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Energy Statement

Hallmark Property Group

69-73 Holmes Road Warehouse Conversion

Final

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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.

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Executive Summary

The purpose of this Energy Statement is to demonstrate that the proposed B8 Warehouse to B1 Office conversion at 69-73 Holmes Road by Hallmark Property Group, 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 and Be Green. 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 3,288m^2 of office space, studios and communal areas. The conversion also forms part of the existing 65-69 Holmes Road development.

A range of energy efficiency (***Be Lean***) measures are proposed to enable the development to meet 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 29% in Regulated CO_2 emissions over Part L (2013) baseline.

In line with the London Plan, the feasibility of decentralised energy production as a ***Be Clean*** measure has been carefully examined. The first stage of the energy system hierarchy prioritises developments connecting to existing heat networks where possible. The proposed development lies within close proximity to an existing heat network and will therefore connect to the existing energy centre which lies outside of this application.

The existing energy centre houses communal boilers and a CHP engine that will provide space heating and hot water capable of covering the demands of the proposed office space. To ensure that the proposed development follows the London Plan energy system hierarchy, SAP 2012 carbon factors have been utilised.

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 communal gas boilers. The combination of energy efficiency measures and heat network with the CHP will enable a reduction in Regulated CO_2 emissions of 31% over the Part L (2013) baseline.

The full spectrum of ***Be Green*** renewable energy sources has been considered. It has been concluded that 11.25 kWp of PV panels can be utilised on the available roof space providing a 5% reduction in regulated CO_2 emissions. This results in a total carbon dioxide reduction of **36%** over Part L (2013) baseline achieving the requirements of the London Plan.

The warehouse conversion has been assessed as a shell only specification using BREEAM methodology, achieving a status of Very Good.

	Regulated non-domestic carbon dioxide saving	
	Tonnes.CO_2 /yr	%
Part L 2A (2013) Baseline	70	-
***Be Lean* Measures**	21	29%
***Be Clean* Measures**	1	2%
***Be Green* Measures**	3	5%
Total cumulative savings	**25**	**36%**

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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 Hallmark Property Group. This Statement sets out the energy strategy for the proposed warehouse to office conversion at 69-73 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 be met.

2. DEVELOPMENT OVERVIEW

Site Location – Development Description

2.1 As shown in Figure 1 below, the proposed development site is located at 69-73 Holmes Road, north-west of the Kentish Town West station in the London Borough of Camden.

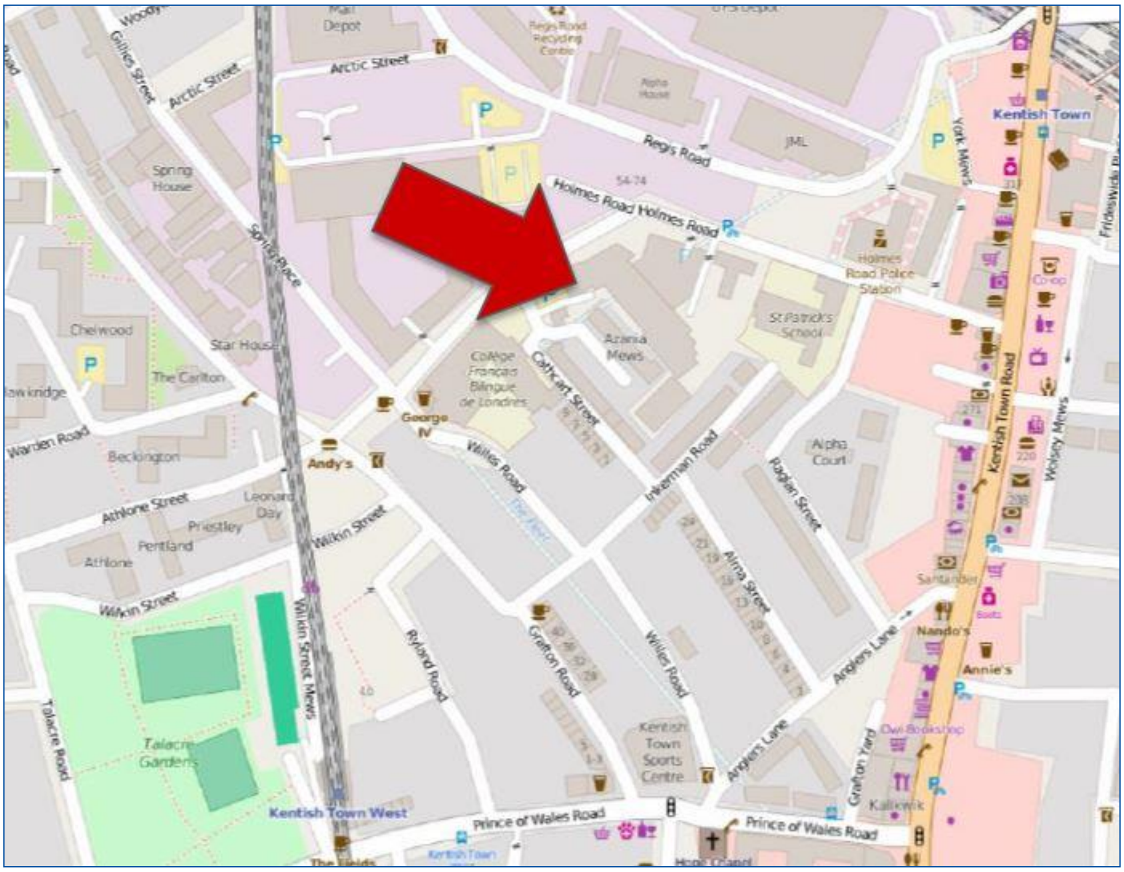

Figure 1: Site Location – © OpenStreetMap Contributors. Go to www.openstreetmap.org/copyright

2.2 The existing B8 warehouse is proposed to be converted into B1 office and light industrial use space. This will incorporate 4 storeys, made up of one ground level storey and three basement level storeys. These will all be incorporated within the shell of the original warehouse and therefore the proposed development is treated as a conversion rather than a new development.

