RUGBY FOOTBALL UNION

Energy Statement

Twickenham Stadium – East Stand Extension

October 2016 rev 9

Twickenham East Stand Redevelopment
Energy Statement

Issue and Revision Record

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1 EXECUTIVE SUMMARY

M-E Engineers have been engaged to develop an energy strategy in support of the extension of the east stand at Twickenham Stadium.

This energy assessment for the proposed redevelopment of the East Stand is written in response to the London Borough of Richmond upon Thames planning policy, and the more recent framework of the Greater London Authority (GLA) London Plan (March 2015), policy 5.2.

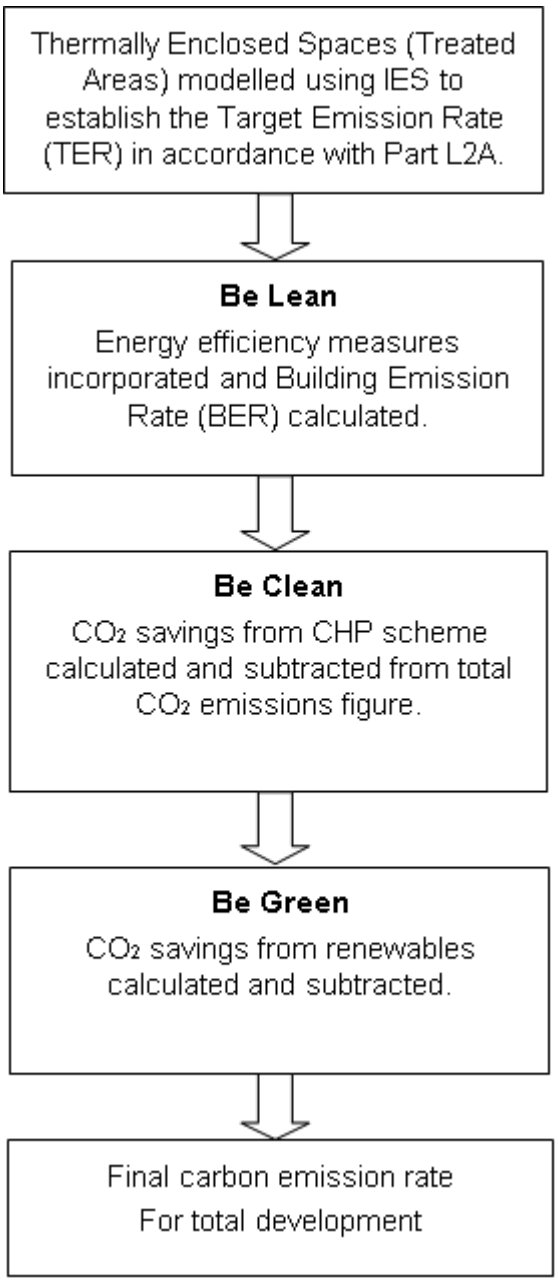
In addition to energy efficiency measures, this document demonstrates that the additional provision of a Combined Heat and Power (CHP) system and a proposed PV array, provide an increased carbon emissions reduction compared to energy efficiency and passive measures alone.

Energy Efficiency and renewable energy technologies have been evaluated for this scheme, and their feasibility for incorporation into the scheme has been assessed.

A dynamic energy simulation has been undertaken to establish the energy consumption and carbon emissions of the proposed building. The building was broken down into Thermally Enclosed Spaces, and Non-Thermally Enclosed Spaces, where only the thermally enclosed spaces have been assessed.

- Thermally Enclosed Spaces: These are spaces within the building that are inside the thermal line, and which will be conditioned. These spaces will have a regulated energy consumption for Heating, Cooling, Hot Water, Lighting and Auxiliary Energy.

1.1 Calculation Methodology



1.2 Be Lean

1.2.1 Passive & Active Energy Solutions

The following summarises the various energy efficiency measures used to reduce the buildings inherent energy consumption and associated CO2 emissions.

- The building envelope U Values have been where possible, improved upon the Part L limiting values when an area weighting is considered. The following U-Values are an average calculated across all the Thermally Enclosed spaces.

Element	Part L2A U-value Limiting Standards (Area Weighted Average)	Average U-values Proposed for Thermally Enclosed Spaces Only
Roof	0.25W/m^{2}K	0.18 W/m^{2}K
Walls	0.35W/m^{2}K	0.26 W/m^{2}K
Floor	0.25W/m^{2}K	0.22 W/m^{2}K
Glazing	2.2W/m^{2}K	1.6 W/m^{2}K

- Improved building air tightness of 4m^3/hr is proposed for thermally enclosed spaces.
- Low energy lighting.
- Automated lighting control systems.
- High efficiency boilers.
- Heat recovery on mechanical ventilation systems.
- High efficiency motors with variable speed drives for pumps and fans.
- Power factor correction on incoming electrical supplies.
- Building energy management system with monitoring and energy targeting software

1.3 Be Clean

1.3.1 District Heating

Currently, there is no local district heating system which can be utilised by the proposed development.

In order to allow for future inclusion into a community-heating network should one become available, the on-site central heating systems will be provided with future connection points.

1.3.2 Combined Heat and Power

A feasibility study has been carried out to determine the Buildings suitability for a Combined Heat and Power (CHP).

To ensure that all the energy generated will be utilized the base heating load of the development has been taken as the criteria for sizing a CHP system. It is no believed that a sufficient base load exists within the east stand alone, and therefore a CHP system exporting to the hotel and gym facility in the adjacent south stand is proposed.

1.4 Be Green

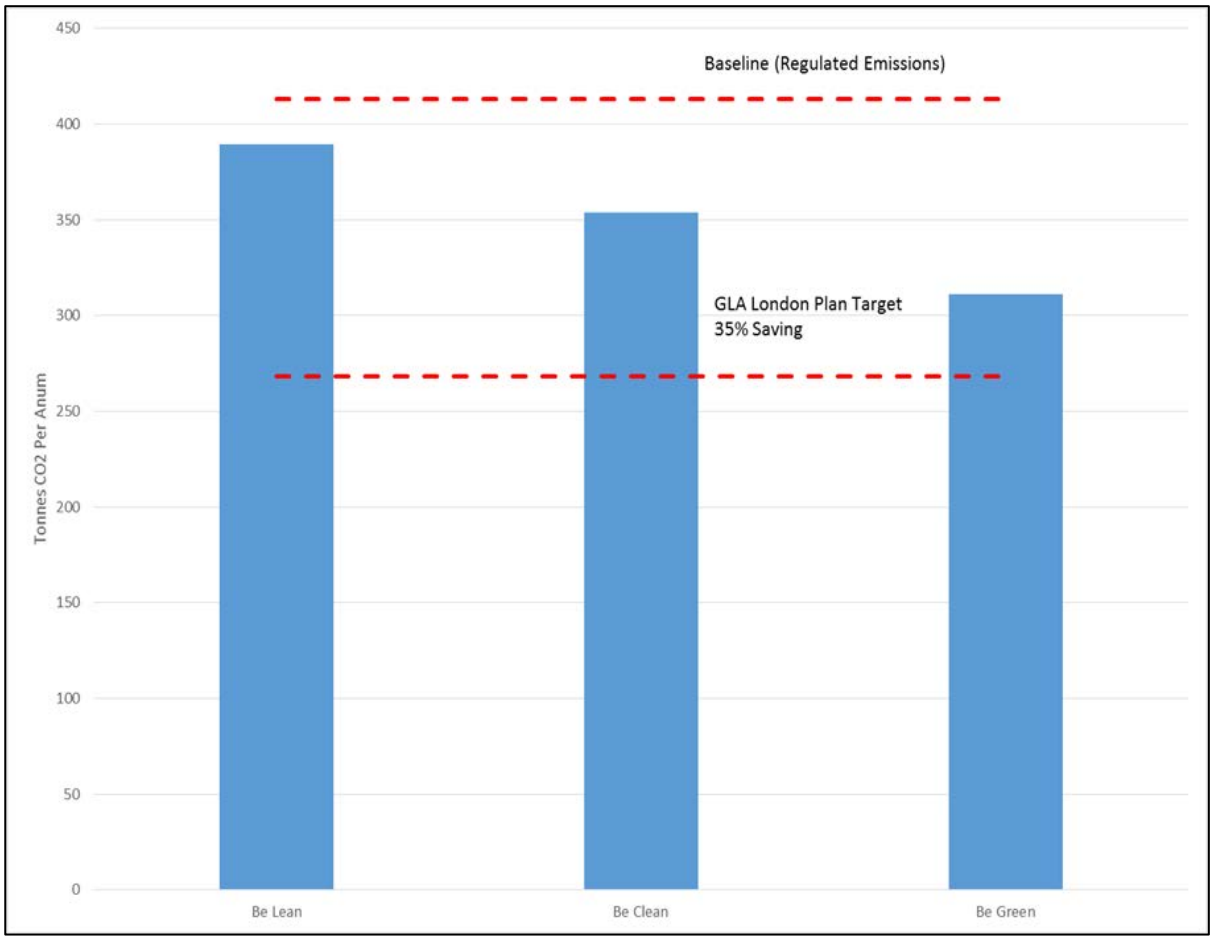
The following table describes the various renewable technologies which have been assessed for inclusion into the development to further reduce CO_2 emissions.

Technology	Comments	Conclusion	Calculated CO_2 Saving ($kgCO_2$/year)
Photovoltaic Panels	Although there is no suitable unshaded south facing roof space on the east stand, a PV system has been considered to be installed on the roof of the south stand, also within the site.	79kW peak system included.	35,760.00
Ground Source Heating and Cooling	Potential Solution (subject to detailed site survey) but conflicts with proposed CHP for heating load. Installation of CHP calculated to achieve the greater CO_2 saving.	Not proposed	N/A
Biomass Heating	Cannot achieve a high renewable target due to installation of CHP. Concerns over future fuel supplies, exhaust flus are problematic, requires additional plant area and has the burden of a high maintenance cost, not considered suitable.	Not proposed	N/A
Solar Hot Water	Solar thermal is not a feasible option for the development due to shading of roof space and would compete for the same hot water/heating load as the CHP.	Not proposed	N/A
Wind	Wind turbines are not thought to be a feasible option. The issues surrounding the use of wind turbines range from noise, to unsuitable (turbulent) wind conditions, and the scale of wind turbine required to get to a high enough point at which they would be favourable	Not suitable.	N/A
Hydrogen Fuel Cell	Only a renewable if run on hydrogen which is as yet not considered commercially viable. Many current installations are running on natural gas.	Not suitable.	N/A

1.5 Summary of Carbon Emissions

	Carbon Dioxide Emissions (Tonnes CO2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	413.08	272.21
After energy demand reduction – Be Lean	389.55	272.21
After CHP – Be Clean	353.80	272.21
After Renewables – Be Green	318.04	272.21

The total reductions in regulated carbon emissions for the stadium amount to 23.01% over baseline emissions rates.



2 INTRODUCTION

2.1 General Information

This energy assessment document has been written to satisfy the requirement of the Greater London Authority's London Plan (March 2015), Policy 5.2 – C which states:

'*Major development proposals should include a detailed energy assessment to demonstrate how the minimum targets for carbon dioxide emissions reduction outlined… are to be met within the framework of the energy hierarchy*'.

As required by Policy 5.2 the following sections are included within this energy assessment:

a) Calculation of the energy demand and carbon dioxide emissions covered by the Building Regulations and, separately, the energy demand and carbon dioxide emissions from any other part of the development, including plant or equipment, that are not covered by the Building Regulations (see paragraph 5.22) at each stage of the energy hierarchy.

b) Proposals to reduce carbon dioxide emissions through the energy efficient design of the site, buildings and services.

c) Proposals to further reduce carbon dioxide emissions through the use of decentralised energy where feasible, such as district heating and cooling and combined heat and power (CHP).

d) Proposals to further reduce carbon dioxide emissions through the use of on-site renewable energy technologies.

2.2 Development Description

The development comprises an extension and refurbishment of the existing East Stand which will be used as additional hospitality space comprising dining and bar areas together with associated kitchen and WC's.

The East Stand will be refurbished, and will include upgrades to its infrastructure, that will improve the overall performance of the building and reduce associated energy consumption relating to the running of the building.

3 POLICY CONTEXT

3.1 National Planning Policy Framework

The energy statement has been structured with the relevant policies of the National Planning Policy Framework (NPPF) in mind. This policy outlines how developments should be planned to reduce carbon emissions and protect the environment.

