TWIN EARTH

Energy Statement for
17 Charterhouse Street

On behalf of: Anglo American and De Beers

August 2017

DOCUMENT CONTROL

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EXECUTIVE SUMMARY

This Energy Statement sets out the approach to minimising energy demands and supplying clean, low carbon power to the proposed redevelopment of 17 Charterhouse Street, London. The assessment has been developed by Twin&Earth for Anglo-American and DeBeers (the applicant) in support of the application for planning permission which will be submitted to the London Borough of Camden.

The proposed redevelopment comprises extensions to the office building to provide 3,700 sqm net additional office floorspace (Class B1a) - including part two-storey and part five-storey extensions within the central courtyard; a single storey roof extension; and demolition of existing floorspace. The building will be remodelled through the part removal of the existing façade and part replacement with new glazed, metal and stonework façade. Access alterations include redesign of the existing pedestrian entrance and relocation of the vehicular entrance on Charterhouse Street. Existing plant and equipment will be remodelled and replaced. The building comprises three ‘blocks: Charterhouse Street block and the Saffron Hill Block, which were originally constructed in 1979, and The Extension, which was constructed in 2003.

This report has been developed with the aim of summarising the proposed energy strategy for the development to demonstrate how this achieves compliance with the planning requirements for both new and refurbished elements. The energy strategy follows the structure set out in the Greater London Authority (GLA) guidance on preparing energy assessments (March 2016).

Figure 1. Proposed Charterhouse Street elevation (MCM Architects)

Regulation and planning policy context

The energy strategy responds to the requirements set out in the current building regulations including Part L (Conservation of Fuel and Power in buildings), and the GLA and London Borough of Camden’s sustainable development policies and guidance. Specifically, the proposed development has been assessed against the policies and guidance set out in The London Plan (March 2016), the Mayor of London’s Sustainable Design and Construction Supplementary Planning Guidance (April 2014), Camden Local Plan (Adopted 2010), Camden Local Plan (Adopted June 2017) and Camden Planning Guidance (CPG 3 – Sustainability). The main policies that have been considered in this statement are:

Camden Local Development Framework:

- Policy CS13: Tackling climate change through promoting higher environmental standards
- Policy DP22: Promoting sustainable design and construction

Camden Local Plan:

- Policy CC1: Climate change mitigation

The London Plan:

- Policy 5.2: Minimising carbon dioxide emissions
- Policy 5.3: Sustainable design and construction
- Policy 5.5: Decentralised energy networks
- Policy 5.6: Decentralised energy in development proposals
- Policy 5.7: Renewable Energy
- Policy 5.9: Overheating and cooling

As the development comprises the extension and major refurbishment of the Charterhouse Street and Saffron Hill Blocks and upgrading of existing plant and equipment in the 2003 Extension, compliance must also be demonstrated against the following building regulation requirements:

Charterhouse Street and Saffron Hill Block:

- Extended areas: Must meet the minimum requirements set out in Part L2A 2016, including compliance with criterion 1 (carbon emissions target) and criterion 3 (solar gain target)
- Refurbished areas: Minimum thermal performance and building services efficiency standards as set out in Part L2B 2016

The Extension Block:

- Refurbished areas: Minimum building services efficiency standards as set out in Part L2B 2016

Proposed Energy Strategy

The energy strategy for the development has been developed using the following energy hierarchy:

1. **Be Lean:** The development should use less energy by adopting passive design principles to limit space heating, cooling, ventilation and lighting energy demands. Any building services that are incorporated including space heating, domestic hot water, ventilation and lighting must be energy efficient.
2. **Be Clean:** Where feasible, the development should connect to low carbon heating infrastructure. This includes consideration of district heating and combined heat and power (CHP).
3. **Be Green:** Where feasible, the development should integrate renewable energy systems to meet the demands of the development. This includes consideration of technologies which complement the connection to low carbon heating infrastructure (where applicable) and includes photovoltaic panels (PV), biomass heating, solar hot water panels (SHW), heat pumps and wind turbines.

The following summarises the proposed energy measures for the development:

Energy Efficient Design (Be Lean):

The energy strategy prioritises passive design measures, taking into account some of the limitations imposed by the existing building form and location. Energy efficient features include:

- Improved U-values for both opaque and transparent elements. U-values of all replaced elements (windows, walls, roof, floors) will be lower than the maximum allowable under both building regulation Part L2A (New Construction) and Part L2B (Existing Construction).
- Solar control glazing, balancing passive solar control versus overheating and controlling thermal comfort;
- High light transmittance glazing to maximise daylight;
- Mixed mode ventilation in the ground floor restaurant area through incorporation of low and high level openings;
- The façade design incorporates deep reveals, providing both vertical and horizontal shading to limit cooling loads;
- Specification of high efficiency lighting systems based on LED technology;
- Presence detection on lighting controls in occupied areas;
- Daylight dimming in perimeter office areas.
- Low energy, variable volume fans;
- Heat recovery integrated into ventilation system main Air Handling Units (AHU);
- Efficient Fan Coil Units (FCU) utilising ec-dc variable speed motors;

Heating infrastructure (Be Clean):

Evaluation of the Be Clean scenario has been undertaken following the hierarchy established by the London Plan policy 5.6 as follows:

1. **Connection to existing heating or cooling networks -** The development is located near to the Citigen energy centre. Following dialogue with the operators (E.On), it is understood that there are significant connection costs and technical constraints of connecting the site to the network, mainly as a result of crossing Farringdon Road which poses a number of hurdles including Cross Rail, the River Fleet culvert, and gas, water and power utilities. As a result, connection to Citigen is considered to be unviable within the timescales of the project. However, the design will incorporate capped connections to allow for future connection to a district heating network.
2. **Site wide CHP network -** Installation of a CHP unit on site has also been considered, but is considered to be unviable due to the lack of a consistent year-round base heating load.
3. **Enabling future connection to DH –** In order to facilitate future connection to the Citigen (or alternative) district heating network, a centralised water based system is proposed to provide space heating and Domestic Hot Water (DHW). An area has been allocated within the existing plant room for a heat exchanger and capped connections that will allow for ease of connection in the future.

Renewable Energy (Be Green):

A feasibility study to evaluate the potential for installation of renewable technologies has been completed. Below is a summary of the conclusions:

- Air to water heat pumps are proposed to meet the base space heating loads in the Charterhouse Street / Saffron Hill Blocks. Chilled (CHW) and low temperature hot water (LTHW) will be provided to fan coil units from roof mounted heat pumps. The proposed system will provide both heated and chilled water within a single unit. A thermal load analysis of the building demonstrates that the building has simultaneous heating and cooling loads for a majority of the year, partly as a result of the highly shaded lower ground floor, more exposed upper floors and hot water demands of the central kitchen and changing facilities. By adopting a combined heat pump, the system can recover heat from areas of the building that have a cooling and direct the heat back to areas with space heating demands. Any surplus heat will also be used to pre-heat the hot water supply to the kitchens and changing room areas.
- A solar analysis study indicates that the roof areas above the Saffron Hill block and St Andrews House and in front of the plant screen facing Charterhouse Street would be suitable for PV panels. The following panels are proposed:
    - Saffron Hill Block (roof): 37 panels at 30° pitch
    - Saffron Hill Block (plant room): 8 panels mounted vertically in front of the plant screen
    - Charterhouse Block (plant room): 52 panels mounted vertically in front of plant screen
    - St Andrews House: 40 panels at 30° pitch
- Wind energy, biomass heating and solar thermal heating are considered unfeasible as a result of either the higher carbon savings of alternative systems (e.g PV), storage, supply and air quality impacts (biomass) and visual, vibration and noise impacts (wind turbines) .

Site wide performance against targets

All efforts have been made to minimise carbon emissions associated to the building following a be lean, be clean, be green approach.

In addition, the development has been future proofed for connection to a district heating network. A centralised water based system served by highly efficient air source heat pumps in the Charterhouse / Saffron Hill block is proposed which will lead to a reduction in carbon emissions, localised NOx emissions from the building, and allow easy connection to a District Heating network if routed past the site in the future.

Although, the development should aim for a 20% on site renewable energy supply, this is not possible due to site constraints. However, a robust strategy has been provided that achieves the following for the site as a whole:

- A 34.2% reduction in carbon emissions against the baseline emissions.
- Cumulative carbon emissions savings of 180.9 tonnes CO_2 when compared against the baseline emissions.
- Carbon emissions savings from renewable energy of 5.4%

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line	530
After energy demand reduction	369
After CHP / heat network connection	369
After renewable energy	349
% Improvement over baseline	**34.2%**

Table 1. Cumulative carbon emissions reductions for the site as a whole

Regulated CO_2 Savings	Tonnes per annum	% over previous stage	% over Baseline
Savings from Energy demand reduction	161.1	30.4%	30.4%
Savings from CHP / heat network connection	0.0	0.0%	0.0%
Savings from renewable energy	16.8	5.4%	3.7%
Total Cumulative Savings	180.9		34.2%

Table 2. Regulated carbon savings per annum for each stage of the energy hierarchy - for the site as a whole

Carbon Offset

As the 35% carbon emissions reduction target hasn't been completely met on site, the carbon emissions shortfall has been calculated to be 4.5 tonnes per annum, or 134 tonnes over 30 years.

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	185.4	
Shortfall	7.5	134

Table 3. Shortfall in carbon emissions against the 35% target

Based on a cost of carbon of £60 per lifetime tonne, the carbon offset is £8,100.

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1. INTRODUCTION

1.1 Purpose of the report

This report sets out the approach to minimising energy demands and supplying clean, low carbon energy to the proposed redevelopment of 17 Charterhouse Street, London. The assessment has been developed in support of the application for planning permission which will be submitted to the London Borough of Camden.

The following sections detail the proposed energy strategy and demonstrates the holistic approach taken to ensure the building has both architectural merit whilst ensuring low energy demands and carbon emissions in line with current regulatory and planning policy requirements. The energy strategy follows the structure set out in the Greater London Authority (GLA) guidance on preparing energy assessments (March 2016).

1.2 Description of proposed development

The site is located on the northern side of Charterhouse Street and forms part of a group of three buildings all owned by Anglo-American and DeBeers (AADB) which surround a central courtyard. The application site concerns the main building (17 Charterhouse Street) which is seven storeys plus basement and has been extended to the north along Saffron Hill in 2003. This building has 3 main elements, the main part facing Charterhouse Street (Charterhouse Street block), the secondary wing which fronts Saffron Hill (Saffron Hill block), and the extension further to the north fronting Saffron Hill (the Extension).

Other buildings owned by AADB but not forming part of this proposal at present are: a four storey Grade II listed St. Andrew's House which comprises ancillary residential accommodation associated with the main office use which bounds the westerns side of the courtyard; and a three storey plus basement building (6 and 6a Bleeding Heart Yard) which forms the northern boundary of the courtyard.

The site is located within the Central Activity zone of Hatton Garden. The area is London and the UK's largest jewellery district and has been established as a centre for the jewellery and diamond trade since the 19th century. Today the area is home to nearly 500 businesses and over 50 shops related to the industry. The application site is located in the eastern part of Hatton Garden which is characterised by large scale office buildings.

The proposed redevelopment comprises the creation of an infill extension to the rear of the existing Charterhouse Block, infill of the eastern portion of the courtyard adjacent to the Saffron Hill Block, addition of a recessed fifth floor extension to the Saffron Hill Block, addition of a plant room above the Charterhouse Street block and replacement of all existing facades with the exception of the 2003 extension. All plant and equipment, including sources of heat and cooling, and ventilation and lighting systems will be replaced within the entirety of the development.

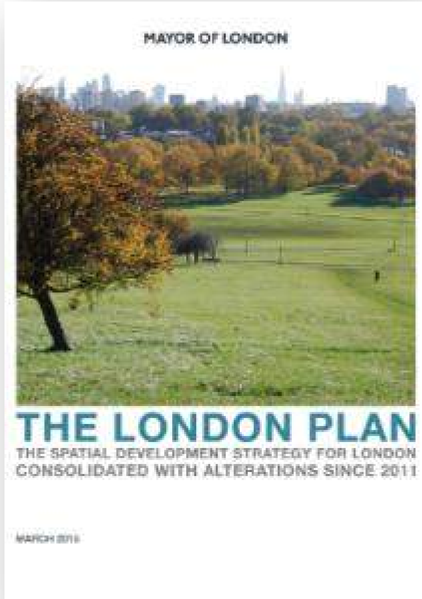
Figure 2. Existing Charterhouse Street elevation

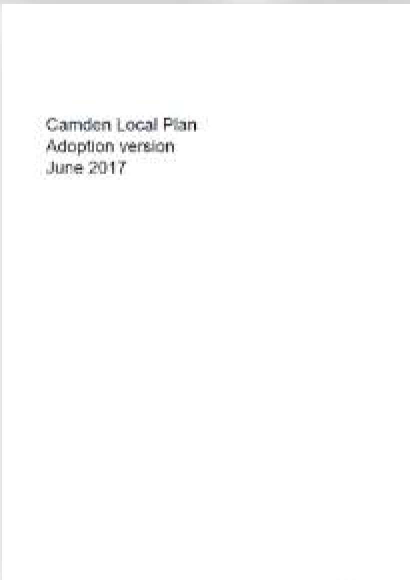
2. POLICY FRAMEWORK

2. POLICY FRAMEWORK

This section summarises the national and local planning policy and regulations applicable to the development. Polices on sustainable design and construction are set out in the following:

- National Planning Policy Framework
- London Plan March 2015 (FALP)
- London Borough of Camden planning policies





2.1 National Policy & Regulation

National Planning Policy Framework

The National Planning Policy Framework (NPPF) was published on 27 March 2012 as a key part of Government reforms to make the planning system less complex and more accessible, to protect the environment and to promote sustainable growth. Planning Practice Guidance (PPG) was published by the Government on 6 March 2014 and provides guidance on the implementation of the NPPF policies. The NPPF and the PPG outline the Government's planning policies for England to support Local Authorities on the development of local planning policies.

Building Regulation Part L

Building regulation Part L considers 'conservation of fuel and power' in both existing and new buildings, and in both domestic and non-domestic buildings. The latest version of the regulations that are applicable to the development are:

- Part L2A (Conservation of fuel and power in new buildings other than dwellings) – 2013 edition with 2016 amendments
- Part L2B (Conservation of fuel and power in existing buildings other than dwellings) – 2010 edition incorporating 2010, 2011, 2013 and 2016 amendments.

The regulations set minimum performance standards for the building fabric thermal efficiency, building services and also set targets for CO_2 emissions in new buildings and/or large extensions. As with most local authorities within England, Camden and the London Plan specify the Part L CO_2 assessment methodology as the basis for setting carbon emissions targets.

2.2 London Plan

The London Plan (March 2016) is the overall strategic plan for London which sets out an integrated economic, environmental, transport and social framework for the development of London over the next 20–25 years.

The plan brings together the geographic and locational (although not site specific) aspects of the Mayor's other strategies including those dealing with: Transport, Economic Development, Housing, Culture, Social issues and Environment including climate change (adaptation and mitigation), air quality, noise and waste.

Guidance on how to demonstrate compliance with sustainability policies within the London Plan is contained in the Mayor of London's Sustainable Design and Construction SPG (April 2014). The SPG contains best practice guidance on how to meet the sustainability targets set out in the London Plan, and provides examples of how to implement sustainability measures within developments.

- The London Plan includes a range of policies that relate to low energy and low carbon design including:. Policy 5.2: Minimising carbon dioxide emissions
- Policy 5.3: Sustainable design and construction
- Policy 5.5: Decentralised energy networks
- Policy 5.6: Decentralised energy in development proposals
- Policy 5.7: Renewable Energy
- Policy 5.9: Overheating and cooling

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2.3 Local Policy

Local planning policy is set out in the London Borough of Camden's Local Development Framework, and the recently adopted Local Plan (June 2017). Applicable energy policies include:

Camden Local Development Framework:

- Policy CS13: Tackling climate change through promoting higher environmental standards
- Policy DP22: Promoting sustainable design and construction

Camden Local Plan:

- Policy CC1: Climate change mitigation

Further information on the specific requirements if the policies, and how these should be addressed with the energy statement is set out within Camden Planning Guidance (CPG 3) – Sustainability.

