CHARLTON RIVERSIDE

PHASE ONE

ENERGY STATEMENT ADDENDUM

Rockwell

Intended for
Leopard Guernsey Anchor Propco Limited

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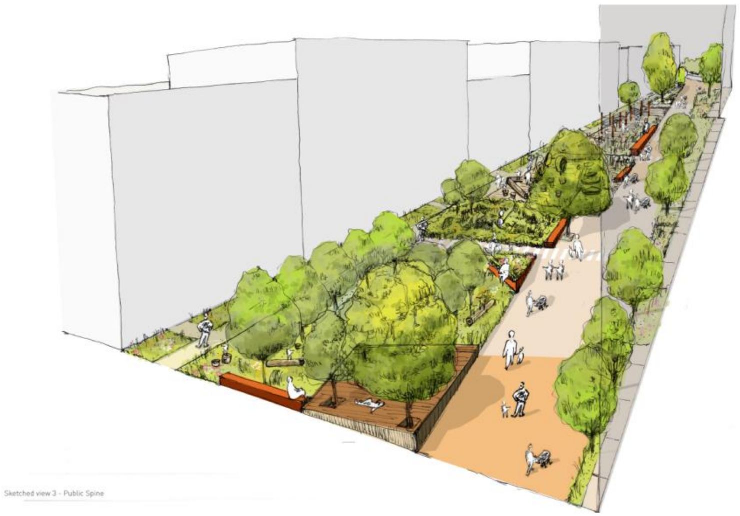
CHARLTON RIVERSIDE
OUTLINE ENERGY STRATEGY



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Made by	**Orestis Angelidis**
Checked by	**Crispin Matson**
Approved by	**Crispin Matson**
Description	**Outline Energy Strategy**

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TABLES

EXECUTIVE SUMMARY

Ramboll was commissioned by Leopard Guernsey Anchor Propco Limited to produce an outline energy strategy document for their proposed development at Charlton Riverside in London. This document is an updated version of a document issued by Ramboll in December 2017 and all proposed amendments do not impact or change the results previously presented. The document is intended to provide an indication of the preferred energy strategy in advance of the final design submission for planning. The proposed development consists of residential buildings, community facilities and office/commercial space.

The purpose of the energy strategy was to explore energy supply options for the proposed development and consider whether they would comply with national and local carbon emissions requirements.

Figure 1: Elevation Courtesy of Simpson Haugh

The key policy factors to consider were:

- **National Part L building regulations** target carbon emissions rating
- **The London Plan** minimum requirement to reduce emissions by 35% in excess of the Part L figures
- **Zero Carbon Homes** objective to reach zero carbon for residential buildings through on-site measures or off-setting.

The study was conducted in accordance with the London Plan's "Be Lean, Be Clean, Be Green" energy hierarchy.

Conclusions and Recommendations

It is recommended that **a heat network supplied by natural gas CHP** is pursued as the preferred option for energy supply to the proposed development in order to comply with building regulations and the London Plan.

Incorporating renewables would further reduce CO_2 emissions and reduce the electricity demand from the National Grid, PV panels where considered as the most applicable renewable energy generation for the proposed development.

Be Lean

In the first instance, a range of LEAN energy efficiency measures has been proposed, such as improved building fabrics and high-performance glazing.
In the first instance, the aim is to "be lean" by reducing energy demand through measures such improved fabric efficiency. The use of communal gas boilers was explored as a base case supply asset, in combination with improved building fabric efficiency measures.

The results showed that this option was suitable as the Carbon Dioxide (CO_2) emissions were found to be below the Part L 2013 building regulations target emissions rate (TER) by 6% for residential buildings and 20% for commercial. The Design Fabric Energy Efficiency (DFEE) of every property modelled met the criteria.

Be Clean

In line with the London Plan energy hierarchy, the CLEAN measure of a natural gas CHP led district heating network was incorporated into the model in combination with the improved building fabric measures.

An appropriate CHP engine size was estimated to be 291 kW_{th}, which would be capable of supplying approximately 87% of the annual heat/hot water supply if operated in conjunction with a thermal store of volume 20 m^3. The energy centre was sized based on the main plant items (CHP boilers, etc.) along with the auxiliary equipment resulting in a total floor area of 171 m^2.

The results showed that natural gas CHP supplying a community heat network would be sufficient to meet Part L and London Plan targets.

The annual CO_2 emissions were found to be 42% below the TER and therefore the option exceeds the London Plan requirement with a margin of 7%.

Be Green

Following a desktop investigation of a range of renewable energy supply opportunities and consultation with the Architect, it was concluded that the preferred option for the incorporation of "green" measures into the design was Solar PV panels which could reduce the residential CO_2 emissions by a further 9% of the TER.

Therefore, a heat network supplied by gas CHP in addition to 205 kWp of PV cells having a total PV area of 1,377 m^2 was deemed to be the preferred strategy, reducing carbon emissions by 51% over the 2013 Building Regulations baseline.

The remaining CO_2 emissions of 396 tonnes per year, will result in a required off-setting payment of approximately £23,726 per annum to achieve zero carbon requirements applicable to the residential element of the development.

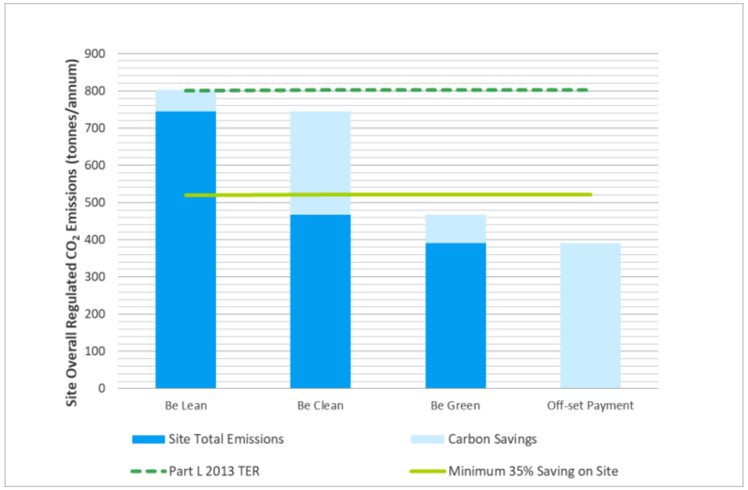


Figure 2: Results summary

1. INTRODUCTION AND BACKGROUND

Ramboll was appointed by Leopard Guernsey Anchor Propco Limited to prepare an outline energy strategy assessment for the proposed development at Charlton Riverside, London. The proposed development will comprise of residential and non-residential buildings.

The purpose of the energy strategy is to achieve the maximum CO_2 emission reduction, explore energy supply options for the proposed development and assess whether they would comply with national and local carbon emissions requirements.

The energy statement relates to the detailed planning application for the proposed development.

1.1 Project Brief

The preparation of this outline energy strategy is intended to provide an initial indication of a viable energy strategy in advance of submission of the full planning application.

The energy demand calculations and technology assessment undertaken as part of the outline energy strategy were primarily intended to provide an indication of the required energy capacity of the proposed development and establish a suitable supply technology to meet current national and local policy requirements.

Key objectives were as follows:

- Carry out Part L Building Regulations Standard Assessment Procedure (SAP) modelling for ten sample residential apartments.
- Assess the potential for connection to a district heating scheme in the vicinity.
- Assess the potential for creation of an energy centre for the development via an Energy Services Company (ESCo).
- Assess potential for integration of low or zero carbon (LZC) technologies including combined heat and power (CHP) and renewables.
- Carry out energy scenarios analysis in order to determine the fraction of annual heat demand that can be met (assuming heat led design) by CHP. Carry out provisional sizing of central CHP plantroom/energy centre and thermal stores. Analyse emissions and provide advice on the flue size/height required.
- Prepare the final Energy Assessment/Statement.

This report provides an overview of the proposed development and the assumptions made by Ramboll in developing this report, followed by the methodology and presentation of energy strategy scenarios.

2. PROPOSED DEVELOPMENT

This section outlines the key information regarding the proposed Charlton Riverside Development and presents the assumptions made for the outline energy strategy.

2.1 Site Description

The proposed development is located alongside Greenwich Peninsula in London.

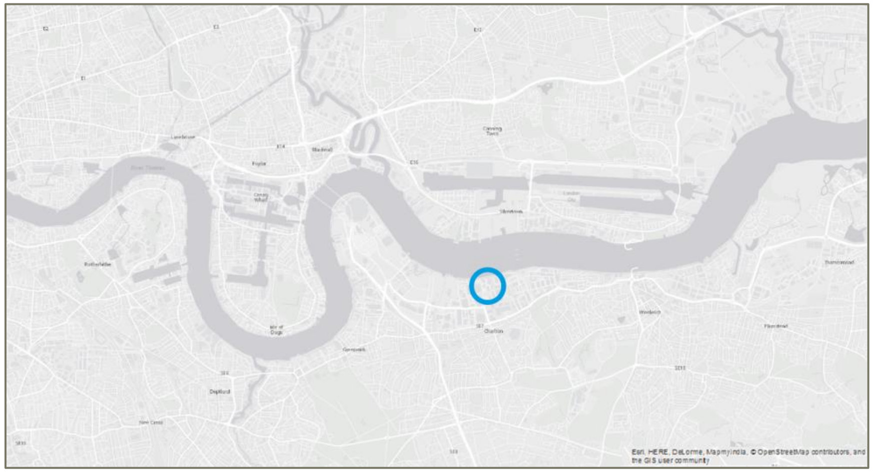


Figure 3: Site Location

The proposed development comprises:

- 771 residential units provided within 11 buildings ranging in height from 2 to 10 storeys, including extensive private gardens and roof terraces;
- 3,280 m^2 (GIA) of flexible business/retail use;
- 496 m^2 (GIA) of flexible community/leisure use;
- 338 m^2 (GIA) of community space for use as a creche;
- Up to 1,400 residential and commercial cycle spaces; and
- Two basements, providing up to 208 car parking spaces (148 within Plot A and 60 within Plot B.

The non-residential space for this proposed development totals 4,114m^2.

2.2 Sources of Information

The Site plan matrices, building schedule and floor plans[1] were used as the preliminary source of information for use in compiling the energy strategy.

2.3 Floor Areas

The floor areas for the eight dwelling categories from the building schedule were the basis for this analysis, as shown in Table 1.

[1] Simpson Haugh and Partners, November 2017 and November 2018.

Dwelling Type	Floor Area (m^2)
Studio apartment	39
1 bed apartment	50
2 bed apartment	66
2 bed townhouse	79
3 bed apartment	80
3 bed townhouse	93
4 bed apartment	94

Table 1: Assumed Floor Areas for Dwellings

With regards to the thermal properties of building materials, in the first instance the national building regulations U-values were incorporated (see section 5).

3. PLANNING POLICY CONTEXT

This section outlines the national and local policy applicable to the preparation of the outline energy strategy.

3.1 Planning Context

The energy strategy must aim to comply with the policies set out in the sub-sections below.

3.1.1 National Planning Policy – Building Regulations

Approved Document Part L2 2013[2] provides requirements and guidance on the Conservation of Fuel and Power.

The main changes from the previous Part L2 2010 regulations that are determined by these criteria are as follows:

- Comparison of actual building against target emission ratings
- Limits on design flexibility
- Limiting solar gain in summer
- Building performance
- Providing information.

The building must meet or exceed the **Target Emissions Rate (TER)** of a notional building as specified by Part L 2013 building regulations approved software.

In order to provide evidence of this, a SAP calculation is carried out both on a notional building with fixed parameters and the actual building.

[2] The Building Regulations 2013, L2: Conservation of Fuel and Power, HM Government

As a result, calculations showing compliance with Part L Standard Assessment Procedure (SAP) and Simplified Building Energy Model (SBEM) are required at both the design stage and once the building has been completed. This enables energy efficiency measures to be incorporated at an early stage and to demonstrate that these have been incorporated.

3.1.2 Local Planning Policy - The London Plan

The London Plan's Energy Planning Guidance[3] was revised in March 2016. The Plan states that from 1st October 2016 new developments should seek to achieve a Zero Carbon target with a minimum reduction in carbon dioxide emissions of **35% below the regulated Carbon Dioxide (CO_2) emissions** (beyond Part L 2013) on-site.

The remaining regulated CO_2 emissions, to 100%, are to be off-set through a financial contribution to the Borough. This contribution will be paid at the value of **£60/tonne** for a period of 30 years.

The policy requires the following Energy Hierarchy: **Be Clean, Be Lean, Be Green** to be adopted.

Figure 4: Flow Diagram of London Plan Energy Hierarchy

The above energy hierarchy outlines the methodology under which the Greater London Authority (GLA) requires sustainable building design to be assessed.

[3] Energy Planning – Greater London Authority Guidance on Preparing Energy Assessments, March 2016

The energy hierarchy first looks at reducing the energy demand of a building through passive design measures (be lean), then by incorporating active energy measures through energy efficient servicing strategy, lighting and electrical controls, community heating (be clean), and finally by further reducing the carbon emissions through the use of on-site renewable energy technologies (be green).

Future projects are encouraged to evaluate the incorporation of CHP into their developments and consider the potential to extend such schemes beyond site boundaries to adjacent energy consumers.

Following on from this goal, it is required that energy systems for all major developments be evaluated and designed with the following factors in mind:

- Connection to an existing heating network or a site wide CHP network.
- Renewables such as PV installation in combination with the above if the Carbon Reduction Targets are not met.

The final London Plan requirement to consider is Policy 5.7: "*There is a presumption that all major development proposals will seek to reduce carbon dioxide emissions by at least 20 per cent through the use of on-site renewable energy generation wherever feasible*[4]."

A draft version of the updated London Plan has been published in December of 2017. The proposed targets and methodologies do not vary from the existing, thus it is unlikely that the final updated version will affect the results of the current report. The offset payment tariff is suggested to rise from £60 to £95 per tonne of carbon per year, which would affect the final off set payment.

[4] https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan/london-plan-chapter-5/policy-57-renewable-energy

3.2 Summary

Taking into account the policies listed, a number of energy and carbon performance parameters and targets can be defined for the proposed development and can be incorporated into the methodology for the outline energy strategy (see section 4). The targets are summarised as follows:

1. Compliance with 2013 Building Regulations Part L2A: Conservation of Fuel and Power.

- Dwelling Carbon Emission Rate (DER) to be less than Target Carbon Emission Rate (TER).
- Design Fabric Energy Efficiency (DFEE) Rate to be less than Target Fabric Energy Efficiency (TFEE) Rate.

The targets are generally expected to be achieved through the application of energy efficiency measures ('be lean') alone.

2. Compliance with London Plan policy 5.2: Minimising carbon dioxide emissions to deliver a site-wide carbon emissions reduction of at least 35% below 2013 Building Regulations and to reflect the Zero Carbon Homes initiative.

3. Compliance with London Plan policy 5.5 and 5.6 by using a district heating network to supply heated water for space heating and DHW from an energy centre that includes CHP.

4. Compliance with London Plan policy 5.7 by including, where feasible, a contribution from on-site renewable generation technologies to support the reduction of carbon emissions.

4. METHODOLOGY

The main objective of this report is to identify an energy strategy which would deliver a site-wide carbon emission reduction of 35% below the 2013 building regulations as required by London Plan Policy.

The energy strategy for the proposed development was prepared using the energy hierarchy methodology presented in section 3.1.2.

The estimated regulated energy demand of residential buildings was modelled using the National Homes Energy Rating (NHER) software to calculate the carbon emissions at each stage of the Energy Hierarchy. The SAP calculations have been undertaken in line with the Part L1A 2013 and SAP 2012[5] methodology and can be found in Appendix 3.

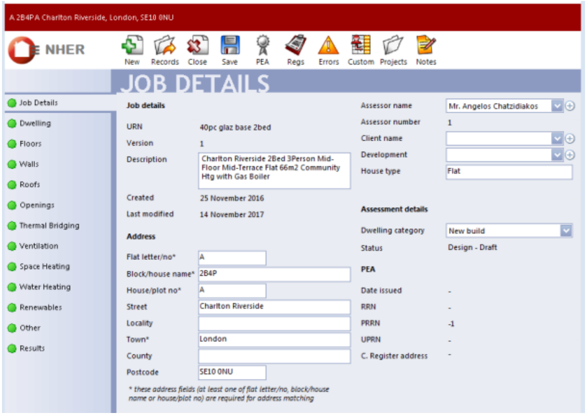


Figure 5: Screenshot of Inputs to SAP Model

For non-residential buildings, the energy demands and CO_2 emissions were determined using the Integrated Environmental Solutions (IES) software. The results from the analysis were given in Building Regulations Part L 2013 (BRUKL) output document. The building schedule indicates that most of the developments are offices (75% of the floor area), a single simulation was performed whose results were used for all commercial consumer classes.

