HODKINSON

Energy Statement

Designated Contractors Ltd

65-69 Holmes Road 7th Floor, Camden

Nikhil Doshi
CEng

September 2021

DOCUMENT CONTROL RECORD

REPORT STATUS: FINAL

Version	Date	Reason for issue	Author	Checked by	Approved for Issue by Project Manager
v.1	14.09.2020	Draft	N Doshi / A Ramos	J Peck / Z Watkins	Z Watkins
v.2	23.09.2021	Final	N Doshi / A Ramos	J Peck / Z Watkins	Z Watkins

ABOUT HODKINSON CONSULTANCY

Our team of technical specialists offer advanced levels of expertise and experience to our clients. We have a wide experience of the construction and development industry and tailor teams to suit each individual project.

We are able to advise at all stages of projects from planning applications to handover.

Our emphasis is to provide innovative and cost effective solutions that respond to increasing demands for quality and construction efficiency.

This report has been prepared by Hodkinson Consultancy using all reasonable skill, care and diligence and using evidence supplied by the design team, client and where relevant through desktop research.

Hodkinson Consultancy can accept no responsibility for misinformation or inaccurate information supplied by any third party as part of this assessment.

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Executive Summary

The purpose of this Energy Statement is to demonstrate that the proposed development at the 7th floor at 65-69 Holmes Road by Designated Contractors Ltd, in the London Borough of Camden is considered sustainable, as measured against relevant local, regional and national planning policies.

The Energy Strategy has been formulated following the London Plan Energy Hierarchy: ***Be Lean***, ***Be Clean, Be Green*** and ***Be Seen***. The chosen approach has prioritised energy efficiency measures in order to reduce demand, thereby demonstrating a cost-effective and technically appropriate approach.

The proposed development will comprise approximately 552 m^2 of student accommodation and communal areas. The development forms an extension to the existing 65-69 Holmes Road development.

A range of energy efficiency (***Be Lean***) measures are proposed to enable the development to meet the Part L 2013 Target Emissions Rate (TER). This represents a good level of sustainable design and construction and indicates the Applicant's commitment to reducing energy demands of the proposed added floor. The combination of energy efficiency measures will achieve a reduction of **7%** in Regulated CO_2 emissions over the Part L (2013) baseline.

In line with the first step of the heating infrastructure hierarchy the opportunity to connect to an existing network is proposed. The development has an existing energy centre that houses communal boilers and a CHP engine that will provide space heating and hot water. In line with GLA Policy SI 2 D, the strategy uses the SAP 2012 carbon factors to enable the connection to the existing heat network.

It is expected that the gas CHP engine will provide **70%** of the heat demand on an annual basis, with the remaining load being served by the gas boilers. The combination of energy efficiency measures and connection to the heat network with the CHP engine will enable a reduction in Regulated CO_2 emissions of **15%** over the Part L (2013) baseline.

The full spectrum of ***Be Green*** renewable energy sources has been considered. It has been concluded that **17.25 kWp** of PV panels can be utilised, and this provides more than 20% of the renewable contribution as required by the London Borough of Camden. A total carbon dioxide reduction of **35%** over Part L (2013) baseline achieving the requirements of the London Plan.

The application of the BREEAM 2014 principles will help deliver a sustainable development. The scheme will be reducing water consumption with fittings and leak detection and provide appropriately lighting through efficient fittings and methods to prevent glare. Further, the development already has sufficient cycle spaces to accommodate the additional units

The table below summarises the Regulated and Total CO_2 emissions for the development after on-site measures have been applied. A **35%** reduction over the Part L (2013) baseline case is predicted.

CO_2 Emissions following Be Green Measures	Regulated TCO_2 (kg/yr)	% Improvement over Baseline
Part L 2A (2013) Baseline	23.5	-
Be Lean Measures	22.0	7%
Be Clean Measures	20.0	15%
Be Green Measures	15.2	35%

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CONTENTS

1. INTRODUCTION

1.1 This Energy Statement has been prepared by Hodkinson Consultancy, a specialist energy and environmental consultancy for planning and development, appointed by Designated Contractors Ltd. This Statement sets out the energy strategy for the development being proposed at the 7th floor of 65-69 Holmes Road in the London Borough of Camden.

1.2 The formulation of the energy strategy for the proposed development takes into account several important concerns and priorities. These include:

- To address all national, regional and local planning policies and requirements;
- To achieve the maximum viable reduction in carbon dioxide (CO_2) emissions with an affordable deliverable and technically appropriate strategy;
- Provision of high quality, low energy buildings that are adapted to future changes in climate;
- To minimise, to the lowest possible extent, emissions of pollutants such as oxides of nitrogen (NOx) and particulate matter, thereby minimising the effects on local air quality.

1.3 This statement first establishes a baseline assessment of the energy demands and associated CO_2 emissions for the development based on current Building Regulations Part L (2013). It will then outline the energy measures that enable this, as well as any additional local policy targets, to target.

2. DEVELOPMENT OVERVIEW

Site Location – Development Description

2.1 As shown in Figure 1 below, the proposed development site is located at 65-69 Holmes Road, north-west of the Kentish Town West station in the London Borough of Camden.

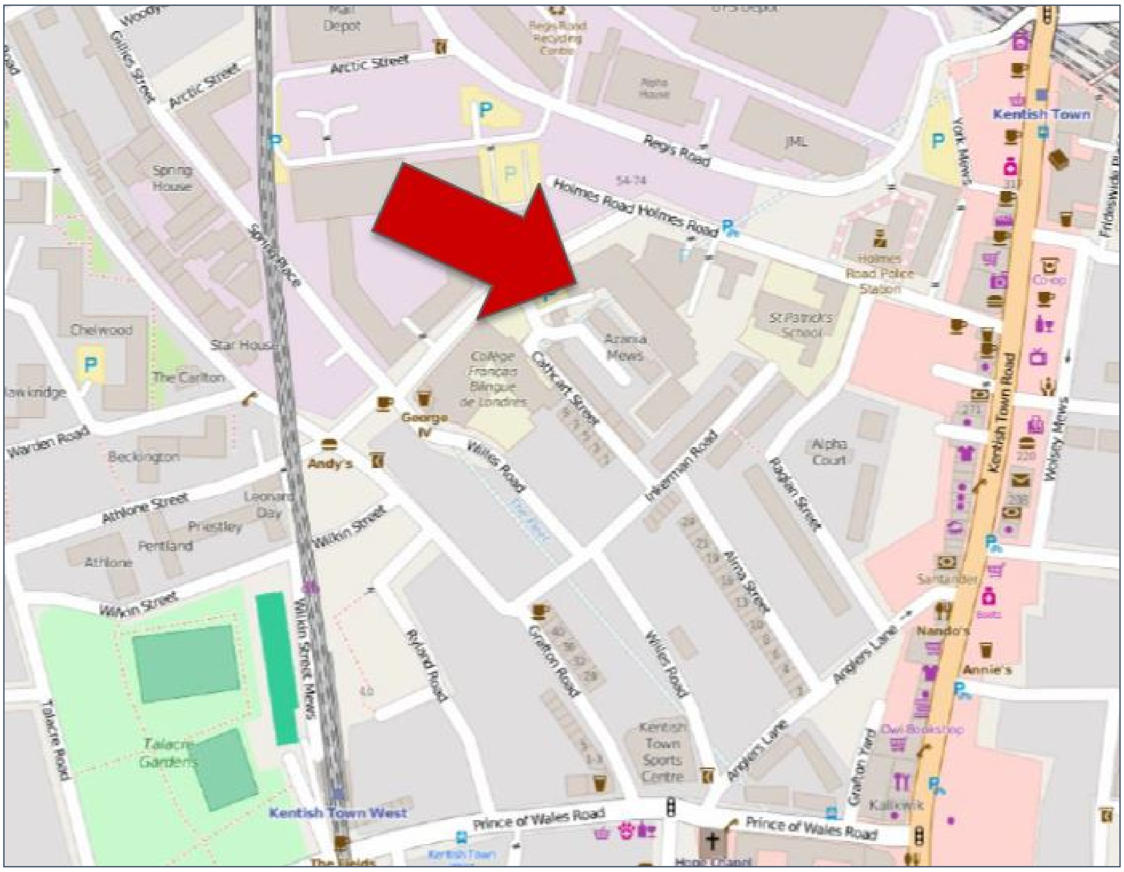

Figure 1: Site Location – © OpenStreetMap Contributors. Go to www.openstreetmap.org/copyright

2.2 The development sits on top of the existing part seven, part three storey student accommodation building.

2.3 The proposed extension that forms this development will comprise of 25 x 1 bedroom units and communal circulation areas in a total of 552 m^2.

2.4 The proposed development is described as follows:

"Erection of seventh floor extension, including the provision of PV panels, to provide additional student accommodation (Sui Generis) in connection with the wider site".