Policy DP22 states that the following points must be considered:

Design:

- The layout of uses
- Floorplates size / depth
- Floor to ceiling heights
- Location, size and depth of windows
- Limiting excessive solar gain
- Reducing the need for artificial lighting
- Shading methods, both on or around the building
- Optimising natural ventilation
- Design for and inclusion of renewable energy technology

Fabric / Services:

- Level of insulation
- Air tightness
- Efficient heating, cooling and lighting systems
- Effective building management system
- The source of energy used
- Metering

2.3.1 Camden Planning Guidance (CGP) 3 – Sustainability

CPG 3 provides guidance on how development should be designed to limit energy demands and carbon emissions. The following sets out what the council expect:

Energy Efficiency: New Buildings:

- All new developments are to be designed to minimise carbon dioxide emissions by being as energy efficient as is feasible and viable.
- A full model of the building should be carried out to ensure the building design optimises solar gain and daylight without resulting in overheating for developments comprising 5 dwellings or more or 500sq m or more of any floorspace
- Consider maximising the use of natural systems within buildings before any mechanical services are considered.
- Any development proposing electric heating (including heat pumps) will need to demonstrate the carbon efficiency of the proposed heating system. Specifications of the electric heating system and calculations will need to be provided to demonstrate that the proposed electric heating system would result in lower carbon dioxide emissions than an efficiency gas fuelled heating system.
- Where traditional mechanical cooling e.g. air conditioning units are proposed applicants must demonstrate that energy efficient ventilation and cooling methods have been considered first, and that they have been assessed for their carbon efficiency.

Energy Efficiency: Existing Buildings:

- All buildings, whether being updated or refurbished, are expected to reduce their carbon emissions by making improvements to the existing building. Work involving a change of use or an extension to an existing property is included. As a guide, at least 10% of the project cost should be spent on the improvements.
- Where retro-fitting measures are not identified at application stage we will most likely secure the implementation of environmental improvements by way of condition.
- Development involving a change of use or a conversion of 5 or more dwellings or 500sq m of any floorspace, will be expected to achieve 60% of the un-weighted credits in the Energy category in their BREEAM assessment
- Special consideration will be given to buildings that are protected e.g. listed buildings to ensure that their historic and architectural features are preserved.

Decentralised energy networks and combined heat and power:

- Energy strategies are to be designed following the steps set out by the energy hierarchy (Be Lean, Clean, Green)
- Where there is more than one occupier, use or building a community heating network will be expected.
- When demonstrating the feasibility and viability of not connecting to a decentralised energy network or including a combined heat and power plant developers will be required to address the relevant considerations including size of the development; distance to existing network pipes; physical barriers e.g. roads or railways; other developments in the vicinity that may also be required to connect to the network; other buildings in the area that are willing to connect/take heat; other building in the area in the same ownership or occupation as the lead development that have a heating load; cost of connection; any grants available; any specific technical compatibility issues; and the business/expansion plan of the network operator.
- Where a development is not connecting immediately to a network the following measures need to be included in your scheme:

- space in the plant room for a heat exchanger, any other plant and pipe and electricity connections; and
- pipes from the plant room to the property boundary where the decentralised energy pipe is most likely to be located.

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.
- Special consideration will be given to heritage buildings and features to ensure that their historic and architectural features are preserved.
- 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.

2.3.2 Pre-Application Advice

Pre-Application feedback from Camden Development Control (Planning Services) was received on 7 June 2017. The feedback includes the following relating to energy use and carbon emissions:

- Follow the hierarchy of energy efficiency, decentralised energy and renewable energy technologies set out in the London Plan to secure the following carbon targets:
    - A minimum of 35% reduction in regulated CO2 emissions below the maximum threshold allowed under Part L 2013. Where any refurbished parts are considered to be a 'deep' refurbishment and therefore assessed under Part L2A, it will need to meet the 35% reduction target for a new build.
    - The fullest contribution to CO2 reduction in the refurbished parts of the development. In particular, improvements should be sought on the minimum building fabric targets set in Part L of the building regulations
- GLA Guidance on preparing energy statements and CPG3 should be followed. The new build parts and refurbished parts should be presented separately within the energy statement and a combined site wide CO2 reduction target also provided.
- All developments are required to achieve a 20% reduction in CO2 emissions through renewable technologies
- Where the London Plan carbon reduction target cannot be met on-site, we may accept the provision of measures elsewhere in the borough or a financial contribution (charged at £60/tonne CO_2/yr over a 30 year period).
- The development should undertake measures to reduce overheating risk and reliance on cooling, and demonstrate in the Energy and Sustainability Statement how the Mayor's Cooling Hierarchy has been followed.
- The development should engage with Citigen to assess if there is enough capacity to connect to this network.
- The development should primarily seek to connect to an existing network. If this is not possible (and an alternative energy strategy is not possible) and proposes CHP instead, then the applicant will be required to demonstrate that it is technically and economically feasible and suitable for the development. This will include submission of details on the heat and electricity demands of the site, and further details on how the CHP will operated to meet these demands. also expect applicants to consider economic feasibility and how the CHP will be maintained and operated and any electricity exports to the grid. The design of the network to be in line with CIBSE Code of Practice. Additionally, a detailed air quality assessment will be required for all schemes proposing CHP.

2.4 Additional Policy References

2.4.1 BREEAM

BREEAM is being used as a benchmarking tool in the design of the development. As the development comprises both refurbished and newly constructed elements, the building is being assessed using the 'bespoke' credit criteria. Due to the timescales to confirm the criteria with the BRE, the pre-assessment issued as part of the Sustainability Statement has been based on the New Construction 2014 BREEAM methodology. In the interim, the development has therefore been assessed against the methodology in Ene01 (New Construction 2014) which assesses the number of credits based on the following performance details which are detailed on the final BRUKL report:

- Heating and Cooling Energy Demand (MJ/m^2 yr)
- Primary energy consumption (kWh/m^2 yr)
- Building Emissions Rate (BER) / Target Emissions Rate (TER)

3. ENERGY STRATEGY

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3.1 Approach to the Energy Strategy

This section summarises the considerations made and technologies proposed to reduce the energy consumption and to minimise carbon emissions associated with the development's operational energy.

The strategy has been developed following the 'Be Lean', 'Be Clean', 'Be Green' energy hierarchy as set out in The London Plan, Policy 5.2 (Minimising Carbon Dioxide Emissions). This ensures that the energy strategy considers passive design before integration of 'active' systems that supply or generate energy to the building. Consideration has also been made of the influence of the behavioural patterns and operation of the building on its "in-use" performance and measures have been proposed to minimise the "performance gap" between predicted and actual energy consumption.

Figure 3. Energy Hierarchy

3.2 Demand Reduction (Be Lean)

3.2.1 Layout of uses and floor plate design

The building will primarily provide office accommodation with associated ancillary spaces (restaurant, kitchens, WC's storage, receptions). Occupied areas have been located to make use of natural daylight:

- The existing structure has been 'de-cluttered' where possible to provide open spaces with regular column grids
- The ground floor glazed restaurant extension has been designed to maximise light levels, whilst providing the opportunity for natural ventilation due to its proximity to the central courtyard.
- Lifts and risers have been consolidated into three cores which are inset from the facade so as not to impede assess to daylight and views.
- The ground floor reception area will provide a deep plan, double height space in parts, to ensure that natural light from the glazed restaurant permeates deep into the space.
- The Saffron Hill Block will maintain its dual aspect to ensure good daylight penetration.

The floor to ceiling heights on the ground to 4th floors are partially constrained by the slab to slab heights of existing structure. Where possible, the ceiling heights have been maximised by minimising the depth of the services void and use of cellular structural beams in the extended areas which maximise the floor to ceiling heights

3.2.2 Shading

Good passive design optimises winter and minimises summer solar gains to reduce the need for active heating, cooling and ventilation systems. As the development is for office use, the main regulated energy loads will be cooling and lighting. The building, including the existing structure and proposed extensions are relatively well shaded including:

- 40 and 50 Holborn Viaduct which shades the Charterhouse Street elevation
- 19 Charterhouse Street (Anglia Ruskin) which shades the Saffron Hill elevation
- St Andrews House which shades the west facing courtyard elevation

This massing minimises cooling loads to the lower floors (ground to 4th) whilst still allowing access to diffuse daylight. The façade will incorporate additional shading including deep reveals on the south elevations which will reduce solar gains from high level (mid-day) sun angles, and vertical shading on the east and west Saffron Hill and courtyard elevations which will reduce solar gains during the morning and evening.

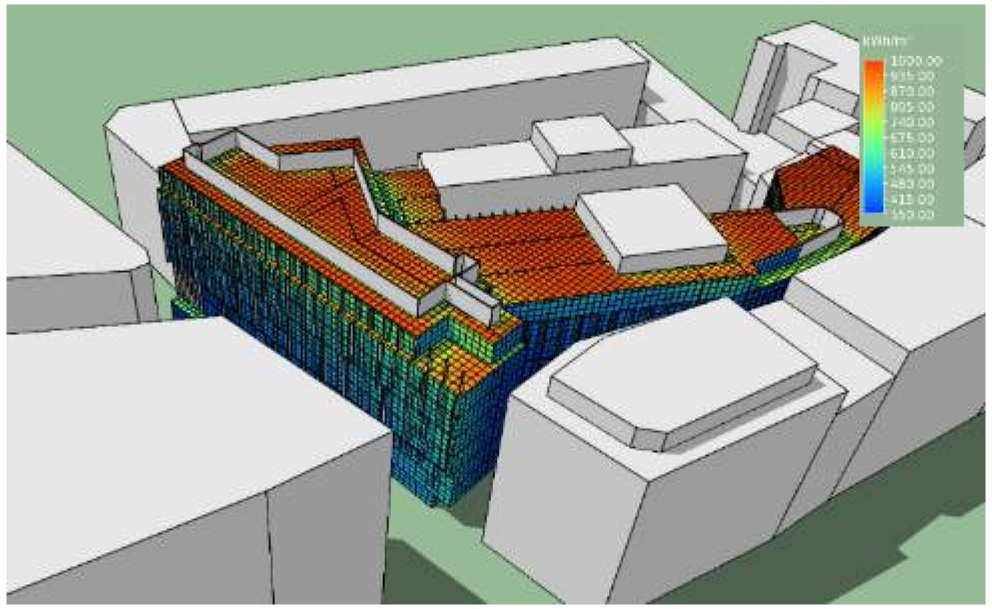

Figure 4. Annual solar energy (kWh/m^2 yr) on the façade and roof. View from the south east of the site.

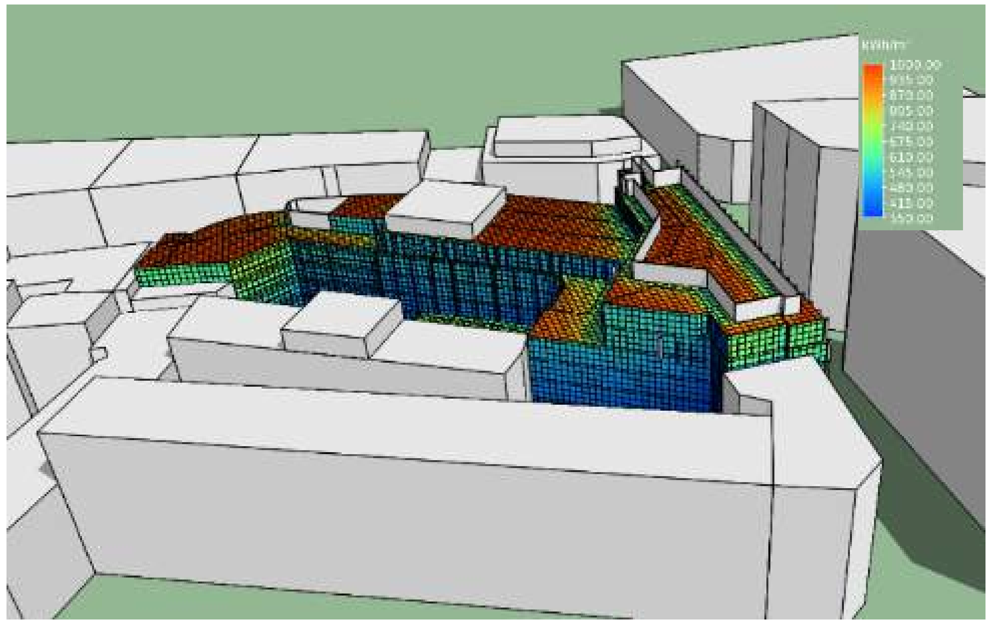

Figure 5. Annual solar energy (kWh/m^2 yr) on the façade and roof. View from the west of the site.

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3.2.3 Location, size and depth of glazing

Whilst the architectural appearance of the building is key, the architectural design has been informed by a number of design principles including optimum glazed/ opaque areas to ensure a balance between good daylight levels, heat loss and solar heat gain. The ground floor (adjacent to Charterhouse Street) and lower ground floors (adjacent to Saffron Hill), which are largely shaded by surrounding buildings and contain largely transient spaces include a high level of opaque elements which will have good thermal performance (see 'Building Envelope'). Floors 1 to 5, which will largely be occupied office space, comprise floor to ceiling glazing with opaque columns at intervals, maximising daylight levels whilst providing a balance between heat loss and gain through the façade. The overhang on the 6th floor above the Charterhouse Street Block will provide shading to the largely uninterpreted glazing which will benefit from low level winter solar gains, whilst minimising high level solar gains during the summer.

The table below shows the relative glazing ratios for each façade:

	Façade Orientation			
	N	W	E	S
Facade Area (m^2)	1372	2437	1996	2072
Glazed Area (m^2)	414	1359	785	901
Glazed/façade percentage (%)	30	56	39	43

Table 4. Approximate glazed area percentages

3.2.4 Building envelope

Improving the thermal performance of the building envelope reduces the heat losses and gains through the façade resulting in a lower energy demand for heating and cooling.

Improved U-values from those specified in PartL2A and PartL2B will be targeted. The table below summarises the targeted specifications for each building element within the Charterhouse Street / Saffron Hill Blocks, including replacement and extended elements within the building.

Building Element	Target performance (no greater than)	Part L2A (new buildings) - maximum values	Part L2B (existing buildings) - maximum values
External walls (W/m^2K)	0.2	0.35	0.28
Ground Floor (W/m^2K)	0.22	0.25	0.22
Roof (W/m^2K)	0.1	0.25	0.18
Windows and glazed doors (W/m^2K)	1.4	2.2	1.8 ++
Windows and glazed doors (g-value)	0.3	-	-
Glazing visible Light Transmittance (%)	65% +	-	-
Air tightness ($m^3/m^2.h$ @ 50Pa)	10	3	-

Table 5. Targeted u-values (Part L2A and Part L2B limiting u-values shown for comparison)

++ Curtain walling: No greater than the better of 1.8W/m2K or a limiting u-value of Ulimit = 0.8 + {(1.2 + (Fraction of opening lights x 0.5) x Glazed Fraction)}

Through the use of high performance solar control glass with a g-value of no greater than 0.3, solar gains on the upper floors will be minimised which will reduce the cooling demands on the building. The glass specification will provide good visible light transmittance, maximizing the opportunities for natural daylight.

3.6.1 Air tightness

The façade will be detailed and constructed to minimise uncontrolled ventilation from air infiltration. This will help to reduce heat losses (winter) and heat gains (summer). The Charterhouse and Saffron Hill blocks will be designed to deliver a maximum air tightness target of $10m^3/m^2$.hr @ 50 Pa.

3.6.2 Natural ventilation

The location of the site, which is adjacent to Charterhouse Street, limit's the opportunities for natural ventilation due to both security risks and noise/pollution from traffic. A natural ventilation strategy will however be incorporated in the double height restaurant facing the central courtyard. Actuated low and high-level openings, along with large operable doors will provide natural ventilation during mid seasons. The incorporation of automatic control will also provide potential for night cooling of the space.

3.6.3 Fresh air ventilation and terminal units

Controlled minimum fresh air ventilation will be provided to all occupied spaces using centralised air handling units located at roof level. By locating the supply intakes at a high level and away from sources of pollution including Charterhouse Street, air quality levels will be significantly improved compared to the current supply which is at ground floor level. All ventilation systems will comprise low pressure ductwork, variable speed drives, heat recovery with a minimum efficiency of 81% and low specific fan powers.

Active space heating and cooling will be provided via efficient four pipe fan coil units located within the ceiling voids. The units will incorporate variable speed ec-dc motors, delivering specific fan powers of 0.2W/l/s or less and allowing the units to operate at lower speeds depending on the space heating and cooling loads.

3.6.4 Heating and Cooling

The heating and cooling strategies have been informed following a review of the condition of existing plant and equipment.

Charterhouse and Saffron Hill Blocks:

Chilled (CHW) and low temperature hot water (LTHW) will be provided to the fan coil units from roof mounted heat pumps, supplemented by the existing high efficiency gas boilers in the Extension Block to meet peak heating loads. The proposed air source system will provide both heated and chilled water within a single unit. A thermal load analysis of the building (see figure below) demonstrates that the building has simultaneous heating and cooling loads for a majority of the year, partly as a result of the highly shaded lower ground floor, more exposed upper floors and hot water demands of the central kitchen and changing facilities. This is particularly the case in mid-season operation (spring and autumn). By adopting a combined heat pump, the system can recover heat from areas of the building that have a cooling and direct the heat back to areas with space heating demands. Any surplus heat can also be used to pre-heat the hot water supply to the kitchens and changing room areas.

