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Energy Statement

Planning Reference 2015/5759/P

Royal Academy of Dramatic Arts

16-18 Chenies Street

Final

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ABOUT HODKINSON CONSULTANCY

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

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

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

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

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

Executive Summary

The purpose of this Energy Statement is to demonstrate that the proposed development at 16-18 Chenies Street by Royal Academy of Dramatic Arts 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 proposed development will comprise alterations and extensions to 16-18 Chenies Street to create a theatre, new refectory, bar and kitchen, library, exhibition space, ancillary offices and 61 bed student accommodation.

A range of energy efficiency **(*Be Lean*)** measures are proposed to enable the development to meet the Part L2B baseline which is based on an assumed specification of the existing building. This represents a good level of sustainable design and construction and indicates the Applicant's commitment to reducing energy demands across the site. The combination of energy efficiency measures will achieve a reduction of **34.4%** in Regulated CO_2 emissions over the assessed baseline.

In line with the London Plan, the feasibility of decentralised energy production as a ***Be Clean*** measure has been carefully examined. It has been determined that due to tight time scales, connection to the existing district heating networks will not be available on time. Dedicated boilers for a site-wide heat network will be installed to provide heating and hot water, while provision will be made for future connection.

Camden's Local Plan requires a **20%** reduction of regulated carbon dioxide emissions over ***Be Lean*** and ***Be Clean*** reductions to be achieved, if feasible. The full spectrum of ***Be Green*** renewable energy sources has been considered. It has been concluded that a benefit from specifying high efficiency Air Source Heat Pumps **(ASHPs)** for heating can be accounted for. Additionally, it has been calculated that there is available roof space to accommodate **4kWp** of PV panels and achieve the **20%** required additional reduction on top of the ***Be Lean*** carbon dioxide reductions already predicted.

The table below summarises the Regulated and Total CO_2 emissions for the development after on-site measures have been applied. A **47.6%** reduction over the assessed baseline case is predicted.

Summary Table – Site Wide Reduction in CO_2 Emissions				
	Regulated CO_2 (kg/year)	**Total CO_2 (kg/year)**	**% Regulated CO_2 Saving**	**% Total CO_2 Saving**
Assessed Baseline	**536,700**	**638,500**	**-**	**-**
Emissions after *Be Lean* Measures	352,100	454,000	34.4%	28.9%
Emissions after *Be Clean* Measures	-	-	-	-
Emissions after *Be Green* Measures	281,000	382,900	20.2%	15.7%
Reduction Achieved over Baseline	**255,700**		**47.6%**	**40%**

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 the Royal Academy of Dramatic Arts.

1.2 This Statement sets out the energy strategy for the proposed development at 16-18 Chenies Street in the London Borough of Camden.

1.3 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 (NO_x) and particulate matter, thereby minimising the effects on local air quality.

1.4 This statement first establishes a Part L2B baseline assessment of the energy demands and associated CO_2 emissions for the development based on the specification of the existing building. It will then outline the energy measures that enable this, as well as any additional local policy targets, to be met.

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2. DEVELOPMENT OVERVIEW

Site Location

2.1 The proposed development site at 16-18 Chenies Street in the London Borough of Camden is located off the A400 (Tottenham Court Road) as shown in Figure 1, below.

Figure 1: Site Location – Map data © 2017 Google

Proposed Development

2.2 The proposed development is described as follows:

"Demolition of part of rear of 16 and 18 Chenies Street. Alterations, extensions (including at basement level) and general refurbishment to 16-18 Chenies Street to create 300 seat Richard Attenborough Theatre, new refectory, bar and kitchen, library, exhibition space, ancillary offices and 61 bed student accommodation."

2.3 The 61 bed student accommodation is being classed as Sui Generis. Other areas of the proposed development are being classed as D1 Non-residential institution and D2 Assembly and Leisure.

2.4 The added extension which includes he student accommodation beds and the library approximately form 1600m^2 of the total floor area, while the exiting building forms the rest of a total of 5300m^2.

2.5 The proposed layout of the site at 16-18 Chenies Street is shown in Figure 1, below.

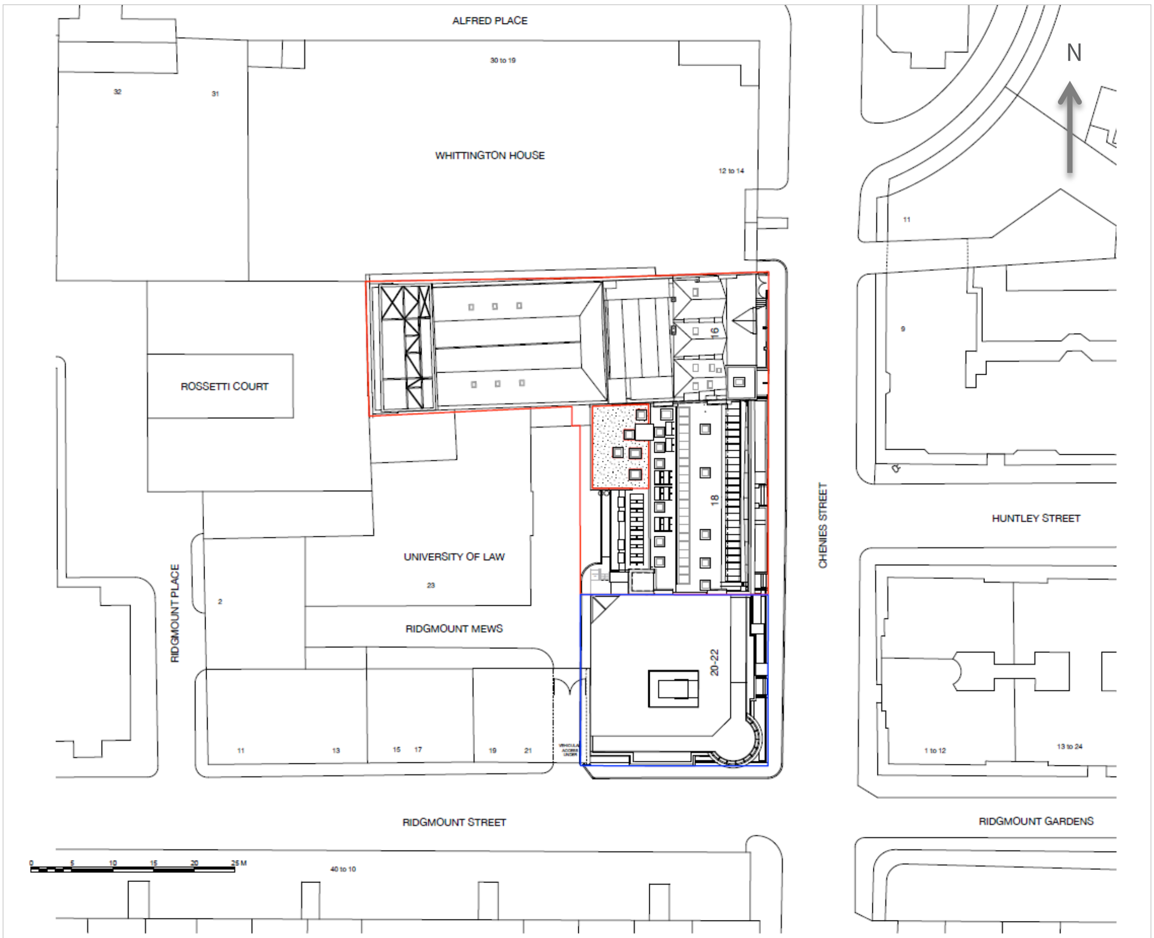

Figure 2: Proposed Site Layout – Haines Phillips Architects

Planning History

2.6 A planning application for the development was submitted in October 2015 (reference 2015/5759/P). This Energy Statement is superseding the Sustainability and Energy Statement presented by Bluesky Limited in January 2016.

