Manor Road / Richmond

Revised Energy Strategy

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Audit sheet.

Rev.	Date	Description of change / purpose of issue	Prepared	Reviewed	Authorised
01	25/10/2019	Draft planning report for team comments	L. Wille	M. Wang	C. Pottage
02	07/11/2019	Second draft issue for the record	M. Wang	L. Wille	-
03	19/11/2019	Third draft issue for legal review	L. Wille	M. Wang	-
04	21/11/2019	Issued for revised planning application	M. Wang	L. Wille	C. Pottage

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Contents.

1. Executive Summary

The Application

This Revised Energy Strategy has been prepared by Hoare Lea on behalf of Avanton Richmond Development Ltd ('the Applicant') in support of the planning application for the development at Manor Road ('the Amended Proposed Development') within the London Borough of Richmond Upon Thames ('LBRuT').

The Amended Proposed Development will provide new homes (including affordable homes) and commercial areas.

Policies & Drivers

This document summarises the pertinent policies and requirements applicable to the Amended Proposed Development. Of these, the principal target is to achieve 'zero carbon' for the new build residential aspects, corresponding to a 100% reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013), and a 35% reduction for commercial areas, as set out in the London Plan (2016) and set out in the LBRuT Local Plan (2018). The commercial areas are required to meet BREEAM New Construction 'Excellent' standard (where feasible).

Further, it is targeted to achieve 10.8% carbon emission reduction for residential areas at the Be Lean stage, exceeding the target set within the Draft London Plan (2019) for residential developments.

Approach

A sample of dwellings of the Amended Proposed Development have been assessed using Part L1A approved SAP methodology. Non-residential spaces have been modelled using Part L compliant software. This has provided the basis for the analysis of the designed building and the consideration of all applicable passive design, energy efficiency and Low or Zero Carbon (LZC) technologies.

The assessment makes use of the Mayor of London's Energy Hierarchy Be lean – Be Clean – Be Green, and the cooling hierarchy from the London Plan (2016).

In line with current GLA guidance, carbon emission reductions have been calculated using the carbon factors set out in the draft SAP10 guidance.

This energy strategy sets out how the highest standards of sustainable design and construction are proposed for the development.

1.1 Be Lean – Passive Design & Energy Efficient Measures

Passive design measures to be implemented at the Amended Proposed Development include:

- Efficient building fabric and air tight construction, minimising heat losses and heat gains
- Optimised glazing performance to ensure good daylight to the spaces whilst limiting solar gains.
- Efficient space heating systems with zonal, programmable and thermostatic controls, with separate programmer for hot water.
- Efficient low-energy lighting throughout all dwellings. External and communal lighting will be coupled to daylight and presence detection sensors to minimise unnecessary use.
- Efficient mechanical ventilation with heat recovery which will limit the need for space heating, aid the mitigation of high internal temperatures in summer months, and maintain good indoor air quality.
- Appropriately insulated pipework and ductwork (and air sealing to ductwork) to minimise losses and gains.
- Variable speed pumps and fans to minimise energy consumption for distribution of services
- Thermally broken lintels and balconies

These measures are expected to lead to 11.1% carbon emission reductions prior to the implementation of low or Zero Carbon technologies.

This represents an improvement on the Original Proposed Development, and the Amended Proposed Development is expected to meet the draft London Plan policy target for carbon reduction at the 'Be Lean' stage.

1.2 Be Clean – Infrastructure & Low-Carbon Supply of Energy

The "Be Clean" stage encourages developments to supply energy as cleanly as possible. An assessment of the energy networks in the area has been undertaken but has shown there are no networks in close vicinity to the site.

An assessment has been carried out to determine likely implications of centralised energy distribution at the development.

It is proposed to include full trenching between all buildings, with space allocation made for future district heating pipework. Space allocation has also been made for future plate heat exchangers at the ground floor to each building, and the pipework in all risers has been sized to be able to serve each building bottom-up in future, in addition to the current top-down arrangement. A further space allocation has been made for a plate heat exchanger at the ground floor near to the site entrance, so that a future potential district energy network would only require one connection point. Pipework sleeves will be included through the building envelope at the location of each future plate heat exchanger to ease future connection, should a viable option become available in the vicinity of the site in future.

It is expected there would be limited benefit from the increased diversity that would arise from combining the heating plant in one location, due to the modular nature of Air Source Heat Pump plant. Moreover, the combined amount of Air Source Heat Pumps required would not fit in one single rooftop location on-site.

Full distribution pipework is not proposed to be installed for the following reasons:

- Increased energy losses related to the distribution between buildings would be estimated to result in an additional 30 tonnes CO_2 emission per annum
- Capped pipework provided, if never used, will result in additional embodied carbon spent at no additional benefit to the scheme. It is also difficult to stop the pipework corroding/ deteriorating over time.
- The embodied carbon content of installing 700m of pipework would be significant as well, and with no certainty this will ever be required, this additional use of resources cannot be justified.

This proposed upgrade to the futureproofing for a potential future distribution network has been made in response to GLA policy, and in discussion with energy officers

Please refer to Appendix K for further detail.

1.3 Be Green – On-site Renewable Energy Generation

The inclusion of on-site renewable energy generation has been assessed, and it is proposed to implement Air Source Heat Pumps (ASHP) and PVs in the design. This is expected to result in significant carbon emission reductions of approx. 45.8% compared to the Part L 'gas boiler baseline'.

ASHP are proposed to provide a proportion of heating and hot water to dwellings, with top-up provided by direct electric energy.

A PV array of 310m^2 (approx. 48kWp) is also proposed as part of this strategy, providing an estimated 8.3tonnes of carbon savings to the site per annum. Please refer to Appendix G for further information on this.

1.4 Overall Carbon Dioxide Emissions Reduction

The development as proposed will deliver buildings which are very energy efficient, resulting in a reduction in energy and carbon consumed by the site. It will target improvements over what is required by the Building Regulations, and the London Plan targets set for on-site carbon emission reductions.

The CO_2 emissions reductions are presented separately for residential and non-residential areas, as outlined in section 9 of the GLA guidance on preparing energy assessments.

1.5 Dwellings

Table 1 below outlines the anticipated CO_2 emissions reductions and carbon offset payment. The combined on-site savings and zero carbon target shortfall is used to calculate a total carbon offset payment of £414,100.

New build dwellings	Regulated Carbon Dioxide Emission Savings (tonnes CO_2/yr)	
	Regulated	Unregulated
Baseline: Part L 2013 Building Regulations with SAP 10 carbon factors	429	216
After energy demand reduction (Be Lean)	383	216
After heat network / CHP (Be Clean)	383	216
After renewable energy (Be Green)	230	216
	Regulated domestic carbon dioxide savings	
	(tonnes CO_2/yr)	(%)
Savings from energy demand reduction	46	10.8%
Savings from heat network / CHP	0	0%
Savings from renewable energy	153	35.6%
Cumulative on-site savings	199	46.4%
Annual savings from offset payment	230	-
Offset Payment Rate (£/tCO_2)	£1,800	
Total Offset Payment	£414,100	

Table 1: Dwellings Summary of regulated carbon emissions saving and carbon offset payment.

1.6 Non-residential areas

Table 2 below outlines the anticipated CO_2 emissions reductions and carbon offset payment. The on-site target is used to confirm that no carbon offset payment is expected for these retail areas.

New build commercial space	Regulated Carbon Dioxide Emission Savings (tonnes CO_2/yr)	
	Regulated	Unregulated
Baseline: Part L 2013 Building Regulations with SAP 10 carbon factors	58	27
After energy demand reduction (Be Lean)	50	27
After heat network / CHP (Be Clean)	50	27
After renewable energy (Be Green)	34	27
	Regulated non-domestic carbon dioxide savings	
	(tonnes CO_2/yr)	(%)
Savings from energy demand reduction	8	13.5%
Savings from heat network / CHP	0	0%
Savings from renewable energy	16	27.8%
Cumulative on site savings	24	41.3%
Total target savings	20	35%
Shortfall	N/A	-
Offset Payment Rate (£/tCO_2)	£1,800	
Total Offset Payment	£0	

Table 2: Retail Summary of regulated carbon emissions saving and carbon offset payment.

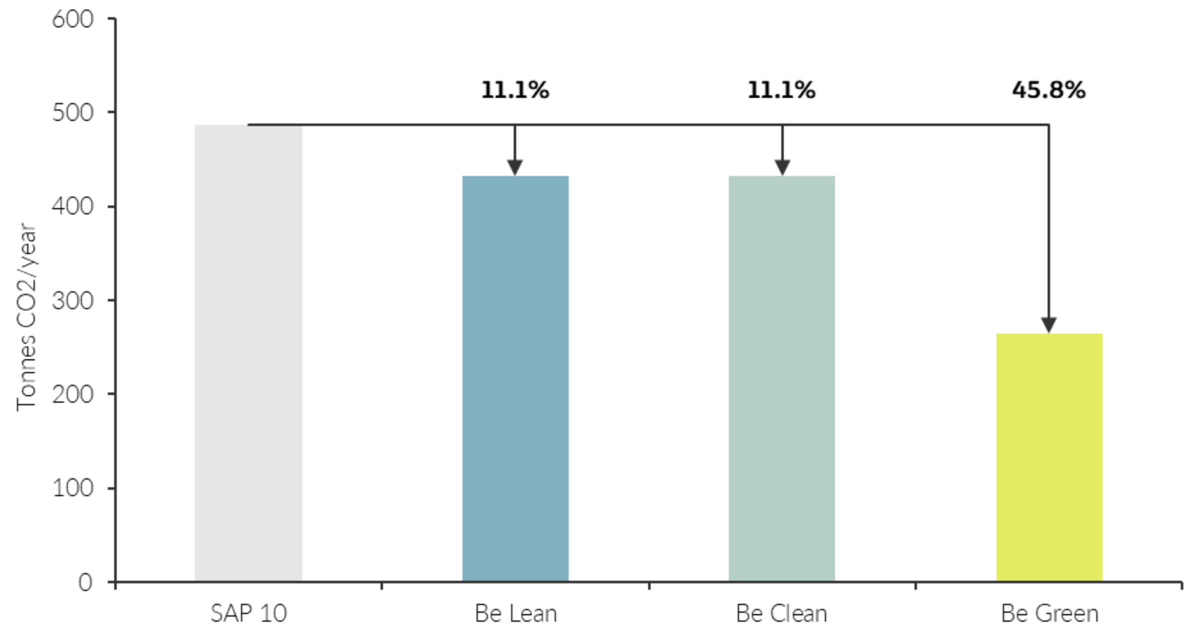


Figure 1: Comparison of regulated carbon emissions saving site-wide.

The over-all carbon emission reduction estimated for the Amended Proposed Development represents an improvement compared to the carbon emission reductions estimated for the Original Proposed Development.

It should be noted here that carbon emission reductions the proposed PV array (8.3 tCO_2/annum) has been included in the energy strategy calculations separately from the modelling. Therefore, a discrepancy of 8.3 tCO_2 will be evident between the results presented here, and the results reported in the GLA carbon emission reporting spreadsheet, since the results reported in the GLA spreadsheet are the outputs from the models only.

1.7 Environmental Assessment Methods

In line with LBRuT Local Plan (2018) Policy 22, proposals for commercial areas will be required to meet BREEAM New Construction (NC) 'Excellent' standard (where feasible). It is the intention of the design team to meet the minimum standards for 'Excellent'. Please refer to the sustainability statement, submitted in support of this planning application, for further information.

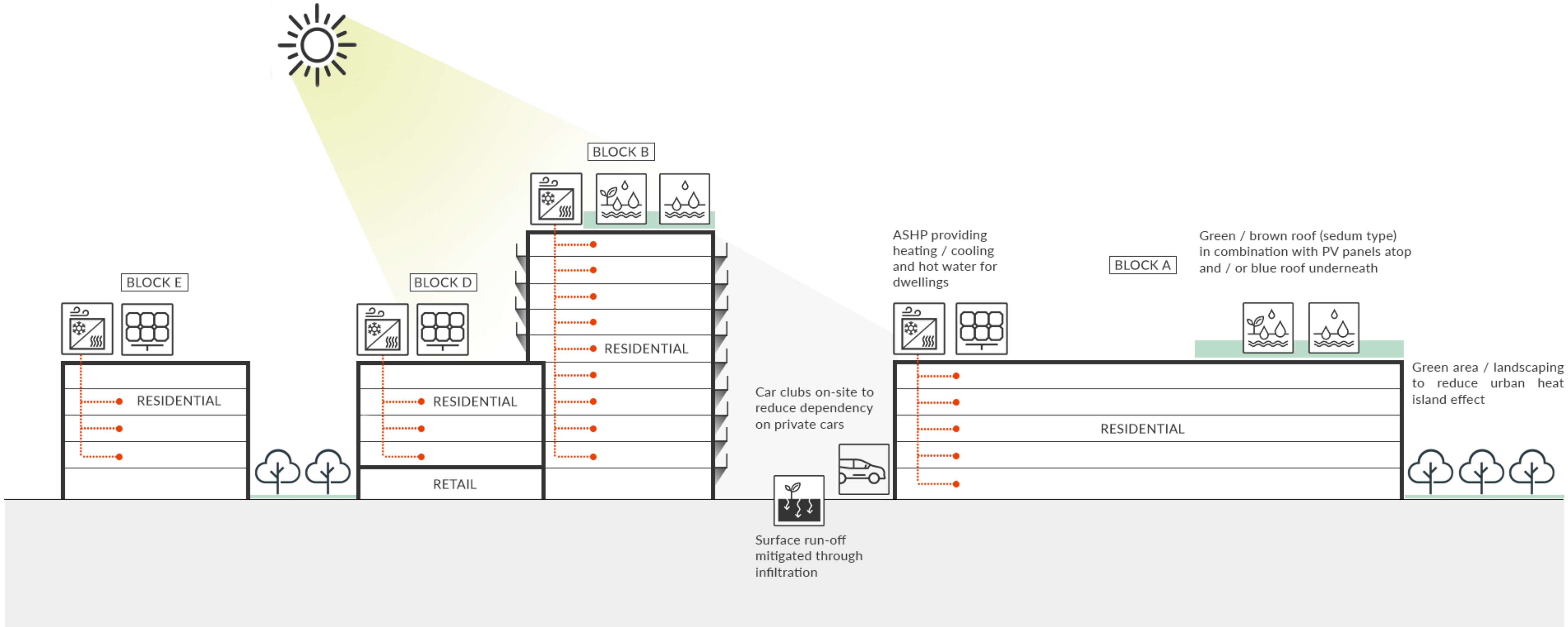


Figure 2: Energy Strategy diagram overview

2. Introduction

2.1 The Application

This Revised Energy Strategy is submitted in support of an application for planning permission concerning the Amended Proposed Development at Manor Road, Richmond.

2.2 Development Description and Site Context – Amended Scheme Summary

On behalf of Avanton Richmond Development Ltd, a detailed planning application (ref. 19/0510/FUL) was submitted to the London Borough of Richmond Upon Thames (LBRuT) in February 2019 for the redevelopment of the Homebase store at 84 Manor Road, North Sheen.

The application was considered at LBRuT Planning Committee on 3 July 2019 and was recommended for refusal by LBRuT officers. The Planning Committee resolved that they were minded to refuse the Application in line with the officer's recommendation for six reasons relating to affordable housing; design; residential amenity; living standards; energy; and absence of a legal agreement.

On 29 July 2019 the Mayor issued a Direction pursuant to Article 7 of the Town and Country Planning (Mayor of London) Order 2008 and powers conferred by Section 2A of the Town and Country Planning Act (1990) that he would act as the LPA for the purposes of determining the Application.

Further to the Mayor's direction to take over the Planning Application for his determination, the Applicant, in consultation with the GLA and TfL, has taken the opportunity to review the scheme with the principle aim of increasing the delivery of affordable housing through additional density and addressing other issues raised in the Mayor's Stage 2 Report.