[5] SAP 2012, The Government's Standard Assessment Procedure for Energy Rating of Dwellings, published on behalf of DECC by: BRE

Emissions associated with unregulated elements (for example, cooking and home appliances) have been calculated based on the SAP 2012 Section 16 methodology. The SAP calculations have been carried out for each apartment type referred to in the accommodation schedule for ground, middle and top floors. Townhouses were not modelled separately in SAP due to their resemblance to apartments.

The first step was to **establish the TER** in tonnes CO_2 per annum for the proposed development. This would set the CO_2 level to be achieved by the proposed development. The TER is calculated in accordance with the Part L 2013 requirements and it was assumed that heating would be provided by gas boilers.

Following this, a **"be lean" scenario** was considered whereby a variety of energy efficiency measures were applied to the building envelopes, their internal mechanical and electrical installations and associated controls to minimise the development's carbon emissions.

The **"be clean" scenario** built on the previous model by incorporating a CHP engine as the primary heat supply asset and considering connection to a nearby existing heat network.

Finally, for the **"be green" scenario** renewable energy was incorporated in the form of solar PV panels.

Based on the results of modelling these scenarios, **conclusions** could then be drawn with regards to the preferred option.

5. TARGET CARBON EMISSIONS

This section presents the calculated TER values which set out the carbon requirements for the proposed development. Each of the scenarios modelled under the energy hierarchy methodology were compared to these results.

5.1 Residential Buildings

As stated in the methodology, SAP modelling of the residential component of the proposed development was carried out using Building Regulations approved NHER software.

The building fabric assumed as a base line corresponds with the standards set out by SAP 2012 for achieving the minimum fabric energy efficiency standards for zero carbon homes for each building type. By adhering to these standards, the energy demand of the dwellings is reduced through passive design measures in accordance with the "Be Lean" philosophy set out in the London Plan.

Element	SAP 2012 Notional Dwelling U-Value (W/m^2K)
Wall	0.18
Floor	0.13
Roof	0.13
Glazing	1.5
Party Wall	0

Table 2: Building Fabric U-Values Incorporated for TER Model

Figure 6 shows the Target CO_2 Emission Rate (TER) for residential properties within the proposed development and the Zero Carbon CO_2 emission rate that is required for compliance with the London Plan. The values were found to be 758 and 521 tonnes CO_2 per annum for Part L 2013 and the London Plan respectively.

5.2 Non-Residential Buildings

For non-residential buildings the BRUKL documents from the IES study, shown in Appendix 4, indicated a TER of 84 tonnes per annum. This results in a London Plan target of 55 tonnes per annum.

The non-residential target emissions are shown in Figure 6 with a lighter colour (hatched) as part of the total site TER.

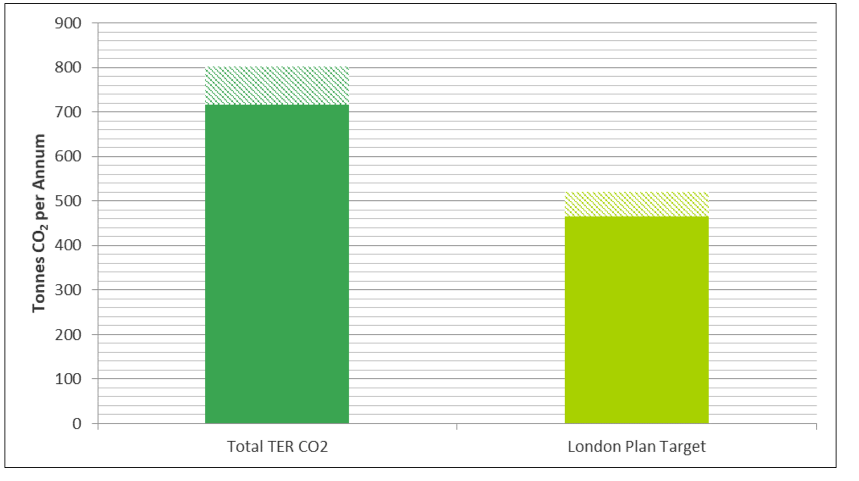


Figure 6: Part L 2013 TER for Domestic and Non-Domestic (hatched) Buildings

6. BE LEAN

As part of a suitable Energy Strategy, the proposed development could feature best practice passive energy saving measures to achieve compliance with Part L of the Building Regulations without reliance on the contribution of renewables and low carbon technologies.

This section analyses the energy efficiency measures that have been considered within the study in order to minimise the energy demand and achieve excellent building performance.

6.1 Building Design Envelope Recommendations

- The general internal layout should be designed to ensure good daylight access for occupied spaces.
- Solar control glazing should be considered on the south, west and east elevations to limit solar gains. Light–coloured curtains should also be used. The g value used to avoid overheating was 0.4. All windows are doubled glazed.
- Each space should be designed with windows which can be opened to allow natural ventilation and be provided with trickle vents for the same purpose during winter times.
- The benefits of heavyweight buildings with good thermal mass properties should be maximised where possible.
- Good practice u-values should be targeted across external elements to reduce heat losses (see Table 3). An air pressure test will be required for each dwelling.

Table 3: Building Properties for Be Lean Scenario

SAP 2012		Energy efficiency measures	
Fabric thermal parameters		U values	
	Roof	0.13	W/m2K
	External Walls	0.18	W/m2K
	Party Walls	-	W/m2K
	Ceiling and Ground floor	0.13	W/m2K
	Windows	1.40	W/m2K
	External Doors	1.00	W/m2K
Window Characteristics	G Value	0.4	
	F Factor	0.8	
Thermal bridges		y-value	
	Other Lintels (including other steel lintels)	0.3	W/mK
	Sill	0.04	W/mK
	Jamb	0.05	W/mK
Ventilation	Air Tightness	3	m3/hr/mw @50Pa
	Mechanical Ventilation	Balanced with heat recovery	
		SPF=0.96 w/l/s, 90% efficiency	
		Rigid ducting	
Heating	Boiler/main heating system	Communal Gas fired, 86% efficiency	
	Controls	Charging system linked to use, programmer and TRV's	
Electrical Demand	Low energy lighting	100%	
	Cooking	Electric	

6.2 Lighting Design Recommendations

Energy consumption from lighting should be minimised via the following measures:

- Dedicated energy efficient light fittings should be installed throughout dwellings;
- Lighting in dwellings should be occupant controlled via a master switch control where feasible and practical;
- In communal and circulation areas, lighting should be controlled by timed switches;
- Lighting in retail spaces should have automatic daylight linking controls (where appropriate);
- The lighting of public toilets and stores should be controlled via presence sensors;
- All other areas should have central scene control or local switching facility to ensure lighting is used as needed;
- External lighting should be energy efficient with daylight and/or time clock controls; and
- Highly efficient LED lighting should be used throughout the proposed development.

6.3 HVAC Systems and Controls Recommendations

6.3.1 Retail Areas:

- Highly efficient cooling; and
- All fans and pumps should operate with variable speed control.

6.3.2 Residential Units:

- Communal boilers should be used and be of high efficiency specifications working at condensing mode when appropriate. An efficiency of 86% was used as per Domestic Building Services Compliance Guide;
- Mechanical ventilation with heat recovery having an SPF of 0.96W/l/s and 90% efficiency. Additionally, there is the capacity for opening the windows; and
- Hot water pipes, tanks and ducts should be insulated.

6.3.3 Across the Proposed Development:

- Electric sub-metering should be installed to monitor and target energy use within the proposed development. At least 95% of all gas and electrical use should be metered to encourage lower energy use and increase control. All major items of plant should also be sub-metered;
- All meters should provide pulsed output to the Building Energy Management System (BMS) for automated metering and centralised monitoring of all energy and water use. The BMS system should also ensure that heating and cooling systems are highly responsive and operate at their optimal efficiency in maintaining internal conditions to comfort standards; and
- The metering strategy should be in alignment with CIBSE TM39[6].

6.4 Cooling Demand Reduction Recommendations

Minimizing the risk of summer overheating is crucial to maintain comfort all around the year. The proposed development will reduce the risk of summer overheating by:

- Using solar controlled glazing on south, west and east elevations;
- Using an overhang on the ground floor to limit high angle solar gain;
- Use of automatic daylighting control of retail lighting; and
- Use of energy efficient LED lights.

[6] TM39 Building Energy Metering, CIBSE

An overheating risk analysis has been performed and the relevant report is presented in Appendix 4 together with recommendations.

6.5 Be Lean Results

6.5.1 Residential Buildings

The predicted regulated domestic site-wide CO_2 emissions for residential buildings under this scenario are shown in Figure 7.

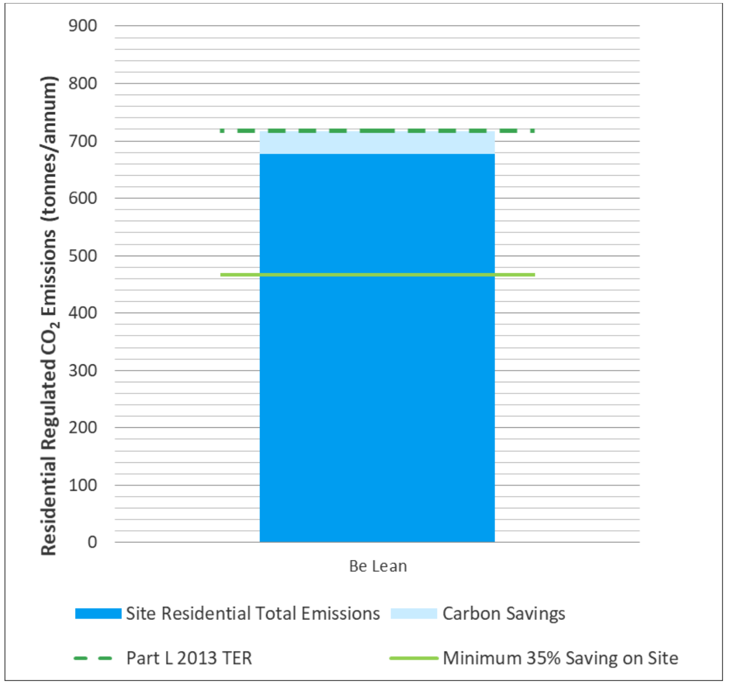


Figure 7: Be Lean Results Carbon Emissions for Residential Buildings

In this scenario the CO_2 emissions are estimated **to be less than the building regulations TER by 6%.**

The Design Fabric Energy Efficiency (DFEE) is also **less than the Target Fabric Energy Efficiency (TFEE) by 9%**, meeting the DFEE/TFEE compliance. The SAP worksheets showing the outputs for all flats can be found in Appendix 3.

6.5.2 Non-Residential Buildings

The predicted non-residential "be lean" outputs from the IES modelling are shown in the following figures. The carbon emissions are **20% less than the TER** so compliance is achieved**.**

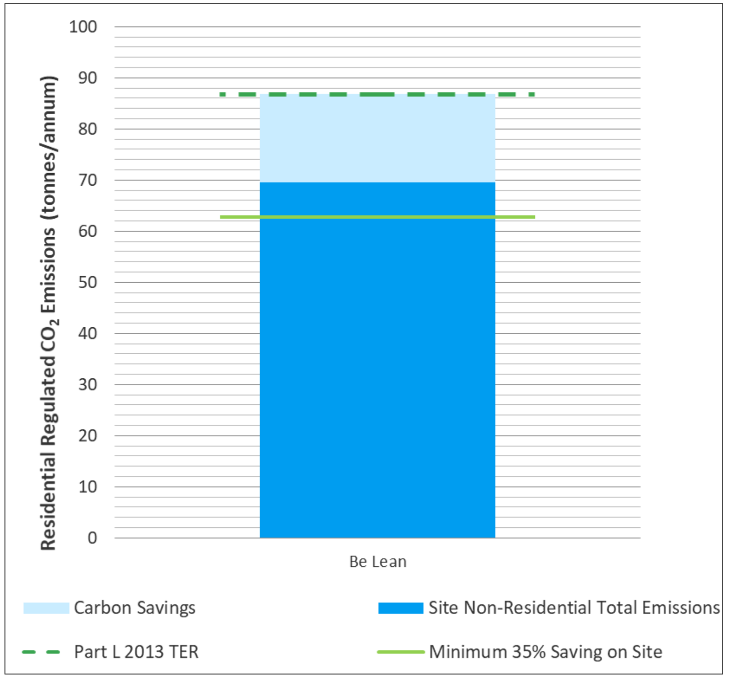


Figure 8: Be Lean Results for Non-Residential Buildings

7. BE CLEAN

Two primary options were considered as part of the "be clean" objective:

- Connection to an existing district heating (DH) network; and
- Creation of a CHP energy centre.

7.1 District Heat Networks

In the first instance, an investigation was carried out into the potential for connection to an existing heat network.

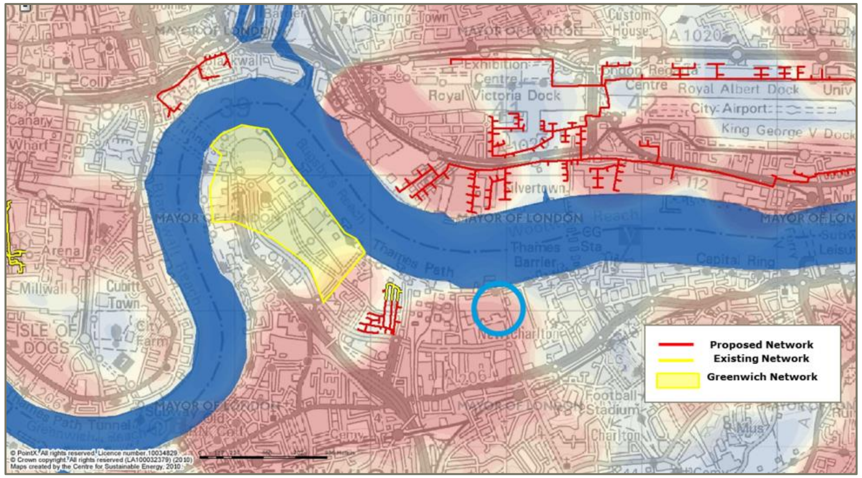


Figure 9: Existing and Proposed Heat Networks (Courtesy of London Heat Map)

An existing heat network is present in Greenwich Peninsula which was considered as an opportunity for connection to the proposed development. It is being supplied by a gas CHP engine and is therefore assumed that carbon reductions could be achieved by connecting to this network.

After contacting the Royal Borough of Greenwich planning office[7], it was confirmed that the closest DH network is the one in the Greenwich Millennium Village, requiring a pipeline of approximately 2 km to connect to as presented in Figure 9. Such a connection was characterised as prohibitively expensive. However, the borough's energy masterplan envisages a potential transmission line through the site at some point in the future. Since no specific timeline is set for the feasibility work for the transmission line, it was decided that the best course of action is to ensure that the energy centre is future proof for such a connection.

Consecutively, the buildings at Charlton Riverside will be designed to incorporate future-proofing measures so it will have the possibility of connecting to a potential network developed in the future. In particular, as required by the London Plan, the following measures will be undertaken:

- **Provision of a single plant room** producing all hot water. Space should be allowed for and identified in the plant room to facilitate the connection of an interfacing heat exchanger.

- **Soft points should be created in the building walls** to allow pipes to be routed through.

- External **pipework routes should be identified** and safeguarded.

An indicative layout of the network is illustrated at Figure 10 below.

[7] Contact: Maria Yashchanka, Planning Policy Officer in the Royal Borough of Greenwich on 12/10/2018.

Figure 10: Indicative District Heat network routing

Table 4, sets out the main considerations that should be raised from an early stage according to the Code of Practise (CoP) for heat networks[8].