2.7 A PV feasibility study was also conducted by MCA to demonstrate that a 20% reduction under ***Be Green*** is not feasible. This Energy Statement supersedes this document as well, taking into consideration more renewable technologies to achieve this planning requirement.

3. RELEVANT PLANNING POLICY

3.1 The following planning policies and requirements have informed the sustainable design of the proposed development.

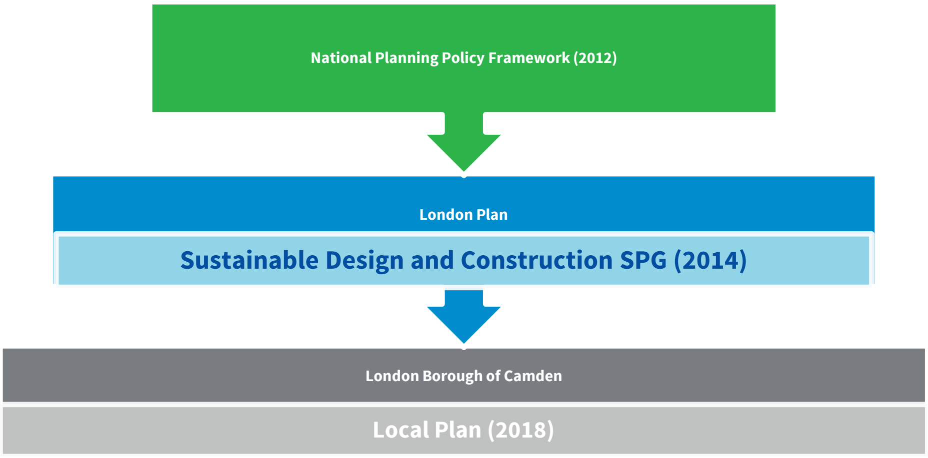

Figure 3: Relevant Planning Policy Documents

National Policy: NPPF

3.2 The Draft National Planning Policy Framework was published for consultation in March 2018, and is due to close on 10th May 2018. This documents sets out the Government's approach to sustainable development, and although in draft it is a material consideration in planning.

3.3 The National Planning Policy Framework (NPPF) was published in March 2012 and sets out the Government's planning policies for England.

"At the heart of the National Planning Policy Framework is a presumption in favour of sustainable development, which should be seen as a golden thread running through both plan-making and decision-taking."

3.4 The NPPF uses the United Nations General Assembly definition to describe sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". The framework also states that there are three dimensions to sustainable development; economic, social and environmental which give rise to the need for the planning system to perform a number of roles:

> **An economic role** – Contributing to building a strong, responsive and competitive economy, by ensuring that sufficient land of the right type is available in the right places and at the right time to support growth and innovation; and by identifying and coordinating development requirements, including the provision of infrastructure;

> **A social role** – Supporting strong, vibrant and healthy communities, by providing the supply of housing required to meet the needs of present and future generations; and by creating a high quality built environment, with accessible local services that reflect the community's needs and support its health, social and cultural well-being; and

> **An environmental role** – Contributing to protecting and enhancing our natural, built and historic environment; and, as part of this, helping to improve biodiversity, use natural resources prudently, minimise waste and pollution, and mitigate and adapt to climate change including moving to a low carbon economy

3.5 The document also makes it clear that the delivery of a wide choice of well-designed high quality homes is central to delivering sustainable development.

Regional Policy: The London Plan (2016)

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

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

3.8 **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*.

3.9 **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.

3.10 **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.

3.11 **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.

3.12 **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.

3.13 **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.

3.14 **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)

3.15 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.

3.16 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.

Local Policy: London Borough of Camden

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

3.18 **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:

> Promote zero carbon development and require all development 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. This is in line with stage three of the energy hierarchy 'Be green'. 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.

3.19 **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;

> Encourage new build residential development to use the Home Quality Mark and Passivhaus design standards; and

> Expecting non-domestic developments of 500 sqm of floorspace of above to achieve 'excellent' in BREEAM assessments and encouraging zero carbon in new development from 2019.

Summary of Targets

3.20 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.

4. PART L2B BASELINE

Methodology

4.1 This statement first establishes a baseline assessment of the energy demands and associated CO_2 emissions for the development. The approach followed uses the information available on the existing building, to provide a Part L2B baseline for energy efficiency improvements. This modelling is used to develop an illustrative fit-out specification to meet the carbon emissions target.

4.2 The estimated annual energy demand for the proposed development has been calculated using the Simplified Building Energy Model (SBEM). SBEM calculates the monthly energy use and carbon emissions associated with hot water, lighting, space heating m equipment and ventilation, auxiliary and cooling.

4.3 Due to limited information on the building fabrics and building services of the existing building, the pre-refurbishment calculation includes performance standards from the superseded Sustainability and Energy Statement carried out by Bluesky Limited in January 2016.

4.4 The pre-refurbishment specification includes the following standards:

Building Fabrics

> Existing external wall U-value of 1.70 W/m^2.K;

> Existing ground floor and exposed floor U-value of 0.60 W/m^2.K;

> Existing pitched roof U-value of 2.30 W/m^2.K;

> Existing flat roof U-value of 1.50 W/m^2.K;

> Existing doors U-value of 2.20 W/m^2.K;

> Existing glazing U-value of 4.80 W/m^2.K and G-value of 0.73;

> Existing building air permeability of 35 m^3/h/m^2.

Building Services

> Existing central ventilation system (theatre) with a Specific Fan Power (SFP) of 3.0 W/l/s;

> Existing extract ventilation system with an SFP of 1.5 W/l/s;

> Existing split cooling system with an EER/SEER of 3.6;

> Existing electric heaters with an efficiency of 100%;

> Existing gas fired boiler with an efficiency of 84%.

Lighting

> T8 lamps with an efficacy of 22.5 Lumens/Watt.

4.5 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 CO2 emissions over the calculated baseline. In order to achieve and go beyond the baseline case, Energy Efficiency measures ***(Be Lean)*** have been prioritised to minimise energy demand.

Existing Building Baseline

4.6 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

Assessed Baseline - Regulated and Total CO_2		
	Regulated CO_2 (kg/year)	Total CO_2 (kg/year)
Total CO_2 emissions	536,700	638,500

5. BE LEAN – ENERGY EFFICIENCY

5.1 In line with the London Plan Energy Hierarchy, the following energy efficient, ***Be Lean*** measures are proposed to be applied to the Proposed Development. These measures will ensure that the assessed baseline is met through energy efficiency measures alone for the refurbished building.

Insulation Standards

5.2 The existing building is a listed and protected building.

5.3 Liaison with the design team has concluded to the fact that improvements in the existing fabric are not recommended.

5.4 New thermal elements of the fabric (thermal elements of the extensions) should target the performance U-values detailed in Building Regulations Part L2B. These are detailed below in Table 2.

Table 2: Standards for new thermal elements (Part L1B)

Element	Limiting U-value
Wall	0.28 W/m²K
Pitched Roof – insulation at ceiling level	0.16 W/m²K
Pitched Roof – insulation between rafters	0.18 W/m²K
Flat Roof	0.18 W/m²K
Floors	0.22 W/m²K

5.5 It is expected that the following U-values will be achieved on the extensions of the building:

> New double glazing with a U-value of 1.4 W/m².K and a g-value of <0.57;

> New external wall U-value of 0.20 W/m².K – (minimum of 150mm of insulation);

> New ground floor and exposed floor U-value of 0.15 W/m².K;

> New flat roof U-value of 0.15 W/m².K;

Air Tightness & Ventilation

5.6 Due to limitations on fabric improvements, deriving from the fact that the existing building is listed, thermal improvements that would improve the air permeability of the existing fabric are limited. Therefore for the existing part of the development, an air permeability of 25 $m^3/hr/m^2$ has been assumed.

5.7 The air leakage of the extensions though is to be minimised and an air permeability of 5.0 $m^3/hr/m^2$ will be targeted, which is a good and at the same time realistic target for this type of building.