2.3 The proposed conversion will comprise approximately 3,288m^2 of office space, studios and communal areas. The conversion also forms part of the existing 69-73 Holmes Road development.

2.4 A proposed site plan is shown below in Figure 2.

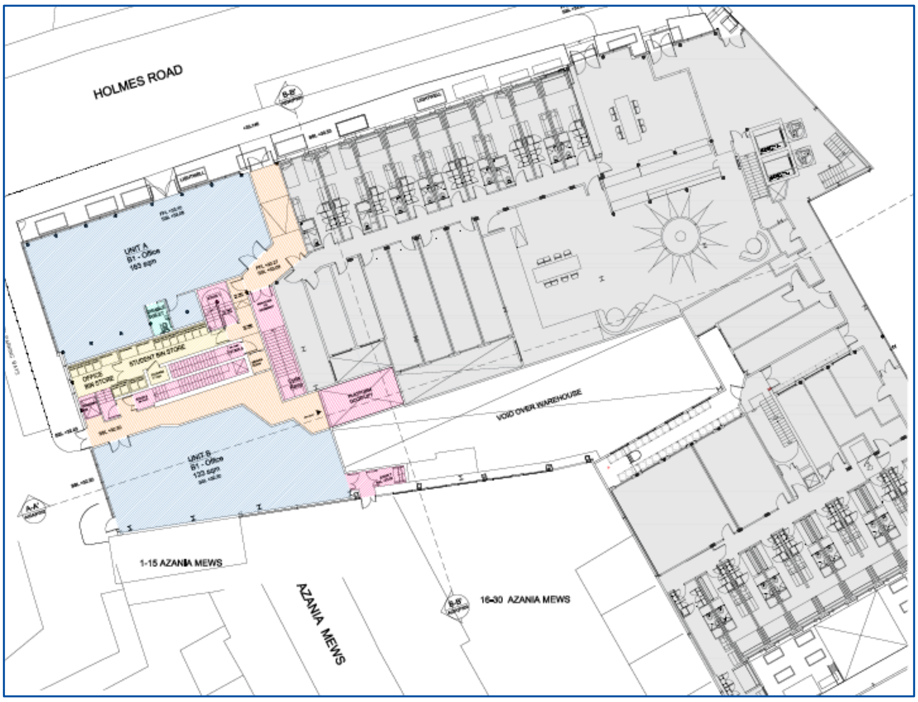

Figure 2: Proposed site layout - Contemporary Design Solutions 2020

3. RELEVANT PLANNING POLICY

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

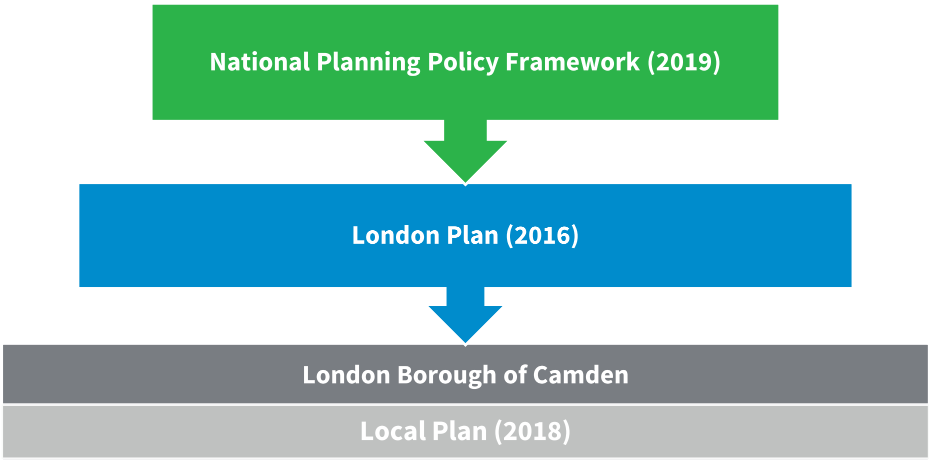

Figure 3: Relevant Planning Policy Documents

National Policy: NPPF

3.2 The 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**.

3.3 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 contribute 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.

3.4 The following planning policies and requirements have informed the sustainable design of the Proposed Development.

Regional Policy: The London Plan (2016)

3.5 The London Plan sets out an integrated economic, environmental, transport and social framework for the development of London over the next 20 - 25 years.

3.6 The following outlines key policies set out in the London Plan which are relevant to the proposed development and this Sustainability Statement.

3.7 **Policy 5.2 – Minimising Carbon Dioxide Emissions** requires development proposals to make the fullest contribution to minimising carbon dioxide emissions in accordance with the Energy Hierarchy: *Be Lean, Be Clean and Be Green*. Major developments to achieve a 40% improvement on 2010 Building Regulations. The London Plan Sustainable Design and Construction SPG (2014) updates this target stating that the Mayor will adopt a carbon dioxide improvement target beyond Part L 2013 of 35%.

3.8 **Policy 5.3 – Sustainable Design and Construction** states that the highest standards of sustainable design and construction should be achieved in London to improve the environmental performance of new developments. Major development should meet the minimum standards outlined in the London Plan Supplementary Planning Guidance and this should be clearly demonstrated. The standards include sustainable design principles such as minimising CO_2 emissions and avoiding internal overheating.

3.9 **Policy 5.5 – Decentralised Energy Networks** states that the Mayor expects 25 per cent of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025. The Mayor will prioritise the development of decentralised heating and cooling networks at the development and area wide levels, including larger scale heat transmission networks.

3.10 **Policy 5.6 – Decentralised Energy** requires that all developments should evaluate the feasibility of Combined Heat and Power (CHP) systems, and examine the opportunities to extend the system beyond the site boundary to adjacent sites.