The Amended scheme now proposes a residential-led redevelopment of five buildings of between three and ten storeys. The development will provide 433 residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), a police facility (Use Class B1), a bus layover with driver facilities (Sui Generis Use), car and cycle parking, landscaping, public and private open spaces and other necessary enabling works.

The proposed changes necessitate an amendment to the Applications description of development. The revised description of development is as follows:

Demolition of existing buildings and structures and comprehensive phased residential-led redevelopment to provide residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), a police facility (Use Class B1), a bus layover with driver facilities (Sui Generis Use), provision of car and cycle parking, landscaping, public and private open spaces and all other necessary enabling works.

The amended scheme is referred as the 'Amended Proposed Development' and its previous iteration that was considered at LBRuT Planning Committee in 3 July 2019, is referred to as the 'Original Proposed Development'.

2.3 Approach

This Energy Strategy follows the Mayor's energy hierarchy: 'Be Lean, Be Clean, Be Green'. This hierarchy shall be the guiding ethos behind decisions regarding the energy performance of the building.

The Amended Proposed Development is assessed as follows:

- New build residential areas - Building Regulations Part L1A 2013: Conservation of Fuel and Power in New Dwellings. These elements have been modelled using SAP v9.92.
- New build commercial areas. Building Regulations Part L2A 2013: Conservation of Fuel and Power in New Buildings other than Dwellings. These elements have been modelled using IES v. 2018.
- In line with current GLA guidance, carbon emission reductions have been calculated using the carbon factors set out in the draft SAP10 guidance.

2.4 Definitions and Limitations

Definitions

The following definitions should be understood throughout this statement:

- Energy demand – the 'room-side' amount of energy which must be inputted to a space to achieve comfortable conditions. In the context of space heating for example, this is the amount of heat which is emitted by a radiator, or other heat delivery mechanism.
- Energy requirement – the 'system-side' requirement for energy (fuel). In the context of a space heating system using a gas boiler, this is the amount of energy combusted (e.g. gas) to generate useful heat (i.e. to meet the energy demand).
- Regulated CO_2 emissions – the CO_2 emissions resulting from the combustion of fuel, or 'consumption' of electricity from the grid, associated with regulated energy uses (those covered by Part L of the Building Regulations).

2.5 Limitations

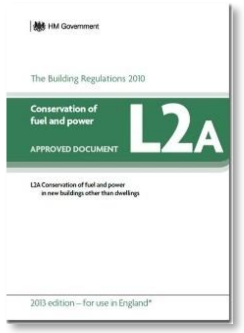
The appraisals within this strategy are based on Part L calculation methodology and should not be understood as a predictive assessment of likely future energy requirements or otherwise. Occupants may operate their systems differently, and / or the weather may be different from the assumptions made by Part L approved calculation methods, leading to differing energy requirements.

Figure 3: Amended proposed development ground floor plan.

3. Regulatory and Policy Context

3.1 The Building Regulations

Building Regulations Part L1A and L2A 2013 edition, incorporating 2016 amendments



Part L1A applies to new dwellings, and Part L2A applies to new buildings other than dwellings.

The requirements are:

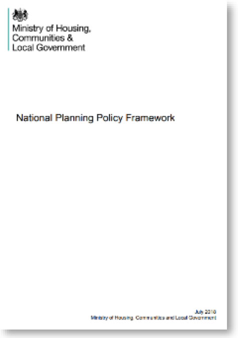
Criterion One of the Building Regulations Part L (2013) requires that the building as designed is not anticipated to generate CO_2 emissions in excess of that set by a Target Emission Rate (TER) calculated in accordance with the approved National Calculation Methodology (NCM).

Criterion Two places upper limits on the efficiency of controlled fittings and services.

Criterion Three requires that dwellings limit the effect of heat gains in summer, and that non-dwellings are not subject to excessive solar gains. This is demonstrated using the procedure given in the National Calculation Methodology.

3.2 Planning Policy

National Planning Policy Framework, February 2019



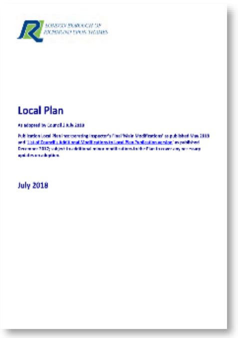
The Revised NPPF came into force in July 2018, and replaces the previous NPPF. It sets out the government's strategy on the delivery of sustainable development through the planning system. It places responsibility for policy making with the Local Authority, who shall communicate their policies through local core strategy documents and other supplementary planning guidance documents. Updates focus on:

- Promoting high quality design of new homes and places
- Stronger protection for the environment
- Building the right number of homes in the right places
- Greater responsibility and accountability for housing delivery from councils and developers.

The NPPF states a presumption in favour of sustainable development, defined as:

"Plans should positively seek opportunities to meet the development needs of their area, and be sufficiently flexible to adapt to rapid change and strategic policies should, as a minimum provide for objectively assessed needs for housing and other uses, as well as any needs that cannot be met within neighbouring areas."

London Borough Richmond upon Thames Local Plan, July 2018



The LBRuT Local Plan details local policies which are applicable to the Amended Proposed Development.

Policy LP 22 states:

- "Development of 1 dwelling unit or more, or 100sqm or more of non-residential floor space (including extensions) will be required to complete the Sustainable Construction Checklist SPD. A completed Checklist has to be submitted as part of the planning application.
- Proposals for commercial areas greater than 100 sqm will be required to meet BREEAM New Construction 'Excellent' standard (where feasible).
- All new major residential developments (10 units or more) should achieve zero carbon standards in line with London Plan policy."

The London Plan, March 2015 (subsequent minor updates in 2016)

The London Plan is the overall strategic plan for London, and it sets out a fully integrated economic, environmental, transport and social framework for the development of the capital to 2031. It forms part of the development plan for Greater London. The first London Plan was published in 2004 with the latest version published in March 2015. One of the main objectives of the London Plan is to improve the environment and reduce climate change by reducing CO_2 emissions and heat loss from new developments

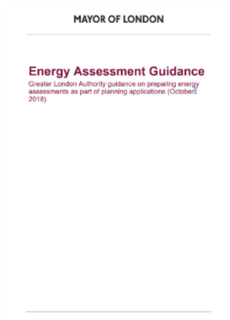
Policy 5.2 Minimising carbon dioxide emissions sets a 'Zero Carbon' target reduction in CO_2 emissions for new build 'Residential Buildings'. The energy assessment SPG defines 'Zero Carbon' homes as those where the residential element of the application achieves at least 35% CO_2 emissions reduction on-site, with the remainder achieved by a combination of off-site measures and a cash in lieu payment (currently set at £1,800 per tonne of CO_2 of remaining emissions to achieve a total reduction of 100%).

The London Plan – Draft with Consolidated Suggested Changes, July 2019

A draft of the proposed new London Plan has been published for consultation. The policies are yet to be adopted, and as such have not been incorporated into the proposals laid out within this document. The notable policy carbon emission changes include non-residential target will be uplifted to 'zero carbon' – i.e. 100% reduction in CO_2 emissions for regulated energy uses. Of this target, 35% reduction should be achieved from on-site measures, and 10-15% from passive design and energy efficiency measures (residential and non-residential areas respectively). Any shortfall is still expected to be made up by a cash-in-lieu payment. The plan also sets targets and policies for further sustainability measures such as:

- Improving Air Quality
- Energy infrastructure
- Managing heat risk
- Water infrastructure
- Reducing waste
- Aggregates.

GLA Energy Assessment Guidance, October 2018



The GLA's guidance to preparing energy assessments sets out a methodology to follow for all developments submitted for planning applications in London. Headline targets are:

- Buildings are compared to a 'gas boiler baseline' with set efficiencies for plant
- As of January 2019, new development applications are encouraged to use the updated carbon emission factors set out in the draft SAP10 documentation.

The GLA state: *'This will ensure that the assessment of new developments better reflects the actual carbon emissions associated with their expected operation. This approach will remain in place until Government adopts new Building Regulations with updated emission factors. The timeline for this has not been confirmed but Part L is expected to be consulted on by early 2019. See section 5 for further details'.*

4. Part L Approach and Methodology

4.1 Approach

This strategy outlines how the Amended Proposed Development could have a reduced effect on climate change by reducing CO_2 emissions associated with energy use in buildings.

Figure 4 outlines the route followed by the Amended Proposed Development when reducing CO_2 emissions and defines the structure of this statement.

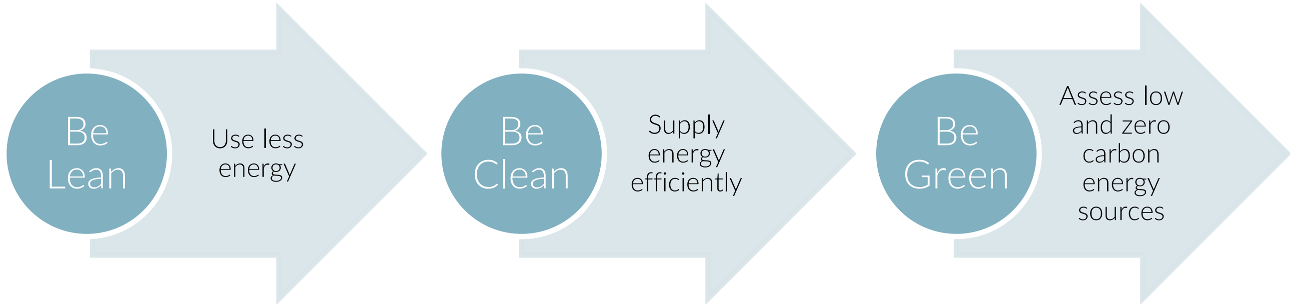


Figure 4 The Energy Hierarchy

The strategic approach to the design of the Amended Proposed Development has been to maximise the energy efficiency of the development through the incorporation of passive design led solutions during the construction process, with the integration of low carbon technology to maximise reduction of carbon emissions from the development.

Further reductions are ensured through the specification of high-efficiency building services to limit losses in energy supply, storage and distribution.

After the inclusion of passive design and energy efficiency measures, various options have been investigated to reduce CO_2 emissions associated with energy supply. The feasibility of LZC technologies has been investigated in line with the policy aspirations.

4.2 Methodology

Calculations demonstrating the energy requirements and associated CO_2 emissions have been modelled as follows:

- New Build Residential - Building Regulations Part L1A 2013: Conservation of Fuel and Power in New Dwellings. A sample of dwellings have been modelled using SAP v9.92 methodology.
- New build commercial areas. Building Regulations Part L2A 2013: Conservation of Fuel and Power in New Buildings other than Dwellings. These elements have been modelled using IES v. 2018.
- In line with current GLA guidance, carbon emission reductions have been calculated using the carbon factors set out in the draft SAP10 guidance.

The following carbon factors were used to convert the energy consumption figures into CO_2 emissions for the Amended Proposed Development, in line with current GLA Energy Assessment Guidance.

Fuel	Emissions Factor ($kgCO_2/kWh$)
Gas	0.210
Electricity	0.233

Table 3 Draft SAP 10 CO_2 Emission Factors.

5. Energy Strategy

The following sections outline considerations of the passive design and energy efficiency measures that have been proposed at Manor Road, Richmond. The measures are described as follows:

Figure 5: The Amended Proposed Development at Manor Road.

5.1 Be Lean – Passive Design Strategy

Passive design measures are those which reduce the demand for energy within buildings, without consuming energy in the process.

These are the most effective and robust measures for reducing CO_2 emissions as the performance of the solutions, for example wall insulation, is unlikely to deteriorate significantly with time, or be subject to change by future property owners.

The following passive design measures will be incorporated in the Amended Proposed Development design:

Thermal Insulation

To minimise the demand for space heating, where new build elements are incorporated these will target an improvement upon the Part L 2013 minimum standards.

Thermal Bridging Minimisation

It is proposed to incorporate proprietary products with thermal breaks into the design of the Amended Proposed Development. Options that are being considered include thermally broken lintels and balconies. SAP calculations currently include for reduced thermal bridging for these elements, compared to the SAP 'default' input. Inputs used have been based on manufacturer's documentation for example products. The improvements made to the thermal bridges result in a better fabric efficiency, thus lowering the total energy consumption of the development. Overall, this has led to an improvement over the original planning application submission. Please refer to section 5.3.1 for further detail.

Fabric Air Permeability

Fabric air permeability is a measure of the volume of air that can penetrate through the fabric of a building, leading to ventilation heat loss and gain. High air permeability can lead to uncomfortable drafts and increase the demand for space heating in winter, and space cooling in summer, when the air-flow works in reverse i.e. cool air escaping from the building.

The development will target an air permeability rate of $3m^3/h.m^2$ at 50Pa for all buildings. This is a 70% reduction beyond that required by Building Regulations Part L 2013.

Glazing - Energy & Light Transmittance

The apartments will have glazing which will be high specification. Solar gains are beneficial in winter months as a means of reducing the need for active heating to maintain comfortable internal temperatures. However, in summer months excessive solar gains can, if not properly managed, lead to overheating and increased cooling load. Details on glazing design are further elaborated in section 5.2.

5.2 Be Lean - Limiting the Effect of Heat Gains in Summer Months

Cooling Hierarchy

The London Plan Policy 5.9 (Overheating and Cooling) requests that developments should reduce potential overheating risks and reliance on air conditioning systems. A 'cooling hierarchy' is provided and the Amended Proposed Development will seek to follow this hierarchy. This is in line with LBRuT Local Plan LP 20.

The London Plan cooling hierarchy has been followed to limit the effects of heat gains in summer, prior to the incorporation of active cooling. Please refer to section 7 for further detail of this assessment.

Summary of Mitigation Measures

The following mitigation methods will be implemented at the Amended Proposed Development.

Reduction of internal heat gains

Internal heat gains will be reduced by energy efficient design measures such as:

- Use of energy efficient lighting (such as LED or compact fluorescent) with low heat output.
- Reduced water circulation temperatures, and insulation added to pipework to minimise circulation heat loss
- High levels of insulation and low fabric air permeability which will retain cool air during the summer months

Reduction of solar ingress

Glazing g-value is linked to light transmittance. For lower g-values, it is likely that the visible light transmittance of the glass is reduced, due to the inclusion of reflective outer surfaces or tints to control solar energy transmittance.

The g-values for the windows will be set based on a combination of aesthetic properties and overall building performance. It is currently expected that a g-value of 0.4 will be used for all glazing.

Managing heat

It is being assessed to incorporate thermal mass to living ceilings in the form of phase change plasterboard which, coupled with windows opened at night, will help to reduce high temperatures in the daytime, as the phase change material acts as a 'coolth-sink'. This approach will be firmed up in the coming design stages, to assess which apartments will gain the greatest benefit from this approach (preference given to those apartments that are not provided with cooling, and which are showing failure to comply with TM59 Criterion 1).

Ventilation and cooling
All apartments will have openable windows to enable occupants to purge air from apartments, in line with Building Regulations Part F. A sample of apartments have been tested using the CIBSE TM59 methodology, and are expected to meet the criteria in the naturally ventilated scenario, using the DSY1 weather file.

Cooling will also be implemented to a proportion of apartments, with preference given to those apartments at risk of experiencing excessive noise from external sources.

Please refer to section 8 for further detail.

5.3 Be Lean - Energy Efficiency Measures

Energy efficiency measures are those which seek to service the demand for energy (i.e. the remaining demand after implementation of passive design measures) in the most efficient way.

All areas will be conditioned using building-by-building systems.

Heating
Heating of the Amended Proposed Development will be served by Air Source Heat Pumps (ASHP) on a block-by-block basis.

The dwellings within each building will connect to the rooftop ASHPs via Heat Interface Units (HIU) (Figure 6).