5.8 It is proposed to install Mechanical Ventilation with Heat Recovery (MVHR) in commercial and commonly used areas. This system will remove stale air and odours whilst retaining the heat within the spaces it serves.

5.9 The selected MVHR system is recommended to have a heat recovery efficiency of at least 50% with a Specific Fan Power (SFP) of 2.6 W/l/s.

5.10 Toilets are recommended to use centralised mechanical extract with an SFP of <0.5 W/l/s, while kitchens are recommended to use local mechanical extract with an SFP of <0.3 W/l/s.

Lighting

5.11 The major energy demand within modern commercial spaces is generally lighting. Specified lighting in these areas is envisaged to be LED (likely to require >60 lumens/circuit watt and a light output ratio of 1, with display lighting of >22 lumens/circuit watt) and designed to CIBSE Illuminance levels.

5.12 Demand reducing lighting controls such as photoelectric control for areas with extensive glazing and occupancy sensors would also be beneficial as they allow light output to be automatically adjusted to suit prevailing conditions.

5.13 Zoning of lighting circuits also allows greater benefit to be made of natural daylight in the areas where it is available, without compromising light levels further away from windows.

Space Heating/Cooling and Hot Water

5.14 For heating purposes, approximately half of the development will be served by central boilers with an efficiency of 91% as per the GLA guidance on the Be Lean step of the formulation of energy statements.

5.15 Areas such as the library, theatre, café etc that form approximately half of the development, will require cooling as well. Therefore it makes sense that heating and cooling will be provided by Air Source Heat Pumps with an SCoP of 2.5 and an EER/SEER of 3.5/4.5.

5.16 The additional benefit of the use of ASHPs for heating purposes will be realised in the ***Be Green*** step.

5.17 Hot water for the entire development is to be provided by gas fed boilers (91% efficient).

Limiting the Risk of Summer Overheating

5.18 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.

5.19 For this purpose, solar control glazing has been specified for the extensions with a U-value of 1.4W/m2K and a g-value of 0.57.

5.20 The initial SBEM calculation does not show a high risk of solar gains exceedance for the existing parts of the building or the extension.

CO_2 Emissions after Energy Efficiency Measures

5.21 Table 3 outlines the CO_2 emissions following the inclusion of the above Energy Efficiency measures. It can be seen that the assessed baseline has been met and exceeded by applying these measures alone.

Table 3: CO_2 Reduction after Energy Efficiency Measures

CO_2 Emissions following Energy Efficiency Measures	Regulated CO_2 (kg/yr)	Total CO_2 (kg/yr)
Assessed Baseline	536,700	638,500
Be Lean Measures	352,100	454,000
Improvement %	**34.4%**	**28.9%**

6. BE CLEAN - COMMUNITY ENERGY NETWORKS

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 potential to connect the development to an existing or planned heat network has been evaluated by reviewing the Camden Borough Wide Heat Demand and Heat Source Mapping prepared by BuroHappold (Figure 4).

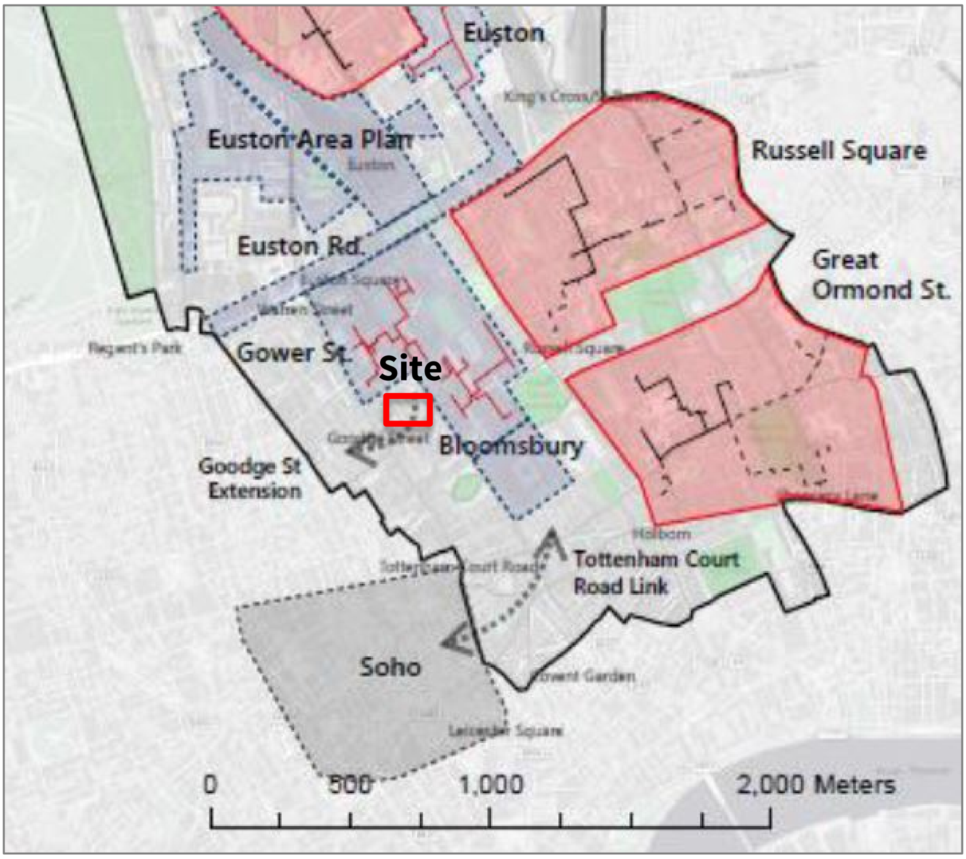

Figure 4: Camden Borough Wide Heat Demand and Heat Source Mapping (Burohapold Engineering)

6.3 As presented in Figure 4, there are two available decentralised energy networks that are operating in the vicinity of the development. Those networks are:

> **The Gower Street** Heat & Power decentralised energy network which serves the main University College London Bloomsbury Campus as well as a number of University College London Hospital (UCLH) buildings.

> **The Bloomsbury** Heat and Power Network which serves a number of colleges of the University of London including Birkbeck and SOAS.

> Both are not known to serve non-university buildings.

6.4 Attempts to liaise with the operators of the network have been made without success. Due to the short time frames for the completion of the development, it is exceedingly unlikely that connection to either of two networks could be made available on time.

6.5 The equipment to serve the development until a potential connection is made available will be provided as per the ***Be Lean*** stage.

6.6 The development will be served by multiple boilers, in two different plant rooms, with one of them located near the boundary of the property close to the expected route of network.

6.7 Provided that the operator of either of the networks agrees to extend the network and provide connection, one of the boilers of the proposed heating system can be replaced by a future heat exchanger should it be appropriate to make such a connection.

6.8 Liaison will be kept open, but firm commitment to supply potential connection by suitable terms is needed by September 2019, if the connection is to be provided in time to serve the development. An actual connection point would be needed by September 2020.

Site Wide Network

6.9 For the following reasons outlined below, it has been determined that a CHP-led site heat network is considered as unsuitable for this development.

> **Size of** development: A development of this size will require a very small Combined Heat and Power (CHP) engine. These are much less efficient than larger ones, having a worse heat to power ratio. This means that they do not enable as large a CO_2 reduction as for a larger development, which would be able to utilise a larger and more efficient CHP engine. Small CHP engines also have a significantly lower electrical efficiency and higher heat: power ratio (typically >2) than larger systems. This means that more fuel must be burnt in proportion to the electricity generated, meaning they are less effective at reducing CO2 emissions.