3.2 GLA London Plan (March 2015)

The GLA (Greater London Authority) sets out in the London plan the various policies relating to sustainable development. The design team acknowledges the requirements which are set out within the various policies within the GLA document, and through exploring the various sustainable design options as set out in this section, will aim to meet those targets wherever viable, and technically possible.

In addition to all other relevant policies, the design team will pay particular attention to the following:

3.2.1 Policy 5.2 Minimising Carbon Dioxide Emissions

Policy 5.2 requires that for both residential and non-domestic buildings a 40% reduction in CO2 emissions is demonstrated, benchmarked against the 2010 Building Regulations target emissions rate. Since the publication of the London Plan 2011 the GLA Guidance on Preparing Energy Assessments (April 2015) has revised the target for both residential and non-domestic buildings to 35% below the Building Regulations 2013 target emission rate.

This energy assessment demonstrates how the GLA 2015 targets for carbon emissions reductions will potentially be achieved. This will be within the framework of the energy hierarchy:

1. Be Lean – Use less energy
2. Be Clean – Supply energy efficiently
3. Be Green – Use renewable energy

3.2.2 Renewable Energy

In line with policy 5.2, the development will, subject to feasibility provide a reduction in expected carbon dioxide emissions through the use of on-site renewables energy generation.

3.3 London Borough of Richmond upon Thames Core Strategy

The design team acknowledges the requirements of London Borough of Richmond upon Thames core strategy, and the development proposals will reflect the following sustainability policies where relevant to the building services design.

3.3.1 CP1 Sustainable Development

This policy seeks to ‘maximise the effective use of resources’ including energy, and reduce the associated environmental impacts. This includes achieving standards under the BREEAM scheme. The MEP design will take these requirements into account, and therefore support achieving the required environmental standards.

3.3.2 CP2 Reducing Carbon Emissions

This policy seeks to minimise carbon emissions through requiring developments to utilise means of energy reduction, and therefore reduce carbon emissions. In addition to the London Plan, the policy stipulates that the development:

1. Evaluate, develop and use decentralised energy, where appropriate, and
2. Achieve a reduction in CO2 emissions of 20% through on-site renewable energy generation.

3.4 London Borough of Richmond upon Thames Development Management Plan

In addition to the core strategy and London plan, the design team proposals will employ sustainable design, and energy efficiency practices to ensure compliance with the following policies:

3.4.1 DM SD1 Sustainable Construction

This policy requires that the development will include measures designed to mitigate the effects of, and enable the adaptation to climate change. The policy also stipulates that developments should meet 'Zero Carbon' Standards.

3.4.2 DM SD2 Renewable Energy and Decentralised Energy Networks

The development will look to comply with this policy through implementing, subject to a feasibility assessment, on site renewables and decentralised energy systems where possible. In line with this policy, the design will incorporate provision for connection to decentralised energy networks should an existing one not yet be feasible to connect to.

3.4.3 DM SD3 Retrofitting

This policy requires that all retrofitting and refurbishment elements of the development ensure that high standards of energy efficiency are maintained throughout. The development refurbishment elements will be designed in line with this policy.

4 DYNAMIC ENERGY MODELLING

4.1 Model

The east stand was modelled to establish baseline regulated emissions using the IES VE software suite.

Thermally Enclosed Spaces are spaces within the building that are inside the thermal line, and which will be conditioned. These spaces will have an associated regulated energy consumption in regards to:

- Heating
- Cooling
- Auxiliary Power
- Lighting
- Hot Water

The Model was further subdivided into Existing areas (to be refurbished), and New Build areas. This is presented in the figure below:

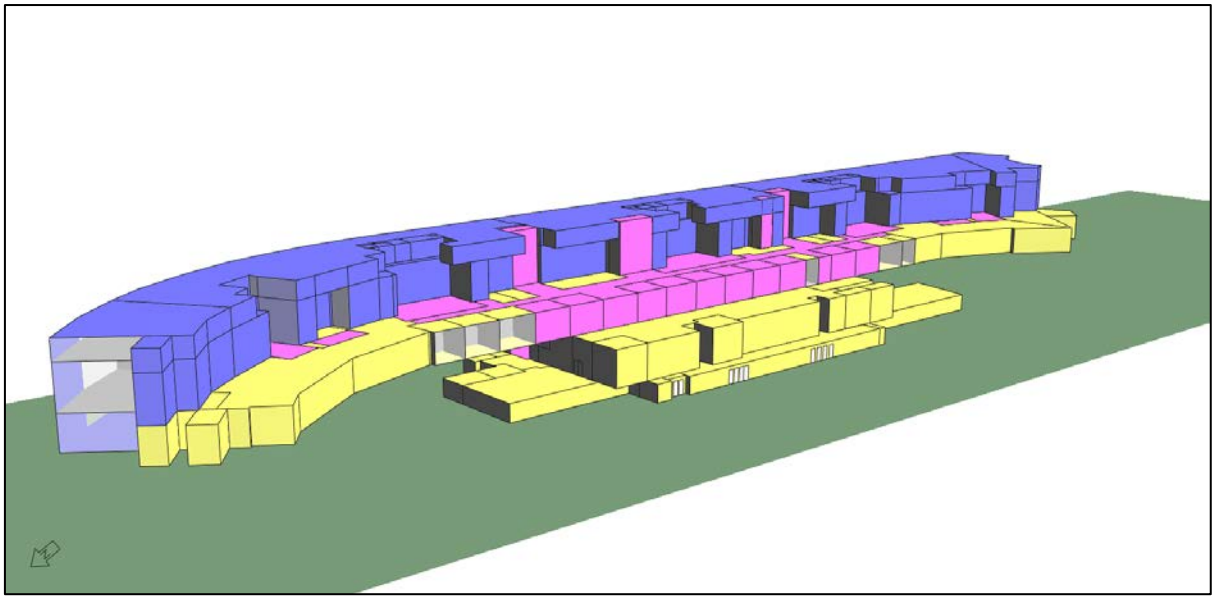


Figure 1 IES Model of Thermally enclosed Spaces

The figure illustrates how the building has been subdivided as follows:

- Blue zones represent the New Build Areas,
- Yellow zones represent the existing building to be refurbished,
- Purple zones consist of existing rooms that will not be altered, lift shafts and stair cores that do not need to be included within the assessment.

4.2 National Calculation Methodology

National Calculation Methodology (NCM) profiles have been applied to the appropriate zones of the model as required.

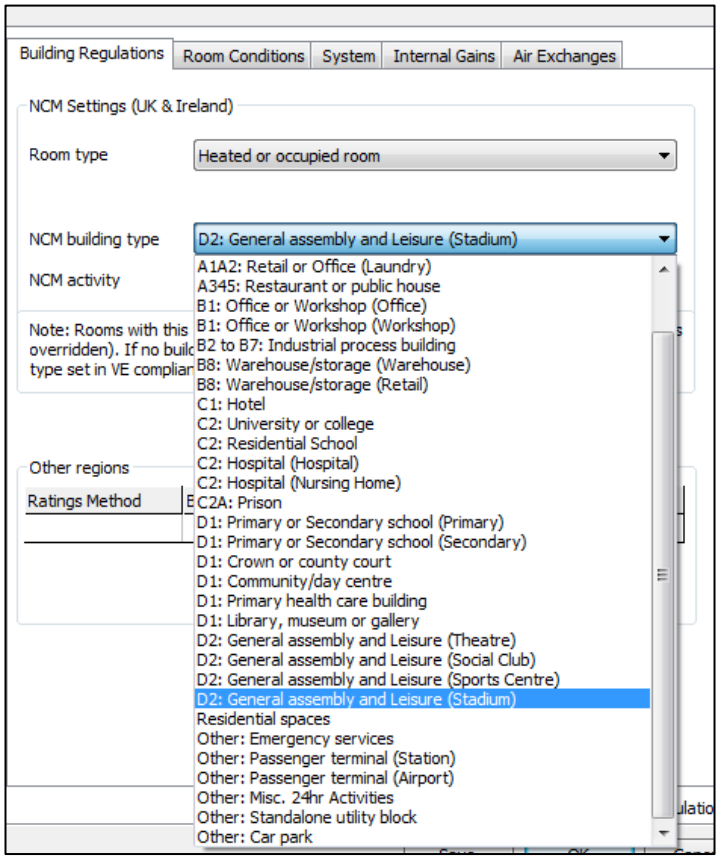


Figure 2 Classification of Building for purposes of Energy Assessment

The class use that has been chosen for the redevelopment of the East Stand at Twickenham stadium as the most appropriate for the NCM energy assessment is “D2: General assembly and Leisure (Stadium)”, as shown in figure 2 above.

The NCM profiles assigned to each of the zones within the building, have been sub categorised into the following uses where appropriate:

- NCM D2St: Circulation area (Stadium)
- NCM D2St: Eating/drinking area (Stadium)
- NCM D2St: Food preparation area (Stadium)
- NCM D2St: Office (Stadium: Open)
- NCM D2St: Light plant room (Stadium)
- NCM D2St: Cupboard (Stadium)
- NCM D2St: Toilet (Stadium)

5 SUSTAINABLE DESIGN PROPOSALS TO USE LESS ENERGY 'BE LEAN'

5.1 General

The east stand will look to adopt good sustainable building services solutions, which provide reduced energy input while maintaining appropriate conditions for the staff and occupants in the stadium. The building will be initially designed to achieve the following 'good practice' objectives.

- The adoption of passive measures, such as external shading have been incorporated in the shape and form of the buildings, wherever possible to limit the base CO_2 emissions in line with the 'Be Lean' principle.
- It is proposed to install mechanical and electrical engineering systems that will assist in achieving the lowest possible annual energy input thereby reducing the level of CO_2 emissions.

5.2 Good Practice Measures

The key focus of the detailed designs will be to minimise energy usage first, and then to find the most efficient and economical systems to serve the required purpose. Spaces shall be evaluated to anticipate seasonal internal temperatures based on the load profile of the room prior to making decisions on conditioning level.

5.3 Sustainable Objectives

5.3.1 General

During the detailed design development, close attention will be paid to coordinating and integrating the structure and the occupied areas to:

a) Minimise direct solar gain.

b) Optimising daylight factors in where possible and appropriate.

c) Optimise utilisation of plant and systems.

d) Optimise control and flexibility of the installations.

e) Incorporate appropriate energy recovery systems.

f) Incorporation of CHP plant

In addition, the environmental services proposals will be designed using the latest techniques for 'active and passive' energy recovery and conservation, to enable the most advantageous, cost effective 'energy targets' possible to be achieved.

The following sections describe the good practice elements to be reviewed and incorporated where suitable with the renewable elements identified and covered in detail in a later section of this report.

5.3.2 Passive Energy Solutions

Among the passive design aspects of the east stand, the thermal performance will be improved beyond the limitation of the building regulations, to minimise heat losses in winter and heat gains in summer.

The table below indicates the U-Values that are being proposed for the east stand.

Element	Part L2A U-value Limiting Standards (Area Weighted Average)	Average U-values Proposed for Thermally Enclosed Spaces Only
Roof	0.25W/m^{2}K	0.18 W/m^{2}K
Walls	0.35W/m^{2}K	0.25 W/m^{2}K
Floor	0.25W/m^{2}K	0.18 W/m^{2}K
Glazing	2.2W/m^{2}K	1.60 W/m^{2}K

The limit for the design air permeability is 10m3/hr/m2 at 50 Pa in accordance with current Building Regulations, however, for this development, improved air tightness is to be achieved for the new construction elements as follows for the thermally enclosed spaces.

3m^3/hr/m2 at 50Pa for the Thermally Enclosed Spaces

5.3.3 Zoning

It is anticipated that the engineering services installation will be suitably zoned, both at a macro level for the whole site and micro level for the individual areas.

Heating, ventilation, water services and electrical zoning shall be configured to promote the maximum flexibility in order to enable remodelling and re-planning to be undertaken at a future date.

To control and monitor energy consumption it is envisaged that provision for sub-metering of all major services to each zone will be required and that this shall be interfaced with the site building management systems.

5.3.4 Variable Speed Drives

The use of frequency inverter variable speed drives is proposed for all major pump sets and ventilation fans. For primary heating and chilled water distribution systems the variable speed circulation pumps are to be used in association with two-port control valves.

The use of variable speed drives will also remove the use of belt drive pumps.