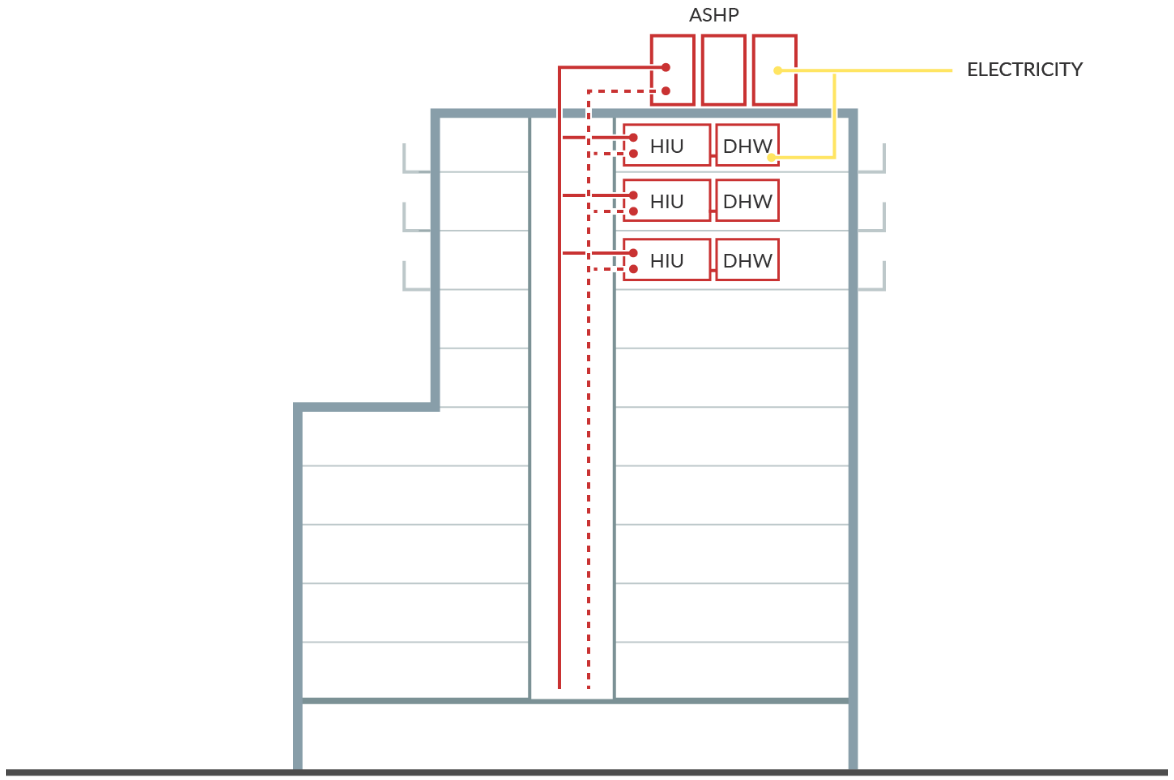


Figure 6: Indicative sketch showing servicing strategy for this type of system.

HIUs will be insulated in accordance with the guidelines in the Building Regulations and the Mayor of London's District Heating Manual for London (2013). This will maximise system efficiency by reducing as far as practically possible the heat loss from the pipework.

A means to connect the heat networks for each building to a wider district heat network will also be provided to allow for future connection should this be technically, economically and legally viable to do. Please refer to section 5.4 and Appendix K for further detail.

All Low Temperature Hot Water (LTHW) network and primary pipework will be insulated to maximise system efficiency and guard against excessive distribution heat loss.

For commercial areas, whilst capped connections to the energy centre will be provided, the fit-out of the commercial areas will be the responsibility of the incoming tenants. The tenants will be required to implement highly efficient systems in line with the standards outlined in the Non-Domestic Building Services Compliance Guide (2013) as a minimum. Sufficient plant space will be provided for each tenant to install their own plant. Commercial tenants will be required to achieve four credits under BREEAM 2018 Ene 01 '*Reduction of energy use and carbon emissions*', in order to achieve the target rating of 'Excellent, and thus it is expected that improvements over the Part L minimum standards will be required.

Hot Water
Hot water for the dwellings will be delivered via the ASHPs, with electric immersion top-up provided in a tank in each apartment.

For retail units, it is anticipated that point of use electric water heaters will be used, and these areas have been modelled based on this assumption. The point of use system will minimise the heat losses in distribution pipework. It also means that, storage losses will be minimal compared with large stored volumes of water at high temperatures.

The Amended Proposed Development will feature water efficient fixtures and fittings including WCs with low flush volume and flow reducers in the taps of wash hand basins and on showers and as a minimum, meet the optional performance stipulations within the Building Regulations Part G (2013), as required by LBRuT Local Plan Policy LP 22, which requires all dwellings to achieve maximum water consumption of 110 litres per person per day (including allowances of 5 litres or less per day for external water consumption).

Space Cooling
Space cooling is proposed for a proportion of apartments at the Amended Proposed Development, with preference given to those apartments at risk of experiencing excessive noise from external sources. It is anticipated that the fit-out of the commercial units will incorporate cooling, and these have been modelled as such. However this would be a tenant design specification.

Lighting
High-efficiency lighting systems will be installed wherever possible, and as a minimum meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013). In addition, the use of lighting controls such as occupancy detection shall be installed in communal areas where possible, to further reduce the use of electric lighting.

The implementation of efficient lighting will not only reduce energy requirement and CO_2 emissions associated with lighting, but will also aid in minimising the energy requirement associated with cooling.

Ventilation
The Amended Proposed Development will be provided with high-efficiency localised mechanical ventilation with heat recovery. Mechanical ventilation is an important addition to the building services to maintain good indoor air quality by providing fresh air to all spaces and extracting stale air. Coupled to a heat exchanger, the warmth in extracted air can be recovered and delivered to the supply air. In this mode, the ventilation system reduces space heating and cooling demand.

To reduce the electrical energy associated with fans, for areas in the Amended Proposed Development with supply and extract, low specific fan powers will be targeted. It is recommended that boosted ventilation and summer bypass will also be incorporated.

Pipework & Ductwork Insulation

All distribution pipework will be insulated in accordance with the requirements of the Building Regulations, as a minimum.

This will serve to minimise heat gains and losses to / from distribution pipework, and maximise system efficiency. Careful attention will be paid to insulating joints, valves and knuckles to minimise standing heat losses. Ductwork will also be insulated to minimise heat gains and losses, and will be of suitable construction to minimise air leakage. Rigid duct work will be used as preference, to avoid inefficiencies from convoluted flexible duct runs.

Due to the nature of ASHP system design, the distribution temperatures will be lower than would be the case for a 'conventional' gas-fired boiler system. This will in turn help to reduce energy losses from distribution.

Operation & Maintenance Manuals

In accordance with the requirements of the Building Regulations detailed Operation and Maintenance (O&M) manuals will be provided to managers of the Amended Proposed Development.

The guides will provide both an overview of the systems and their intended operation, and relevant engineering details of the installations.

Unregulated Energy

Unregulated energy includes small power electricity use (computers, plug in devices, washing machines, refrigeration) and catering energy consumption.

It is anticipated that the proportion of unregulated energy would gain in significance when compared to regulated energy as each revision of Building Regulations Part L comes into force and regulated energy is reduced.

It is therefore foreseeable that energy efficiency and the rising cost of energy would play an increasing role when future building users are deciding which appliances to purchase and the frequency of their use. However, it is not possible at present to quantify the extent of this potential reduction.

Given the uncertainty, measures to educate the future building users on how they can reduce their equipment energy use would be encouraged. This can be provided in the form of building user guides and tenant fit-out guides. The guidance measures detailed within these types of documents would consider:

- Use of A / A+ rated white goods
- Energy star rated computers and flat screen monitors, and Voltage optimization and power factor correction.

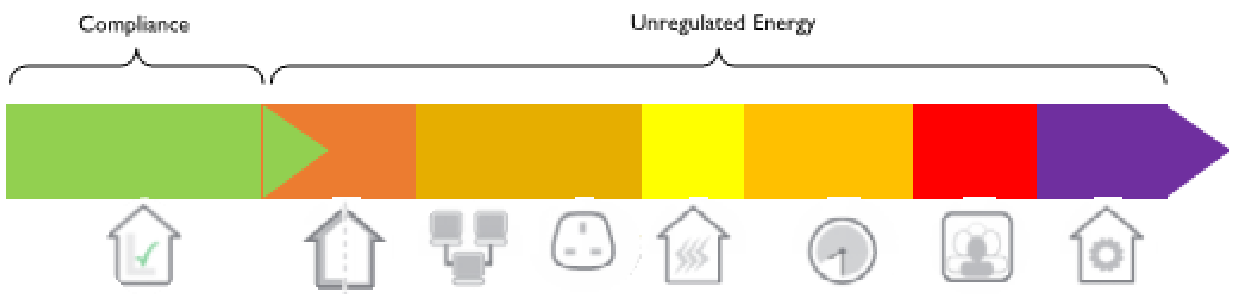


Figure 7: Regulated Energy and Unregulated Emissions Summary.

Summary of Passive Design & Energy Efficiency Measures

Table 4 summarises the passive design and energy efficiency measures for the Amended Proposed Development. As the commercial units are being developed to shell only, but targeting BREEAM excellent (i.e. 4 credits under Ene 01, BREEAM NC 2018) the inputs in Table 4 are aligned to an estimate of what would be required in terms of the tenant fit-out for these spaces. These estimates have been based on previous, similar schemes.

	Parameter	Dwellings	Commercial areas
Passive Design	Roof U-value (W/m^2.K)	0.16	-
	External Wall U-value (W/m^2.K)	0.15	0.15
	Floor U-value (W/m^2.K)	0.13	0.13
	Party Wall U-value (W/m^2.K)	0.00 (fully filled cavity with effective edge sealing)	-
	Sheltered Wall U-value (W/m^2.K)	0 (fully filled cavity with effective edge sealing)	N/A
	Window U-value (W/m^2.K)	1.4	1.4
	Glazing g-value	0.4	0.4-0.6
	Fabric Air Permeability ((m^3/m^2.h) at 50 Pa)	3.0	3.0
	Thermal Bridging	Default values used everywhere except for lintels, where a ψ -value of 0.06 W/m.K was used based on example product manufacturer data. Balcony thermal bridges have been input as 'wall insulation continuous', with a ψ -value of 0.04 W/m.K (default). However, a similar value may also be achieved by use of proprietary, thermally broken product.	10% addition made
	Other measures	N/A	Awning included over all glazed areas: – 1.5m depth – 45 degree angle
Energy Efficiency	Space Heating	Building-by-building ASHP system (total 180% efficiency) with Heat Interface Units (HIU) per dwelling coupled to hot water systems and radiators.	Variable Refrigerant Flow (VRF) system with COP = 5
	Hot Water	Served from ASHP, with electric top-up.	Electric point of use 10% distribution losses.
		Water efficient fixtures and fittings to minimise water demand. HIU with minimal heat loss	
	Space Cooling	Cooling provided by ASHP in a proportion of apartments, with preference given to those apartments at risk of experiencing excessive noise from external sources. Cooling SEER = 4.05; SCOP = 3.5	SEER 5.0
	Lighting	High efficiency lighting. Daylight and presence detection in common areas.	Target efficacy of 90 luminaire lumens per circuit Watt. Display Lighting is 80 lamp lumens per circuit Watt.
	Ventilation	MVHR with specific fan power 0.55 W/l.s (average) with Heat Recovery of 90% or better.	Target SFP of 1.6W/l/s and HR of 80%
	Metering & Controls	Zonal, programmable thermostatic controls for heating. Separate programmable control for hot water. Electricity meter and heat meter with potential link to energy display device.	To be provided in accordance with the requirements of the Building Regulations.
	Pipework & Ductwork Insulation	To be provided in accordance with the requirements of the Building Regulations.	To be provided in accordance with the requirements of the Building Regulations.
	Variable Speed Pumping	To be provided.	To be provided.
	O&M Manuals	Systems overview and detailed descriptions in plain and clear English.	To be provided in accordance with the requirements of the Building Regulations.

Table 4: Summary of Passive Design & Energy Efficiency Measures.

5.3.1 Be Lean - Energy Requirement & CO_2 Emissions appraisal

The following is an appraisal of the anticipated energy requirements and resultant CO_2 emissions that could arise as a result of the Amended Proposed Development, after the inclusion of the passive design and energy efficiency measures described above.

The appraisal has been based on the Government's approved calculation methodology and should not be understood as a predictive assessment as occupants may operate their systems differently, and / or the weather may be different from the assumptions made within the calculations. The appraisal simply reflects the regulated energy consumption and carbon emissions based on the design inputs at this stage and the Building Regulations Part L calculation methodology.

Regulated sources of energy requirement are those controlled by the Building Regulations, as follows:

- space heating
- hot water
- space cooling
- lighting
- auxiliary (combining fans, pumps and controls)

As outlined in Figure 8 the majority of the regulated energy demand, approximately 80%, is as a result of thermal energy demand (domestic hot water and space heating), of which hot water is the most significant contributor.

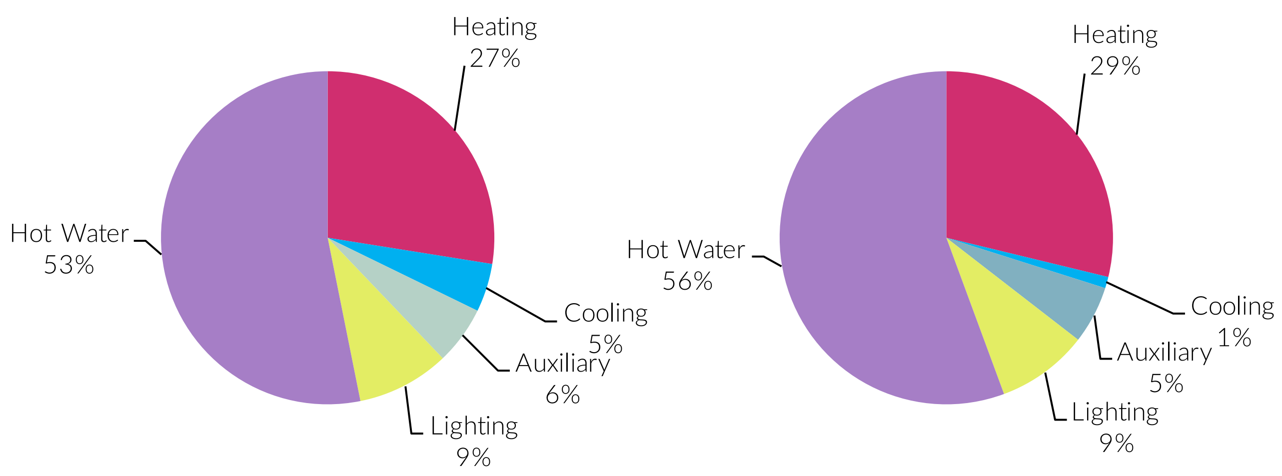


Figure 8: A breakdown of the anticipated annual regulated energy demand (left) and CO_2 emissions (right) by service and space use for the development.

The results presented below are based on Building Regulations Part L1A 2013 compliance modelling carried out on a sample of new build dwellings. The results have been applied to all the residential areas of the Amended Proposed Development. The calculations demonstrating the energy requirements and associated CO_2 emissions for dwellings have been carried out using Building Regulations Part L1A approved SAP 2012 v9.92 methodology.

The results demonstrate that, based on the measures listed in section 4.3 above, before the implementation of 'be clean' or 'be green' measures, the development is expected to meet the requirements of the Part L2013 'baseline'.

The annual regulated energy requirement of the new build elements of the Amended Proposed Development is summarised in Table 5.

The Amended Proposed Development is expected to achieve 11.1% improvement over Part L 2013 compliance via Be Lean measures, i.e. prior to the consideration of any LZC technologies. As such, the Amended Proposed Development meets the draft London Plan policy target for carbon reduction at the 'Be Lean' stage. This is an improvement over the original planning application submission (where a 7% saving was proposed at the Be Lean stage). This improvement has been made chiefly from further detailing the thermal bridging inputs.

Tables 6&7 provide an indicative breakdown of anticipated energy requirements and CO_2 emissions by service for each space use.

Table 8 provides a comparison of the notional and actual building cooling requirements for the areas modelled at this stage. The anticipated cooling requirement is slightly higher than the notional cooling requirement, however cooling accounts for only 1% of regulated carbon emissions for the development as shown in Figure 8 above.