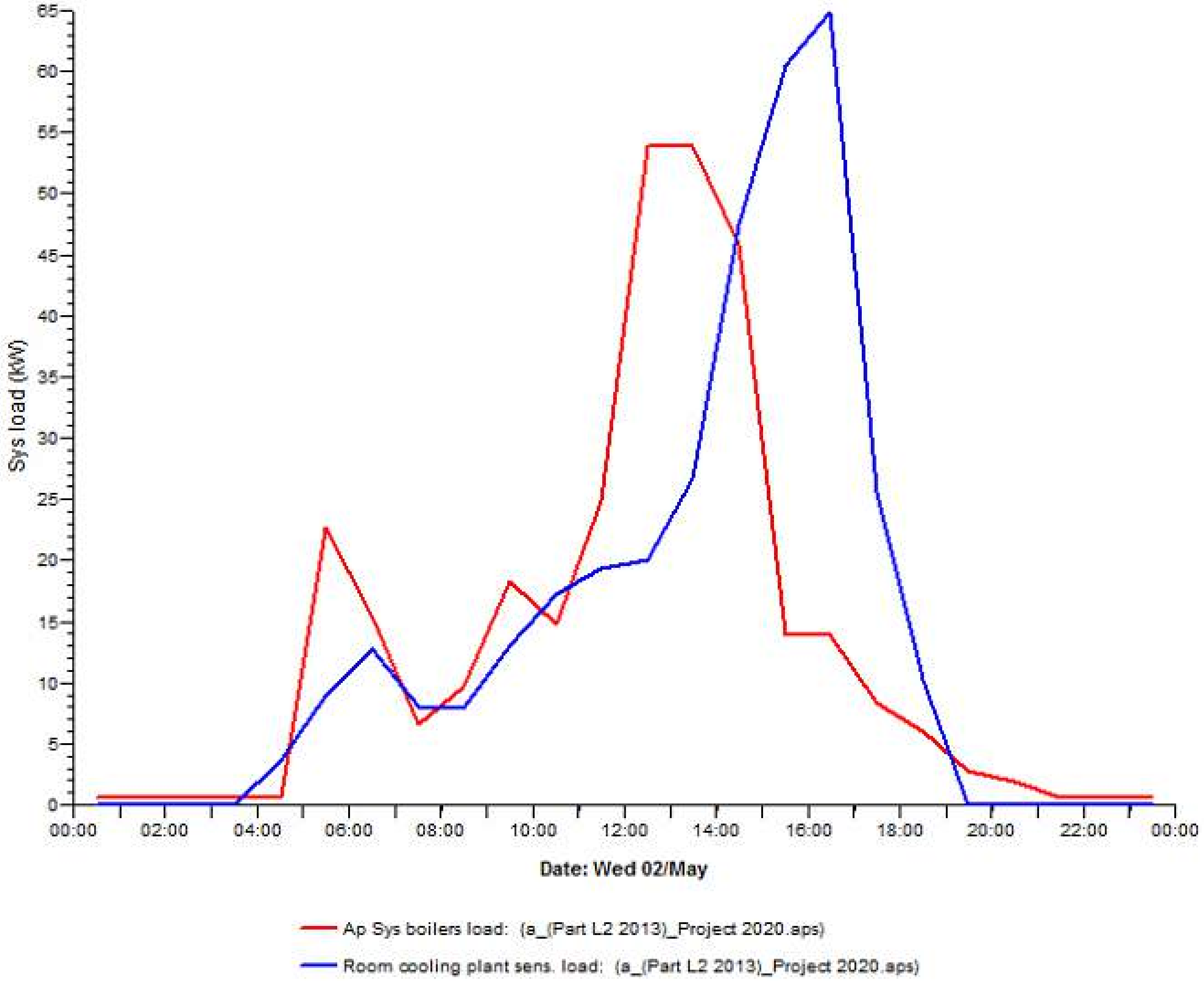

Figure 6. Typical daily heating and cooling load for the development

The fan coil units will designed to operate at low flow temperatures of ~45°C , with the ability to run at higher temperatures during peak heating. This will maximise the coefficient of performance of the heat pump. The minimum seasonal efficiencies (heating and cooling) of the air source heat pump system will be:

- Heating SCOP: 3.27 (to EN14825)
- Cooling SEER: 4.05 (to EN14511)

The above figures exclude the benefit of simultaneous heating/cooling demands which will further increase the efficiencies. Based on the above seasonal heating efficiency, the system will deliver carbon savings of approximately 30% when compared to an equivalent high efficiency gas fired condensing boiler (assuming a gross efficiency of 95%). This is based on current carbon emission factors for electricity, as set out in SAP 2012. The whole life emissions of the system should be significantly lower than an equivalent gas fired boiler system as a result of the expected reduction in the carbon intensity of grid supplied electricity over the lifetime of the system (15-20 years).

By designing the system based around electric heat pumps, local emissions from the site will be significantly reduced. This recognises the fact that Camden has some of the poorest air quality levels in London[1] and since 2000 the whole of the borough has been declared an Air Quality Management Area (AQMA) for both NO_2 (Nitrogen Dioxide) and PM10 (Particulate Matter). The use of electrification aligns with Camden policy CC4 (Air Quality) that states that the council will take into account the impact of air quality when assessing development proposals.

The Extension:

Heating will be provided from existing high efficiency gas fired boilers that were installed in 2003. These will feed new four pipe fan coil units in the Extension. Cooling will be provided from an independent high efficiency Turbocor chiller with a seasonal efficiency (ESEER) of no less than 4.89 (to EN14511)

3.6.5 Domestic Hot Water

The domestic hot water strategy has been developed to limit heat losses to fittings (e.g. toilet wash hand basins) that will be used intermittently, whilst providing low carbon hot water from a central storage system for kitchen use and showers.

Office toilets (located within the core areas): Hot water for wash hand basins will be supplied from local electric point of use water heaters. These will do away with the need for hot water storage and secondary circulation pipework from centralised heating plant, reducing standing losses which can be significant in large buildings with large distribution distances.

Kitchen and changing rooms: Hot water for taps and showers will be provided from a centralised heat pump and hot water storage system located in the basement. The system will work in combination with the roof mounted heat pumps which will pre-heat the water in two cylinders to 45°C. A second high temperature heat pump will raise the temperature of the hot water from 45°C to 65°C. The combined seasonal efficiency (SCOP) of the system will be at least 3.2.

3.6.6 Lighting

Energy efficient internal LED lighting will be specified for all areas, which will significantly exceed the minimum luminaire efficacy of 60 luminaire lumens per circuit watt, required by Building Regulations. The existing lighting in the Extension, which currently comprises a mixture of T5 luminaires, compact fluorescent and halogen downlights will be replaced with LED fittings throughout.

Lighting will be controlled via digital-addressable DALI controllers which will provide occupancy sensing in all areas of the building, and daylight dimming in perimeter zones. With the exception of occupancy sensors in circulation and toilet areas, the existing Extension block doesn't include functioning lighting controls. The lighting strategy will include the incorporation of daylight control in perimeter offices and occupancy sensing throughout, with the exception of the reception and gym areas which will adopt manual controls for functional reasons.

A summary of the lighting control strategy is provided below.

Area	Minimum efficacy (luminaire lumens/W)	Occupancy sensing	Daylight control
Office (Perimeter zones)	100	Auto on-off	Auto dimming
Office (core zones)	100	Auto on-off	None
Reception, kitchen, plant room, gym	100	Manual switching	None
Circulation, WCs, changing rooms, stores	100	Auto on-off	None

Table 6. Proposed internal lighting efficacies and lighting control strategy

[1] Camden Local Plan – Adopted Version. June 2017

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All external lighting (except safety and security lighting) will be automatically switched off between 23:00 and 07:00. The average luminaire efficacy of the external light fittings will be no less than 60 luminaire lumens per circuit Watt.

3.6.7 Building Energy Management and Metering

A central Building Management System (BMS) which will have integrated Building Energy Management Functions will be installed. The system will ensure that heating, cooling and ventilation systems operate correctly and efficiently, and maintain internal conditions to achieve a comfortable environment. The system will be connected to sub-meters which are designed to meet the sub metering credit within BREEAM. The system shall be capable of metering >90% of the overall electrical energy for the site. Metering shall be provided for the following elements:

- Lighting (Internal & External)
- Small power services
- Cooling/Heating systems
- Ventilation systems
- Lifts
- Controls
- Low carbon technologies (PV)

Power Factor Correction (PFC) will be installed within the main distribution board. Power factor correction (PFC) techniques aim to bring the power factor closer to unity by reducing the effects of reactive power. In the great majority of cases, poor power factor is due to inductive loads which can be compensated by adding electrical devices called capacitors into the circuit. The advantages of PFC are:

- By reducing losses and inefficiencies, improving the power factor means less electricity is drawn from the network.
- Power factor correction (PFC) can prolong the life of electrical equipment.
- It can help avoid voltage drops over long cables and reduce efficiency losses in the supply transformers.
- PFC will increase the effective capacity of the local electricity network – potentially deferring future investment in electrical infrastructure and allowing connection of more machinery to the same utility connection.

3.6.8 Demand Reduction – Development performance

Charterhouse / Saffron Hill Block

The impact of the demand reduction measures for the Charterhouse and Saffron Hill Blocks was tested in government approved software (IES Virtual Environment) based on the proposed architectural design and M&E strategy. The regulated CO_2 emissions are calculated to be 12% less than a Part L compliant development.

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line (PartL 2016 compliant development)	331
After energy demand reduction	291
% Improvement over baseline	**12.0%**

Table 9. Regulated carbon emissions improvement of the Charterhouse and Saffron Hill Blocks after taking into account demand reduction measures

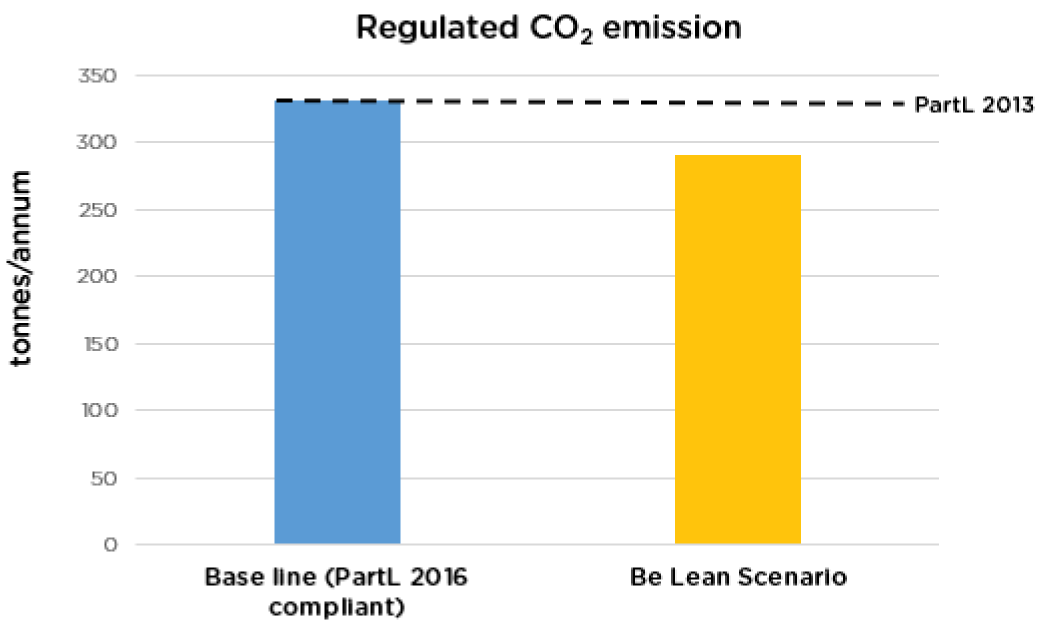

Figure 6. Regulated carbon emissions improvement of the Charterhouse Street / Saffron Hill blocks after taking into account demand reduction measures.

The Extension

As this part of the building comprises a refurbishment of the existing building services with no changes to the facade, the GLA Guidance on Preparing Energy Statements requires the base-line to be based on the existing, pre-refurbishment performance. The regulated CO_2 emissions of the Extension have been calculated in compliant software to determine a baseline, based on the building's Building Emissions Rate (BER). The performance of the proposed upgrades to the building services have been calculated following the same energy hierarchy as for the Charterhouse / Saffron Hill blocks i.e. Be Lean, Be Clean, Be Green. The regulated CO_2 emissions of the proposed development are calculated to be 61.1% less than the existing building, largely as a result of improved lighting, lighting controls, and efficient ventilation systems with heat recovery.

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line (Existing building)	199
After energy demand reduction	78
% Improvement over baseline	**61.1%**

Table 10. Regulated carbon emissions improvement of the Extension after taking into account demand reduction measures

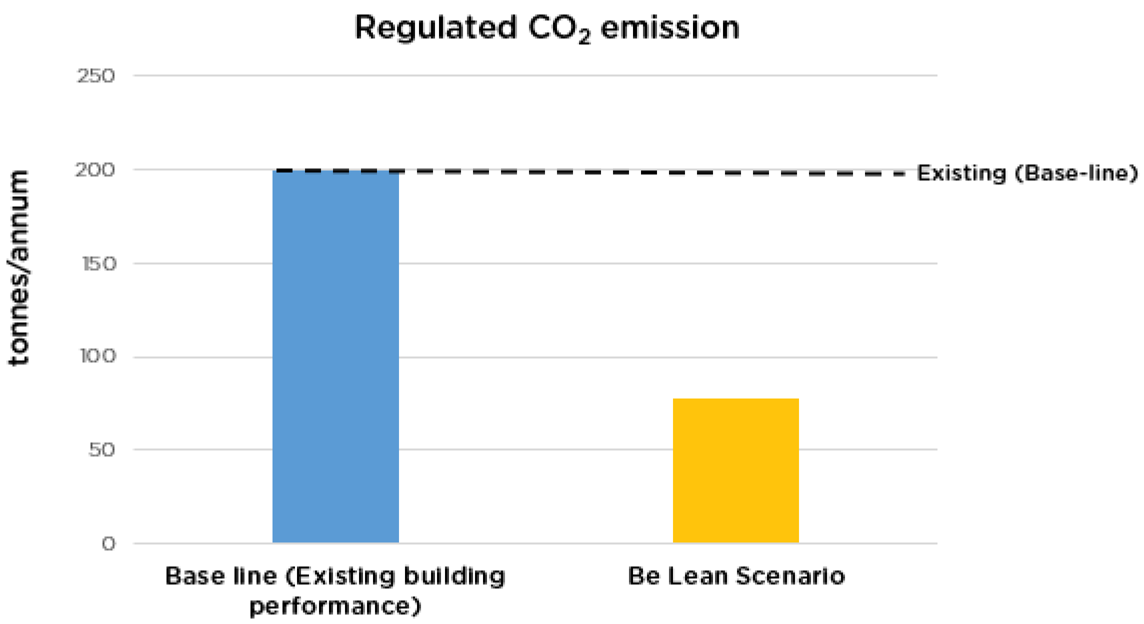

Figure 7. Regulated carbon emissions improvement of the Extension after taking into account demand reduction measures.

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3.7 Energy Efficient Supply (Be Clean)

3.7.1 Heating infrastructure

Camden planning policy CS13, DP2 and CC1 requires that all development considers connection to decentralised energy in response to the second 'Be Clean' stage of the energy hierarchy. The approach in the GLA's Guidance on preparing energy assessments (March 2016) requires that all applications demonstrate how their energy systems have been selected in accordance with the following order of preference:

1. **Connection to existing heat networks**
2. **Enable connection to future planned heat networks**
3. **Create a site wide heat network supplied by on-site combined heat and power (CHP)**

The following sets out the investigations and feasibility of each of these options.

3.7.2 Existing low carbon heat networks

The development is located approximately 150 meters from the Citigen energy centre, when measured from the eastern corner of the Charterhouse Street Block. The energy centre is located at 47-53 Charterhouse Street and contains a mixture of gas fired boilers, gas fired combined heat and power (CHP) engines and electrical chillers. Citigen is a wholly owned subsidiary of E.On and currently supplies heat and chilled water from their facility to a number of customers to the east of the energy centre, including the Barbican and Guildhall.

A detailed review of the potential to connect to the Citigen network has been undertaken including a review of whether E.On plan to extend the network to the west of the energy centre along Charterhouse Street. A meeting was held with Emily Lister, Business Development Manager at E.On on the 23rd June 2017. The meeting included a site visit of the facility. A briefing note which summarises the discussions has been included in Appendix C. In summary:

- The carbon emissions factor of the chilled water (0.125kgCO2/kWh based on SAP 2012 carbon factors) are higher than an equivalent on-site chiller, assuming the onsite chiller achieves a seasonal energy efficiency ratio (SEER) of 4.0 or more – as proposed for the building.
- E.On have confirmed an indicative connection fee of £10,000/m of heat pipe. The high cost is as a result of the potential technical constraints of crossing Farringdon Road including – Cross Rail, River Fleet culvert, gas, water and power utilities. In addition, traffic disruption and road closures would need to be agreed with Camden, Islington and the City of London which would incur costs. Assuming the shortest distance between the Citigen energy centre and the development, the initial connection costs would be-£1.45M. This would cover the costs of installing the pipework, but would exclude costs for the heat exchanger within the building.
- EOn are currently undertaking a review to plan for future connections of buildings in the area; however, they have no commitments to extend the network to the west of their site past 17 Charterhouse Street.
- EOn can't commit to a tariff at this stage, but have confirmed that they benchmark all tariffs against equivalent on-site gas boilers.