5.3.5 Plant Sizing

All the central plant including air handling units, boilers and chiller units will be selected so that they correctly reflect the required loadings for the building. Over sizing of fans will be avoided, unless they are provided with inverter drives for variable duty operation or to assist in the testing and commissioning process of the plant and system.

5.3.6 Heating Systems

The heating for the development is provided by CHP generation paralleled with natural gas boilers for peak load and standby. The CO2 emission savings through implementation of the proposed CHP scheme is considered elsewhere within this report.

The heating system will incorporate zonal pumping arrangements with run and standby facilities as appropriate, with compensated variable temperature heating circuits to supply the terminal heaters.

5.3.7 Day lighting

The design of the buildings will seek to maximise daylight where possible and appropriate, while limiting direct solar gains and mitigating the risk of overheating through specification of solar control glazing and provision of shading where feasible and appropriate. Although daylight in some areas may be slightly affected by any potential solar shading, the reduction in cooling demand for internal spaces outweighs the requirement for supplementary artificial lighting. Daylight dimming will be utilised to further reduce the amount of associated energy consumption for the lighting installation.

5.3.8 Lighting Installation

The lighting installation throughout the stadium shall maximise the use of low energy lamps and high efficiency electronic ballast technology wherever possible, and linked to daylight and PIR sensors for dimming and switching.

In addition long life lamps will be incorporated into all aspects of the installation, utilising LED technology whenever the task permits.

The complete lighting installation shall be controlled via separate automatic PLC based control systems. The system generally operates on a pre-set time based programme to minimise the operating hours of all luminaires. The systems provide fully interactive control terminals, which enable the operator to override or amend the programme should the required operational needs the separate areas change.

The lighting throughout the stadium will form a mixture of functional and decorative luminaires.

5.3.9 Ventilation Systems

The mechanical ventilation systems will include where appropriate recirculation system with a free cooling capacity, and heat recovery components such as plate exchangers, thermal wheels, or run around coils.

These facilities will be designed to recover both heating and cooling energy in the winter and summer seasons. The choice of clean or dirty extract systems shall be selected to achieve the most efficient energy recovery option, back into their respective supply air systems.

The use of variable speed drives will be considered on ventilation plant where there is likely to be variations in occupancy levels and the air volume can be controlled by the use of CO_2 or occupancy sensors.

5.3.10 Building Management

The development shall be provided with a Building Energy Management System (BEMS) to fully control, monitor and record the various Mechanical, Electrical and Public Health systems.

The BEMS has full stand-alone intelligent outstation and/or local controllers, linked via main LAN to an operator terminal. The BEMS shall not only control the Mechanical, Electrical and Public Health systems but also fully monitor the energy usage by the installation of local energy monitors. This shall be linked to software so that the building manager can record energy usage and identify where improvement to energy consumption can be made.

6 ANNUAL ENERGY CONSUMPTION AND CO_2 EMISSIONS

This section describes the computational modelling process used to establish the baseline CO2 emissions from which any improvements are measured and to then calculate the resulting CO2 emissions once the 'Be Lean' enhancements are implemented.

6.1 Design Standards used in Energy Model

The table below sets out the design criteria used for the stadium energy model to establish the 'baseline' emissions.

System Description	Proposed
Boiler Seasonal Efficiency	88%
Cooling Plant System Seasonal Energy Efficiency Ratio (SSEER)	2.8
Fan Coil Unit (Specific Fan Power)	0.5 W/l/s
Heat Recovery Efficiency	0.7
Building Air Permeability @ 50 Pa	3 $m^3/(m^2.hr)$

6.2 Fuel Loads and CO_2 Emissions

Conversion factors for calculating carbon dioxide emissions are shown in the table below, these are the factors used in calculating compliance with Part L of UK Building Regulations 2013.

	CO_2 Emissions (kg/kWh)
Natural Gas	0.216
Grid Supplied Electricity	0.519

6.3 Development Total Calculated Energy Emissions:

Areas:	Treated Floor Area (m^2)	Carbon Emissions ($kgCO_2/m^2.year$)				Reduction
		TER	TER Annual CO_2 Emissions (tonnes)	BER	BER Annual CO_2 Emissions (Tonnes)	
Thermally Enclosed Areas	9409.5	43.9	413.08	41.4	389.55	5.69%

7 FEASIBILITY ASSESSMENT OF CHP AND DISTRICT HEATING 'BE CLEAN'

7.1 District Heating

The London heat map shows there are no existing heating or cooling networks close to the stadium site.

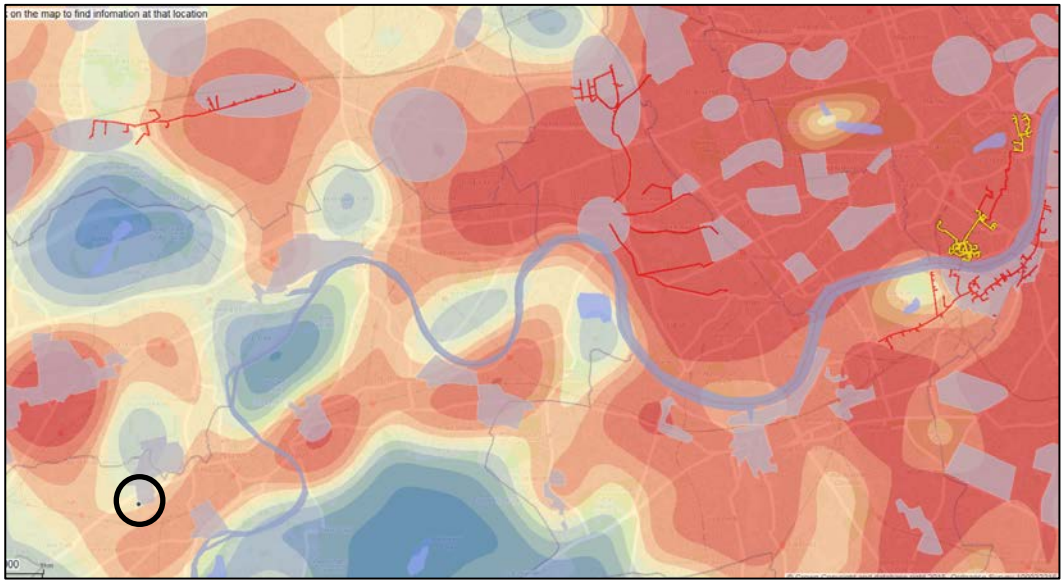


Figure 3 London Heat map indicating the location of the stadium

7.2 Combined Heat and Power (CHP)

A combined heat and power (CHP) generator suitable for this type of application typically comprises a natural gas fuelled generator coupled directly to the buildings electrical distribution system with heat exchangers to recover heat from the cooling system, exhaust gasses and sometimes the engines lubricating oil.

CHP plant can reduce the yearly CO2 emissions, by providing improved efficiencies as a result of utilising the waste heat from the electrical generation engine. These systems can result in efficiencies of up to 85/90% under ideal operating conditions. It is necessary to have a fairly constant electrical and heating demand throughout the year. The CHP systems are sized on either the base electrical or the heating load.

Heat is recovered at 70 to 90°C, depending on the manufacturer's specification, and may be used for the buildings space heating and generation of domestic hot water.

For gas spark ignition engines the recoverable heat to power ratio is in the region of 1.2:1 with a total efficiency of approximately 80 to 90%.

So that the capital investment is viable the aim is to size the CHP plant to run for the maximum number of hours at or near maximum electrical rating with as much of the available heat being utilised as possible.

CIBSE gives a rule of thumb that a CHP generator should run for a minimum of 4000 hours per year whilst recovering all waste heat to be considered viable. The simplest way to guarantee this is to size the CHP generator, based on its recoverable heat output, to meet the base heating load of the building. The base heating load is defined as the minimum constant load that can be expected throughout the year during the operation hours of the building, in many cases amounts to the domestic hot water load.

7.2.1 Sizing the CHP

The stadium itself is unlikely to have a reliable or continuous base load that is high enough to warrant a CHP to be installed for the stadium only. Therefore, it is proposed that the CHP be connected via heat exchangers to the adjacent hotel and gym facilities in the south stand.

For this initial assessment it is considered that the CHP generator should run for a minimum of 5,110 hour/year to prove feasible. This is based on a 14 hour day. As the detailed design develops a more in depth analysis of the daily CHP plant operation will be carried out, this may impact on the actual CHP capacity selected.

Based on an assumed load of the hotel and gym, a provisional CHP size of 79kWt has been considered for this assessment. The final size of the CHP would be subject to future load monitoring. The allocation of thermal energy which the size of the CHP is based on is presented in the table below.

Allocation	Energy Share
156 Room Hotel	45 kW Thermal
Swimming pool and associated energy requirements	8 kW Thermal
Virgin Gym	10 kW Thermal
East Stand (HWS, System and Distribution Losses)	16 kW Thermal

A CHP engine with the following inputs was then applied to the model, and rerun to determine the contribution of the CHP to the Carbon Emissions reductions that can be expected.

Efficiencies	
CHP Efficiency	90%
CHP Outputs	
kW Electric	50
kW Thermal	79

The following table incorporates this saving into the carbon emissions calculations for the stadium.

Areas:	Treated Floor Area (m^2)	Carbon Emissions ($kgCO_2/m^2.year$)				Reduction
		TER	TER Annual CO2 Emissions (tonnes)	BER	BER Annual CO2 Emissions (Tonnes)	
Thermally Enclosed Areas – Be Lean	9409.5	43.9	413.08	41.3	389.55	5.69%
CHP Contribution					-35.76	
Totals After CHP	9409.5	43.9	413.08	37.6	**353.8**	**14.38%**

The CHP will comply with the emission limits set out by the IAQM/EPUK and the Mayor of London's sustainable Design and Construction Supplementary Planning Guidance. For further information please refer to the Air Quality Assessment.

8 ASSESSMENT OF SUITABLE RENEWABLE ENERGY TECHNOCLOGIES 'BE GREEN'

This section analyses potential onsite renewable energy generation and considers their technical feasibility.

8.1 Renewable energy Systems

The following technologies are considered as possible renewable energy sources.

- Photovoltaic Panels
- Ground Source Heat Pump
- Solar Thermal, Hot water Generation
- Biomass Boilers
- Wind
- Hydrogen Fuel Cell

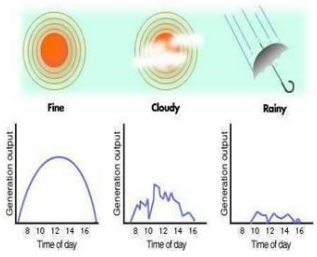
8.2 Photovoltaic Panels

Photovoltaic (PV) modules convert solar radiation into DC electricity. The PV modules are made up of several PV cells consisting of a thin layer of semiconductor material such as silicon. A semiconductor consists of two layers referred to as p-type and n-type. A flow of electrons is created between these two layers through the absorption of solar radiation, this flow of electrons produces a DC current.

The majority of PV panels are made from silicon based materials and are categorised as crystalline silicon cells of thin film cells.

Crystalline cells are available as monocrystalline or polycrystalline; monocrystalline cells have a solar energy to electricity conversion efficiency of 15-18% whilst polycrystalline cells are typically 13-16% efficient.

Photovoltaic panels should be mounted facing between southeast and southwest at an ideal angle of between 30° and 40°. Architectural and planning constraints will limit the amount of area available for such an array.



The area of photovoltaic cells required is dependent on the efficiency of the type cells used, at present there are a number of varying operating efficiencies available, which directly affects the area coverage required to give the same output (1kWp).

Photovoltaic panels should be mounted facing between south-east and south-west at an ideal angle of between 30° and 40°. Architectural and planning constraints will limit the amount of area available for such an array.

A lack of sufficient unshaded south facing roof area on the east stand has led to a 79kWp system to be considered for on roof space on the south stand of the stadium. The following table sets out the contribution of PV's to the reduction of Carbon emissions.

The total PV System size proposed is 490m^2. This is equivalent to 79kW peak. Based upon a floor area pro-rata approximation, the total area of the east stand is around 21% of the total stadium.

For this reason the PV Contribution to the east stand has been pro-rated based on the percentage of floor area. The output CO2 emissions from this calculation has been used to approximate the total CO2 Reduction for the overall system as follows.