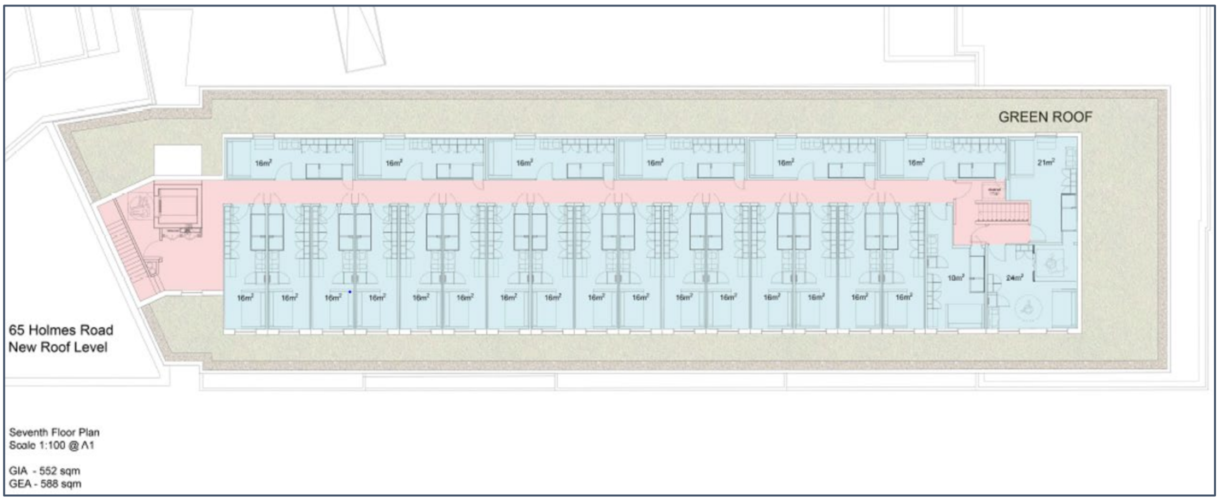

Figure 2: Proposed 7th Floor Plan – Contemporary Design Solution LLP

3. RELEVANT PLANNING POLICY

3.1 The planning policies and requirements in Figure 3 below have informed the sustainable design of the proposed development.

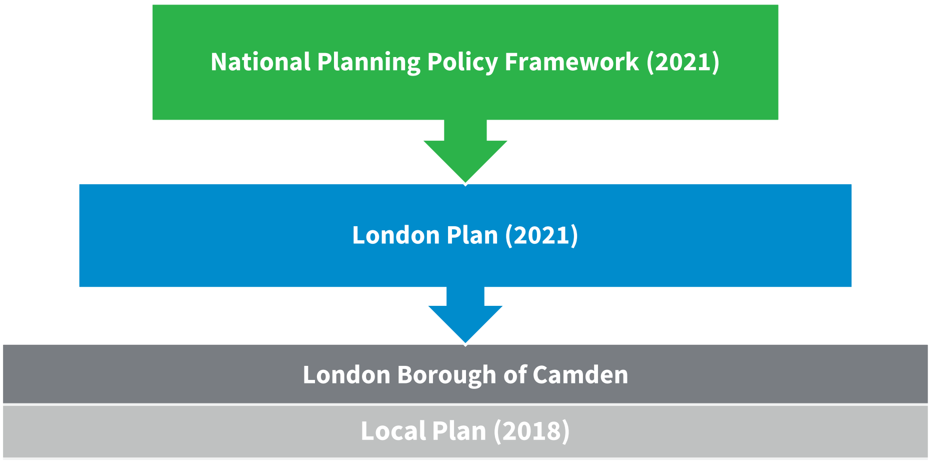

Figure 3: Relevant Planning Policy Documents

National Policy: NPPF

3.2 The revised National Planning Policy Framework (NPPF) was published on the 20th July 2021 and sets out the Government's planning policies for England.

3.3 The NPPF provides a framework for achieving sustainable development, which has been summarised as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*" (Resolution 42/187 of the United National General Assembly). At the heart of the framework is a **presumption in favour of sustainable development**.

3.4 The document states that the planning system has three overarching objectives which are interdependent and need to be pursued in mutually supportive ways:

a) **An economic objective** – to help build a strong, responsive, and competitive economy, by ensuring that sufficient land of the right types is available in the right places and at the right time to support growth, innovation, and improved productivity; and by identifying and coordinating the provision of infrastructure;

b) **A social objective** – to support strong, vibrant, and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering a well-designed and safe built environment, with accessible services and open spaces that reflect current and future needs and support communities' health, social and cultural well-being; and

c) **An environmental objective** – to protecting and enhancing our natural, built, and historic environment; including making effective use of land, helping to improve biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy.

Regional Policy: The London Plan

London Plan (2021)

3.5 The London Plan sets out an integrated economic, environmental, transport and social framework for the development of London. The following policies are considered relevant to the proposed planning application and this Statement:

3.6 **Policy SI2 Minimising Greenhouse Gas Emissions** states that major development should be net zero-carbon. This is to be demonstrated through the application of the energy hierarchy demonstrated in Figure 3, which has an added step from those in previous versions of the London Plan. Though, at this stage still to be consulted upon, "*Be Seen*" intends to monitor, verify, and report on carbon emissions for major developments.

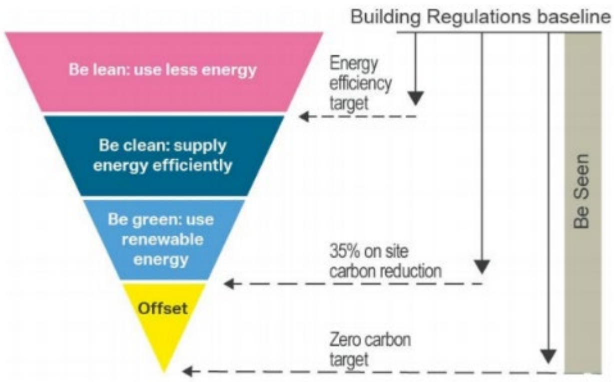

Figure 4: New London Plan Energy Hierarchy (GLA)

3.7 The requirement for major developments is to:

- Achieve a 10% and 15% reduction in carbon emissions for residential and non-residential developments, respectively, through energy efficiency measures alone against a Part L baseline;
- Maximise onsite renewable energy.
- Achieve a minimum onsite reduction in carbon emissions of 35% beyond the Part L baseline.
- Offset shortfalls between the onsite improvements and zero carbon emissions.

3.8 Where there is a requirement to offset onsite carbon emissions, it can be completed in two ways:

- Through a cash in lieu contribution to the borough's carbon offset fund;
- Or alternatively, off-site provided it is identifiable as a deliverable alternative.

3.9 This policy further discusses considering carbon emissions from other elements of the development and thereby conducting a life-cycle carbon assessment.

3.10 **Policy SI3 Energy Infrastructure** states that energy masterplans should be developed for large-scale development locations which establish the most effective energy supply options. The policy further discusses that energy masterplans should consider options to produce the most effective energy supply option. Developments within a Heat Network Priority Areas should have communal low-temperature heating systems, with heat sources from communal systems following a heating hierarchy as follows:

> Connect to local existing or planned heat network;

> Use zero-emission or local secondary heat sources in conjunction with heat pumps if required;

> Use Low Emission CHP;

> Use ultra-low NOx gas boilers

3.11 Such heat networks are expected to be designed in line with CIBSE / ADE Code of Practice CP1 or equivalent.

3.12 **Policy SI4 Managing Heat Risk** states that major development proposals should demonstrate through an energy strategy how they will reduce the potential for internal overheating and reliance on air conditioning systems in accordance with the cooling hierarchy.

Energy Assessment Guidance (October 2020)

3.13 The Greater London Authority (GLA) have published their Energy Assessment Guidance. It provides advice on how the energy statement can demonstrate compliance with the London Plan Policy SI 2. The following are key points taken from the document:

> It provides guidance on the approach on how to complete the assessment for various planning application types. For instance, existing buildings should use the specification noted in the guidance;

> The GLA encourage the use of SAP 10.0 carbon factors for referable schemes except for those expecting to connect to an existing heat network;

Local Policy: London Borough of Camden

3.14 The London Borough of Camden's Local Plan document was adopted in July 2017. The following policies are considered relevant to this Statement:

3.15 **Policy CC1: Climate Change Mitigation** – The Council will require all development to minimise the effects of climate change and encourage all developments to meet the highest feasible environmental standards that are financially viable during construction and occupation. The Council will:

> Require all developments to reduce carbon dioxide emissions through following the steps in the energy hierarchy;

> The Council will expect developments of five or more dwellings and/or more than 500 sqm of any gross internal floor space to achieve a 20% reduction in carbon dioxide emissions from on-site renewable energy generation (which can include sources of site related decentralised renewable energy), unless it can be demonstrated that such provision is not feasible. The 20% reduction should be calculated from the regulated CO_2 emissions of the development after all proposed energy efficiency measures and any CO_2 reduction from non-renewable decentralised energy (e.g. CHP) have been incorporated;

> Support and encourage sensitive energy efficiency improvements to existing buildings.

3.16 **Policy CC2: Adapting to Climate Change –** All development should adopt appropriate climate change adaption measures such as:

> Measures to reduce the impact of urban and dwelling overheating, including application of the cooling hierarchy.

> The Council will promote and measure sustainable design and construction by:

> Ensuring development schemes demonstrate how adaptation measures and sustainable development principles have been incorporated into the design and proposed implementation;

3.17 Non-domestic developments of 500 sqm of floorspace or above to achieve "excellent" in BREEAM assessments and zero carbon is encouraged in new development from 2019.

Energy efficiency and adaptation – Camden Planning Guidance 2019

3.18 Table 2b of this guidance document sets out that major and medium non-domestic planning applications should achieve a minimum of a 35% reduction over Part L 2013 and target a 20% reduction through renewables.

Summary of Targets

3.19 The development is subject the following targets:

> Hierarchy of ***Be Lean***, ***Be Clean***, ***Be Green*** to be followed to achieve a site-wide **35% regulated CO_2 reduction**;

> Be seen is not required as this is not a major application;

> 20% reduction in carbon dioxide emissions from on-site renewable energy generation on the ***Be Green*** step.

> BREEAM – "Excellent" rating required.