Table 4: CoP for Heat Networks Considerations

Code of Practice Theme	Consideration
Correct sizing of plant and network	Taking into account diversification of loads.
Achieving low heat network losses	The network routing should be developed to minimize the overall length of the network. Use of correct sized pre-insulated pipework for distribution would reducing losses to 10%. Use of share risers in the buildings avoiding large branch lengths would reduce the building losses to 10%.
Achieving consistently low return temperatures and keeping flow temperatures low	Radiators or other emitters should be sized and balanced carefully in order to operate between 70 C and 40 C, allowing lower operating temperatures. Heat exchangers should be sized for low return temperatures as well. A temperature optimization study to be carried out for the heat network accounting for lifecycle costs and environmental impacts.
Use of variable control principles	Use of variable speed pumps in a range of duties, two port control valves and variable flow temperature control.
Optimising the use of low carbon heat sources to supply the network	Suitable thermal store to minimize use of boiler during peaks and extend the CHP operating hours, CHP engines sized to supply at least 75%. A range of low carbon heat source solution will be considered for the future (eg heat pumps).
Delivery of a safe, high quality scheme where risks are managed and environmental impacts controlled.	Adoption of international standards (ISO 9001, ISO 14001, ISO 3100, ISO 18001, PAS 55). Compliance with the requirements of the Heat Trust scheme.

[8] CIBSE CP1 : Heat Networks: Code of Practice for the UK

7.2 CHP Contribution

Decentralised energy production through a combined heat and power (CHP) installation in combination with other fossil fuel sources and/or other renewable technologies is identified as the most cost effective mechanism for delivering carbon dioxide reductions in London. The advantage of a DH system is its flexibility and its ability to utilise a variety of heat sources, including what can be called low-grade heat, in order to supply a wide range of Consumers and Building types.

CHP entails the use of waste heat from electrical generation for space heating and domestic hot water. It is considered a Low or Zero Carbon technology (LZC) rather than a renewable technology unless a renewable fuel source is used, e.g. biomass. The advantage of CHP is high efficiency – approximately 80% to 90% overall – compared with power stations where heat is not recovered (50% efficiency).

The space heating and hot water demand profiles estimated as part of the "be lean" calculations have been combined with local hourly temperature data and non-domestic typical demand profiles. The peak heat demand requirement was estimated through the Danish standard DS 439 diversity curve[9] and incorporated in the energy model.

The energy model was developed in energy pro in order to estimate hourly energy demand and CHP contributions. No cooling demand was modelled, and it was assumed that all the electricity produced is exported to the grid at a fixed tariff. The hourly annual heat demand profile produced by energy pro can be found in Figure 11 along with some monthly profiles for winter and summer months. The configuration of the Energy Pro model can be seen in Figure 14.

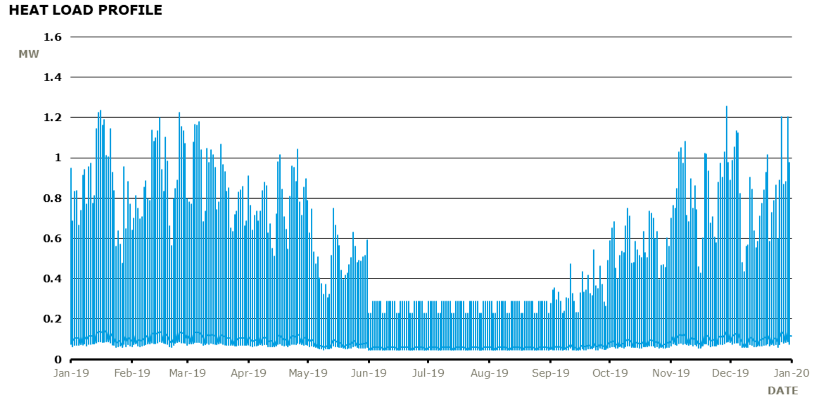


Figure 11: Annual Hourly Heat Demand Profile

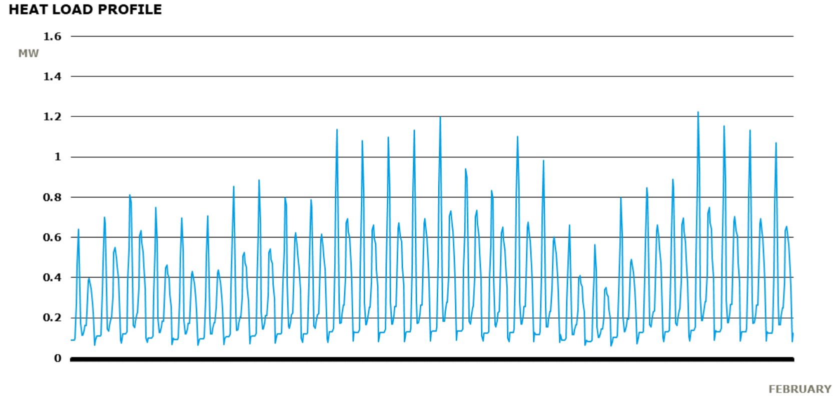


Figure 12: February Hourly Heat Demand Profile

[9] CIBSE (2015), Heat Networks: Code of Practice for the UK

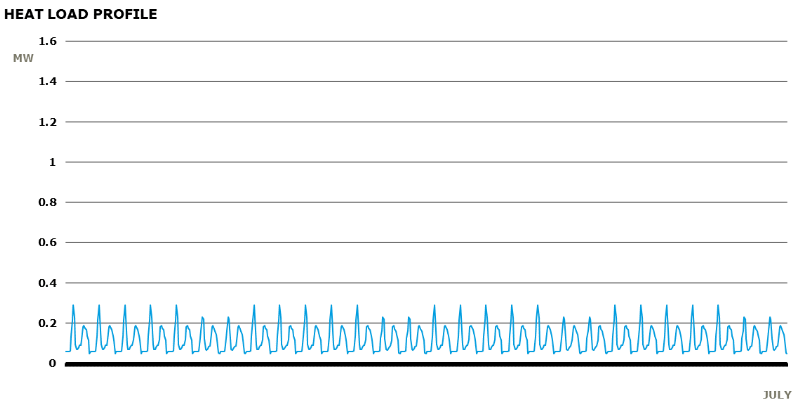


Figure 13: July Hourly Heat Demand Profile

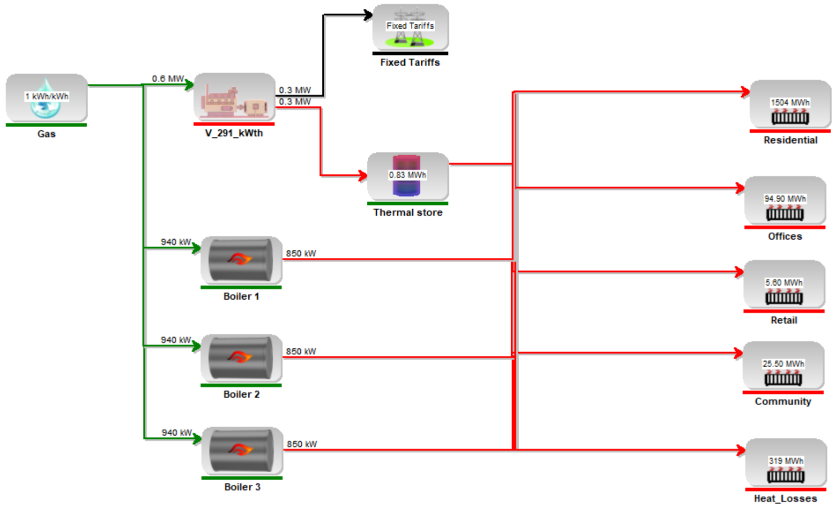


Figure 14: Energy pro model

As part of the exercise, four real CHP engines from 200 to 300 kW thermal have been modelled with appropriate thermal stores to conclude in the optimal engine size. The modelling was based on the SAP calculations with loads varying with temperatures based on historical weather data.

A CHP engine of 250 kW_{el} -291 kW_{th} backed up with 20 m^3 of thermal store and 3x850 kW low NOx gas boilers, has proven the optimal configuration covering the demand with the smallest engine footprint, while exceeding 75% CHP share of heat threshold. That CHP engine achieved 5,909 run hours and 87% of the annual heat share. The gross thermal efficiency of the CHP is 77.47% while the engine data sheets providing additional technical information are included in Appendix 2.

Figure 15 and Figure 16 set out the asset contribution in production for a typical winter and summer period respectively. It is clear that during the hours of low demand the CHP is charging the thermal store in order to meet the peak demand requirements later on the day.

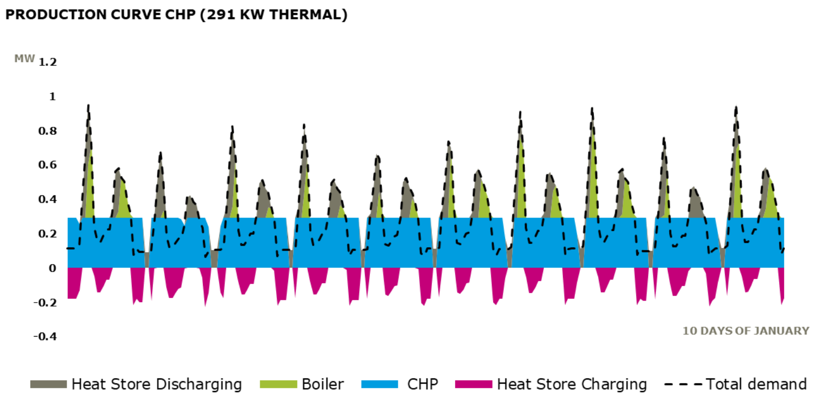


Figure 15: Production curve during winter

During summer, where the heat demand is less than winter, the boilers are rarely used since the CHP in combination with the thermal store have sufficient capacity to meet the demand.

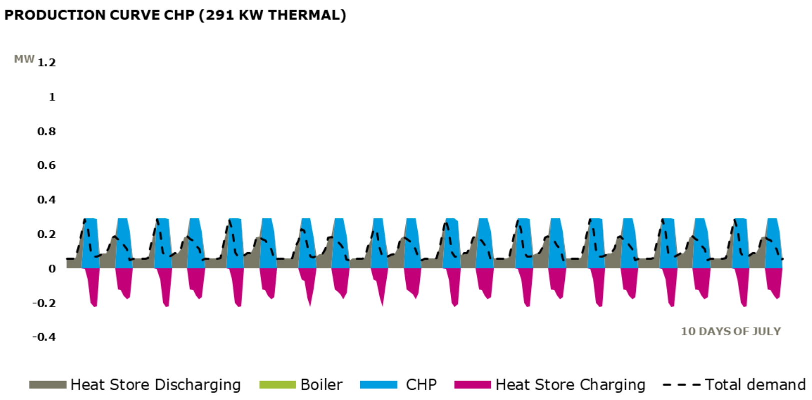


Figure 16: Production curve during summer

7.3 Energy Centre Requirements

The floor area requirement for the energy centre (including main plant items and auxiliary equipment) should be at least 171 m^2, taking into account the need for back-up/peaking boilers and thermal store. It was assumed that thermal stores would be required with a capacity equivalent to approx. 2.5-3 hours of the full CHP thermal output. This equates to a volume requirement of 20 m^3.

It is assumed that two thermal stores will be fitted in order to maintain good thermal stratification without massive height requirements. An indicative layout of the energy centre is shown in Figure 17 and Appendix 1.

The Code of Practice for Heat Networks[10] requires a minimum aspect ratio of 2:1 excluding any supports or fittings. The reason behind this constraint is that high tanks with small diameters can preserve the hot water stratified in different temperature layers which allows more heat to be stored with less heat losses.

A common solution in spaces with limited heights is to increase the number of tanks connected in series. In the present case, instead of two tanks of 3.7 m each, three tanks of 2.5 m height would be an alternative.

Space for equipment required for a future connection to a district heating transmission line, such as a heat exchanger, has been included. This was sized to be 4 m by 2 m based on engineering experience.

[10] CP1 : Heat Networks: Code of Practice for the UK

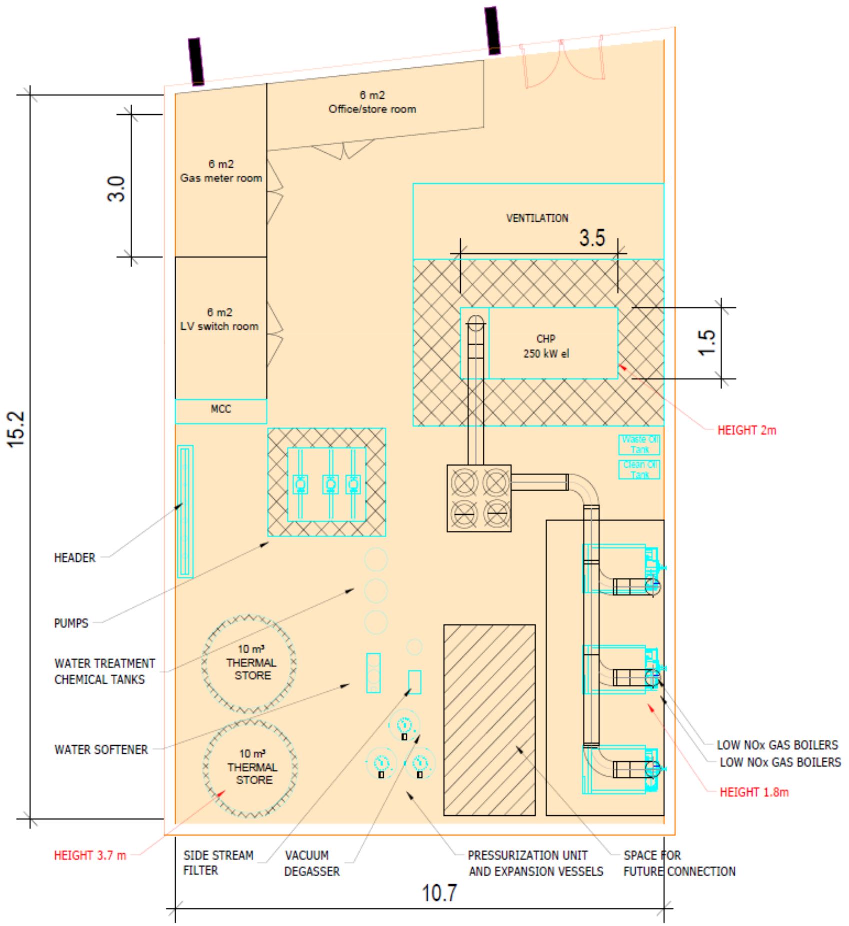


Figure 17: Energy centre layout

7.4 Environmental Considerations

CHP has relatively little visual impact when installed in a dedicated energy centre. However, there could be noise and air quality impacts.

Noise can be mitigated by the enclosure of the energy centre and reduced operation overnight.

Emissions from CHP engines depend mainly on the design and efficiency of the plant and the fuel characteristics. As with most combustion plants, the main emissions are NO_x, CO, volatile organic compounds (VOCs), and CO_2. Modifications of the engine to reduce certain pollutants can lead to an increase of other emissions. Engine selection is location specific and all of these factors need to be considered.

The impact of the emissions in the local area can be modified by adequate chimney heights (allowing a better dispersion of the pollutants) or with the installation of Selective Non-Catalytic Reduction (SNCR) or Selective Catalytic Reduction (SCR) equipment. To comply with the London Plan the CHP unit at the proposed development must achieve target NOx levels that are less than 95 $mgNOx/Nm^3$. The proposed CHP unit would achieve this target through the use of a 3-way Catalytic Converter, which would reduce the unit's NOx emissions rate to less than 50 $mgNOx/Nm^3$. Modifications to allow lower NOx levels are an option, if the updated London plans requires further reduction to meet those of ultra-low NOx boilers. The data sheet for this CHP plant can be found in the Appendix 2.

Noise can sometimes be an issue in residential building especially if the plant room is on an upper floor with occupied dwellings underneath it. The noise output from the proposed CHP plant would be 65 dB(A) at 1m. This level of noise should not be an issue especially if the plant is located in a basement plant room and only runs between 7am and Midnight. If the plant room is to be located on an upper floor it is recommended that an acoustic mat be placed under the CHP unit to reduce noise from vibration.

The Peaking Boilers proposed for this site achieve NOx emissions levels of 32.5mgNOx/kWh. The target level required under the London Plan is 40mgNOx/kWh and therefore these boilers would be compliant.

