions associated with the PV solution.

A1.3 Installation of wind turbines is neither feasible nor suitable for Willingham Terrace. There are a number of concerns with wind turbines in an urban environment including; visual impact, noise, cost, maintenance, space, as well as mechanical loading implications for installation of turbines 'on building'. 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 and recording devices in order to give an accurate prediction in terms of energy output derived by the real wind speed measurements recorded on site.

A1.4 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. Turbulence can be overcome by installing turbines on minimum 30m high towers but this will exacerbate the concerns/impacts listed above.

A1.5 Life cycle assessment of wind turbines shows that they can repay embodied energy within a few years if suitably sited. Additionally 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

A1.6 In comparison to PV panels, the energy output is less predictable, as the annual sun path remains the same year on year whereas wind is unpredictable. In addition, roof structures at Willingham Terrace would need to be properly assessed in order to determine whether it will be able to withstand the loading on the building caused by the turbines.

A1.7 Therefore, wind turbines have been determined to be unsuitable for the development at Willingham Terrace.

A.2 BIOMASS HEATING

A2.1 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.

A2.2 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

A2.3 Although the calculations show that a biomass Boiler could provide a higher level of carbon reductions than gas boilers (from the Efficient Baseline), the main operational concerns are raised in relation to air quality, storage capacity and logistics of parking for delivery of wood pellets/chips etc.

A2.4 Air quality is another major concern with biomass heating due to NOx (Nitrogen Oxides) and Particulate Matter (PM10) emissions.

A2.5 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. Therefore, it is determined that biomass heating solution cannot be practically implemented and it is not a suitable renewable energy technology for the site.

A2.6 Life cycle assessment of biomass boilers shows that the embodied energy is usually repaid within a few years.

A2.7 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.

A2.8 When considering noise impact, the impact of fuel deliveries must be considered, otherwise, the impact is similar to conventional plant.

A2.9 Therefore, it is determined that a biomass heating solution cannot be practically implemented and is not suitable for the development at Willingham Terrace.

A.3 SOLAR THERMAL

A.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.

A.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

A.3.3 Solar thermal contributes towards hot water provision for dwellings. This technology offsets carbon emissions for hot water supplied by gas boilers. PV offsets electrical consumption from mains electricity. As mains gas has lower carbon intensity than mains electricity, Solar Thermal contributes a lower carbon reduction than PV. Therefore, it is determined that the solar thermal water heating option is not the optimal renewable solution for the development at Willingham Terrace.

A.4 GROUND SOURCE HEAT PUMP (GSHP)

A.4.1 In the UK, soil temperatures stay at a constant temperature of around 11-12℃, 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

A.4.2 It has been determined that connection to existing or installation of new Ground Source Heat Pump (GSHP) plant is not a feasible option for the Willingham Terrace scheme. This is due to the large area required for boreholes exterior to the dwellings and the additional impact the plant space required for the external heat pump units has to the visual quality and size of the amenity space.

A.4.3 Energy modelling and cost analysis show that 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.

A.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.

A.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.

A.4.6 Life cycle assessment shows that this technology has a low embodied energy and carbon which is repaid within a few years.

A.4.7 The capital cost of a heat pump system, the collector system and the heat distribution system compromises this technology as a cost effective solution. The cost of the heat pump itself is directly proportional to the output, so over-sizing should be avoided. A large proportion of the total cost is the cost of installing the collector, with vertical systems working out at around 25-50% more expensive owing to the need for borehole drilling. Larger systems will require major ground works to install a large horizontal collector or several boreholes. Installation costs can be reduced if the collector is installed as part of the ground works. The associated energy savings and RHI will reduce the lifecycle costs.

A.4.8 Studies have raised concerns over operational efficiencies matching manufacturers stated efficiencies and costs of maintenance required. Taking all of these considerations into account, it is judged that GSHP is not a suitable or affordable technology for Willingham Terrace.