Due to the high capital costs associated with the extension of the network, along with uncertainty over the technical feasibility of crossing Farringdon road, connecting to Citigen as the primary heating source is deemed to be unfeasible. However, the design will incorporate capped connections to allow for future connection to the network.

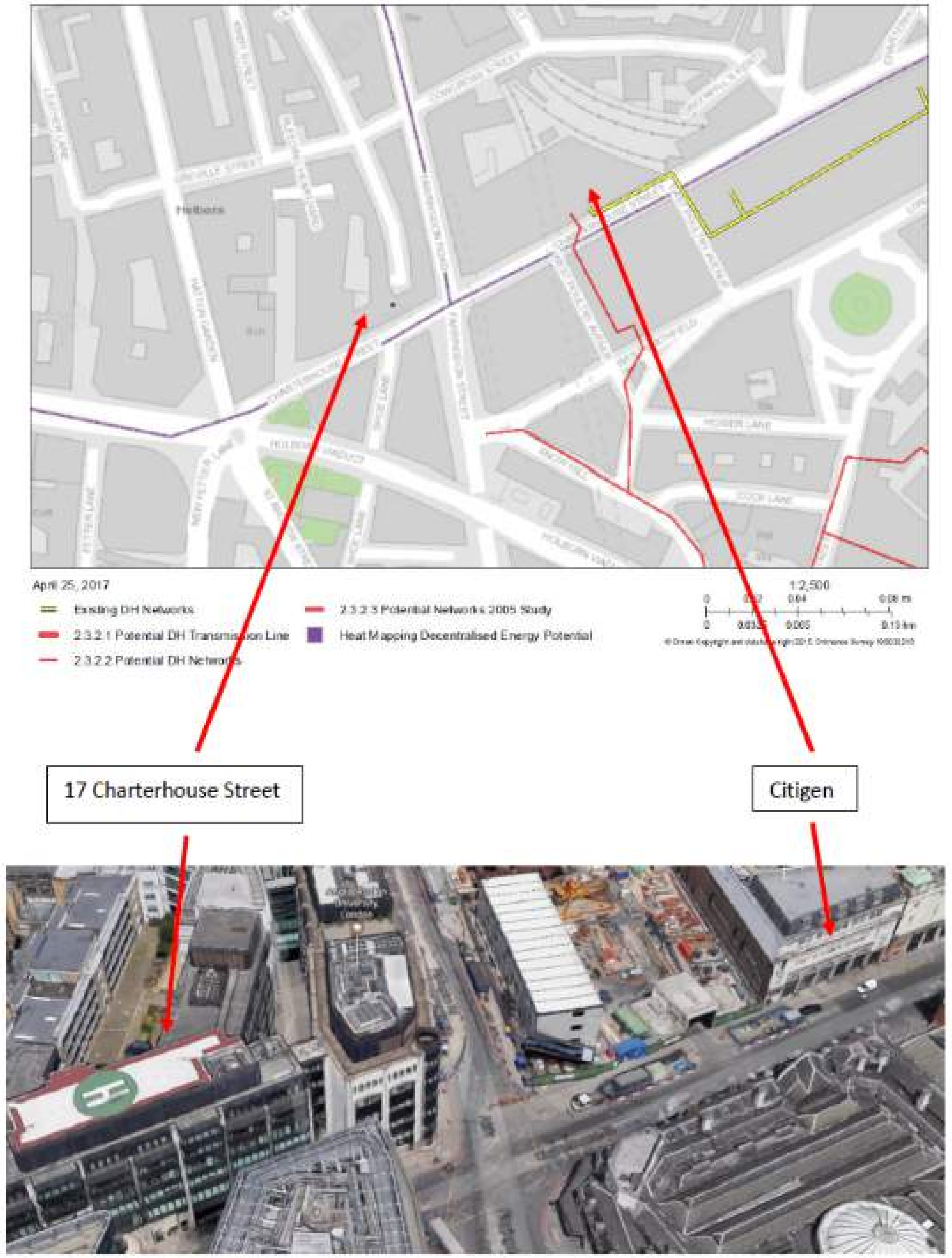

Figure 7. Location of Citigen energy centre relative to the site

3.7.3 Enable Connection to future planned heat networks

The heating strategy for the development is based on a site wide water based circulation system that will move heat from heat pumps located on the roof of the Charterhouse Street Block, and gas boilers in the existing Extension block. The Charterhouse Street plant room will be designed to include space for future heat exchangers / capped connections to allow for connection to a future heat network – as shown in Appendix D.

3.7.4 Create site wide heat network supplied from on-site CHP

Section 11.30 of the GLA guidance on preparing energy assessments (March 2016), states that Combined Heat and Power will not be applicable for non-domestic developments with a simultaneous demand for heat and power for less than 5000 hours per annum. Camden Local Plan also states that developments should focus on energy efficiency and efficient supply of energy with CHP only accepted if it is shown to be the most appropriate choice.

The development will largely be used as office space and therefore the base load (represented by the domestic hot water consumption) will be relatively intermittent resulting in CHP being financially and technically unfeasible. The development will however be based on a site wide water based circulation system, allowing for future connection to heat networks.

3.7.5 Proposed heat supply approach

The table below summarises the feasibility of connecting to existing or planned heat networks within close proximity to the site following the technical and commercial review of options.

Heating option	Feasible for the development?	Reason why the option is / is not feasible
Connect to existing low carbon heat network.	No	The Citigen energy centre is close to the development. However, the high connection costs and uncertainty over the technical feasibility of crossing Farringdon road means connection at the current time is not feasible.
Enable future connection	Yes	The development uses a water based heating system and includes basement space to facilitate future connection to a heat network.
Create a site wide heat network, connected to CHP engine	No	Installation of a CHP unit has been deemed unfeasible due to the anticipated low domestic hot water demand.

Table 8. Feasibility of heating infrastructure options

The proposed strategy is to supply the Charterhouse / Saffron Hill Block with heat from roof mounted heat pumps, and The Extension from existing high efficiency gas fired boilers, as detailed in the previous sections.

3.7.6 Energy Efficient Heating: Development Performance

As no CHP has been specified, the performance of the Be Clean remains the same as the Be Lean scenario for both the Charterhouse Street / Saffron Hill blocks and The Extension.

Charterhouse / Saffron Hill Block

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line (PartL 2016 compliant development)	331
After energy demand reduction	291
After CHP / heat network connection	291
% Improvement over baseline	**12%**

Table 7. Regulated carbon emissions for the Be Clean scenario.

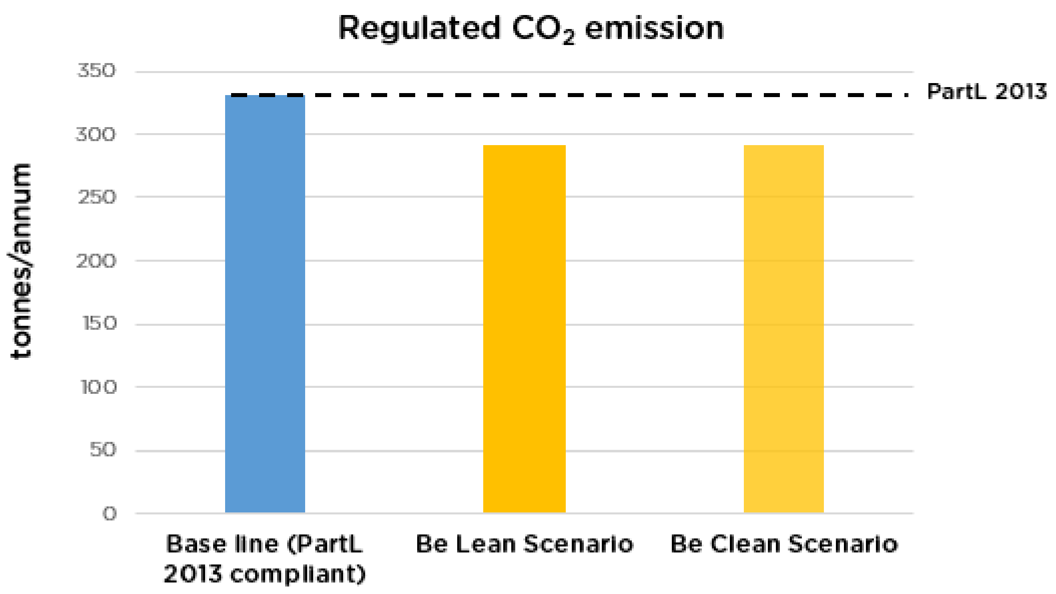

Figure 8. Carbon emissions reduction for the Be Clean scenario

The Extension

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line (Existing building)	199
After energy demand reduction	78
After CHP / heat network connection	78
% Improvement over baseline	**61.1%**

Table 9. Regulated carbon emissions for the Be Clean scenario

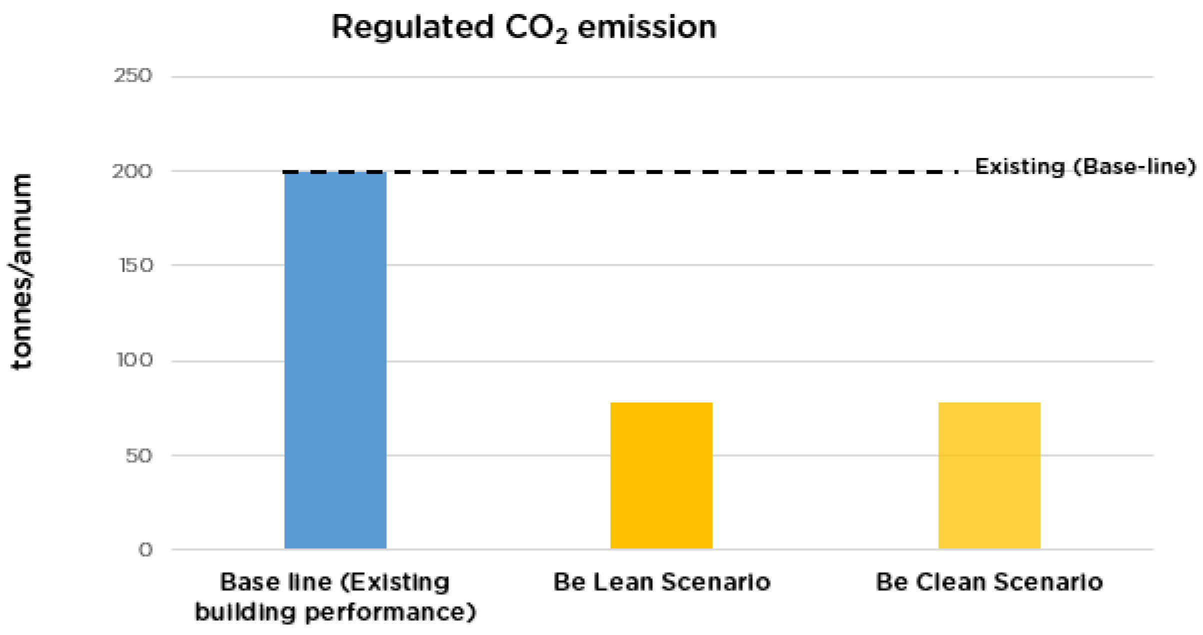

Figure 9. Carbon emissions reduction for the Be Clean scenario

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3.8 Renewable Energy (Be green)

3.8.1 Feasibility of renewable technologies

A feasibility study has been undertaken to evaluate the viability of incorporating low and zero carbon technologies within the development.

The suitability of each technology for the development has been evaluated based on technical viability, considering spatial requirements, suitability for the development, energy demand profile and potential for carbon emissions savings. In addition, the compatibility of each technology with the proposed heating strategy was considered.

Appendix E provides details of each technology and the appropriateness to the development. The following technologies were considered:

- Photovoltaic Panels
- Solar Hot Water
- Heat Pumps (air and ground source)
- Wind Turbines
- Biomass Heating

Following the review of each technology, photovoltaic panels and air source heat pumps were considered as viable for the assessed development.

Technology	Technical Feasibility	Recommended?
Photovoltaic panels (PV)	A solar analysis study indicates that the roof area above the Saffron Hill block would be suitable for roof mounted panels. Whilst the Charterhouse roof and The Extension block roof has relatively good solar exposure, these area will be taken up with Building maintenance Units (BMU) and building services plant.	Yes
Solar hot water (SHW)	As solar collectors generally offset gas used for domestic hot water rather than grid electricity, which has a higher carbon burden, achievable carbon emissions savings per unit of area are lower than those achieved with PV.	No
Heat Pumps	The installation of air source heat pumps which can recover heat can deliver lower carbon emissions than an equivalent gas boiler and chiller combination, helping to deliver excellent heating and cooling efficiencies. As the building façade is being replaced, lower heat losses means that fan coil units can operate at lower temperatures in heating mode, maximising the efficiency of the heat pump. Ground source heat pumps are considered to be unfeasible to the limited ground works that are proposed for the development.	Yes
Wind turbines	Large scale wind turbines can present nuisances such as noise and flicker effect which are not considered acceptable for an urban development of this nature, and are likely to face significant objection through the planning process.	No
Biomass heating	Biomass based systems have been ruled out as the project cannot accommodate the spatial requirements for fuel loading and storage. Additionally, biomass has high NOx emissions and is therefore not deemed a suitable solution for the development given its city centre location.	No

Table 10. Renewables – feasibility of each technology Renewable energy: Development Performance

3.8.2 Photovoltaic panels (PV)

A detailed overshadowing assessment has been undertaken to assess the potential to integrate photovoltaic panels (PV) within the development – as shown in the figure below.

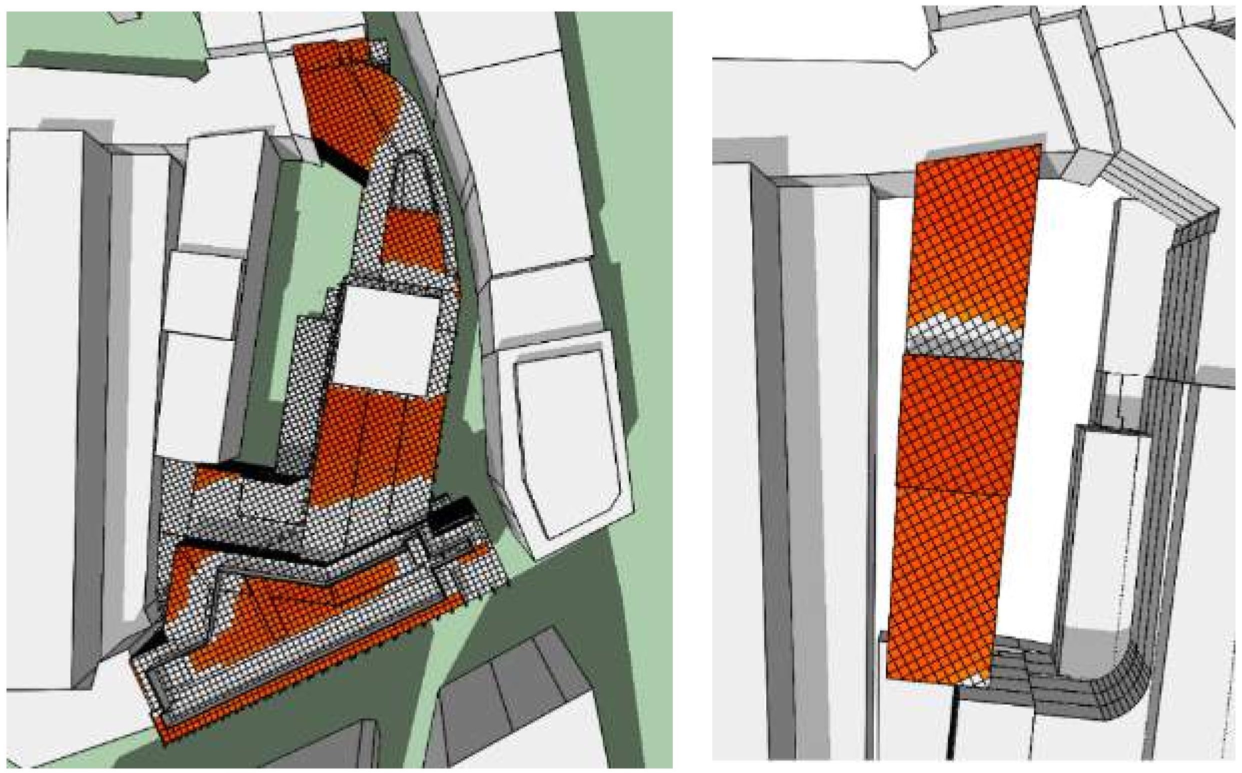

Figure 10. Plan view of development showing areas with solar levels over 850 kWh/m²/yr

Due to the presence of a Building Maintenance Unit (BMU) around the perimeter of the Charterhouse Street block and a BMU and ventilation ductwork on the roof of the Extension, PV panels cannot be installed in these areas.