3.11 **Policy 5.7 – Renewable Energy** states that within the framework of the energy hierarchy, major development proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible.

3.12 **Policy 5.8 – Innovative Energy Technologies** encourages the more widespread use of innovative energy technologies to reduce use of fossil fuels and carbon dioxide emissions.

3.13 **Policy 5.9 – Overheating and Cooling** seeks to reduce the impact of the urban heat island effect, reduce potential overheating and reduce reliance on air conditioning systems in line with the cooling hierarchy.

Sustainable Design and Construction Supplementary Planning Guidance (2014)

3.14 The London Plan Sustainable Design and Construction SPG was adopted in April 2014 and provides detail and best practice guidance on how to implement the sustainable design and construction and wider environmental sustainability London Plan policies.

3.15 The SPG provides guidance on topics such as energy efficient design; meeting carbon dioxide reduction targets; decentralised energy; how to off-set carbon dioxide where the targets set out in the London Plan are not met; retro-fitting measures; monitoring energy use during occupation; air quality; resilience to flooding; urban greening; pollution control; basements and local food growing.

Energy Assessment Guidance (2018)

3.16 The GLA have published Energy Assessment Guidance (2018) that provides advice on how the energy statement can demonstrate compliance with the London Plan Policy 5.2. The following key points have been taken from the document:

3.17 The first stage of the energy system hierarchy states:

'Where a heat network exists in the vicinity of the proposed development, the applicant must prioritise connection and provide evidence of correspondence with the network operator. This must include confirmation from the network operator of whether the network has the capacity to serve the new development, together with supporting estimates of installation cost and timescales for connection.'

3.18 Where connection to an existing heat network is possible, the use of SAP 2012 carbon factors is justified if a scheme will not be compliant using SAP 10 carbon factors.

Local Policy: London Borough of Camden

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

3.20 **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.

3.21 **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;

3.22 Non-domestic developments of 500 sqm of floorspace or above to achieve the following:

> BREEAM Method 2008 multi-residential assessment of the Student Accommodation obtaining at least a Very Good, Excellent or Outstanding rating and attaining at least 60% of the credits in each of Energy and Water and 40% of the credits in Materials categories;

> BREEAM assessment of the commercial element of the Development with a target of achieving a Very Good, Excellent or Outstanding rating and attaining at least 60% of the credits in each of Energy and Water and 40% of the credits in Materials categories.

Energy efficiency and adaptation – Camden Planning Guidance 2019

3.23 Table 2b of this guidance document sets out that major non-domestic planning applications should achieve the greatest possible reduction over Part L 2013 and target a 20% reduction through renewables.

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Summary of Targets

3.24 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**;

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

> Minimum of BREEAM – Very Good, to be achieved, and attaining at least 60% of the credits in each of Energy and Water and 40% of the credits in Materials categories.

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	
	Tonnes.CO_2/year
Total CO_2 emissions	**70**

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;

> Ground/Exposed Floor U-Value of 0.15 W/m^2.K;

Air Tightness & Ventilation

5.4 Air leakage is to be minimised and an air permeability of 10.0 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) with a Specific Fan Power (SFP) of 1.50 W/l/s and heat recovery efficiency of 75%. 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 with a 110 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 warehouse conversion. To cover the space heating and hot water demand, it is proposed to connect to the existing district heating network.

Limiting the Risk of Summer Overheating

5.10 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.

5.11 The development will therefore be subject to measures that reduce the risk of summer overheating as much as possible.

5.12 In line with GLA Policy 5.9, the cooling hierarchy, has considered a range of passive and active mitigation measures to respond to climate change.

5.13 Figure 4 describes the cooling hierarchy.

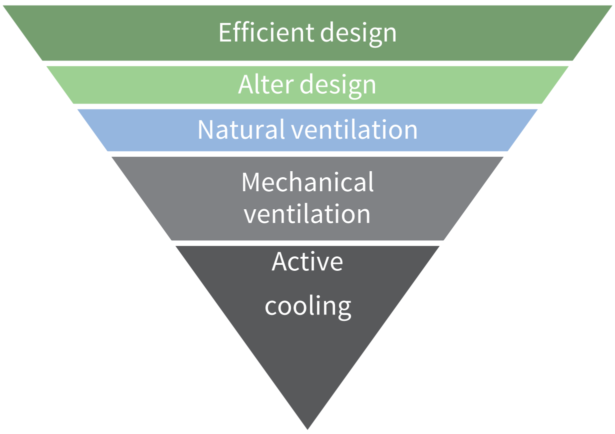

Figure 4: Cooling hierarchy.

5.14 It is proposed to install low g-value glazing to minimise energy demands.

5.15 The design has already discussed the use of efficient equipment such as LED lighting to efficiency reduce heat gains.

5.16 Several passive design changes have been considered and applied to the development. The items considered were reducing the glazing area, utilising solar control glazing and considering shading devices.

5.17 The commercial area is shell only and as such the final fit-out specification requirements are not known. This means that the density and utilisation of the space is not known at this stage. In line with the Energy Assessment Guidance, it has been assumed that the non-domestic spaces will be cooled.

5.18 Given the point above and in line with GLA energy assessment guidance at this stage Criterion 3 of the Part L calculation has been used as a proxy to determine the overheating risk.

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

Cooling

5.20 Cooling is only considered for the non-domestic areas where there is a significant need as a result of the space use. The spaces are considered as shells where required cooling will be designed to maximise natural cooling before using energy.

5.21 The cooling is expected to be delivered with a seasonal efficiency (SEER) of 8.00. and a peak efficiency (EER) of 6.0. Table 2 shows the cooling demand calculated using the National Calculation Methodology.

Table 2: Non-domestic cooling demand.

	Cooling demand (MJ/m^2)
Actual	95
Notional	130

CO_2 Emissions after Energy Efficiency Measures

5.22 Table 3 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.

5.23 This goes significantly beyond the requirements of 15% reduction in carbon dioxide from energy efficiency measures proposed by the Draft London Plan.