The chimney height is also relevant in terms of dispersion of the pollutants. The Local Authority must approve the chimney height during the planning permission process under the Clean Air Act 1993. Dispersion modelling will be required in the planning process. A1 Flues have been contacted by Ramboll and have provided outline guidance on the required flue heights for this proposed development. As the overriding requirements of Clause 25 of the Clean Air Act Memorandum are not applicable, the flue should terminate at a minimum of 1.8m above any structure within a 14.7m (5U) radius of the flue. Concluding to a height of 47.3m from ground level.

Clean Air Act Memorandum Clause 25.

Overriding minimum requirements for chimney height

The final corrected chimney height determined by the above procedures (method of calculation outlined in the CAAM) should be checked against the following requirements. If it does not satisfy them it should be increased appropriately:

a. a chimney should terminate at least 3m above the level of any adjacent area to which there is general access (ie ground level, roof areas or adjacent openable windows)

b. a chimney should never be less than the calculated uncorrected chimney height.

c. a chimney should never be less than the height of ***any part*** of an attached building within a distance of 5U.

Figure 18: Clean Air Act Memorandum Extract

7.5 Be Clean Results

7.5.1 Residential Buildings

The calculated regulated domestic CO_2 emissions for the "be clean" case are presented in Figure 19. The SAP calculations can be seen in Appendix 3.

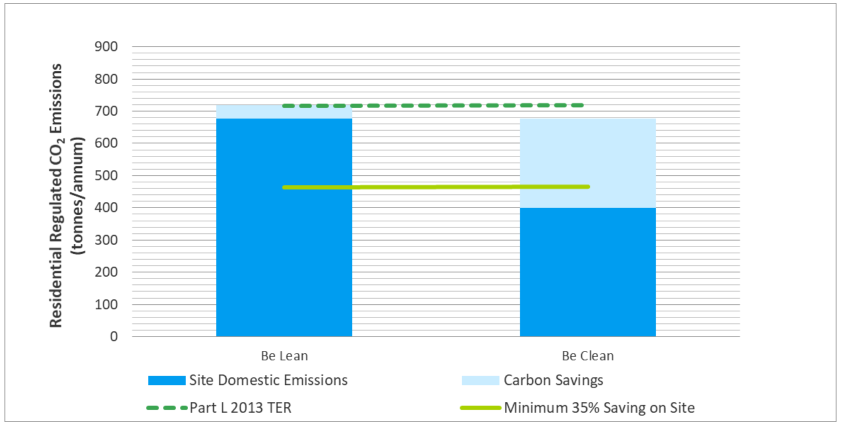


Figure 19: Domestic Be Clean Results

The results show that incorporation of a CHP district heating scheme across the site would be a sufficient measure to reduce the annual CO_2 emissions to a level acceptable under London Plan regulations.

The estimated carbon savings would be **277 tonnes per annum** and the emissions are **44% below the building regulations TER**, therefore meeting the London Plan requirement with a 9% margin.

7.5.2 Overall Site

The results from the IES modelling for the commercial buildings were added to the ones of the residential properties and the results are illustrated below. The BRUKL sheets can be found in Appendix 4.

The effect of the CHP to the commercial emissions was found to be minimal from the IES analysis, occurring due to the small heating energy requirements to the overall energy demand. The scheme's total emissions **42% below the building regulations** and so meet the London Plan requirement with a 7% margin.

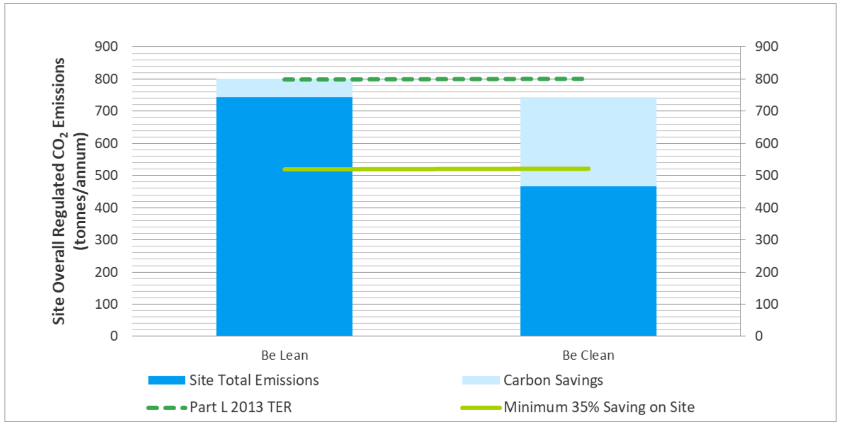


Figure 20: Non-Domestic Be Clean Results

8. BE GREEN

The results presented in section 7 demonstrate that the "be clean" measure of CHP would be sufficient to meet GLA regulations. However, it is considered good practice to follow the full energy strategy methodology to assess the potential for further savings through the use of renewable technologies.

In accordance with the GLA hierarchy (be lean, be clean, be green) Ramboll has identified that the proposed development could incorporate the following renewable energy technologies:

- Wind turbines (in suitable locations);
- Solar thermal collectors;
- Ground Source Heat Pumps;
- Water Source Heat pumps; and
- PV panels.

A high-level options appraisal has been undertaken to consider the application of renewable technologies at the proposed development.

8.1 Technology Appraisal

8.1.1 Wind Turbines

Wind turbines harness the power of the wind to produce electricity through circular motion. They can produce electricity without carbon dioxide emissions, and range in outputs from watts to megawatts.

Recently the findings of the Warwick Wind Trials have found that even after sufficient adjustment of the usually referenced NOABL wind data to account for an urban setting, the actual output has been found to be half the electrical energy claimed by turbine manufacturers.

Figure 21: Photograph of Wind Turbine (Ramboll Image Bank)

Wind turbines are not considered as an efficient option in an urban area due to low wind profiles and turbulence, leading to very low energy yields. Wind turbines are also associated with visual and acoustic impacts. It is therefore considered that wind turbines would not be appropriate for the proposed development.

8.1.2 Solar Thermal Collectors

Solar thermal collectors convert the sun's radiation into heat, which is transferred to a medium such as a water/glycol mix (to prevent freezing). Solar water heating is usually used for hot water generation, as this is a year-round demand. It is not normally used for space heating as the greatest demand is in winter, when the sun's rays are weakest. Annual incident solar radiation in the London area is about 1,100 kWh. Ideally the collectors should be mounted on a South–facing roof, although southeast and southwest will also function successfully. The collectors need to be inclined at between 10-60° from horizontal – with 35° being the optimum.

Figure 22: Photograph of Solar Thermal Array (Ramboll Image Bank Courtesy of Scanpix)

Solar hot water uses a heat collector, usually as panels on the roof in which liquid is heated by the sun. The fluid is used to heat up water that is stored in either a separate hot water cylinder or a twin hot water cylinder. There are two types of solar collector: flat plate and evacuated tubes, the latter being generally more efficient. There are a large number of manufacturers and suppliers, and an examination of products from a number of manufacturers suggests that the average output is approximately 600 kWh/m^2. Capital costs are approximately £600/m^2. Maintenance costs vary and mainly relate to replacement of parts.

Solar thermal has been discounted for this proposed development due to:

- It's limited effectiveness in high rise buildings;
- The requirement of thermal storage within the flats; and
- The effect of the high cost on the payback period.

8.1.3 Ground Source Heat Pump (GSHP)

GSHPs are a Low Carbon Technology, not a renewable system, as they require electricity to run the pumps and extract the energy from the ground. A minimum coefficient of performance (CoP) of 2.2 is required to start carbon saving, with a recommended design CoP of at least 3.5 to make the system cost-effective. For the proposed development a vertical closed loop system would be required. The system comprises of vertically drilled boreholes, usually up to 100 to 150 m deep.

Although this technology may be possible for the site, it would not be recommended in an urban area where land area is scarce and the costs and complexity of digging or drilling to install the required pipework would be excessive.

8.1.4 Water Source Heat Pump (WSHP)

Heat pumps can deliver heat with approximately three times the energy value of the electricity fed in to operate the pump and offer a way of upgrading low-grade heat with low carbon emissions. However, on district heating networks the heat pump system is usually assisted by a higher heat grade technology in order to achieve higher flow temperatures (65°C to 70°C). Even with ammonia heat pumps temperatures higher than 65 °C have a negative impact on the performance of the heat pump.

As part of this energy assessment, WSHP technology supplied by the River Thames was considered.

Past experiences demonstrate that when there is gas available on-site, WSHP technology is often financially uncompetitive when compared to technologies such as gas CHP, which also benefits from electricity sales.

This is particularly relevant in this case due to the fact that the proposed development is 200 m away from the River Thames at its closest and the resulting infrastructure costs would be high.

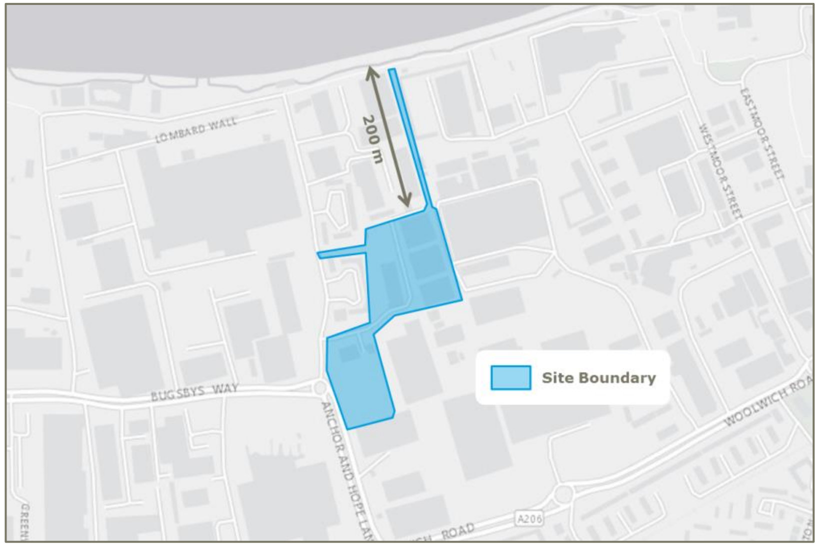


Figure 23: Site Boundary and Indication of Distance to River Thames

The plans for the proposal development include provision for a pathway linking the proposed development to the River, which may present the opportunity for location of pipes. If this cannot be utilised, then another route through privately owned land would have to be sought which could present a number of commercial and legal challenges.

Additional challenges would include the requirement for inlet and outlet pipes to be installed in the river. Return temperatures higher than that of the River are likely to have environmental implications and an environmental study would have to be conducted into the effect of potential temperature changes.

Due to the financial and commercial challenges associated with this technology, it was not considered to be a viable energy source for the proposed development.

8.1.5 Solar PV

Photovoltaic cells (PV cells) convert solar radiation directly into DC electricity. PV cells use energy from light to create electricity: when light shines on a PV cell it creates an electric field across the layers causing electricity to flow. Individual PV cells only provide a small amount of electricity, so they are generally grouped together into a module for convenience.

A key advantage of PV cells in the urban environment is their potential to be integrated into the fabric of the building. Maintenance costs are predicted to be low, requiring occasional cleaning and maintaining/ replacing tiles and inverters as necessary. There can be low land take associated with the technology provided the panels can be mounted on the roofs of buildings.

The Architect was asked to allocate the maximum floor space available for PVs. The full roof space of several buildings for the use of PV panels (Buildings D, E, F, G, H, J, M, N and O) was thus provided. Building J was not considered due to the shadow from building K.

From this available roof area, a design was made in the PV software HelioScope to determine the total capacity if the PVs are facing Southwards (165°). The outputs include a shadowing report, power and annual production figures and source of system loss. It was shown that the maximum number of PV modules that can be fitted are 840, yielding 1,377 m^2 of PV area.

The PV layout can be seen in Figure 24 while the detailed analysis can be found Appendix 4.

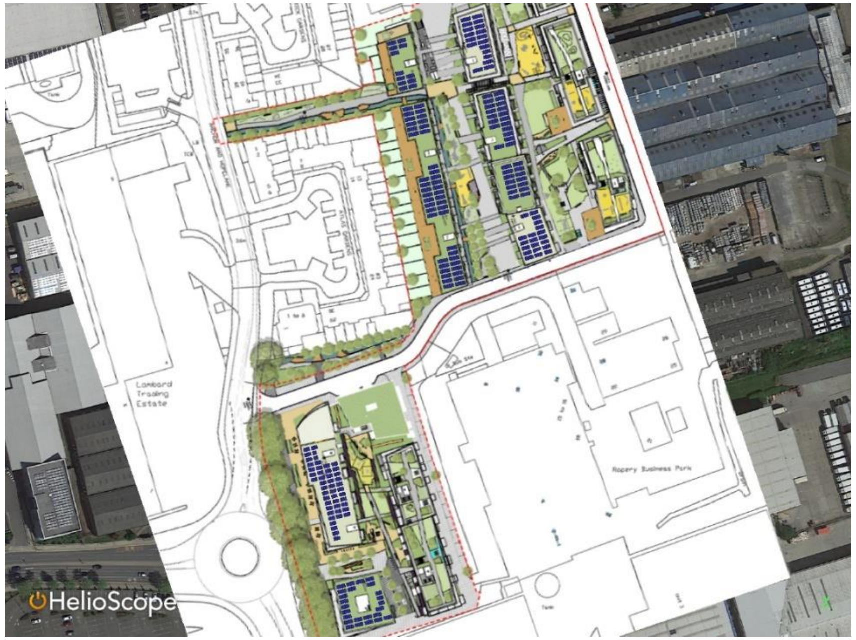


Figure 24: HelioScope detailed layout

8.2 Be Green Results

The proposed PV panel configuration and performance is based on the analysis carried out in HelioScope. The PV areas are then split between residential and commercial buildings and incorporated into a SAP compliant software for the residential. The PV characteristics can be found below

- 1.64 m^2 panels of 245 Wp, average peak output of 150 W/m^2;
- 205 kWp capacity;
- Annual production of 178.5 MWh and performance ratio of 82.3%;
- South facing, 10^o angle (as per previous London projects);
- None or very little shading; and
- 867 full load operating hours.

8.2.1 Residential Buildings

The calculated regulated domestic CO_2 emissions for the "be green" case is presented in **Error! Reference source not found.**. It was assumed that 90% of the capacity will be assigned to residential properties. The capacity was then split between each flat based on the individual to total floor area ratio and imported into SAP.

The results show the proposed PV system reduces the annual **CO_2 emissions by a further 73 tonnes (10%)**. The estimated carbon value would be **54% below the building regulations TER** and would meet the London Plan requirement with a 19% margin.

However, the "be green" measures are not suitable to meet the zero carbon homes requirement and therefore a carbon offsetting payment is likely to be required as outlined in section 10.

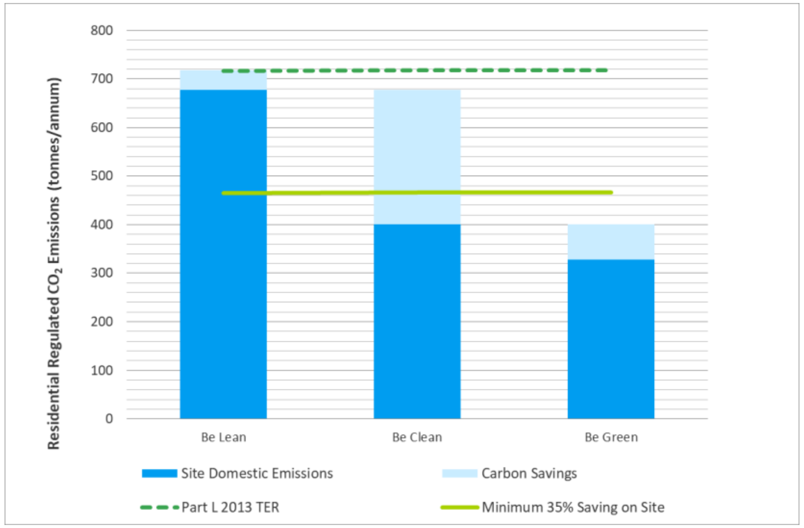


Figure 25: Domestic Be Green Results

8.2.2 Overall Site

The Zero carbon goal applies to residential buildings until 2019, so the non-domestic properties are able to achieve the building regulations with the CHP network. Overall emissions are **reduced by 9%,** leading to emissions being **51% below the building regulations TER** and thus meets the London Plan requirement with a 16% margin. Figure 26 illustrates overall "be green" emissions.