Area	Percentage	Emissions Reduction
East Stand:	21%	**7.51* Tonnes CO_2 (Pro-Rated)**
Remainder of stadium	79%	**28.25* Tonnes CO_2 (Pro-Rated)**
Total	100%	**35.76 Tonnes CO_2 (Calculated)**

Areas:	Treated Floor Area (m^2)	Carbon Emissions ($kgCO_2/m^2$.year)				Reduction
		TER	TER Annual CO2 Emissions (tonnes)	BER	BER Annual CO2 Emissions (Tonnes)	
Thermally Enclosed Areas – Be Lean	9409.5	43.9	413.08	41.3	389.55	5.69%
CHP Contribution					-35.76	
Totals After CHP	9409.5	43.9	413.08	37.6	353.8	14.38%
PV Contribution					-35.76	
Totals After PV Contribution	9409.5	43.9	413.08	33.8	**318.04**	**23.01%**

*Based on Pro-Rated Calculation

8.3 Solar Thermal, Hot Water Generation

The use of solar heating for hot water generation would require the installation of solar panels at roof level. Ideally the panels should be aligned in a southerly direction with a tilt of between 30° and 40°. Practical and planning constraints will limit the amount of roof area available for such an array.



Solar thermal panels will also require to be mounted in areas that are unshaded. The potential therefore of incorporating solar thermal is limited for the same reasons as those discussed in the PV section.

There is also no benefit in using solar heating for this development as the proposed CHP system shall provide hot water heating throughout the year and the installation of solar panels will mean that both systems shall be competing for the same load.

8.4 Biomass Boilers

Biomass technology could be installed as part of the central heating provision. The most economical option and the best for reducing CO2 emission levels would normally be to install Biomass Boilers to act as the lead boiler to cater for the base hot water heating load with the remaining gas fuelled boilers sized to meet the total heating load and to form a standby facility.

The Bio-energy boiler system will require the installation of additional components for the storage of the wood chips or pellets used as fuel, along with the necessary transportation components to link between the storage hoppers and the boiler.

Wood chips or pellets would need to be stored in external or internal hoppers. The amount of wood chips or pellets stored will affect the choice of the silo or bunker storage types. Storage systems require sufficient space for large delivery vehicle to ‘shoot’ the wood fuel directly into the storage facility.

The wood chips or pellets are transferred from the storage facility by screw or similar transportation system linking between the wood hoppers and the boiler house.


The waste combustion products from the boilers (in the form of ash) can either be removed manually or automatically by the use of screw feed units direct to a collection skip. This plant ash is an inert ash and can be used as fertiliser assuming that the wood is obtained from clean sources (i.e. non industrial and not contaminated with plastics). The use of automatic removal of the plant ash will reduce maintenance costs but increase the initial capital installation costs.

Wood burning boilers have comparable combustion efficiencies as basic gas fired systems. The fluing requirements for modern wood fired boilers are comparable with those of gas fired systems and the emissions are similar to that of gas fired units. Where the heat output to water is above 300kW (400kW input) there is a requirement under the clean air regulations when using waste wood to install continuous flue monitoring of the waste gas products. These systems are relatively expensive to install and maintain.

Biomass Boilers can also operate on a modulating basis to vary the heat output. Boilers can operate as low as 30% of their maximum load they do, however require additional plant room area then the standard models.

The installation of Biomass Boiler with pellet storage as the main heating boiler is not usually a viable option when CHP plant is proposed, as the majority of the base heating would be provided by CHP. Biomass boilers also cause other issues such as fuel storage, which need to be maintained in a dry storage area. With space being at a high premium in the proposed stadium, it is not anticipated that biomass fuel store will be a provision that is easy to make.

Biomass boilers will require the associated flues to terminate above the highest point of the building presenting obvious issues in this high rise development. This will mean that the architectural character of the building will be fundamentally changed to these flu requirements.

Biomass is therefore discounted as a feasible and viable option for the stadium.

8.5 Ground Source Heat Pump

Ground source systems provide the opportunity to obtain both heating and cooling via water to water or water to refrigerant heat pumps. This technology can reduce the demand for conventional energy and thus reduce overall CO2 emissions. They do however have limited effect in reducing CO2 emission levels compared to the other renewable energy technologies.

Geothermal technology can be utilised virtually anywhere in the UK and be installed under landscape areas and car parks. A more efficient and less expensive option is to utilise a nearby body of water for heat extraction/rejection.

Geothermal systems provide the opportunity to connect to water-to-water heat pump units for heat rejection and to VRF heat pump units for cooling and heating.

VRF system heat pumps using inverter controls on the compressors can provide improved energy efficient operation, where the heating and cooling input are mixed so that the actual load is limited to the resultant difference thereby further reducing the energy input.

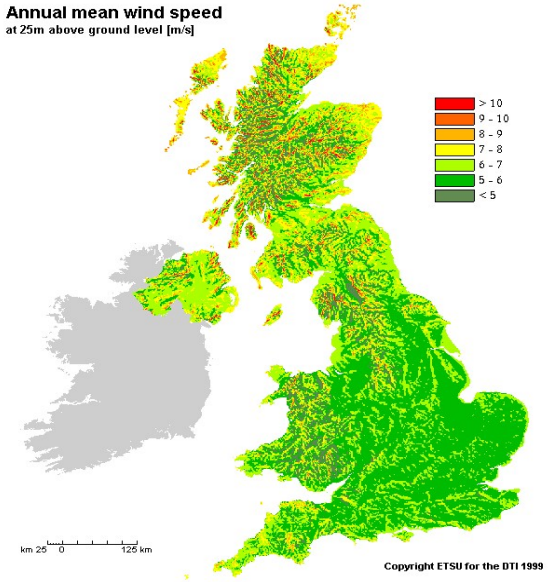
Because the site footprint for this development is limited a solution of directionally drilled boreholes has been considered as the only viable option. However, the drilling of boreholes and installation of the system would create disruption to programme, and come at a very high cost for a relatively low gain.

Additionally, installing a ground source system will require approval from the environment agency to pump heat in and out of the ground. As a large system would be required for the stadium, it is not known how the ground conditions will react to such a large system, and there are risks associated with ecology that will affect the size of system that will be possible.

It has been concluded that a GSHP is not viable due to constrained site, ecological implications and conflict with CHP for base heating load.

8.6 Wind Power.

To evaluate the suitability for wind power generation it is necessary to undertake a full survey and analysis for the site, to ascertain the likely wind speeds available on the site to support the viability of wind generation.



British Wind Energy Association (BWEA) wind data base suggests that wind speed at the site would be around 4-6m/s at 25m could support small wind turbine, however, annual load generation will be relatively low.

Installation of wind turbines would certainly impact negatively on the architectural character of the stadium. This issue aside, wind turbines can have a detrimental effect on telecommunications in the vicinity of their location. Given the extent of telecommunication that would be installed in the stadium (Wifi, Mobile phone operators, TV broadcasting, etc.), the size of possible turbines is limited for this reason.

Another limiting factor in the installation of wind turbines would be location of the site in an urban area. Wind patterns in urban areas can be very turbulent, and are not the best conditions to yield a good output from small scale wind turbines.

In addition, planning requirements from the local authority regarding potential noise from the wind generators would have to be considered. It is likely that during the day sound levels would not be noticeable but at night with lower background levels this could be invasive to the buildings particularly for the residential blocks.

Other important considerations, would be the potential impact on wild birds.

It would therefore be reasonable to conclude that based on the above information, even without a technical review the installation costs, the requirements for maintenance and the installation restraints are unlikely to support the installation of electrical wind generation for this development.

8.7 Hydrogen Fuel Cells

Hydrogen fuel cells have been considered for use within the hotel and serviced apartment building but have been discounted due to the current lack of a commercially viable source of hydrogen. Many current installations are known to be running on natural gas until the hydrogen becomes available.

There is currently no commercially available fuel cell technology in Europe.

9 OVERHEATING RISK ASSESSMENT

In accordance with the new greater London Authority guidance, an overheating risk assessment has been carried out for the proposed development.

9.1 TM52

The risk of overheating is determined through a TM52 assessment. A space is considered to have no risk of overheating where at least two of the criteria are met.

Criteria 1: Hours of Exceedance

The number of hours that the actual operative temperature in any given occupied zones one degree (K) or more above the limiting (maximum) temperature shall not occur for more than 3 percent of occupied hours, for the period 1st May to 30th September.

Criteria 2: Daily Weighted Exceedance

The weighted Exceedance shall be less than or equal to 6 in any given day.

Criteria 3: Upper Limit Temperature

To set an absolute maximum value for the indoor operative temperature, the operative temperature shall never be greater than 4 degrees (k) above the maximum acceptable temperature.

9.2 Cooling Hierarchy

9.2.1 Passive Design

In order to minimise unwanted heat gain and manage heat, various passive design solutions have been included.

- Insulation: Utilising in the new building where possible, and upgrading existing façade details where possible, to achieve better than Building Regulation Benchmark thermal performances, mean that fabric heat gains in the summer will be mitigated against.
- Air Tightness: Although in a stadium, air tightness is not an easy thing to achieve, the building is targeting an average APR of $3m^3/m^2h$, thus reducing the amount of heat gain through infiltration.
- Thermal Mass: The existing structure currently has high levels of thermal mass due to the concrete construction. This will, where possible and where it will not compromise the thermal performance of the building fabric, be maintained in order to take advantage of the thermal mass and its temperature stabilisation qualities.
- Energy Efficient Lighting Equipment: All lighting in the proposed building, both in the new build elements and in the refurbished parts will be LED, and low energy lighting where the task permits.

9.2.2 Passive & Natural Cooling

The building design does not currently allow for natural or passive ventilation to be effectively utilised. The addition of the extension, and the desire to upgrade the thermal performance and air leakage rates of the existing façade, mean that it is not feasible to introduce passive or natural ventilation openings in the conventional way that would provide a cooling effect.

9.2.3 Mixed Mode Cooling

The building does not allow for the use of passive or natural cooling solutions, and therefore a mixed mode cooling solution would not have any passive our natural solutions to supplement. Mixed mode has therefore not been considered.

9.2.4 Full Building Mechanical

Where external conditions permit, outside air will be used to ventilate and cool the spaces without the need to bring the cooling coil on. This will be achieved through automatic controls and monitoring, that will assess whether the external conditions are favourable to allow for natural cooling.

Only where external conditions will not be sufficient to provide cooling to the space will the cooling coils be activated.

9.3 Overheating Risk

The TM52 assessment was carried out for thermally enclosed spaces in accordance with the guidance set out in TM49.

The assessment was carried out within IES VE software, and based on NCM profiles applied to each relevant space.

The TM52 assessment is summarised below:

Total number of Occupied thermally enclosed spaces	92
Number of Spaces Passing TM52	91
Number of Spaces Failing TM52	0
Number of Unoccupied Spaces	1

The full overheating output has been appended to this report in appendix B.

10 USAGE PROFILE REDUCTION

The unique usage of the Stadium and the East Stand is not reflected in the IES Software Modelling and standard usage profile templates prescribed by the National Calculation Methodology (NCM).

The building is only used to full capacity during Major Events and largely unoccupied for the remainder of the time when the environmental conditions are automatically set back by the BMS system to save energy. Only relatively small parts of the building will be in use for other, non-major, events such as conferences and banqueting.

ME Engineers have investigated sensible methods to estimate the equivalent Carbon shortfall when compared to the annual shortfall calculated by the standard NCM compliance methodology.

For the purposes of these calculations, the 2016 and 2017 events schedule has been utilised to form the basis of usage.

Although the majority of Major Events will not result in full utilisation of the proposed hospitality areas in the East Stand (for example, hospitality usage for a concert is likely to be low), a conservative 100% utilisation has been assumed for these approximation calculations as not to restrict future usage.

To allow for event build up and wind down, 208 days have been assumed to allow partial occupation at 40% load. This is equivalent to 3 build-up days prior to an event, and 1 wind down day following an event.

For the remainder of the year the building will be mostly unoccupied, except for non-major events, however a conservative 20% utilisation has been assumed in the calculation.

This is consistent with the estimate, used elsewhere in the application, of 90% of non-major event days in the East Stand being attended by fewer than 300 people (see Transport Assessment, Section 5.2).

As this is approximately 5% of the East Stand's c.6,500 capacity, 20% usage allowance throughout the year except Major Event days is therefore robust.

The calculation criteria is summarised as follows:

- 52 major event days per year @ 100% utilisation
- 3 x 52 build-up days before major event + 1 x 52 wind down days after major event days per year @ 40% utilisation
- 261 days per year when building is unoccupied/lightly used for non-major events @ 20% utilisation for plant set back mode.