Parameters	Energy Consumption		Regulated CO_2 Emissions	
	MWh/yr	% Reduction	tCO_2/yr	% Reduction
Part L 2013 'Gas Boiler Baseline'	2,280	-	488	-
'Be Lean'	2,014	11.7%	433	11.3%

Table 5: Summary of Be Lean Regulated Energy Requirements and Associated CO_2 Emissions.

Space Use	Regulated Energy Consumption						Unregulated
	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total	
	kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr
Residential areas (C3)	627,000	14,000	85,400	127,700	943,100	1,797,200	925,200
Commercial areas (A1/A3/B1) & Ancillary areas	28,000	9,100	66,400	113,600	900	217,100	115,400
Total	655,000	23,100	151,800	240,300	944,000	2,014,300	1,040,600

Table 6: Anticipated Regulated Energy Requirements – Be Lean

Space Use	Regulated Carbon Emissions						Unregulated
	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total	
	$kgCO_2$/yr	$kgCO_2$/yr	$kgCO_2$/yr	$kgCO_2$/yr	$kgCO_2$/yr	$kgCO_2$/yr	$kgCO_2$/yr
Residential areas (C3)	131,700	3,300	19,900	29,700	198,100	382,600	215,600
Commercial areas (A1/A3/B1) & Ancillary areas	5,900	2,200	15,500	26,200	200	49,900	26,900
Total	137,600	5,500	35,400	55,900	198,300	432,500	242,500

Table 7: Anticipated Regulated CO_2 Emissions – Be Lean

Space use	Residential areas (C3)	Commercial areas (A1/A3/B1)
	kWh/m^2	kWh/m^2
Notional Building Cooling	0	5.88
Actual Building Cooling	0.54	8.82

Table 8: Summary of Anticipated Cooling Requirement

	Target Fabric Energy Efficiency (MWh/m^2.year)	Design Fabric Energy Efficiency (MWh/m^2.year)	Improvement (%)
Residential units area-weighted average Fabric Energy performance	42.7	37.7	11.7%

Table 9: Residential units area-weighted average Design Fabric Energy performance (DFEES) against target (TFEES)

5.4 Be Clean

The following sections detail considerations of the infrastructure and low-carbon energy supply measures that have been considered.

Off-site Decentralised Energy Networks (DEN)

The Amended Proposed Development is not within an 'Opportunity Area' for the implementation of a decentralised energy network, but does lie within an area of moderate to high heat density, as identified by the London Heat Map (http://www.londonheatmap.org.uk). The nearest "Potential Network" is a significant distance away (cannot be seen in overview below), and so is not thought to represent a viable energy source for this scheme.

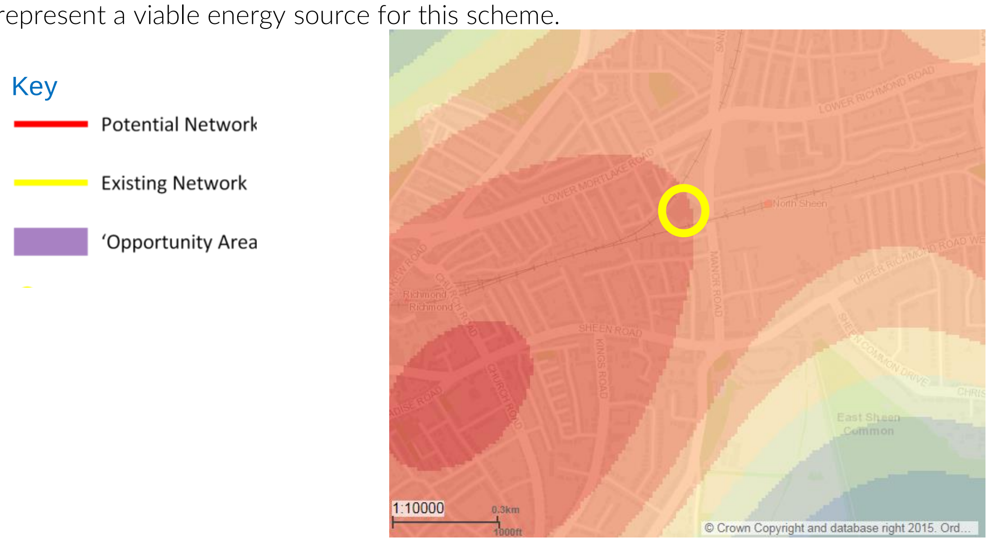


Figure 9 Extract from London Heat Map

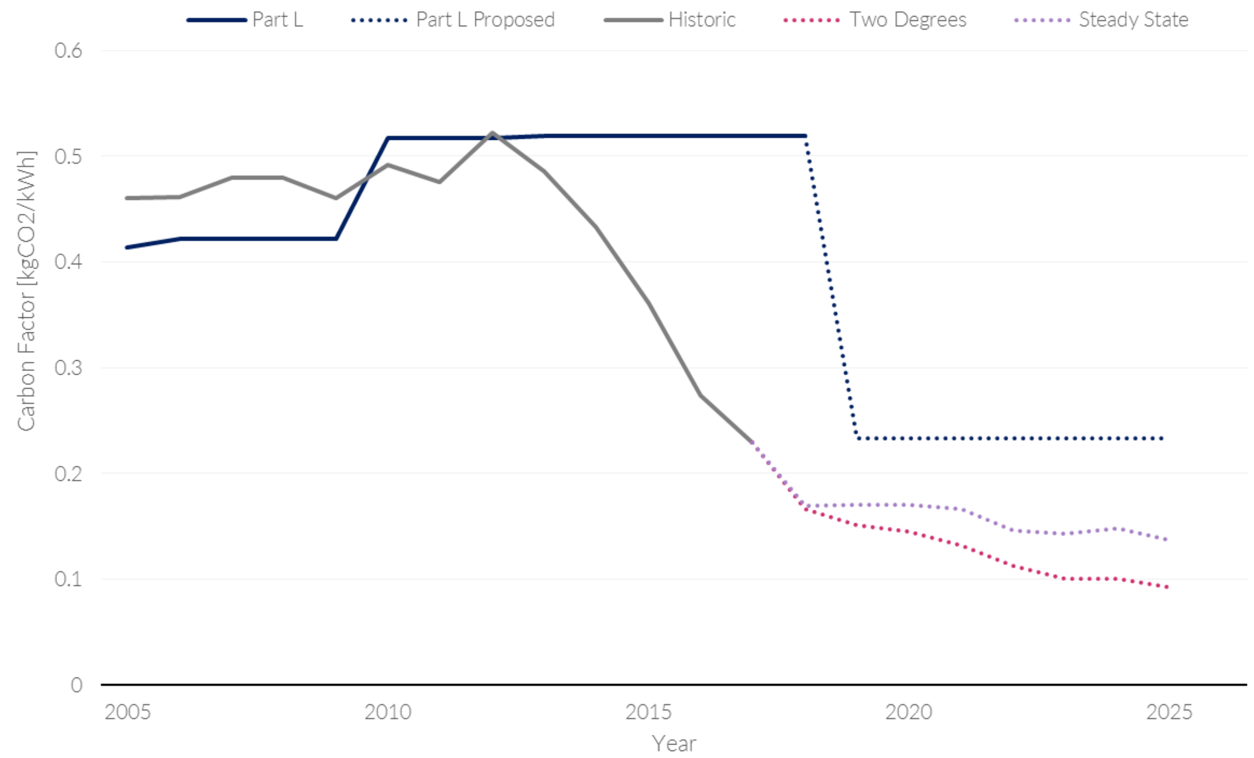


Figure 10 Changes in grid electricity carbon factors Distribution losses

Technology Appraisal

This section considers the relative merits of providing a stand-alone on-site DEN served by a dedicated energy centre with centralised plant.

Combined Heat and Power (CHP)

Changes to the carbon factors of grid electricity have meant that previously favoured systems such as Combined Heat and Power (CHP) are becoming much less carbon efficient. In fact, CHP systems are now expected to lead to greater carbon emissions than conventional gas-fired boilers due to their lower efficiency. Electric systems are far more likely to achieve substantial carbon emission savings. Please refer to Figure 10.

Further, CHP engines are an on-site source of pollutants which may adversely affect the local air quality. CHP is therefore not proposed for this development.

Centralised energy distribution on-site

An assessment has been carried out to determine likely implications of centralised energy distribution at the development. Since the original planning application, work has been undertaken to further detail the implications of this potential connection.

It is expected that there would be limited benefit from the increased diversity that would arise from combining the heating plant in one location, due to the modular nature of Air Source Heat Pump plant.

Further, it has been assessed whether a centralised location for the ASHP systems could be allocated, and it is found that none of the roof spaces are large enough on their own to host the ASHP equipment in one place. Appendix D shows the indicative layout of the proposed plant. Figure 12 (overleaf) shows what the space allocation would have to be, were the ASHP to be centralised in one location.

Therefore, the current proposed strategy includes space allocation which has been made for future plate heat exchangers at the ground floor to each building, and the pipework in all risers appropriately sized to be able to serve each building bottom-up in future, in addition to the current top-down arrangement. It is further proposed to include full trenching between all buildings, with space allocation made for future district heating pipework. A further space allocation has been made for a plate heat exchanger at the ground floor near to the site entrance, so that a future potential district energy network would only require one connection point. Pipework sleeves will be included through the building envelope at the location of each future plate heat exchanger to further ease future connection, should a viable option become available in the vicinity of the site in future. Please refer to appendix K for further detail.

This proposed upgrade to the futureproofing for a potential future distribution network has been made in response to GLA policy, and in discussion with energy officers.

Estimated distribution loss factors have been calculated for the development (See Table 10). The value that would be expected for site-wide distribution (18%) presents a significant increase compared to existing Part L guidelines (5%). Please refer to Appendix K for further details on the inputs and results of this assessment.

	Building-by-building distribution	Site-wide distribution
Distribution loss factor	1.07	1.18

Table 10: Estimated distribution loss factors based on the current design.

It is estimated that an additional ~25 tonnes CO_2/year could be lost if a centralised energy centre is implemented. Please refer to Figure 11. This would be equivalent to a carbon emission reduction ~4.5% worse than the current estimate.

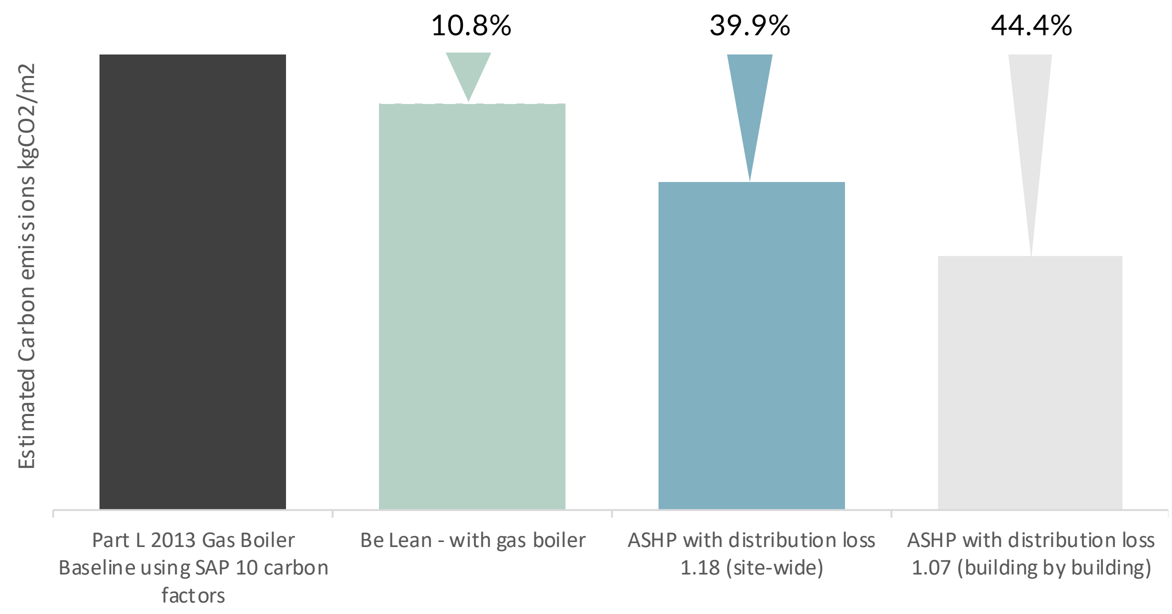


Figure 11 Expected reduction in carbon emissions for residential areas with various energy strategy inputs

In summary, full distribution pipework is not proposed to be installed for the following reasons:

– Increased energy losses related to the distribution between buildings would be estimated to result in an additional 25 tonnes CO_2 emission per annum
– Capped pipework provided, if never used, will result in additional embodied carbon spent at no additional benefit to the scheme. It is also difficult to stop the pipework corroding/ deteriorating over time.
– The embodied carbon content of installing 700m of pipework would be significant as well, and with no certainty this will ever be required, this additional use of resources cannot be justified.

Please refer to appendices for further details, as follows:

- Appendix D: External Services Layout
- Appendix E: Concept LTHW/CHW Schematic
- Appendix K: Centralised vs decentralised energy strategy analysis

5.5 Summary of district energy assessment

It is clear from the above sections that building-by-building ASHP is be the most suitable solution from a carbon reduction perspective at day 1. Incorporating district energy pipework would not only add to the capital cost of the development but would also be expected to add increased operational cost due to increased distribution losses in district pipework, resulting in increased carbon emissions as well.

As there is no existing or planned district energy network in the vicinity of the site, and due to the site constraints (railways against two of the three boundaries) it is considered that the probability of a district energy network arriving at the one available site boundary is small. It is further expected that a connection would only be feasible if the potential future connection has a lower carbon content than the site systems. Given that the site systems are running on electricity, linked to a decreasing grid electricity carbon factor, this is also considered to have a low probability.

Nevertheless, the Amended Proposed Development has been future-proofed for connection to district energy as described in this section.

Please refer to Appendix K for further detail.

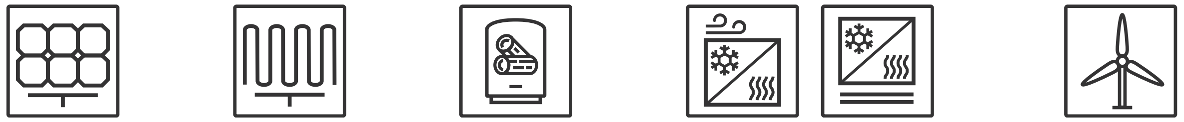
5.6 Be Green

The following sections outline considerations of the renewable energy generation measures that have been considered, and those which will be implemented at the Amended Proposed Development.

Renewable Technology Appraisal

Renewable technologies harness energy from the environment and convert this to a useful form. Many renewable technologies are available. However, not all these are commercially viable, suitable for conservation areas or appropriate for the Amended Proposed Development.

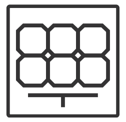
Technologies considered for the Amended Proposed Development include:



Photovoltaics | Solar thermal panels | Biomass boilers | Heat pumps (closed and open loop ground-source/ water source open loop/ air-source) | Wind turbines

Where calculations are provided, these are representative of improvements over the new building dwellings only.

Photovoltaic (PVs) Panels



The potential areas suitable for PVs are limited given the location of the development in a conservation area.

However, an appraisal of roof space available for PV has been undertaken, taking into consideration the following:

- Overshading
- Area allocated for plant space
- Area required for access

Considering the roof space available, as shown in Figure 12, it is estimated that a 310m^2 PV panel area could be incorporated on roofs of the Amended Proposed Development. Please refer to appendix G for a more detailed roof layout drawing.

Based on the solar irradiance data for London, an array of this size would generate approximately 35,000kWh of electricity per annum, reducing CO_2 emissions by 8.3 tonnes per annum. This is equivalent to a reduction in regulated CO_2 emissions of 1.5% beyond the GLA Gas boiler 'baseline'.