4. BUILDING REGULATIONS (2013) BASELINE

Methodology

4.1 This statement first establishes a baseline assessment of the energy demands and associated CO_2 emissions for the development based on the Part L (2013) Building Regulations baseline case.

4.2 To ensure the energy system hierarchy is appropriately followed, SAP 2012 carbon factors have been used throughout this assessment. This is discussed further in "***Be Clean***."

4.3 The report will then follow the London Plan Energy Hierarchy approach of ***Be Lean, Be Clean and Be Green*** to enable the maximum viable reductions in Regulated and Total CO_2 emissions over the calculated baseline. In order to achieve and go beyond the baseline case, a fabric first approach using Energy Efficiency measures ***(Be Lean)*** has been prioritised to minimise energy demand.

4.4 The estimated annual CO_2 emissions have been calculated using Simplified Building Energy Model (SBEM) methodology.

4.5 Table 1 shows the Regulated baseline CO_2 emissions per year. The calculations summary sheet is presented in **Appendix A** and the supporting BRUKL sheets are presented in **Appendix B**.

Table 1: Part L (2013) Baseline Emissions

Building Regulations Baseline Part L (2013) - Regulated and Total CO_2		
	Regulated TCO_2 (kg/year)	**Unregulated TCO_2 (kg/year)**
Total CO_2 emissions	23.5	4.3

5. *BE LEAN* – ENERGY EFFICIENCY

5.1 The first step of a sustainable energy strategy is to reduce energy demand. It is therefore the Applicant's intention that the energy efficiency measures will be prioritised over the generation of energy to meet a demand that need not exist.

5.2 The following energy efficiency measures will be incorporated into the design to enable the proposed development to exceed Part L (2013) of the Building Regulations through energy efficiency measures alone.

Insulation Standards

5.3 The building will incorporate enhanced insulation in the building envelope (walls, roofs, floors and glazing) to achieve average U-values better than those required by Part L (2013) Building Regulations. There are likely to include:

> External wall U-value of 0.22W/m^2.K;

> Flat roof U-value of 0.15 W/m^2.K;

> Double glazing with a U-value of 1.5 W/m^2.K and a g-value of <0.22;

Air Tightness & Ventilation

5.4 Air leakage is to be minimised and an air permeability of 7.0 m^3/hr/m^2 will be targeted, which is a good and at the same time realistic target for this type of building.

5.5 It is proposed to install low-energy Mechanical Extract Ventilation (MEV) for the bedroom pods and the toilets with a Specific Fan Power (SFP) of <0.30 W/l/s. This system will provide background ventilation.

Lighting

5.6 The major energy demand within modern commercial spaces is generally lighting. Specified lighting in these areas is envisaged to be LED (likely to require >70 lumens/circuit watt and a light output ratio of 1, designed to CIBSE Illuminance levels.

5.7 Demand reducing lighting controls such as occupancy sensors for zones with transient occupancy (parasitic power of <0.1 W/m^2) would be beneficial, as they would allow light output to be automatically adjusted to suit prevailing conditions.

Space Heating and Hot Water

5.8 The space heating requirement will be reduced by the fabric and air tightness measures detailed above.

5.9 A communal heat distribution network already exists within close proximity to the proposed 7th floor development. To cover the space heating and hot water demand, it is proposed to connect to the existing district heating network.

5.10 The boiler has a seasonal efficiency of 95% and is used for this stage of the assessment.

Limiting the Risk of Summer Overheating

5.11 Minimising the risk of summer overheating is important to ensure that the proposed building is adapted to climate change and remains comfortable to occupy in the future.

5.12 The development will therefore be subject to measures that reduce the risk of summer overheating as much as possible. As standard, all bedrooms will have blinds.

5.13 Solar control glazing is proposed, with a solar transmittance (g) value of 0.22.

5.14 Based on this strategy, the SBEM software does not show a risk of solar gains exceedance in the bedroom areas.

CO_2 Emissions after Energy Efficiency Measures

5.15 Table 2 outlines the CO_2 emissions following the inclusion of the above Energy Efficiency measures. It can be seen that the Building Regulations baseline has been met just by applying these measures alone.

Table 2: CO_2 Reduction after Energy Efficiency Measures

CO_2 Emissions following Be Green Measures	Regulated TCO_2 (kg/yr)	% Improvement over Baseline
Part L 2A (2013) Baseline	23.5	-
Be Lean Measures	22.0	7%

6. *BE* CLEAN - HEATING INFRASTRUCTURE

6.1 In line with Policy SI 3 of the London Plan, the feasibility of community energy networks has been evaluated. This is the next step in the Energy Hierarchy after ***Be Lean***. London Plan outlines the following order of preference:

> Connection to local existing or planned heat networks;

> Use zero-emission or local secondary heat sources (in conjunction with heat pump, if required);

> Use low-emission combined heat and power (CHP);

> Use ultra-low NOx boilers.

Connection to existing District Heating Network

6.2 The adjacent 65-69 Holmes Road development has a site-wide Energy Centre. In line with the energy system hierarchy, noted above, this development will connect to the existing network. The heat network utilises a gas fired CHP and back-up boilers.

6.3 The energy centre operators have confirmed that the CHP engine in the existing energy centre has a thermal efficiency of >41.5%, a heat to power ratio of 1.66 and a size of 81kWth. Furthermore, they have confirmed that it has sufficient capacity for the proposed development.

6.4 It is expected that 70% of the total annual heat demand is to be provided by the CHP. The remaining 30% of the load is expected to be met through gas boilers.

6.5 The gas boilers in the existing energy centre are proposed to maintain an efficiency of 95% as per the ***Be Lean*** case.

CO_2 Emissions after *Be Clean* Measures

6.6 Following the connection of the proposed development to the existing heat network, the reductions in CO_2 emissions over the Be Lean measures are estimated in Table 3 below.

Table 3: CO_2 emissions following *Be Clean* measures

CO_2 Emissions following Be Green Measures	Regulated TCO_2 (kg/yr)	% Improvement over Baseline
Part L 2A (2013) Baseline	23.5	-
Be Lean Measures	22.0	7%
Be Clean Measures	20.0	8%

7. *BE GREEN* – RENEWABLE ENERGY

7.1 It can be seen from Chapter 5 of this report that the Building Regulations (2013) have been met with energy efficiency measures alone.

7.2 Camden council, in line with London Plan, requires a 20% reduction in CO_2 emissions to be achieved by renewable energy measures, and on an overall reduction of 35%.

7.3 Further details on the renewable technologies discussed in this section can also be found in **Appendix C.**

7.4 **Appendix D** provides a feasibility study table of the technologies that have been considered.

Biomass Boiler

7.5 Biomass boilers generate heat on a renewable basis as they are run on biomass fuel which is carbon neutral.

7.6 In line with the energy system hierarchy, the proposed development will connect to the Energy Centre which is designed to utilise gas boilers and a CHP engine, which remains preferable.

7.7 As there is no control over the heat generation technology, a biomass boiler cannot be selected.

Heat Pumps

7.8 Ground Source Heat Pump (GSHP) utilise ground temperatures to produce renewable heat. This application is above an existing building and has no access to ground. As a result, GSHP are not considered applicable.

7.9 Air Source Heat Pumps (ASHP) utilise ambient air to generate renewable heat. Their use would conflict with the heat provided by the network. As a result, to ensure the energy system hierarchy is followed, ASHP are not considered appropriate.

Micro Wind Turbines

7.10 Small rooftop wind turbines are designed to generate electricity from the wind.

7.11 Urban rooftop wind turbines do not generally perform sufficiently well to warrant their installation, due to the low and turbulent wind conditions present. They are therefore likely to remain technically unfeasible.

7.12 It has therefore been concluded that wind turbines are not a suitable technology for this site.

Solar Thermal (Hot Water) Panels

7.13 Solar thermal panels use the sun's radiant heat to generate hot water. Due to the seasonality of solar radiation, solar thermal panels can provide up to a good proportion of hot water demand, with the remainder being provided as top-up by the conventional heating system.

7.14 Roof space will however be lost for the placement of the storage tanks, which will reduce their impact.

7.15 Whilst technically viable, solar thermal panels would conflict with the proposed heating connection, and the roof space requirements of PV panels, with the latter considered a more appropriate option for this particular site.

7.16 Therefore Solar Thermal Panels have not been specified.

Selected Technology - Photovoltaic (PV) Panels

7.17 Unlike solar thermal panels, PV panels are not constrained by the hot water demand. PV panels are good at enabling substantial reductions in CO_2 emissions as a result.

7.18 It has been calculated that a total of 17.25kWp of horizontally placed PV panels is required, for a 20% reduction in carbon dioxide emissions to be realised from renewables.

7.19 With a figure of 13 m^2/kWp, a total of 224m^2 of roof space is required to accommodate the amount of PV mentioned above, in order to allow for spacing between rows for overshadowing and access for maintenance.

7.20 Provided that the total internal area is approximately 552 m^2, it is predicted that there is enough space to accommodate the PV panels.

7.21 An indicative roof plan is presented in **Appendix E**.

CO_2 Emissions after *Be Green* Measures

7.22 Table 4 outlines the savings from the selected renewable energy sources for the development.

7.23 It is demonstrated that the 20% carbon dioxide reduction requirement through renewable energy sources is achieved and exceeded.

Table 4: CO_2 emissions following *Be Green* measures

CO_2 Emissions following Be Green Measures	Regulated TCO_2 (kg/yr)	% Improvement over Baseline
Part L 2A (2013) Baseline	23.5	-
Be Lean Measures	22.0	7%
Be Clean Measures	20.0	15%
Be Green Measures	15.2	35%

8. BREEAM

8.1 The student accommodation in the wider development has been assessed as a fully fitted assessment and is certified against the BREEAM New Construction 2014 scheme (BREEAM number: BREEAM-0078-8448; date of certification: 14.07.2020) and achieved a 'Very Good' rating.