Pro rata Building occupation and usage:

(52 x 100%) + (208 x 40%) + (261 x 20%)

➔ **52 + 83.2 + 52.2 = 187.4 days**

The total CO2 Shortfall calculated using the NCM methodology is 49.54 tonnes CO2 per year.

The equivalent daily pro rata energy shortfall equates to (49.54 / 365) 0.125 tonnes CO2 per day.

Using the pro rata building occupation and usage of 187.4 days per year, the equivalent shortfall – based upon estimated utilisation **equates to 23.425 Tonnes of CO2 per year**.

11 CONCLUSION

The design solutions for the development will endeavour to maximise the provision of passive energy saving measures before considering any active techniques.

The Principle of 'Be Lean' has continued as the architectural form of the building has developed during this period to achieve as thermally efficient a building as possible without detracting from the architectural character of the stadium. This forms part of the passive design proposals, incorporated to reduce the base energy levels as reflected in the carbon emissions calculated for the stadium.

The east stand has been modelled to assess the energy consumption using a dynamic energy simulation, and from this the carbon emissions for the Thermally Enclosed has been calculated, and aggregated to give an overall stadium wide reduction of 5.69% over part L from 'Be Lean' measures alone.

As part of the 'Be Clean' requirement, a CHP scheme outputting 79kW thermal has been assessed. This provisional size of CHP is envisaged to provide for the base domestic hot water demand of the stadium.

With an overall efficiency of 90% for the CHP unit, and an expected running time of 5,110 hours annually, the calculated saving in carbon emissions due to CHP is 35,760 kg CO_2 per year. Factoring this saving into the 'Be Lean' measures this increases the reduction to 14.35% over part L baseline emissions rates.

Various renewable technologies have been reviewed for inclusion into the redevelopment of the grounds, as part of the London Plan Energy Hierarchy 'Be Green'. Following this review it was concluded that the potential of renewable energy technologies was extremely limited, and in some cases not viable at all.

However, it was considered that a PV installation was feasible on the roof of the adjacent south stand, and a 79kWp system was therefore incorporated. The 'Be Green' measures further reduced the carbon emissions by 35,760 kg CO_2 per year, bringing the reduction to 23.01% over part L baseline emission rates.

The London Plan requires a reduction of 35% of carbon emissions. This means that based on current designs, CHP and PV scheme, the stadium is expected to fall short of this target by 11.99%. This equates to 49,541 kg CO_2 per year.

When taking into account the actual usage profile of the stadium, the actual carbon emissions shortfall equates to 23,425 kg CO_2 per year.

12 APPENDIX A - BRUKL

12.1 BRUKL – Be Lean

12.2 BRUKL – Be Clean

12.3 BRUKL – Be Green

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

16002_Twickenham East Stand_NBE_BELEAN

As designed

Date: Fri Jun 24 16:32:03 2016

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.5

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.5

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	43.9
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	43.9
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	41.4
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 the building services should achieve reasonable overall standards of energy efficiency

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.25	0.25	01000051:Surf[0]
Floor	0.25	0.18	0.18	01000052:Surf[0]
Roof	0.25	0.18	0.18	01000057:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	01000052:Surf[4]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = 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	3

Building services

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

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

1- Main system

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.88	2.8	0	0.5	0.7
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

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

2- Kitchen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.88	-	0.2	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

3- Toilet Extrct

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.88	-	0.2	0	0.7
Standard value	0.91*	N/A	N/A	N/A	0.5
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.

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

Local mechanical ventilation, exhaust, and terminal units

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

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	**Zone**	**Standard**
Level 04 Goods	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Kitchen	-	-	-	-	-	-	-	-	0.4	-	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
Level 04 Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 04 Debenture Bar	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Toilet	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 Debenture Lounge	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Toilet	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 Debenture Lounge	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Toilet	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Goods	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 A Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Super Premium Suite	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Super Premium Bar	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Super Premium Suite	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	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	
Level 04 Goods	90	-	-	36
Level 04 Kitchen	-	90	-	2574
Level 04 Kitchen	-	90	-	2862

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Level 04 Debenture Bar	-	90	-	1526
Level 04 Toilet	-	90	-	166
Level 04 Debenture Lounge	-	90	-	2645
Level 04 Toilet	-	90	-	211
Level 04 Debenture Lounge	-	90	-	2493
Level 04 Toilet	-	90	-	172
Level 04 A Goods	90	-	-	20
Level 04 A Kitchen	-	90	-	2419
Level 04 AToilets	-	90	-	10
Level 04 AToilets	-	90	-	15
Level 04 AToilets	-	90	-	16
Level 04 AToilets	-	90	-	20
Level 04 AToilets	-	90	-	25
Level 04 AToilets	-	90	-	11
Level 04 AToilets	-	90	-	46
Level 04 A Super Premium Suite	-	90	-	1616
Level 04 AToilets	-	90	-	11
Level 04 AToilets	-	90	-	51
Level 04 AToilets	-	90	-	27
Level 04 AToilets	-	90	-	13
Level 04 AToilets	-	90	-	16
Level 04 AToilets	-	90	-	20
Level 04 AToilets	-	90	-	16
Level 04 A Super Premium Bar	-	90	-	1330
Level 04 AToilets	-	90	-	11
Level 04 AToilets	-	90	-	46
Level 04 AToilets	-	90	-	25
Level 04 AToilets	-	90	-	13
Level 04 AToilets	-	90	-	16
Level 04 AToilets	-	90	-	18
Level 04 AToilets	-	90	-	14
Level 04 A Super Premium Suite	-	90	-	1627
Level 04 A Kitchen	-	90	-	2410
Level 03 Premium Hospitality	-	90	-	2688
Level 03 Kitchen	-	90	-	3357
Level 03 Premium Hospitality	-	90	-	2249

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?
Level 04 Goods	N/A	N/A
Level 04 Debenture Bar	YES (+14.2%)	NO
Level 04 Debenture Lounge	NO (-4%)	NO
Level 04 Debenture Lounge	NO (-3.4%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Level 04 A Goods	N/A	N/A
Level 04 A Super Premium Suite	NO (-60.2%)	NO
Level 04 A Super Premium Bar	NO (-56%)	NO
Level 04 A Super Premium Suite	NO (-61.2%)	NO
Level 03 Premium Hospitality	YES (+38.2%)	NO
Level 03 Premium Hospitality	NO (-10.9%)	NO

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

Separate submission

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

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
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]	9409.5	9409.5
External area [m²]	13341.1	13341.1
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	6740.42	5746.04
Average U-value [W/m²K]	0.51	0.43
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
	D1 Non-residential Inst.: Education
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: Crown and County Courts
100	**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	22.77	14.47
Cooling	6.96	3.58
Auxiliary	23.92	34.99
Lighting	2.8	6.8
Hot water	89.89	82.58
Equipment*	55.74	55.74
TOTAL**	**146.33**	**142.43**

* 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]	114.05	93.77
Primary energy* [kWh/m²]	238.23	254.21
Total emissions [kg/m²]	41.4	43.9

* 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] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	69.7	71.7	27.7	8.9	11	0.7	2.25	0.88	2.8
	Notional	53.9	62.2	17.4	4.6	17.7	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	51.4	0	18.2	0	57.9	0.79	0	0.88	0
	Notional	58.5	0	18.9	0	75	0.86	0	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	4.2	0	1.5	0	74.6	0.79	0	0.88	0
	Notional	0.5	0	0.2	0	104.1	0.86	0	----	----

Key to terms

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

Key Features

The BCO can give particular attention to items with specifications that 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	0.25	01000051:Surf[0]
Floor	0.2	0.18	01000052:Surf[0]
Roof	0.15	0.18	01000057:Surf[0]
Windows, roof windows, and rooflights	1.5	1.6	01000052:Surf[4]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	3

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

16002_Twickenham East Stand_NBE_BECLEAN

As designed

Date: Fri Jun 24 16:01:56 2016

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.5

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.5

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	43.9
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	43.9
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	37.6
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.25	0.25	01000051:Surf[0]
Floor	0.25	0.18	0.18	01000052:Surf[0]
Roof	0.25	0.18	0.18	01000057:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	01000052:Surf[4]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = 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	3

Building services

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

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

1- Main system

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.88	2.8	0	0.5	0.7
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

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

2- Kitchen

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.88	-	0.2	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

3- Toilet Extrct

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.88	-	0.2	0	0.7
Standard value	0.91*	N/A	N/A	N/A	0.5
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.

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

1- CHECK2-CHP

	CHPQA quality index	**CHP electrical efficiency**
This building	0	0.35
Standard value	Not provided	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
Level 04 Goods	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 04 Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 04 Debenture Bar	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Toilet	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 Debenture Lounge	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Toilet	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 Debenture Lounge	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 Toilet	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Goods	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 A Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Super Premium Suite	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Super Premium Bar	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.4	-	-	-	-	-	-	N/A
Level 04 A Super Premium Suite	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Kitchen	-	-	-	-	-	-	-	-	0.4	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	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	
Level 04 Goods	90	-	-	36

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Level 04 Kitchen	-	90	-	2574
Level 04 Kitchen	-	90	-	2862
Level 04 Debenture Bar	-	90	-	1526
Level 04 Toilet	-	90	-	166
Level 04 Debenture Lounge	-	90	-	2645
Level 04 Toilet	-	90	-	211
Level 04 Debenture Lounge	-	90	-	2493
Level 04 Toilet	-	90	-	172
Level 04 A Goods	90	-	-	20
Level 04 A Kitchen	-	90	-	2419
Level 04 AToilets	-	90	-	10
Level 04 AToilets	-	90	-	15
Level 04 AToilets	-	90	-	16
Level 04 AToilets	-	90	-	20
Level 04 AToilets	-	90	-	25
Level 04 AToilets	-	90	-	11
Level 04 AToilets	-	90	-	46
Level 04 A Super Premium Suite	-	90	-	1616
Level 04 AToilets	-	90	-	11
Level 04 AToilets	-	90	-	51
Level 04 AToilets	-	90	-	27
Level 04 AToilets	-	90	-	13
Level 04 AToilets	-	90	-	16
Level 04 AToilets	-	90	-	20
Level 04 AToilets	-	90	-	16
Level 04 A Super Premium Bar	-	90	-	1330
Level 04 AToilets	-	90	-	11
Level 04 AToilets	-	90	-	46
Level 04 AToilets	-	90	-	25
Level 04 AToilets	-	90	-	13
Level 04 AToilets	-	90	-	16
Level 04 AToilets	-	90	-	18
Level 04 AToilets	-	90	-	14
Level 04 A Super Premium Suite	-	90	-	1627
Level 04 A Kitchen	-	90	-	2410
Level 03 Premium Hospitality	-	90	-	2688
Level 03 Kitchen	-	90	-	3357
Level 03 Premium Hospitality	-	90	-	2249

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?
Level 04 Goods	N/A	N/A
Level 04 Debenture Bar	YES (+14.2%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Level 04 Debenture Lounge	NO (-4%)	NO
Level 04 Debenture Lounge	NO (-3.4%)	NO
Level 04 A Goods	N/A	N/A
Level 04 A Super Premium Suite	NO (-60.2%)	NO
Level 04 A Super Premium Bar	NO (-56%)	NO
Level 04 A Super Premium Suite	NO (-61.2%)	NO
Level 03 Premium Hospitality	YES (+38.2%)	NO
Level 03 Premium Hospitality	NO (-10.9%)	NO

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

Separate submission

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

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
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]	9409.5	9409.5
External area [m²]	13341.1	13341.1
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	6740.42	5746.04
Average U-value [W/m²K]	0.51	0.43
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
	D1 Non-residential Inst.: Education
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: Crown and County Courts
100	**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	27.29	14.47
Cooling	6.96	3.58
Auxiliary	23.92	34.99
Lighting	2.8	6.8
Hot water	99.95	82.58
Equipment*	55.74	55.74
TOTAL**	**147.5**	**142.43**

* 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	13.4	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	114.05	93.77
Primary energy* [kWh/m²]	214.86	254.21
Total emissions [kg/m²]	37.6	43.9

* 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] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	69.7	71.7	18.6	8.9	11	0.7	2.25	0.88	2.8
	Notional	53.9	62.2	17.4	4.6	17.7	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	51.4	0	7	0	57.9	0.79	0	0.88	0
	Notional	58.5	0	18.9	0	75	0.86	0	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	4.2	0	1.3	0	74.6	0.79	0	0.88	0
	Notional	0.5	0	0.2	0	104.1	0.86	0	----	----

Key to terms

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

Key Features

The BCO can give particular attention to items with specifications that 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	0.25	01000051:Surf[0]
Floor	0.2	0.18	01000052:Surf[0]
Roof	0.15	0.18	01000057:Surf[0]
Windows, roof windows, and rooflights	1.5	1.6	01000052:Surf[4]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	3

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

16002_Twickenham East Stand_NBE_BEGREEN

As designed

Date: Wed Oct 19 11:21:21 2016

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.6

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.6

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	43.9
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	43.9
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	33.8
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.25	0.25	01000051:Surf[0]
Floor	0.25	0.18	0.18	01000052:Surf[0]
Roof	0.25	0.18	0.18	01000057:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	01000052:Surf[4]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = 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	3

Building services

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

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

1- Main system

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.88	2.8	0	0.4	0.7
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

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

2- Kitchen

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.88	-	0.2	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

3- Toilet Extrct

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.88	-	0.2	0	0.7
Standard value	0.91*	N/A	N/A	N/A	0.5
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.