> **Diversity of demand:** CHP is best suited to developments where there is a diversity of energy demand. A large mixed-use scheme, or a large residential scheme (>1000 homes) will have extended periods of the day in which there is a continuous demand for heat. In these circumstances, a CHP engine can operate consistently to generate electricity, with heat as a by-product. On a commercial scheme such as this, there will be long periods of low heat demand with unregulated peaks in demand for hot water. Sharp peaks in demand must be dealt with either by running CHP engines for shorter hours (resulting in a decreased potential for CO_2 reductions) with storage of heat in large central thermal buffer vessels with substantial space (and height) requirements, OR 'dumping' of heat by connecting CHP engines to heat rejection plant at roof level, or in very well ventilated basements.

> **Installed Costs**: On a smaller scheme the upfront cost of commercial heating plant with CHP systems is high. In addition, export licenses for grid connection are harder to negotiate on favourable terms for small developments.

> **Running Costs:** Fixed costs associated with the management and operation of a communal plant room could affect the price of renting the student accommodation, as part of an energy standing charge; hence the fewer the number of units, the greater the cost for the individual occupant. CHP engines impose additional running costs because contracts for maintenance and replacement parts are typically handled by specialist companies.

6.10 It has therefore been concluded that, due to the size and density of the proposed **development**, the use and the associated space heating and hot water demand, CHP cannot be recommended for the scheme.

Communal heating and cooling

6.11 With CHP considered as unfeasible the next step is to consider communal heating (and cooling) for the development.

6.12 It has been determined that the construction of a heat network that serves approximately half of the development, equipped with communal boilers would be the most appropriate means of efficiently delivering hot water to the whole of the development and space heating to parts of the development.

6.13 Two plant rooms (17m^{2}and 15m^2) have been designed to house the communal boilers.

6.14 The communal boiler will have a high seasonal efficiency of 91% or above.

CO_2 Emissions after Be Clean Measures

6.15 The measures detailed above have been included within the Be Lean case in line with GLA Guidance. Therefore the reduction in Regulated CO_2 emissions is as per the Be Lean (see Table 3). Be Green Measures will be assessed in line with the London Plan hierarchy.

7. BE GREEN – RENEWABLE ENERGY

7.1 It can be seen from Table 3 that the assessed baseline's carbon dioxide emissions have been exceeded with energy efficiency measures alone.

7.2 Renewable technologies have been assessed for their feasibility within the Proposed Development. The details are summarised in this chapter but further information can be found in Appendices C and D.

Biomass Boiler

7.3 Biomass boilers generate heat on a renewable basis as they are run on biomass fuel which can be considered carbon neutral. A biomass boiler would require a central plant room and heat distribution network which is available on site.

7.4 Expensive NO_X and particular matter filters will be required as will bespoke maintenance and fuel management services. Therefore it is expected that both the capital and running costs will be high.

7.5 That would result in increased maintenance costs and potentially high energy bills for the tenants of the student accommodation units.

7.6 Whilst technically feasible, a biomass boiler is not appropriate for this development due to the high costs that are associated with it.

Ground Source Heat Pumps

7.7 GSHPs are able to provide substantial reductions in energy. However, they are generally limited to sites with large amount of space. It is expected that the Proposed Development will not have sufficient space for the installation of ground coils, as the entire site is occupied by the existing building.

7.8 It has therefore been concluded that GSHPs are not a suitable technology for the proposed development.

Air Source Heat Pumps (Selected technology)

7.9 Air Source Heat Pumps are most efficient when providing low temperature heat, for example to fan coil units in a commercial space.

7.10 They can also provide cooling efficiently making them viable for this development, as spaces such as the theatre, the library, café and rehearsals will have a significant cooling demand.

7.11 As ASHPs require a small contribution of electricity to run, only the additional reduction in CO_2 emissions above the SBEM standard SCoP value has been taken as a contribution to the development's renewable energy requirement in achieving a 20% of CO_2 reductions under the ***Be Green*** step of the Energy Hierarchy.

7.12 The required **SCoP is 3.8**.

Micro Wind Turbines

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

7.14 Rural rooftop wind turbines generally perform better than those in urban locations. The Government's NOABL database provides a basic estimation of wind speed, which in the area of the proposed development is 5.6/s at 25m above ground and 6.1m/s at 45m. This is at the lower end of viability for wind turbines. In addition, before specifying or installing wind turbines, extensive analysis of the wind resource at the specific site should be undertaken to ensure that wind conditions are suitable.

7.15 Additionally, the development is regarding an existing listed building. Wind turbines would affect drastically the historic character and the aesthetics of the building.

7.16 It has been concluded that wind turbines are not the most appropriate renewable energy technology for the proposed development.

Solar Thermal (Hot Water) Panels

7.17 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 ~60% of hot water demand, with the remainder being provided as top-up by the conventional heating system. They are a robust technology that provides substantial benefits in terms of 'free' energy.

7.18 Solar thermal panels are generally installed on roofs, with panels facing as close to south as possible to maximise their efficiency.

7.19 Whilst technically viable, solar thermal panels conflict with the roof space requirements of PV panels, with the latter considered a more appropriate option.

Photovoltaic (PV) Panels (Selected technology)

7.20 PV panels generate electricity from solar radiation. The generating potential of PV panels is not dependent on development demand, but only on available roof space for installation and ensuring that they are not overshadowed. Due to their current low cost, it has been concluded that PV panels would be a viable technology for the development.

7.21 Planning constraints as per the historic character of the building, space constraints, orientation and available roof space (green roof, roof lighting, services etc.) have been taken into account in order to determine the total amount of PV that can be specified.

7.22 It has been calculated that **4.0kWp** of PV panels can be accommodated to enable 20% of CO_2 reductions under the ***Be Green*** step of the Energy Hierarchy.

7.23 Using a figure of **8m²** per kWp it has been determined that 4kWp of panels would require approximately **64m²** of available area.

7.24 The roof area identified as suitable and available to accommodate PV panels is the rear half of the roof of No.18 Chenies Street.

7.25 This area is not visible from Chenies Street and therefore it does not affect the aesthetics of the existing building and is structurally designed to accommodate the additional load.

7.26 An indicative roof plan is presented in Appendix E.

CO_2 Emissions after Be Green Measures

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

Table 4: CO_2 emissions following *Be Green* measures

CO_2 Emissions following Energy Efficiency Measures	Regulated CO_2 (kg/yr)	Total CO_2 (kg/yr)
***Be Lean* Measures**	352,100	454,000
***Be Green* Measures**	281,000	382,900
Improvement %	**20.2%**	**15.7%**

7.28 Table 5 below outlines the energy generated by each one of the selected renewable technologies, the associated CO2 savings and the feasibility of exporting heat and electricity.

Selected Technologies	PV panels	ASHP
Energy generated (kWh/annum)	3,157	N/A
CO2 savings (%)	0.6%	19.6%
Exporting feasibility	Electricity can be exported to the grid	Heat generated will be used on site

8. SUMMARY

8.1 The purpose of this Energy Statement is to demonstrate that the proposed development at 16-18 Chenies Street by Royal Academy of Dramatic Arts 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.***

8.2 The proposed development will comprise alterations and extensions to 16-18 Chenies Street to create a theatre, new refectory, bar and kitchen, library, exhibition space, ancillary offices and 61 bed student accommodation.

8.3 A range of energy efficiency ***(Be Lean)*** measures are proposed to enable the development to meet the Part L2B baseline which is based on an assumed specification of the existing building. This represents a good level of sustainable design and construction and indicates the Applicant's commitment to reducing energy demands across the site. The combination of energy efficiency measures will achieve a reduction of **34.4%** in Regulated CO_2 emissions over the assessed baseline.

8.4 In line with the London Plan, the feasibility of decentralised energy production as a ***Be Clean*** measure has been carefully examined. It has been determined that due to tight time scales, connection to the existing district heating networks will not be available on time. Dedicated boilers for a site-wide heat network will be installed to provide heating and hot water, while provision will be made for future connection.