It is proposed to allocate PVs in the locations shown in the adjacent Figure 12.

Legend:

- Roof area allocated for plant, or overshaded area
- Green / brown roof / PVs
- Roof area deemed too small for PV panel array

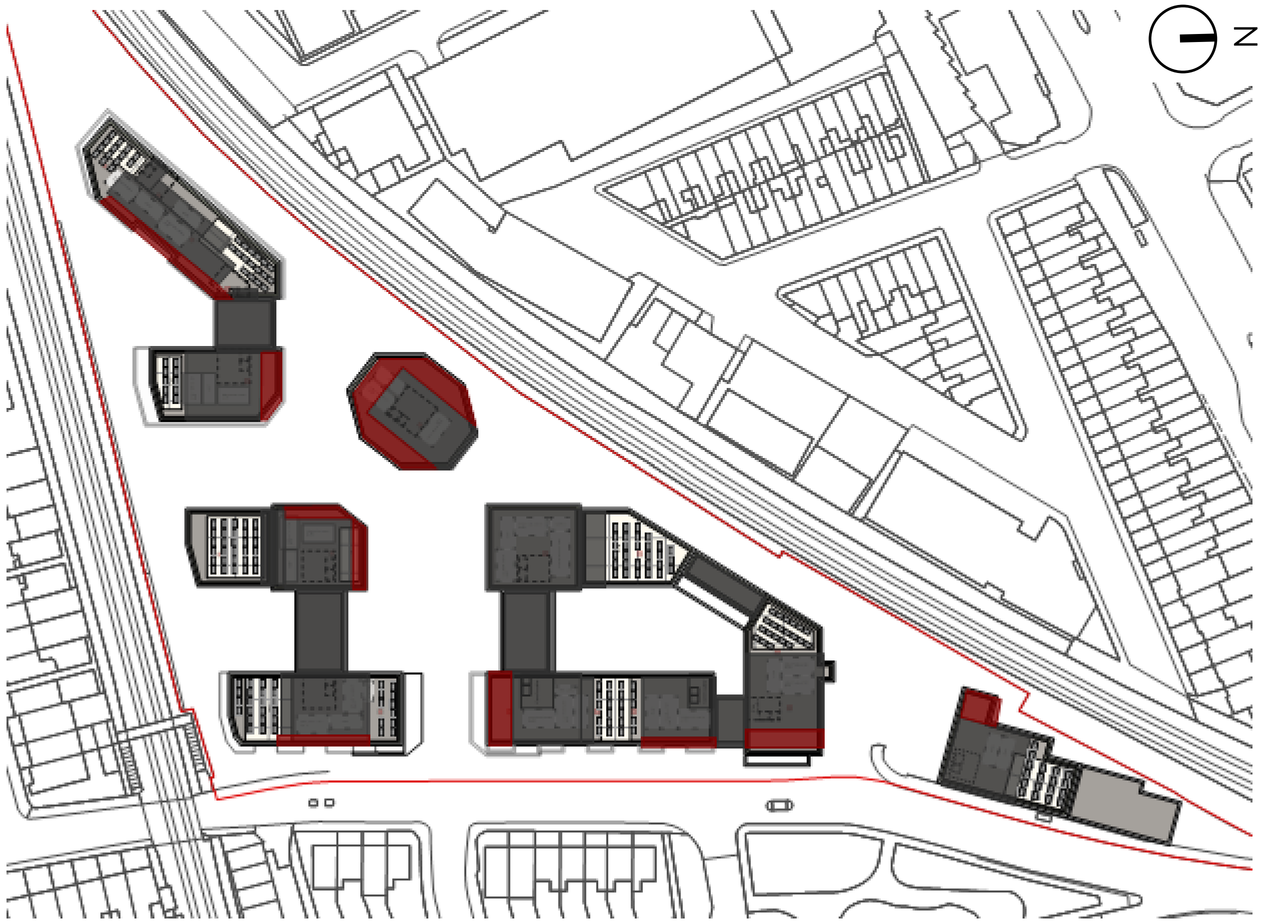


Figure 12: Roof plan demonstrating potential roof area for PV, plant, green/brown roofs and amenity space.

Solar Thermal Panels

Solar thermal panels operate by capturing solar energy and transferring this via a fluid (e.g. glycol) to a thermal store to generate hot water. These systems can operate at efficiencies up to ~75% thus a high yield of energy can be derived from small collector areas.

The appraisal of solar thermal panels has been undertaken with the same approach as for PV. Considering the available roof space, and allowing for access and maintenance requirements, a total solar thermal system size of 155kW could be installed at the Amended Proposed Development.

Based on the solar irradiance data for London, an array of this size would generate approximately 140,000kWh of heat per annum. This level of thermal generation is equivalent to 13% of the annual hot water demand, reducing CO_2 emissions by 34 tonnes per annum.
This is equivalent to a reduction in regulated CO_2 emissions of 6.3% beyond the Building Regulations Part L (2013) 'baseline'.

However, as roof area has already been allocated for PVs, and since the electrical output from PV panels will be more suitable for implementation with the energy strategy, a solar thermal system is not proposed for this development.

Biomass Boilers

Biomass boilers burn wood fuel or other bio-fuel sources to generate heat. These boilers can operate at high efficiencies, comparable to condensing gas boilers.

However, they require a large fuel store to maintain continuous operation during the winter months. Spatially this would be very difficult to accommodate at the Amended Proposed Development.

High numbers of fuel deliveries are required to keep the fuel store topped up during the peak heating season. The carbon associated with the delivery vehicles and their journeys reduces the net carbon saving gained from using a renewable fuel.

The reasons listed above alongside high maintenance implications and air quality implications mean that biomass boilers are not considered a suitable technology for the scheme.

Air / Water / Ground Source Heat Pumps

Ground Source systems work to extract heat or cooling energy from the ground. They are generally more efficient than air source systems, as the ground temperature is more stable over the course of the year relative to air temperature. There are four common varieties of ground source systems:
- Vertical, open loop, direct cooling (i.e. without heat pump)
- Vertical, open loop, with heat pump
- Horizontal, closed loop, with heat pump
- Vertical, closed loop, with heat pump

Regardless of the type of ground source heat loop used, all would require new below ground works to bury and install the system on site. This would incur substantial cost to the development. Further Ground Source Heat Pumps require a balanced heating and cooling load ion order to ensure heat and coolth is exchanges in balance to the aquifer. Due to the heating-led energy profile of this development, Ground Source Heat Pumps are not proposed for Manor Road.

Water source heat pumps use bodies of water, such as rivers, lakes or oceans to provide heating or cooling energy to a building. However, there are no such bodies of water local to site, therefore this technology could not be used.

Air source heat pumps use thermodynamic principles to convert heat from the air into useable heat within the building. Unlike some other sources of renewable energy, heat pumps do require energy (typically electricity or gas) to pump and compress refrigerant through the system. However, under the Renewable Energy Directive 2009/28/EC they are classified as renewable technologies provided that the final energy output significantly exceeds the primary energy input required to drive the heat pump.

Due to the changes in carbon factors for grid electricity, it is expected that carbon emission reductions from ASHP is greatly improved compared to previous iterations of SAP.
In order to serve a proportion of heating and hot water for the Amended Proposed Development, an ASHP system size of 3,800kW will be installed at the Amended Proposed Development to generate a proportion of heating and cooling for the scheme. Please refer to section 5.3 where this approach is described in further detail.

This system is expected to result in regulated CO_2 emission reductions of 45.8% beyond the Building Regulations Part L (2013) 'baseline' on a site-wide basis.

Air Source Heat Pumps are proposed for the development.

Micro Wind Turbines

For efficient operation and to yield high energy output, wind turbines require a smooth laminar flow of air. The Amended Proposed Development is located a conservation area and therefore deemed unsuitable for micro wind turbines.

Moreover, mounting wind turbines on the roof of the building could result in unacceptable vibration and resonance being felt within occupied spaces. The turbines are also likely to generate noise which may be a nuisance to neighbouring residential properties. This scenario is likely to result in the turbines being switched off.

Therefore, given the complexities of installing this technology, the use of micro wind turbines is not proposed at the Amended Proposed Development.

5.7 Summary

Preferred Strategy for Implementation
Table 11 provides a summary of the technologies assessed above.

	Pros	Cons	Suitability
Solar Photovoltaic Panels (PV)	Generates electricity from solar energy	Cost implications.	✓
Solar Thermal Panels	Generates hot water from solar energy	Roof space has been allocated for PV, which is better suited in interaction with the energy strategy as a whole.	✗
Wood Pellet Biomass Boiler	Uses a renewable fuel source to generate hot water	Large fuel stores required High number of fuel deliveries required High maintenance required Negative impacts on local air quality	✗
Ground Source Heat Pumps	Uses heat/coolth from the ground to provide usable heating or cooling to the building	Requires an auxiliary energy source to drive system Great cost implication to drill the required bore holes to feed system	✗
Air Source Heat Pumps	Uses heat/coolth from the air to provide usable heating or cooling to the building. Same technology can deliver the heating and cooling requirements of the building. Use of the refrigerant cycle delivers high energy efficiencies	Requires an energy source to drive system (can be fed in part by PVs). Roof space allocation required.	✓
Micro Wind Turbines	Generates electricity from wind energy	Potential noise and vibration impacts on the Amended Proposed Development and neighbouring properties	✗

Table 11: Renewable Technologies Appraisal.

6. Operational Cost

Operational costs for end users are an important consideration when appraising energy strategy options. Focussing solely on carbon emissions can lead to unintended consequences in the form of higher than expected occupant energy bills if capital and operation expenditure of the energy systems and networks are passed on to end users.

This section provides an appraisal of potential end user costs for both boiler-led communal heating, and communal heat-pump strategies.

A summary of the appraisal is shown below in Table 12. An overview of inputs and results is provided in Appendix J.

The applicability of Renewable Heat Incentive payments relies specifically on two inputs: The efficiency of the ASHP in heating mode, and whether or not the ASHP is designed to provide cooling.

For this assessment, it has been assumed that the minimum efficiency (2.9) in heating mode can be achieved.

System:	Estimated Cost per Unit of Heat (pence/kWh)	Notes / Basis of Assessment:
Communal gas boiler	4.0p / kWh	District heating network, no local thermal storage.
ASHP with Renewable Heat Incentive (RHI) included	2.4p / kWh	ASHP system + local storage with immersion. Renewable Heat Incentive (RHI) included.
ASHP with no Renewable Heat Incentive (RHI)	5.2p / kWh	ASHP system + local storage with immersion. Renewable Heat Incentive (RHI) not included.

Table 12: Operational Cost Appraisal Summary

As it is expected that some cooling will be provided for Manor Road, and therefore not all ASHP installations will be eligible for RHI payments, it is expected that the actual cost to consumers will fall between the two estimated costs calculated in Table 12 above.

Details of the cost assessment for each scenario, including assumptions, are shown below.

Global inputs		
Commercial gas	p/kWh	2.57
Commercial electricity	p/kWh	11.04
Commercial electricity exported	p/kWh	4.00
Dwelling gas	p/kWh	4.38
Dwelling electricity	p/kWh	16.48
ASHP RHI	p/kWh	2.69
Communal riser air temperature	C	20
Cold water temperature	C	10

Table 13: Cost Assessment Global Inputs

7. Summary of Results

The following tables demonstrate the relative carbon emission savings of the Amended Proposed Development, compared to Part L 2013 baseline for the Be Lean, Be Clean and Be Green stages of the Mayor's energy hierarchy.

In line with GLA Energy Strategy guidelines, the results are presented separately for the residential and retail areas.

7.1 Dwellings

Table 14 below outlines the anticipated CO_2 emissions reductions and carbon offset payment. The combined on-site savings and zero carbon target shortfall is used to calculate a total carbon offset payment of £414,100.

New Build Dwellings	Regulated Carbon Dioxide Emission Savings (tonnes CO_2/yr)	
	Regulated	Unregulated
Baseline: Part L 2013 Building Regulations with SAP 10 carbon factors	429	216
After energy demand reduction (Be Lean)	383	216
After heat network / CHP (Be Clean)	383	216
After renewable energy (Be Green)	230	216
	Regulated domestic carbon dioxide savings	
	(tonnes CO_2/yr)	(%)
Savings from energy demand reduction	46	10.8%
Savings from heat network / CHP	0	0%
Savings from renewable energy	153	35.6%
Cumulative on-site savings	199	46.4%
Annual savings from offset payment	230	-
Offset Payment Rate (£/tCO_2)	£1,800	
Total Offset Payment	£414,100	

Table 14: Dwellings Summary of regulated carbon emissions saving and carbon offset payment.

7.2 Flexible Commercial Areas

Table 15 below outlines the anticipated CO_2 emissions reductions and carbon offset payment for the flexible commercial areas. The on-site target is used to confirm that no carbon offset payment is expected for these areas.

New Build Flexible Commercial	Regulated Carbon Dioxide Emission Savings (tonnes CO_2/yr)	
	Regulated	Unregulated
Baseline: Part L 2013 Building Regulations with SAP 10 carbon factors	58	27
After energy demand reduction (Be Lean)	50	27
After heat network / CHP (Be Clean)	50	27
After renewable energy (Be Green)	34	27
	Regulated non-domestic carbon dioxide savings	
	(tonnes CO_2/yr)	(%)
Savings from energy demand reduction	8	13.5%
Savings from heat network / CHP	0	0%
Savings from renewable energy	16	27.8%
Cumulative on site savings	24	41.3%
Total target savings	20	35%
Shortfall	N/A	-
Offset Payment Rate (£/tCO_2)	£1,800	
Total Offset Payment	£0	

Table 15: Commercial Summary of regulated carbon emissions saving and carbon offset payment.

It should be noted here that carbon emission reductions the proposed PV array (8.3 tCO_2/annum) has been included in the energy strategy calculations separately from the modelling. Therefore, a discrepancy of 8.3 tCO_2 will be evident between the results presented here, and the results reported in the GLA carbon emission reporting spreadsheet, since the results reported in the GLA spreadsheet are the outputs from the models only.

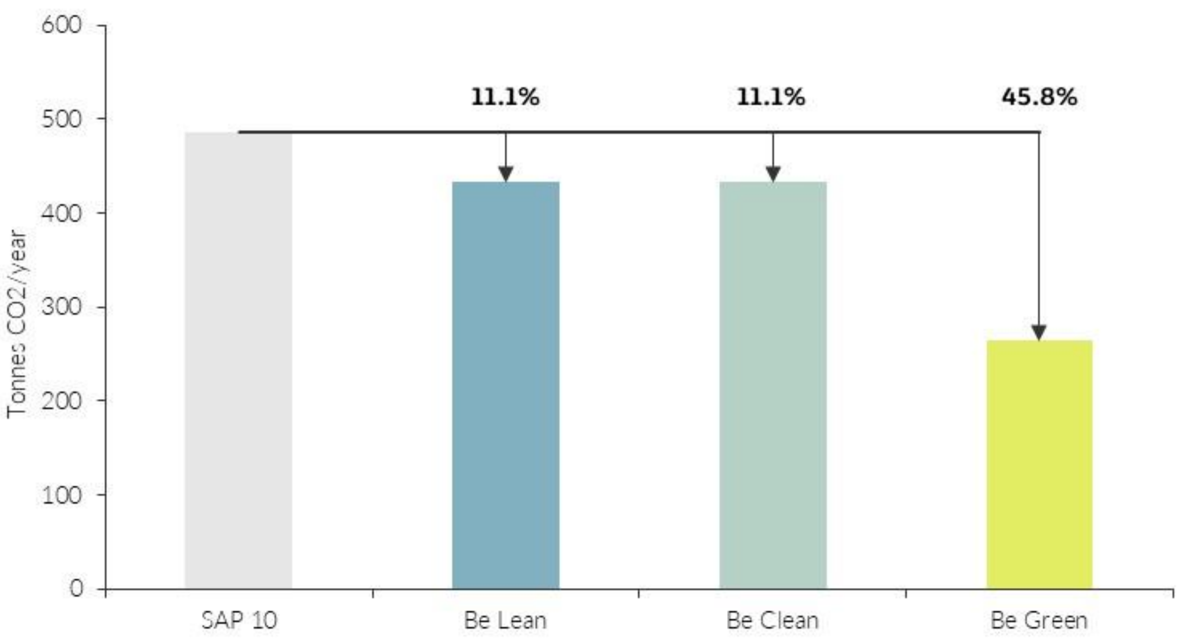


Figure 13: Comparison of regulated carbon emissions saving and carbon offset payment.