The proposal is to install the following:

Saffron Hill Block:

- Roof mounted: 37 panels, 30° inclination; 1.8m apart (to minimise self-shading and provide access).
- Plant screen mounted: 8 panels, vertically mounted
- Approximate panel size: 1.6m x 1m
- Minimum peak power output per panel: 270Wp
- Minimum panel efficiency: 16.5%

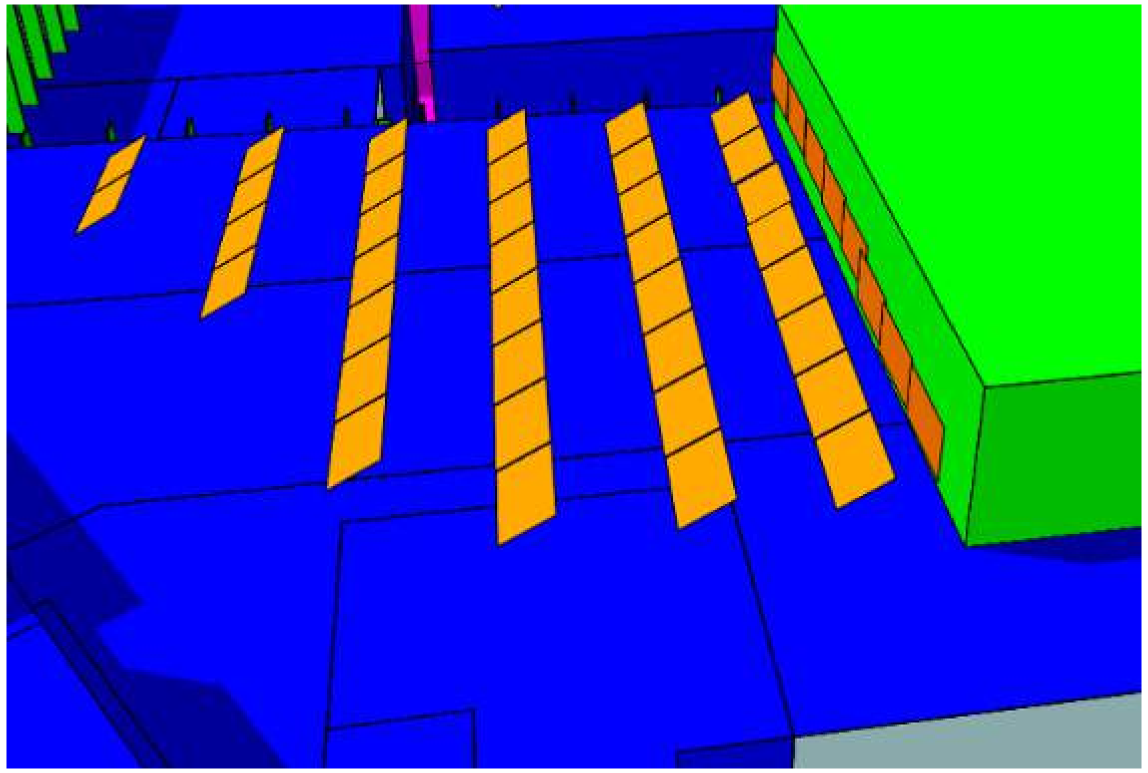

Figure 11. Proposed PV layout on the Saffron Hill Block

Figure 12. Indicative PV / green roof arrangement

Charterhouse Street Block:

- Plant screen mounted: 52 panels, vertically mounted
- Approximate panel size: 1.6m x 1m
- Minimum peak power output per panel: 270Wp
- Minimum panel efficiency: 16.5%

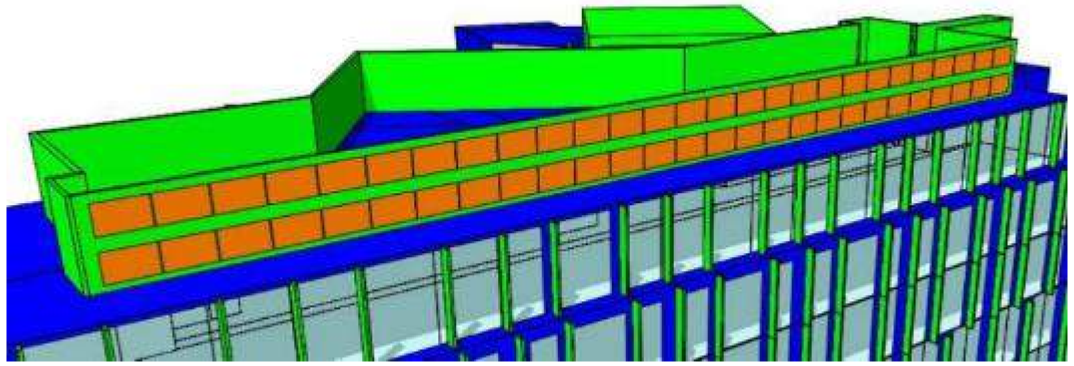

Figure 13. Proposed PV layout on the Saffron Hill Block

St Andrews House

- Roof mounted: 40 panels, 30° inclination; 1.8m apart (to minimise self-shading and provide access).
- Approximate panel size: 1.6m x 1m
- Minimum peak power output per panel: 270Wp
- Minimum panel efficiency: 16.5%

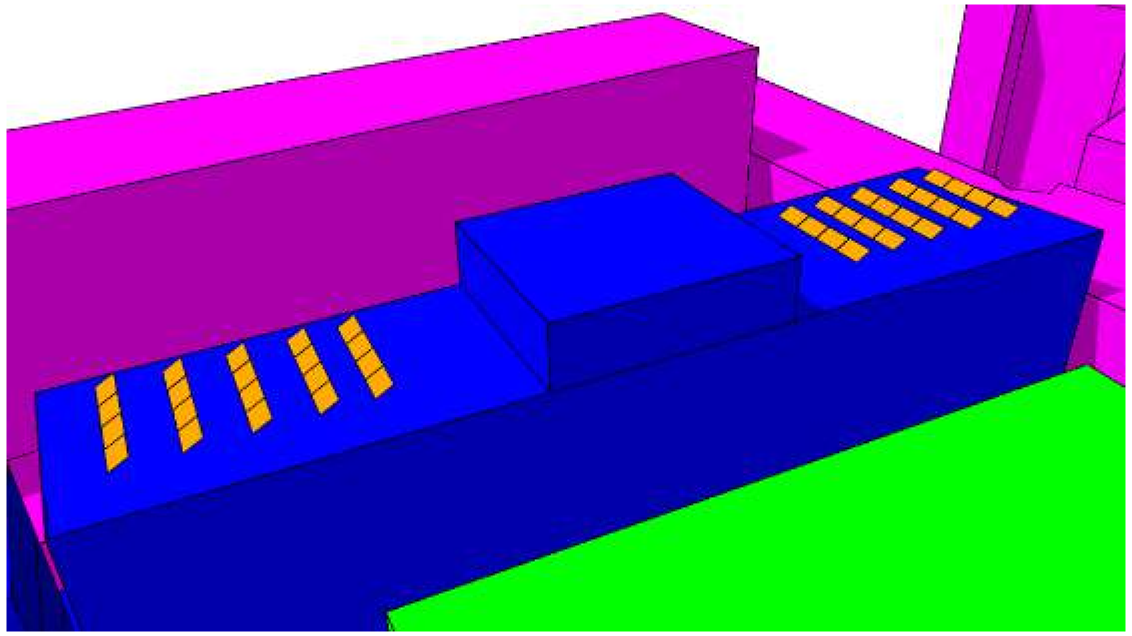

Figure 14. Proposed PV layout on St Andrews House

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3.8.3 Renewable Technology: Development Performance

Charterhouse / Saffron Hill Block

The impact of the renewable energy systems for the Charterhouse and Saffron Hill Blocks was tested in government approved software (IES Virtual Environment). The inclusion of photovoltaic panels on the Saffron Hill Block and air source heat pump to provide space heating and domestic hot water heating delivers an additional emissions saving of 6% after accounting for passive and energy efficient design.

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line (PartL 2013 compliant development)	331
After energy demand reduction	291
After CHP / heat network connection	291
After renewable energy	271
% Improvement over baseline	**18.0%**

Table 11. Regulated carbon emissions improvement of the development after taking into account demand reduction, CHP and renewables.

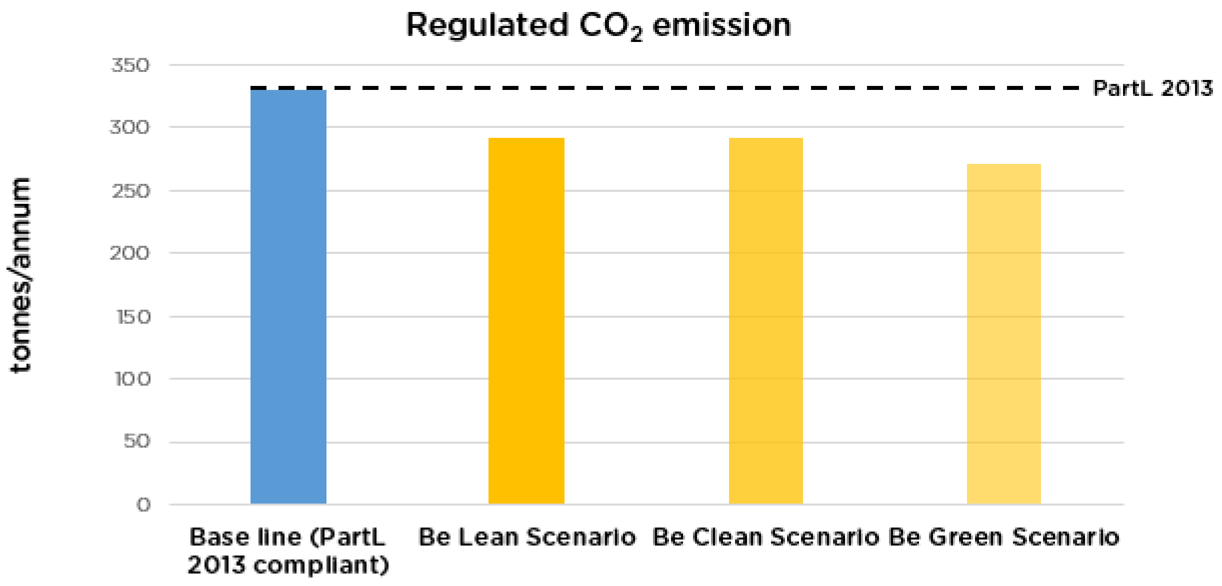

Figure 15. Regulated carbon emissions improvement of the development after taking into account demand reduction, CHP and renewables

The Extension

No renewable energy systems are proposed for the Extension block as a result of constraints from building services plant and the Building Maintenance Unit (BMU) at roof level and the proposal to retain the existing high efficiency gas fired boilers to provide space heating

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line (Existing building)	199
After energy demand reduction	78
After CHP / heat network connection	78
After renewable energy	78
% Improvement over baseline	**61.1%**

Table 12. Regulated carbon emissions improvement of the development after taking into account demand reduction, CHP and renewables.

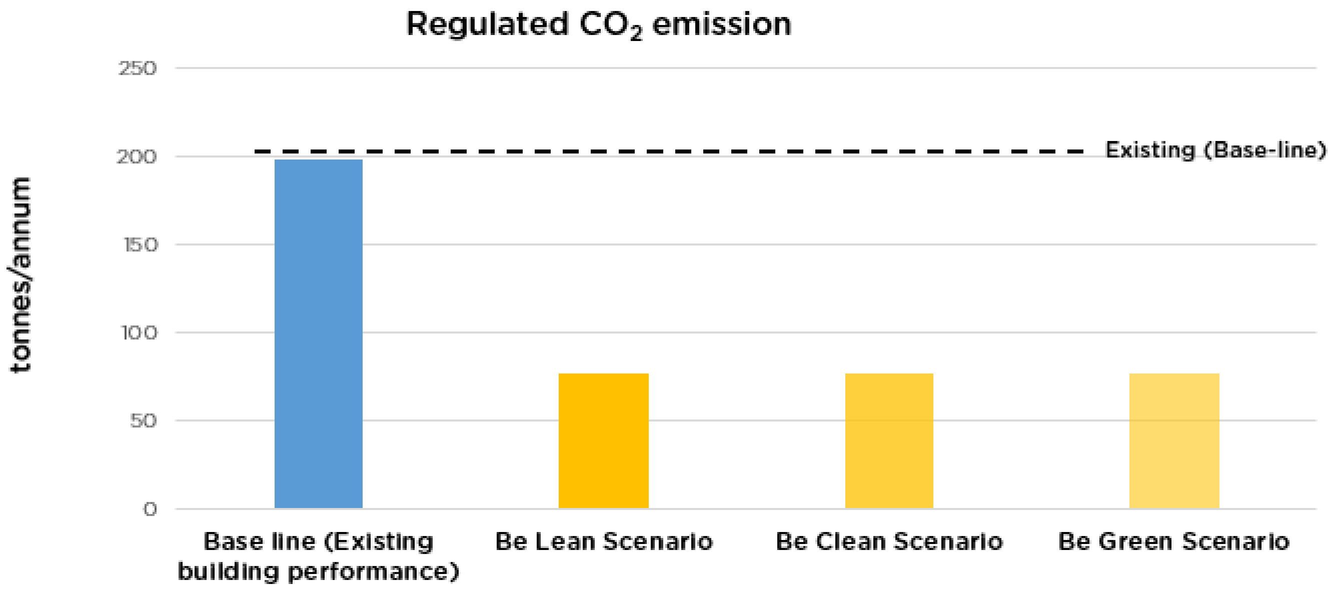

Figure 16. Regulated carbon emissions improvement of the development after taking into account demand reduction, CHP and renewables

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3.8.4 Site wide performance against targets

All efforts have been made to minimise carbon emissions associated to the building following a be lean, be clean, be green approach.

In addition, the development has been future proofed for connection to a district heating network. A centralised water based system served by highly efficient air source heat pumps in the Charterhouse / Saffron Hill block is proposed which will lead to a reduction in carbon emissions, localised NOx emissions from the building, and allow easy connection to a District Heating network if routed past the site in the future.

Although, the development should aim for a 20% on site renewable energy supply, this is not possible due to site constraints. However, a robust strategy has been provided that achieves the following for the site as a whole:

- A 34.2% reduction in carbon emissions against the baseline emissions.
- Cumulative carbon emissions savings of 180.9 tonnes CO_2 when compared against the baseline emissions.
- Carbon emissions savings from renewable energy of 5.4%

CO_2 Emissions (Tonnes CO_2 per annum)	Regulated
Base line	530
After energy demand reduction	369
After CHP / heat network connection	369
After renewable energy	349
% Improvement over baseline	**34.2%**

Table 13. Cumulative carbon emissions reductions for the site as a whole

Regulated CO_2 Savings	Tonnes per annum	% over previous stage	% over Baseline
Savings from Energy demand reduction	161.1	30.4%	30.4%
Savings from CHP / heat network connection	0.0	0.0%	0.0%
Savings from renewable energy	19.8	5.4%	3.7%
Total Cumulative Savings	180.9		34.2%

Table 14. Regulated carbon savings per annum for each stage of the energy hierarchy - for the site as a whole

3.8.5 Carbon Offset

As the 35% carbon emissions reduction target hasn't been completely met on site, the carbon emissions shortfall has been calculated to be 4.5 tonnes per annum, or 134 tonnes over 30 years.

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	185.4	
Shortfall	7.5	134

Table 15. Shortfall in carbon emissions against the 35% target

Based on a cost of carbon of £60 per lifetime tonne, the carbon offset is £8,100.