8.2 The Applicant is committed to incorporating all applicable BREEAM requirements in the design and development of the proposed additional units in line with those undertaken in the completed student accommodation. However, a BREEAM assessment on the additional units will not be carried out because the proposed amendments would not meet the criteria for a full BREEAM New Construction assessment.

8.3 Some of the key requirements that will be incorporated include:

> Connecting the new rooms to the existing BMS;

> A 40% improvement over baseline water consumption. The following flow rates will be used, as per the rest of the development. As the sanitaryware fittings for the 7th floor will be the same as those on floors 1 – 6, the water calculation will not change. The flow rates and flush volumes specified are noted below:

  > WCs – 6/4 dual flush;

  > Basin taps – 4.5 litres/min;

  > Showers – 6 litres/min;

  > Kitchen taps – 5 litres/min.

> Internal lighting to be energy-efficient, zoned, and occupant controlled;

> The BREEAM sound insulation requirements will be met, as per the rest of the development;

> Solenoid valves will be installed to regulate leaks and wastage from sanitary facilities;

> Glare control to be installed in each bedroom space;

> The existing development had a surplus of cycle spaces and refuse spaces so the addition of the new rooms will not impact these provisions.

8.4 To summarise, the Applicant is committed to following the requirements of the BREEAM assessment completed in July 2020 in the design and development of the proposed changes.

9. SUMMARY

9.1 The purpose of this Energy Statement is to demonstrate that the proposed development at the 7th floor at 65-69 Holmes Road by Designated Contractors Ltd, in the London Borough of Camden is considered sustainable, as measured against relevant local, regional and national planning policies.

9.2 The Energy Strategy has been formulated following the London Plan Energy Hierarchy: Be Lean, Be Clean, Be Green and Be Seen. The chosen approach has prioritised energy efficiency measures in order to reduce demand, thereby demonstrating a cost-effective and technically appropriate approach.

9.3 The proposed development will comprise approximately 552 m^2 of student accommodation and communal areas. The development forms an extension to the existing 65-69 Holmes Road development.

9.4 A range of energy efficiency (Be Lean) measures are proposed to enable the development to meet the Part L 2013 Target Emissions Rate (TER). This represents a good level of sustainable design and construction and indicates the Applicant's commitment to reducing energy demands of the proposed added floor. The combination of energy efficiency measures will achieve a reduction of 7% in Regulated CO_2 emissions over the Part L (2013) baseline.

9.5 In line with the first step of the heating infrastructure hierarchy the opportunity to connect to an existing network is proposed. The development has an existing energy centre that houses communal boilers and a CHP engine that will provide space heating and hot water. In line with GLA Policy SI 2 D, the strategy uses the SAP 2012 carbon factors to enable the connection to the existing heat network.

9.6 It is expected that the gas CHP engine will provide 70% of the heat demand on an annual basis, with the remaining load being served by the gas boilers. The combination of energy efficiency measures and connection to the heat network with the CHP engine will enable a reduction in Regulated CO_2 emissions of 15% over the Part L (2013) baseline.

9.7 The full spectrum of Be Green renewable energy sources has been considered. It has been concluded that 17.25 kWp of PV panels can be utilised, and this provides more than 20% of the renewable contribution as required by the London Borough of Camden. A total carbon dioxide reduction of 35% over Part L (2013) baseline achieving the requirements of the London Plan.

9.8 The application of the BREEAM 2014 principles will help deliver a sustainable development. The scheme will be reducing water consumption with fittings and leak detection and provide appropriately lighting through efficient fittings and methods to prevent glare. Further the development already has sufficient cycle spaces to accommodate the additional units

9.9 The table below summarises the Regulated and Total CO_2 emissions for the development after on-site measures have been applied. A 35% reduction over the Part L (2013) baseline case is predicted.

Table 5: CO_2 emissions following *Be Green* measures

CO_2 Emissions following Be Green Measures	Regulated TCO_2 (kg/yr)	% Improvement over Baseline
Part L 2A (2013) Baseline	23.5	-
Be Lean Measures	22.0	7%
Be Clean Measures	20.0	15%
Be Green Measures	15.2	35%

APPENDICES

Appendix A:
Energy Efficiency Calculations

Appendix B:
SBEM BRUKL Outputs

Appendix C:
Low Carbon and Renewable Energy Technologies

Appendix D:
Low Carbon and Renewable Energy Technology Feasibility Table

Appendix E:
Indicative Roof Layout

Appendix A

Building Regulations Be Lean, Be Clean and Be Green Calculations

Non-domestic

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	23.5	4.3
After energy demand reduction (be lean)	22.0	4.3
After heat network connection (be clean)	20.0	4.3
After renewable energy (be green)	15.2	4.3

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be lean: savings from energy demand reduction	1.5	7%
Be clean: savings from heat network	2.0	8%
Be green: savings from renewable energy	4.8	20%
Total Cumulative Savings	**8.3**	**35%**
Annual savings from off-set payment	15.2	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**457**	-
Cash in-lieu contribution (£)	**43,391**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development Information' tab

Appendix B

SBEM BRUKL Documents

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

65-69 Holmes Road 7th Floor

As designed

Date: Mon Jul 30 15:28:54 2018

Administrative information

Building Details

Address: 65-69 Holmes Road, London, NW5 3AU

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.4.b.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.4.0

BRUKL compliance check version: v5.4.b.0

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address:

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	42.6
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	42.6
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	36.2
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	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.22	0.22	0_7th Floor - Circulation_W_8
Floor	0.25	-	-	"No heat loss floors"
Roof	0.25	0.15	0.15	0_7th Floor - Circulation_R_4
Windows***, roof windows, and rooflights	2.2	1.5	1.5	0_7th Floor - Bedrooms_G_6
Personnel doors	2.2	-	-	"No external personnel doors"
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

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

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]

$U_{i\text{-}Calc}$ = 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	7

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	>0.95

1- Communal Heating CHP underfloor

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
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.

1- Project DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	0
Standard value	N/A	N/A

1- CHP 1

	CHPQA quality index	CHP electrical efficiency
This building	110	0.26
Standard value	105	0.2

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
0_7th Floor - Circulation	-	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bedrooms	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A

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
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
0_7th Floor - Circulation	-	70	-	340
0_7th Floor - Bedrooms	-	70	-	1551
0_7th Floor - Bathroom	-	70	-	19
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	17
0_7th Floor - Bathroom	-	70	-	19
0_7th Floor - Bathroom	-	70	-	31
0_7th Floor - Bathroom	-	70	-	17

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
0_7th Floor - Bedrooms	NO (-89%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	773.4	773.4
External area [m^2]	1140.2	1140.2
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	7	3
Average conductance [W/K]	265.19	431.19
Average U-value [W/m^{2}K]	0.23	0.38
Alpha value* [%]	11.09	15.02

* 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
	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
100	**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/m^2]

	Actual	Notional
Heating	48.82	24.06
Cooling	0	0
Auxiliary	16.61	20.75
Lighting	4.09	5.31
Hot water	196.05	112.19
Equipment*	7.86	7.86
TOTAL**	**213.32**	**162.31**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	52.25	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	98.96	111.09
Primary energy* [kWh/m^2]	200.3	244.22
Total emissions [kg/m^2]	36.3	42.6

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
	Actual	25.8	12.8	8.5	0	16.6	0.85	0	0.95	0
	Notional	70.9	40.2	24.1	0	20.7	0.82	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

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	0.22	0_7th Floor - Circulation_W_8
Floor	0.2	-	"No heat loss floors"
Roof	0.15	0.15	0_7th Floor - Circulation_R_4
Windows, roof windows, and rooflights	1.5	1.5	0_7th Floor - Bedrooms_G_6
Personnel doors	1.5	-	"No external personnel doors"
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"

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	7

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

65-69 Holmes Road 7th Floor

As designed

Date: Mon Jul 30 15:21:32 2018

Administrative information

Building Details

Address: 65-69 Holmes Road, London, NW5 3AU

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.4.b.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.4.0

BRUKL compliance check version: v5.4.b.0

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address:

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	42.6
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	42.6
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	27.6
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	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.22	0.22	0_7th Floor - Circulation_W_8
Floor	0.25	-	-	"No heat loss floors"
Roof	0.25	0.15	0.15	0_7th Floor - Circulation_R_4
Windows***, roof windows, and rooflights	2.2	1.5	1.5	0_7th Floor - Bedrooms_G_6
Personnel doors	2.2	-	-	"No external personnel doors"
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

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

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]

$U_{i\text{-}Calc}$ = 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	7

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	>0.95

1- Communal Heating CHP underfloor

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
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.