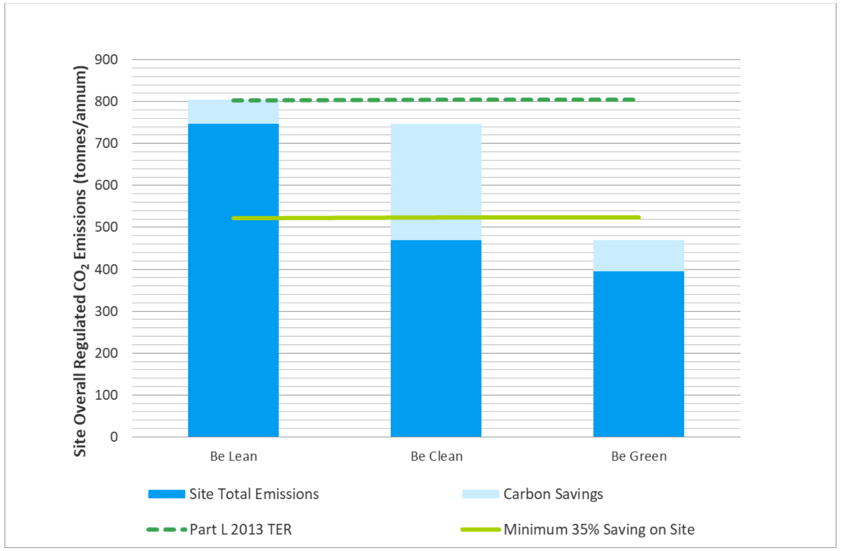


Figure 26: Total Be Green Results

9. CONCLUSIONS AND RECOMMENDATIONS

A summary of the results for each scenario is presented in Table 5 for domestic buildings:

Table 5: Regulated Domestic Carbon Dioxide Savings from SAP Modelling

	Regulated Domestic Carbon Dioxide Savings	
	Tonnes CO_2 per Annum	Percentage Reduction
Savings from Energy Demand Reduction ("Be Lean")	40	5.6%
Savings from CHP ("Be Clean")	277	38.6%
Savings from Solar PV ("Be Green")	73	10.2%
Cumulative On Site Savings	390	54.3%
Annual Savings from Off-set Payment	328	
	Offset Payment	
Cumulative Savings for Off-set Payment London Plan 2016	£19,655	
Cumulative Savings for Off-set Payment Draft London Plan 2017	£31,120	

The remaining CO_2 emissions will result in a required off-setting contribution of approximately **£19,655 per annum** for a 30-year period to meet Zero Carbon regulations. This payment will need to be made in order to adhere to London Plan Policy 5.2. According to the Draft London Plan issued in 2017 and which is still under consultation, due to the increased offset payment tariff this figure could increase to **£31,120 per annum**.

A summary of the results for non-domestic buildings is presented in Table 6.

Table 6: Non-Domestic Results Summary

	Regulated Commercial Carbon Dioxide Savings	
	Tonnes CO_2 per Annum	Percentage Reduction
Savings from Energy Demand Reduction ("Be Lean")	17	19.9%
Savings from CHP ("Be Clean")	18	20.4%
Savings from Solar PV ("Be Green")	1	1.5%
Cumulative On Site Savings	35	41.7%
Annual Savings from Off-set Payment	68	
	Offset Payment	
Cumulative Savings for Off-set Payment London Plan 2016	£4,071	
Cumulative Savings for Off-set Payment Draft London Plant 2017	£6,446	

Therefore, the total offset payment is **£23,726 per annum** for a 30-year period to meet Zero Carbon regulations for both residential and commercial properties according to the 2016 London Plan.

The total regulated emissions are presented in Figure 27.

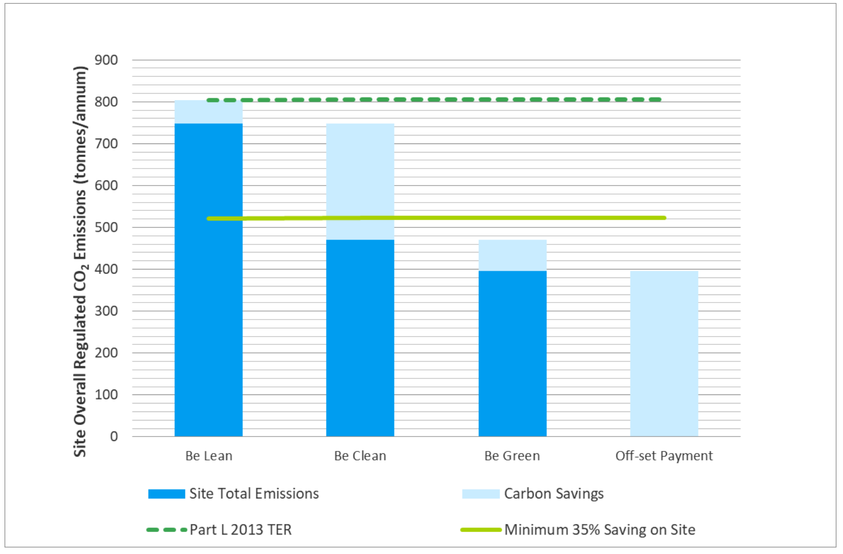


Figure 27: Total Energy Hierarchy Targets

The key observations from the assessment of the modelling scenarios are as follows:

- A centralised gas boiler system supplying heat to dwellings designed to the minimum fabric efficiency standards is not an appropriate energy strategy to meet either the building regulations target emissions rate or the London Plan requirement.

- A centralised gas boiler system supplying heat to dwellings designed with best practice fabric and ventilation standards is sufficient to meet the building regulations TER, but not the London Plan requirement; therefore it is not an appropriate strategy for energy supply.

- A site-wide heat network supplied by a gas CHP engine in combination with best practice fabric and ventilation standards is a suitable solution to meet both national buildings regulations and the London Plan requirement of reducing CO_2 emissions to 35% below Part L.

- A roof-mounted solar PV array could supply sufficient electricity to reduce the regulated residential CO_2 emissions by a further 4% of the target emission rate.

It is recommended that a heat network supplied by gas CHP and supported by solar PV is considered as the preferred option by the Applicant.

APPENDIX 1 - ENERGY CENTRE LAYOUT

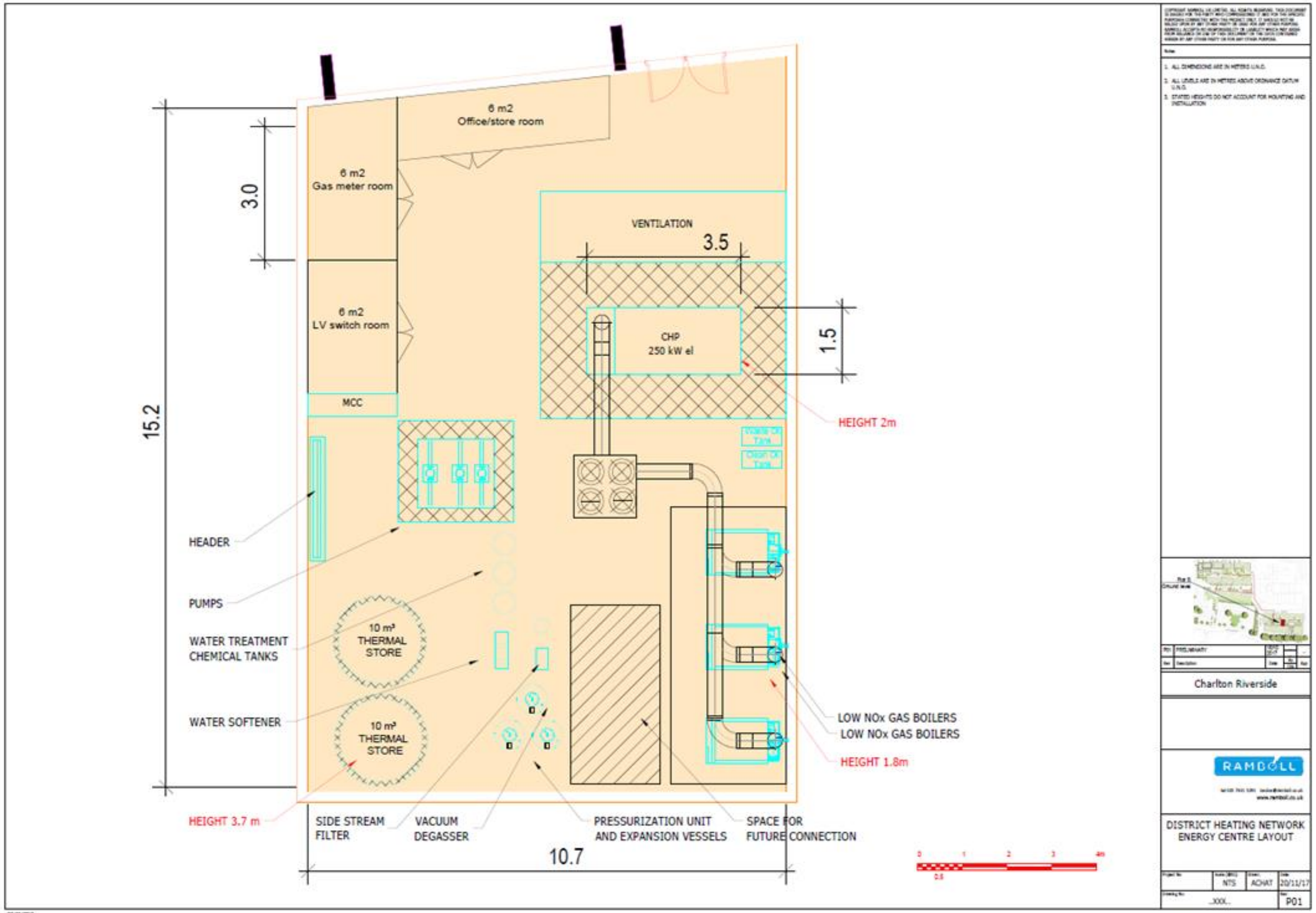


Figure 29: Energy centre indicative layout drawing

APPENDIX 2 - HEATING PLANT DATA SHEETS

Technical Datasheet

V-0250MA-070-NG-50-500_L6
-

Datasheet ref. no. TDR12025087090BHL

VEOLIA

Performance & Efficiency	Units	100	%	75	%	50	%
Electrical Power (1)	kW	250	39.7%	188	39.1%	125	37.0%
Energy Input (2)	kW	629	-	480	-	338	-
Total Useable Energy	kW	541	86.0%	411	85.6%	290	85.8%
Total Useable Heat Out (3)	kW	291	46.3%	223	46.5%	165	48.8%
Heat output from Engine (3)	kW	137	21.8%				
Heat output from Intercooler (3)	kW	23	3.7%				
Heat Output from Exhaust gases @ temp (a)	kW	153	24.3%				
Radiated & unaccounted for heat (4)	kW	42	6.7%				
Fuel Supply							
Fuel (12) / Methane number (13)	-	Natural Gas			>80		
Range of heating value (LHV): design / operation (5)	kJ/Nm3	36000			Not specified		
Fuel Mass Flow	kg/hr	49.2					
Fuel Volume Flow (5)	Nm3/hr	61.3					
Gas Supply Pressure Range (dynamic)	mbar	30-70					
Maximum gas pressure fluctuation (6)	%	10					
Exhaust							
Exhaust gas temp before cooler (7)	°C	497					
Exhaust Gas Temperature after H/E	(a) °C	120					
Exhaust Gas Mass Flow (wet)	kg/hr	1294					
Exhaust Gas Volume Flow (wet) (5)	Nm^3/hr	1019					
Exhaust Gas Volume Flow (wet) @ temp (a)	m^3/hr	1428					
Catalyst Type	-	None					
Nox emissions (dry,5% O2) (5)	mg/Nm^3	500					
Max. exhaust back pressure: after engine / after heat exchanger	mbar	50			18		
Secondary Water Circuit							
Secondary Water in temp (0% glycol)	°C	70					
Secondary water outlet temperature	°C	90.0					
Secondary Water Flow Minimum	m^3/hr	16.6					
Secondary circuit max. operating press.	bar	6					
Pressure drop across plate H/E	kPa	40					
Intercooler circuit (LT)							
Intercooler Coolant in temp (30% glycol) (8)	°C	38					
Intercooler Coolant out temp (30% glycol) (8)	°C	41.0					
Intercooler Coolant flow min. (30% Glycol) (9)	m^3/hr	7.6					
Intercooler circuit max. operating pressure (10)	bar	3					
Enclosure							
Enclosure type	-	Canopy					
Ventilation Air Volume flow (inc. combustion air) (11)	Nm^3/hr	9473					
Electrical Connections							
Voltage	V	400					
Frequency	Hz	50					
Current per phase @ PF0.9 & 100% CHP duty	A	401					
Miscellaneous							
Engine Manufacturer	-	MAN					
Engine type	-	A306					
Generator Manufacturer	-	LEROY SOMER					
Generator type	-	LSA 47.2 S4/4p					
Weights & Dimensions							
Weight genset only (wet)	kg	4330					
Weight canopy only inc. fans	kg	800					
Weight complete canopied unit (wet)	kg	5130					
Weight complete containerised unit (wet)	kg	N/A					
Dimensions & termination points							

Tolerances

(1) Alternator gross power at nominal voltage & power factor = 1.0
(2) +5%, ref. ISO 3046-1
(3) +/- 8%
(4) Guidance only
(5) Where normal (N) conditions are 0°C, 101.325 Pa
(6) Ref. ISO 15550
(7) +/- 8%, Ref. ISO 15550
(8) +/- 2°C, Ref. ISO 15550
(9) +/- 10 %, ref. ISO 15550, adj, for coolant 30% glycol,70% water
(10) +/- 5%, Ref. ISO 15550
(11) Where normal (N) conditions are 25°C, 101.325 Pa, Rel. humidity 30%
(12) Fuel quality requirements are defined by the engine mfg.
(13) Min. methane number as defined by the engine mfg.

Efficiency specifications are based on an engine in new condition. An abatement in efficiency over the service life is reduced with observance of the maintenance requirements.

Unless otherwise specified, all data is based on full engine load with the respective indicated media temperatures and subject to technical improvements. The generator output measured at the generator terminals serves as the basis for the delivered electrical power. All power and efficiency specifications are gross specifications. The operating fluids and plant system layout must conform to the 'Technical instructions' of Veolia CHP.

Power reduction due to installation at altitude > 300m a.s.l. and/or air suction temperature > 25°C shall be determined specifically for each project according "TI-049 Load reduction".