4. APPROACH TO MINIMISING COOLING ENERGY

4. APPROACH TO MINIMISING COOLING ENERGY

The development has been designed to limit the internal heat gains and optimising the façade to minimise the need for cooling. The approach to the design has followed the cooling hierarchy as set out in Policy 5.8 of the London Plan:

1. **Minimising internal heat generation through energy efficient design:**
   - All distribution pipework will be thermally insulated in compliance with minimum Part L standards.
   - Pipe lengths will be minimised, particularly lateral pipework in corridors
   - Pipe configurations will minimise heat loss e.g. through twin pipe / flow and return configurations.
   - Specification of energy efficient lighting will reduce the internal heat gains.
2. **Reducing the amount of heat entering the building in summer:**
   - All new facades have been carefully designed to incorporate shading measures, including deep reveals and shading from surrounding buildings. In addition, the use of high performance solar control glass will limit solar heat gains.
   - High reflective internal roller blinds with low transmittance will be installed in both new and refurbished part of the development.
3. **Use of thermal mass and high ceilings to manage heat within the building**
   - Thermal mass has been considered; however, given the limited exposed facades and glazing, the amount of area receiving direct sunlight would not be sufficient to justify its use.
   - The floor to ceiling heights are largely set by the existing slab to slab heights. Where possible, the ceiling heights have been maximised by minimising the depth of the services void and use of cellular structural beams in the extended areas which maximise the floor to ceiling heights
4. **Passive ventilation**
   - Due to the urban location of the development and impact from noise and air pollution, the development will use fixed windows in all office areas.
   - A natural ventilation strategy will however be incorporated in the double height restaurant facing the central courtyard. Actuated low and high-level openings, along with large operable doors will provide natural ventilation during mid seasons. The incorporation of automatic control will also provide potential for night cooling of the space.
5. **Mechanical ventilation:**
   - All ventilation systems will comprise low pressure ductwork, variable speed drives, heat recovery with a minimum efficiency of 81% and low specific fan powers.

APPENDICES

Charterhouse / Saffron Hill Block – HVAC and lighting assumptions

Space Type / Grouping	NCM Building Type	NCM Activity	HVAC - System level	Ventilation - Zonal level	DHW	Lighting	Building Management	LZC Technologies
CH - Cupboard	B1: Office	Office - Cupboard	HVAC-1	-	DHW-1	LT-4	BM-1	-
CH - Circulation	B1: Office	Office - Circulation area	HVAC-1	-	DHW-1	LT-4	BM-1	-
CH - Toilet	B1: Office	Office - Toilet	HVAC-1	VENT-2	DHW-1	LT-4	BM-1	-
CH - Reception	B1: Office	Office - Reception	HVAC-1	VENT-1	DHW-1	LT-3	BM-1	-
CH - Light Plant Room	B1: Office	Office - Light Plant Room	HVAC-1	-	DHW-1	LT-3	BM-1	-
CH - Open Plan Office (Perimete	B1: Office	Office - Open Plan Office	HVAC-1	VENT-1	DHW-1	LT-1	BM-1	-
CH - Open Plan Office (Core)	B1: Office	Office - Open Plan Office	HVAC-1	VENT-1	DHW-1	LT-2	BM-1	-
CH - Meeting Room	B1: Office	Office - Meeting Room	HVAC-1	VENT-1		LT-2	BM-1	-
CH - Changing Facilities	B1: Office	Office - Changing Facailities	HVAC-1	VENT-1	DHW-2	LT-4	BM-1	-
CH - Food preperation	B1: Office	Office - Food preperation	HVAC-1	VENT-3	DHW-2	LT-4	BM-1	-
CH - Eating drinking area	B1: Office	Office - Eating drinking area	HVAC-1		DHW-1	LT-4	BM-1	-
CH - Void/Lift/Riser	B1: Office	Internal void	-	-	-	-	-	-
CH - Carpark	B1: Office	Carpark	-	-	-	-	-	-

Table 16. Systems assigned to each space type

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Heating, Cooling & Ventilation (HVAC) - SYSTEM LEVEL		
		HVAC-1
System description	Description	Fan coil units - fed from elec heat pumps with peak loads met from existing gas boilers
Applies to....	Room types	All office areas, F&B and retail
UK NCM type	Type	Fan coil units
Heating System		
- Heat Fuel Type	Elec/gas	Elec (peak loads from gas boilers - assumed to cover 30% of annual demand)
- Heat generator seasonal efficiency	SCOP	327% (Gas boiler: 91.5%)
- Does it Qualify for ECA?	Yes	N/A
Cooling System		
- Cooling system type (assumed system in model)	Description	Electric heat pump
- Chiller fuel type	Description	Elec
- Nominal Seasonal EER	SEER	4.05
- Nominal EER	EER	2.93
- Does it Qualify for ECA?	Yes	N/A
System adjustment		
- Ductwork Leakage Classification	Class	Class D
- AHU Leakage Classification	Class	Class L1
- Specific Fan Power (AHUs)	W/l/s	1.9
- Pump type	Description	Variable speed with multiple pressure sensors
Metering Provision		
- Does the system have provision for metering?	Yes/No	Yes
- Does the system warn of "out of range" values	Yes/No	Yes
Ventilation & pumping		
- Cooling/vent mechanism	Air con / nat vent	Air conditioned
- Air supply mechanism	Description	Centralised balanced
- Heat recovery	% efficiency or n/a	81.00
System Controls		
- Central Time Control?	Yes	Yes
- Optimum start/stop control?	No	Yes
- Local Time Control?	No	Yes
- Local Temperature Control?	Yes	Yes
- Weather Compensation Control?	No	Yes

Building Management		
		BM-1
Electric Power Factor of the building	Power Factor Control	0.95-0.98
Lighting systems have provision for metering?	Yes/No	Yes
Lighting systems metering warns of 'out of range' values?	Yes/No	Yes
Does the system have provision for metering?	Yes/No	Yes
Does the metering warn "out of range" values?	Yes/No	Yes

Ventilation - ZONAL LEVEL				
		VENT-1	VENT-2	VENT-3
System description	Description	FCUs - terminal unit SFP	Toilet ventilation - supply and extract	Kitchen ventilation - extract
Applies to....	Room types	All areas with HVAC-1	All toilets	All kitchen areas
Specific Fan Power (Terminal units)	W/l/s	0.2	1.5	1.4
Fan location	Description	N/A	Remote from room	Remore from room
Air change rate (if applicable)	ACH	N/A	10	40
Demand Control Ventilation (DCV)	Description / type	No	No	No

Domestic DHW			
		DHW-1	DHW-2
System description	Description	Electric POU	Electric heat pump
Applies to....	-	All office areas	Changing rooms / showers & restaurant
Heating fuel	Elec/gas	Electric	Electric
Heat generator seasonal efficiency	%	100%	3.21
Is a CHP system installed? (see below for details)	Yes/No	No	No
DHW delivery efficiency	%	0.95	0.95
Is the system a storage system?	Yes/No	No	Yes
Storage system size	litres	-	2505litres (3000 x 83.5%)
Storage system losses	kWh/(l.day)	-	0.0047
Does the system have secondary circulation?	Yes/No	-	Yes
Secondary circulation total flow & return pipe length & losses	m / W/m	-	50 / 8
DHW pump power / time switch?	W / Time switch?	-	250 / Yes

Lighting					
		LT-1	LT-2	LT-3	LT-4
Applies to....	-	Office (perimeter)	Office (Core)	Reception, Kitchen, plant room, Gym	Circulation, toilet, changing, store
Averaged lighting power density across the building OR....	Lumens/circuitW	100	100	100	100
Installed lighting Power Density	W/m2/(100lx)	-	-	-	-
PIR controls?	Description	Auto on/off	Auto on/off	Manual	Auto on/off
PIR - Parasitic Power	W/m²	0.1	0.1	-	0.1
PIR - Time switching?	Yes/No	Yes	Yes	-	Yes
Automatic Daylighting Control?	Yes/No	Yes	-	-	-
Control Type (Switching/Dimming)	Switch/Dim	Dimming	-	-	-
Sensor Type (Standalone/Addressable)	Stand/Add	Addressable	-	-	-
Daylight - Parasitic Power	W/m²	-	-	-	-
Display lighting uses efficient lamps?	lm	22	22	22	22

The Extension Block – HVAC and lighting assumptions

Space Type / Grouping	NCM Building Type	NCM Activity	HVAC - System level	Ventilation - Zonal level	DHW	Lighting	Building Management	LZC Technologies
SF - Cupboard	B1: Office	Office - Cupboard	-	-	-	-	-	-
SF - Circulation	B1: Office	Office - Circulation area	HVAC-11	-	DHW-10	LT-11	BM-1	-
SF - Toilet	B1: Office	Office - Toilet	HVAC-11	VENT-11	DHW-10	LT-11	BM-1	-
SF - Reception	B1: Office	Office - Reception	-	-	-	-	-	-
SF - Light Plant Room	B1: Office	Office - Light Plant Room	-	-	-	-	-	-
SF - Open Plan Office (Perimeter)	B1: Office	Office - Open Plan Office	HVAC-10	VENT-10	DHW-10	LT-10	BM-1	-
SF - Open Plan Office (Core)	B1: Office	Office - Open Plan Office	-	-	-	-	-	-
SF - Meeting Room	B1: Office	Office - Meeting Room	-	-	-	-	-	-
SF - Changing Facilities	B1: Office	Office - Changing Facailities	HVAC-10	VENT-10	DHW-10	LT-11	BM-1	-
SF - Food preperation	B1: Office	Office - Food preperation	-	-	-	-	-	-
SF - Eating drinking area	B1: Office	Office - Eating drinking area	-	-	-	-	-	-
SF - Voild/Lift/Riser	B1: Office	Internal void	-	-	-	-	-	-
SF - Voild/Lift/Riser	B1: Office	Internal void	-	-	-	-	-	-
SF - Gym	B1: Office	Gym	HVAC-10	VENT-10	DHW-10	LT-11	BM-1	-

Table 17. Systems assigned to each space type

Heating, Cooling & Ventilation (HVAC) - SYSTEM LEVEL			
		HVAC-10	HVAC-11
System description	Description	Fan coil units - fed from gas fired boilers	Radiators - fed from gas fired boilers
Applies to....	Room types	All office areas	Circulation
UK NCM type	Type	Fan coil units	Radiators
Heating System			
- Heat Fuel Type	Elec/gas	Gas	Gas
- Heat generator seasonal efficiency	SCOP	0.915	0.915
- Does it Qualify for ECA?	Yes	N/A	N/A
Cooling System			
- Cooling system type (assumed system in model)	Description	Electric heat pump	-
- Chiller fuel type	Description	Elec	-
- Nominal Seasonal EER	SEER	4.89	-
- Nominal EER	EER	3.11	-
- Does it Qualify for ECA?	Yes	N/A	-
System adjustment			
- Ductwork Leakage Classification	Class	Class D	-
- AHU Leakage Classification	Class	Class L1	-
- Specific Fan Power (AHUs)	W/l/s	190%	-
- Pump type	Description	Variable speed	-
Metering Provision			
- Does the system have provision for metering?	Yes/No	No	No
- Does the system warn of "out of range" values	Yes/No	No	No
Ventilation & pumping			
- Cooling/vent mechanism	Air con / nat vent	Air conditioned	Nat vent
- Air supply mechanism	Description	Centralised balanced	-
- Heat recovery	% efficiency or n/a	81%	-
System Controls			
- Central Time Control?	Yes	Yes	Yes
- Optimum start/stop control?	No	Yes	Yes
- Local Time Control?	No	Yes	Yes
- Local Temperature Control?	Yes	Yes	Yes
- Weather Compensation Control?	No	Yes	Yes

Building Management		
		BM-1
Electric Power Factor of the building	Power Factor Control	None fitted
Lighting systems have provision for metering?	Yes/No	None fitted
Lighting systems metering warns of 'out of range' values?	Yes/No	None fitted
Does the system have provision for metering?	Yes/No	None fitted
Does the metering warn "out of range" values?	Yes/No	None fitted

Ventilation - ZONAL LEVEL			
		VENT-10	VENT-12
System description	Description	FCUs - terminal unit SFP	Toilet extract
Applies to....	Room types	All areas with HVAC-1	Toilets
Specific Fan Power (Terminal units)	W/l/s	20%	Not known (use default = 1.8)
Fan location	Description	N/A	Remote from zone
Air change rate (if applicable)	ACH	N/A	10
Demand Control Ventilation (DCV)	Description / type	No	No

Domestic DHW		
		DHW-10
System description	Description	Electric POU
Applies to....	-	All office areas
Heating fuel	Elec/gas	Electric
Heat generator seasonal efficiency	%	100%
Is a CHP system installed? (see below for details)	Yes/No	No
DHW delivery efficiency	%	0.95
Is the system a storage system?	Yes/No	No
Storage system size	litres	None (POU)
Storage system losses	kWh/(l.day)	-
Does the system have secondary circulation?	Yes/No	-
Secondary circulation total flow & return pipe length & losses	m / W/m	-
DHW pump power / time switch?	W / Time switch?	-

Lighting				
		LT-10	LT-11	LT-12
Applies to....	-	Office areas	Toilets, Changing Facilities, Circulation, Gym	Plant room
Averaged lighting power density across the building OR....	Lumens/circuitW	100	100	100
Installed lighting Power Density	W/m2/(100lx)	-	-	-
PIR controls?	Description	Auto on/off	Auto on/off	Manual
PIR - Parasitic Power	W/m²	0.1	0.1	-
PIR - Time switching?	Yes/No	Yes	Yes	-
Automatic Daylighting Control?	Yes/No	Yes	-	-
Control Type (Switching/Dimming)	Switch/Dim	Dimming	-	-
Sensor Type (Standalone/Addressable)	Stand/Add	Addressable	-	-
Daylight - Parasitic Power	W/m²	-	-	-
Display lighting uses efficient lamps?	lm	22	22	22

APPENDIX B: BRUKL REPORTS

Charterhouse St / Saffron Hill Blocks: Be Lean (Base-line)

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Project 2020 — As designed

Date: Wed Aug 02 15:48:12 2017

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.7

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.7

BRUKL compliance check version: v5.3.a.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	21.7
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	21.7
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	19.1
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.2	0.2	00000004:Surf[0]
Floor	0.25	0.22	0.22	00000004:Surf[2]
Roof	0.25	0.1	0.1	00000013:Surf[5]
Windows***, roof windows, and rooflights	2.2	1.4	1.4	00000023:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

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Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- HVAC-1

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	2.93	0	1.9	0.81
Standard value	0.91*	2.7	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

2- HVAC-3

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.27	2.93	0	1.9	0.81
Standard value	2.5*	2.7	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
00_Open Office 003	-	-	-	-	-	-	-	0.2	-	-	N/A
00_Open Office 004	-	-	-	-	-	-	-	0.2	-	-	N/A
00_Reception	-	-	-	-	-	-	-	0.2	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	15241.7	15241.7
External area [m²]	12307.5	12307.5
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	10	3
Average conductance [W/K]	5590.99	5572.42
Average U-value [W/m²K]	0.45	0.45
Alpha value* [%]	10.25	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	6.81	2.72
Cooling	5.3	8.41
Auxiliary	15.13	12.15
Lighting	10.72	18.9
Hot water	5.42	4.45
Equipment*	49.27	49.27
TOTAL**	43.38	46.62

* Energy used by equipment does not count towards the total for calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	81.84	123.1
Primary energy* [kWh/m²]	116.18	126.61
Total emissions [kg/m²]	19.1	21.7

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	$U_{i\text{-}Typ}$	$U_{i\text{-}Min}$	Surface where the minimum value occurs*
Wall	0.23	0.2	00000004:Surf[0]
Floor	0.2	0.22	00000004:Surf[2]
Roof	0.15	0.1	00000013:Surf[5]
Windows, roof windows, and rooflights	1.5	1.1	01000005:Surf[2]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)] $U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]
* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	10

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TWIN EARTH

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Project 2020

As designed

Date: Wed Aug 09 12:22:38 2017

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.7

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.7

BRUKL compliance check version: v5.3.a.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	21.9
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	21.9
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	17.8
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.26	0.26	00000004:Surf[1]
Floor	0.25	0.22	0.22	00000004:Surf[4]
Roof	0.25	0.18	0.18	00000013:Surf[9]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	00000004:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
m³/(h.m²) at 50 Pa	10	10

Page 1 of 17

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- HVAC-1

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1.77	2.93	0	1.9	0.81
Standard value	2.5*	2.7	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

2- HVAC-3

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.27	2.93	0	1.9	0.81
Standard value	2.5*	2.7	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
00_Open Office 003	-	-	-	-	-	-	-	0.2	-	-	N/A
00_Open Office 004	-	-	-	-	-	-	-	0.2	-	-	N/A
00_Reception	-	-	-	-	-	-	-	0.2	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A
00_WC	-	-	-	-	-	-	-	1	-	-	N/A

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TWINEARTH

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	15241.7	15241.7
External area [m²]	12307.5	12307.5
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	10	3
Average conductance [W/K]	5572.42	5572.42
Average U-value [W/m²K]	0.45	0.45
Alpha value* [%]	10.2	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	2.99	1.22
Cooling	5.3	8.41
Auxiliary	15.13	12.15
Lighting	10.72	18.9
Hot water	3.22	4.45
Equipment*	49.27	49.27
TOTAL**	37.36	45.11