8.5 Camden's Local Plan requires a **20%** reduction of regulated carbon dioxide emissions over ***Be Lean*** and ***Be Clean*** reductions to be achieved, if feasible. The full spectrum of ***Be Green*** renewable energy sources has been considered. It has been concluded that a benefit from specifying high efficiency Air Source Heat Pumps (ASHPs) for heating can be accounted for. Additionally, it has been calculated that there is available roof space to accommodate **4kWp** of PV panels and achieve the **20%** required additional reduction on top of the Be Lean carbon dioxide reductions already predicted.

8.6 The table overleaf summarises the Regulated and Total CO_2 emissions for the development after on-site measures have been applied. A 47.6% reduction over the assessed baseline case is predicted.

Summary Table – Site Wide Reduction in CO_2 Emissions				
	Regulated CO_2 (kg/year)	**Total CO_2 (kg/year)**	**% Regulated CO_2 Saving**	**% Total CO_2 Saving**
Assessed Baseline	**536,700**	**638,500**	**-**	**-**
Emissions after *Be Lean* Measures	352,100	454,000	34.4%	28.9%
Emissions after *Be Clean* Measures	-	-	-	-
Emissions after *Be Green* Measures	281,000	382,900	20.2%	15.7%
Reduction Achieved over Baseline	**255,700**		**47.6%**	**40%**

APPENDICES

Appendix A:
Energy Efficiency Calculations

Appendix B:
SBEM BRUKL Outputs

Appendix C:
Low Carbon and Renewable Energy Technologies

Appendix D:
Low Carbon and Renewable Energy Technology Feasibility Table

Appendix E:
Roof Layout

Appendix A:
Energy Efficiency Calculations

Part L 2B Baseline Calculations

SAP / SBEM Outputs per Unit

Unit Type	Test Unit Location	Energy (kWh/yr/m2)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)	
		Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
RADA	0	98	216	121	45	N/A	122.40	N/A	145.64

Energy Demands & CO2 Emissions

Unit Type	Unit Area (m2)	No. Units	Energy (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/m2/yr)	
			Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
RADA	4384	1	430,285	947,907	530,293	196,333	N/A	536,651	N/A	638,548
TOTAL			430,285	947,907	530,293	196,333	N/A	536,651	N/A	638,548
Area Weighted Average						0	N/A	122.40	N/A	145.64

Be Lean Energy Calculations

SAP / SBEM Outputs per Unit

Unit Type	Test Unit Location	Energy (kWh/yr)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)	
		Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
RADA	0	43	73	64	45	122.40	80.30	145.64	103.54

Energy Demands & CO2 Emissions

Unit Type	Unit Area (m2)	No. Units	Energy (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/m2/yr)	
			Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
RADA	4384	1	187652	318483	280689	196333	536651	352067	638548	453964
TOTAL			187,652	318,483	280,689	196,333	536,651	352,067	638,548	453,964
Area Weighted Average						0	122	80	146	104
Improvement over Target							34.4%		28.9%	

Be Green Energy Calculations

SAP / SBEM Outputs per Unit

Unit Type	Test Unit Location	Energy (kWh/yr)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)	
		Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
0	0	43	73	59	45	122.40	64.10	122.40	64.10

Energy Demands & CO2 Emissions

Unit Type	Unit Area (m2)	No. Units	Energy (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/m2/yr)	
			Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	BER	TER	DER/BER
RADA	4384	1	187,652	318,483	256,882	196,333	536,651	281,040	638,548	382,937
TOTAL			187,652	318,483	256,882	196,333	536,651	281,040	638,548	382,937
Area Weighted Average							122.40	64.10	#REF!	#REF!
Improvement over Target							47.6%		40.0%	

HODKINSON

Appendix B:
SBEM BRUKL Outputs

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Existing Building

As designed

Date: Tue May 08 19:14:57 2018

Administrative information

Building Details

Address: ,

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.3.a.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.0.3

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

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Georgios Koronaios

Telephone number:

Address: , Harrow,

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

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	63.9
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	63.9
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	122.4
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	2.11	2.3	0b theatre - Theatre_W_12
Floor	0.25	0.31	0.6	0a Rear - library_F_3
Roof	0.25	1.29	2.3	0e side addition - Kitchen_R_14
Windows***, roof windows, and rooflights	2.2	4.8	4.8	0a Rear - library_G_9
Personnel doors	2.2	2.2	2.2	0d side existing - Stairs_D_7
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	35

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- No vent rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.84	-	-	-	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	NO				

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

2- Existing HVAC system

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.84	3.4	-	-	-
Standard value	0.91*	2.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	NO				

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

1- Project DHW

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

Local mechanical ventilation, exhaust, and terminal units

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

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	**Zone**	**Standard**
0a Rear - library	-	-	-	-	-	-	-	-	-	-	N/A
0e side addition - Kitchen	1.5	-	-	-	-	-	-	-	-	-	N/A
0c front - WC	-	-	-	-	-	-	-	-	1.5	-	N/A
0d side existing - WC	1.5	-	-	-	-	-	-	-	-	-	N/A
0d side existing - Stairs	-	-	-	-	-	-	-	-	-	-	N/A
2a rear - WC	1.5	-	-	-	-	-	-	-	-	-	N/A
1d side addition - Bathrooms	-	-	-	-	-	-	-	-	1.5	-	N/A
1d side addition - Bedrooms	-	-	-	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
3c front - Living zone	-	1.5	-	-	-	-	-	-	-	-	N/A
0b theatre - Theatre	-	3	-	-	-	-	-	-	-	-	N/A
00 Basement - Studio Theatre 1	-	-	1.5	-	-	-	-	-	-	-	N/A
00 Basement - Laundry	1.5	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Plant	-	-	-	-	-	-	-	-	-	-	N/A
00 Basement - WC	1.5	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Store - Archive	-	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Dressing Rooms	-	-	1.5	-	-	-	-	-	-	-	N/A
0c front - Break out	-	3	-	-	-	-	-	-	-	-	N/A
0c front - Reception	-	3	-	-	-	-	-	-	-	-	N/A
0d side existing - Cafe	-	3	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
0a Rear - library	28	-	-	8336
0e side addition - Kitchen	-	55	-	1510
0c front - WC	-	55	-	602
0d side existing - WC	-	55	-	216
0d side existing - Stairs	-	55	-	1689
2a rear - WC	-	55	-	281
1d side addition - Bathrooms	-	55	-	787
1d side addition - Bedrooms	-	55	-	5039
3c front - Living zone	-	55	-	147
0b theatre - Theatre	-	55	-	5506
00 Basement - Studio Theatre 1	-	55	-	3143
00 Basement - Laundry	-	55	-	190
00 Basement - Plant	28	-	-	1811
00 Basement - WC	-	55	-	4506
00 Basement - Store - Archive	28	-	-	656
00 Basement - Dressing Rooms	-	55	-	812
0c front - Break out	28	-	-	21233
0c front - Reception	-	55	15	847
0d side existing - Cafe	-	55	-	2240

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?
0a Rear - library	NO (-71.7%)	NO
1d side addition - Bedrooms	NO (-47.8%)	NO
0b theatre - Theatre	NO (-71%)	NO
0c front - Break out	NO (-56.3%)	NO
0c front - Reception	NO (-56.2%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
0d side existing - Cafe	NO (-47.7%)	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]	4384.4	4384.4
External area [m²]	5613.5	5613.5
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	35	3
Average conductance [W/K]	10079	2793.99
Average U-value [W/m²K]	1.8	0.5
Alpha value* [%]	4.16	20.68

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
30	**C2 Residential Institutions: Residential schools**
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
8	**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
61	**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	125.57	26.05
Cooling	7.74	5.35
Auxiliary	34.73	10.31
Lighting	51.05	14.4
Hot water	216.2	199.57
Equipment*	44.78	44.78
TOTAL**	**435.3**	**255.68**

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

Energy Production by Technology [kWh/m²]

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

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	476.05	213.38
Primary energy* [kWh/m²]	704.1	365.25
Total emissions [kg/m²]	122.4	63.9

