Buro Happold

St Giles

Energy Statement

028676

24 October 2012

Revision 01

Revision	Description	Issued by	Date	Checked
00	Draft	JD	16/08/12	WM
01	Final submission	JD	24/10/12	BS

O:\028676 St Giles Circus\F42 Sustainability - SAT\03 Reports\All Finished Reports for Planning - November 2012\121024 JD Energy Statement 01.docx

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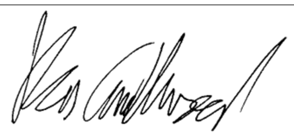
signature	
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Contents

1 Executive Summary

This document summarises the energy and carbon emissions associated with the St Giles Circus planning application, a large mixed-use development located in Camden, London. This statement has been written in accordance with Camden Planning Policy as well as the London Plan, and the key planning requirements identified are presented below;

- Energy strategies are to be designed following the steps set out by the energy hierarchy (Lean, Clean, Green)
- New developments must make a 25% improvement on the current 2010 Building Regulations
- New build housing required to meet Code for Sustainable Homes Level 3 by 2010 and Level 4 by 2013
- Dwelling refurbishments to achieve 'Very good' Ecohomes assessments
- Non-domestic developments to achieve BREEAM 'Very good' rating

This statement specifically addresses the first two points above, with the sustainability assessment requirements dealt with separately in the sustainability statement. Key findings from the report are presented below.

1.1 Denmark Place to Andrew Borde Street and Denmark Street North

This building comprises new build and refurbishment elements, and is the largest building of the application. A $200kW_{th}/120\ kW_e$ CHP engine is proposed to deliver low carbon heat and electricity to the development, alongside a $340m^2$ PV array located at roof level on the new build elements.

Carbon emissions for the whole building are presented in Figure 1 at each stage of the Lean, Clean, Green energy hierarchy. There is no planning policy requirements relating to the overall building emissions rate, however through application of the energy hierarchy a reduction of 26% has been achieved on the Lean building emission rate.

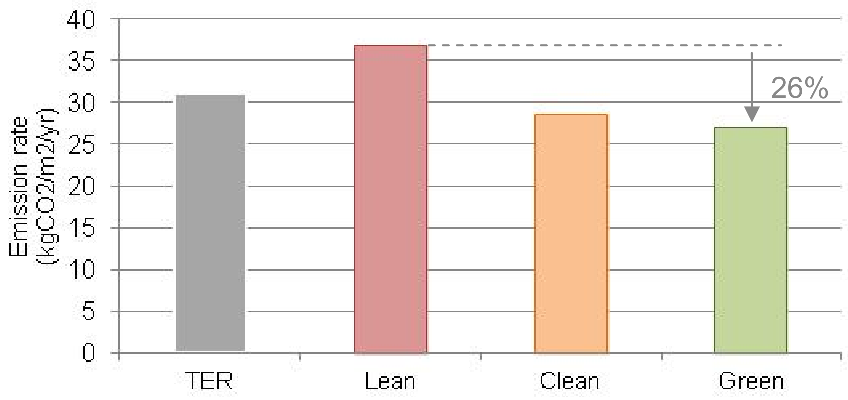


Figure 1 Denmark Place to Andrew Borde Street and Denmark Street North Building Summary

NB: The TER (target emissions rate) has been calculated from the modelling process and is relative to a new build construction. It is therefore particularly onerous and not an accurate target for the development as it includes large amounts of refurbishment.

New build

New build elements are required to achieve a 25% improvement on 2010 Building Regulations as stipulated in the London Plan. The Denmark Place to Andrew Borde Street is the major new build component of the planning application and its performance is presented in Figure 2

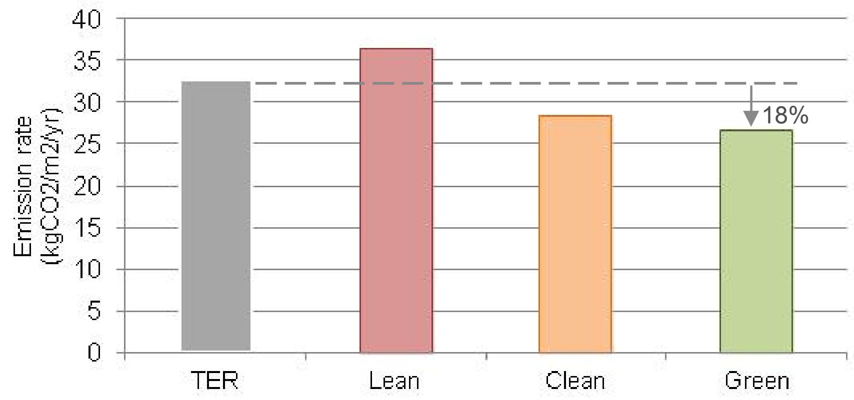


Figure 2 Denmark Place to Andrew Borde Street Summary

The new build element fails to meet the planning requirement and achieves an 18% improvement on the Part L TER, this target however is considered very onerous for this type of development. The mixed use nature of the development requires the services design to accommodate a wide range of demands, which tends to reduce the overall operational efficiency of the systems compared to a non-mixed use development. For this reason it is difficult to achieve above and beyond the notional building requirements. The use of CHP has been utilised to its full potential, and all available roof areas have been used for PV arrays.

1.2 Denmark Street South

This building is largely refurbishment including multiple buildings with Grade 2 listed status, however one new build dwelling is to be constructed. A small PV array of $15m^2$ is proposed to be installed on the roof of this new dwelling. Carbon emissions for the whole building are presented in Figure 3 at each stage of the Lean, Clean, Green hierarchy, a 24% reduction has been achieved on the Lean building emissions rate.

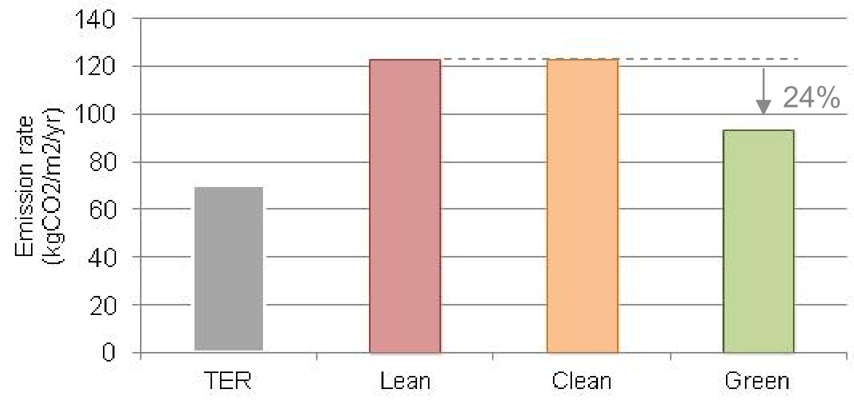


Figure 3 Denmark Street South Summary

NB: The TER (target emissions rate) has been calculated from the modelling process and is relative to a new build construction. It is therefore particularly onerous and not an accurate target for the development as it includes large amounts of refurbishment. Furthermore it doesn't take into consideration the listed build status of many of the buildings.

New Build

One new build element is to be built on the 4th and 5th floors of Number 4 Denmark Street, carbon emissions are reported in Figure 4. The 25% improvement on 2010 Building Regulations has been exceeded, with the proposed design achieving a 31% improvement on the TER. This is largely due to the photovoltaic panels on the roof of the dwelling.

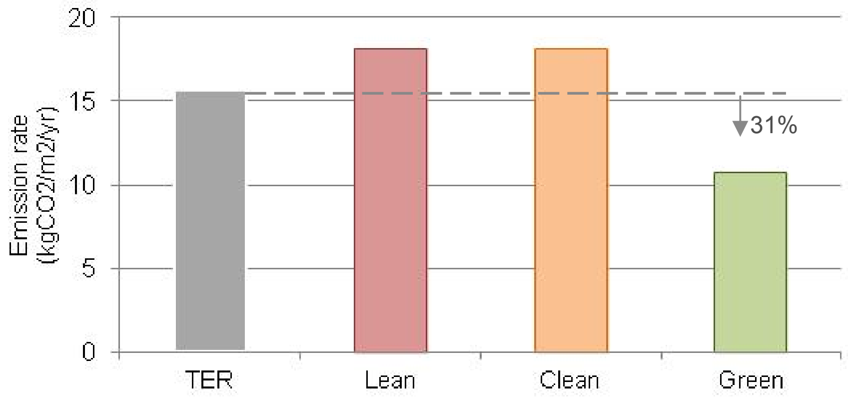


Figure 4 New Build 4 Denmark Street Summary

1.3 Endell Street

This building is a major refurbishment to create 7 affordable dwellings. A $34m^2$ PV array has been proposed for the roof, with the renewable energy generated attributed to each dwelling proportional to their floor areas. Carbon emissions for the whole building are presented in Figure 5 at each stage of the Lean, Clean, Green hierarchy, a 24% reduction has been achieved on the Lean building emissions rate.

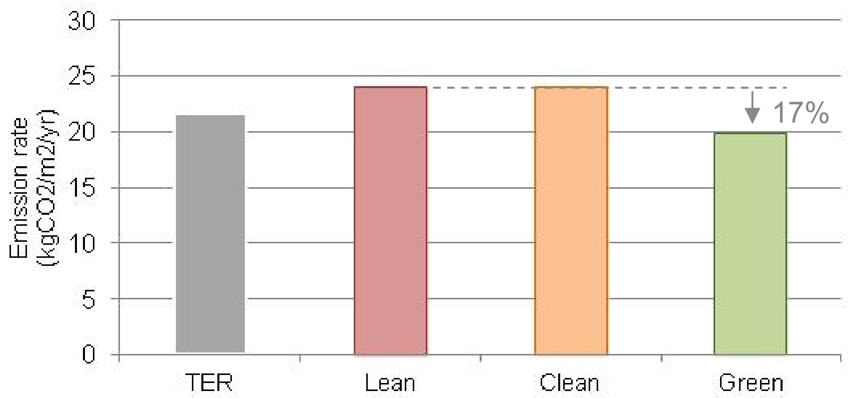


Figure 5 Endell Street Summary

NB: The TER (target emissions rate) has been calculated from the modelling process and is relative to a new build construction. It is therefore particularly onerous and not an accurate target for the development as it includes large amounts of refurbishment.

2 Introduction

2.1 Project Description

The St Giles development is a large mixed use development located in Camden, London. The project consists of three separate buildings, however they are all encompassed within the same scheme and planning application. Figure 6 shows the extent of the planning application for St Giles. The planning application consists of new build, major refurbishment and light refurbishment. The application has a class mix of shops, restaurant/cafe, drinking establishments, hotel, business, assembly, leisure and dwellings. A breakdown of the use classes between the three buildings is also presented in Table 1.