* Energy used by equipment does not count towards the total for calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	1.76	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	81.84	123.1
Primary energy* [kWh/m²]	121.17	129.35
Total emissions [kg/m²]	17.8	21.9

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U_{i-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.2	00000004:Surf[0]
Floor	0.2	0.22	00000004:Surf[2]
Roof	0.15	0.1	00000013:Surf[5]
Windows, roof windows, and rooflights	1.5	1.1	01000005:Surf[2]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

U_{i-Typ} = Typical individual element U-values [W/(m²K)] U_{i-Min} = Minimum individual element U-values [W/(m²K)]
* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	10

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Project 2020

As designed

Date: Sun Jul 23 20:39:43 2017

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.7

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.7

BRUKL compliance check version: v5.3.a.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

The building does not comply with England Building Regulations Part L 2013

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	24.5
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	24.5
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	60.6
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.35	0.35	01000001:Surf[0]
Floor	0.25	0.25	0.25	03000012:Surf[0]
Roof	0.25	0.25	0.25	03000004:Surf[1]
Windows***, roof windows, and rooflights	2.2	2.2	2.2	01000001:Surf[1]
Personnel doors	2.2	0.35	0.35	0300000E:Surf[0]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

Page 1 of 8

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	NO
Whole building electric power factor achieved by power factor correction	<0.9

1- HVAC-11

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.92	-	0.2	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	NO				

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

2- HVAC-10

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.92	2.5	0	2.9	-
Standard value	0.91*	2.55	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	NO				

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

3- HVAC-1

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	2.93	0	1.9	0.75
Standard value	0.91*	2.7	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
01_WC	-	0.8	1	-	-	-	-	-	-	-	N/A

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TWIN EARTH

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	3283.9	3283.9
External area [m²]	3271.4	3271.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	10	3
Average conductance [W/K]	2373.18	2193.19
Average U-value [W/m²K]	0.73	0.67
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	31.23	13.71
Cooling	17.95	3.77
Auxiliary	37.39	11.61
Lighting	42	23.67
Hot water	11.62	7.08
Equipment*	44.66	44.66
TOTAL**	140.18	59.85

* Energy used by equipment does not count towards the total for calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	182.22	94.03
Primary energy* [kWh/m²]	356.37	141.99
Total emissions [kg/m²]	60.6	24.5

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U_{i-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.35	01000001:Surf[0]
Floor	0.2	0.25	03000012:Surf[0]
Roof	0.15	0.25	03000004:Surf[1]
Windows, roof windows, and rooflights	1.5	2.2	01000001:Surf[1]
Personnel doors	1.5	0.35	0300000E:Surf[0]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

U_{i-Typ} = Typical individual element U-values [W/(m²K)] U_{i-Min} = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	10

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Project 2020

As designed

Date: Wed Aug 02 16:48:24 2017

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.7

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.7

BRUKL compliance check version: v5.3.a.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	24.8
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	24.8
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	23.6
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.35	0.35	01000001:Surf[0]
Floor	0.25	0.25	0.25	03000012:Surf[0]
Roof	0.25	0.25	0.25	03000004:Surf[1]
Windows***, roof windows, and rooflights	2.2	2.2	2.2	01000001:Surf[1]
Personnel doors	2.2	0.35	0.35	0300000E:Surf[0]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]

U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)] U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* There might be more than one surface where the maximum U-value occurs.

** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

*** Display windows and similar glazing are excluded from the U-value check.

N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

Page 1 of 8

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- HVAC-11

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.92	-	0.2	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

2- HVAC-10

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.92	3.1	0	1.9	0.81
Standard value	0.91*	3.2	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

3- HVAC-1

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	2.93	0	1.9	0.81
Standard value	0.91*	2.7	N/A	1.6^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Allowed SFP may be increased by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
01_WC	-	-	1	-	-	-	-	-	-	-	N/A

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	3283.9	3283.9
External area [m²]	3271.4	3271.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	10	3
Average conductance [W/K]	2373.18	2193.19
Average U-value [W/m²K]	0.73	0.67
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	25.74	16.72
Cooling	3.17	3.5
Auxiliary	17.05	11.25
Lighting	9.11	23.67
Hot water	9.23	7.08
Equipment*	44.66	44.66
TOTAL**	64.29	62.22

* Energy used by equipment does not count towards the total for calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	123.66	99.62
Primary energy* [kWh/m²]	137.95	143.75
Total emissions [kg/m²]	23.6	24.8

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

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Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U_{i-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.35	01000001:Surf[0]
Floor	0.2	0.25	03000012:Surf[0]
Roof	0.15	0.25	03000004:Surf[1]
Windows, roof windows, and rooflights	1.5	2.2	01000001:Surf[1]
Personnel doors	1.5	0.35	0300000E:Surf[0]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

U_{i-Typ} = Typical individual element U-values [W/(m²K)] U_{i-Min} = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	10

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APPENDIX C: CITIGEN – BRIEFING NOTE

TWIN&EARTH

Client: GDM

Project: 17 Charterhouse Street

Citigen – Briefing note

Date: 20th June 2017

The following provides a summary of initial discussions between Matt Cotton (Twin&Earth) and Emily Lister (Business Development Manager, Eon)

1.0 Summary:

Citigen is a district heating and cooling network that is supplied with heat/chilled water from an energy centre located at 47-53 Charterhouse Street, Farringdon London. The building was formally owner by the 'Port of London Authority' and is opposite Smithfield market.

Citigen is a wholly owned subsidiary of EOn energy, and sell heat / chilled water to customers through a heat supply agreement.

2.0 Location of existing network:

The heat/cooling network currently supplies buildings that are mainly to the east and south of the site, including:

- Barbican
- Guildhall
- Museum of London
- Brewers Hall

Eon are currently undertaking a design review to plan for future connection of buildings in the area as they are receiving a lot of interest given planning policy in London which favours connection to district energy networks.

Consideration is being given to extending the heat network to the west along Charterhouse Street to connect in other buildings, so connecting to 17 Charterhouse Street is definitely of interest to Citigen.

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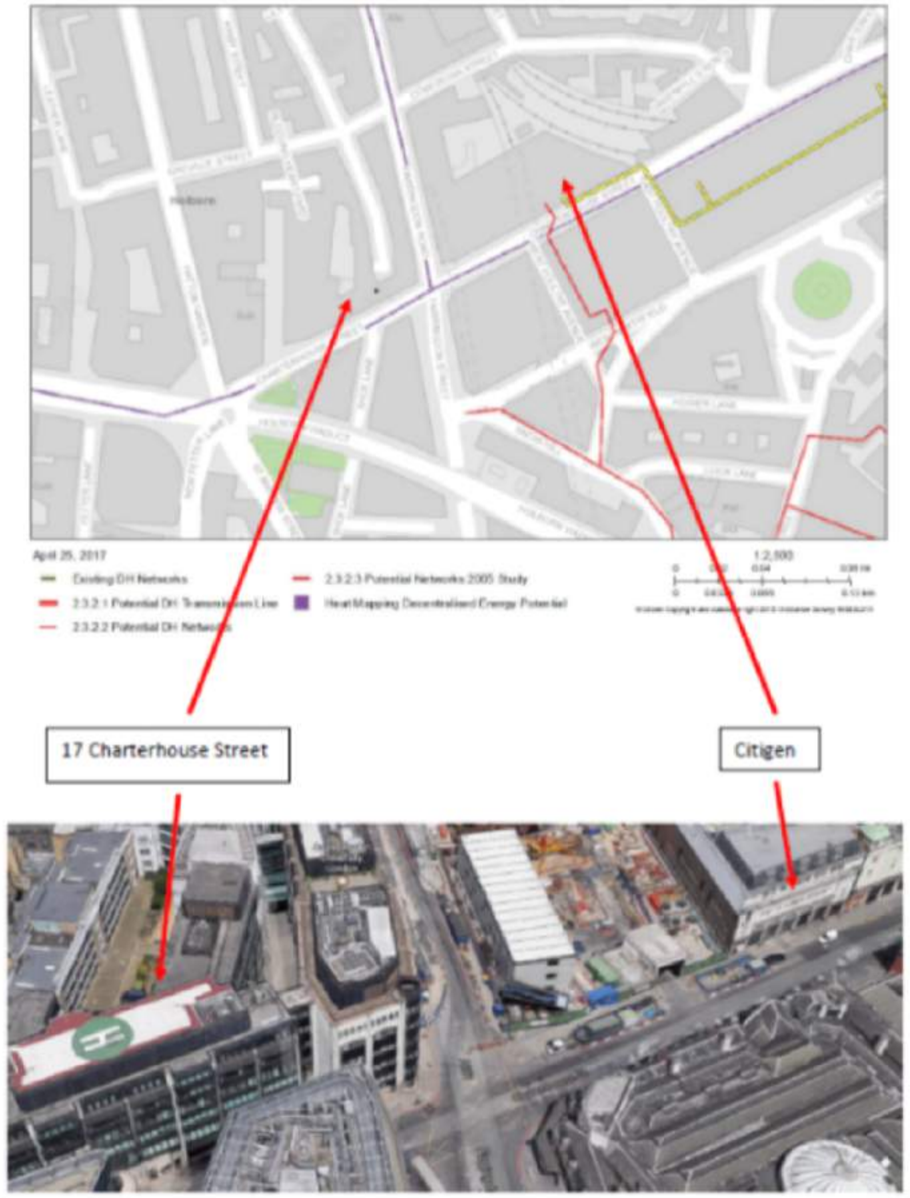
TWIN&EARTH

London HeatMap



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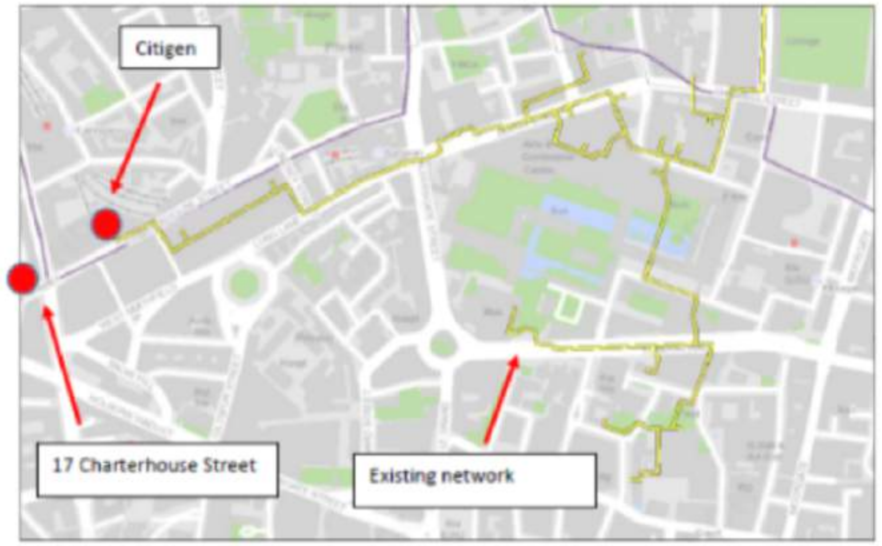
TWIN EARTH

London HeatMap



TWIN EARTH

3.0 Capacity & resilience:

Citigen generation plant includes:

- 2 x CHP (MWM TCG 2032 V16 engines) - 4.3MW each
- Electric chillers
- Adsorption chillers
- Gas boilers (primary) - 3 x 3.3MW
- Gas boilers (back up) - 9MW Museum of London + 9MW Guildhall.

(There are additional / back up boilers located at Guildhall and Museum of London which can be back fed onto the network to provide additional resilience).

4.0 Connection:

Eon would own all generation plant and pipework up to a 'substation' in the building which would comprise a plate heat exchanger.

Client would need to pay a connection fee - approx. costs are £10k/m (£1.45M) based on the following:

- Indicative pipe length: 145m.
- Fee covers installation of pipework from Citigen to the boundary of the building.
- £10K/m is based on average costs for London, and take into account the complexity of trenching in London, including a culverted river that runs down Farringdon Road, existing mains water pipework and the rail line that runs south from Farringdon Station)
- % split between developer and Citigen to be agreed during contract negotiations. Citigen confirmed that it is likely that the developer would pay more, although exact split cannot be confirmed at this stage.
- If other buildings make use of the pipework by connecting at a future date, there could be some compensation (although details not confirmed at the current time).

TWIN EARTH

5.0 Tariffs:

- Eon would agree an initial heat / chilled water price, and separate standing charge
- The tariff is reviewed annually in line with market rates.
- Citigen aim to provide heat / chilled water that is the same cost or cheaper than the least cost
- Tariffs are compared to equivalent price assuming gas boilers / electric chillers
- Citigen are members of the Heat Trust which is a customer protection scheme for the district heating sector (http://www.heattrust.org/)

6.0 Planning:

The Greater London Authority guidance on preparing energy assessments (March 2016) states the following:

- Existing networks: The applicant must investigate the potential for connecting to an existing network
- Where a heat network exists in the vicinity of the development, the applicant must prioritise connection and provide an indication of installation costs and timescales
- Where a development is within an area that could be supplied by a district heating network but the applicant is contending that providing a site heat network to allow future connection will result in uneconomic costs to end users, the applicant must provide a whole life cost (WLC) analysis comparing the communal and individual systems
- At the planning stage a point must be agreed by which connection must be made. This could be set in a number of ways:
    - A stated number of years following occupation of the development
    - A particular date
    - An agreed trigger point, e.g. occupation of the Xth dwelling.
- If connection is not made by the agreed point, the developer must either:
    - Install an on-site low carbon generation heat source to achieve the CO2 reductions originally envisaged from connection to the heat network;
    - Pay a cash-in-lieu contribution to the Borough. The value of the contribution should be the product of the envisaged CO2 reductions from connection to the heat network and the price of CO2 applied by the Borough; or
    - A combination of the above two options.

6.0 Carbon emission factors:

The following emissions factors for heat and chilled water have been confirmed by EOn. For comparison, the emissions from 'conventional' gas boilers and chillers have been provided:

	Citigen (SAP 2012 figures)	Conventional systems **
Chill emissions	0.125 kgCO2/kWh	0.1038 kgCO2/kWh
Heat emissions	0.117 kgCO2/kWh	0.237 kgCO2/kWh

See Appendix A for email confirming emissions factors.

** Assumptions:
Gas emissions factor- 0.216 kghCO2/kWh
Elec emissions factor - 0.519 kgCO2/kWh
Gas boiler efficiency: 91% (inc distribution losses)
Chiller seasonal efficiency (SEER): 5 (inc distribution losses)

As chilled water emissions are higher in the case of Citigen, it is recommended that 'on-site' conventional air cooled or water cooled chillers are considered to provide chilled water to the building.

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7.0 Contact details:

Emily Lister
Business Development Manager
City Connections
Community Energy
+44 (0) 7773 476091
emily.lister@eon-uk.com

E.ON Citigen (London) Ltd
Community Energy
47-53 Charterhouse Street
Farringdon
London
EC1M 6PB
eonenergy.com

Appendix A:

matt cotton

From: Lister, Emily <emily.lister@eon-uk.com>
Sent: 13 June 2017 09:57
To: matt cotton
Subject: Citigen carbon factors

Hi Matt,

Thanks for getting in touch, it was good to catch up.

Please see below carbon factors for the Citigen heat and chill supply:

Citigen carbon intensity based on SAP2009 carbon factors:
- **Chill emissions:** 0.109kgCO_2/kWh as per replant completion in 2015
- **Heat emissions:** 0.062kgCO_2/kWh as per replant completion in 2015

Citigen carbon intensity based on SAP2012 carbon factors:
- **Chill emissions:** 0.125kgCO_2/kWh as per replant completion in 2015
- **Heat emissions:** 0.117kgCO_2/kWh as per replant completion in 2015

As discussed, you are more than welcome to come and have a look around the site. Let me know if there is anything else you need in the meantime.