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
	Actual	371	93.1	137.4	0	41.7	0.75	0	0.84	0
	Notional	101.6	94.1	34.5	0	13	0.82	0	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	270.7	235.2	96	27.1	17.3	0.78	2.41	0.84	3.4
	Notional	15	242.5	5.1	18.7	3.5	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-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	2.1	0a Rear - library_W_8
Floor	0.2	0.18	00 Basement - Dressing Rooms_S_3
Roof	0.15	0.35	0a Rear - library_R_20
Windows, roof windows, and rooflights	1.5	4.8	0a Rear - library_G_9
Personnel doors	1.5	2.2	0d side existing - Stairs_D_7
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"

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

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

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

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	35

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Be Lean

As designed

Date: Tue May 08 19:18:24 2018

Administrative information

Building Details

Address: ,

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.3.a.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.0.3

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

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Georgios Koronaios

Telephone number:

Address: , Harrow,

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

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	56
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	56
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	80.3
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	1.46	2.3	0b theatre - Theatre_W_12
Floor	0.25	0.29	0.6	0d side existing - WC_F_4
Roof	0.25	1.7	2.3	0c front - WC_R_10
Windows***, roof windows, and rooflights	2.2	3.9	4.8	0c front - WC_G_13
Personnel doors	2.2	2.2	2.2	0d side existing - Stairs_D_7
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	18.5

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- Refurbished central heating boiler

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

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

2- Refurbished VAV

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	2.5	3.5	-	-	-
Standard value	2.5*	2.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

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

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**
0c front - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
0d side existing - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
0d side existing - Stairs	-	-	-	-	-	-	-	-	-	-	N/A
2a rear - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1d side addition - Bathrooms	-	-	0.5	-	-	-	-	-	-	-	N/A
1d side addition - Bedrooms	-	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Laundry	-	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Plant	-	-	-	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
00 Basement - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
00 Basement - Store - Archive	-	-	-	-	-	-	-	-	-	-	N/A
0a Rear - library	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0e side addition - Kitchen	0.3	-	-	-	-	-	-	-	-	-	N/A
0c front - Break out	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0c front - Reception	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0d side existing - Cafe	-	-	-	2.6	-	-	-	-	-	0.5	0.5
3c front - Living zone	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0b theatre - Theatre	-	-	-	2.6	-	-	-	-	-	0.5	0.5
00 Basement - Studio Theatre 1	-	-	-	2.6	-	-	-	-	-	0.5	0.5
00 Basement - Dressing Rooms	-	-	-	2.6	-	-	-	-	-	0.5	0.5

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
0c front - WC	-	60	-	276
0d side existing - WC	-	60	-	99
0d side existing - Stairs	-	60	-	774
2a rear - WC	-	60	-	129
1d side addition - Bathrooms	-	60	-	361
1d side addition - Bedrooms	-	60	-	2309
00 Basement - Laundry	-	60	-	87
00 Basement - Plant	60	-	-	830
00 Basement - WC	-	60	-	2065
00 Basement - Store - Archive	60	-	-	301
0a Rear - library	60	-	-	3821
0e side addition - Kitchen	-	60	-	692
0c front - Break out	60	-	-	9732
0c front - Reception	-	60	22	388
0d side existing - Cafe	-	60	-	1027
3c front - Living zone	-	60	-	67
0b theatre - Theatre	-	60	-	2524
00 Basement - Studio Theatre 1	-	60	-	1441
00 Basement - Dressing Rooms	-	60	-	372

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?
1d side addition - Bedrooms	NO (-52%)	NO
0a Rear - library	NO (-77.8%)	NO
0e side addition - Kitchen	NO (-41.6%)	NO
0c front - Break out	NO (-50.2%)	NO
0c front - Reception	NO (-47.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
0d side existing - Cafe	NO (-37.8%)	NO
3c front - Living zone	NO (-80.2%)	NO
0b theatre - Theatre	NO (-72.9%)	NO
00 Basement - Studio Theatre 1	NO (-64.1%)	NO
00 Basement - Dressing Rooms	NO (-95.7%)	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]	4384.4	4384.4
External area [m^2]	5613.6	5613.6
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	18	3
Average conductance [W/K]	8193.54	2793.74
Average U-value [W/m^{2}K]	1.46	0.5
Alpha value* [%]	5.15	20.69

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
30	**C2 Residential Institutions: Residential schools**
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
8	**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
61	**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	59.42	18.54
Cooling	8.15	8.15
Auxiliary	15.97	10.56
Lighting	23.51	15.84
Hot water	72.64	67.26
Equipment*	44.78	44.78
TOTAL**	**179.69**	**120.36**

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

Energy Production by Technology [kWh/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]	381.81	207.96
Primary energy* [kWh/m^2]	472.52	330.28
Total emissions [kg/m^2]	80.3	56

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
	Actual	250.6	46.9	85.7	0	14.5	0.81	0	0.91	0
	Notional	99.9	76.5	33.9	0	15.5	0.82	0	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	278.8	187	33.2	16.3	17.5	2.33	3.2	2.5	4.5
	Notional	28.5	210.8	3.3	16.3	5.7	2.43	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-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.2	0d side existing - Stairs_W_16
Floor	0.2	0.15	1d side addition - Bedrooms_F_4
Roof	0.15	0.15	0d side existing - Stairs_R_33
Windows, roof windows, and rooflights	1.5	1.4	0d side existing - Stairs_G_35
Personnel doors	1.5	2.2	0d side existing - Stairs_D_7
Vehicle access & similar large doors	1.5	-	"No external vehicle access doors"
High usage entrance doors	1.5	-	"No external high usage entrance doors"

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

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

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

Air Permeability	Typical value	This building
$m^3/(h.m^2)$ at 50 Pa	5	18.5

BRUKL Output Document

Compliance with England Building Regulations Part L 2013

HM Government

Project name

Be Green

As designed

Date: Tue May 08 19:20:51 2018

Administrative information

Building Details

Address: ,

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.3.a.0

Interface to calculation engine: DesignBuilder SBEM

Interface to calculation engine version: v5.0.3

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

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Georgios Koronaios

Telephone number:

Address: , Harrow,

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

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	56
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	56
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	64.1
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	1.46	2.3	0b theatre - Theatre_W_12
Floor	0.25	0.29	0.6	0d side existing - WC_F_4
Roof	0.25	1.7	2.3	0c front - WC_R_10
Windows***, roof windows, and rooflights	2.2	3.9	4.8	0c front - WC_G_13
Personnel doors	2.2	2.2	2.2	0d side existing - Stairs_D_7
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

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

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

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	18.5

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- Refurbished central heating boiler

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

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

2- Refurbished VAV

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.8	3.5	-	-	-
Standard value	2.5*	2.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	NO				

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

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

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**
0c front - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
0d side existing - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
0d side existing - Stairs	-	-	-	-	-	-	-	-	-	-	N/A
2a rear - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1d side addition - Bathrooms	-	-	0.5	-	-	-	-	-	-	-	N/A
1d side addition - Bedrooms	-	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Laundry	-	-	-	-	-	-	-	-	-	-	N/A
00 Basement - Plant	-	-	-	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
00 Basement - WC	-	-	0.5	-	-	-	-	-	-	-	N/A
00 Basement - Store - Archive	-	-	-	-	-	-	-	-	-	-	N/A
0a Rear - library	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0e side addition - Kitchen	0.3	-	-	-	-	-	-	-	-	-	N/A
0c front - Break out	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0c front - Reception	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0d side existing - Cafe	-	-	-	2.6	-	-	-	-	-	0.5	0.5
3c front - Living zone	-	-	-	2.6	-	-	-	-	-	0.5	0.5
0b theatre - Theatre	-	-	-	2.6	-	-	-	-	-	0.5	0.5
00 Basement - Studio Theatre 1	-	-	-	2.6	-	-	-	-	-	0.5	0.5
00 Basement - Dressing Rooms	-	-	-	2.6	-	-	-	-	-	0.5	0.5