8. Overheating Risk (TM59)

In tandem with the energy and CO_2 emissions appraisal, an assessment has been undertaken to determine the risk of summertime overheating and consider measures for the minimisation of cooling demand.

8.1 Basis of the Assessment

The London Plan policy 5.9 (Overheating and Cooling) requests that Developments should reduce potential overheating risk and reliance on air conditioning systems. A 'cooling hierarchy' is provided and the Development has sought to follow this hierarchy.

The following cooling hierarchy has been followed to limit the effects of heat gains in summer:

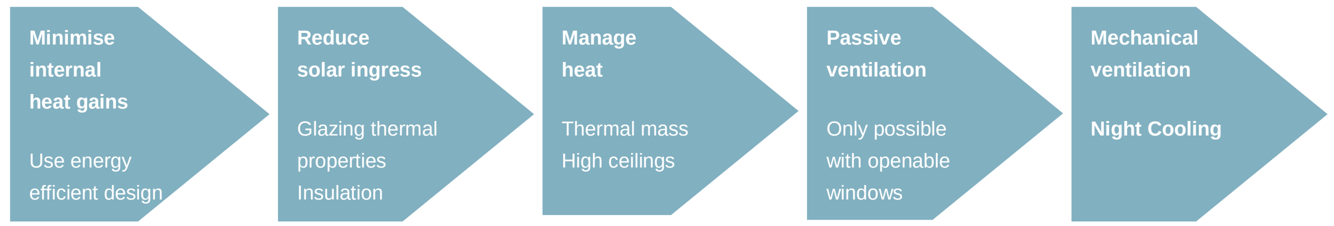


Figure 14: Mayor of London's cooling hierarchy

8.2 Mitigation Strategy

The following mitigation methods will be implemented at the Amended Proposed Development.

Minimising internal heat generation through energy efficient design

The following mitigation methods will be implemented to minimise the internal heat generation through energy efficient design at the Amended Proposed Development:

- Energy efficient lighting (such as LED or CFL) with low heat output
- Insulation to heating and hot water pipework and ductwork and minimisation of dead-legs to avoid standing heat loss (from pipework to dwellings)
- Energy efficient white goods with low heat output
- Low temperature hot water from air source heat pump to further reduce heat gain in communal pipework and risers

Reducing the amount of heat entering the building in summer

The following mitigation methods will be implemented at the Amended Proposed Development to reduce the amount of heat entering the building in summer:

- Suitable glazing ratio responding to orientation and space use
- Low g-value glazing to limit solar heat gains (where appropriate)
- High levels of insulation and low fabric air permeability which will retain cool air during summer months

Passive ventilation

All dwellings will be fitted with fully openable windows, which allow passive solar heating and natural ventilation. Balconies will also provide shading.

Mechanical ventilation

All dwellings will also be provided with ventilation at rate in accordance with Part F through Mechanical Ventilation with Heat Recovery (MVHR).

MVHR units are an important addition to the building services to maintain good indoor air quality, by providing fresh air to living rooms and bedrooms and extracting vitiated air from bathrooms and kitchens. Providing fresh air minimises the risk of stale and stagnant air and limits the risk of condensation and mould growth. The heat recovery mechanism will be provided with a bypass to avoid returning hot air to the dwellings in summer.

It is anticipated that the MVHR units will be capable of delivering fresh air at a rate of 75 litres per second (l/s), which will aid the mitigation of high internal temperatures in summer months where required. Ductwork would be rigid type, circular wherever possible, with minimal flexible ductwork (for connections only).

8.3 Part L heat gain check

It is anticipated that the Amended Proposed Development will achieve compliance with the Building Regulations Part L 2013 Criterion 3 and limit the effects of heat gains in summer months and reduce the need for comfort cooling/ air-conditioning. It is proposed that active cooling is provided to a proportion of dwellings, based on an assessment of site background noise, risk of overheating, and market expectations. It is anticipated

	TM59 Criterion 1 - % pass Living rooms and bedrooms	TM59 Criterion 2 - % pass Bedrooms only	Communal Corridors – 28°C operative temperature
Natural Ventilation – pass rates			
DSY1	100% of tested rooms	100% of tested rooms	
DSY2	83% of tested rooms	28% of tested rooms	Meets target
DSY3	60% of tested rooms	3% of tested rooms	

that cooling will be provided as top-up cooling only to allow rooms to cool to 26 degrees, rather than full comfort cooling. In terms of commercial areas, it is likely that these will be actively cooled as part of the tenant fit-out.

Flow rate (l/s)	Cooling capacity (kW)	CIBSE Guide A - % pass Living rooms and bedrooms	Communal Corridors – 28°C operative temperature
Mechanical Ventilation - pass rates			
75	1.5	40% of tested rooms	
90	1.5	56% of tested rooms	Meets target
90	2.5	65% of tested rooms	

Summary of SAP reports attached in Appendix H, and summary BRUKL reports attached in Appendix I.

8.4 CIBSE TM59 Overheating risk assessment

An overheating risk assessment was undertaken on a sample of dwellings across the Amended Proposed Development. This is in line with the guidance set out under Policy SI4 in the draft London Plan. The dwellings selected for assessment accounted for a range of orientations, layouts, and external acoustic environments.

The CIBSE TM59 guidance stipulates that modelling must be undertaken with the weather file most appropriate to the location for the project, for the 2020s, high emissions scenario 50^{th} percentile. The most appropriate file for the location of the Manor Road Development is London Heathrow.

The set of weather file used for this assessment is the design summer years (DSY) for London Heathrow, for the 2020s high emissions scenario 50^{th} percentile.

- DSY1: Moderately warm summer
- DSY2: Short, intense warm spell
- DSY3: Long, less intense warm spell

With regards to external acoustic environment, the acoustic consultant has advised the site is exposed to moderate noise levels, with required sound reduction achieved through acoustic double glazing. Railway noise is the primary influencer on the acoustic environment and is most apparent on the south and west elevations. Exposure to noise levels reduce with height.

The building has been assessed against the predominantly naturally ventilated criteria. This is representative of 'free running' type buildings where people expect internal temperature to track external temperature, hence can adapt and tolerate in accordance with the adaptive comfort model. Please refer to Appendix C for further details.

All tested apartments meet TM59 requirements by passing the natural ventilation scenario under the DSY 1 weather file. (see table overleaf)

All dwellings will be provided with mechanical ventilation with heat recovery and openable windows, allowing the occupant to adapt their internal environment according to their own needs.

Results have also been presented for the mechanical ventilation scenario, where it is assumed that windows are closed (see table overleaf).

As the external ambient temperatures in the London DSY1 weather file exceed 26°C for 2.7% of annual hours, there is very little margin (0.3% of annual hours) left as flexibility. Once unavoidable internal heat gains are included in the model (cooking, lighting, people, small power equipment), it can therefore be expected that rooms will quickly exceed the threshold in a dynamic model. Nevertheless, a number of rooms are expected to pass the criterion on the mechanical ventilation scenario (see table below).

An assessment has been made of the fresh air rate that could be delivered to apartments by mechanical means, and the impact this is expected to have on temperatures achieved. As a result of this assessment, it is proposed to increase the ventilation rate in some apartments from 75 l/s to 90 l/s which will further aid the mitigation of high internal temperatures in summer months.

The fresh air will be tempered by implementation of a cooling coil into the supply ductwork where necessary, with initial cooling capacities tested as listed in Table 17 below. This will be further developed in the detailed design stages.

Comfort cooling will also be implemented to a proportion of apartments, with preference given to those apartments at risk of experiencing excessive noise from external sources.

Table 16: Summary of CIBSE TM59 assessment results

Table 17: Summary of CIBSE TM59 assessment results

9. Conclusion

This report has shown that the Amended Proposed Development will result in a highly efficient, low-carbon scheme. New, high efficiency servicing equipment and efficient façades will minimise the energy usage of the building. Using the Mayor's energy hierarchy, the strategy has been developed to ensure that the Amended Proposed Development is efficient and economical.

The carbon emissions from regulated energy uses at the proposed development have been compared with the GLA London Plan emissions targets. It is expected that a carbon offset payment made to the local authority will be required. The current estimated offset payment is given in Table 14 and Table 15.

In line with LBRuT Local Plan (2018) Policy 22, proposals for new commercial areas will be required to meet BREEAM New Construction (NC) 'Excellent' standard (where feasible). It is the intention of the design team to meet the minimum standards for 'Excellent'. Please refer to the Sustainability Statement, submitted in support of this planning application, for further information.

Key changes since the Original Proposed Development submission have been:

- Improvement to the carbon emission reductions expected to be achieved at the 'Be Lean' stage. This improvement has been achieved chiefly from improvements to thermal bridging inputs. This has resulted in an improved estimated carbon emission reduction at the Be Lean stage of the energy hierarchy, exceeding the draft London Plan (2019) target for carbon reductions at the 'Be Lean' stage.
- Improvement to the carbon emission reductions expected to be achieved at the 'Be Green' stage. This improvement has been achieved chiefly from further detailed estimates of the distribution losses expected to result from energy distribution from the centralised supply from building-by-building air source heat pumps. This has resulted in an improved estimated carbon emission reduction at the Be Green stage of the energy hierarchy, exceeding the draft London Plan (2019) target for on-site carbon reductions.

In summary, as an improvement on the Original Proposed Development, the Amended Proposed Development meets the draft London Plan policy target for carbon reduction at the 'Be Lean' stage and shows expected improvement at the 'Be Green' stage of the energy hierarchy.

This energy strategy has thus set out how the highest standards of sustainable design and construction are proposed for the development.

Appendix A: Regulatory & Policy Context

The following outlines the regulatory and planning policy requirements applicable to the Amended Proposed Development.

National Policy

Current Policy Framework
The Amended Proposed Development is not considered to be preferable to the Mayor of London. The policies considered when preparing this strategy are contained in the London Plan (GLA, 2016) and the Local Development Plan of LBRuT (2018). The Supplementary Planning Guidance (SPG) has also been reviewed and taken into consideration in the Energy Strategy.

Building Regulations Part L 2013

Approved Document Part L
Part L of the Building Regulations is the mechanism by which government is driving reductions in the regulated CO_2 emissions from new buildings.

Current Requirements: Part L 2013
Part L has five key criteria which must be satisfied as follows:

a. Criterion 1 - Achieving the Target Emission Rate (TER)
b. Criterion 2 - Limits on design flexibility
c. Criterion 3 - Limiting the effects of solar gains in summer
d. Criterion 4 - Building performance consistent with the Dwelling Emission Rate (DER)
e. Criterion 5 - Provision for energy efficient operation of the dwelling

Criteria one, two and three are addressed within this strategy.

Criterion one requires that the building as designed is not predicted to generate CO_2 emissions in excess of that set by the Target Emission Rate (TER) calculated in accordance with the approved Standard Assessment Procedure (SAP) 2012. Part L (2013) requires the following reductions:

a. A 6% aggregate reduction in CO_2 emissions beyond the requirements of Part L 2010 for dwellings; and
b. A 9% aggregate reduction in CO_2 emissions beyond the requirements of Part L 2010 for non-domestic buildings.

Criterion two places upper limits on the efficiency of controlled fittings and services for example, an upper limit to an external wall U-value of 0.30W/m^2.K (dwellings).

A Fabric Energy Efficiency Standard (FEES) has been introduced for new dwellings although no definitive targets have been set in this regard. Part L 2013 requires the following Fabric Energy Efficiency performance targets to be met:

a. Target Fabric Energy Efficiency (TFEE). The TFEE is calculated independently for each dwelling, based upon an elemental recipe of efficiency parameters, applied to the geometry of the dwelling in question. This would generate a notional value which would then be relaxed by 15% to generate the TFEE

Criterion three requires that dwellings are not at 'high' likelihood of high internal temperatures in summer months (June, July & August) and that zones in commercial buildings are not subject to excessive solar gains. This is demonstrated using the procedure given in SAP 2012 Appendix P for dwellings, and Simplified Building Energy Model (SBEM) or Dynamic Simulation Method (DSM) for non-residential buildings.

GLA Planning Policy

The London Plan (March 2016) Consolidated with Alterations Since 2011
The regional policies of the GLA are contained within the London Plan (2016), and the relevant SPGs.

The latest version of the consolidated London Plan (2016) was published and adopted in March 2016 and is current for any Stage 1 submissions to the GLA. This constitutes the London Plan 2011 consolidated with:

- Revised Early Minor Alterations to the London Plan (October 2013)
- Further Alterations to the London Plan (March 2015)
- Housing Standards Minor Alterations to the London Plan (March 2016)
- Parking Standards Minor Alterations to the London Plan (March 2016)

The target reduction in CO_2 emissions for Residential Buildings is to achieve 'zero carbon homes' for Stage 1 applications. The definition of this is clarified in the GLA's publication G*uidance on Preparing Energy Assessments*. The target for 'Non-Domestic Buildings' is to achieve 35% reduction in CO_2 emissions.

Energy Planning - Greater London Authority guidance on preparing energy assessments (March 2016)

This document was produced by the GLA to provide further detail on how to prepare an energy assessment to accompany strategic planning applications. Within this, the definition of 'zero carbon homes' is made as follows:

'Zero carbon' homes are homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (beyond Part L 2013) on-site. The remaining regulated carbon dioxide emissions, to 100 per cent, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere (in line with policy 5.2E).

The cash in lieu payment is currently set at £1,800 per tonne of CO_2 (equivalent to £60 per tonne per year over 30 year period).

Use Type	CO_2 Reduction Target (beyond Part L 2013)	
	2013 – 2016	2016 – 2019 (1st October 2016)
Residential Buildings	35%	'Zero Carbon'
Non-Domestic Buildings	35%	35%

Table A1: Uplift in CO_2 emissions targets

London Plan Policy
Development within LBRuT is subject to the policy requirements of the London Plan 2016. The following policies of the London Plan (2016) have informed this strategy.

Policy 5.2: Minimising CO_2 Emissions

Policy 5.2 sets out the target CO_2 emission reductions as described above.

Policy 5.6: Decentralised Energy in Development Proposals

Policy 5.6 requires development proposals to evaluate the feasibility of Combined Heat & Power (CHP) systems and where a new CHP system is appropriate, examine opportunities to extend the system beyond the Site boundary. Developments should select energy systems on the following hierarchy:

a. connection to existing heating or cooling networks
b. site wide CHP network
c. communal heating and cooling

Where future network opportunities are identified, proposals should be designed to connect to these networks.

Policy 5.7: Renewable Energy

Policy 5.7 requires that developments should provide a reduction in expected CO_2 emissions through the use of on-site renewable energy generation, where feasible.

Policy 5.9: Overheating and Cooling

The GLA have produced a 'Domestic Overheating Checklist' (Appendix 5 of the 'Energy Planning' guidance) for use early in the design process to identify potential overheating risks and to trigger the incorporation of passive measures within the building envelope. The 'Energy Planning' guidance document also includes an update to the guidance on compliance with overheating policy that design teams should be aware of when undertaking risk analysis and thermal comfort modelling for dwellings.

It is the GLA's expectation that dynamic thermal modelling should be undertaken to determine overheating risk and demonstrate compliance with London Plan Policy 5.9. This should be in addition to the Building Regulations 'Criterion 3' assessment of heat gains in summer months.

The GLA has set out that dynamic modelling should be carried out in accordance with the guidance and data sets in CIBSE TM49 'Design Summer Years' for London (2014) using the three design weather years as follows:

- 1976: a year with a prolonged period of sustained warmth.
- 1989: a moderately warm summer (current design year for London).
- 2003: a year with a very intense single warm spell.