Thanks,

Emily Lister
Business Development Manager
City Connections
Community Energy
Tel: +44 (0) 7773 476091
emily.lister@eon-uk.com

E.ON Citigen (London) Ltd
Community Energy
47-53 Charterhouse Street
Farringdon
London
EC1M 6PB
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APPENDIX D: HEAT NETWORK CAPPED CONNECTIONS

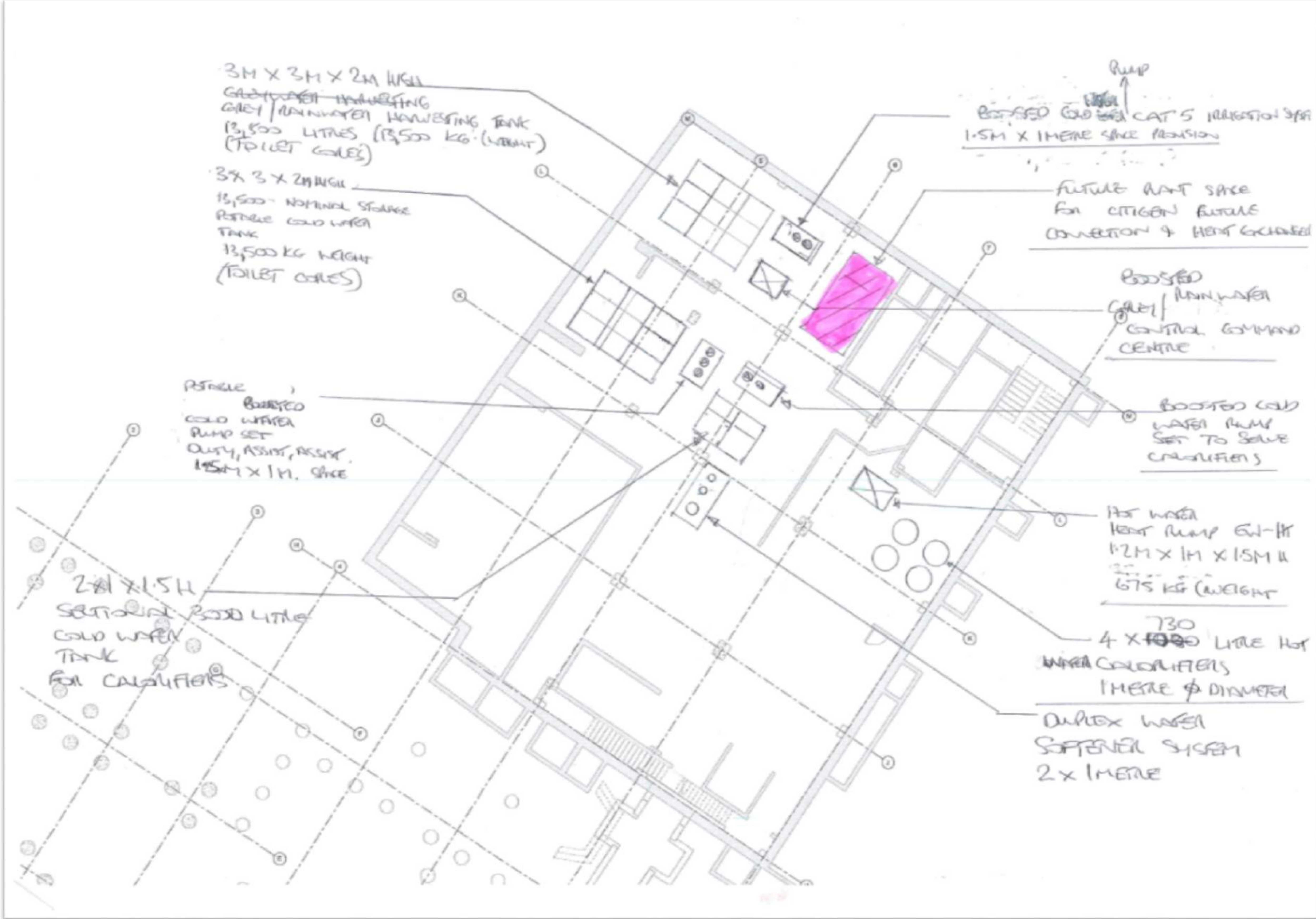

Figure 17. Sketch showing location of plant space for heat exchangers / capped connections for future connection to heat network (e.g Citigen)

APPENDIX E: RENEWABLE TECHNOLOGIES

Photovoltaics

Figure 18. Image of a PV panel

Photovoltaics (PV) are a method of generating electrical power by converting sunlight into direct current electricity using semiconducting materials. Uses of this technology have been explored for more than 50 years and nowadays it is a well-established and reliable technology which has seen prices dramatically reduce over the last decade thanks to economies of scale and the introduction of Feed-in-Tariff's in the UK which provide an additional income from the generation of renewable power. This has resulted in typical financial payback of 8-9 years with returns on investment over 20 years typically in the order of 8-12%.

Types of PV panels

There are three basic types of PV technologies: Monocrystalline, Polycrystalline (or Mutli-crystalline) and Amorphous.

Monocrystalline cells are cut from a single crystal of silicon. In appearance, it has a smooth texture and the thickness of the slice can be easily seen. These PV cells have efficiencies of 13-17% and are the most efficient of the three types of silicon PV cell. However, they require more time and energy to produce than polycrystalline silicon PV cells, and are therefore more expensive.

Polycrystalline (or Multicrystalline) Polycrystalline silicon is produced from a molten and highly pure molten silicon, but using a casting process. The silicon is heated to a high temperature and cooled under controlled conditions in a mould. It sets as an irregular poly- or multi-crystalline form. The square silicon block is then cut into 0.3mm slices. The typical blue appearance is due to the application of an anti-reflective layer. The thickness of this layer determines the colour - blue has the best optical qualities. It reflects the least and absorbs the most light. More chemical processes and fixing of the conducting grid and electrical contacts complete the process. Mass-produced polycrystalline PV cell modules have an efficiency of 11-15%.

Amorphous silicon is non-crystalline silicon. Cells made from this material are found in pocket calculators etc. The layer of semi-conductor material is only 0.5-2.0um thick, where 1um is 0.001mm. This means that considerably less raw material is necessary in their production compared with crystalline silicon PV production. The film of amorphous silicon is deposited as a gas on a surface such as glass. Further chemical processes and the fixing of a conducting grid and electrical contacts follow. These PV cells have an efficiency of between 6-8%. Multi-junction amorphous thin film PV cells are also available which are sensitive to different wavelengths of the light spectrum. These have slightly higher efficiencies.

The favourable efficiency to cost ratio of polycrystalline silicon makes them the most commonly used form of PV. The amount of silicon waste produced during manufacture is also less compared to monocrystalline panels.

Building Integrated PV panels (BIPV)

Although often used as a visible statement of a building's 'green' credentials, the visual impact of building integrated PV can sometimes be considered a limitation. Improvements have been made to improve the aesthetical integration of the technology. Integrated solutions currently available in the market include glazing integrated PV cells, façade integrated PV systems, PV tiles and more recently PV glazing which incorporates the technology in glazed surfaces in an almost fully translucent form.

Figure 19. Image of PV glass sold by Onyx solar

Applicability to development

Installation of solar technologies (PV and/or solar hot water) requires unshaded flat or south facing areas. The areas above the roof on the Saffron Hill Block, in front of the plant screen facing Charterhouse Street and on the roof above St Andrews House provide a good opportunity for the installation of a roof mounted array.

For the above reasons, **PV is a deemed a viable renewable energy solution for the development.**

TWIN EARTH

Solar Hot Water

Solar water heating is a widely used technology within a number of hot and sunny countries and has also been proven a viable technology within the UK climate.

Heat is trapped by collectors usually located on the roof which in turn is used to preheat water which is typically stored in a dual coil cylinder. In order to ensure adequate hot water (particularly during the winter months), and to prevent legionella, the hot water tank is usually has a second heating coil which is heated via a gas boiler or electric immersion heater.

Types of Solar Water Heating collectors

There are two main types of solar water heating collectors: evacuated tubes and flat plate.

Evacuated tube solar thermal systems are one of the most popular solar thermal systems available and are the most efficient with an efficiency of up to 70%. Their efficiency is achieved because of the way in which the evacuated tube systems are constructed, meaning they have excellent insulation and are virtually unaffected by air temperatures. The collector itself is made up of rows of insulated glass tubes which contain a vacuum with copper pipes at their core. Water is heated in the collector and is then sent through the pipes to the water tank.

The cylindrical shape of evacuated tubes means that they are able to collect sunlight throughout the day and at all times in the year. Evacuated tube collectors are also easier to install as they are light, compact, easy to maintain - the tubes can be replaced individually if one becomes faulty – and reliable, but are also the most expensive type of collectors.

The system is efficient and durable with the vacuum inside the collector tubes having been proven to last for over twenty years. The reflective coating on the inside of the tube will also not degrade unless the vacuum is lost.

Figure 20. Image of an evacuated tubes solar thermal panel

Flat plate solar thermal systems comprise a dark coloured flat plate absorber with an insulated cover, a heat transfer liquid containing antifreeze to transfer heat from the absorber to the hot water tank, and an insulated backing. The flat plate feature of the solar panel increases the surface area for heat absorption. The heat transfer liquid is circulated through copper or silicon tubes contained within the flat surface plate.

In an area of the UK that produces an average level of solar energy, the amount of energy a flat plate solar collector generates equates to around one square foot panel generating one gallon (4.5 litres) of one day's hot water.

This design of solar panel is, overall, slightly less compact and less efficient when compared with an evacuated tube system, however this is reflected in a lower overall price. Solar thermal can typically provide up to 50% of total hot water demand (depending on the size of the system), and can have a life expectancy of over 25 years.

Figure 21. Image of a flat plate solar thermal panel

Applicability to development

As with PV panels, installation of solar collectors requires unshaded surfaces which receive direct sunlight. As solar collectors generally offset domestic hot water loads, achievable carbon emissions savings per unit of area are lower than those achieved with PV which offsets grid supplied electricity. For this reason, it is recommended that the available roof area is used for the installation of PV rather than solar thermal panels.

Therefore, **Solar Hot Water is not recommended.**

TWIN EARTH

Heat Pumps

A heat pump is a device that is able to transfer heat from one fluid (e.g. external air) which is at a lower temperature to another fluid (e.g. internal air) at a higher temperature. This is typically achieved through use of a refrigerant that is pumped around a closed circuit of pipework using a pump (compressor). Heat Pumps can be considered low or zero carbon when the heat is take from a renewable source such as ground heat or external air. The efficiency of a heat pump is termed 'coefficient of performance' or C.O.P, and is the ratio of electrical (input) energy to drive the pump to the heat or output energy of the system. A typical air source heat pump has a COP of ~2.5 which means that for every unit of electrical energy used by the pump, the system will produce 2.5 units of heat energy (of which 1.5 units comes from the air, and the other 1 unit comes from the pumping energy).

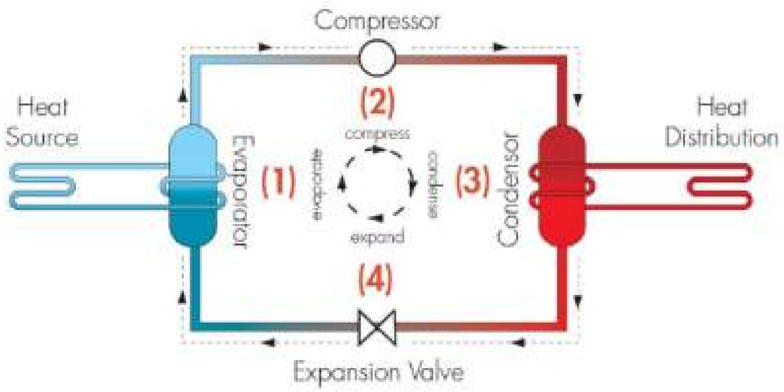

Figure 22. Heat Pump cycle

Types of Heat Pumps

HPs are categorised as follows depending on the source of heat:

A **Ground Source Heat Pump** (GSHP) uses buried coils to extract the heat from the ground into a fluid that contains a mixture of water and antifreeze. The fluid is then passed through a heat exchanger into the heat pump. The ground stays at a fairly constant temperature under the surface, so the heat pump can be used throughout the year – even in the middle of winter.

Coils can be laid down horizontally, which requires larger surface areas, vertically into 100-150m deep boreholes or can be integrated into the building piles – also called thermal piles. When there is an aquifer in close proximity to the site, boreholes can be 'open loop' and directly circulate water from the aquifer as the working fluid.

A **Water Source Heat Pump** (WSHP) produces heat in a similar way to ground source systems. Pipes are submerged in a river, stream or lake, where temperatures can remain at a relatively constant level of between 7 and 12 degrees. Fluid in the pipes absorb the heat from the open water source. This fluid in turn is passed through a heat pump which transfers the heat energy to a distribution system within the building (e.g. radiators, underfloor heating or fan coil units).

An **Air Source Heat Pump** (ASHP) takes heat directly from the external air and boosts it to a higher temperature using a heat pump. As with the above systems, the pump (compressor) needs electricity to operate. As with most Heat Pumps, ASHPs come in different sizes and configurations. One form of ASHP is called Variable Refrigerant Flow / Volume (VRF/VRV) which can deliver both heating and cooling within a building, but also recover heat from one area and transfer the heat to another area through a refrigeration circuit. This can therefore maximise the carbon emissions savings when installed in buildings that may have concurrent heating and cooling demand such as in offices.

Applicability to the development

The installation of air source heat pumps which can recover heat can deliver lower carbon emissions than an equivalent gas boiler and chiller combination, helping to deliver excellent heating and cooling efficiencies. As the building façade is being replaced, lower heat losses means that fan coil units can operate at lower temperatures in heating mode, maximising the efficiency of the heat pump.

Ground source heat pumps are considered to be unfeasible to the limited ground works that are proposed for the development.

For the above reasons, **air source heat pumps are deemed to be a viable renewable energy solution for the development.**

Wind Turbines

Wind turbines use the energy of the wind to generate electricity. On-shore and off-shore wind farms are one of the most widely used technologies for large scale generation of renewable energy with a total installed capacity in the UK of over 28 gigawatts with a 60%/40% on-shore/off-shore split (as of 2014)[2]. Whilst large scale turbines (1MW+) are a financially viable technology for producing clean energy, their visual impact together with the extensive area requirements make them unsuitable for use in most city/town centre locations.

Figure 23. Image of a wind turbine

With sizes typically between 0.3 and 10kW 'Microwind', or 'Small-wind' turbines, are an alternative which can be considered for on-site use as roof mounted devices. According to the Energy Saving Trust, forty percent of all the wind energy in Europe blows over the UK, making it an ideal country for domestic turbines. Whilst this statement applies to some areas, ground roughness due to the built landscape can create turbulence which quite often make the use of roof mounted turbines unfeasible. Also, it is recommended that annual wind speeds average at least 6m/s to provide significant carbon emissions savings.

Applicability to development

Large scale wind turbines can present nuisances such as noise and flicker effect which are not considered acceptable for an urban development of this nature, and are likely to face significant objection through the planning process.

[2] According to the Department of Energy and Climate Change "Digest of United Kingdom Energy Statistics 2014"

With regards to roof mounted wind turbines, recent studies demonstrate that they underperform in urban environments as a result of turbulent air flows, and therefore they are not deemed suitable for a building in this location. Additionally, roof mounted turbines present issues to the currently proposed building structure due to vibration and structural loading.

Therefore, **Wind Turbines are not considered a suitable option for this development.**

Biomass Heating

Biomass heating systems for domestic or commercial use typically burn wood pellets, chips or logs to provide warmth to a single room, or multiple rooms when the heat is delivered through a central heating system. Biomass can also be produced from non-woody fuel sources such as sugar, starch or oils, although most commercially available systems in the UK work with wood based fuel usually in the shape of wood chips or pellets. Wood, in the form of logs, can also be used in some systems, but need to be manually fed and therefore are not viable for most commercial buildings.

Figure 24. Image of wood pellets

Wood chips are typically the cheapest form of biomass (depending on the source of supply), but require larger storage space than pellets as they typically have a lower calorific value per unit volume of fuel as a result of their irregular shape and higher moisture content. On the other hand, **pellets** require more energy to manufacture and quality can significantly vary so sourcing needs careful consideration. In both cases, in addition to the storage requirements of biomass fuels, long term local reliable supply can be an issue. With limited availability in the UK, it is important to set up supply agreements when installing a biomass boiler to avoid price escalation, lack of supply or sourcing of the fuel from abroad. New sustainability criteria regarding biomass has been introduced for the Renewable Heat Incentive (RHI) which will make sure biomass meets the Government's carbon and environmental objectives, ensuring that support delivers value for money. This will affect domestic and non-domestic RHI participants; producers and traders of biomass fuels.

Biomass boilers come in a wide range of sizes and fuel storage / feed configurations. As well as heat only boilers, a limited number of manufacturers also produce biomass combined heat and power systems that can run on biomass fuel, although they are relatively expensive and are only available in a limited range of sizes (outputs).

Applicability to development

Use of biomass heating requires a large area for the supply of pellets which must be within easy reach for the pellets/chips to be blown. The development does not have any available area making the use of this technology unfeasible. In addition, the burning of biomass produces high particulate and NOx emissions which can reduce local air quality, particularly in urban settings.

For these reasons **Biomass heating is not considered a suitable option for this development.**

Biomass Combined Heat and Power

Combined heat and power (CHP) systems integrate the production of usable heat and power (electricity) in one single, highly efficient process. CHP generates electricity whilst also capturing usable heat that is produced as a by-product of the generation process. This contrasts with conventional methods of generating electricity where heat, produced as a by-product of the generation process, is simply wasted. When comparing the energy needed to generate equivalent amounts of heat and electricity via a coal powered station (for electricity) and a conventional boiler (for heat) with a CHP, the overall efficiency of the process increases from less than 50% to over 80%.