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

1- CHECK2-CHP

	CHPQA quality index	**CHP electrical efficiency**
This building	0	0.35
Standard value	Not provided	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
Level 04 Goods	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 04 Kitchen	-	-	-	-	-	-	-	-	0.3	-	N/A
Level 04 Kitchen	-	-	-	-	-	-	-	-	0.3	-	N/A
Level 04 Debenture Bar	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 04 Toilet	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 Debenture Lounge	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 04 Toilet	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 Debenture Lounge	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 04 Toilet	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 A Kitchen	-	-	-	-	-	-	-	-	0.3	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 A Super Premium Suite	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 A Super Premium Bar	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 AToilets	-	-	-	0.3	-	-	-	-	-	-	N/A
Level 04 A Super Premium Suite	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 03 Kitchen	-	-	-	-	-	-	-	-	0.3	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.3	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
Level 04 Goods	90	-	-	36

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Level 04 Kitchen	-	90	-	2574
Level 04 Kitchen	-	90	-	2862
Level 04 Debenture Bar	-	90	-	1526
Level 04 Toilet	-	90	-	332
Level 04 Debenture Lounge	-	90	-	2645
Level 04 Toilet	-	90	-	422
Level 04 Debenture Lounge	-	90	-	2493
Level 04 Toilet	-	90	-	344
Level 04 A Goods	90	-	-	20
Level 04 A Kitchen	-	90	-	2419
Level 04 AToilets	-	90	-	20
Level 04 AToilets	-	90	-	30
Level 04 AToilets	-	90	-	32
Level 04 AToilets	-	90	-	40
Level 04 AToilets	-	90	-	49
Level 04 AToilets	-	90	-	23
Level 04 AToilets	-	90	-	91
Level 04 A Super Premium Suite	-	90	-	1616
Level 04 AToilets	-	90	-	23
Level 04 AToilets	-	90	-	101
Level 04 AToilets	-	90	-	55
Level 04 AToilets	-	90	-	25
Level 04 AToilets	-	90	-	32
Level 04 AToilets	-	90	-	40
Level 04 AToilets	-	90	-	32
Level 04 A Super Premium Bar	-	90	-	1330
Level 04 AToilets	-	90	-	23
Level 04 AToilets	-	90	-	91
Level 04 AToilets	-	90	-	49
Level 04 AToilets	-	90	-	25
Level 04 AToilets	-	90	-	32
Level 04 AToilets	-	90	-	35
Level 04 AToilets	-	90	-	28
Level 04 A Super Premium Suite	-	90	-	1627
Level 04 A Kitchen	-	90	-	2410
Level 03 Premium Hospitality	-	90	-	2552
Level 03 Kitchen	-	90	-	3341
Level 03 Premium Hospitality	-	90	-	835
Level 03 Premium Hospitality	-	90	-	1544

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?
Level 04 Goods	N/A	N/A
Level 04 Debenture Bar	YES (+86.4%)	NO
Level 04 Debenture Lounge	YES (+56.6%)	NO
Level 04 Debenture Lounge	YES (+39.1%)	NO
Level 04 A Super Premium Suite	NO (-42.7%)	NO
Level 04 A Super Premium Bar	NO (-28.3%)	NO
Level 04 A Super Premium Suite	NO (-36.8%)	NO
Level 03 Premium Hospitality	YES (+71.6%)	NO
Level 03 Premium Hospitality	NO (-47.8%)	NO
Level 03 Premium Hospitality	YES (+73.4%)	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]	9409.5	9409.5
External area [m²]	13405.3	13405.3
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	6747.48	5787.31
Average U-value [W/m²K]	0.5	0.43
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
	D1 Non-residential Inst.: Education
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: Crown and County Courts
100	**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	20.61	14.05
Cooling	8.94	4.37
Auxiliary	23.83	36.33
Lighting	3.56	7.56
Hot water	100.15	82.61
Equipment*	56.63	56.63
TOTAL**	**144.6**	**144.92**

* 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	8.04	0
Wind turbines	0	0
CHP generators	13.4	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	138.58	103.18
Primary energy* [kWh/m²]	217.72	262.38
Total emissions [kg/m²]	33.8	43.9

* 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] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	58.2	115	13.9	11.4	15.1	0.78	2.8	0.88	2.8
	Notional	51.9	76	16.7	5.6	18.7	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	37.4	0	6.9	0	53.2	0.79	0	0.88	0
	Notional	50.8	0	16.4	0	89.8	0.86	0	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	7.1	0	2	0	56	0.79	0	0.88	0
	Notional	4.2	0	1.3	0	102.9	0.86	0	----	----

Key to terms

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

Key Features

The BCO can give particular attention to items with specifications that 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	0.25	01000051:Surf[0]
Floor	0.2	0.18	01000052:Surf[0]
Roof	0.15	0.18	01000057:Surf[0]
Windows, roof windows, and rooflights	1.5	1.6	01000052:Surf[4]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	3

13 APPENDIX B – TM52 OVERHEATING RISK ANALYSIS

Overall	
Passed:	92 rooms:
Failed:	0 rooms:
Unoccupied:	1 rooms:

Data:			
Days data=	365	01-Jan	31-Dec
Days (summer)=	153	01-May	30-Sep
Data OK?	OK	Full summer	

Note:	This report assesses occupied periods only. Please be aware that TM52 should be conducted for occupied and/or "available hours".
	Use of educational NCM profiles may be seen as inappropriate due to prolonged unoccupied periods during summer months.
	See Section 6.1.2 (a) of TM52 for further information.

Passed:	92 rooms:					
Room Name	Room ID	Occupied days (%)	Criteria 1 (%Hrs Top-Tmax>=1K)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Criteria failing
Level 01 Debentures Bar	1000006	100	0	0	0	-
Level 01 Kitchen	1000002	100	1.1	9	1	2
Level 01 Kitchen	0100000B	100	7.5	0	0	1
Level 01 Lobby	1000001	100	0	0	0	-
Level 01 Lobby	1000005	100	0	0	0	-
Level 01 Lobby	1000007	100	0	0	0	-
Level 01 Lobby	0100000C	100	0	0	0	-
Level 01 Premium Hospitality	1000008	100	0	0	0	-
Level 01 Store	1000009	100	0	0	0	-
Level 01 Store	0100000E	100	0	0	0	-
Level 01 Store	0100000F	100	0	0	0	-
Level 01 Store	1000010	100	0	0	0	-
Level 01 Store	1000014	100	0	0	0	-
Level 01 Strore	1000016	100	0	0	0	-
Level 01 Toilets	1000003	100	0.2	5	1	-
Level 01 Toilets	1000004	100	0	0	0	-
Level 01 Toilets	1000012	100	0	```0	0	-

Level 01 Toilets	1000013	100	0	0	0	-
Level 01 Toilets	1000011	100	0	0	0	-
Level 01 Toilets	1000015	100	0	0	0	-
Level 01 Waste	1000000	100	0	0	0	-
Level 02 A Office	0100001B	100	0	0	0	-
Level 02 Food Preperation	1000024	100	2.9	13	0	2
Level 02 Kitchen	0100001C	100	2.7	14	0	2
Level 02 Lobby	0100001F	100	0	0	0	-
Level 02 Premium Hospitality	LV000000	100	0	0	0	-
Level 02 Store	1000019	100	0	0	0	-
Level 02 store	0100001A	100	0	0	0	-
Level 02 Toilets	1000017	100	0	0	0	-
Level 02 Toilets	1000018	100	0.1	3	1	-
Level 03 Goods	1000045	100	0	0	0	-
Level 03 Kitchen	1000041	100	2.9	15	0	2
Level 03 Kitechen	1000049	100	2.7	19	0	2
Level 03 Ktichen	0100004C	100	2.7	21	0	2
Level 03 New Box	1000022	100	0	0	0	-
Level 03 New Box	1000023	100	0	0	0	-
Level 03 New Box	1000025	100	0	0	0	-
Level 03 New Box	0100002E	100	0	0	0	-
Level 03 New Box	1000031	100	0	0	0	-
Level 03 New Box	1000032	100	0	0	0	-
Level 03 Premium Hospitality	0100004A	100	0	0	0	-
Level 03 Premium Hospitality	0100004B	100	0	0	0	-
Level 03 Store	0100003C	100	0	0	0	-
Level 03 Store	1000043	100	0	0	0	-
Level 03 Store	1000048	100	0	0	0	-
Level 03 Toilet	0100003D	100	0.6	7	2	2
Level 03 Toilet	0100003B	100	1.8	10	2	2
Level 03 Toilet	0100003F	100	1.1	10	2	2
Level 03 Toilet	0100004D	100	0.9	10	2	2
Level 03 Toilet	1000050	100	1.1	10	2	2
Level 03 Toilet	1000044	100	0.4	5	1	-
Level 03 Toilet	1000042	100	0.3	5	1	-
Level 03 Toilet	1000046	100	0.4	5	1	-
Level 03 Toilet	0100003E	100	0.4	5	1	-
Level 03 Toilet	0100004E	100	0.4	5	1	-
Level 03 Toilet	0100004F	100	0.3	5	1	-
Level 04 A Goods	0100005A	100	0	0	0	-
Level 04 A Kitchen	0100005B	100	2.7	18	0	2

Level 04 A Kitchen	0100005C	100	2.9	16	0	2
Level 04 A Super Premium Bar	1000070	100	0	0	0	-
Level 04 A Super Premium Suite	1000061	100	0	0	0	-
Level 04 A Super Premium Suite	1000060	100	0	0	0	-
Level 04 AToilets	1000062	100	0	0	0	-
Level 04 AToilets	1000064	100	0	0	0	-
Level 04 AToilets	1000065	100	0	0	0	-
Level 04 AToilets	1000066	100	0.2	5	1	-
Level 04 AToilets	1000067	100	0	0	0	-
Level 04 AToilets	1000063	100	0	0	0	-
Level 04 AToilets	1000068	100	0	0	0	-
Level 04 AToilets	0100005D	100	0	0	0	-
Level 04 AToilets	0100006A	100	0	0	0	-
Level 04 AToilets	0100005E	100	0	0	0	-
Level 04 AToilets	0100006B	100	0	0	0	-
Level 04 AToilets	0100006D	100	0	0	0	-
Level 04 AToilets	0100006C	100	0.2	5	1	-
Level 04 AToilets	0100006E	100	0	0	0	-
Level 04 AToilets	0100005F	100	0	0	0	-
Level 04 AToilets	0100006F	100	0	0	0	-
Level 04 AToilets	1000069	100	0	0	0	-
Level 04 AToilets	1000071	100	0	0	0	-
Level 04 AToilets	1000073	100	0	0	0	-
Level 04 AToilets	1000072	100	0	1	1	-
Level 04 AToilets	1000074	100	0	0	0	-
Level 04 Debenture Bar	1000054	100	0	0	0	-
Level 04 Debenture Lounge	1000055	100	0	0	0	-
Level 04 Debenture Lounge	1000053	100	0	0	0	-
Level 04 Goods	1000051	100	0	0	0	-
Level 04 Kitchen	1000052	100	2.9	17	0	2
Level 04 Kitchen	1000057	100	2.7	18	0	2
Level 04 Toilet	1000059	100	1	9	2	2
Level 04 Toilet	1000058	100	0.5	5	1	-
Level 04 Toilet	1000056	100	3	16	3	1

Failed:	0 rooms:

Room Name	Room ID	Occupied days (%)	Criteria 1 (%Hrs Top-Tmax>=1K)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Criteria failing

Unoccupied:	0 rooms:					
Room Name	Room ID	Occupied days (%)	Criteria 1 (%Hrs Top-Tmax>=1K)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Criteria failing
Level 02 Plant	1000075	-	-	-	-	-

14 APPENDIX C

14.1 012 DN Existing Building Energy Assessment

14.2 Existing Building Current (1991 Regulations) BRUKL

14.3 Existing Building Refurbished BRUKL

16002	Twickenham East Stand Extension	DESIGN NOTE	012

Date:	09/09/2016	
Subject:	Existing Building Energy Assessment	
Circulation:		

ME Engineers Limited
57 Great Suffolk Street
London, SE1 0BB
T: +44 (0) 20 7401 8382
E: info@me-engineers.co.uk

Rev	Date	Description	Prepared By
1.0	09/09/2016	First Issue	Meir Kojman

1.0 INTRODUCTION

The purpose of this design note is to approximate the extent to which the refurbishment to the existing parts of the East Stand (through upgrade to the façade, systems, and lighting, among other energy efficiency measures) will affect the energy performance and thus the carbon emissions rate associated with the existing building.