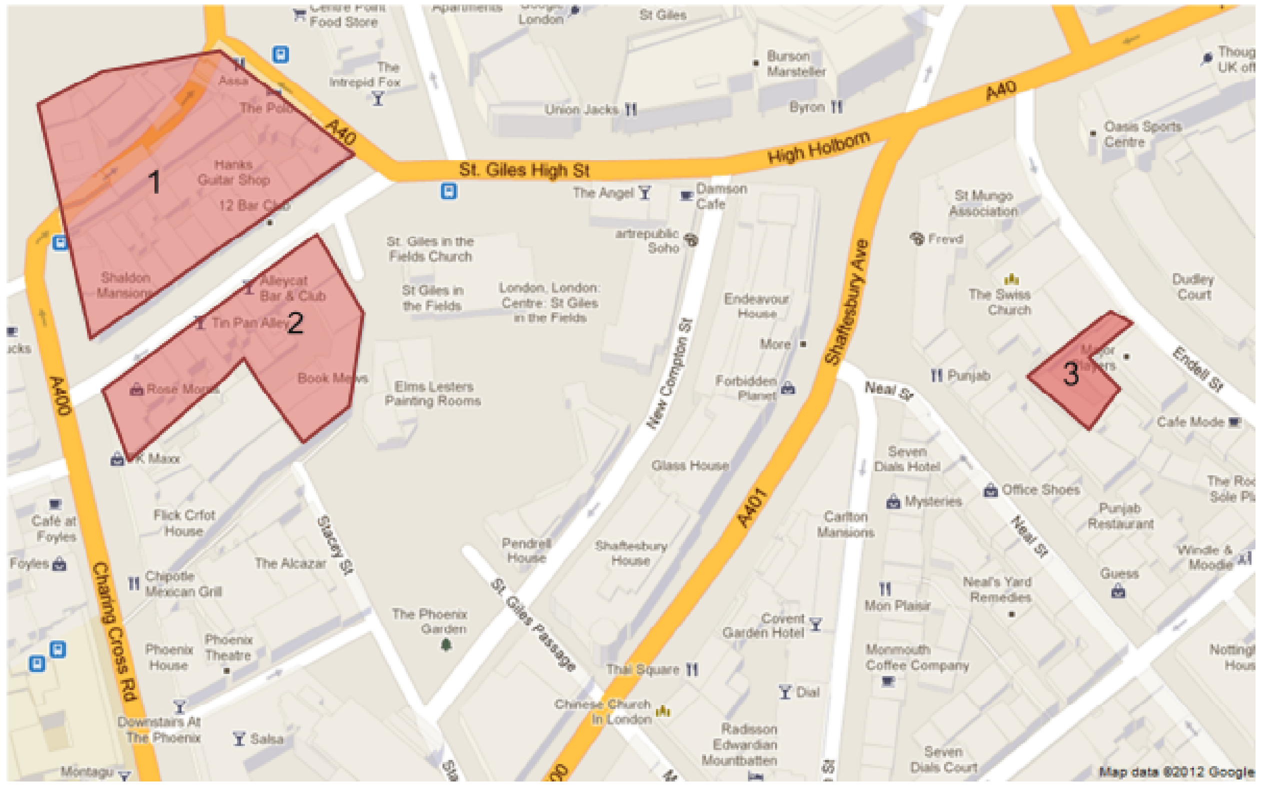


Figure 6 Site Layout

1) **Denmark Place to Andrew Borde Street and Denmark Street North**

This is the major component of the development and is approximately 70% new build (Denmark Place to Andrew Borde Street) and 30% refurbishment (Denmark Street North). It is to be constructed above the Tottenham Court Rd Crossrail station. The plot is divided by a small street, Denmark Place, which the building spans across with largely the new build elements to the north of this street and the refurbishments to the south. The new build area will contain a large auditorium, restaurant areas and a large public gallery space which is to be open to the adjacent streets during certain parts of the day. Within this gallery is over 900 m^2 of LED screens which create a large media display for the space.

2) **Denmark Street South**

This is an existing building which is being refurbished as part of this development. There are several shops located along Denmark Street which will be subject to light or no refurbishment works. There will also be major refurbishment of a restaurant and varying degree of refurbishment to 16 dwellings. In addition, one extra dwelling is to be constructed at roof level. Significant portions of this building are Grade 2 listed and this will have implications on the degree of refurbishment, particularly fabric improvements, which can take place.

3) **Endell Street**

This is a small development currently being used as offices, but is to be refurbished into 7 affordable dwellings. All of the dwellings will have varying levels of refurbishment.

Building	A1 Shops	A3 Restaurants/ cafes	A4 Drinking Establishment	B1 Business	C1 Hotel	C3 Dwelling House	D1 Non-Residential Institution	D2 Assembly and Leisure
1: Denmark Place to Andrew Borde Street and Denmark Street North								
2: Denmark Street South								
3: Endell Street								

Table 1 Use class breakdown

2.2 Policy and Guidance

With regards to the energy performance of the St Giles development, there are a number of local and national policies and guidance notes which define certain targets to which the development must adhere to. A summary of the relevant targets and their source is presented below.

2.2.1 National Policy

2.2.1.1 Building Regulations Part L

Part L of the 2010 Building Regulations refers to the Conservation of Fuel and Power. This document stipulates the minimum level of energy efficiency that buildings must be constructed to. It provides guidance on new build as well as refurbishments, and covers all domestic and non-domestic buildings.

New build domestic and non-domestic developments must comply with Approved documents L1A and L2A respectively. For domestic buildings this is demonstrated through SAP (standard assessment procedure calculations) and for non-domestic a dynamic simulation energy model or SBEM (simplified building energy model) is required.

For refurbishments a modelling approach is not needed. Instead minimum requirements for particular aspects of the building are defined which must be matched or improved upon. In some instances consequential improvements are required which dictates that further work must be performed to improve the energy efficiency of the building. This information is detailed in Approved Documents L1B and L2B for domestic and non-domestic developments respectively.

For listed buildings, similar to refurbishments, a modelling approach is not required. They must comply with the requirements of Part L2B, however heritage concerns associated with the listed status can superseded these if stipulated by the relevant listed buildings officer.

2.2.2 Local Policy

2.2.2.1 Camden Development Policies 2010 – 2015

This document details the Local Development Framework (LDF) of Camden Council, it is considered a key document in defining the sustainability objectives for St Giles. Section 3 is focussed on the sustainability aspirations of the council. Policy DP22 is of particular importance:

DP22: Promoting sustainable design and construction

A summary of the key targets relating to the St Giles development is presented below:

- Developments are required to incorporate sustainable design and construction measures
- New build housing required to meet Code for Sustainable Homes Level 3 by 2010 and Level 4 by 2013
- Dwelling refurbishments to achieve 'Very good' Ecohomes assessments
- Non-domestic developments to achieve BREEAM very good rating

The above targets are certainly influenced by the energy performance; however information regarding compliance with the above targets will be dealt with in the respective assessment reports.

2.2.2.2 Camden Planning Guidance CPG3: Sustainability (2011)

The CPG3 document supports and builds on policy CS13 from the Camden Core Strategy. It is not official planning policy for Camden, however it provides additional guidance relating to sustainable construction and how it is considered by the council.

CS13- Tackling climate change through promoting higher environmental standards

A summary of the key targets relating to the St Giles development is presented below:

- Energy strategies are to be designed following the steps set out by the energy hierarchy (Lean, Clean, Green)
- New developments must make a 25% improvement on the current 2012 Building Regulations [London Plan policy 5.2]
- In existing buildings, at least 10% of the project cost should be spent on environmental improvements.

2.2.2.3 London Plan

The London Plan is a policy planning framework for the greater London area, within which Camden is located. Almost all of the energy targets are inherent in the Camden Planning Guidance however they have been outlined below for completeness.

- Developments must make a 25% improvement on the current 2012 Building Regulations (Part L TER)
- These improvements should be implemented in order of the energy hierarchy (Lean, Clean, Green)

A summary of all the applicable planning requirements and policy for the scheme is presented in Figure 7.

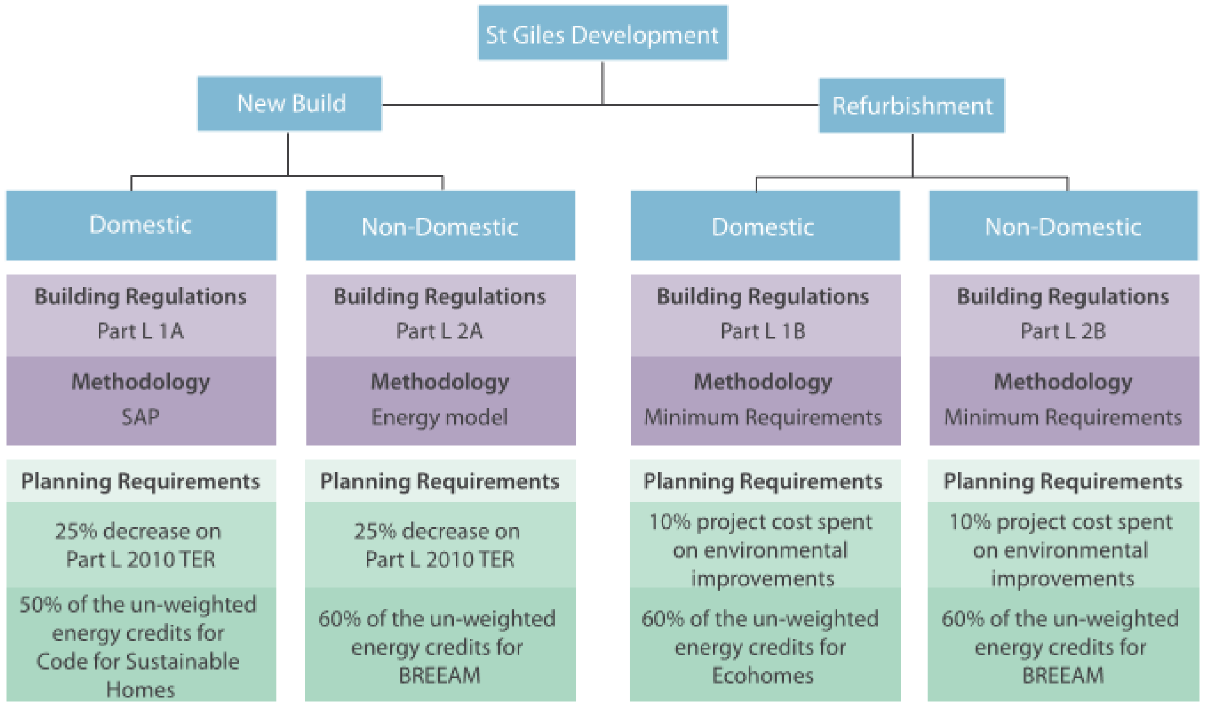


Figure 7 Key Policy Flow Chart

3 Approach

3.1 Strategy

In accordance with the London Plan and Camden Planning Guidance, energy efficiency of the development has been achieved through following the energy hierarchy. A graphical representation of the process is shown in Figure 8.

The approach aims to minimise energy consumption from the outset through the use of low energy, passive measures and efficient systems before the deployment of low carbon and renewable energy technologies.

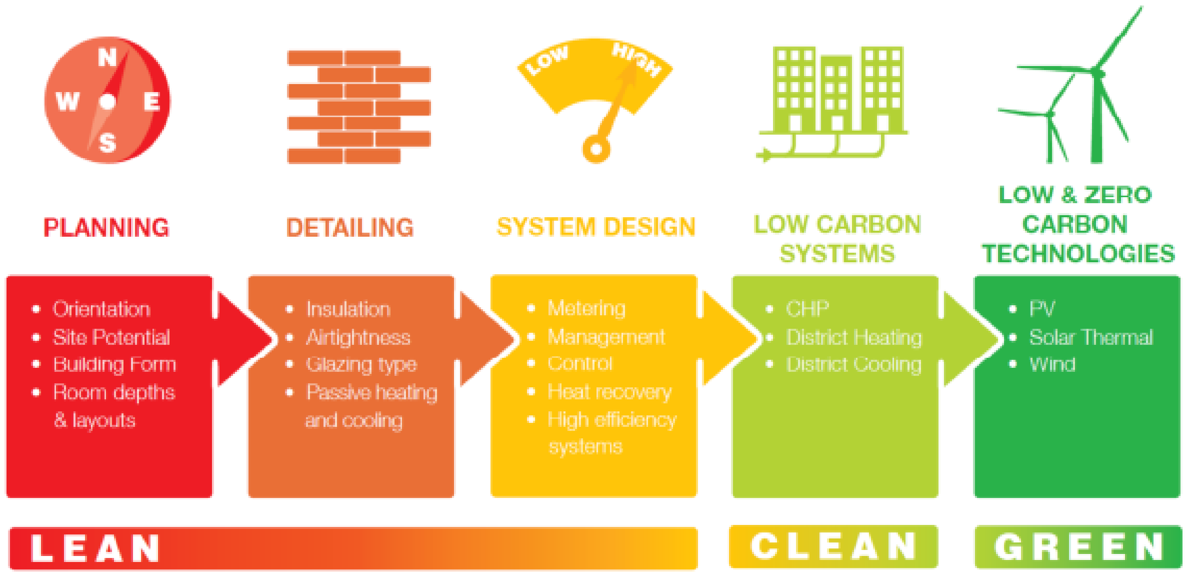


Figure 8 Energy hierarchy

3.2 Energy Strategy

Due to the combination of domestic/non-domestic and new build/refurbishment, the energy strategy of the site is very complex. Each of the three buildings has been considered as an isolated development with separate services and carbon emissions. In order to further simplify the scheme as much as possible and provide a clear energy strategy for all of the separate elements, the below approach has been followed:

- **Policy:** Where required, compliance with the relevant Building Regulations and Planning Requirements has been demonstrated for the individual elements of each building.
- **Energy hierarchy:** Where applicable, the carbon emissions and resulting reductions for each step of the Lean, Clean, Green approach have been reported on for all parts of the development.
- **Unregulated energy:** Building regulation modelling methodologies are limited in their scope to regulated energy which incorporates lighting, heating, hot water, cooling and auxiliary demands. As stipulated in Camden's planning guidance un-regulated energy consumption (catering, computing, etc.) should also be reported on.
- **Low or Zero Carbon and renewable energy technology**: For each building, any provision of low carbon or renewable energy technology has been spread across all of the individual units. The carbon savings have been spread pro-rata based on floor area. In some instances this is not applicable however this has been explained when appropriate.