1- Project DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	0
Standard value	N/A	N/A

1- CHP 1

	CHPQA quality index	CHP electrical efficiency
This building	110	0.26
Standard value	105	0.2

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**
0_7th Floor - Circulation	-	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bedrooms	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A

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
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
0_7th Floor - Circulation	-	70	-	340
0_7th Floor - Bedrooms	-	70	-	1551
0_7th Floor - Bathroom	-	70	-	19
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	17
0_7th Floor - Bathroom	-	70	-	19
0_7th Floor - Bathroom	-	70	-	31
0_7th Floor - Bathroom	-	70	-	17

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
0_7th Floor - Bedrooms	NO (-89%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	773.4	773.4
External area [m^2]	1140.2	1140.2
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	7	3
Average conductance [W/K]	265.19	431.19
Average U-value [W/m^{2}K]	0.23	0.38
Alpha value* [%]	11.09	15.02

* 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
	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
100	**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/m^2]

	Actual	Notional
Heating	48.82	24.06
Cooling	0	0
Auxiliary	16.61	20.75
Lighting	4.09	5.31
Hot water	196.05	112.19
Equipment*	7.86	7.86
TOTAL**	**213.32**	**162.31**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	16.7	0
Wind turbines	0	0
CHP generators	52.25	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	98.96	111.09
Primary energy* [kWh/m^2]	200.3	244.22
Total emissions [kg/m^2]	27.6	42.6

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
	Actual	25.8	12.8	8.5	0	16.6	0.85	0	0.95	0
	Notional	70.9	40.2	24.1	0	20.7	0.82	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

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	0.22	0_7th Floor - Circulation_W_8
Floor	0.2	-	"No heat loss floors"
Roof	0.15	0.15	0_7th Floor - Circulation_R_4
Windows, roof windows, and rooflights	1.5	1.5	0_7th Floor - Bedrooms_G_6
Personnel doors	1.5	-	"No external personnel doors"
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"

$U_{i\text{-}Typ}$ = 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**
$m^3/(h.m^2)$ at 50 Pa	5	7

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

65-69 Holmes Road 7th Floor

As designed

Date: Mon Jul 30 15:34:02 2018

Administrative information

Building Details

Address: 65-69 Holmes Road, London, NW5 3AU

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.4.b.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.4.0

BRUKL compliance check version: v5.4.b.0

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address:

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	42.6
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	42.6
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	39.8
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	0.22	0.22	0_7th Floor - Circulation_W_8
Floor	0.25	-	-	"No heat loss floors"
Roof	0.25	0.15	0.15	0_7th Floor - Circulation_R_4
Windows***, roof windows, and rooflights	2.2	1.5	1.5	0_7th Floor - Bedrooms_G_6
Personnel doors	2.2	-	-	"No external personnel doors"
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

$U_{a-Limit}$ = 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	7

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	>0.95

1- Communal Heating CHP underfloor

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	-	-	-	-
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.

1- Project DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	0
Standard value	N/A	N/A

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
0_7th Floor - Circulation	-	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bedrooms	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A

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
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A
0_7th Floor - Bathroom	0.3	-	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
0_7th Floor - Circulation	-	70	-	340
0_7th Floor - Bedrooms	-	70	-	1551
0_7th Floor - Bathroom	-	70	-	19
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	21
0_7th Floor - Bathroom	-	70	-	17
0_7th Floor - Bathroom	-	70	-	19
0_7th Floor - Bathroom	-	70	-	31
0_7th Floor - Bathroom	-	70	-	17

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
0_7th Floor - Bedrooms	NO (-89%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	773.4	773.4
External area [m^2]	1140.2	1140.2
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	7	3
Average conductance [W/K]	265.19	431.19
Average U-value [W/m^2K]	0.23	0.38
Alpha value* [%]	11.09	15.02

* 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
	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
100	**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/m^2]

	Actual	Notional
Heating	28.21	24.06
Cooling	0	0
Auxiliary	16.61	20.75
Lighting	4.09	5.31
Hot water	107.68	112.19
Equipment*	7.86	7.86
TOTAL**	**156.6**	**162.31**

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

Energy Production by Technology [kWh/m^2]

	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/m^2]	98.96	111.09
Primary energy* [kWh/m^2]	227.75	244.22
Total emissions [kg/m^2]	39.8	42.6

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
	Actual	86.1	12.8	28.2	0	16.6	0.85	0	0.95	0
	Notional	70.9	40.2	24.1	0	20.7	0.82	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

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	0.22	0_7th Floor - Circulation_W_8
Floor	0.2	-	"No heat loss floors"
Roof	0.15	0.15	0_7th Floor - Circulation_R_4
Windows, roof windows, and rooflights	1.5	1.5	0_7th Floor - Bedrooms_G_6
Personnel doors	1.5	-	"No external personnel doors"
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"

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
$m^3/(h.m^2)$ at 50 Pa	5	7

Appendix C
Low Carbon and Renewable Energy Technologies

1. INTRODUCTION

> This Appendix is intended to provide the background information for the low carbon and renewable energy technologies that have been considered in the formulation of this Energy Statement.

> The information provided here forms the basis for the project specific technical selection of low carbon/renewable energy technologies contained in the main section of this Energy Statement.

2. COMBINED HEAT AND POWER (CHP)

> CHP is a form of decentralised energy generation that generally uses gas to generate electricity for local consumption, reducing the need for grid electricity and its associated high CO_2 emissions. As the CHP system is close to the point of energy demand, it is possible to use the heat that is generated during the electricity generation process. As both the electricity and heat from the generator is used, the efficiency of the system is increased above that of a conventional power plant where the heat is not utilised.

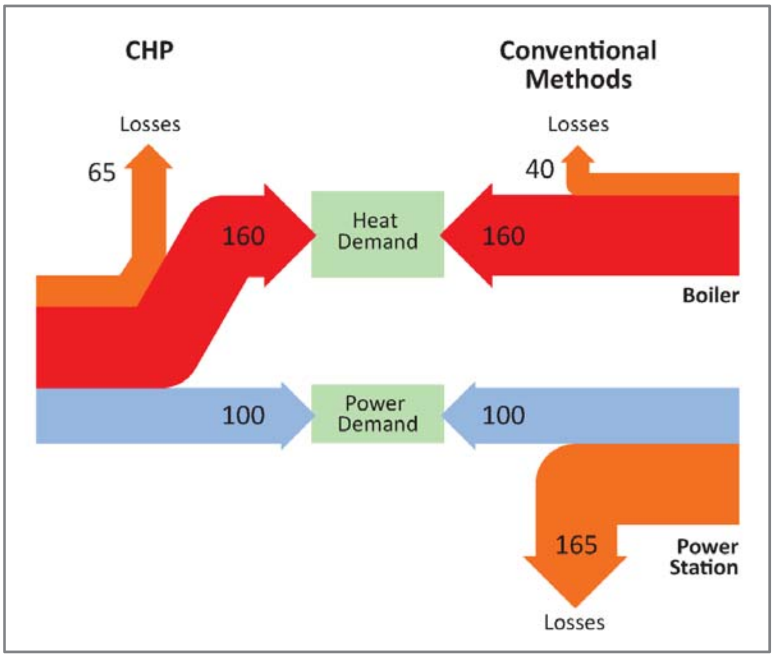

Diagram 1 – CHP Diagram

> However, the overall efficiency of ~80% is still lower than the ~90% efficiency of a heat only gas boiler.

> Where there are high thermal loads, CHP can be used within district heating networks to supply the required heat.

> **Performance and Calculation Methodology: -**

> > Most commonly sized on the heat load of a development, not the electrical load. This prevents an over-generation of heat.

> > Require a high and relatively constant heat demand to be viable.

> > CHP engines are best suited to providing the base heating load of a development (~year round hot water demand) with conventional gas boilers responding to the peak heating demand (~winter space heating). CHP engines are not able to effectively respond to peaks in demand.

> In general, CHP engines have an electrical efficiency of ~30% and a thermal efficiency of ~45%. Larger engines have a better heat to power ratio and are therefore able to reduce CO_2 emissions by greater amount.
>
> Electricity produced by the CHP engine displaces grid electricity which is given a carbon intensity of 0.519 kg per kWh.

- **Capital Cost: -**
  - Around £1,000 per kW of electrical output.
  - Relative cost reduces as the size of engine increases.
  - Generally best suited to larger sites, where there is a suitable economy of scale.
- **Running Costs/Savings: -**
  - CHP engines often struggle to provide cost-effective energy to dwellings on smaller residential schemes compared to conventional individual gas boilers.
  - Onsite use of CHP generated electricity; power Purchase Agreement with electricity Supply Company or Private Wire arrangement to local large non-domestic demand enhances economic case.
- **Land Use Issues and Space Required: -**
  - CHP engines require a plant room, and possibly an energy centre for large residential developments.
  - CHP engines require a flue to effectively disperse pollutants. This is best to rise to a minimum of 2m above the roofline of the tallest building.
  - Route for district heating pipe around the site must be safeguarded.
- **Operational Impacts/Issues: -**
  - Often run by Energy Services Company (ESCo) who maybe unenthusiastic about getting involved in small – medium scale schemes.
  - Can also be run in-house with specialist maintenance and customer services activities contracted out.
  - Issues with rights to dig up roads for district heating networks.
  - Emissions of oxides of nitrogen – ~500mg/kWh – 10 times higher than for a gas boiler. Specialist technologies exist (e.g. selective catalytic reduction) to reduce this to ~20mg/kWh if air quality issues require.
- **Embodied Energy:** - Comparable to that of a conventional gas boiler.
- **Funding Opportunities: -**
  - Tax relief for businesses under the Enhanced Capital Allowances scheme..
- **Reductions in Energy Achievable: -** Can provide some reductions in effective primary energy, but when distribution losses and other local losses are included more fuel is required.

- **Reductions in CO_2 Achievable: -** Can provide greater reductions in CO_2 than energy, aided by the emissions factor of grid displaced electricity of 0.519 kg CO_2/kWh. CO_2 reduction increase as size of engine increases.
- **Advantages: -**
  - Good reductions in overall primary energy and CO_2 emissions.
  - Most cost effective and appropriate strategy to achieve substantial CO_2 reductions on large schemes.
- **Disadvantages: -**
  - On smaller schemes often do not supply energy cost-effectively in comparison to conventional individual gas boilers.
  - Requires sale of generated electricity to maximise cost effectiveness.