Table 3: CO_2 reduction after energy efficient measures.

	Regulated non-domestic carbon dioxide saving	
	Tonnes.CO_2 /yr	%
Part L 2A (2013) Baseline	70	-
***Be Lean* Measures**	21	29%

6. *BE CLEAN* - HEATING INFRASTRUCTURE

6.1 In line with Policy 5.6 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 an existing district heating network;

> Site wide CHP network;

> Communal heating and cooling.

Connection to existing District Heating Network

6.2 The first stage of the energy system hierarchy is to connect to an existing heating network.

6.3 The adjacent 69-73 Holmes Road development has a site-wide Energy Centre compromising of a gas fired CHP and back-up boilers.

6.4 To ensure compliance with the energy system hierarchy and connecting to existing networks , this statement considers the use of SAP 2012 carbon factors.

6.5 In line with the energy system hierarchy, noted above, this development will connect to the existing network.

6.6 The energy centre operators have confirmed that the CHP engine in the existing energy centre has a thermal efficiency of 51.5%, a heat to power ratio of 1.65 and a size of 81kWth. Furthermore, they have confirmed that it has sufficient capacity for the proposed development.

6.7 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.

6.8 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

6.9 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 4 below.

Table 4: CO_2 emissions following be clean measures.

	Regulated non-domestic carbon dioxide saving	
	Tonnes.CO_2 /yr	%
Part L 2A (2013) Baseline	70	-
Be Lean Measures	21	29%
Be Clean Measures	1	2%
Total cumulative savings	**22**	**31%**

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 the 29% reduction in regulated carbon emissions being met through 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 onsite renewable energy generation unless it can be demonstrated that such provision is not feasible.

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

Biomass Boiler

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

7.5 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.

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

Heat Pumps

7.7 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.

7.8 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

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

7.10 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.

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

Solar Thermal (Hot Water) Panels

7.12 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.

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

7.14 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.

7.15 Therefore, Solar Thermal Panels have not been specified.

Selected Technology - Photovoltaic (PV) Panels

7.16 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.

7.17 Limited roof space is available as part of the warehouse conversion as a result of the remainder of the development. Solar PV has already been proposed on the main student accommodation block, therefore leaving limited roof space available to supply the warehouse conversion.

7.18 It has been calculated that a total of 180m[2] of roof space is available to accommodate solar PV panels, allowing for spacing between rows, overshadowing and access for maintenance. This would result in a solar PV capacity of 11.25kWp.

7.19 An indicative roof plan is presented in **Appendix D**.

CO_2 Emissions after *Be Green* Measures

7.20 Table 5 outlines the savings from the selected renewable energy sources for the development.

7.21 It is demonstrated that the 35% reduction in carbon emissions is achieved, primarily through reductions in energy demand at the Be Lean stage resulting in a 29% reduction. Further reductions of 2% were achieved by following the energy system hierarchy and connecting to the existing heat network.

7.22 A roof area of 180m[2] has been predicted to provide 11.25kWp of capacity and contribute to a further 5% reduction in CO_2.

Table 5: CO_2 following be green measures.

	Regulated non-domestic carbon dioxide saving	
	Tonnes.CO_2 /yr	%
Part L 2A (2013) Baseline	70	-
***Be Lean* Measures**	21	29%
***Be Clean* Measures**	1	2%
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Total cumulative savings	**25**	**36%**

8. BREEAM

8.1 In accordance with the original S106 (Clause 2.35) and Policy CC2 of Camden Local Plan, the building is being assessed under the BREEAM Methodology.

8.2 The current warehouse space within the development has been registered under BREEAM New Construction 2014 (BREEAM-0062-3652) and achieved design stage certification on 5th September 2017 and post construction certification is imminent as it is currently with the BRE for auditing.

8.3 The warehouse space was originally assessed to a shell only specification, and as such the proposed shell only office spaces are not likely to require a further assessment.

8.4 The BREEAM credits that would be applicable to the proposed floorspace will be:

> **Life cycle impacts (Mat 01) –** The external façade materials and roof materials used for the proposed office are not changing so the Green Guide ratings used on the warehouse space will apply.

> **Insulation (Mat 02) –** The insulation used in the external areas and roof spaces will not change as the offices are being constructed to a shell only specification.

> **Responsible sourcing of materials (Mat 03) –** The same manufacturers will be used for the proposed floorspace so the same responsible sourcing certification will apply.

> **Energy monitoring (Ene 02) –** The proposed offices will have the ability to connect to the BMS that has been specified in the building, which meets the requirements of BREEAM.

> **Water consumption (Wat 01) –** A pulsed water meter and leak detection has been installed in the shell only warehouse build, which will also apply to the proposed office space.

8.5 It is therefore deemed applicable for the new proposed floor to be included as part of the ongoing BREEAM assessment (registration number: BREEAM-0062-3652).

9. SUMMARY

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9.8 The full spectrum of ***Be Green*** renewable energy sources has been considered. It has been concluded that **11.25 kWp** of PV panels can be utilised on the available roof space providing a 5% reduction in regulated CO_2 emissions. This results in a total carbon dioxide reduction of **36%** over Part L (2013) baseline achieving the requirements of the London Plan.

9.9 The warehouse conversion has been assessed as a shell only specification using BREEAM methodology, achieving a status of Very Good.