3.3 Modelling methodology

As stipulated in the planning guidance, all carbon emissions of the buildings must be reported on. For the new build elements, this is has been carried out within the required modelling to demonstrate Building Regulations compliance. For the refurbished elements, modelling is not required to demonstrate compliance and a minimum set of requirements is dictated instead. Therefore, in order to model the building carbon emissions, additional modelling has been carried out. The chosen methodologies have been selected based on what is required for the relevant energy assessments such as BREEAM. A summary of all the methodologies is presented in Table 2 .

Typology	Methodology	Required for
New Build – Domestic	SAP	Building Regulations
New Build – Non-domestic	Dynamic Simulation Model	Building Regulations
Refurbishment – Domestic	SAP	Environmental Assessments/ Planning
Refurbishment – Non-domestic	Dynamic Simulation Model	Environmental Assessments/ Planning

Table 2 Modelling Methodology

In all cases the methodologies are based on the NCM (National Calculation Methodology), which defines profiles etc for all of the buildings dependent on their use.

In addition to the proposed design energy performance, the carbon emissions and resulting reductions for each step of the Mean, Clean, Green approach have also been reported on for all parts of the development. These values have been calculated by performing multiple runs on the required energy models (SAP and Dynamic Simulation Model), removing or adding design measures in line with the hierarchy. Full details of what has been included in each run are presented in Appendix B.

The results of following the energy hierarchy have also been presented cumulatively for the three buildings in their entirety. These results were calculated by using a Dynamic Simulation Model of the whole building, including the dwellings which only require SAP modelling. This was necessary as results from differing modelling methodologies are not comparable, and so this method provided a consistent approach for the whole development.

Unregulated energy demands for domestic buildings have been calculated using the methodology dictated in the SAP 2009 document Appendix L. For non-domestic building it has been calculated within the dynamic simulation model and is reported in the BRUKL output report as an 'Equipment' demand.

4 Denmark Place to Andrew Borde Street and Denmark Street North

4.1 Site Context

The Denmark Place to Andrew Borde Street and Denmark Street North is the largest part of the development, and contains the major new build element of the development. It is a combination of new build and refurbishment, with the majority of the new build being located to the north of the site and refurbishment to the south. With the combination of new build and refurbishment, as well as the combination of domestic and non-domestic, a comprehensive set of modelling was performed to ensure compliance with Building Regulations. A summary of the breakdown is presented in Table 3. The new build non-domestic elements are shown in Figure 11, the refurbishments and new build domestic in Figure 10.

New build/refurbishment	Typology	Modelling
New build	Entertainment, hotel, retail, restaurants and bars	Dynamic Simulation Model - Part L
New build	Domestic	SAP
Refurbishment	Domestic	SAP
Refurbishment	Office	Dynamic Simulation Model - EPC
Refurbishment	Retail	Dynamic Simulation Model - EPC

Table 3 Typologies

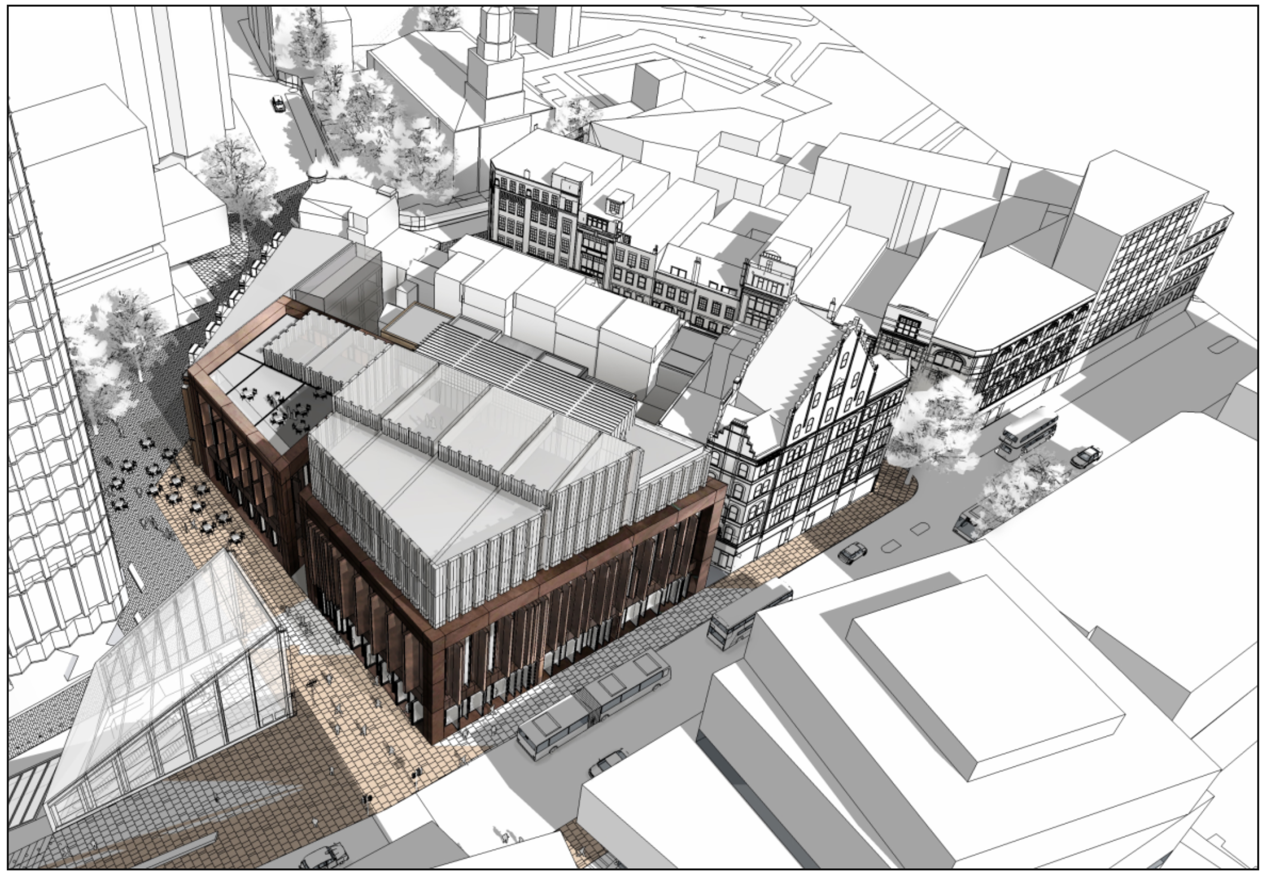


Figure 9 Denmark Place to Andrew Borde Street and Denmark Street North Aerial View

Figure 10 North elevation from Denmark Street

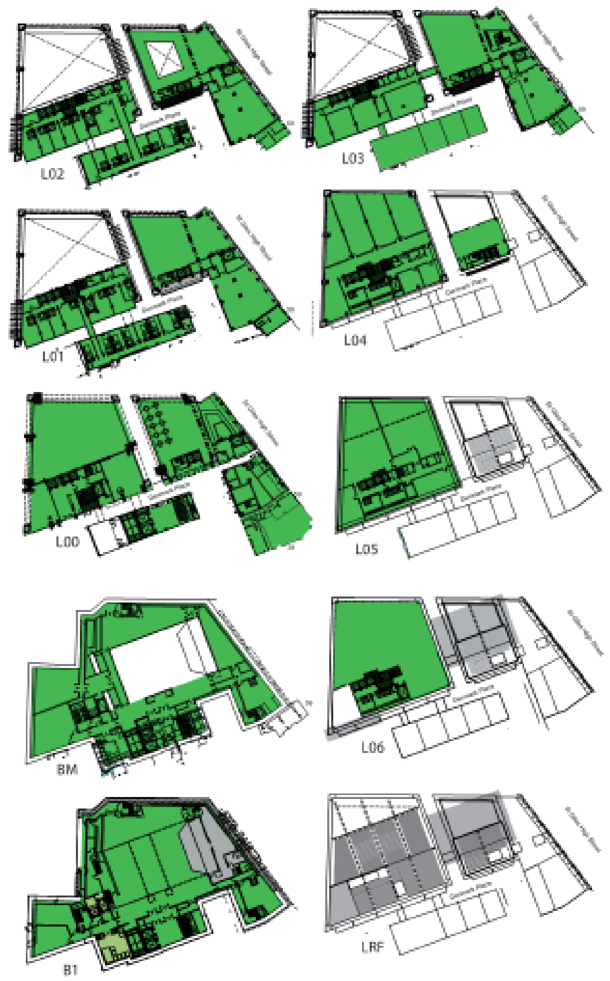


Figure 11 Plan of new build non-domestic elements

4.2 Site wide systems

CHP

As part of both the London Plan and Camden planning guidance it is advised to investigate the potential use of CHP (combined heat and power) engines where at all feasible. CHP engines can be very beneficial in improving the environmental performance of a building as in addition to heat they provide low carbon electricity which can offset that which would be normally received from a carbon intensive grid supply. It is advised that CHP systems should be investigated from a very holistic viewpoint considering the potential for future heat networks and district heating systems as well as building only systems.

A CHP system was identified as a feasible option for the development following a quick feasibility study using EnergyPRO software, which identified a sufficiently large base load which is required for efficient system operation. Discussions were established with local planners, property developers and existing building facility managers to explore the possibility of a district or wider system. It was agreed however on 15/05/12 in the presence of Harold Garner, Sustainability manager of Technical Projects, from Camden Council that it was an un-feasible option. The main restrictions were the disruption that would be caused to the surrounding roads to install a heat network, and the lack of suitable development potential in the area.

Within the development it is therefore proposed to install a 200 kW thermal/120kW electric CHP engine to serve the whole building with hot water and space heating. Based on preliminary studies it is expected that this system will meet 60% of the heat demand, with the remaining demand met by gas-fired boilers. The CHP consequently supplies the whole building with 590 MWh/year of low carbon electricity.

It was investigated whether the CHP could be used to service the other buildings included in the development, particularly Denmark Street South due to its close proximity. However it was ruled out because of the disruption that would be caused to install a heat main beneath Denmark Street.

Renewables

Regardless of how beneficial the CHP engine performs, it is anticipated that a significant contribution from renewable energy generation technologies will be required in order to meet the 25% improvement on 2012 Building Regulations. A feasibility study was carried out in order to identify the most suitable renewable options for the Circus building. Table 4 summarises the findings of this study.