In order to comply with the Veolia policy of continuous improvement this information is subject to change without prior notice. Issued: 30/09/2015

Figure 30: CHP Engine data sheet

APPENDIX 3 – SAP WORKSHEETS

BE LEAN

Table 7: Be Lean Calculation Details

				DER	TER	DFEE	TFEE	TFA
Total number of flats	**Number of flats**	**Dwelling Type**	**Location**	**kg CO_2/m^2/year**	**kg CO_2/m^2/year**	**kWh/m^2/year**	**kWh/m^2/year**	**m^2**
	0		**Ground**	18	20	35	39	39
144	**126**	**Studio**	**Mid Floor**	17	18	27	31	39
	18		**Roof**	18	20	35	39	39
	0		**Ground**	17	18	35	38	50
202	**182**	**1 Bed**	**Mid Floor**	15	16	27	30	50
	20		**Roof**	17	18	35	38	50
	31		**Ground**	16	16	34	38	66
291	**229**	**2 Bed Apt**	**Mid Floor**	14	15	26	29	66
	31		**Roof**	16	16	34	37	66
	11		**Ground**	16	16	34	38	79
11	**0**	**2 Bed Townhouses**	**Mid Floor**	14	15	26	29	79
	0		**Roof**	16	16	34	37	79
	16		**Ground**	15	15	34	38	80
108	**79**	**3 Bed Apt**	**Mid Floor**	13	14	26	29	80
	13		**Roof**	15	15	34	37	80
	12		**Ground**	15	15	34	38	93

				DER	TER	DFEE	TFEE	TFA
Total number of flats	**Number of flats**	**Dwelling Type**	**Location**	**kg CO_2/m^2/year**	**kg CO_2/m^2/year**	**kWh/m²/year**	**kWh/m²/year**	**m²**
12	**0**	**3 Bed Townhouses**	**Mid Floor**	13	14	26	29	93
	0		**Roof**	15	15	34	37	93
	1		**Ground**	14	15	35	38	94
3	**2**	**4 Bed Apt**	**Mid Floor**	12	13	27	30	94
	0		**Roof**	14	14	34	37	94

Table 8: Be Lean Summary

Total Floor Area	m²	45,829
Average TER	kg CO_2/m^2/year	15.66
Average DER	kg CO_2/m^2/year	14.78
Average DFEE	kWh/m²/year	28.44
Average TFEE	kWh/m²/year	31.38
Compliance		**PASS**
% Improvement DER/TER		6%
% Improvement DFEE/TFEE		9%

BE CLEAN

Table 9: Be Clean Calculation Details

				DER	TER	DFEE	TFEE	TFA
Total number of flats	**Number of flats**	**Dwelling Type**	**Location**	**kg CO_2/m^2/year**	**kg CO_2/m^2/year**	**kWh/m^2/year**	**kWh/m^2/year**	**m^2**
	0		**Ground**	10	20	35	39	10
144	**126**	**144**	**Mid Floor**	10	18	27	31	10
	18		**Roof**	10	20	35	39	10
	0		**Ground**	10	18	35	38	10
202	**182**	**202**	**Mid Floor**	9	16	27	30	9
	20		**Roof**	10	18	35	38	10
	31		**Ground**	9	16	34	37	9
291	**229**	**291**	**Mid Floor**	8	15	26	29	8
	31		**Roof**	9	16	34	37	9
	11		**Ground**	9	16	34	37	9
11	**0**	**11**	**Mid Floor**	8	15	26	29	8
	0		**Roof**	9	16	34	37	9
	16		**Ground**	9	15	34	38	9
108	**79**	**108**	**Mid Floor**	8	14	26	29	8
	13		**Roof**	9	15	34	37	9
	12		**Ground**	9	15	34	38	9

				DER	TER	DFEE	TFEE	TFA
Total number of flats	**Number of flats**	**Dwelling Type**	**Location**	**kg CO_2/m^2/year**	**kg CO_2/m^2/year**	**kWh/m^2/year**	**kWh/m^2/year**	**m^2**
12	**0**	**12**	**Mid Floor**	8	14	26	29	8
	0		**Roof**	9	15	34	37	9
	1		**Ground**	8	15	35	38	8
3	**2**	**3**	**Mid Floor**	8	13	27	30	8
	0		**Roof**	8	14	34	37	8

Table 10: Be Clean Summary

Total Floor Area	m^2	45,829
Average TER	kg CO_2/m^2/year	15.67
Average DER	kg CO_2/m^2/year	8.74
Average DFEE	kWh/m^2/year	28.41
Average TFEE	kWh/m^2/year	31.36
Compliance		**PASS**
% Improvement DER/TER		44%
% Improvement DFEE/TFEE		9%

BE GREEN

Table 11: Be Green Calculation Details

				DER	TER	DFEE	TFEE	TFA
Total number of flats	**Number of flats**	**Dwelling Type**	**Location**	**kg CO_2/m^2/year**	**kg CO_2/m^2/year**	**kWh/m²/year**	**kWh/m²/year**	**m²**
	0		**Ground**	8	20	35	39	39
144	**126**	**Studio**	**Mid Floor**	8	18	27	31	39
	18		**Roof**	9	20	35	39	39
	0		**Ground**	8	18	35	38	50
202	**182**	**1 Bed**	**Mid Floor**	7	16	27	30	50
	20		**Roof**	8	18	35	38	50
	31		**Ground**	8	16	34	37	66
291	**229**	**2 Bed Apt**	**Mid Floor**	7	15	26	29	66
	31		**Roof**	8	16	34	37	66
	11		**Ground**	8	16	34	37	79
11	**0**	**2 Bed Townhouses**	**Mid Floor**	7	15	26	29	79
	0		**Roof**	8	16	34	37	79
	16		**Ground**	7	15	34	38	80
108	**79**	**3 Bed Apt**	**Mid Floor**	6	14	26	29	80
	13		**Roof**	7	15	34	37	80
	12		**Ground**	7	15	34	38	93

				DER	TER	DFEE	TFEE	TFA
Total number of flats	**Number of flats**	**Dwelling Type**	**Location**	**kg CO_2/m^2/year**	**kg CO_2/m^2/year**	**kWh/m²/year**	**kWh/m²/year**	**m²**
12	**0**	**3 Bed Townhouses**	**Mid Floor**	6	14	26	29	93
	0		**Roof**	7	15	34	37	93
	1		**Ground**	7	15	35	38	94
3	**2**	**4 Bed Apt**	**Mid Floor**	6	13	27	30	94
	0		**Roof**	7	14	34	37	94

Table 12: Be Green Summary

Total Floor Area	m²	45,829
Average TER	kg CO_2/m^2/year	15.67
Average DER	kg CO_2/m^2/year	7.15
Average DFEE	kWh/m²/year	28.41
Average TFEE	kWh/m²/year	31.36
Compliance		**PASS**
% Improvement DER/TER		54%
% Improvement DFEE/TFEE		9%

APPENDIX 4 – BRUKL AND DER SHEETS

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Charlton Riverside-BS-OFFICE-Be Lean

As designed

Date: Fri Oct 12 15:21:58 2018

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.10

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.10

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

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	21.1
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	21.1
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	16.9
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.18	0.18	LV000014:Surf[6]
Floor	0.25	0.13	0.13	LV000000:Surf[0]
Roof	0.25	-	-	UNKNOWN
Windows***, roof windows, and rooflights	2.2	1.43	1.43	LV000014:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = 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- Charlton Riverside Heating and Cooling

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.86	4	0	0	0.85
Standard value	0.91*	3.2	N/A	N/A	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

"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
WC	-	-	0.4	-	-	-	-	-	-	-	N/A
Office 1F - S	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - N	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - WC	-	-	0.4	-	-	-	-	-	-	-	N/A
Office 1F - E1	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - E2	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - W2	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - W1	-	1.1	0	-	-	-	-	-	-	-	N/A
Office-S	-	1.1	0	-	-	-	-	-	-	-	N/A
Office-W	-	1.1	0	-	-	-	-	-	-	-	N/A
Office-W	-	1.1	0	-	-	-	-	-	-	-	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	
WC	-	120	-	50
Office 1F - S	120	-	-	453
Office 1F - N	120	-	-	460

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
Office 1F - WC	-	120	-	49
Office 1F - E1	120	-	-	256
Office 1F - E2	120	-	-	249
Office 1F - W2	120	-	-	191
Office 1F - W1	120	-	-	209
Office-S	120	-	-	378
Office-W	120	-	-	446
Office-W	120	-	-	437

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?
WC	N/A	N/A
Office 1F - S	NO (-17.7%)	YES
Office 1F - N	NO (-31.1%)	YES
Office 1F - WC	N/A	N/A
Office 1F - E1	NO (-21.8%)	YES
Office 1F - E2	NO (-4.6%)	YES
Office 1F - W2	NO (-10.9%)	YES
Office 1F - W1	NO (-8.4%)	YES
Office-S	NO (-3.3%)	YES
Office-W	NO (-5.5%)	YES
Office-W	NO (-30.3%)	YES

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?	YES
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	587.5	587.5
External area [m²]	819.4	819.4
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	745.96	486.44
Average U-value [W/m²K]	0.91	0.59
Alpha value* [%]	10	10

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

Building Use

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

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	27.25	15.19
Cooling	10.51	9.5
Auxiliary	4.48	2.78
Lighting	5.27	21.64
Hot water	3.42	3.07
Equipment*	41.32	41.32
TOTAL**	**50.94**	**52.18**

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

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	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]	195.89	176.71
Primary energy* [kWh/m²]	98.09	123.81
Total emissions [kg/m²]	16.9	21.1

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	82.7	113.2	27.2	10.5	4.5	0.84	2.99	0.86	4
	Notional	47.1	129.6	15.2	9.5	2.8	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 Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	**U_{i-Typ}**	**U_{i-Min}**	**Surface where the minimum value occurs***
Wall	0.23	0.18	LV000014:Surf[6]
Floor	0.2	0.13	LV000000:Surf[0]
Roof	0.15	-	UNKNOWN
Windows, roof windows, and rooflights	1.5	1.43	LV000014:Surf[0]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

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

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

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Charlton Riverside-BS-OFFICE-Be Clean — As designed

Date: Fri Oct 12 15:25:42 2018

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.10

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.10

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

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	21.1
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	21.1
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	16.8
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.18	0.18	LV000014:Surf[6]
Floor	0.25	0.13	0.13	LV000000:Surf[0]
Roof	0.25	-	-	UNKNOWN
Windows***, roof windows, and rooflights	2.2	1.43	1.43	LV000014:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = 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- Charlton Riverside Heating and Cooling

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.86	4	0	0	0.85
Standard value	0.91*	3.2	N/A	N/A	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system	YES				
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

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

1- CHECK2-CHP

	CHPQA quality index	CHP electrical efficiency
This building	105	0.4
Standard value	105	0.2

Local mechanical ventilation, exhaust, and terminal units

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

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	**Zone**	**Standard**
WC	-	-	0.4	-	-	-	-	-	-	-	N/A
Office 1F - S	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - N	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - WC	-	-	0.4	-	-	-	-	-	-	-	N/A
Office 1F - E1	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - E2	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - W2	-	1.1	0	-	-	-	-	-	-	-	N/A
Office 1F - W1	-	1.1	0	-	-	-	-	-	-	-	N/A
Office-S	-	1.1	0	-	-	-	-	-	-	-	N/A
Office-W	-	1.1	0	-	-	-	-	-	-	-	N/A
Office-W	-	1.1	0	-	-	-	-	-	-	-	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	
WC	-	120	-	50

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Office 1F - S	120	-	-	453
Office 1F - N	120	-	-	460
Office 1F - WC	-	120	-	49
Office 1F - E1	120	-	-	256
Office 1F - E2	120	-	-	249
Office 1F - W2	120	-	-	191
Office 1F - W1	120	-	-	209
Office-S	120	-	-	378
Office-W	120	-	-	446
Office-W	120	-	-	437

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?
WC	N/A	N/A
Office 1F - S	NO (-17.7%)	YES
Office 1F - N	NO (-31.1%)	YES
Office 1F - WC	N/A	N/A
Office 1F - E1	NO (-21.8%)	YES
Office 1F - E2	NO (-4.6%)	YES
Office 1F - W2	NO (-10.9%)	YES
Office 1F - W1	NO (-8.4%)	YES
Office-S	NO (-3.3%)	YES
Office-W	NO (-5.5%)	YES
Office-W	NO (-30.3%)	YES

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?	YES
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	587.5	587.5
External area [m^2]	819.4	819.4
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	745.96	486.44
Average U-value [W/m^{2}K]	0.91	0.59
Alpha value* [%]	10	10

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

Building Use

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

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

	Actual	Notional
Heating	27.41	15.19
Cooling	10.51	9.5
Auxiliary	4.48	2.78
Lighting	5.27	21.64
Hot water	3.42	3.07
Equipment*	41.32	41.32
TOTAL**	**50.94**	**52.18**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0.15	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	195.89	176.71
Primary energy* [kWh/m^2]	97.81	123.81
Total emissions [kg/m^2]	16.8	21.1

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

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	82.7	113.2	27	10.5	4.5	0.84	2.99	0.86	4
	Notional	47.1	129.6	15.2	9.5	2.8	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 Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U_{i-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.18	LV000014:Surf[6]
Floor	0.2	0.13	LV000000:Surf[0]
Roof	0.15	-	UNKNOWN
Windows, roof windows, and rooflights	1.5	1.43	LV000014:Surf[0]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

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

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

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

DER Worksheet
Design - Draft

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Mr Orestis Angelidis	Assessor number	1
Client		Last modified	11/10/2018
Address	A 2B4P A Charlton Riverside, London, SE10 0NU		

1. Overall dwelling dimensions

		Area (m^2)			Average storey height (m)			Volume (m^3)	
Lowest occupied		80.00	(1a)	x	3.00	(2a)	=	240.00	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	80.00	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			240.00	(5)

2. Ventilation rate

			m^3 per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)

				Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.15	(18)
Number of sides on which the dwelling is sheltered		3	(19)
Shelter factor	1 - [0.075 x (19)] =	0.78	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.12	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.15	0.15	0.14	0.13	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.14	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	76.50	(23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.24	0.25	0.25	(24a)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.24	0.25	0.25	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Door			1.89	x	1.00	=	1.89			(26)
Window			12.48	x	1.33	=	16.55			(27)
External wall			11.52	x	0.18	=	2.07			(29a)
Party wall			78.11	x	0.00	=	0.00			(32)
Roof			80.00	x	0.13	=	10.40			(30)
Total area of external elements ∑A, m²			105.89							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	30.91	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		2.37	(36)
Total fabric heat loss	(33) + (36) =	33.28	(37)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	21.04	20.81	20.58	19.43	19.20	18.05	18.05	17.82	18.51	19.20	19.66	20.12	(38)
Heat transfer coefficient, W/K (37)m + (38)m	54.33	54.10	53.87	52.71	52.48	51.33	51.33	51.10	51.79	52.48	52.94	53.41	
Average = ∑(39)1...12/12 =												52.66	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	0.68	0.68	0.67	0.66	0.66	0.64	0.64	0.64	0.65	0.66	0.66	0.67	
Average = ∑(40)1...12/12 =												0.66	(40)
Number of days in month (Table 1a)	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.46	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	92.69	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)	101.96	98.25	94.55	90.84	87.13	83.42	83.42	87.13	90.84	94.55	98.25	101.96	
∑(44)1...12 =												1112.32	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	151.21	132.25	136.47	118.97	114.16	98.51	91.28	104.75	106.00	123.53	134.85	146.44	
∑(45)1...12 =												1458.42	(45)
Distribution loss 0.15 x (45)m	22.68	19.84	20.47	17.85	17.12	14.78	13.69	15.71	15.90	18.53	20.23	21.97	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	0.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	0.00	(48)
Temperature factor from Table 2b	1.00	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.00	(50)
Enter (50) or (54) in (55)	0.00	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(57)

Primary circuit loss for each month from Table 3

23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)

Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m

174.47	153.26	159.73	141.49	137.42	121.02	114.55	128.01	128.51	146.80	157.36	169.70	(62)

Solar DHW input calculated using Appendix G or Appendix H

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)

Output from water heater for each month (kWh/month) (62)m + (63)m

174.47	153.26	159.73	141.49	137.42	121.02	114.55	128.01	128.51	146.80	157.36	169.70

∑(64)1...12 = 1732.32 (64)

Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]

68.89	60.78	63.99	57.57	56.57	50.76	48.96	53.44	53.26	59.69	62.85	67.30	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	123.14	123.14	123.14	123.14	123.14	123.14	123.14	123.14	123.14	123.14	123.14	123.14	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	20.01	17.77	14.46	10.94	8.18	6.91	7.46	9.70	13.02	16.53	19.29	20.57	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	219.44	221.72	215.98	203.76	188.34	173.85	164.17	161.89	167.63	179.84	195.27	209.76	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	35.31	35.31	35.31	35.31	35.31	35.31	35.31	35.31	35.31	35.31	35.31	35.31	(69)
Pump and fan gains (Table 5a)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (Table 5)	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	-98.51	(71)
Water heating gains (Table 5)	92.59	90.45	86.00	79.96	76.03	70.51	65.81	71.83	73.97	80.22	87.29	90.46	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	391.98	389.88	376.38	354.61	332.50	311.21	297.38	303.36	314.56	336.54	361.79	380.73	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthWest	0.77	x	12.48	x	36.79	x 0.9 x	0.40	x	0.80	=	101.83	(79)

Solar gains in watts ∑(74)m...(82)m

101.83	173.45	237.33	294.06	329.37	326.99	315.25	288.91	256.97	191.70	121.97	87.14	(83)

Total gains - internal and solar (73)m + (83)m

493.81	563.34	613.70	648.66	661.87	638.19	612.63	592.27	571.53	528.24	483.76	467.87	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(˚C) 21.00 (85)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area n1,m (see Table 9a)	1.00	0.99	0.96	0.88	0.72	0.51	0.37	0.40	0.62	0.90	0.99	1.00	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