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APPENDICES

Appendix A:
Energy Efficiency Calculations

Appendix B:
SBEM BRUKL Outputs

Appendix C:
Low Carbon and Renewable Energy Technologies

Appendix D:
Indicative Roof Layout

Appendix A
Building Regulations Be Lean, Be Clean and Be Green Calculations

Appendix A: Building Regulations Be Lean, Be Clean and Be Green Calculations

SAP / SBEM Outputs per Unit									
		Energy (kWh/m ^{2}/yr)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)	
Unit Type	Test Unit Location	Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
Multi-residential	Holmes Road	1	3	26	42	20.20	14.28	42.09	36.17

Energy Demands & CO2 Emissions - Be Lean										
			Energy (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/m2/yr)	
Unit Type	Unit Area (m2)	No. Units	Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
Multi-residential	3455	1	3,593	11,056	88,966	145,110	69,791	49,338	145,408	124,955
#			3,593	11,056	88,966	145,110	69,791	49,338	145,408	124,955
Area Weighted Average							20.20	14.28	42.09	36.17
Improvement over Target (Apartments)							29.3%		14.1%	

SAP / SBEM Outputs per Unit									
		Energy (kWh/m ^{2}/yr)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)	
Unit Type	Test Unit Location	Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
Multi-residential	Holmes Road	2	5	26	42	20.20	13.92	42.09	36.17

Energy Demands & CO2 Emissions - Be Clean										
			Energy (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/m2/yr)	
Unit Type	Unit Area (m2)	No. Units	Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
Multi-residential	3455	1	5,735	17,240	88,966	145,110	69,791	48,088	145,408	124,955
TOTAL			5,735	17,240	88,966	145,110	69,791	48,088	145,408	124,955
Area Weighted Average									42.09	36.17
Improvement over Target (Apartments)							31.1%		14.1%	

SAP / SBEM Outputs per Unit									
		Energy (kWh/m ^{2}/yr)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)	
Unit Type	Test Unit Location	Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
Multi-residential	Holmes Road	2	5	26	42	20.20	12.97	20.20	12.97

Energy Demands & CO2 Emissions - Be Green										
			Energy (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/m2/yr)	
Unit Type	Unit Area (m2)	No. Units	Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
Multi-residential	3455	1	5,735	17,240	88,966	145,110	69,791	44,806	69,791	44,806
TOTAL			5,735	17,240	88,966	145,110	69,791	44,806	69,791	44,806
Area Weighted Average							20.20	12.97	20.20	12.97
Improvement over Target (Apartments)							35.8%		35.8%	

Appendix B
SBEM BRUKL Documents

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name **Shell and Core**

OFFICE

As built

Date: Thu Jul 16 17:28:27 2020

Administrative information

Building Details

Address: 69–73 Holmes Road, LONDON, NW5 3AN

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.6.a.1

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v6.1.0

BRUKL compliance check version: v5.6.a.1

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Hodkinson Consultancy

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	20.2
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	20.2
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	14.3
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	0.23	0.23	02 Upper basement a - Office_W_8
Floor	0.25	0.23	0.23	03 Ground Floor - Office_S_18
Roof	0.25	0.15	0.15	02 Upper basement a - Office_R_5
Windows***, roof windows, and rooflights	2.2	1.5	1.5	03 Ground Floor - Circulation Non-Resi_G_13
Personnel doors	2.2	1.6	1.6	03 Ground Floor - Circulation Non-Resi_D_12
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	10

Building services

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

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

1- Boiler with Ventilation

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	6	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

1- Project DHW

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

1- CHP 1

	CHPQA quality index	CHP electrical efficiency
This building	110	0.31
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**
02 Upper basement a - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
03 Ground Floor - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
0 Lower Basement - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
01 Mid_basement - Office	-	-	-	1.2	-	-	-	-	-	0.75	0.5

Shell and core configuration

Zone	Excluded from calculation?
02 Upper basement a - Office	NO
03 Ground Floor - Office	NO
03 Ground Floor - Circulation Non-Resi	NO
0 Lower Basement - Office	NO
01 Mid_basement - Office	NO

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
02 Upper basement a - Office	110	-	-	5384
03 Ground Floor - Office	110	-	-	1228
03 Ground Floor - Circulation Non-Resi	110	-	-	329
0 Lower Basement - Office	110	-	-	5913
01 Mid_basement - Office	110	-	-	5783

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?
02 Upper basement a - Office	N/A	N/A
03 Ground Floor - Office	N/A	N/A
03 Ground Floor - Circulation Non-Resi	NO (-97.5%)	NO
0 Lower Basement - Office	N/A	N/A
01 Mid_basement - Office	NO (-94.9%)	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]	3455	3455
External area [m^2]	2383	2383
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	583.84	579.2
Average U-value [W/m^2K]	0.25	0.24
Alpha value* [%]	11.42	11.1

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

Building Use

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

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	1.04	0.88
Cooling	4.42	10.01
Auxiliary	5.49	2.68
Lighting	15.84	25.46
Hot water	3.2	3.34
Equipment*	42.19	42.19
TOTAL**	**29.98**	**42.37**

* 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]	98.52	132.31
Primary energy* [kWh/m^2]	84.2	119.35
Total emissions [kg/m^2]	14.3	20.2

* 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] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	3.5	95	1	4.4	5.5	0.93	5.98	0.95	8
	Notional	2.6	129.7	0.9	10	2.7	0.82	3.6	----	----

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	0.23	02 Upper basement a - Office_W_8
Floor	0.2	0.23	03 Ground Floor - Office_S_18
Roof	0.15	0.15	02 Upper basement a - Office_R_5
Windows, roof windows, and rooflights	1.5	1.5	03 Ground Floor - Circulation Non-Resi_G_13
Personnel doors	1.5	1.6	03 Ground Floor - Circulation Non-Resi_D_12
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	10

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name **Shell and Core**

OFFICE

As built

Date: Thu Jul 16 17:21:36 2020

Administrative information

Building Details

Address: 69–73 Holmes Road, LONDON, NW5 3AN

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.6.a.1

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v6.1.0

BRUKL compliance check version: v5.6.a.1

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Hodkinson Consultancy

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	20.2
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	20.2
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	13.9
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	0.23	0.23	02 Upper basement a - Office_W_8
Floor	0.25	0.23	0.23	03 Ground Floor - Office_S_18
Roof	0.25	0.15	0.15	02 Upper basement a - Office_R_5
Windows***, roof windows, and rooflights	2.2	1.5	1.5	03 Ground Floor - Circulation Non-Resi_G_13
Personnel doors	2.2	1.6	1.6	03 Ground Floor - Circulation Non-Resi_D_12
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	10