Technology	Comments	Viability
Wind turbine	• Urban environment creates turbulence that significantly reduces and fluctuates the turbine output therefore not effective • Only very small-scale system would be viable – low carbon savings	
Biomass	• Limited plant space available to house required large fuel store • Delivery of biomass difficult, with limited space for large vehicle access and turning • Potential air and noise pollution issues	
Air Source Heat Pump	• Minimal carbon savings compared to a condensing gas boiler • Air Source Heat pumps can only supply low temperature hot water which will still need boilers to meet the required temperatures for domestic hot water	
Ground Source Heat Pump	• Building to be constructed above an underground construction (Crossrail), so no area for possible borehole field	
Solar thermal	• Significant distribution length from roof → plant room → use • Large plant area required for expansion vessel and additional plant • System conflict with CHP	
Solar PV	• Large flat roof area available • Simple, low maintenance renewable technology • Simple installation and maintenance, with very small plant space requirements	

Table 4 Feasibility study findings

PV

Following the renewable energy generation feasibility study, PV has been identified as the most viable generation technology. A 320m^2 array of photovoltaic panels is proposed to be installed on the large roof area above the restaurant. This is the largest installation possible, ensuring sufficient space is allowed for access, maintenance and to minimise panel overshadowing. All of the electricity generated from this array will be fed back to the main power supply for the building, and consequentially the resultant carbon emission savings will be attributed to all of the building elements based proportionally on their TFA.

Figure 12 PV Layout

4.3 New Build

4.3.1 Mixed Use

The mixed use area is the largest part of the whole St Giles development. It is a combination of smaller building elements, joined on different floors by conditioned walkways and by a basement auditorium. It is connected to the existing building through a similar manner with services being routed along these walkways.

Lean

In general all building fabric elements and proposed systems have been matched to the notional building or improved upon where it was feasible. High efficiency gas fired boilers are used to provide additional heating and hot water, however the majority of this load is supplied by the CHP (Clean measure). High efficiency lighting fixtures and fittings will be specified across the whole development. A summary of some of the lean measures is presented in Table 5.

	New Build	Notional
Air tightness (m^3/m^2.h @ 50pa test pressure)	5	5
External Wall U Value (W/m^2.K)	0.20	0.26
Roof U Value (W/m^2.K)	0.135	0.18
Floor U Value (W/m^2.K)	0.12	0.22
Double Glazing U Value incl frame (W/m^2.K)	1.6	1.8
Rooflight U Value incl frame (W/m^2.K)	1.8	1.8

Table 5 Lean measures

A breakdown of the building energy consumption after inclusion of lean measures is shown below in Table 6.

Energy consumption	Notional (kWh/m^2/yr)	Actual (kWh/m^2/yr)
Heating	25.06	19.76
Cooling	2.34	3.53
Auxiliary	13.87	16.71
Lighting	14.5	17
Hot Water	59.22	66.93
TOTAL	**114.99**	**123.94**

Table 6 Energy breakdown

The above table demonstrates the difficulty in outperforming the notional building for a construction of this type. The notional building fabric has been matched if not improved upon in all areas, which is demonstrated by the low heating energy demand. Because of the mixed-use nature of the development, building services systems need to incorporate a wide range of demands and usage typologies. Installed plant therefore operates at a lower efficiency than if it was installed for a single building typology. This leads to a poorer performance in other energy consumption areas and a BER higher than the notion building TER at this stage of the energy hierarchy.

Clean

The CHP engine is used as a low carbon heating system and energy generation technology. Heat from a CHP engine is delivered at a lower efficiency than heat from a gas fired boiler, however this heat is generated as a by-product of electricity generation and it is the concurrent electricity generation which is also fed to the building which makes them a low carbon solution. Carbon emissions as a result of the CHP engine are presented in Table 7.

Lean BER (kgCO_2/m^2/yr)	Clean BER (kgCO_2/m^2/yr)	Percentage saving
36.4	28.4	22%

Table 7 Clean measures

Due to the complexity of the building and limitations of the modelling methodology a bespoke approach was used to accurately calculate the carbon savings due to the CHP engine. This process is explained in Appendix A.

Green

The photovoltaic panel installation on the roof contributes a small amount of renewable energy to the development. This is divided between all the elements of the building based on the floor areas. The contribution and associated carbon savings attributed to the new build mixed use area of the development are shown in Table 8.

Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings (kgCO_2/yr)
253	30,643	16,210

Table 8 Green measures

Unregulated energy

Unregulated energy for the development has been calculated from the 'equipment' load defined in the BRUKL output of the energy model. The results are shown in Table 9. This demand includes all unregulated energy demands as defined in the NCM (National calculation methodology) profiles for the applicable building typologies. The large un-conditioned public space at ground level to the north of the development is to have a large multimedia display installed comprising of 921 m^2 of LCD display screens. This load will be outside of the NCM profile unregulated emissions and has therefore been added separately.

Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
321.8 (75.7 without screens)	166.3 (39.1 without screens)	BRUKL and manual calculations for screens

Table 9 Unregulated energy

Summary

The Part L2A modelling results for the mixed use elements of the building are presented in Table 10 and Figure 13.

TFA (m^2)	TER ($kgCO_2/m^2/yr$)	BER ($kgCO_2/m^2/yr$)	Improvement
10,050	32.6	26.6	18%

Table 10 Summary

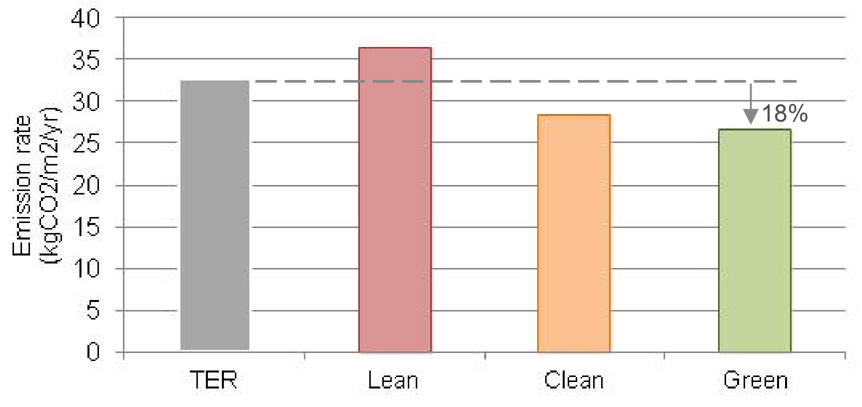


Figure 13 Summary Graph

As shown in Figure 13, with the application of both the proposed CHP and photovoltaics the St Giles Building far outperforms the notional Part L2A baseline building satisfying building regulation requirements; however the 25% improvement on the TER has not been achieved with only an 18% improvement. Due to the nature of the development this 25% improvement is considered very onerous. The mixed use nature of the development requires the services design to accommodate a wide range of demands and this is difficult to achieve above and beyond the notional building requirements. The CHP delivers significant carbon savings from the electricity generated, however this system has been optimised to the meet the required heat demands so no further carbon savings are available. Feasibility for renewable energy generation technologies is limited, with photovoltaics identified as the only viable option. An array is proposed to be installed on the available roofscapes, however this area is limited and has been used to its full potential.

4.3.2 Domestic

The new build domestic properties are located on the 5th floor of the south side of the development. A total of 3 dwellings are proposed to be constructed above the 6 dwellings which are to be refurbished as part of the scheme.

Lean

In general all proposed systems have been matched to the notional building or improved upon where this was felt feasible. The same specifications for the new build mixed use area have been used and a summary is presented in Table 5.

Clean

Carbon emissions as a result of the CHP engine are presented in Table 11.

Dwelling	Lean DER ($kgCO_2/m^2/yr$)	Clean DER ($kgCO_2/m^2/yr$)	Percentage savings
Unit 6 - 5th	18.6	9.3	50%
Unit 7 - 5th	16.0	7.8	50%
Unit 8 - 5th	17.3	8.3	50%

Table 11 Clean measures

Green

The generated electricity and associated carbon savings attributed to each of the dwellings from the roof mounted photovoltaic array previously described is shown in Table 12.

Dwelling	Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings ($kgCO_2/yr$)
Unit 6 - 5th floor	1.94	266.1	140.8
Unit 7 - 5th floor	2.84	386.3	204.3
Unit 8 - 5th floor	2.61	360.5	190.7

Table 12 Green measures

This information has been taken from the SAP calculations based on Part L1A modelling methodology. In reality it is anticipated that the output from this PV installation would be higher as the model assumes very conservative values for PV system efficiencies. For the St Giles development a higher specification photovoltaic system with greater panel and inverter efficiencies would be proposed to maximise the potential carbon savings.

Unregulated energy

Unregulated energy for the development has been calculated using Appendix L of the SAP 2009 document and is presented in Table 13. These values include catering, and it is assumed that electric hobs and ovens are used throughout.

Dwelling	Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
Unit 6 - 5th floor	37.0	19.1	SAP 2009 Appendix L
Unit 7 - 5th floor	32.5	16.8	SAP 2009 Appendix L
Unit 8 - 5th floor	33.7	17.4	SAP 2009 Appendix L

Table 13 Unregulated energy

Summary

The SAP calculation results for the new build domestic elements of the building are presented in Table 14.

Dwelling	TFA (m^2)	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	Improvement
Unit 6 - 5th floor	70.0	17.39	7.3	58%
Unit 7 - 5th floor	102.3	14.37	5.8	60%
Unit 8 - 5th floor	94.0	15.26	6.3	59%

Table 14 Summary

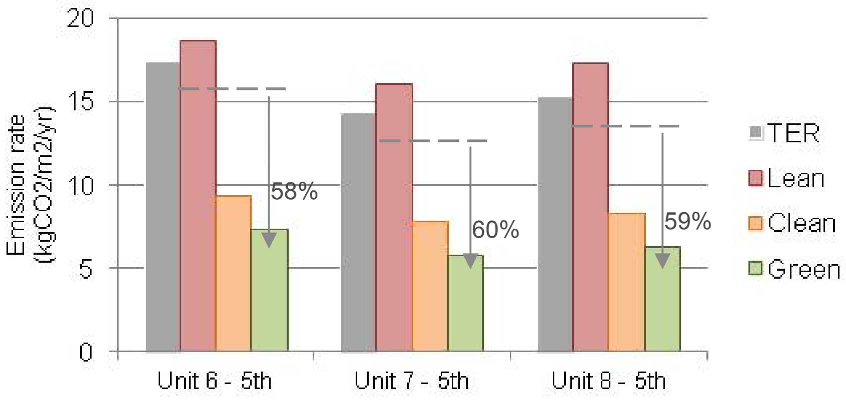


Figure 14 Summary Graph

For the three new build dwellings building regulation Part L1A requirements are satisfied with DER values below the TER. Additionally, as demonstrated above they all achieve the 25% improvement on 2010 Building Regulations as stipulated in Camden planning policy.

4.4 Refurbishments

4.4.1 Domestic

The domestic refurbishments are located across the 2nd, 3rd and 4th floors of the development. In total, 6 dwellings are included and they are all serviced from the central system (CHP, gas boilers, PV etc.)

Lean

Unlike the new build constructions, refurbishments do not have to outperform the calculated TER (target emission rate) calculated as part of the SAP modelling. Building regulations relevant to refurbishments dictate a set of minimum requirements where elements are upgraded or replaced. These requirements have been used to inform the design of the refurbished dwellings. A summary of some of the lean measures is presented in Table 15. Threshold Part L values refer to the limit on fabric performance where any building elements with worse thermal performance than this must be upgraded to the U-values presented in brackets.

	Refurbishment	Threshold Part L
Air tightness (m^3/m^2.h @ 50pa test pressure)	10	-
External Wall U Value (W/m^2.K)	0.3	0.7 (0.55)
Roof U Value (W/m^2.K)	0.50*	0.35 (0.18)
Floor U Value (W/m^2.K)	0.12	0.7 (0.25)
Glazing U Value incl frame (W/m^2.K)	1.6	1.8 (1.8)

Table 15 Lean measures (*roof refurbishment only present on listed building)

Clean

Carbon emissions as a result of the CHP engine are presented in Table 16.

Dwelling	Lean DER ($kgCO_2/m^2/yr$)	Clean DER ($kgCO_2/m^2/yr$)	Percentage savings
Listed unit - 1st to 3rd floor	30.2	12.9	57%
Unit 1 - 3rd floor	15.9	7.9	50%
Unit 3 - 3rd floor	13.3	6.5	51%
Unit 2 - 3rd floor	15.7	7.8	50%
Unit 4 - 4th floor	14.4	7.1	51%
Unit 5 - 4th floor	16.1	7.7	52%

Table 16 Clean measures

Green

The generated electricity and associated carbon savings attributed to each of the dwellings is shown in Table 17.