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
0c front - WC	-	60	-	276
0d side existing - WC	-	60	-	99
0d side existing - Stairs	-	60	-	774
2a rear - WC	-	60	-	129
1d side addition - Bathrooms	-	60	-	361
1d side addition - Bedrooms	-	60	-	2309
00 Basement - Laundry	-	60	-	87
00 Basement - Plant	60	-	-	830
00 Basement - WC	-	60	-	2065
00 Basement - Store - Archive	60	-	-	301
0a Rear - library	60	-	-	3821
0e side addition - Kitchen	-	60	-	692
0c front - Break out	60	-	-	9732
0c front - Reception	-	60	22	388
0d side existing - Cafe	-	60	-	1027
3c front - Living zone	-	60	-	67
0b theatre - Theatre	-	60	-	2524
00 Basement - Studio Theatre 1	-	60	-	1441
00 Basement - Dressing Rooms	-	60	-	372

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?
1d side addition - Bedrooms	NO (-52%)	NO
0a Rear - library	NO (-77.8%)	NO
0e side addition - Kitchen	NO (-41.6%)	NO
0c front - Break out	NO (-50.2%)	NO
0c front - Reception	NO (-47.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
0d side existing - Cafe	NO (-37.8%)	NO
3c front - Living zone	NO (-80.2%)	NO
0b theatre - Theatre	NO (-72.9%)	NO
00 Basement - Studio Theatre 1	NO (-64.1%)	NO
00 Basement - Dressing Rooms	NO (-95.7%)	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]	4384.4	4384.4
External area [m^2]	5613.6	5613.6
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	18	3
Average conductance [W/K]	8193.54	2793.74
Average U-value [W/m^2K]	1.46	0.5
Alpha value* [%]	5.15	20.69

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
30	**C2 Residential Institutions: Residential schools**
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
8	**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
61	**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	53.73	18.54
Cooling	8.15	8.15
Auxiliary	15.97	10.56
Lighting	23.51	15.84
Hot water	47.79	67.26
Equipment*	44.78	44.78
TOTAL**	**149.14**	**120.36**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0.72	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]	381.81	207.96
Primary energy* [kWh/m^2]	378.74	330.28
Total emissions [kg/m^2]	64.1	56

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Natural Gas										
	Actual	250.6	46.9	85.7	0	14.5	0.81	0	0.91	0
	Notional	99.9	76.5	33.9	0	15.5	0.82	0	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	278.8	187	21.9	16.3	17.5	3.54	3.2	3.8	4.5
	Notional	28.5	210.8	3.3	16.3	5.7	2.43	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	0.2	0d side existing - Stairs_W_16
Floor	0.2	0.15	1d side addition - Bedrooms_F_4
Roof	0.15	0.15	0d side existing - Stairs_R_33
Windows, roof windows, and rooflights	1.5	1.4	0d side existing - Stairs_G_35
Personnel doors	1.5	2.2	0d side existing - Stairs_D_7
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	18.5

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.

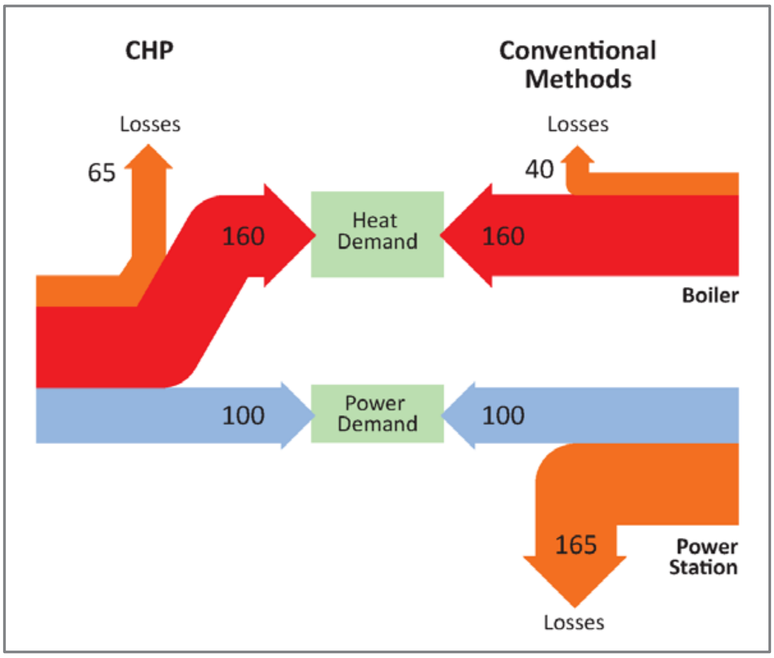

Diagram 1 – CHP Diagram

> 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.

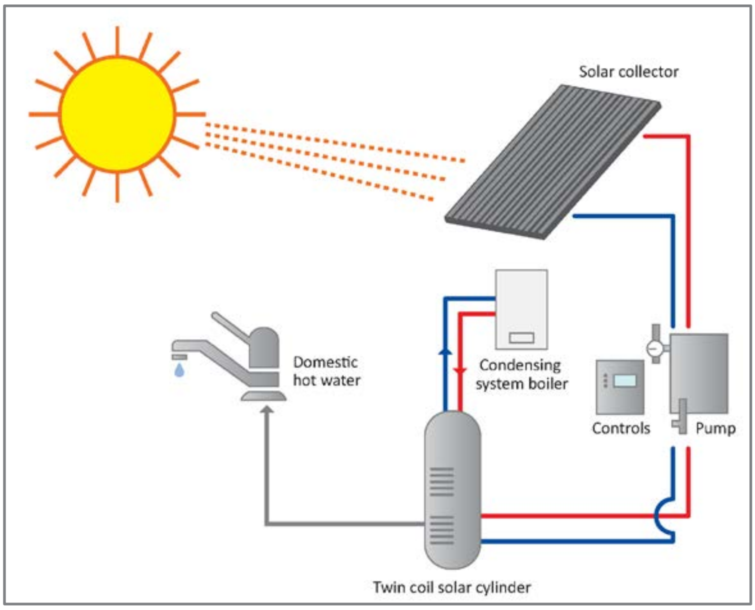

Diagram 2 – Solar Thermal System

> 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

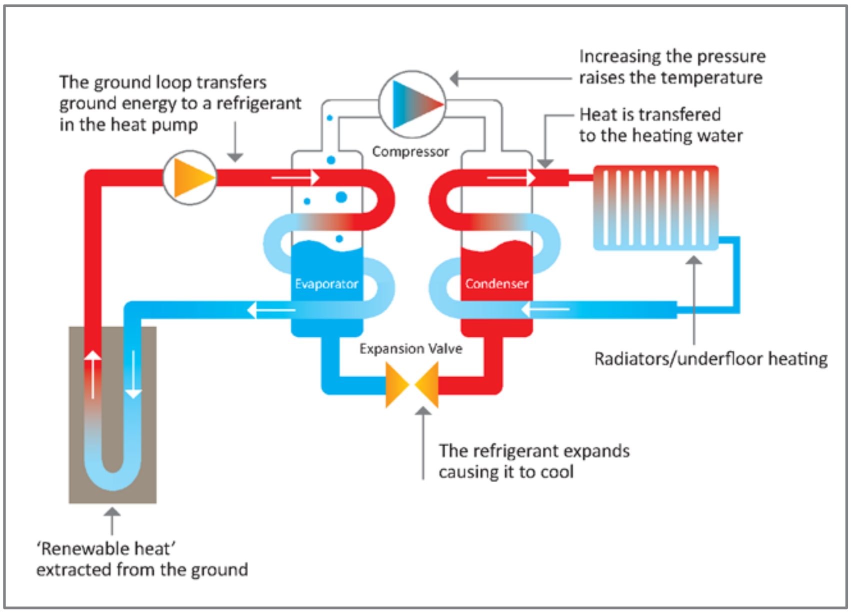

Diagram 3 – Ground Source Heat Pump

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.