Building services

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

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

1- VRF with Ventilation

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.95	6	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

1- Project DHW

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

1- CHP 1

	CHPQA quality index	CHP electrical efficiency
This building	110	0.31
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**
02 Upper basement a - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
03 Ground Floor - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
0 Lower Basement - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
01 Mid_basement - Office	-	-	-	1.2	-	-	-	-	-	0.75	0.5

Shell and core configuration

Zone	Excluded from calculation?
02 Upper basement a - Office	NO
03 Ground Floor - Office	NO
03 Ground Floor - Circulation Non-Resi	NO
0 Lower Basement - Office	NO
01 Mid_basement - Office	NO

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
02 Upper basement a - Office	110	-	-	5384
03 Ground Floor - Office	110	-	-	1228
03 Ground Floor - Circulation Non-Resi	110	-	-	329
0 Lower Basement - Office	110	-	-	5913
01 Mid_basement - Office	110	-	-	5783

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?
02 Upper basement a - Office	N/A	N/A
03 Ground Floor - Office	N/A	N/A
03 Ground Floor - Circulation Non-Resi	NO (-97.5%)	NO
0 Lower Basement - Office	N/A	N/A
01 Mid_basement - Office	NO (-94.9%)	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]	3455	3455
External area [m^2]	2383	2383
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	583.84	579.2
Average U-value [W/m^{2}K]	0.25	0.24
Alpha value* [%]	11.42	11.1

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

Building Use

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

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	1.66	0.88
Cooling	4.42	10.01
Auxiliary	5.49	2.68
Lighting	15.84	25.46
Hot water	4.99	3.34
Equipment*	42.19	42.19
TOTAL**	**30.7**	**42.37**

* 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	1.7	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	98.52	132.31
Primary energy* [kWh/m^2]	81.92	119.35
Total emissions [kg/m^2]	13.9	20.2

* 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] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0.9	95	0.3	4.4	5.5	0.93	5.98	0.95	8
	Notional	2.6	129.7	0.9	10	2.7	0.82	3.6	----	----

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	0.23	02 Upper basement a - Office_W_8
Floor	0.2	0.23	03 Ground Floor - Office_S_18
Roof	0.15	0.15	02 Upper basement a - Office_R_5
Windows, roof windows, and rooflights	1.5	1.5	03 Ground Floor - Circulation Non-Resi_G_13
Personnel doors	1.5	1.6	03 Ground Floor - Circulation Non-Resi_D_12
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	10

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name **Shell and Core**

OFFICE

As built

Date: Thu Jul 16 17:18:07 2020

Administrative information

Building Details

Address: 69–73 Holmes Road, LONDON, NW5 3AN

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.6.a.1

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v6.1.0

BRUKL compliance check version: v5.6.a.1

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Hodkinson Consultancy

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	20.2
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	20.2
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	13
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	0.23	0.23	02 Upper basement a - Office_W_8
Floor	0.25	0.23	0.23	03 Ground Floor - Office_S_18
Roof	0.25	0.15	0.15	02 Upper basement a - Office_R_5
Windows***, roof windows, and rooflights	2.2	1.5	1.5	03 Ground Floor - Circulation Non-Resi_G_13
Personnel doors	2.2	1.6	1.6	03 Ground Floor - Circulation Non-Resi_D_12
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	10

Building services

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

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

1- VRF with Ventilation

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.95	6	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

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

1- Project DHW

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

1- CHP 1

	CHPQA quality index	**CHP electrical efficiency**
This building	110	0.31
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**
02 Upper basement a - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
03 Ground Floor - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
0 Lower Basement - Office	-	-	-	1.5	-	-	-	-	-	0.75	0.5
01 Mid_basement - Office	-	-	-	1.2	-	-	-	-	-	0.75	0.5

Shell and core configuration

Zone	**Excluded from calculation?**
02 Upper basement a - Office	NO
03 Ground Floor - Office	NO
03 Ground Floor - Circulation Non-Resi	NO
0 Lower Basement - Office	NO
01 Mid_basement - Office	NO

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
02 Upper basement a - Office	110	-	-	5384
03 Ground Floor - Office	110	-	-	1228
03 Ground Floor - Circulation Non-Resi	110	-	-	329
0 Lower Basement - Office	110	-	-	5913
01 Mid_basement - Office	110	-	-	5783

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?
02 Upper basement a - Office	N/A	N/A
03 Ground Floor - Office	N/A	N/A
03 Ground Floor - Circulation Non-Resi	NO (-97.5%)	NO
0 Lower Basement - Office	N/A	N/A
01 Mid_basement - Office	NO (-94.9%)	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 [m2]	3455	3455
External area [m2]	2383	2383
Weather	LON	LON
Infiltration [m3/hm2@ 50Pa]	10	3
Average conductance [W/K]	583.84	579.2
Average U-value [W/m2K]	0.25	0.24
Alpha value* [%]	11.42	11.1

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

Building Use

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

Energy Consumption by End Use [kWh/m2]

	Actual	Notional
Heating	1.66	0.88
Cooling	4.42	10.01
Auxiliary	5.49	2.68
Lighting	15.84	25.46
Hot water	4.99	3.34
Equipment*	42.19	42.19
TOTAL**	**30.7**	**42.37**

* 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/m2]

	Actual	Notional
Photovoltaic systems	1.83	0
Wind turbines	0	0
CHP generators	1.7	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m2]	98.52	132.31
Primary energy* [kWh/m2]	81.92	119.35
Total emissions [kg/m2]	13	20.2

* 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] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0.9	95	0.3	4.4	5.5	0.93	5.98	0.95	8
	Notional	2.6	129.7	0.9	10	2.7	0.82	3.6	----	----

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	0.23	02 Upper basement a - Office_W_8
Floor	0.2	0.23	03 Ground Floor - Office_S_18
Roof	0.15	0.15	02 Upper basement a - Office_R_5
Windows, roof windows, and rooflights	1.5	1.5	03 Ground Floor - Circulation Non-Resi_G_13
Personnel doors	1.5	1.6	03 Ground Floor - Circulation Non-Resi_D_12
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	10

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.