Dwelling	Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings ($kgCO_2/yr$)
Listed unit - 1st to 3rd floor	2.8	387.5	204.0
Unit 1 - 3rd floor	3.1	420.0	221.0
Unit 3 - 3rd floor	6.2	842.2	443.3
Unit 2 - 3rd floor	3.4	459.4	241.8
Unit 4 - 4th floor	3.4	461.8	243.0
Unit 5 - 4th floor	3.1	419.9	221.0

Table 17 Green measures

This information has been taken from the SAP calculations based on Part L1A modelling methodology. In reality it is anticipated that the output from this PV installation would be higher as the model assumes very conservative values for PV system efficiencies. For the St Giles development a higher specification photovoltaic system with greater panel and inverter efficiencies would be proposed to maximise the potential carbon savings.

Unregulated energy

Unregulated energy for the development has been calculated using Appendix L of the SAP 2009 document and is presented in Table 18. These values include catering, and it is assumed that electric cooking is used throughout.

Dwelling	Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
Listed unit - 1st to 3rd floor	32.6	16.8	SAP 2009 Appendix L
Unit 1 - 3rd floor	31.4	16.2	SAP 2009 Appendix L
Unit 3 - 3rd floor	21.8	11.3	SAP 2009 Appendix L
Unit 2 - 3rd floor	30.1	15.5	SAP 2009 Appendix L
Unit 4 - 4th floor	30.0	15.5	SAP 2009 Appendix L
Unit 5 - 4th floor	31.4	16.2	SAP 2009 Appendix L

Table 18 Unregulated energy

Summary

The SAP modelling results for the dwellings are presented in Table 19.

Dwelling	TFA (m^2)	DER ($kgCO_2/m^2/yr$)
Listed unit - 1st to 3rd floor	102.0	10.9
Unit 1 - 3rd floor	110.5	5.9
Unit 3 - 3rd floor	221.6	4.5
Unit 2 - 3rd floor	120.9	5.8
Unit 4 - 4th floor	121.5	5.1
Unit 5 - 4th floor	110.5	5.7

Table 19 Summary

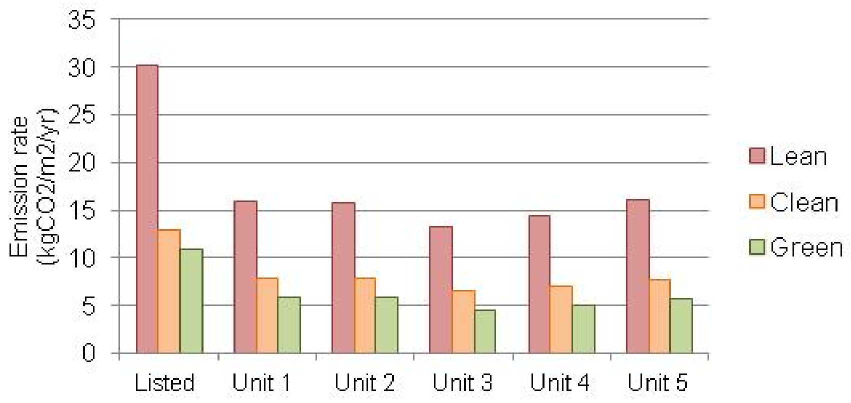


Figure 15 Summary Graph

All of the dwellings perform very well, and even though it is not a Building Regulations requirement they all display a 25% improvement over the TER value. For refurbishments the TER generated as part of the SAP calculation, is an especially onerous target as it compares the refurbished buildings to the requirements of a new build construction. However due to the carbon savings delivered from the PV and CHP these dwellings outperform the target. The target set out in Camden planning guidance is that 10% of the construction costs should be spent on improving the environmental performance. Because all of the systems are being re-fitted including central gas boilers and CHP it is anticipated that this will be comfortably exceeded.

4.4.2 Office

The office refurbishments are located on the southern side of the development across the 2nd floor of the building. The space is serviced from the central system (CHP, gas boilers, PV etc.) Hot water however is provided through point of use electric heated hot water outlets. Because offices have a very low hot water demand, installing significant lengths of pipework to provide hot water from the central system creates significant heat losses in the system as water sits in the pipes un-used for long periods of time. This significantly reduces the efficiency of such a system, and therefore electric point of use delivery provides the more efficient options as losses are eliminated entirely.

Lean

The same specifications for the domestic refurbishment units have been used and a summary is therefore presented in Table 15.

Clean

Carbon emissions as a result of the CHP are presented in Table 20.

Lean BER ($kgCO_2/m^2/yr$)	Clean BER ($kgCO_2/m^2/yr$)	Percentage saving
25.8	25.7	0.5%

Table 20 Clean measures

Green

The generated electricity and associated carbon savings attributed to the office area is shown in Table 21.

Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings ($kgCO_2/yr$)
9.5	1,265	670

Table 21 Green measures

Unregulated energy

Unregulated energy for the development has been calculated using the equipment demand from the NCM profiles in the dynamic simulation model. It is presented in Table 22

Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
43.5	22.5	NCM model

Table 22 unregulated energy

Summary

The modelling results for the office are presented in Table 23.

TFA (m^2)	BER ($kgCO_2/m^2/yr$)
342	23.9

Table 23 Summary

Figure 16 Summary Graph

Figure 16 shows how the carbon emissions of the office have been reduced through the proposed design. Due to the fact it is a refurbishment, there is no requirement to be below a particular TER. The carbon emissions rate is 7% lower than the TER for a new build office. As a new build office would be expected to have much better building fabric and envelope standards, these carbon emissions savings are largely due to the photovoltaics and the CHP engine. The planning target for 10% of the project cost to be spent on improving the environmental performance is very likely to be achieved with the full services re-fit.

4.4.3 Retail

The retail refurbishments are located at ground level along the southern side of the development. The space is serviced from the central system (CHP, gas boilers, PV etc.). Hot water however is provided through point of use electric heated hot water outlets. Retail units have a very low hot water demand, therefore installing significant lengths of pipework to provide hot water from the central system creates significant heat losses in the system as water sits in the pipes un-used for long periods of time. This significantly reduces the efficiency of such a system, and therefore electric point of use delivery provides the more efficient options as losses are eliminated entirely.

Lean

A summary of the lean measures proposed in the design is shown in Table 24.

	Refurbishment
Air tightness (m^3/m^2.h @ 50pa test pressure)	10
External Wall U Value (W/m^2.K)	0.3
Roof U Value (W/m^2.K)	0.50
Floor U Value (W/m^2.K)	0.12
Double Glazing U Value incl frame (W/m^2.K)	1.6
Single Glazing U Value incl frame (W/m^2.K)	10

Table 24 Lean Measures

Clean

Carbon emissions as a result of the CHP engine are presented in Table 25.

Lean BER ($kgCO_2/m^2/yr$)	Clean BER ($kgCO_2/m^2/yr$)	Percentage saving
40.1	34.7	13.5%

Table 25 Clean measures

Green

The generated electricity and associated carbon savings from the photovoltaic panels attributed to the retail is shown in Table 26.

Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings ($kgCO_2/yr$)
28.0	3,990	2,110

Table 26 Green measures

Unregulated energy

Unregulated energy for the development has been calculated using the equipment demand from the NCM profiles in the dynamic simulation model. The results are shown in Table 27

Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
11.5	5.9	NCM model

Table 27 Unregulated energy

Summary

The modelling results for the office are presented in Table 28.

TFA (m^2)	BER ($kgCO_2/m^2/yr$)
1008	32.6

Table 28 Summary

Figure 17 shows how the carbon emissions of the retail units have been reduced through the proposed design. Due to the fact it is a refurbishment, there is no requirement to be below a particular TER. Testament to the design, the carbon emissions rate is 7% lower than the TER for a new build retail unit. As a new build unit would be expected to have much better building fabric and envelope standards, these carbon emissions savings are largely due to the photovoltaics and the CHP engine. The planning target for 10% of the project cost to be spent on improving the environmental performance is very likely to be achieved with the full services re-fit.

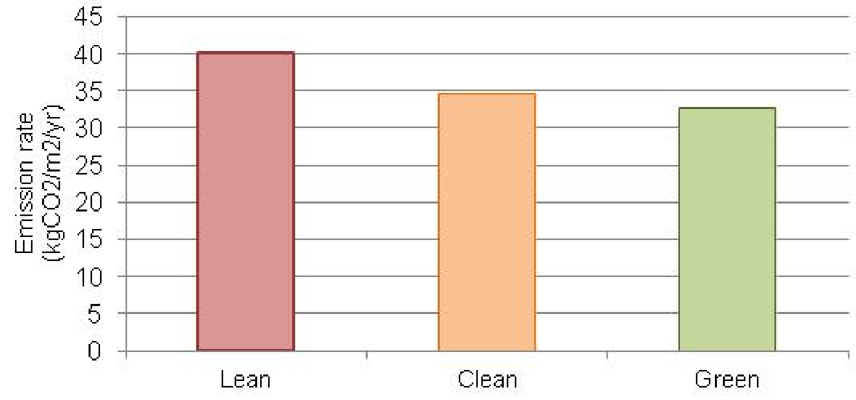


Figure 17 Summary Graph

4.5 Whole Building

In order to demonstrate how the whole building carbon emissions have been reduced through the Mean, Clean, Green approach, all of the separate building elements were modelled together within a dynamic simulation model. The results from this model will not co-ordinate with averaging out the reported DER and BER results because emissions values from different methodologies are not directly comparable. The results from this 'overall' model are to demonstrate the level of reduction achieved on a whole building basis.

Also included below is a baseline emissions rating. This is the generated TER from the dynamic simulation model and is based on the parameters of the notional building as defined when modelling to show building regulations compliance. This value is not a very accurate baseline, as it defines all of the refurbishment areas as required to meet new build requirements which is un-realistic. Regardless of this it is a good reference point to demonstrate that the building has a very good environmental performance. The baseline value is not applicable to a large part of the building, however it is still improved upon through efficient building design and inclusion of low and zero carbon technologies such as the PV array and the CHP engine. An overall improvement of 13% has been achieved compared to a new build TER.

Circus	Regulated CO_2 emissions (kg CO2/yr)	Emissions rate ($kgCO_2/m^2/yr$)
Baseline (TER)	435,975	31.1
Lean	514,479	36.7
Clean	400,929	28.6
Green (BER)	378,500	27

Table 29 Summary

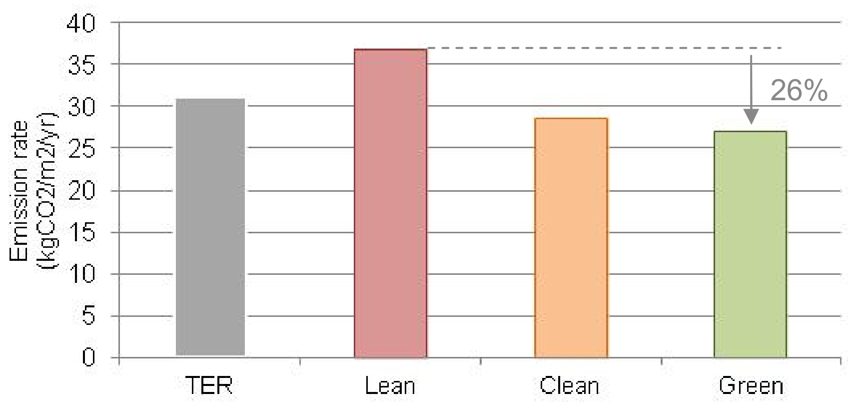


Figure 18 Denmark Place to Andrew Borde Street and Denmark Street North Summary

5 Denmark Street South

5.1 Site Context

Denmark Street South is a largely residential building located south of Denmark Street. It is comprised of many small building elements located within the plot, but they are all largely unconnected. It contains mostly dwelling refurbishments with one new build, restaurants, retail units and an office.

A large proportion of the buildings (see Figure 19) along Denmark Street on the south of the building is Grade 2 listed which means that heritage requirements can supersede Building Regulation Requirements, and the level of refurbishment which can be undertaken is restricted. The ground level units are only subject to very light touch refurbishment as part of this development, and due to this very minor intervention they have not been detailed individually within the following section however their emissions are included within the overall dynamic simulation model.