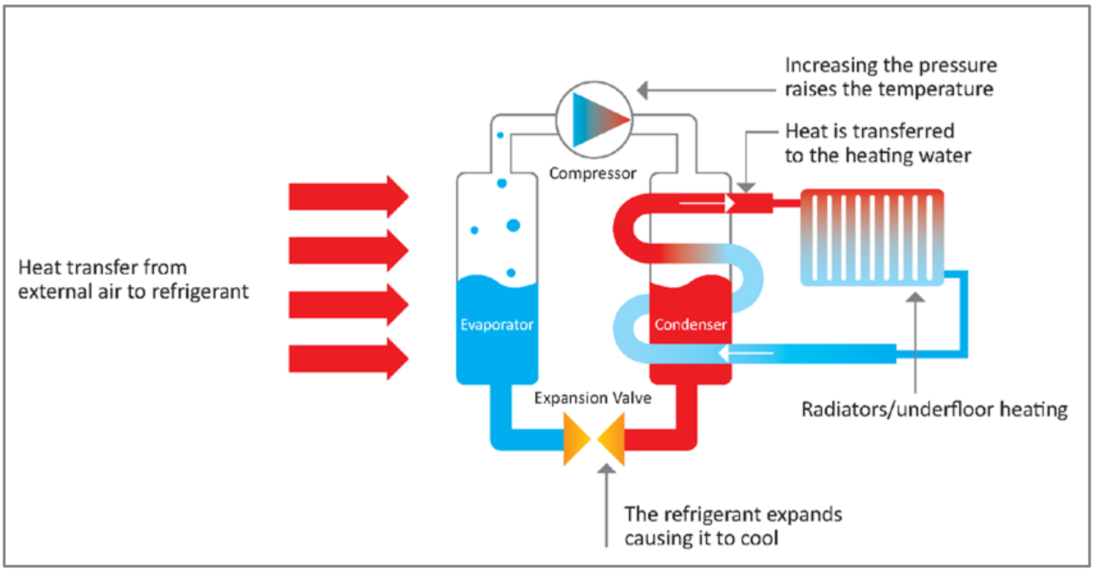

Diagram 4 – Air Source Heat Pump

- 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

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Appendix D:
Low Carbon and Renewable Energy Technology Feasibility Table

Appendix D - 16-18 Chenies Street Feasibility Table of Low Carbon Renewable Energy Technologies

Feasibility Study Table

Technology	Sufficient Energy Generated?	Payback	Land Use Issues	Local Planning Requirements	Noise	Carbon Payback	Available Grants	Feasible?	Reason not Feasible or Selected
Combined Heat & Power (CHP)	Yes	Medium	Air quality in residential area	Emphasis on district heating	In Plant Room	Yes	Tax Relief - ECA, RHI	No	High installed and running costs
Biomass	Yes	None	Air quality in residential area	Encouraged for large scale developments	In Plant Room	Yes	RHI; Bio-energy Capital Grants Scheme	No	Same reasons as CHP
Solar Thermal	Yes	High	Sufficient roof space required	Encouraged	None	~2 years	RHI	No	Roofspace required for PV panels
Solar Photovoltaic (PV)	Yes	Very High	Sufficient roof space required	Encouraged	None	2-5 years	FiT	Yes	Selected
Ground Source Heat Pumps (GSHPs)	Yes	High	Requires large area for coils or borehole	Encouraged	None	Low	RHI	No	High cost associated with ground excavations
Air Source Heat Pumps (ASHPs)	Yes	Very High	Visual intrusion of external units	Encouraged	Low	Low	RHI	Yes	Selected
Wind Power	No	Low	Urban Area - low and turbulent wind; Visual impact	Encouraged for large scale developments	Yes	~1 year	FiT	No	Wind speeds in area insufficient
Hydro Power	No	Medium	Requires suitable water resource; Visual impact	None	Low	~1 year	FiT	No	Renewable targets already met

RHI - Renewable Heat Incentive
FiT - Feed in Tariff

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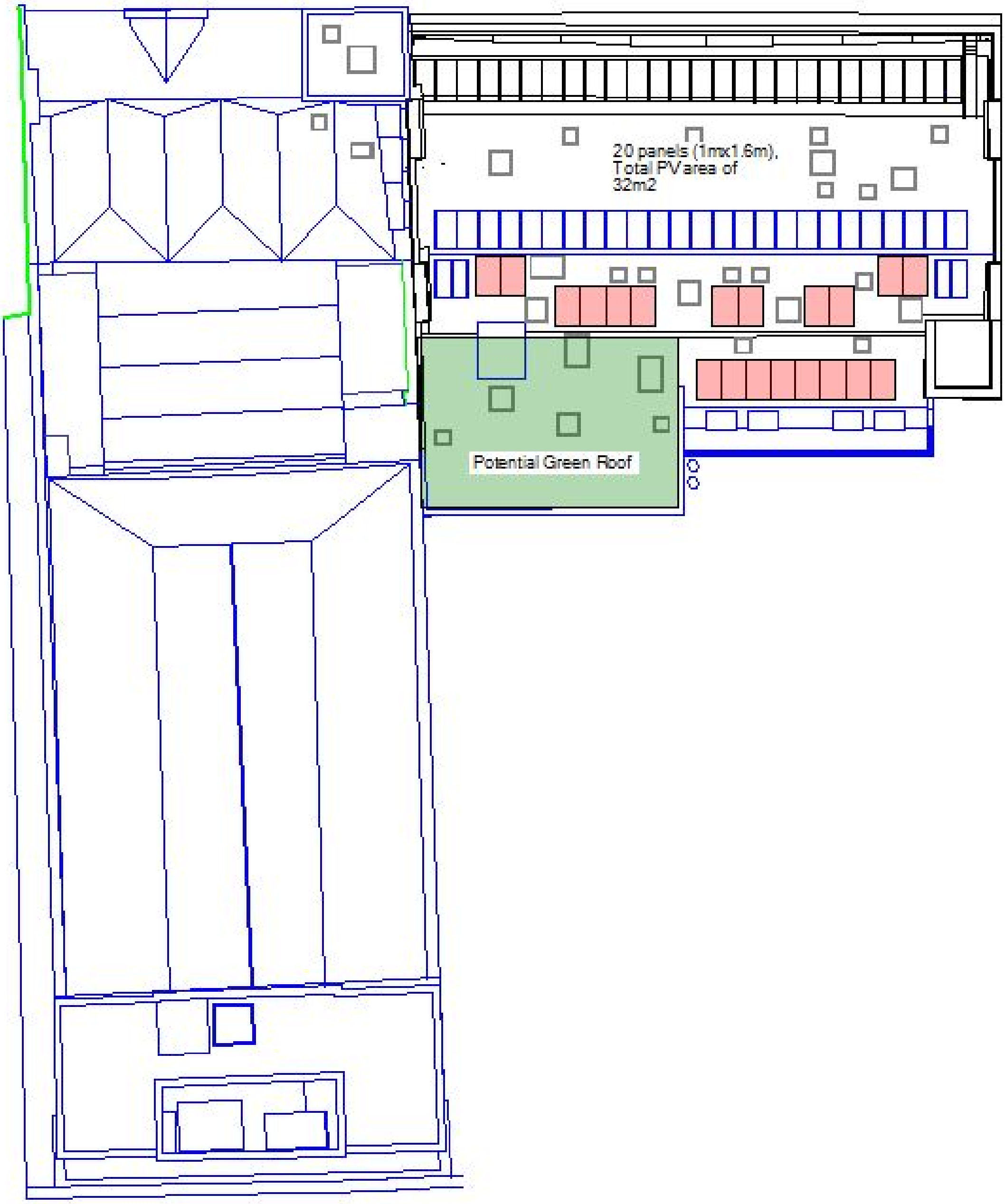
Appendix E:
Roof Layout


20 panels (1mx1.6m),
Total PV area of
32m2
Potential Green Roof