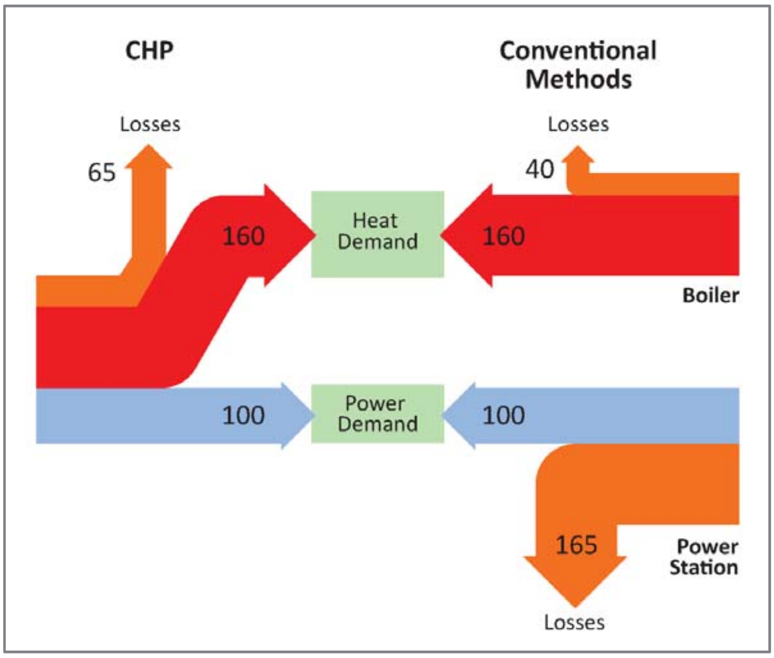

Diagram 1 – CHP Diagram

> 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.

---

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.

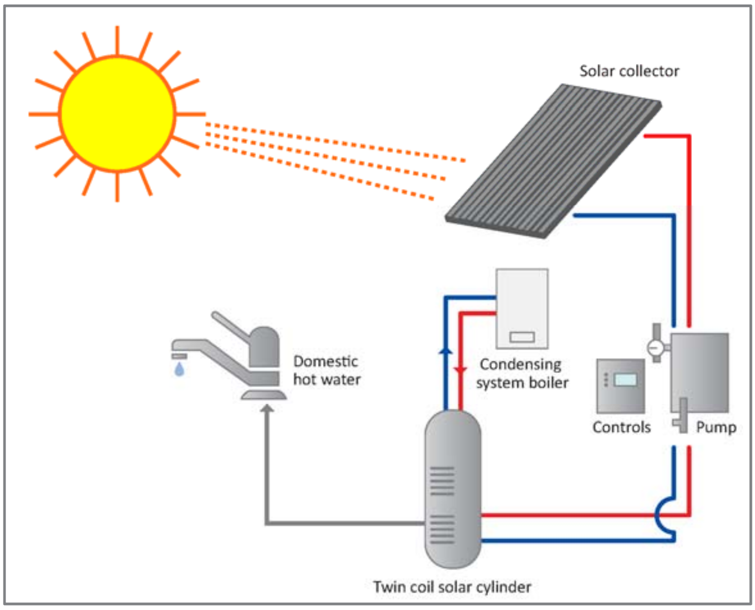

Diagram 2 – Solar Thermal System

- 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

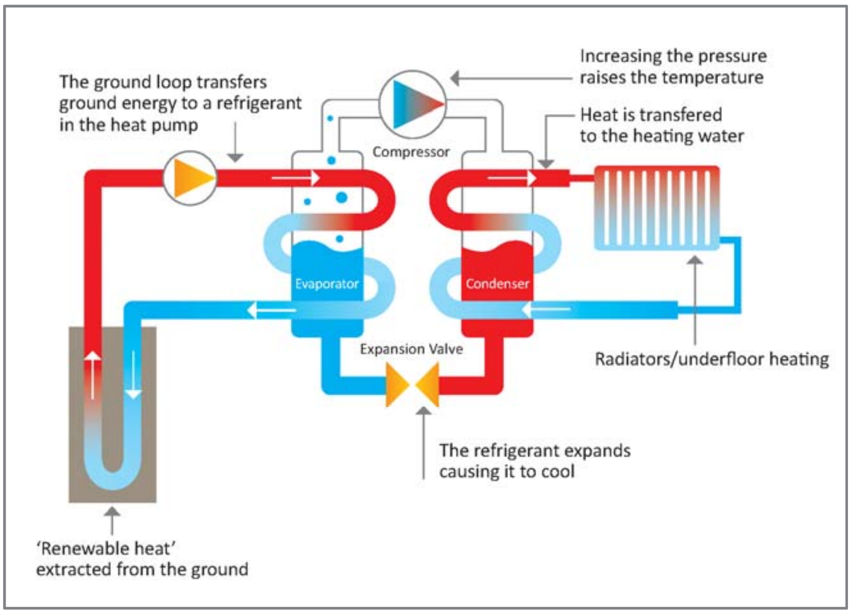

Diagram 3 – Ground Source Heat Pump

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.