Application: - Best suited to larger developments.

3. COMBINED COOLING HEAT AND POWER (CCHP)

- CCHP is a CHP system which additionally has the facility to transform heat into energy for cooling. This is done with an absorption chiller which utilises a heat source to provide the energy needed to drive a cooling system. As absorption chillers are far less efficient than conventional coolers (CoP of 0.7 compared to >4) they are generally only used where there is a current excess generation of heat. New CHP systems are generally sized to provide the year round base heating load only.
- For this reason it is generally not suitable for new CHP systems to include cooling.
- Where there are high thermal loads, CCHP can be used within district heating and cooling networks to supply the required heat and coolth.
- **Performance and Calculation Methodology: -**
  - Most commonly sized on the heat load of a development, not the electrical load. This prevents an over-generation of heat.
  - Require a high and relatively constant heat and cooling demand to be viable.
  - CCHP systems are best suited to providing the base loads of a development with conventional gas boilers and chillers responding to the peak demands. CCHP systems are not able to effectively respond to peaks in demand.

    - In general, CHP engines have an electrical efficiency of ~30% and a thermal efficiency of ~45%.
    - Absorption chillers have a CoP of ~0.7.
    - Electricity produced by the CHP engine displaces grid electricity which is given a carbon intensity of 0.519 kg per kWh.
- **Capital Cost: -**
    - High in comparison to biomass boilers and increased further by inclusion of absorption chiller.
- **Running Costs/Savings: -**
    - Coolth from absorption chillers is more expensive than from conventional systems unless heat used id genuine waste heat.
- **Land Use Issues and Space Required: -**
    - CCHP systems require a plant room, and possibly an energy centre for large residential developments.
    - CHP engines require a flue to effectively disperse pollutants. This is best to rise to a minimum of 2m above the roofline of the tallest building. Additionally the absorption chiller requires either a cooling tower or dry cooler bed for heat rejection purposes.
    - Heating and cooling distribution pipework required around the site.
- **Operational Impacts/Issues: -**
    - Often run by an ESCo who are unenthusiastic about getting involved in small – medium scale schemes.
    - Can also be run in-house with specialist maintenance and customer services activities contracted out.
    - Issues with rights to dig up roads for heat networks.
    - Emissions of oxides of nitrogen– ~500mg/kWh – 10 times higher than for gas boilers. Specialist technologies exist (e.g. selective catalytic reduction) to reduce this ~20mg/kWh if air quality issues require.
    - Rejection of heat is higher than for conventional cooling, thus enforcing the urban heat island effect.
    - Embodied Energy: - Comparable to conventional gas boilers.
- **Funding Opportunities: -**
    - Tax relief for businesses under Enhanced Capital Allowance scheme.
    - Reductions in Energy Achievable: - Absorption cooling generally requires more energy than conventional chillers.

  - Reductions in CO_2 Achievable: - Can provide greater reductions in CO_2 than energy, aided by the emissions factor of grid displaced electricity of 0.519 kg CO_2/kWh.
- **Advantages: -**
  - Reasonable reductions in overall primary energy and CO_2 emissions.
  - Disadvantages: - More expensive to install than conventional chillers.
  - Operational costs higher than for conventional chillers.
- **Application: -** Best suited where there is genuine waste heat available.

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4. BIOMASS BOILERS

- Biomass boilers generate heat on a renewable basis as they are run on biomass fuel which is almost carbon neutral. Fuel is generally wood chip or wood pellets. Wood pellets are slightly more expensive than wood chips but have a significantly higher calorific value and enable greater automation of the system.
- Various other suitable fuels are available including organic materials including straw, dedicated energy crops, sewage sludge and animal litter. Each fuel tends to have its own advantages dependant on site requirements.
- Can be used with district heating networks or as individual boilers on a house-by-house basis.
- **Performance and Calculation Methodology: -**
  - Biomass boilers are best suited to providing the base heating load of a development (~year round hot water demand) with conventional gas boilers responding to the peak heating demand (~winter space heating).
  - Operate with an efficiency of around 90%.
  - Small models available.
  - Conflicts with CHP they are both best suited to providing the base heating load of a development. As such they should not be installed in tandem unless surplus hot water capacity is available. Special control measures would be required in this case.
- **Capital Cost: -**
  - Low in comparison to CHP.
  - More suitable to smaller developments than CHP as installed cost is lower.

- **Running Costs/Savings: -**
  - Biomass fuel is more expensive than gas and as such heat being provided to dwellings is generally more expensive than alternatives.
- **Land Use Issues and Space Required: -**
  - Biomass boilers require a plant room and possibly separate energy centre for large residential developments.
  - Require a flue to effectively disperse pollutants. This is best to rise to a minimum of 2m above the roofline of the tallest building. Additionally the absorption chiller requires either a cooling tower or dry cooler bed for heat rejection purposes.
  - Fuel store will be required. This should be maximised to reduce fuel delivery frequency.
  - Space must be available for delivery vehicle to park close to plant room.
  - Route for district heating pipe around the site must be safeguarded.
- **Operational Impacts/Issues: -**
  - Normally run on biomass, but can also work with biogas.
  - Require some operational support and maintenance.
  - Fuel deliveries required.
  - Boiler and fuel store must be sited in proximity to space for delivery vehicle to park.
  - Issues with rights to dig up roads, etc (for heat networks).
  - Emissions of oxides of nitrogen – ~80-100mg/kWh.
  - Emissions of particulate matter. To minimise this ceramic filter systems are required.
  - Embodied Energy: - Comparable to conventional gas boiler.
- **Funding Opportunities: -**
  - Renewable Heat Incentive (RHI) provides incentive funds to developers of small or medium installations with a reasonable heat load that meet a minimum energy efficiency standard & meet the RHI eligibility criteria.
  - Reductions in Energy Achievable: - No reduction in energy demand, but energy generated from a renewable fuel. Significant long term running costs (fuel).
  - Reductions in CO_2 Achievable: - Can provide significant reductions in CO_2, but generally limited by the hot water load (base heating load).
  - Advantages: - Reductions in CO_2 at low installed cost.

> **Disadvantages: -**
  > High long-term running costs, unless receiving RHI.
  > Often do not supply energy cost-effectively in comparison to gas boilers.

5. SOLAR THERMAL PANELS

> Solar Thermal Heating Systems contribute to the hot water demand of a dwelling or building. Water or glycol (heat transfer fluid) is circulated to roof level where it is heated using solar energy before being returned to a thermal store in the plant room where heat is exchanged with water from the conventional system. Due to the seasonal availability of heat, solar thermal panels should be scaled to provide no more than 1/2 of the hot water load.

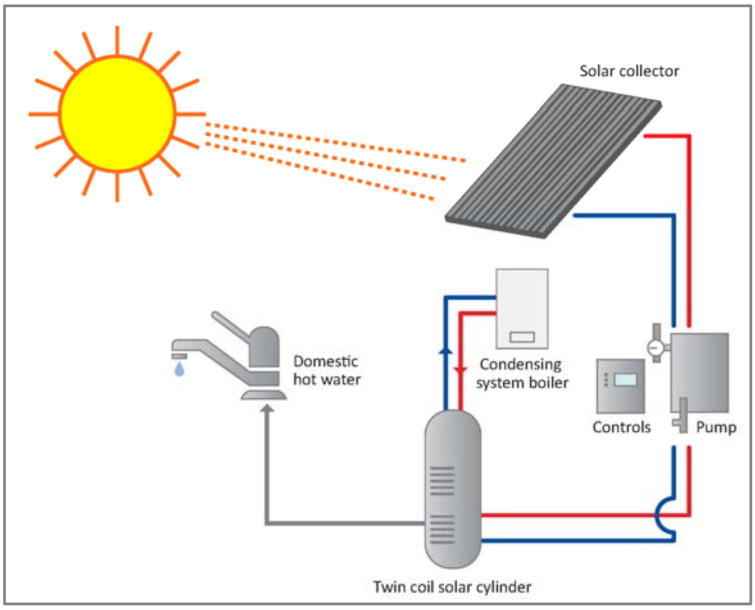

Diagram 2 – Solar Thermal System

> Can also be used to provide energy for space heating in highly insulated dwellings.

> There are two types of solar thermal panel: evacuated tube collectors and flat plate collectors.

> **Performance and Calculation Methodology: -**
  > Evacuated Tube Collectors: ~60% efficiency.
  > Flat Plate Collectors: ~50% efficiency.
  > SAP Table H2 used for solar irradiation at different angles.

  - Operate best on south facing roofs angled at 30-450 and free of shading, or on flat roofs on frames. East/West facing panels suffer a loss in performance of 15-20% depending on the angle of installation.
  - Flat plate collectors cannot be installed horizontally as this would prevent operation of the water pump. Must therefore be angled and separated to avoid overshadowing each other.
- **Capital Cost: -** Typically £2,500 per 4m^2 plus installation. Costs higher for evacuated tubes than flat plate collectors.
- **Running Costs/Savings: -**
  - Reduce reliance on gas and therefore reduce costs.
  - Payback period of ~20 years per dwelling.
- **Land Use Issues and Space Required: -**
  - Installed on roof so no impact on land use.
  - Requires hot water cylinders in dwellings.
  - Due to amount of roof space required and distance from tank to panels, less suitable for dense developments of relatively high rise flats.
  - Within permitted development rights unless in a conservation area where they must not be visible from the public highways.
  - Dormer and Velux windows may conflict if energy/CO_2 reduction required is large.
- **Operational Impacts/Issues:** - Biggest reductions achieved by people who operate their hot water system with consideration of the panels.
  - Embodied Energy: - Carbon payback is ~2 years.
  - Funding Opportunities: - none
- **Reductions in Energy Achievable:** - Reduce primary energy demand by more per standard panel area than solar PV panels.
  - Reductions in CO_2 Achievable: - Comparable to solar PV per m^2.
- **Advantages: -** Virtually free fuel, low maintenance and reductions in energy/CO_2.
- **Disadvantages: -** Benefits limited to maximum ~50% of hot water load.
  - Higher Costs in comparison to PV
- **Application: -** Best suited for small to medium housing developments ~1-100

6. SOLAR PHOTOVOLTAIC (PV) PANELS

> Solar PV panels generate electricity by harnessing the power of the sun. They convert solar radiation into electricity which can be used on site or exported to the grid in times of excess generation.