APPENDIX B – CALCULATION RESULTS

Notional Baseline

Residential					Energy Consumption Breakdown								Gas Consumption	Electricity Grid	Electricity Offset	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	SAP 2009		% 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)	Un-Reg (kWh/an)	kWh/annum	kWh/annum	kWh/annum	$kgCO_2$/annum	$kgCO_2$/annum	DER	TER	
Ground floor	G.01	Apartment	38	58.4	1,507			1,755		229	205	1,653	3,262	2,087	0	**870**	**855**	24.85	24.73	-0.5%
	G.02	Apartment	38	57.5	1,473			1,756		229	205	1,653	3,229	2,087	0	**864**	**855**	24.67	24.73	0.2%
	G.03	Apartment	38	56.5	1,437			1,756		230	205	1,653	3,193	2,088	0	**857**	**855**	24.54	24.73	0.8%
	G.04	Apartment	38	57.3	1,471			1,755		230	205	1,653	3,226	2,088	0	**864**	**855**	24.72	24.73	0.0%
	G.05	Apartment	38	57.3	1,471			1,755		230	205	1,653	3,226	2,088	0	**864**	**855**	24.72	24.73	0.0%
	G.06	Apartment	38	53.8	1,358			1,758		230	205	1,653	3,116	2,088	0	**842**	**855**	24.04	24.73	2.8%
First floor	1.01	Apartment	38	43.5	903			1,774		229	205	1,653	2,677	2,087	0	**754**	**855**	21.61	21.72	0.5%
	1.02	Apartment	38	42.6	871			1,776		229	205	1,653	2,647	2,087	0	**748**	**855**	21.43	21.72	1.3%
	1.03	Apartment	38	41.4	827			1,777		230	205	1,653	2,604	2,088	0	**740**	**855**	21.25	21.72	2.2%
	1.04	Apartment	38	42.2	860			1,776		230	205	1,653	2,636	2,088	0	**747**	**855**	21.43	21.72	1.3%
	1.05	Apartment	38	42.2	860			1,776		230	205	1,653	2,636	2,088	0	**747**	**855**	21.43	21.72	1.3%
	1.06	Apartment	38	38.8	761			1,780		230	205	1,653	2,541	2,088	0	**728**	**855**	20.79	21.72	4.3%
Second floor	2.01	Apartment	38	43.5	903			1,774		229	205	1,653	2,677	2,087	0	**754**	**855**	21.61	21.72	0.5%
	2.02	Apartment	38	42.6	871			1,776		229	205	1,653	2,647	2,087	0	**748**	**855**	21.43	21.72	1.3%
	2.03	Apartment	38	41.5	832			1,777		230	205	1,653	2,609	2,088	0	**741**	**855**	21.27	21.72	2.1%
	2.04	Apartment	38	56.8	1,449			1,756		230	205	1,653	3,205	2,088	0	**859**	**855**	24.6	23.98	-2.6%
	2.05	Apartment	38	56.8	1,449			1,756		230	205	1,653	3,205	2,088	0	**859**	**855**	24.6	23.98	-2.6%
	2.06	Apartment	38	38.8	761			1,780		230	205	1,653	2,541	2,088	0	**728**	**855**	20.79	21.72	4.3%
Third floor	3.01	Apartment	38	57.3	1,479			1,754		237	205	1,653	3,233	2,095	0	**869**	**855**	24.95	23.98	-4.0%
	3.02	Apartment	38	56.5	1,444			1,755		237	205	1,653	3,199	2,095	0	**862**	**855**	24.77	23.98	-3.3%
	3.03	Apartment	38	63.3	1,729			1,748		246	205	1,653	3,477	2,104	0	**922**	**855**	26.45	25.6	-3.3%
	3.04	Apartment	38	61.8	1,682			1,749		246	205	1,653	3,431	2,104	0	**913**	**855**	26.15	25.6	-2.1%
Total / Average	**22**		**836**	**50.47**	**26,398**	**0**	**0**	**38,819**	**0**	**5,100**	**4,510**	**36,372**	**65,217**	**45,982**	**0**	**17,881**	**18,805**	**23.28**	**23.30**	**0.1%**