1.1 Existing Building: 1991 Regulations Assumptions

The following assumptions were taken for the purposes of assessing the current energy performance of the building, according to Building Regulations standards of 1991.

1.1.1 Thermal Performances

Element:	U-Value (W/m^{2}K)
Roofs	0.25
Exposed floors and Ground floors	0.45
Exposed Walls	0.45
Windows, Personnel doors and roof lights	3.3

1.1.2 Air Permeability Rate

15 m^3/(h.m^2) at 50 Pa

1.1.3 Lighting

An average lighting efficiency has been assumed as 45lm/w across the existing parts of the building.

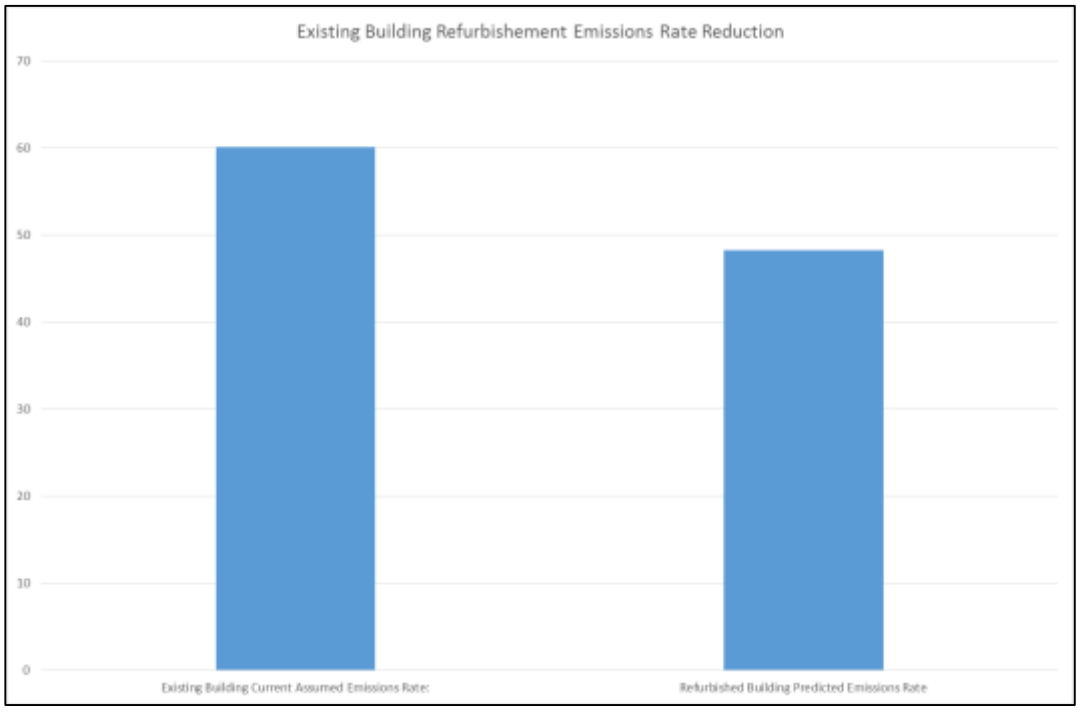
1.2 Refurbished Building assumption

It has been assumed, for the purposes of this assessment that the refurbished building will be upgraded to at least current building regulations standards.

1.3 Outputs

Based on the assumptions as set out above, the following reductions in carbon emissions associated with the existing building refurbishment.

Existing Building Current Assumed Emissions Rate:	**60.1 kgCO_2/m^2**
Refurbished Building Predicted Emissions Rate:	**48.3 kgCO_2/m^2**
Reduction Achieved:	**11.8 kgCO_2/m^2 (19.6%)**



BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

16002_Twickenham East Stand_EXE_1991

As built

Date: Fri Sep 09 14:09:34 2016

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.6

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.6

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

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

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	54.3
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	54.3
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	60.1
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 the building services should achieve reasonable overall standards of energy efficiency

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.45	0.45	01000000:Surf[2]
Floor	0.25	0.45	0.45	01000000:Surf[0]
Roof	0.25	0.25	0.25	01000000:Surf[1]
Windows***, roof windows, and rooflights	2.2	3.34	3.34	01000022:Surf[2]
Personnel doors	2.2	2.2	2.2	01000000:Surf[3]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

* 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	15

Building services

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

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

1- Main system

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.88	2.8	0	0.5	0.7
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

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

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

Local mechanical ventilation, exhaust, and terminal units

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

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
Level 01 Waste	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Kitchen	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Debentures Bar	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Kitchen	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Premium Hospitality	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.7	-	-	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
Level 01 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 01 Strore	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Toilets	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Kitchen	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 02 Lobby	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Food Preperation	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 02 A Office	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Goods	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Kitechen	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 03 Ktichen	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Plant	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 store	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 02 Premium Hospitality	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Kitchen	-	-	-	-	-	-	-	0.7	0.4	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.7	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.7	-	-	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	
Level 01 Waste	45	-	-	34
Level 01 Lobby	-	90	-	51
Level 01 Kitchen	-	90	-	965
Level 01 Toilets	-	90	-	127
Level 01 Toilets	-	90	-	132
Level 01 Debentures Bar	-	90	-	2279
Level 01 Lobby	-	90	-	171
Level 01 Lobby	-	90	-	290
Level 01 Store	45	-	-	31
Level 01 Kitchen	-	90	-	7615
Level 01 Lobby	-	90	-	249
Level 01 Store	45	-	-	41
Level 01 Store	45	-	-	44
Level 01 Store	45	-	-	44
Level 01 Premium Hospitality	-	90	-	5369
Level 01 Toilets	-	90	-	152
Level 01 Toilets	-	90	-	123
Level 01 Toilets	-	90	-	30
Level 01 Store	45	-	-	18
Level 01 Toilets	-	90	-	33
Level 01 Strore	45	-	-	30
Level 02 Toilets	-	90	-	194
Level 02 Toilets	-	90	-	202
Level 02 Store	45	-	-	71
Level 02 Kitchen	-	90	-	4011
Level 02 Lobby	-	90	-	229
Level 02 Food Preperation	-	90	-	1224
Level 02 A Office	45	-	-	4080
Level 03 New Box	-	90	-	242
Level 03 New Box	-	90	-	256
Level 03 New Box	-	90	-	271
Level 03 New Box	-	90	-	173
Level 03 New Box	-	90	-	271
Level 03 New Box	-	90	-	186
Level 03 Store	45	-	-	36
Level 03 Toilet	-	90	-	174
Level 03 Toilet	-	90	-	47
Level 03 Toilet	-	90	-	202
Level 03 Store	45	-	-	25
Level 03 Toilet	-	90	-	40
Level 03 Toilet	-	90	-	206
Level 03 Toilet	-	90	-	41

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Level 03 Toilet	-	90	-	204
Level 03 Store	45	-	-	61
Level 03 Goods	45	-	-	55
Level 03 Kitechen	-	90	-	1284
Level 03 Ktichen	-	90	-	1182
Level 03 Toilet	-	90	-	146
Level 03 Toilet	-	90	-	146
Level 03 Toilet	-	90	-	146
Level 03 Toilet	-	90	-	136
Level 02 Plant	45	-	-	371
Level 02 store	45	-	-	74
Level 02 Premium Hospitality	-	90	-	5776
Level 03 Premium Hospitality	-	90	-	3174
Level 03 Kitchen	-	90	-	5882
Level 03 Premium Hospitality	-	90	-	221
Level 03 Premium Hospitality	-	90	-	266
Level 03 Premium Hospitality	-	90	-	1819

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?
Level 01 Waste	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Kitchen	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Debentures Bar	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Kitchen	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Premium Hospitality	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Strore	N/A	N/A
Level 02 Toilets	N/A	N/A
Level 02 Toilets	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Level 02 Store	N/A	N/A
Level 02 Kitchen	N/A	N/A
Level 02 Lobby	N/A	N/A
Level 02 Food Preperation	N/A	N/A
Level 02 A Office	N/A	N/A
Level 03 New Box	YES (+135.3%)	NO
Level 03 New Box	YES (+171.1%)	NO
Level 03 New Box	YES (+170.8%)	NO
Level 03 New Box	YES (+173.5%)	NO
Level 03 New Box	YES (+170.8%)	NO
Level 03 New Box	YES (+173%)	NO
Level 03 Store	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Store	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Store	N/A	N/A
Level 03 Goods	N/A	N/A
Level 03 Kitechen	N/A	N/A
Level 03 Ktichen	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 02 Plant	N/A	N/A
Level 02 store	N/A	N/A
Level 02 Premium Hospitality	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A
Level 03 Kitchen	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A

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?	YES
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]	6523.8	6523.8
External area [m²]	11308.4	11308.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	15	3
Average conductance [W/K]	5115.75	4107.02
Average U-value [W/m²K]	0.45	0.36
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
	D1 Non-residential Inst.: Education
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: Crown and County Courts
100	**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	38.91	14.9
Cooling	7.23	6.16
Auxiliary	31.28	41.56
Lighting	15.48	9.13
Hot water	112.71	103.54
Equipment*	67.98	67.98
TOTAL**	**205.61**	**175.29**

* 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]	156.66	130.31
Primary energy* [kWh/m²]	346.59	314.66
Total emissions [kg/m²]	60.1	54.3

* 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] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	98.1	58.6	38.9	7.2	31.3	0.7	2.25	0.88	2.8
	Notional	46.2	84.1	14.9	6.2	41.6	0.86	3.79	----	----

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 BCO can give particular attention to items with specifications that 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	0.45	01000000:Surf[2]
Floor	0.2	0.45	01000000:Surf[0]
Roof	0.15	0.25	01000000:Surf[1]
Windows, roof windows, and rooflights	1.5	3.34	01000022:Surf[2]
Personnel doors	1.5	2.2	01000000:Surf[3]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	15

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

16002_Twickenham East Stand_EXE_BELEAN

As designed

Date: Fri Sep 09 10:16:11 2016

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.6

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.6

BRUKL compliance check version: v5.2.g.3

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	54.3
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	54.3
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	48.3
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 the building services should achieve reasonable overall standards of energy efficiency

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.25	0.25	01000000:Surf[2]
Floor	0.25	0.18	0.18	01000000:Surf[0]
Roof	0.25	0.18	0.18	01000000:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	01000022:Surf[2]
Personnel doors	2.2	2.2	2.2	01000000:Surf[3]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

* 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	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	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Main system

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.88	2.8	0	0.5	0.7
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