> **Performance and Calculation Methodology: -**

> > The best PV panels operate with an efficiency approaching 20%. ~7m^2 of these high performance panels will produce 1kWp of electricity.

> > Operate best on south facing roofs angled at 30-450 or on flat roofs on frames. Panels orientated east/west suffer from a loss in performance of 15-20% depending on the angle of installation.

> > Must be free of any potential shading.

> > Cannot be installed horizontally as would prevent self-cleaning. Must therefore be angled and separated to avoid overshadowing each other.

> > Electricity produced displaces grid electricity which has a carbon intensity of 0.519 kg CO_2 per kWh.

> **Capital Cost:** - ~£2,000 per kWp.

> **Running Costs/Savings: -**

> > Reduce reliance on grid electricity and therefore reduce running costs.

> > At current electricity prices, payback period of ~60-70 years per dwelling.

> > Feed-in tariff and Renewables Obligation Certificates (ROCs) payments required for maximum financial benefit.

> **Land Use Issues and Space Required: -**

> > Installed on roof so no impact on land use.

> > Due to amount of roof space required are less suitable for dense developments of relatively high rise flats.

> > Within permitted development rights unless in a conservation area where they must not be visible from the public highways.

> > Dormer and Velux windows may conflict if energy/CO_2 reduction required is large.

> **Operational Impacts/Issues: -**

> > Proportionately large arrays may need electrical infrastructure upgrade.

> Virtually maintenance free and panels are self-cleaning at angles in excess of 10 degrees.
>
> Provision for access to solar panels installed on flat roofs needs to be incorporated into the design of PV arrays layout as well as inclusion of spaces for inverters within the development.
>
> Quality of PV panels varies dramatically.

- **Embodied Energy: -** Carbon payback of 2-5 years.
- **Funding Opportunities: -** Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable:** - Reduce energy demand by less per m^2 than solar thermal panels.
- **Reductions in CO_2 Achievable:** - Provide greater percentage reductions in CO_2 than energy. Comparable to solar thermal per square metre.
- **Advantages: -** Virtually free fuel, very low maintenance and good reductions in CO_2.
  - Cheaper in comparison to solar thermal panels.
- **Disadvantages: -**
  - Slightly greater loss in performance than solar thermal panels when orientated away from south.
- **Application:** Best suited for a variety of developments from single houses to multi apartment blocks and even whole estates.

7. GROUND SOURCE HEAT PUMPS (GSHPS)

- Ground Source Heat Pumps work in much the same way as a refrigerator, converting low grade heat from a large 'reservoir' into higher temperature heat for input in a smaller space. Electricity drives the pump which circulates a fluid (water/antifreeze mix or refrigerant) through a closed loop of underground pipe. This fluid absorbs the solar

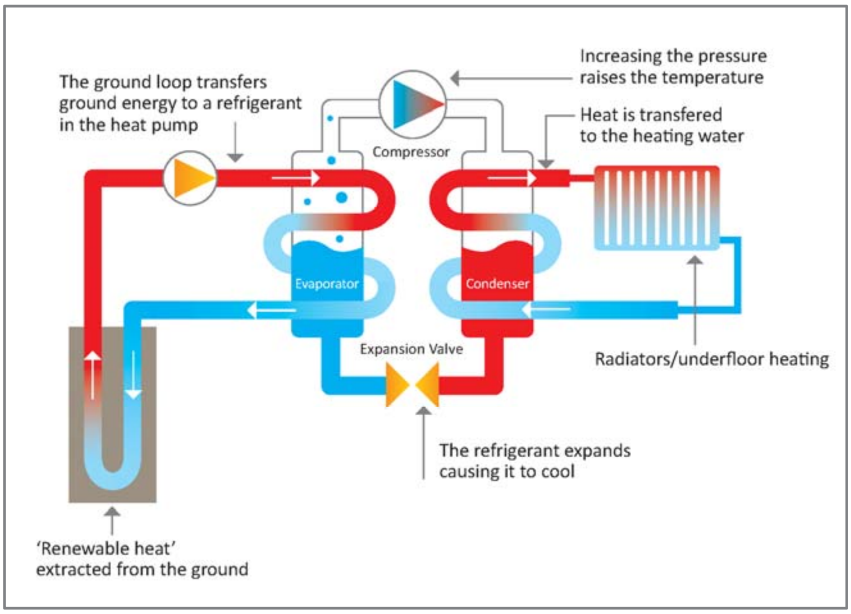

Diagram 3 – Ground Source Heat Pump

energy that is stored in the earth (which in the UK remains at a near constant temperature of 12oC throughout the year) and carries it to a pump. A compressor in the heat pump upgrades the temperature of the fluid which can then be used for space heating and hot water.

- **Performance and Calculation Methodology: -**
  - System requires electricity to drive the pump. Therefore displaces gas heating with electric, which has higher carbon intensity (gas: 0.216; electricity: 0.519).
  - As they are upgrading heat energy from the earth, GSHPs operate at 'efficiencies' in excess of 350%. This is limited in SAP unless Appendix Q rated model used.
  - Due to the lower temperature of the output of GSHPs compared to traditional gas boilers, GSHPs work best in well insulated buildings and with underfloor heating. They can, however, also be installed with oversized radiators, albeit with a consequent reduction in performance.
- **Capital Cost: -** ~£7,500 per house. Additional costs if underfloor heating is to be installed.
- **Running Costs/Savings: -**
  - Electricity more expensive than gas, thus fuel costs not reduced as much as energy is reduced.
  - Payback period of ~20 years per dwelling.
- **Land Use Issues and Space Required: -**
  - Require extensive ground works to bury the coils that extract the low grade heat from the earth. They therefore require a large area for horizontal burial (40-100m long trench) or a vertical bore (50-100m) which is considerably more expensive but can be used where space is limited.
  - Best suited to new developments that have provision for large ground works already in place, to minimise ground work costs.
  - Must be sized correctly to prevent freezing of the ground during winter and consequent shutdown of the system.
  - May require planning permission for engineering works. Once buried, there is no external evidence of the GSHPs.
- **Operational Impacts/Issues: -**
  - Work best in well insulated houses.
  - Need immersion backup for hot water.

> Highly reliable and require virtually no maintenance.

> Problems if ground bore fails.

> **Embodied Energy:** - Low, but as gas is being replaced with the more carbon intensive electricity, carbon payback is slowed. Carbon payback depends on CoP.

> **Funding Opportunities:** - Renewable Heat Incentive (RHI) provides incentive funds to developers of small or medium installations with a reasonable heat load that meet a minimum energy efficiency standard & meet the RHI eligibility criteria.

> **Reductions in Energy Achievable:** - Reduce energy demand by less per m^2 than solar thermal panels.

> **Reductions in CO_2 Achievable: -** Provide greater %age reductions in CO_2 than energy. Comparable to solar thermal (esp. in SAP).

> **Advantages:** - Large reductions in Energy. Currently receives benefit from SAP of an electrical baseline rather than gas.

> **Disadvantages: -**

> Small reduction in CO_2. CoP limited in SAP. Only small cost savings.

> GSHPs are not entirely a 'renewable' technology as they require electricity to drive their pumps or compressors.

> **Application: -** Best suited for small to medium developments ~1-100

8. AIR SOURCE HEAT PUMPS (ASHPS)

> Air Source Heat Pumps work in much the same way as a refrigerator, converting low grade heat from a large 'reservoir' into higher temperature heat for input into a smaller space. Electricity drives the pump which extracts heat from the air as it flows over the coils in the heat pump unit. A compressor in the heat pump upgrades the temperature of the extracted energy which can then be used for space heating and hot water.