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Efficient Baseline

Residential					Energy Consumption Breakdown								Gas Consumption	Electricity Grid	Electricity Offset	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	SAP 2009		% 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)	Un-Reg (kWh/an)	kWh/annum	kWh/annum	kWh/annum	$kgCO_2$/annum	$kgCO_2$/annum	DER	TER	
Ground floor	G.01	Apartment	38	51.3	1,235			1,353		183	205	1,653	2,588	2,041	0	**713**	**855**	20.57	24.73	16.8%
	G.02	Apartment	38	52.1	1,266			1,352		183	205	1,653	2,618	2,041	0	**719**	**855**	20.74	24.73	16.1%
	G.03	Apartment	38	52.4	1,287			1,351		184	205	1,653	2,638	2,042	0	**723**	**855**	20.91	24.73	15.4%
	G.04	Apartment	38	51.7	1,256			1,352		184	205	1,653	2,608	2,042	0	**717**	**855**	20.74	24.73	16.1%
	G.05	Apartment	38	51.7	1,256			1,352		184	205	1,653	2,608	2,042	0	**717**	**855**	20.74	24.73	16.1%
	G.06	Apartment	38	48.2	1,146			1,355		184	205	1,653	2,501	2,042	0	**696**	**855**	20.08	24.73	18.8%
First floor	1.01	Apartment	38	39.7	773			1,370		183	205	1,653	2,143	2,042	0	**625**	**855**	18.07	21.72	16.8%
	1.02	Apartment	38	40.4	802			1,368		183	205	1,653	2,170	2,041	0	**630**	**855**	18.23	21.72	16.1%
	1.03	Apartment	38	40.6	815			1,368		184	205	1,653	2,183	2,042	0	**633**	**855**	18.35	21.72	15.5%
	1.04	Apartment	38	39.8	785			1,369		184	205	1,653	2,154	2,042	0	**628**	**855**	18.19	21.72	16.3%
	1.05	Apartment	38	39.8	785			1,369		184	205	1,653	2,154	2,042	0	**628**	**855**	18.19	21.72	16.3%
	1.06	Apartment	38	36.4	689			1,373		184	205	1,653	2,062	2,042	0	**609**	**855**	17.57	21.72	19.1%
Second floor	2.01	Apartment	38	39.7	773			1,370		183	205	1,653	2,143	2,042	0	**625**	**855**	18.07	21.72	16.8%
	2.02	Apartment	38	40.4	802			1,368		183	205	1,653	2,170	2,041	0	**630**	**855**	18.23	21.72	16.1%
	2.03	Apartment	38	40.7	820			1,368		184	205	1,653	2,188	2,042	0	**634**	**855**	18.38	21.72	15.4%
	2.04	Apartment	38	52.2	1,278			1,351		184	205	1,653	2,629	2,042	0	**722**	**855**	20.86	23.98	13.0%
	2.05	Apartment	38	52.2	1,278			1,351		184	205	1,653	2,629	2,042	0	**722**	**855**	20.86	23.98	13.0%
	2.06	Apartment	38	36.4	689			1,373		184	205	1,653	2,062	2,042	0	**609**	**855**	17.57	21.72	19.1%
Third floor	3.01	Apartment	38	50.9	1,232			1,352		190	205	1,653	2,584	2,048	0	**716**	**855**	20.79	23.98	13.3%
	3.02	Apartment	38	51.6	1,264			1,351		190	205	1,653	2,615	2,048	0	**722**	**855**	20.96	23.98	12.6%
	3.03	Apartment	38	58.4	1,541			1,342		196	205	1,653	2,883	2,054	0	**778**	**855**	22.57	25.6	11.8%
	3.04	Apartment	38	55.2	1,427			1,345		196	205	1,653	2,772	2,054	0	**756**	**855**	21.93	25.6	14.3%
Total / Average	**22**		**836**	**46.45**	**23,199**	**0**	**0**	**29,903**	**0**	**4,079**	**4,510**	**36,372**	**53,102**	**44,961**	**0**	**14,955**	**18,805**	**19.66**	**23.30**	**15.6%**