20.47	20.60	20.76	20.91	20.98	21.00	21.00	21.00	21.00	20.91	20.67	20.45	(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

20.36	20.36	20.36	20.38	20.38	20.39	20.39	20.40	20.39	20.38	20.37	20.37	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.99	0.98	0.95	0.86	0.68	0.47	0.32	0.34	0.57	0.88	0.98	1.00	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

19.64	19.83	20.06	20.28	20.37	20.39	20.39	20.40	20.38	20.28	19.95	19.62	(90)

Living area fraction — Living area ÷ (4) = 0.29 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

19.88	20.05	20.26	20.46	20.54	20.57	20.57	20.57	20.56	20.46	20.15	19.86	(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

19.88	20.05	20.26	20.46	20.54	20.57	20.57	20.57	20.56	20.46	20.15	19.86	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm													
	0.99	0.98	0.95	0.86	0.69	0.48	0.33	0.36	0.58	0.88	0.98	1.00	(94)
Useful gains, ηmGm, W (94)m x (84)m													
	490.74	553.69	584.32	557.61	455.82	305.83	203.56	212.95	332.76	465.06	475.02	465.80	(95)
Monthly average external temperature from Table U1													
	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]													
	846.26	819.54	741.13	609.55	464.09	306.21	203.57	212.98	334.54	517.67	691.03	836.10	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m													
	264.51	178.65	116.67	37.40	6.16	0.00	0.00	0.00	0.00	39.15	155.53	275.50	

∑(98)1...5, 10...12 = 1073.55 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) 13.42 (99)

9b. Energy requirements - community heating scheme

Fraction of space heat from secondary/supplementary system (table 11)	'0' if none	0.00	(301)
Fraction of space heat from community system	1 - (301) =	1.00	(302)
Fraction of community heat from boilers		1.00	(303a)
Fraction of total space heat from community boilers	(302) x (303a) =	1.00	(304a)
Factor for control and charging method (Table 4c(3)) for community space heating		1.00	(305)
Factor for charging method (Table 4c(3)) for community water heating		1.00	(305a)
Distribution loss factor (Table 12c) for community heating system		1.15	(306)

Space heating

Annual space heating requirement	1073.55			(98)
Space heat from boilers		(98) x (304a) x (305) x (306) =	1234.59	(307a)

Water heating

Annual water heating requirement	1732.32			(64)
Water heat from boilers		(64) x (303a) x (305a) x (306) =	1992.16	(310a)
Electricity used for heat distribution		0.01 × [(307a)...(307e) + (310a)...(310e)] =	32.27	(313)

Electricity for pumps, fans and electric keep-hot (Table 4f)

mechanical ventilation fans - balanced, extract or positive input from outside 351.36 (330a)

Total electricity for the above, kWh/year		351.36	(331)
Electricity for lighting (Appendix L)		353.42	(332)
Total delivered energy for all uses	(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	3931.53	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from boilers	1234.59	x	4.24	x 0.01 =	52.35	(340a)
Water heating from boilers	1992.16	x	4.24	x 0.01 =	84.47	(342a)
Pumps and fans	351.36	x	13.19	x 0.01 =	46.34	(349)
Electricity for lighting	353.42	x	13.19	x 0.01 =	46.62	(350)
Additional standing charges					120.00	(351)
Total energy cost			(340a)...(342e) + (345)...(354) =		349.77	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.18	(357)
SAP value	83.61	
SAP rating (section 13)	84	(358)
SAP band	B	

12b. CO_2 emissions - community heating scheme

	Energy kWh/year		Emission factor		Emissions (kg/year)	
Emissions from other sources (space heating)						
Efficiency of boilers	86.00					(367a)
CO2 emissions from boilers [(307a)+(310a)] x 100 ÷ (367a) =	3752.04	x	0.216	=	810.44	(367)
Electrical energy for community heat distribution	32.27	x	0.519	=	16.75	(372)
Total CO2 associated with community systems					827.19	(373)
Total CO2 associated with space and water heating					827.19	(376)
Pumps and fans	351.36	x	0.519	=	182.36	(378)
Electricity for lighting	353.42	x	0.519	=	183.42	(379)
Total CO_2, kg/year				(376)..(382) =	1192.97	(383)
Dwelling CO_2 emission rate				(383) ÷ (4) =	14.91	(384)
EI value					87.21	
EI rating (section 14)					87	(385)
EI band					B	

13b. Primary energy - community heating scheme

	Energy kWh/year		Primary factor		Primary energy (kWh/year)	
Primary energy from other sources (space heating)						
Efficiency of boilers	86.00					(367a)
Primary energy from boilers [(307a)+(310a)] x 100 ÷ (367a) =	3752.04	x	1.22	=	4577.48	(367)
Electrical energy for community heat distribution	32.27	x	3.07	=	99.06	(372)
Total primary energy associated with community systems					4676.55	(373)
Total primary energy associated with space and water heating					4676.55	(376)
Pumps and fans	351.36	x	3.07	=	1078.68	(378)
Electricity for lighting	353.42	x	3.07	=	1084.99	(379)
Primary energy kWh/year					6840.22	(383)

Dwelling primary energy rate kWh/m2/year	85.50	(384)

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Mr Orestis Angelidis	Assessor number	1
Client		Last modified	11/10/2018
Address	A 2B4P A Charlton Riverside, London, SE10 0NU		

1. Overall dwelling dimensions

		Area (m^2)			Average storey height (m)			Volume (m^3)	
Lowest occupied		39.00	(1a)	x	3.00	(2a)	=	117.00	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	39.00	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			117.00	(5)

2. Ventilation rate

			m^3 per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)

				Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.15	(18)
Number of sides on which the dwelling is sheltered		3	(19)
Shelter factor	1 - [0.075 x (19)] =	0.78	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.12	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.15	0.15	0.14	0.13	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.14	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	76.50	(23c)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.24	0.25	0.25	(24a)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.24	0.25	0.25	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Door			1.89	x	1.00	=	1.89			(26)
Window			5.72	x	1.33	=	7.58			(27)
External wall			10.78	x	0.18	=	1.94			(29a)
Party wall			62.01	x	0.00	=	0.00			(32)
Roof			39.00	x	0.13	=	5.07			(30)
Total area of external elements ∑A, m²			57.39							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	16.48	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		1.49	(36)
Total fabric heat loss	(33) + (36) =	17.97	(37)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	10.26	10.15	10.03	9.47	9.36	8.80	8.80	8.69	9.03	9.36	9.59	9.81	(38)
Heat transfer coefficient, W/K (37)m + (38)m	28.23	28.12	28.01	27.45	27.33	26.77	26.77	26.66	27.00	27.33	27.56	27.78	
Average = ∑(39)1...12/12 =												27.42	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	0.72	0.72	0.72	0.70	0.70	0.69	0.69	0.68	0.69	0.70	0.71	0.71	
Average = ∑(40)1...12/12 =												0.70	(40)
Number of days in month (Table 1a)	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	1.38	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	66.98	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)	73.67	70.99	68.31	65.64	62.96	60.28	60.28	62.96	65.64	68.31	70.99	73.67	
∑(44)1...12 =												803.71	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	109.25	95.56	98.60	85.97	82.49	71.18	65.96	75.69	76.59	89.26	97.43	105.81	
∑(45)1...12 =												1053.78	(45)
Distribution loss 0.15 x (45)m	16.39	14.33	14.79	12.89	12.37	10.68	9.89	11.35	11.49	13.39	14.62	15.87	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	0.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	0.00	(48)
Temperature factor from Table 2b	1.00	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.00	(50)
Enter (50) or (54) in (55)	0.00	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(57)

Primary circuit loss for each month from Table 3

23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)

Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m

132.52	116.57	121.87	108.48	105.75	93.69	89.22	98.95	99.10	112.52	119.95	129.07	(62)

Solar DHW input calculated using Appendix G or Appendix H

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)

Output from water heater for each month (kWh/month) (62)m + (63)m

132.52	116.57	121.87	108.48	105.75	93.69	89.22	98.95	99.10	112.52	119.95	129.07

∑(64)1...12 = 1327.68 (64)

Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]

54.94	48.58	51.40	46.59	46.04	41.68	40.54	43.78	43.48	48.29	50.41	53.79	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	69.00	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	10.97	9.75	7.93	6.00	4.49	3.79	4.09	5.32	7.14	9.06	10.58	11.28	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	119.03	120.26	117.15	110.52	102.16	94.30	89.05	87.81	90.92	97.55	105.91	113.78	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	29.90	29.90	29.90	29.90	29.90	29.90	29.90	29.90	29.90	29.90	29.90	29.90	(69)
Pump and fan gains (Table 5a)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (Table 5)	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	-55.20	(71)
Water heating gains (Table 5)	73.84	72.29	69.08	64.71	61.88	57.88	54.49	58.84	60.38	64.90	70.01	72.30	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	247.54	246.00	237.86	224.94	212.22	199.67	191.33	195.67	202.15	215.22	230.20	241.05	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthWest	0.77	x	5.72	x	36.79	x 0.9 x	0.40	x	0.80	=	46.67	(79)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	46.67	79.50	108.77	134.78	150.96	149.87	144.49	132.42	117.78	87.86	55.90	39.94	(83)
Total gains - internal and solar (73)m + (83)m	294.21	325.50	346.63	359.71	363.18	349.54	335.82	328.08	319.93	303.08	286.10	280.99	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(˚C) 21.00 (85)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area n1,m (see Table 9a)	0.99	0.97	0.94	0.85	0.69	0.49	0.35	0.37	0.58	0.85	0.97	0.99	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

20.53	20.65	20.79	20.93	20.99	21.00	21.00	21.00	21.00	20.93	20.72	20.51	(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(˚C)

20.32	20.32	20.32	20.34	20.34	20.35	20.35	20.36	20.35	20.34	20.33	20.33	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.99	0.97	0.92	0.82	0.64	0.44	0.30	0.32	0.53	0.82	0.96	0.99	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

19.70	19.87	20.07	20.26	20.33	20.35	20.35	20.36	20.35	20.27	19.99	19.68	(90)

Living area fraction — Living area ÷ (4) = 0.49 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

20.10	20.25	20.42	20.58	20.65	20.67	20.67	20.67	20.66	20.59	20.35	20.08	(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

20.10	20.25	20.42	20.58	20.65	20.67	20.67	20.67	20.66	20.59	20.35	20.08	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm													
	0.98	0.97	0.93	0.83	0.66	0.46	0.32	0.35	0.55	0.83	0.96	0.99	(94)
Useful gains, ηmGm, W (94)m x (84)m													
	289.46	314.62	321.18	297.42	240.51	162.21	108.90	113.80	176.33	252.47	274.89	277.46	(95)
Monthly average external temperature from Table U1													
	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]													
	446.13	431.54	389.85	320.67	244.59	162.44	108.91	113.82	177.17	273.16	365.07	441.23	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m													
	116.57	78.57	51.09	16.74	3.04	0.00	0.00	0.00	0.00	15.39	64.93	121.84	

∑(98)1...5, 10...12 = 468.17 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 12.00 (99)

9b. Energy requirements - community heating scheme

Fraction of space heat from secondary/supplementary system (table 11)	'0' if none	0.00	(301)
Fraction of space heat from community system	1 - (301) =	1.00	(302)
Fraction of community heat from boilers		0.14	(303a)
Fraction of community heat from CHP		0.86	(303b)
Fraction of total space heat from community CHP	(302) x (303a) =	0.86	(304a)
Fraction of total space heat from community boilers	(302) x (303b) =	0.14	(304b)
Factor for control and charging method (Table 4c(3)) for community space heating		1.00	(305)
Factor for charging method (Table 4c(3)) for community water heating		1.00	(305a)
Distribution loss factor (Table 12c) for community heating system		1.15	(306)

Space heating

Annual space heating requirement	468.17			(98)
Space heat from CHP		(98) x (304a) x (305) x (306) =	463.02	(307a)
Space heat from boilers		(98) x (304b) x (305) x (306) =	75.38	(307b)

Water heating

Annual water heating requirement	1327.68			(64)
Water heat from CHP		(64) x (303a) x (305a) x (306) =	1313.08	(310a)
Water heat from boilers		(64) x (303b) x (305a) x (306) =	213.76	(310b)

Electricity used for heat distribution	0.01 × [(307a)...(307e) + (310a)...(310e)] =	20.65	(313)

Electricity for pumps, fans and electric keep-hot (Table 4f)

mechanical ventilation fans - balanced, extract or positive input from outside	171.29		(330a)
Total electricity for the above, kWh/year		171.29	(331)
Electricity for lighting (Appendix L)		193.78	(332)
Total delivered energy for all uses	(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	2430.29	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from CHP	463.02	x	2.97	x 0.01 =	13.75	(340a)
Space heating from boilers	75.38	x	4.24	x 0.01 =	3.20	(340b)
Water heating from CHP	1313.08	x	2.97	x 0.01 =	39.00	(342a)
Water heating from boilers	213.76	x	4.24	x 0.01 =	9.06	(342b)
Pumps and fans	171.29	x	13.19	x 0.01 =	22.59	(349)
Electricity for lighting	193.78	x	13.19	x 0.01 =	25.56	(350)
Additional standing charges					120.00	(351)
Total energy cost			(340a)...(342e) + (345)...(354) =		233.16	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.17	(357)
SAP value	83.74	
SAP rating (section 13)	84	(358)
SAP band	B	

12b. CO_2 emissions - community heating scheme

	Energy kWh/year		Emission factor		Emissions (kg/year)	
Emissions from community CHP (space and water heating)						
Power efficiency of CHP unit	35.70					(361)
Heat efficiency of CHP unit	41.77					(362)
Space heating from CHP (307a) × 100 ÷ (362) =	1108.5112	x	0.2160	=	239.4384	(363)
less credit emissions for electricity	-395.7436	x	0.5190	=	-205.3909	(364)
Water heated by CHP	3143.6207	x	0.2160	=	679.0221	(365)
less credit emissions for electricity	-1122.2871	x	0.5190	=	-582.4670	(366)
Emissions from other sources (space heating)						
Efficiency of boilers	86.00					(367b)
CO2 emissions from boilers [(307b)+(310b)] x 100 ÷ (367b) =	336.20	x	0.216	=	72.62	(368)
Electrical energy for community heat distribution	20.65	x	0.519	=	10.72	(372)
Total CO2 associated with community systems					213.94	(373)
Total CO2 associated with space and water heating					213.94	(376)
Pumps and fans	171.29	x	0.519	=	88.90	(378)
Electricity for lighting	193.78	x	0.519	=	100.57	(379)
Total CO_2, kg/year				(376)..(382) =	403.41	(383)
Dwelling CO_2 emission rate				(383) ÷ (4) =	10.34	(384)
EI value					93.56	
EI rating (section 14)					94	(385)

EI band	A

13b. Primary energy - community heating scheme

		Energy kWh/year		Primary factor		Primary energy (kWh/year)	
Primary Energy from community CHP (space and water heating)							
Power efficiency of CHP unit		35.70					(361)
Heat efficiency of CHP unit		41.77					(362)
Space heating from CHP	(307a) × 100 ÷ (362) =	1108.51	x	1.22	=	1352.38	(363)
less credit energy for electricity		-395.74	x	3.07	=	-1214.93	(364)
Water heated by CHP		3143.62	x	1.22	=	3835.22	(365)
less credit energy for electricity		-1122.29	x	3.07	=	-3445.42	(366)
Primary energy from other sources (space heating)							
Efficiency of boilers		86.00					(367b)
Primary energy from boilers	[(307b)+(310b)] x 100 ÷ (367b) =	336.20	x	1.22	=	410.16	(368)
Electrical energy for community heat distribution		20.65	x	3.07	=	63.40	(372)
Total primary energy associated with community systems						1000.81	(373)
Total primary energy associated with space and water heating						1000.81	(376)
Pumps and fans		171.29	x	3.07	=	525.85	(378)
Electricity for lighting		193.78	x	3.07	=	594.89	(379)
Primary energy kWh/year						2121.56	(383)
Dwelling primary energy rate kWh/m2/year						54.40	(384)

DER Worksheet
Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Mr Orestis Angelidis	Assessor number	1
Client		Last modified	26/11/2018
Address	A 2B4P A Charlton Riverside, London, SE10 0NU		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		66.00	(1a)	x	3.00	(2a)	=	198.00	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	66.00	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			198.00	(5)