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

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

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

Local mechanical ventilation, exhaust, and terminal units

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

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
Level 01 Waste	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Kitchen	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Debentures Bar	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Kitchen	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 01 Lobby	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.4	-	-	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
Level 01 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 01 Strore	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Kitchen	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 02 Lobby	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Food Preperation	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 02 A Office	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 New Box	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Goods	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Kitechen	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 03 Ktichen	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Toilet	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Plant	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 store	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 02 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Kitchen	-	-	-	-	-	-	-	0.4	0.4	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	N/A
Level 03 Premium Hospitality	-	-	-	-	-	-	-	0.4	-	-	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	
Level 01 Waste	90	-	-	17
Level 01 Lobby	-	90	-	25
Level 01 Kitchen	-	90	-	483
Level 01 Toilets	-	90	-	64
Level 01 Toilets	-	90	-	66
Level 01 Debentures Bar	-	90	-	1140
Level 01 Lobby	-	90	-	85
Level 01 Lobby	-	90	-	145
Level 01 Store	90	-	-	16
Level 01 Kitchen	-	90	-	3807
Level 01 Lobby	-	90	-	124
Level 01 Store	90	-	-	21
Level 01 Store	90	-	-	22
Level 01 Store	90	-	-	22
Level 01 Premium Hospitality	-	90	-	2684
Level 01 Toilets	-	90	-	76
Level 01 Toilets	-	90	-	62
Level 01 Toilets	-	90	-	15
Level 01 Store	90	-	-	9
Level 01 Toilets	-	90	-	16
Level 01 Strore	90	-	-	15
Level 02 Toilets	-	90	-	97
Level 02 Toilets	-	90	-	101
Level 02 Store	90	-	-	35
Level 02 Kitchen	-	90	-	2005
Level 02 Lobby	-	90	-	114
Level 02 Food Preperation	-	90	-	612
Level 02 A Office	90	-	-	2040
Level 03 New Box	-	90	-	121
Level 03 New Box	-	90	-	128
Level 03 New Box	-	90	-	136
Level 03 New Box	-	90	-	87
Level 03 New Box	-	90	-	136
Level 03 New Box	-	90	-	93
Level 03 Store	90	-	-	18
Level 03 Toilet	-	90	-	87
Level 03 Toilet	-	90	-	23
Level 03 Toilet	-	90	-	101
Level 03 Store	90	-	-	12
Level 03 Toilet	-	90	-	20
Level 03 Toilet	-	90	-	103
Level 03 Toilet	-	90	-	21

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Level 03 Toilet	-	90	-	102
Level 03 Store	90	-	-	30
Level 03 Goods	90	-	-	28
Level 03 Kitechen	-	90	-	642
Level 03 Ktichen	-	90	-	591
Level 03 Toilet	-	90	-	73
Level 03 Toilet	-	90	-	73
Level 03 Toilet	-	90	-	73
Level 03 Toilet	-	90	-	68
Level 02 Plant	90	-	-	186
Level 02 store	90	-	-	37
Level 02 Premium Hospitality	-	90	-	2888
Level 03 Premium Hospitality	-	90	-	1587
Level 03 Kitchen	-	90	-	2941
Level 03 Premium Hospitality	-	90	-	110
Level 03 Premium Hospitality	-	90	-	133
Level 03 Premium Hospitality	-	90	-	910

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?
Level 01 Waste	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Kitchen	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Debentures Bar	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Kitchen	N/A	N/A
Level 01 Lobby	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Premium Hospitality	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Store	N/A	N/A
Level 01 Toilets	N/A	N/A
Level 01 Strore	N/A	N/A
Level 02 Toilets	N/A	N/A
Level 02 Toilets	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Level 02 Store	N/A	N/A
Level 02 Kitchen	N/A	N/A
Level 02 Lobby	N/A	N/A
Level 02 Food Preperation	N/A	N/A
Level 02 A Office	N/A	N/A
Level 03 New Box	YES (+125.6%)	NO
Level 03 New Box	YES (+160.1%)	NO
Level 03 New Box	YES (+159.8%)	NO
Level 03 New Box	YES (+162.3%)	NO
Level 03 New Box	YES (+159.8%)	NO
Level 03 New Box	YES (+161.8%)	NO
Level 03 Store	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Store	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Store	N/A	N/A
Level 03 Goods	N/A	N/A
Level 03 Kitechen	N/A	N/A
Level 03 Ktichen	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 03 Toilet	N/A	N/A
Level 02 Plant	N/A	N/A
Level 02 store	N/A	N/A
Level 02 Premium Hospitality	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A
Level 03 Kitchen	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A
Level 03 Premium Hospitality	N/A	N/A

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?	YES
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]	6523.8	6523.8
External area [m²]	11308.4	11308.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	5	3
Average conductance [W/K]	2709.49	4107.02
Average U-value [W/m²K]	0.24	0.36
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
	D1 Non-residential Inst.: Education
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: Crown and County Courts
100	**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	11.01	14.9
Cooling	9.63	6.16
Auxiliary	25.16	41.56
Lighting	7.89	9.13
Hot water	112.71	103.54
Equipment*	67.98	67.98
TOTAL**	**166.4**	**175.29**

* 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]	105.79	130.31
Primary energy* [kWh/m²]	278.7	314.66
Total emissions [kg/m²]	48.3	54.3

* 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] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	27.7	78	11	9.6	25.2	0.7	2.25	0.88	2.8
	Notional	46.2	84.1	14.9	6.2	41.6	0.86	3.79	----	----

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 BCO can give particular attention to items with specifications that 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	0.25	01000000:Surf[2]
Floor	0.2	0.18	01000000:Surf[0]
Roof	0.15	0.18	01000000:Surf[1]
Windows, roof windows, and rooflights	1.5	1.6	01000022:Surf[2]
Personnel doors	1.5	2.2	01000000:Surf[3]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

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

15 APPENDIX D – LBRUT CO2 BREAKDOWN

16002	Twickenham East Stand Extension	DESIGN NOTE	012

Date:	19/10/2016
Subject:	Emissions Figures As Per LBRuT Request
Circulation:	

ME Engineers Limited
57 Great Suffolk Street
London, SE1 0BB
T: +44 (0) 20 7401 8382
E: info@me-engineers.co.uk

Rev	Date	Description	Prepared By
1.0	03/10/2016	First Issue	Meir Kojman
2.0	19/10/2016	Second Issue	Meir Kojman

1.0 INTRODUCTION

This design note Is intended to present CO_2 Reduction figures, as calculated in the Energy Strategy, in the format requested by LBRuT.

The same information has also been presented according to the GLA Energy Hierarchy.

2.0 SUMMARY CO_2 SAVINGS REPRESENTED IN LINE WITH LBRUT REQEST

	TER/BER (kg/CO2/m2)	Total emissions (kg/CO2)	Reduction in emissions at this stage (kg/CO2)	% reduction at this stage	Reduction in emissions from baseline (kg/CO2)	Cumulative % reduction from baseline
Baseline	43.9	413,077				
Be Lean	41.3	388,612	24,465	5.92%	24,465	5.92%
Be Clean - Including CHP savings from the East Stand only	39.4	371,125	17,488	4.50%	41,952	10.16%
Be Green - Including % of PV based on floor area of the East Stand	38.6*	363,616	7,509	2.02%	49,461	11.97%
Be Clean - Including CHP savings from the rest of the stadium	36.8*	346,288	17,328	4.77%	66,789	16.17%
Be Green - Including the rest of the PV	33.8	318,041	28,247	8.16%	95,036	23.01%

*Calculated / Pro-rated figure.

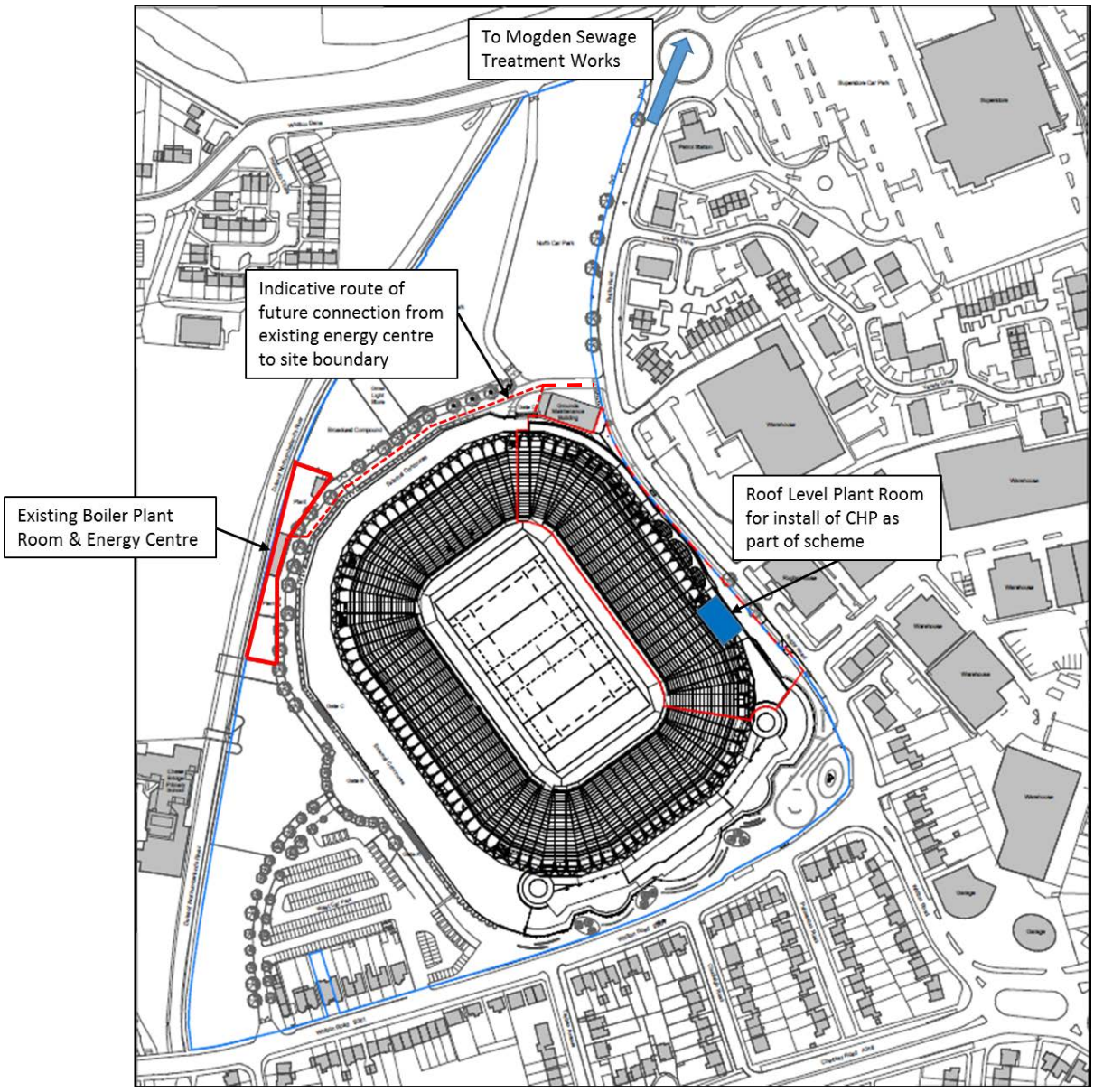
3.0 SUMMARY CO2 SAVINGS REPRESENTED IN LINE WITH GLA HIERACHY

	TER/BER ($kg/CO_2/m^2$)	Total emissions (kg/CO_2)	Reduction in emissions at this stage (kg/CO_2)	% reduction at this stage	Reduction in emissions from baseline (kg/CO_2)	% reduction from baseline
Baseline	43.9	413,077				
Be Lean	41.3	388,612	24,465	5.92%	24,465	5.92%
Be Clean - Including CHP savings from the East Stand only	39.4*	371,125	17,488	4.50%	41,952	10.16%
Be Clean - Including CHP savings from the rest of the stadium	37.6	353,797	17,328	4.67%	59,280	14.35%
Be Green - Including % of PV based on floor area of the East Stand	36.8*	346,288	7,509	2.12%	66,789	16.17%
Be Green - Including the rest of the PV	33.8	318,041	28,247	8.16%	95,036	23.01%

*Calculated / Pro-Rated figure.

16 APPENDIX E – PLANT LOCATION AND DISTRIBUTION ROUTES

The figure below shows the location of existing plant rooms & energy centre, the location of the proposed new plant room at roof level on the East Stand, and an indicative route from existing plant rooms and energy centre to site boundary.



17 APPENDIX F – COOLING DEMAND

	Area Weighted average building cooling demand (MJ/m2)
Actual	71.7
Notional	62.2

Due to the complex nature of the development, and the way in which the new build extension is connected to the existing parts of the building, (factored into and accounted for in the dynamic thermal model: please see section 4 of this report), the application of applicable elements of the cooling hierarchy have a limited effect.

Further from the passive design measures listed in section 9.2.1 of this report, no other means of demand reduction were found to be feasible for this development. (For further details please refer to section 9.2.2 and 9.2.3 of this report).