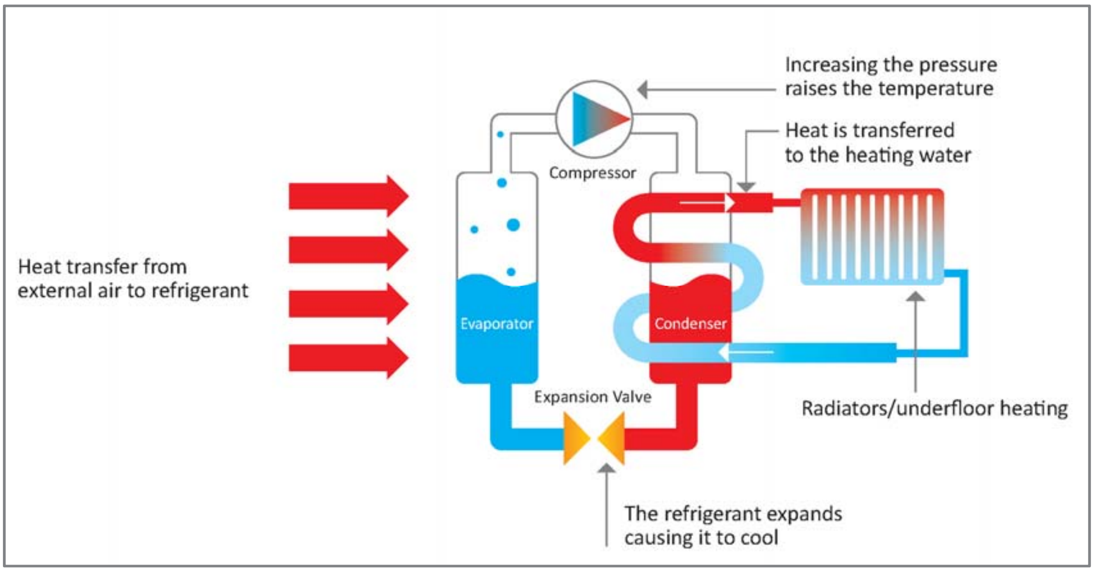

Diagram 4 – Air Source Heat Pump

- 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

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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.

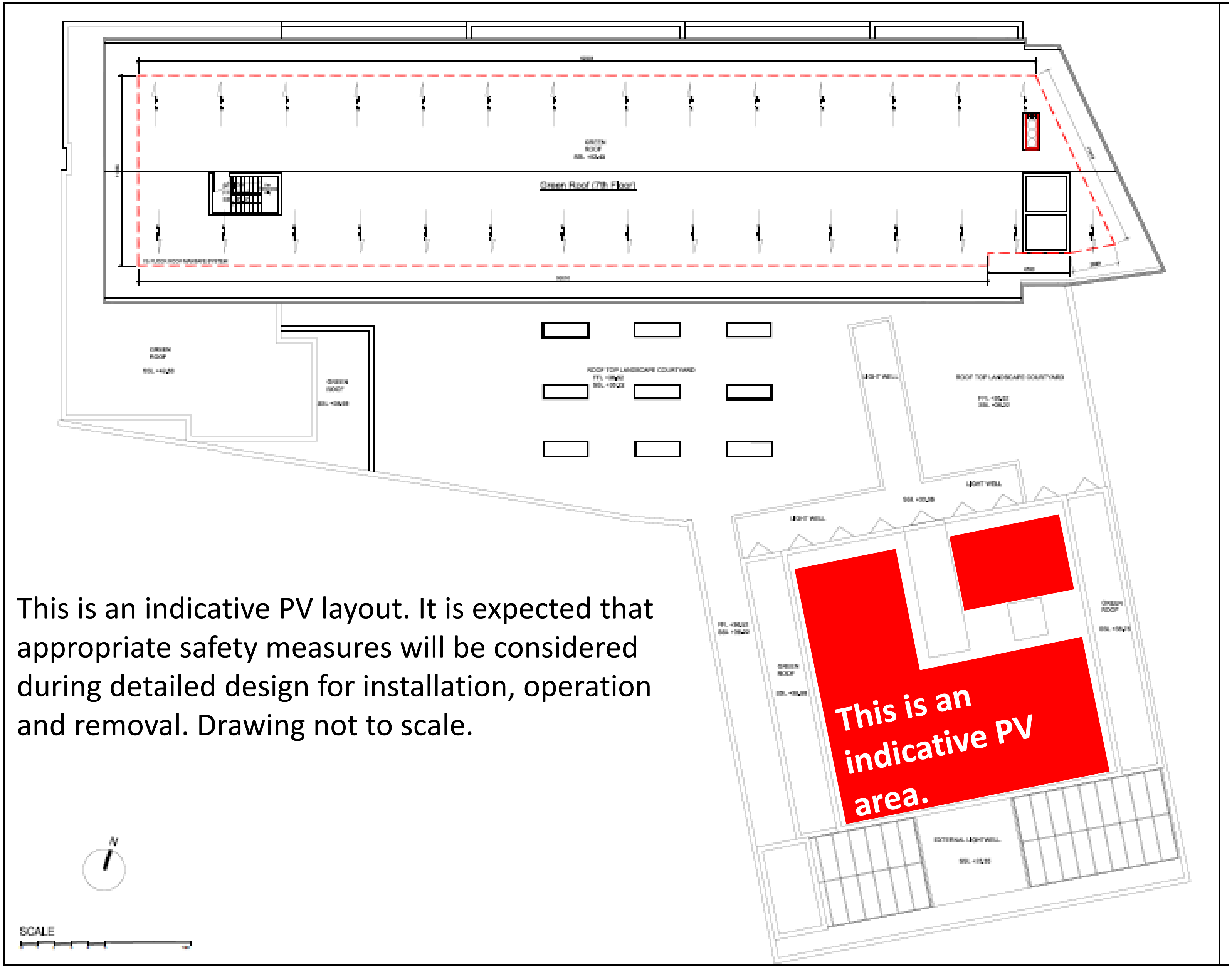
    - Maintenance costs.
    - Often not building integrated.
- **Application:** Best suited for small to large developments in rural open areas

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
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.