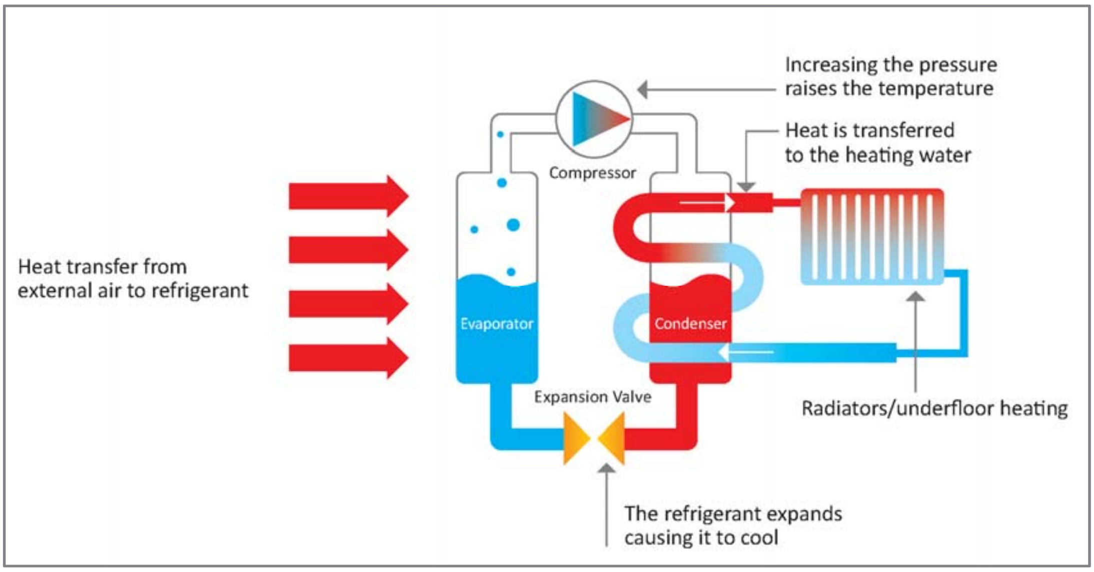

Diagram 4 – Air Source Heat Pump

- Generally ASHPs are air-to-water devices but can also be air-to-air.
- **Performance and Calculation Methodology: -**
    - System requires electricity to drive the pump. Therefore displaces gas heating with electric, which has higher carbon intensity (gas: 0.216; electricity: 0.519).
    - Performance defined by the Coefficient of Performance (CoP) which is a measure of electricity input to heat output. However, the concept of a CoP must be treated with caution as it is an instantaneous measurement and does not take account of varying external conditions throughout the year.
    - As they are upgrading heat energy from the air, ASHPs operate at 'efficiencies' in excess of 250%. This is limited in SAP unless an Appendix Q rated model is used.
    - British winter conditions (low temperatures and high humidity) lead to freezing of external unit. Reverse cycling defrosts the ASHP, but can substantially reduce performance when it is most needed. Performance under these conditions varies considerably between models. Vital that ASHP that has been proven in British winter conditions is installed.
    - Due to the lower temperature of the output of ASHPs compared to traditional gas boilers, ASHPs work best in well insulated buildings and with underfloor heating. They can, however, also be installed with oversized radiators, albeit with a consequent reduction in performance.
- **Capital Cost: -** ~£2,000 per house.
- **Running Costs/Savings: -**
    - Electricity more expensive than gas, thus fuel costs not reduced as much as energy is reduced.
    - Payback period of ~10 years per dwelling.
- **Land Use Issues and Space Required: -**
    - No need for external ground works, only a heat pump unit for the air to pass through.
    - Minimal external visual evidence.
- **Operational Impacts/Issues: -**
    - Work best in well insulated houses.
    - Unit must be sized correctly for each dwelling.
    - Vital that ASHP model selected has been proven to maintain performance at the low temperature and high humidity conditions of the British winter.

> May need immersion backup for hot water.

> Highly reliable and require virtually no maintenance.

> Noise from ASHPs must be below 42 dB at a position one metre external to the centre point of any door or window in a habitable room. According to planning standards MCS020.

> **Embodied Energy:** - Low. Carbon payback longer than for GSHPs as the CoP is lower.

> **Funding Opportunities:** - Renewable Heat Incentive (RHI) provides incentive funds to developers of small or medium installations with a reasonable heat load that meet a minimum energy efficiency standard & meet the RHI eligibility criteria.

> **Reductions in Energy Achievable: -** Large reductions in energy demand. Less so than GSHPs.

> **Reductions in CO_2 Achievable:** - Provide smaller percentage reductions in CO_2 than energy. Less than GSHPs.

> **Advantages:** - Large reductions in Energy. Currently receives benefit from SAP of an electrical fuel factor rather than a gas baseline.

> **Disadvantages: -**

> Small reduction in CO_2 CoP limited in SAP. Only small cost savings.

> ASHPs are not entirely a 'renewable' technology as they require electricity to drive their pumps or compressors.

> **Application: -** Best suited for small to medium developments ~1-100

9. WIND POWER

> Wind energy installations can range from small domestic turbines (1kW) to large commercial turbines (140m tall, 2MW). There are also different designs and styles (horizontal or vertical axis; 1 blade to multiple blades) to suit the location. They generate clean electricity that can be provided for use on-site, or sold directly to the local electricity network

> **Performance and Calculation Methodology: -**

> Power generated is proportional to the cube of the wind speed. Therefore, wind speed is critical.

> Horizontal axis turbines require >~6m/s to operate effectively and vertical axis turbines require >~4.5m/s. The rated power of a turbine is often for wind speeds double these figures.

> Wind speeds for area from BERR's Wind Speed Database.

> Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg/kWh.

- **Capital Cost: -**
  - ~£1,000 per kW. Smaller models are more expensive per kW.
  - Vertical axis turbines more expensive than horizontal.
- **Running Costs/Savings: -**
  - Reduce reliance on grid electricity and therefore reduce costs.
  - Payback period of ~15-20 years per dwelling.
  - Feed-in tariff and ROC payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -**
  - Smaller models (<6kW) can be roof mounted.
  - Must be higher than surrounding structures/trees.
  - Planning permission required.
- **Operational Impacts/Issues: -**
  - Urban environments generally have low wind speeds and high turbulence which reduce the effectiveness of turbines.
  - Vertical axis turbines have a lower performance than horizontal axis turbines but work better in urban environments.
  - Annual services required.
  - Turbines rated in excess of 5kW may require the network to be strengthened and arrangements to be made with the local Distribution Network Operator and electricity supplier.
  - Noise.
- **Embodied Energy: -** Carbon payback is ~1 year for most turbines.
- **Funding Opportunities:** - Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable:** - Significant reduction in reliance on grid electricity.
- **Reductions in CO_2 Achievable: -** Good. Greater reduction in CO_2 than PV for same investment.
- **Advantages: -** Virtually free fuel; reductions in CO_2.
- **Disadvantages: -**
  - Expensive, although cheaper than PV for same return.
  - Lack of suitable sites.

    - Maintenance costs.
    - Often not building integrated.
- **Application:** Best suited for small to large developments in rural open areas

10. HYDRO POWER

- Hydro power harnesses the energy of falling water, converting the potential or kinetic energy of water into electricity through use of a hydro turbine. Micro hydro schemes (<100kW) tend to be 'run-of-river' developments, taking the flow of the river that is available at any given time and not relying on a reservoir of stored water. They generate clean electricity that can be provided for use on-site, or sold directly to the local electricity network.
- **Performance and Calculation Methodology: -**
    - Flow rates at particular sites from National River Flow Archive held by Centre for Ecology and Hydrology.
    - Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg/kWh.
- **Capital Cost: -**
    - £3,000 - £5,000 per kW.
    - Particularly cost effective on sites of old water mills where much of the infrastructure is in place.
- **Running Costs/Savings: -**
    - Reduce reliance on grid electricity and therefore reduce costs.
    - Payback period of ~10-15 years per dwelling
    - Feed-in tariff and ROC payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -**
    - Require suitable water resource.
    - Visual intrusion of scheme.
    - Special requirements where river populated by migrating species of fish.
    - Planning permission will require various consents and licences including an Environmental Statement and Abstraction Licence.
- **Operational Impacts/Issues: -**
    - Routine inspections and annual service required.
    - Automatic cleaners should be installed to prevent intake of rubbish.
- **Embodied Energy: -** Carbon payback for small schemes of ~1 year.

- **Funding Opportunities: -** Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable:** - significant reduction in reliance on grid electricity.
- **Reductions in CO_2 Achievable:** - High.
- **Advantages:** - Virtually free fuel, reductions in CO_2.
- **Disadvantages: -**
  - Expensive, but good payback period.
  - Lack of suitable sites.
  - Planning obstructions.
- **Application: -** Best suited to medium to larger developments in rural places ~ 100+ units

Appendix D
Low Carbon and Renewable Energy Technologies Feasibility Table

Appendix D - Feasibility Table of Low Carbon Renewable Energy Technologies

Feasibility Study Table

Technology	Sufficient Energy Generated?	Payback	Land Use Issues	Local Planning Requirements	Noise	Carbon Payback	Available Grants	Feasible?	Reason not Feasible or Selected
Combined Heat & Power (CHP)	Yes	Medium	Air quality in residential area	Emphasis on district heating	n Plant Roon	Yes	Tax Relief - ECA, RHI	No	Selected
Biomass	Yes	None	Air quality in residential area	Encouraged for large scale developments	In Plant Room	Yes	RHI; Bio-energy Capital Grants Scheme	No	Connection to Energy Centre to be provided for heating / No control over heat source
Solar Thermal	Yes	High	Sufficient roof space required	Encouraged	None	~2 years	RHI	No	Conflicts with CHP
Solar Photovoltaic (PV)	Yes	Very High	Sufficient roof space required	Encouraged	None	2-5 years	FiT	Yes	Selected
Ground Source Heat Pumps (GSHPs)	Yes	High	Requires large area for coils or borehole	Encouraged	None	Low	RHI	No	Connection to Energy Centre to be provided for heating / No control over heat source
Air Source Heat Pumps (ASHPs)	Yes	Very High	Visual intrusion of external units	None	Low	Low	RHI	Yes	Connection to Energy Centre to be provided for heating / No control over heat source
Wind Power	No	Low	Urban Area - low and turbulent wind; Visual impact	Encouraged for large scale developments	Yes	~1 year	FiT	No	Wind speeds in area insufficient
Hydro Power	No	Medium	Requires suitable water resource; Visual impact	None	Low	~1 year	FiT	No	No water source in proximity

RHI - Renewable Heat Incentive
FiT - Feed in Tariff

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Appendix E
Indicative Roof Layout

This is an indicative PV layout. It is expected that appropriate safety measures will be considered during detailed design for installation, operation and removal. Drawing not to scale.