For developments in high density urban areas (e.g. Canary Wharf) and the 'Central Activity Zone' the 'London Weather Centre' data set should be used. In lower density urban and suburban areas the 'London Heathrow' dataset should be used. These data sets have been adjusted to account for future climate effects.

The modelling should also consider the additional guidance contained in CIBSE TM52 'The Limits of Thermal Comfort: Avoiding Overheating in European Buildings'.

The London Plan – Draft with Consolidated Changes, July 2019

A draft of the proposed new London Plan has been published for consultation. The following policies are yet to be adopted but the changes pertinent to an energy strategy for residential and non-residential developments are set to shift substantially if adopted. The notable policy carbon emission targets are as follows:

For residential developments:

- Target zero-carbon (annual regulated energy)
- 10% carbon saving must be from energy efficiency measures
- 35% carbon saving must be from on-site reduction measures

For non-residential developments:

- Target zero-carbon (annual regulated energy)
- 15% carbon saving must be from energy efficiency measures
- 35% carbon saving must be from on-site reduction measures

Any carbon emissions shortfall will need to be offset by making a carbon offset payment to the Local Authority and the carbon offset price is under review and expected to be updated

The proposed policy targets have not been used to determine the energy efficiency and carbon offset payment calculations reported in this energy strategy.

GLA Sustainable Design and Construction SPG (April 2014)

This SPG provides more detailed guidance to aid implementation that cannot be covered in the London Plan. It updates the standards that were developed for the Mayor's SPG on Sustainable Design and Construction in 2006 and identifies these as priorities for the Mayor. The SPG provides guidance and practical advice for those designing schemes including architects, developers and engineers as well as those developing planning policy and neighbourhood plans.

To support the policies in the London Plan, the Sustainable Design and Construction SPG includes guidance on:

- energy efficient design
- meeting the carbon dioxide reduction targets
- decentralised energy
- how to offset carbon dioxide where the targets set out in the London Plan are not met
- retro-fitting measures
- support for monitoring energy use during occupation
- an introduction to resilience and demand side response
- air quality neutral
- resilience to flooding
- urban greening
- pollution control
- basements policy and developments
- local food growing

London Borough of Richmond upon Thames Local Plan

Local Plan (2018)

LBRuT's Local Plan was adopted in July 2018. The Local Plan replaces the previous Local Plan as well as the Local Development Management policies. Key policies relating to energy and sustainability are summarised below.

Policy LP 1 Local Character and Design Quality

The council will require all development to be of high architectural and urban design quality. The high quality character and heritage of the borough and its Villages will need to be maintained and enhanced where opportunities arise. Development proposals will have to demonstrate a thorough understanding of the site and how it relates to its existing context, including character and appearance, and take opportunities to improve the quality and character of buildings, spaces and the local area.

Policy LP 8 Amenity and Living Conditions

Design and layout of buildings enables good standards of daylight and sunlight to be achieved in new development and in existing properties affected by new development.

Policy LP 10 Local Environmental Impacts, Pollution and Land Contamination

Development proposals should not lead to detrimental effects on the health, safety and amenity of existing and new users or occupiers of the development site, or the surrounding land. These potential impacts can include, but are not limited to, air pollution, noise and vibration, light pollution, odours and fumes, solar glare, solar dazzle and land contamination.

Policy LP 17 Green Roofs and Walls

Green/brown roofs should be incorporated into new major developments with roof plate areas of 100sqm or more where technically feasible and subject to considerations of visual impact. If it is not feasible to incorporate a green/brown roof, then a green wall should be incorporated.

Policy LP 20 Climate Change Adaptation

Developments will be encouraged to be fully resilient to the future impacts of climate change in order to minimise vulnerability of people and property.

New developments should minimise the effects of overheating in accordance with the cooling hierarchy.

Policy LP 22 Sustainable Design and Construction

LP22A Sustainable Design and Construction

1. Developments of 1 dwelling or more, or 100sqm or more of non-residential floor space (including extensions) will be required to comply with the Sustainable Construction Checklist SPD.

2. Developments with new dwellings must achieve a water consumption of 110l per person per day for homes.

3. New non-residential buildings over 100sqm must achieve BREEAM “Excellent”

4. Change of use residential should meet BREEAM Domestic Refurbishment “Excellent”, where feasible.

LP22B Reducing Carbon Dioxide Emissions

1. All new major residential developments should achieve zero carbon standards in line with London Plan policy.

2. All other new residential buildings should achieve 35% reduction

3. All major non-residential buildings should achieve a 35% reduction. From 2019 all major non-residential should achieve zero carbon standards in line with London Plan Policy.

LP22D Decentralised Energy Networks

1. All new development required to connect to existing DE network where feasible (including planned DE networks operational within 5 years of development completion).

2. Major developments will need to provide an assessment of the provision of on-site DE networks and CHP.

3. Where feasible, major developments will need to provide on-site DE and CHP. Provision for future connection should be incorporated where required.

Policy LP 23 Water Resources and Infrastructure

Water resources and supplies will be protected by resisting proposals that would pose an unacceptable threat. Proposals that seek to increase water availability or protect and improve water quality will be encouraged.

Policy LP 30 Health and Wellbeing

Developments that support the following will be encouraged:

- Sustainable modes of travel
- Access to green infrastructure
- Access to local community facilities, services and shops
- Access to local healthy food
- Access to toilet facilities open to all
- Inclusive public realm layout

Appendix B: GLA Overheating Checklist

Section 1 – Site Features affecting vulnerability to overheating		Please respond Yes or No
Site Location	Urban – within central London or high density conurbation	No
	Peri-urban – on the suburban fringes of London	Yes
Air Quality and/or Noise sensitivity – are any of the following in the vicinity of buildings?	Busy roads / A roads	Yes
	Railways / Overground / DLR	Yes
	Airport / Flight Path	Yes
	Industrial uses / waste facility	No
Proposed building use	Will any buildings be occupied by vulnerable people (e.g. elderly, disabled, young children)?	Yes, possibly elderly.
	Are residents likely to be at home during the day (e.g. students)?	Yes
Dwelling aspect	Are there any single aspect units?	Yes
Glazing ratio	Is the glazing ratio (glazing : internal floor area) greater than 25%?	No
	If yes, is this to allow acceptable levels of daylighting?	N/A
Security – Are there any security issues that could limit opening of windows for ventilation?	Single storey ground floor units	No
	Vulnerable areas identified by the Police Architectural Liaison Officer	No
	Other	

Table 18: GLA Overheating checklist – Section 1

Section 2 – Design Features Implemented to Mitigate Overheating Risk		Please Respond
Landscaping	Will deciduous trees be provided for summer shading (to windows and pedestrian routes)?	Yes
	Will green roofs be provided?	Yes
	Will other green or blue infrastructure be provided around buildings for evaporative cooling?	Yes Roof terraces and soft landscaping around buildings
Materials	Have high albedo (light colour) materials been specified?	Yes White stone material specified on three building blocks

Section 2 – Design Features Implemented to Mitigate Overheating Risk		Please Respond
Dwelling Aspect	% of total units that are single aspect	41%
	% of single aspect with N/NE/NW orientation	TBC
	% single aspect with E orientation	TBC
	% single aspect with S/SE/SW orientation	TBC
	% single aspect with W orientation	TBC
Glazing Ratio – What is the glazing ratio (glazing: internal floor area) on each façade?	North/ Northeast/ Northwest	3.2%
	South/ Southeast/ Southwest	4.5%
	East	6.1%
	West	4.7%
Daylighting	What is the average daylight factor range	TBC
Window Opening	Are windows openable?	Yes
	What is the average percentage of openable area for the windows?	100% (all are openable doors)
Window Opening – what is the extent of the opening?	Fully openable	Yes (part)
	Limited (e.g. for security, safety, wind loading reasons)	Yes (part)
Security	Where there are security issues (e.g. ground floor flats) has an alternative night time natural ventilation method been provided (e.g. ventilation grates)?	N/A
Shading	Is there any external shading?	No
	Is there any internal shading?	Yes Blinds
Glazing Specification	Is there any solar control glazing?	Yes – g-value of 0.4 throughout
Ventilation – what is the ventilation strategy?	Natural - background	No
	Natural – purge	Yes
	Mechanical – background (e.g. MVHR)	Yes
	Mechanical – purge	No
	What is the average design air change rate?	In line with part F requirements

Section 2 – Design Features Implemented to Mitigate Overheating Risk		Please Respond
Heating System	Is communal heating present?	Yes
	What is the flow/return temperature?	55/30
	Have horizontal pipe runs been minimized?	Yes
	Do the specifications include insulation levels in line with the London Heat Network Manual?	Yes

Table 19: GLA Overheating checklist – Section 2

Appendix C: CIBSE TM59 Results

Summary of Input Parameters
The following table provides an overview of the input parameters/ modelling assumptions.

Software	IESve 2019	Window Covering (SF = Shading Factor)	None
Weather Data	Design Summer Year (DSY1,2,3) London Heathrow 2020 High Emissions Scenario 50th Percentile	Window opening type	90° opening angle, side hung, with 85% openable area 10° opening angle at night
Assessment Criteria	CIBSE TM59	Occupancy	Bedrooms/Studio: 24/7 Living room/Kitchen: 9am-10pm
Wall U-Value	0.15 W/m².K	Max. Occupancy Density	1Bed – 2 People 2 Bed – 4 People 3 Bed – 6 People
Window Averaged U-value	1.4 W/m².K	Occupancy Heat Gains	75W / person (Sensible) 55W / person (Latent)
Window g-Value	0.4	Communal Corridor Internal Gains	12 W/m² (Initial estimation based upon improved pipework insulation)
Roof U-Value	0.16 W/m².K	Lighting Gains	2 W/m² (All areas)
Floor (ground) U-value	0.13 W/m².K	Max. Equipment Gains – Kitchen & Living	450 W (as per CIBSE TM59)
Floor (exposed) U-value	0.13 W/m².K	Max. Equipment Gains – Bedroom	80 W (as per CIBSE TM59)
Infiltration	0.25 ACH	Heat Interface Unit	20W – continuous output

Table 20: Summary of input parameters used in the TM59 assessment

Mechanical ventilation in dwellings	75 l/s, 90 l/s
Temperature offset	14°C
Communal corridor ventilation	200 l/s
Communal corridor ventilation temperature	External air

Results summary
Summary of TM59 results in the following tables. Both natural ventilation and mechanical ventilation scenarios have been included.

<u>All tested apartments meet TM59 requirements by passing the natural ventilation scenario under the DSY 1 weather file.</u>

Results for DSY2 and DSY3 weather files are presented as well, in line with GLA requirements. As can be seen, the overheating risk increases with these more extreme heatwave scenarios. It should be noted that for DSY2 and DSY3 represent heatwave scenarios, and as such provide challenging conditions for the assessment of CIBSE overheating criteria. The DSY3 weather file contains a prolonged period of sustained warmth, with maximum daily temperatures ranging from 30-35°C. The DSY2 weather file contains a very intense single warm spell, with maximum daily temperatures in excess of 35°C.

All dwellings will be provided with mechanical ventilation with heat recovery and openable windows, allowing the occupant to adapt their internal environment according to their own needs.

As the external ambient temperatures in the London DSY1 weather file exceed 26°C for 2.7% of annual hours, there is very little margin (0.3% of annual hours) left as flexibility. Once unavoidable internal heat gains are included in the model (cooking, lighting, people, small power equipment), it can therefore be expected that rooms will quickly exceed the threshold in a dynamic model. Nevertheless, a number of rooms are expected to pass the criterion on the mechanical ventilation scenario.

An assessment has been made of the fresh air rate that could be delivered to apartments by mechanical means, and the impact this is expected to have on temperatures achieved. As a result of this assessment, it is proposed to increase the ventilation rate in some apartments from 75 l/s to 90 l/s which will further aid the mitigation of high internal temperatures in summer months.

The fresh air will be tempered by implementation of a cooling coil into the supply ductwork where necessary, with initial cooling capacities tested as listed in Table 22 below. This will be further developed in the detailed design stages.

Comfort cooling will also be implemented to a proportion of apartments, with preference given to those apartments at risk of experiencing excessive noise from external sources.

Table 21: Natural ventilation analysis results

	TM59 Criterion 1 % pass Living rooms and bedrooms	TM59 Criterion 2 % pass Bedrooms only	Communal Corridors – 28°C operative temperature
Natural Ventilation			
DSY1	100% of tested rooms	100% of tested rooms	Meets target
DSY2	83% of tested rooms	28% of tested rooms	
DSY3	60% of tested rooms	3% of tested rooms	

Table 22: Mechanical ventilation/ sealed façade analysis results

Flow rate (l/s)	Cooling capacity (kW)	CIBSE Guide A % pass Living rooms and bedrooms	Communal Corridors – 28°C operative temperature
Mechanical Ventilation - pass rates			
75	1.5	40% of tested rooms	Meets target
90	1.5	56% of tested rooms	
90	2.5	65% of tested rooms	