2. Ventilation rate

			m³ per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs (6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.15	(18)
Number of sides on which the dwelling is sheltered		3	(19)
Shelter factor	1 - [0.075 x (19)] =	0.78	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.12	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.15	0.15	0.14	0.13	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.14	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	76.50	(23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.24	0.25	0.25	(24a)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.24	0.25	0.25	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Door			1.89	x	1.00	=	1.89			(26)
Window			9.88	x	1.33	=	13.10			(27)
External wall			14.12	x	0.18	=	2.54			(29a)
Party wall			72.36	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			25.89							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	17.53	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		2.03	(36)
Total fabric heat loss	(33) + (36) =	19.56	(37)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	17.36	17.17	16.98	16.03	15.84	14.89	14.89	14.70	15.27	15.84	16.22	16.60	(38)
Heat transfer coefficient, W/K (37)m + (38)m	36.92	36.73	36.54	35.59	35.40	34.46	34.46	34.27	34.84	35.40	35.78	36.16	
Average = ∑(39)1...12/12 =												35.55	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	0.56	0.56	0.55	0.54	0.54	0.52	0.52	0.52	0.53	0.54	0.54	0.55	
Average = ∑(40)1...12/12 =												0.54	(40)
Number of days in month (Table 1a)	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.15	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	85.15	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)	93.66	90.26	86.85	83.45	80.04	76.63	76.63	80.04	83.45	86.85	90.26	93.66	
∑(44)1...12 =												1021.79	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	138.90	121.48	125.36	109.29	104.87	90.49	83.86	96.23	97.38	113.48	123.87	134.52	
∑(45)1...12 =												1339.73	(45)
Distribution loss 0.15 x (45)m	20.84	18.22	18.80	16.39	15.73	13.57	12.58	14.43	14.61	17.02	18.58	20.18	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	0.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	0.00	(48)
Temperature factor from Table 2b	1.00	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.00	(50)
Enter (50) or (54) in (55)	0.00	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(57)

Primary circuit loss for each month from Table 3

23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

Combi loss for each month from Table 3a, 3b or 3c

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)

Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m

162.16	142.50	148.62	131.80	128.13	113.01	107.12	119.49	119.89	136.74	146.39	157.78	(62)

Solar DHW input calculated using Appendix G or Appendix H

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)

Output from water heater for each month (kWh/month) (62)m + (63)m

162.16	142.50	148.62	131.80	128.13	113.01	107.12	119.49	119.89	136.74	146.39	157.78

∑(64)1...12 = 1613.63 (64)

Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]

64.79	57.20	60.29	54.35	53.48	48.10	46.49	50.61	50.39	56.34	59.20	63.34	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	107.26	107.26	107.26	107.26	107.26	107.26	107.26	107.26	107.26	107.26	107.26	107.26	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.25	15.32	12.46	9.43	7.05	5.95	6.43	8.36	11.22	14.25	16.63	17.73	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	187.79	189.74	184.83	174.37	161.18	148.77	140.49	138.54	143.45	153.90	167.10	179.50	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	33.73	33.73	33.73	33.73	33.73	33.73	33.73	33.73	33.73	33.73	33.73	33.73	(69)
Pump and fan gains (Table 5a)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (Table 5)	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	-85.81	(71)
Water heating gains (Table 5)	87.09	85.12	81.04	75.49	71.88	66.80	62.49	68.02	69.98	75.73	82.22	85.13	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	347.30	345.36	333.50	314.47	295.28	276.71	264.59	270.09	279.83	299.06	321.12	337.54	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthWest	0.77	x	9.88	x	36.79	x 0.9 x	0.40	x	0.80	=	80.61	(79)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	80.61	137.32	187.88	232.80	260.75	258.87	249.57	228.72	203.44	151.76	96.56	68.99	(83)
Total gains - internal and solar (73)m + (83)m	427.92	482.67	521.38	547.26	556.04	535.57	514.16	498.81	483.27	450.82	417.68	406.53	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(˚C) 21.00 (85)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area n1,m (see Table 9a)	0.99	0.97	0.91	0.77	0.59	0.41	0.29	0.32	0.50	0.79	0.96	0.99	(86)
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)	20.69	20.80	20.91	20.98	21.00	21.00	21.00	21.00	21.00	20.98	20.85	20.67	(87)

Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

20.47	20.47	20.47	20.48	20.49	20.50	20.50	20.50	20.50	20.49	20.48	20.48	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.99	0.96	0.89	0.74	0.56	0.38	0.26	0.28	0.46	0.76	0.95	0.99	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

20.06	20.22	20.37	20.47	20.49	20.50	20.50	20.50	20.50	20.47	20.29	20.04	(90)

Living area fraction — Living area ÷ (4) = 0.38 (91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2

20.30	20.44	20.57	20.66	20.68	20.69	20.69	20.69	20.68	20.66	20.50	20.28	(92)

Apply adjustment to the mean internal temperature from Table 4e where appropriate

20.30	20.44	20.57	20.66	20.68	20.69	20.69	20.69	20.68	20.66	20.50	20.28	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.99	0.96	0.90	0.75	0.57	0.39	0.27	0.29	0.47	0.77	0.95	0.99	(94)
Useful gains, ηmGm, W (94)m x (84)m	421.76	463.68	467.76	410.65	317.27	209.76	140.86	147.00	229.30	347.84	398.88	402.27	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	590.66	570.73	514.26	418.67	317.90	209.77	140.86	147.00	229.38	356.27	479.61	581.50	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	125.66	71.94	34.59	5.78	0.47	0.00	0.00	0.00	0.00	6.28	58.13	133.34	

∑(98)1...5, 10...12 = 436.18 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) 6.61 (99)

9b. Energy requirements - community heating scheme

Fraction of space heat from secondary/supplementary system (table 11)	'0' if none	0.00	(301)
Fraction of space heat from community system	1 - (301) =	1.00	(302)
Fraction of community heat from boilers		0.14	(303a)
Fraction of community heat from CHP		0.86	(303b)
Fraction of total space heat from community CHP	(302) x (303a) =	0.86	(304a)
Fraction of total space heat from community boilers	(302) x (303b) =	0.14	(304b)
Factor for control and charging method (Table 4c(3)) for community space heating		1.00	(305)
Factor for charging method (Table 4c(3)) for community water heating		1.00	(305a)
Distribution loss factor (Table 12c) for community heating system		1.15	(306)

Space heating

Annual space heating requirement	436.18			(98)
Space heat from CHP		(98) x (304a) x (305) x (306) =	431.39	(307a)
Space heat from boilers		(98) x (304b) x (305) x (306) =	70.23	(307b)

Water heating

Annual water heating requirement	1613.63			(64)
Water heat from CHP		(64) x (303a) x (305a) x (306) =	1595.88	(310a)
Water heat from boilers		(64) x (303b) x (305a) x (306) =	259.79	(310b)
Electricity used for heat distribution		0.01 × [(307a)...(307e) + (310a)...(310e)] =	23.57	(313)

Electricity for pumps, fans and electric keep-hot (Table 4f)						
mechanical ventilation fans - balanced, extract or positive input from outside			289.87			(330a)
Total electricity for the above, kWh/year					289.87	(331)
Electricity for lighting (Appendix L)					304.58	(332)
Energy saving/generation technologies						
electricity generated by PV (Appendix M)					-202.29	(333)
Total delivered energy for all uses				(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	2749.45	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from CHP	431.39	x	2.97	x 0.01 =	12.81	(340a)
Space heating from boilers	70.23	x	4.24	x 0.01 =	2.98	(340b)
Water heating from CHP	1595.88	x	2.97	x 0.01 =	47.40	(342a)
Water heating from boilers	259.79	x	4.24	x 0.01 =	11.02	(342b)
Pumps and fans	289.87	x	13.19	x 0.01 =	38.23	(349)
Electricity for lighting	304.58	x	13.19	x 0.01 =	40.17	(350)
Additional standing charges					120.00	(351)
Energy saving/generation technologies						
pv savings	-202.29	x	13.19	x 0.01 =	-26.68	(352)
Total energy cost				(340a)...(342e) + (345)...(354) =	245.93	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	0.93	(357)
SAP value	87.02	
SAP rating (section 13)	87	(358)
SAP band	B	

12b. CO_2 emissions - community heating scheme

		Energy kWh/year		Emission factor		Emissions (kg/year)	
Emissions from community CHP (space and water heating)							
Power efficiency of CHP unit		35.70					(361)
Heat efficiency of CHP unit		41.77					(362)
Space heating from CHP	(307a) × 100 ÷ (362) =	1032.7758	x	0.2160	=	223.0796	(363)
less credit emissions for electricity		-368.7057	x	0.5190	=	-191.3583	(364)
Water heated by CHP		3820.6801	x	0.2160	=	825.2669	(365)
less credit emissions for electricity		-1364.0004	x	0.5190	=	-707.9162	(366)
Emissions from other sources (space heating)							
Efficiency of boilers		86.00					(367b)
CO2 emissions from boilers	[(307b)+(310b)] x 100 ÷ (367b) =	383.74	x	0.216	=	82.89	(368)
Electrical energy for community heat distribution		23.57	x	0.519	=	12.23	(372)
Total CO2 associated with community systems						244.20	(373)
Total CO2 associated with space and water heating						244.20	(376)
Pumps and fans		289.87	x	0.519	=	150.44	(378)
Electricity for lighting		304.58	x	0.519	=	158.08	(379)
Energy saving/generation technologies							

pv savings		-202.29	x	0.519	=	-104.99	(380)
Total CO_2, kg/year				(376)..(382) =		447.73	(383)
Dwelling CO_2 emission rate				(383) ÷ (4) =		6.78	(384)
EI value						94.59	
EI rating (section 14)						95	(385)
EI band						A	

13b. Primary energy - community heating scheme

		Energy kWh/year		Primary factor		Primary energy (kWh/year)	
Primary Energy from community CHP (space and water heating)							
Power efficiency of CHP unit		35.70					(361)
Heat efficiency of CHP unit		41.77					(362)
Space heating from CHP	(307a) × 100 ÷ (362) =	1032.78	x	1.22	=	1259.99	(363)
less credit energy for electricity		-368.71	x	3.07	=	-1131.93	(364)
Water heated by CHP		3820.68	x	1.22	=	4661.23	(365)
less credit energy for electricity		-1364.00	x	3.07	=	-4187.48	(366)
Primary energy from other sources (space heating)							
Efficiency of boilers		86.00					(367b)
Primary energy from boilers	[(307b)+(310b)] x 100 ÷ (367b) =	383.74	x	1.22	=	468.17	(368)
Electrical energy for community heat distribution		23.57	x	3.07	=	72.37	(372)
Total primary energy associated with community systems						1142.35	(373)
Total primary energy associated with space and water heating						1142.35	(376)
Pumps and fans		289.87	x	3.07	=	889.91	(378)
Electricity for lighting		304.58	x	3.07	=	935.07	(379)
Energy saving/generation technologies							
Electricity generated - PVs		-202.29	x	3.07	=	-621.03	(380)
Primary energy kWh/year						2346.29	(383)
Dwelling primary energy rate kWh/m2/year						35.55	(384)

APPENDIX 5 - HELIOSCOPE SUMMARY

Charlton site V3 Charlton site, 51.491889, 0.031527

Report

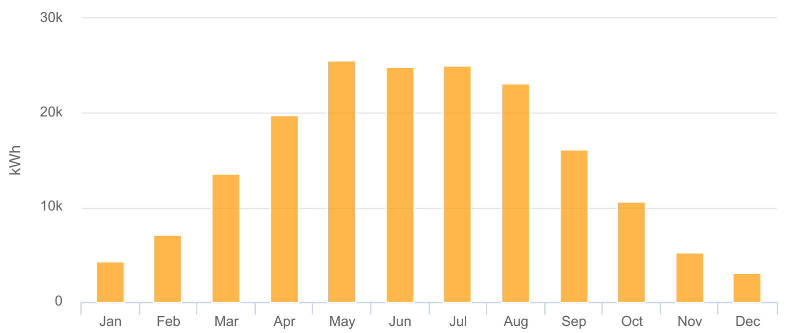
Project Name	Charlton site
Project Address	51.491889, 0.031527
Prepared By	Peter Ritter peter.ritter@ramboll.com

System Metrics

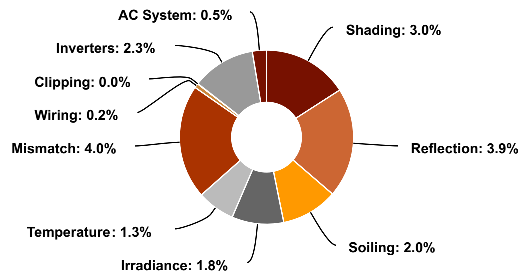
Design	Charlton site V3
Module DC Nameplate	205.8 kW
Inverter AC Nameplate	195.0 kW Load Ratio: 1.06
Annual Production	178.5 MWh
Performance Ratio	82.3%
kWh/kWp	867.3
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)
Simulator Version	33b33aee60-8741125e19-5c067e27e5-350f6f2a5c

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	975.5	
	POA Irradiance	1,054.2	8.1%
	Shaded Irradiance	1,022.2	-3.0%
	Irradiance after Reflection	982.4	-3.9%
	Irradiance after Soiling	962.7	-2.0%
	Total Collector Irradiance	**962.8**	**0.0%**
Energy (kWh)	Nameplate	197,825.8	
	Output at Irradiance Levels	194,182.3	-1.8%
	Output at Cell Temperature Derate	191,593.5	-1.3%
	Output After Mismatch	183,838.3	-4.0%
	Optimal DC Output	183,561.5	-0.2%
	Constrained DC Output	183,539.9	0.0%
	Inverter Output	179,396.0	-2.3%
	Energy to Grid	**178,499.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		14.1 °C
	Avg. Operating Cell Temp		19.5 °C
Simulation Metrics			
		Operating Hours	4545
		Solved Hours	4545

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Characterization
1 STH-245 (1 Soltech)	Spec Sheet Characterization, PAN

Component Characterizations

Device	Characterization
Sunny Tripower 17000TL (SMA)	Default Characterization
Sunny Tripower 20000TL-US (SMA)	Modified CEC
Sunny Tripower 12000TL (SMA)	Spec Sheet
Sunny Tripower 25000TL-30 (SMA)	Default Characterization
Sunny Tripower Core1 CEC (SMA)	Default Characterization

Components

Component	Name	Count
Inverters	Sunny Tripower 17000TL (SMA)	4 (68.0 kW)
Inverters	Sunny Tripower 20000TL-US (SMA)	2 (40.0 kW)
Inverters	Sunny Tripower 12000TL (SMA)	1 (12.0 kW)
Inverters	Sunny Tripower 25000TL-30 (SMA)	1 (25.0 kW)
Inverters	Sunny Tripower Core1 CEC (SMA)	1 (50.0 kW)
Strings	10 AWG (Copper)	39 (1,286.3 m)
Module	1 Soltech, 1 STH-245 (245W)	840 (205.8 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	6-24	Along Racking
Wiring Zone 2	12	13-24	Along Racking
Wiring Zone 3	12	13-24	Along Racking
Wiring Zone 4	12	13-24	Along Racking
Wiring Zone 5	12	6-24	Along Racking
Wiring Zone 6	12	6-24	Along Racking
Wiring Zone 7	12	15-24	Along Racking
Wiring Zone 8	12	14-24	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
B-1	Fixed Tilt	Portrait (Vertical)	10°	165°	1.0 m	1x5	18	88	21.6 kW
B-2	Fixed Tilt	Portrait (Vertical)	10°	166°	1.0 m	1x5	14	70	17.2 kW
B-3	Fixed Tilt	Portrait (Vertical)	10°	163°	1.0 m	1x4	20	80	19.6 kW
B- 4	Fixed Tilt	Portrait (Vertical)	10°	166°	1.0 m	1x3	48	142	34.8 kW
B-5	Fixed Tilt	Portrait (Vertical)	10°	166°	1.0 m	1x5	19	95	23.3 kW
B-6	Fixed Tilt	Portrait (Vertical)	10°	167°	1.0 m	1x5	44	220	53.9 kW
B-7	Fixed Tilt	Portrait (Vertical)	10°	166°	1.0 m	1x4	12	48	11.8 kW
B-8	Fixed Tilt	Portrait (Vertical)	10°	166°	1.0 m	1x4	25	97	23.8 kW