The residential units and the restaurant are subject to more extensive refurbishment works and so they have been treated individually in the following section, detailing the approach taken in line with the energy hierarchy.

A summary of the new build and major refurbishment elements considered in the following section is presented in Figure 19, Figure 20 and Table 30.

New build/refurbishment	Typology	Modelling
New build	Domestic	SAP
Refurbishment	Domestic	SAP
Refurbishment	Restaurant	Dynamic Simulation Model

Table 30 Typologies

Figure 19 South elevation from Denmark Street

Figure 20 West Elevation from Flitcroft Street

5.2 Site Wide Systems

CHP

As mentioned in Section 4, it was investigated during design development whether the CHP engine proposed for the Circus building could be expanded to deliver low carbon heat and electricity to the Denmark Street South building. Unfortunately this was established as un-feasible due to the disruption that would be caused in order to install a heat main below Denmark Street. A CHP engine to serve the Denmark Street South building exclusively is un-feasible due to the relatively small demand, space restrictions and the associated difficulty in retrofitting such a system.

Renewables

A feasibility study was carried out in order to identify the most suitable renewable options for the Denmark Street South building. Table 31 summarises the findings of this study.

Technology	Comments	Viability
Wind turbine	• Urban environment creates turbulence that significantly reduces and fluctuates the turbine output therefore not effective • Only very small-scale system would be viable – low carbon savings	
Biomass	• Considered building elements are disconnected • Centralised system unfeasible • Very difficult to retrofit a centralised system	
Air Source Heat Pump	• Minimal carbon savings compared to a condensing gas boiler • Air Source Heat pumps can only supply low temperature hot water which will still need boilers to meet the required temperatures for domestic hot water • Irregular roof areas available • Effective for spaces requiring heating and cooling (Restaurant)	
Ground Source Heat Pump	• No suitable ground area available	
Solar thermal	• Irregular roof areas for solar installations across most of the units • No room for plant areas • Centralised system unfeasible	
Solar PV	• Irregular roof areas for solar installations across most of the units • Flat roof available on the new build dwelling • Simple installation and maintenance, with very small plant space requirements	

Table 31 Feasibility study summary

5.3 New build

5.3.1 Domestic

One new build dwelling is to be constructed within the Denmark Street South building. It is located on the 4th and 5th floors above the refurbished dwellings at Number 4 Denmark Street.

Lean

Unlike the new build constructions, refurbishments do not have to outperform the calculated TER (target emission rate) calculated as part of the SAP modelling. Building regulations relevant to refurbishments dictate a set of minimum requirements where elements are upgraded or replaced. These requirements have been used to inform the design of the refurbished dwellings. A summary of some of the lean measures is presented in Table 32. All space heating and domestic hot water demands are met through a combi-boiler in the apartment. Threshold Part L values refer to the limit on fabric performance where any building elements with worse thermal performance than this must be upgraded to the U-values presented in brackets.

	New Build	Threshold Part L
Air tightness ($m^3/m^2.h$ @ 50pa test pressure)	5	-
External Wall U Value ($W/m^2.K$)	0.25	0.7 (0.55)
Roof U Value ($W/m^2.K$)	0.18	0.35 (0.18)
Floor U Value ($W/m^2.K$)	0.12	0.7 (0.25)
Glazing U Value incl frame ($W/m^2.K$)	1.8	1.8 (1.8)
Gas Boiler Winter Seasonal Efficiency	89.7%	N/A

Table 32 Lean measures

Green

Due to the listed building restrictions and irregularity of the roof, there is very limited scope for renewable energy technologies on the Denmark Street South building. The new build dwelling however has a large roof area, slightly inclined and orientated towards south which makes it a prime location for a photovoltaic panel installation. The system will not be visible from street level and should therefore not create any problems in relation to listed building planning restrictions for the adjacent building elements. The carbon savings are presented in Table 33

Dwelling	Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings ($kgCO_2/yr$)
4 Denmark St - 3rd and 4th	15	1,476	781

Table 33 Green measures

This information has been taken from the SAP documents generated by the Part L1A modelling methodology. In reality it is anticipated that the output from this PV installation would be higher as the model assumes very conservative values for PV system efficiencies. For the St Giles development a higher specification photovoltaic system with greater panel and inverter efficiencies would be proposed to maximise the potential carbon savings.

Unregulated energy

Unregulated energy for the dwelling has been calculated using Appendix L of the SAP 2009 document and is presented in Table 34. This value includes catering, and it is assumed that electric cooking is used.

Dwelling	Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
4 Denmark St - 3rd and 4th	32.1	16.6	SAP 2009 Appendix L

Table 34 Unregulated energy

Summary

The SAP modelling results for the dwellings are presented in Table 35.

Dwelling	TFA (m^2)	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	Improvement
4 Denmark St - 3rd and 4th	105.6	15.6	10.7	31%

Table 35 Summary

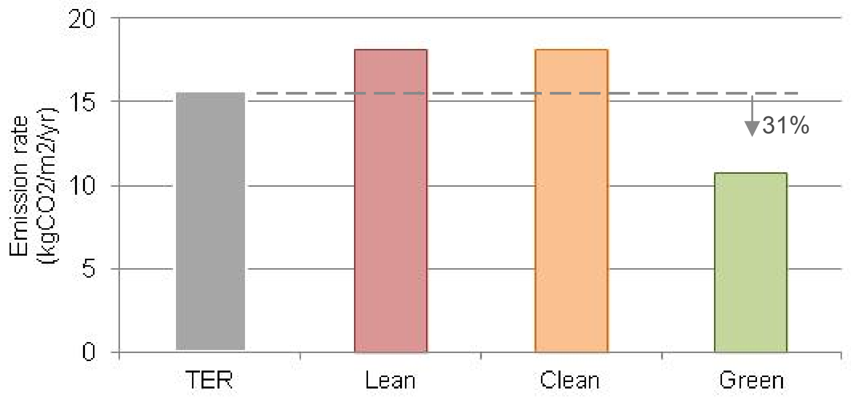


Figure 21 4 Summary Graph

The new build dwelling satisfies building regulation SAP requirements and as demonstrated above achieves the 25% improvement on 2010 Building Regulations. This is largely attributed to the 15m^2 PV array located on the roof.

5.4 Refurbishment

5.4.1 Domestic

Sixteen major dwelling refurbishments are located within the Denmark Street South development. These dwellings are located along Flitcroft and Denmark Street.

Lean

Unlike the new build constructions, refurbishments do not have to outperform the calculated TER (target emission rate) calculated as part of the SAP modelling. Building regulations relevant to refurbishments dictate a set of minimum requirements where elements are upgraded or replaced. These requirements have been used to inform the design of the refurbished dwellings. A summary of some of the lean measures is presented in Table 36. Threshold Part L values refer to the limit on fabric performance where any building elements with worse thermal performance than this must be upgraded to the U-values presented in brackets.

	Refurbishment	Part L Threshold
Air tightness (m^3/m^2.h @ 50pa test pressure)	10	-
External Wall U Value ($W/m^2.K$)	0.30	0.7 (0.55)
Roof U Value ($W/m^2.K$)	0.18	0.35 (0.18)
Floor U Value ($W/m^2.K$)	0.12	0.7 (0.25)
Glazing U Value incl frame ($W/m^2.K$)	1.8	1.8 (1.8)
Gas Boiler Winter Seasonal Efficiency	89.7%	N/A

Table 36 Lean measures

Unregulated energy

Unregulated energy for the development has been calculated using Appendix L of the SAP 2009 document, shown in Table 37. These values include catering, and it is assumed that electric cooking is used throughout.

Dwelling	Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
4 Denmark St - 1st and 2nd	33.2	17.1	SAP 2009 Appendix L
6 Denmark St - 1st	39.2	20.3	SAP 2009 Appendix L
7 Denmark St - 1st	39.3	20.3	SAP 2009 Appendix L
9 Denmark St - 1st	39.3	20.3	SAP 2009 Appendix L
10 Denmark St - 1st	39.4	20.4	SAP 2009 Appendix L
6 Denmark St - 2nd	39.2	20.3	SAP 2009 Appendix L
7 Denmark St - 2nd	39.3	20.3	SAP 2009 Appendix L
9 Denmark St - 2nd	39.5	20.4	SAP 2009 Appendix L
10 Denmark St - 2nd	39.8	20.6	SAP 2009 Appendix L
6 Denmark St - 3rd	39.2	20.3	SAP 2009 Appendix L
7 Denmark St - 3rd	39.0	20.2	SAP 2009 Appendix L
9 Denmark St - 3rd	38.5	19.9	SAP 2009 Appendix L
10 Denmark St - 3rd	39.5	20.4	SAP 2009 Appendix L
4 Flitcroft St - 1st	35.0	18.1	SAP 2009 Appendix L
4 Flitcroft St - 2nd	35.0	18.1	SAP 2009 Appendix L
4 Flitcroft St - 3rd	33.8	17.5	SAP 2009 Appendix L

Table 37 Unregulated energy

Summary

The SAP modelling results for the dwellings are presented in Table 38.

Dwelling	TFA (m^2)	DER ($kgCO_2/m^2/yr$)
4 Denmark St - 1st and 2nd	97.9	20.3
6 Denmark St - 1st	53.7	29.1
7 Denmark St - 1st	53.0	29.4
9 Denmark St - 1st	53.0	28.7
10 Denmark St - 1st	52.5	26.7
6 Denmark St - 2nd	53.7	26.2
7 Denmark St - 2nd	53.0	26.5
9 Denmark St - 2nd	51.9	26.5
10 Denmark St - 2nd	50.1	26.8
6 Denmark St - 3rd	53.8	30.3
7 Denmark St - 3rd	55.2	31.7
9 Denmark St - 3rd	58.4	29.9
10 Denmark St - 3rd	51.8	30.9
4 Flitcroft St - 1st	84.5	22.4
4 Flitcroft St - 2nd	84.8	22.0
4 Flitcroft St - 3rd	93.5	24.1

Table 38 Summary

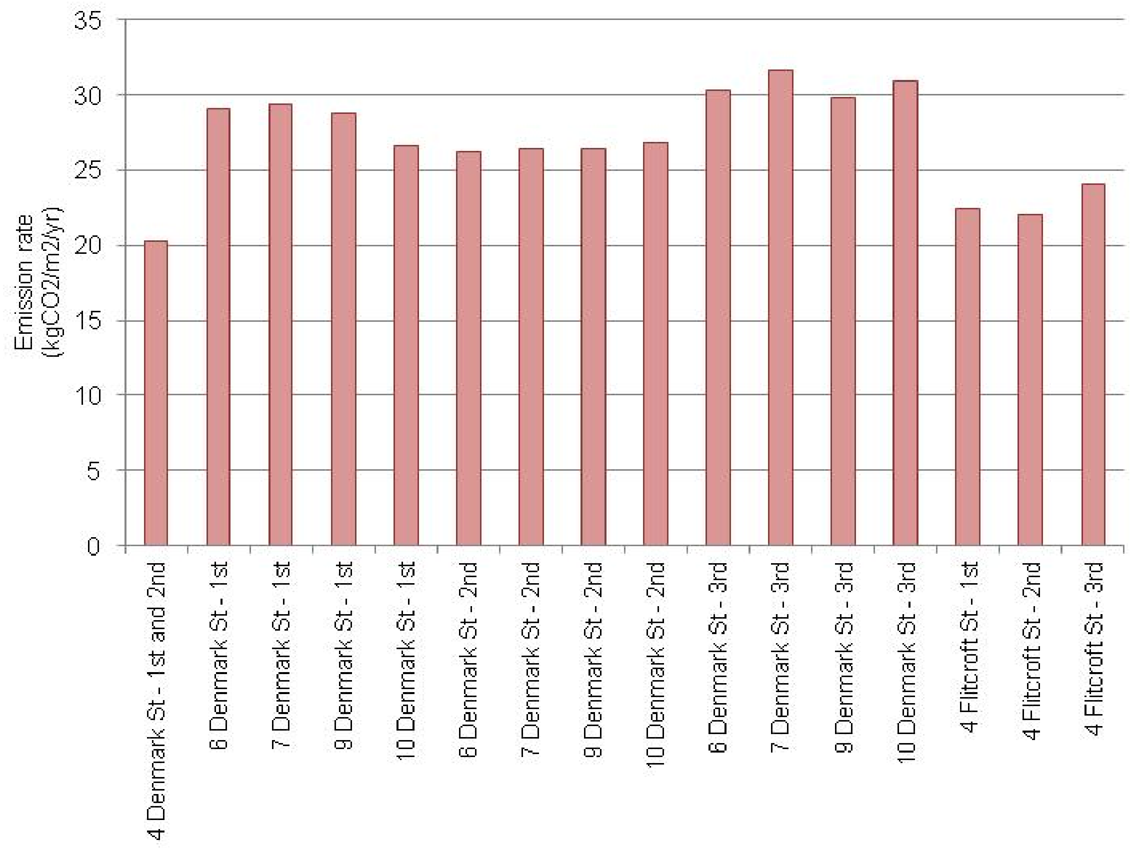


Figure 22 Summary Graph

All improvements have been made in line with Building Regulations Part L1B minimum requirements, and it is anticipated that because all of the services are being replaced over 10% of the project cost will be spent on environmental improvements in line with Camden planning policy. The modelled emission rates can be seen to be relatively high in comparison to other refurbished dwellings in the development; however this is due to the absence of CHP and renewable energy technologies. The roofscape offers very little potential for photovoltaics, and because of the disjointed building layout it was seen as preferable to supply all of the electricity generated from the new build dwelling PV panels exclusively to that dwelling to simplify the installation.