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Renewables Baseline

Residential					Energy Consumption Breakdown								PVs		Gas Consumption	Electricity Grid	Electricity Offset	Regulated CO_2 Emissions	Unregulated CO_2 Emissions	SAP 2009		Code 2010 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)	Un-Reg (kWh/an)	PVs kWp	PVs Energy Offset	kWh/annum	kWh/annum	kWh/annum	$kgCO_2$/annum	$kgCO_2$/annum	DER	TER	Standard case emissions	Actual case emissions		
Ground floor	G.01	Apartment	38	51.3	1,235	0	0	1,353	0	183	205	1,653	0.491	-421.40	2,588	2,041	-421	**490**	**855**	14.70	24.73	45.53	37.20	40.5%	18.3%
	G.02	Apartment	38	52.1	1,266	0	0	1,352	0	183	205	1,653	0.491	-421.40	2,618	2,041	-421	**496**	**855**	14.87	24.73	45.68	37.37	39.9%	18.2%
	G.03	Apartment	38	52.4	1,287	0	0	1,351	0	184	205	1,653	0.491	-421.40	2,638	2,042	-421	**501**	**855**	15.04	24.73	45.76	37.54	39.2%	18.0%
	G.04	Apartment	38	51.7	1,256	0	0	1,352	0	184	205	1,653	0.491	-421.40	2,608	2,042	-421	**495**	**855**	14.87	24.73	45.61	37.37	39.9%	18.1%
	G.05	Apartment	38	51.7	1,256	0	0	1,352	0	184	205	1,653	0.491	-421.40	2,608	2,042	-421	**495**	**855**	14.87	24.73	45.61	37.37	39.9%	18.1%
	G.06	Apartment	38	48.2	1,146	0	0	1,355	0	184	205	1,653	0.491	-421.40	2,501	2,042	-421	**473**	**855**	14.21	24.73	45.11	36.71	42.5%	18.6%
First floor	1.01	Apartment	38	39.7	773	0	0	1,370	0	183	205	1,653	0.491	-421.40	2,143	2,042	-421	**402**	**855**	12.20	21.72	43.32	34.70	43.8%	19.9%
	1.02	Apartment	38	40.4	802	0	0	1,368	0	183	205	1,653	0.491	-421.40	2,170	2,041	-421	**407**	**855**	12.36	21.72	43.45	34.86	43.1%	19.8%
	1.03	Apartment	38	40.6	815	0	0	1,368	0	184	205	1,653	0.491	-421.40	2,183	2,042	-421	**410**	**855**	12.48	21.72	43.49	34.98	42.5%	19.6%
	1.04	Apartment	38	39.8	785	0	0	1,369	0	184	205	1,653	0.491	-421.40	2,154	2,042	-421	**405**	**855**	12.32	21.72	43.35	34.82	43.3%	19.7%
	1.05	Apartment	38	39.8	785	0	0	1,369	0	184	205	1,653	0.491	-421.40	2,154	2,042	-421	**405**	**855**	12.32	21.72	43.35	34.82	43.3%	19.7%
	1.06	Apartment	38	36.4	689	0	0	1,373	0	184	205	1,653	0.491	-421.40	2,062	2,042	-421	**386**	**855**	11.70	21.72	42.96	34.20	46.1%	20.4%
Second floor	2.01	Apartment	38	39.7	773	0	0	1,370	0	183	205	1,653	0.491	-421.40	2,143	2,042	-421	**402**	**855**	12.20	21.72	43.32	34.70	43.8%	19.9%
	2.02	Apartment	38	40.4	802	0	0	1,368	0	183	205	1,653	0.491	-421.40	2,170	2,041	-421	**407**	**855**	12.36	21.72	43.45	34.86	43.1%	19.8%
	2.03	Apartment	38	40.7	820	0	0	1,368	0	184	205	1,653	0.491	-421.40	2,188	2,042	-421	**411**	**855**	12.51	21.72	43.51	35.01	42.4%	19.5%
	2.04	Apartment	38	52.2	1,278	0	0	1,351	0	184	205	1,653	0.491	-421.40	2,629	2,042	-421	**499**	**855**	14.99	23.98	45.71	37.49	37.5%	18.0%
	2.05	Apartment	38	52.2	1,278	0	0	1,351	0	184	205	1,653	0.491	-421.40	2,629	2,042	-421	**499**	**855**	14.99	23.98	45.71	37.49	37.5%	18.0%
	2.06	Apartment	38	36.4	689	0	0	1,373	0	184	205	1,653	0.491	-421.40	2,062	2,042	-421	**386**	**855**	11.70	21.72	42.96	34.20	46.1%	20.4%
Third floor	3.01	Apartment	38	50.9	1,232	0	0	1,352	0	190	205	1,653	0.491	-421.40	2,584	2,048	-421	**493**	**855**	14.92	23.98	45.51	37.42	37.8%	17.8%
	3.02	Apartment	38	51.6	1,264	0	0	1,351	0	190	205	1,653	0.491	-421.40	2,615	2,048	-421	**499**	**855**	15.09	23.98	45.67	37.59	37.1%	17.7%
	3.03	Apartment	38	58.4	1,541	0	0	1,342	0	196	205	1,653	0.491	-421.40	2,883	2,054	-421	**555**	**855**	16.70	25.6	47.10	39.20	34.8%	16.8%
	3.04	Apartment	38	55.2	1,427	0	0	1,345	0	196	205	1,653	0.491	-421.40	2,772	2,054	-421	**533**	**855**	16.06	25.6	46.56	38.56	37.3%	17.2%
Total / Average	**22**	Apartment	**836**	**46.45**	**23,199**	**0**	**0**	**29,903**	**0**	**4,079**	**4,510**	**36,372**	**10.80**	**-9,270.72**	**53,102**	**44,961**	**-9,271**	**10,050**	**18,805**	**13.80**	**23.30**	**44.67**	**36.29**	**40.8%**	**18.8%**

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