5.4.2 Restaurant

The major restaurant refurbishment, including an extension of the basement, is located along Flitcroft Street at ground level.

Lean

Unlike the new build constructions, refurbishments do not have to outperform the calculated TER (target emission rate) calculated as part of the SAP modelling. Building regulations relevant to refurbishments dictate a set of minimum requirements where elements are upgraded or replaced. These requirements have been used to inform the design of the restaurant. A summary of some of the lean measures is presented in Table 39. An air source heat pump system is used for space heating and cooling demands, electric storage water heaters provide hot water and a Mechanical Ventilation heat Recovery system provides ventilation with the kitchens on a dedicated supply and extract. Threshold Part L values refer to the limit on fabric performance where any building elements with worse thermal performance than this must be upgraded to the U-values presented in brackets.

	Refurbishment	Threshold Part L
Air tightness (m^3/m^2.h @ 50pa test pressure)	10	-
External Wall U Value (W/m^2.K)	0.30	0.7 (0.55)
Roof U Value (W/m^2.K)	0.18	0.35 (0.18)
Floor U Value (W/m^2.K)	0.12	0.7 (0.25)
Glazing U Value incl frame (W/m^2.K)	1.8	1.8 (1.8)
Air Source Heat Pump Heating efficiency	3.5	N/A
Air Source Heat Pump Cooling efficiency	4.0	N/A

Table 39 Lean measures

Green

Carbon emissions savings as a result of the air source heat pump are presented below in

Clean BER ($kgCO_2/m^2/yr$)	Green BER ($kgCO_2/m^2/yr$)	Percentage saving
111.6	108.9	2.5%

Unregulated energy

Unregulated energy for the development has been calculated using the equipment demand from the NCM profiles in the dynamic simulation model, and is presented in Table 40. These values include catering, and assumptions have been made regarding the proportion of gas and electric used within this.

Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
112.63*	40.3	NCM model

Table 40 Unregulated energy

*This include both gas and electric demands. Assumed to be 50% electric (ovens, appliances) and 50% gas (hobs).

Summary

TFA (m^2)	BER ($kgCO_2/m^2/yr$)
422	108.9

Table 41 Summary

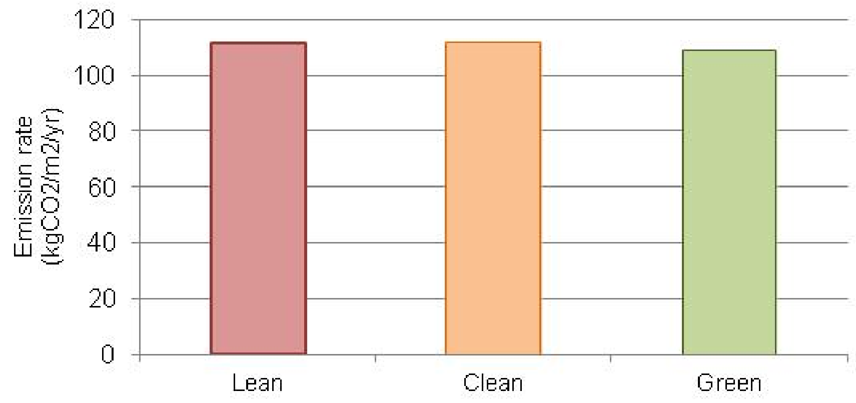


Figure 23 Summary Graph

All improvements to the building fabric and services have been made in line with Building Regulations Part L2B minimum requirements, and it is anticipated that because all of the services are being replaced over 10% of the project cost will be spent on environmental improvements in line with Camden planning policy.

5.5 Whole Building

The whole building emissions reported below include all of the major refurbishment elements, the new build dwelling, as well as all of the light touch refurbishments which were not considered individually in the section above. The carbon emissions were calculated using a dynamic simulation model, applying the relevant NCM profiles to all of the different typologies. A baseline has also been provided and this is based on the generated TER assuming all of the building elements are new build. Because almost the entirety of the building is refurbishment, with a large proportion of the elements listed and therefore very restricted with the level of improvements possible this is a very unrealistic value and has only been included for completeness. Note these whole building emissions rates include the light touch refurbishment units that have not been treated individually in this section.

With these listed building restrictions, no viable CHP system and a small amount of renewables there is a small improvement achieved through the Lean, Clean, Green approach.

Denmark Street South	Regulated CO_2 emissions (kg CO2/yr)	Emissions rate ($kgCO_2/m^2/yr$)
Baseline (TER)	35,647	69.8
Lean	62,612	122.6
Clean	62,612	122.6
Green (BER)	47,495	93.0

Table 42 Summary

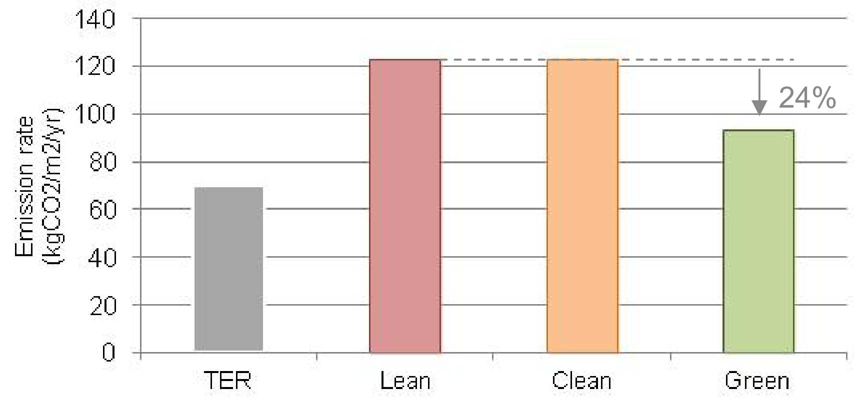


Figure 24 Denmark Street South Summary

Note: TER does not take into account the listed status of the buildings.

6 Endell Street

6.1 Site Context

Endell Street is a small development of 7 affordable dwellings located along Endell Street, East of the other buildings included in the planning application. All of the dwellings (Figure 25) are major refurbishments and therefore SAP modelling has been performed for all.

Figure 25 Endell Street Plan

6.2 Site Wide Systems

Renewables

A feasibility study was carried out in order to identify the most suitable renewable options for the Denmark Street South building. Table 43 summarises the findings of this study.

Technology	Comments	Viability
Wind turbine	• Urban environment creates turbulence that significantly reduces and fluctuates the turbine output therefore not effective • Only very small-scale system would be viable – low carbon savings	
Biomass	• Limited plant space available to house required large fuel store and engine • Delivery of biomass difficult, with limited space for large vehicle access and turning • Potential air and noise pollution issues • Difficult to retrofit to an existing building	
Air Source Heat Pump	• Minimal carbon savings compared to a condensing gas boiler • Air Source Heat pumps can only supply low temperature hot water which will still need boilers to meet the required temperatures for domestic hot water	
Ground Source Heat Pump	• No suitable ground area available	
Solar thermal	• Large roof areas available • Limited space available for plant rooms to house equipment • Available roof space is not centrally located complicating distribution and pipework	
Solar PV	• Large roof area available • Simple installation and maintenance, with very small plant space requirements	

Table 43 Feasibility Study Summary

PV

Following the feasibility study, 34m^2 of photovoltaic panels are proposed to be installed on the large roof area above the first floor. The available roof area is more expansive than this, however due to overshadowing risks from the adjacent buildings the array is restricted to the northern corner of the roof as shown in Figure 26. The panels have been laid out to account for access and maintenance, as well as to prevent overshadowing from the panels. All of the electricity generated from this array will be fed back to the power supply for the building, and consequentially the resultant carbon emission savings have been attributed to the apartments based on their TFA.

Figure 26 PV layout

6.3 Refurbishment

6.3.1 Domestic

The dwellings are spread over all 5 floors (including basement) of the building.

Lean

Unlike the new build constructions, refurbishments do not have to outperform the energy performance of a notional building. Building regulations relevant to refurbishment dictate a set of minimum requirements where elements are upgraded or replaced. These requirements have been used to inform the design of the refurbished dwellings. A summary of some of the lean measures is presented in Table 44. All space heating and hot water demands are met through efficient gas fired combi-boilers. Ventilation is supplied through window openings, with local extract fans for toilets/bathrooms. High efficiency lighting will be installed throughout.

	Refurbishment
Air tightness ($m^3/m^2.h$ @ 50pa test pressure)	10
External Wall U Value ($W/m^2.K$)	0.3
Roof U Value ($W/m^2.K$)	0.16
Floor U Value ($W/m^2.K$)	0.23
Double Glazing U Value incl frame ($W/m^2.K$)	1.6
Gas Boiler Winter Seasonal Efficiency	89.7%

Table 44 Lean measures

Green

The generated electricity and associated carbon savings attributed to each of the dwellings is shown in Table 45.

Dwelling	Area of PV allocated (m^2)	Electricity generated (kWh/yr)	Carbon savings ($kgCO_2$/yr)
Unit 1	4.1	567	300
Unit 2	3.3	455	241
Unit 3	5.8	790	418
Unit 4	6.1	833	440
Unit 5	4.1	558	295
Unit 6	3.8	524	277
Unit 7	6.8	927	490

Table 45 green measures

This information has been taken from the SAP documents generated by the Part L1B modelling methodology. In reality it is anticipated that the output from this PV installation would be higher as the model assumes very conservative values for PV system efficiencies. For the St Giles development a higher specification photovoltaic system with greater panel and inverter efficiencies would be proposed to maximise the potential carbon savings.

Unregulated energy

Unregulated energy for the development has been calculated using Appendix L of the SAP 2009 document and is presented in Table 46. These values include catering, and it is assumed that electric cooking is used throughout.

Dwelling	Unregulated energy ($kWh/m^2/yr$)	Carbon emissions ($kgCO_2/m^2/yr$)	Calculation methodology
Unit 1	37.6	19.4	SAP 2009 Appendix L
Unit 2	39.4	20.4	SAP 2009 Appendix L
Unit 3	34.1	17.6	SAP 2009 Appendix L
Unit 4	33.4	17.3	SAP 2009 Appendix L
Unit 5	37.8	19.5	SAP 2009 Appendix L
Unit 6	38.3	19.8	SAP 2009 Appendix L
Unit 7	31.9	16.5	SAP 2009 Appendix L

Table 46 Unregulated energy

Summary

The SAP modelling results for the dwellings are presented in Table 47.

Dwelling	TFA (m^2)	DER ($kgCO_2/m^2/yr$)
Unit 1	65.4	21.5
Unit 2	52.5	23.1
Unit 3	91.1	15.0
Unit 4	95.9	21.5
Unit 5	63.9	21.4
Unit 6	60.4	20.3
Unit 7	106.9	15.3

Table 47 Summary

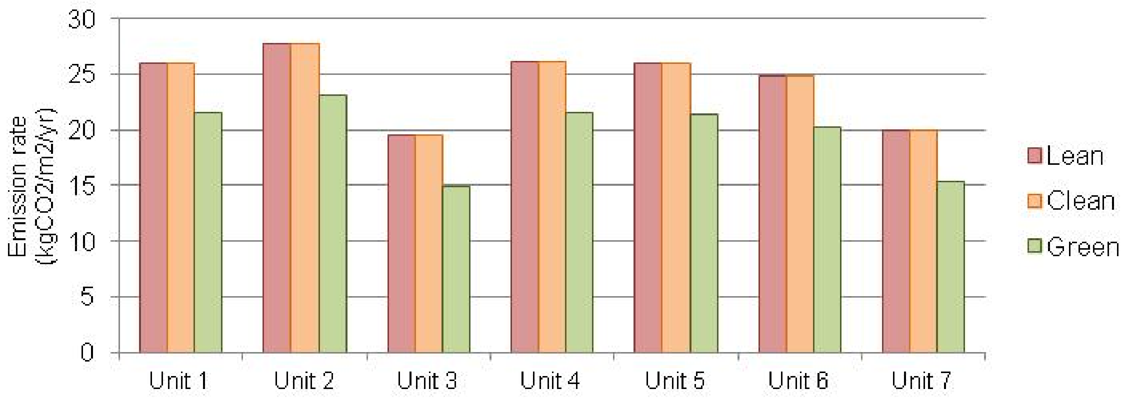


Figure 27 Summary Graph

All of the dwellings perform well considering they are refurbishments of an existing building, and some even surpass the SAP generated TER even though that is based on new build requirements. High fabric standards have helped to reduce demand as much as possible and the small amount of PV does provide some carbon emissions savings.

All improvements to the building fabric and services have been made in line with Building Regulations Part L1B minimum requirements, and it is anticipated that because all of the services are being replaced over 10% of the project cost will be spent on environmental improvements in line with Camden planning policy.

6.4 Whole Building

The Whole building emissions reported below includes all of the dwellings combined with the 34 m^2 PV array also included. The baseline value refers to the TER generated through the SAP calculations, based on new build requirements. As all of the dwellings have been modelled using SAP methodology a similar graphic could be produced based on those results, but to remain consistent between all three buildings it has again been modelled using a dynamic simulation model based on NCM profiles.

Endell Street	Regulated CO_2 emissions (kg CO2/yr)	Emissions rate (kgCO_2/m^2/yr)
Baseline (TER)	11,580	21.6
Lean	12,870	24.0
Clean	12,870	24.0
Green (BER)	10,670	19.9

Table 48 Summary

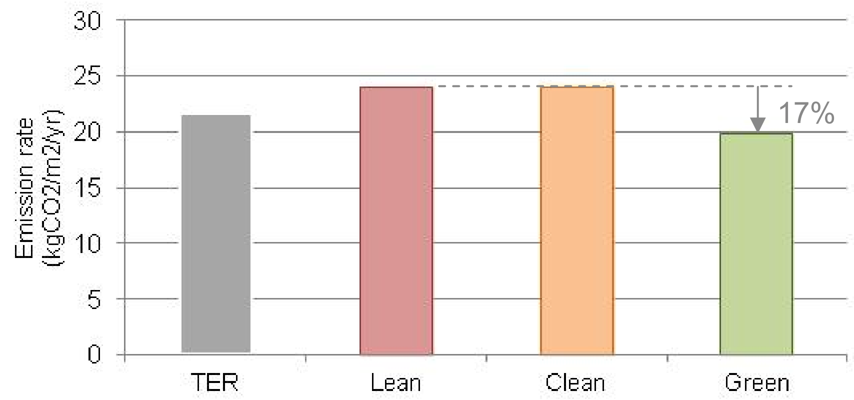


Figure 28 Endell Street Summary

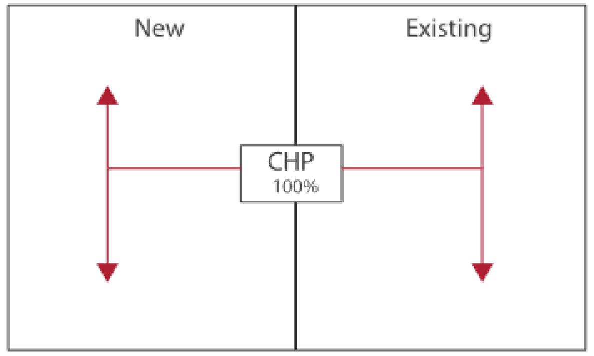
7 Conclusion

All buildings have demonstrated compliance with building regulations or refurbishment targets through the adoption of a Lean, Clean, Green hierarchical energy strategy. Even within the refurbished elements of the development where conservation listings and spatial limitations have reduced available options for energy improvement measures, measures have been taken to ensure that all available fabric and system efficiency upgrades are adopted. The application of a 200kWth CHP system to serve the Denmark Place to Andrew Borde Street and Denmark Street North developments and PV arrays across all the buildings further demonstrates the development's commitment to reaching both national and local requirements and targets. The only outstanding target currently unmet is the GLA's 25% CO_2 reduction target for the new build mixed use development of Denmark Place to Andrew Borde Street, which is demonstrated to currently achieve an 18% reduction. Currently all reasonable avenues for carbon reduction in relation to this target are considered to have been fully explored with the mixed use nature of the development and the limitation opportunities for the application of low carbon and renewable technologies.

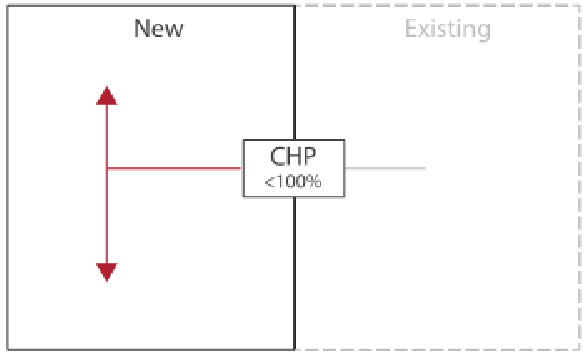
Appendix A CHP modelling methodology

The Denmark Place to Andrew Borde Street and Denmark Street North Building is comprised of many different elements which require individual energy models, therefore an unconventional approach was required to model the operation of the CHP engine. All dynamic simulation models have been run using IES (Integrated Environmental Solutions) software.

Typically a CHP engine can be input into an energy model as a system; with primary heat source as CHP and Gas Fired Boilers as the secondary heat source. In this instance an alternative approach was needed because the CHP engine is serving numerous different buildings which are each modelled separately. Running the dynamic simulation model for Part L2A for example, the model includes all new build elements of the Circus building. This is problematic as the CHP engine has been sized for the whole building, and therefore does not operate optimally as the heat load is smaller than what it was designed for during the Part L2A calculation.



Actual Set-up

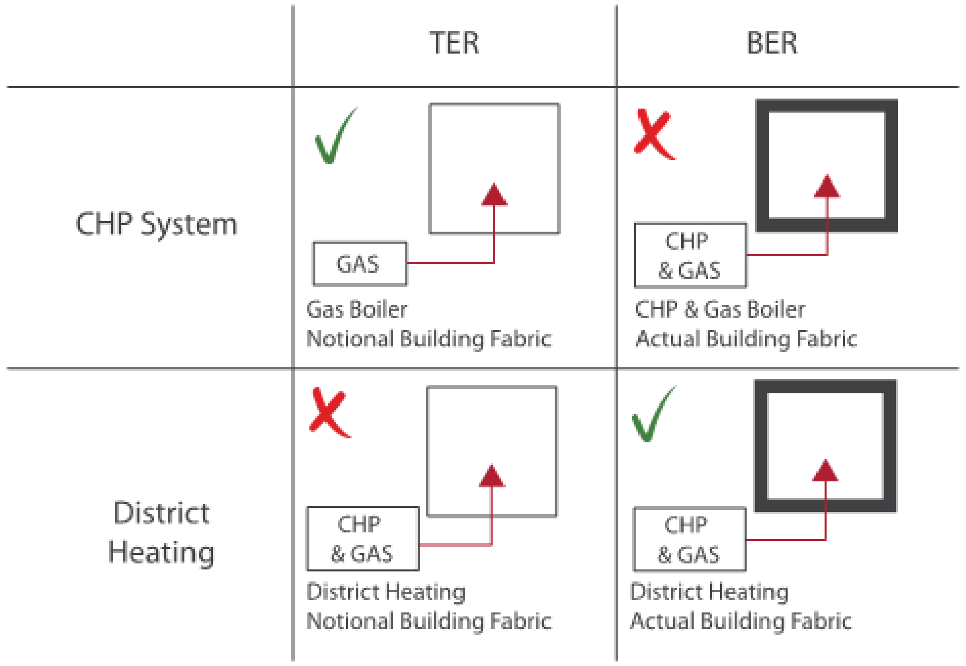


Part L2a Example Calculation

To overcome this problem, the CHP engine has been input into the energy model as the district heating option. This input only requires the carbon factors of the supplied heat to be specified, removing all complications of the system size and operation from the model . Carbon factors of the supplied heat have been based on the fact that 60% of all heat is supplied from the CHP, with the remaining 40% from the Gas Fired Boilers. This information was calculated from the EnergyPro model created in order to size the CHP engine (carbon factor calculations and EnergyPro outputs included). The actual percentage contribution from the CHP will vary between each of the building typologies, however this has been treated a valid assumption.

Using this workaround allows the Building Emissions Rate (BER) to be calculated accurately including all carbon emissions and savings from the CHP operation. Within these calculations as well as a BER, a Target Emissions Rate (TER) is also calculated. This TER is based on a notional building of the same form and function but with notional building fabric standards and services systems. The notional fabric is defined by the form of the building, however the notional systems vary depending on what systems have been specified in the design.

When modelling a CHP engine as a system input the Target Emission Rate (TER) for the notional building is calculated assuming gas fired boilers as the primary heat source. This recognises that CHP engines are a sustainable design measure and therefore this delivers improvements on the TER. Unfortunately, when using the district heating system to input the CHP the definition of the TER matches the district heating system as this would likely be a system supplying multiple developments and therefore be beyond the design scope of one building. For this reason the TER generated when calculating the BER, is inaccurate and penalises the building by ignoring the savings achieved through the specification of a CHP engine. Therefore to accurately show the savings achieved, a TER needs to be generated which includes gas fired boilers as the primary heat source. For this reason there are 2 individual Part L2A calculation outputs, one incorporating district heating to accurately calculate the BER, and one including gas fired boilers to accurately represent the TER.



Appendix B Modelling Summary

The table below summarises what was included in each modelling run, to produce the carbon emissions at each stage of the Lean, Clean, Green approach to energy.

	TER							Lean							Clean							Green						
	Notional Construction	Actual Construction	Gas Boilers	CHP + Gas Boilers	Electric Calorifier DHW	Solar Photovoltaics	Air source heat pump	Notional Construction	Actual Construction	Gas Boilers	CHP + Gas Boilers	Electric Calorifier DHW	Solar Photovoltaics	Air source heat pump	Notional Construction	Actual Construction	Gas Boilers	CHP + Gas Boilers	Electric Calorifier DHW	Solar Photovoltaics	Air source heat pump	Notional Construction	Actual Construction	Gas Boilers	CHP + Gas Boilers	Electric Calorifier DHW	Solar Photovoltaics	Air source heat pump
Denmark Place to Andrew Borde Street and Denmark Street North (All Buildings)																												
Denmark Street South - Domestic New																												
Denmark Street South - Domestic Refurbishment																												
Denmark Street South - Restaurant																												
Endell Street (All Units)																												

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