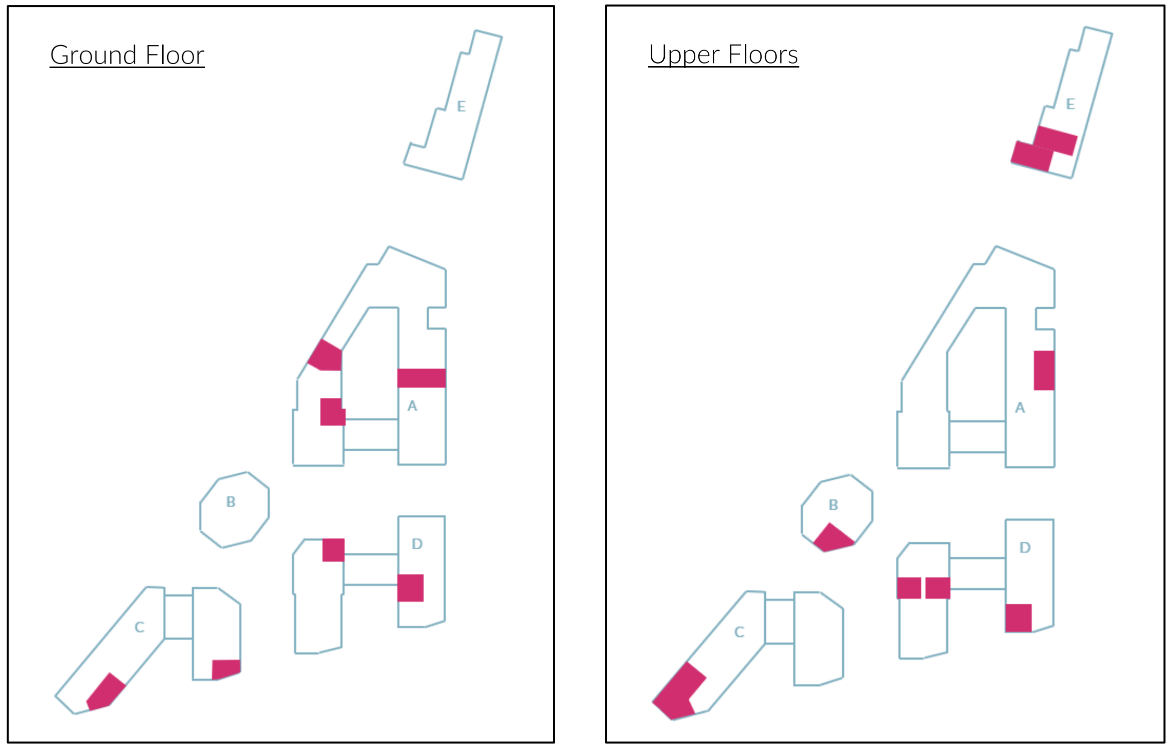
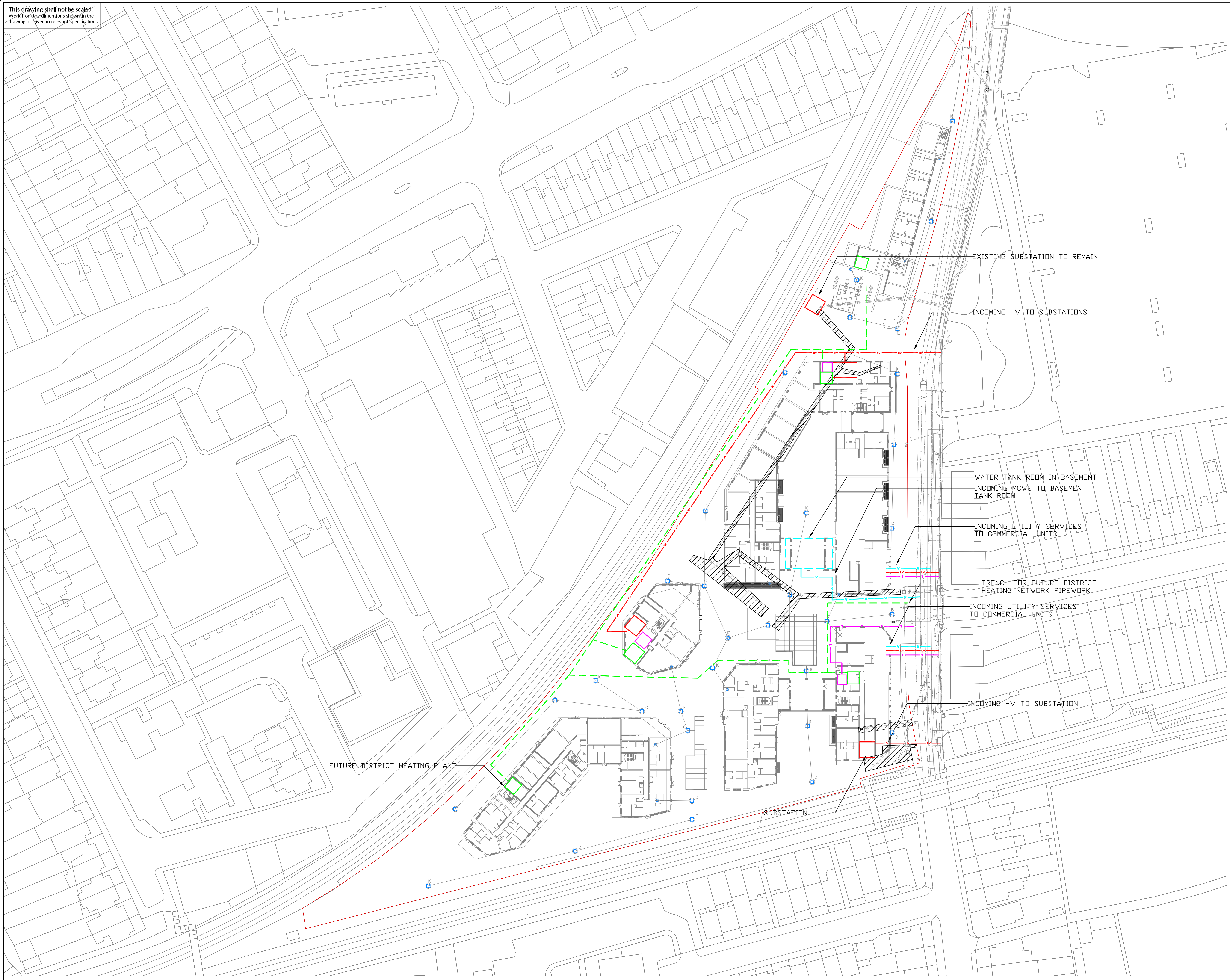


Figure 15: Sample of apartments tested. All 'upper floor' tested apartments are located on the top-most floor of the respective building

Appendix D: External Services Layout

A1

This drawing shall not be scaled.
Work from the dimensions shown in the drawing or given in relevant specifications



CDM Regulations:

In addition to any information included in this drawing or the model from which it is derived, refer also to the project CDM Risk Register for information on residual risks.

General Notes:

- The drawing does not necessarily show all the information needed to interpret the design intent or the construction details.
- The drawing contains information from more than one source and must be read in conjunction with all relevant specifications.
- Any apparent drafting errors and differences between other drawings and specifications shall be brought to our attention.

Project Notes:

1. THIS DRAWING SHOWS INDICATIVE UTILITY ROUTES. FURTHER DETAILS TO BE DEVELOPED AS THE DESIGN PROGRESSES.
2. FOR FURTHER INFORMATION REGARDING EXISTING UTILITIES, REFER TO EXISTING UTILITY INFORMATION.

LEGEND

HV	High Voltage Electricity
LV	Low Voltage Electricity
SL	Street Lighting Cable
W	Water Main
G	Gas Main
FW	Foul Water
SW	Surface Water
CS	Combined Sewer
T	British Telecom
CT	Cable Television
FO	Fibre Optics
TS	Traffic Signalling
LV Overhead / LV	Overhead Service (applies to any service)
	Future District Heating
	Services to be made safe and removed
	Surface water attenuation tank
	Future District Heating Plant
	Incoming Comms Intake
	Substation

Index	Description	Designed	Reviewed	Authorised	Date
P1	REVISED STAGE 2 ISSUE	TC	TC	MAH	11/19
P1	STAGE 2 ISSUE	GC	TC	MAH	02/19

REVISIONS:

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PROJECT TITLE:
MANOR ROAD
RICHMOND

DRAWING TITLE:
COMBINED SERVICES
EXTERNAL SERVICES LAYOUT

PRELIMINARY ISSUE

PERSON RESPONSIBLE FOR:

Design:	Review:	Authorising Issue:
GC	TC	MAH

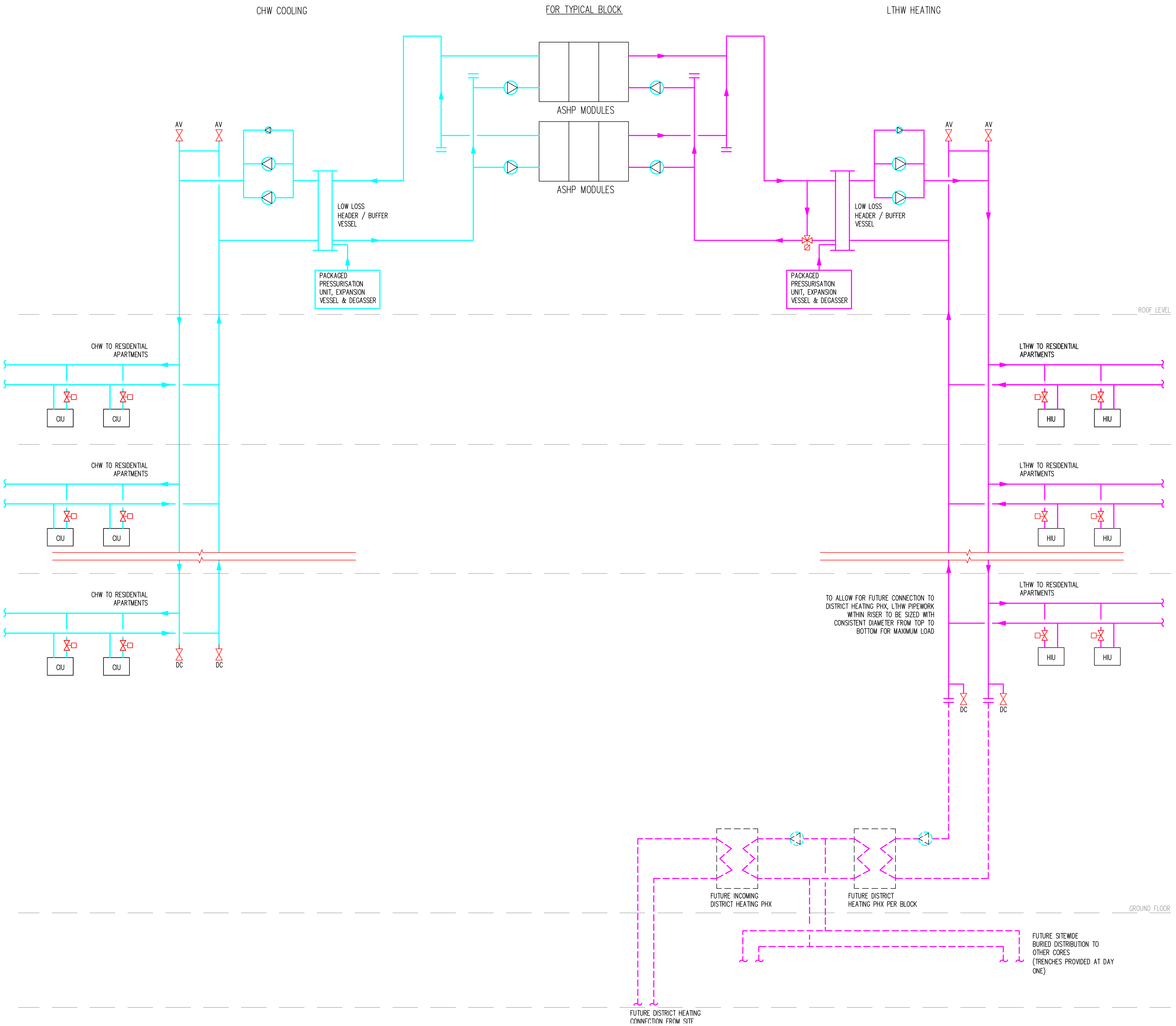
Project No:	Date:	Scale @ A1:
0209506	JANUARY 2019	NTS

DRAWING NUMBER:	Revision:
0209506-HL-XX-XX-GA-U-500-0001	P2

Appendix E: Concept LTHW/CHW Schematic

A1

This drawing shall not be scaled.
Work from the dimensions shown in the drawing or given in relevant specifications



CDM Regulations:

In addition to any information included in this drawing or the model from which it is derived, refer also to the project CDM Risk Register for information on residual risks.

General Notes:

- The drawing does not necessarily show all the information needed to interpret the design intent or the construction details.
- The drawing contains information from more than one source and must be read in conjunction with all relevant specifications.
- Any apparent drafting errors and differences between other drawings and specifications shall be brought to our attention.

Project Notes:

1. THIS DRAWING SHOWS THE TYPICAL ARRANGEMENT FOR A SINGLE BLOCK.
2. COOLING PROVISION TO APARTMENTS TO BE CONFIRMED.

LEGEND :

- CHW F&R PIPEWORK
- LTHW F&R PIPEWORK
- FLOW DIRECTION
- CIRCULATING PUMP
- DC DRAIN COCK
- 3-PORT MOTORISED VALVE
- ASHP AIR SOURCE HEAT PUMP
- PHX PLATE HEAT EXCHANGE
- AV AIR VENT
- CONTROL VALVE (PICV)

Index	Description	Designed	Reviewed	Authorised	Date
P2	REVISED STAGE 2 ISSUE	TC	TC	MAH	11/19
P1	STAGE 2 ISSUE	GC	TC	MAH	02/19

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PROJECT TITLE:
MANOR ROAD
RICHMOND

DRAWING TITLE:
MECHANICAL SERVICES
CONCEPT LTHW / CHW SCHEMATIC

PRELIMINARY ISSUE

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GC	TC	MAH

Project No:	Date:	Scale @ A1:
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0209506-HL-XX-XX-SM-M-590-0001	P1

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Appendix F: Grid Decarbonisation.

Historic progress

The carbon factor of the National Grid – the amount of carbon dioxide released per kilowatt hour of electricity produced and distributed – is recognised in current Building Regulations as being 0.519 kgCO_2/kWh. However, the national mix of electricity generation methods is progressing towards greener solutions with renewable sources accounting for 29.4% of the electricity generated in the UK in 2017; up from 24.5% in 2016 [3].

As a consequence, the Building Regulations Part L 2013 value of the National Grid carbon factor has been shown to be substantially higher than how the grid is performing in reality. This severely impacts the calculated emissions produced by all heat raising plant which use electricity directly or generate it to offset other emissions. The figure below shows how the mix of generation techniques serving the National Grid, as well as the associated carbon factor, has varied over the past six years – encouragingly, the carbon intensity of the grid has reduced to less than half its value in 2012 [HM Government, "Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal", 02 January 2018].

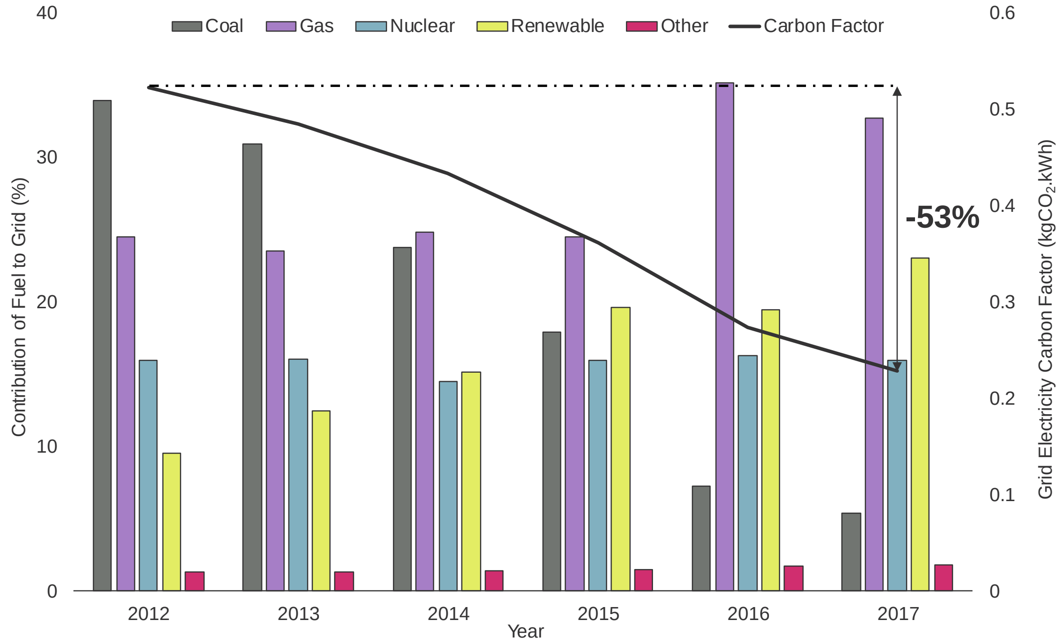


Figure 16: Historic mix of generation methods and associated carbon factor for the National Grid. 8% transmission and distribution losses are included. Sources: *electricityinfo.org* (generation mix); *BEIS Green Book* (historic carbon factors).

Future projections

The Future Energy Scenarios (FES) document, produced by the National Grid, discusses how the UK's energy landscape is changing. In this year's report, FES 2018, the carbon factor of the National Grid is projected to be less than 0.170 kgCO_2/kWh by the end of this year, meaning the actual carbon emissions associated with electricity consumption are much lower than reported in Building Regulations. This means that, under the Part L 2013 methodology the CO_2 emissions associated with electrically-driven plant are being overestimated by over 200%. FES 2018 makes projections of how the mix of generation in the grid is likely to change between now and 2050 – the year by which the Climate Change Act 2008 set the target of reducing the UK's CO_2 emissions by 80% from 1990 levels.

FES discusses these projections in one of four scenarios with the best and worst-case scenarios (from an emissions perspective) being Two Degrees and Steady State respectively. Two Degrees describes a situation where a combination of drastic policy intervention and innovation pushes an ambitious agenda with a focus on long-term environmental goals – it is described as the 'cost optimal pathway to meet the UK's 2050 carbon emissions reduction target'. In contrast, Steady State is a 'business as usual' situation, where society is focussed on the short term and ensuring the security of the UK's energy supply.

The figure below combines these future trajectories with the actual carbon intensity of the National Grid over the past seven years. The reported emissions associated with electricity generation have fallen steeply since 2012 and in all cases, the FES 2018 scenarios see the carbon factor of electricity fall below 100gCO_2/kWh by 2035.

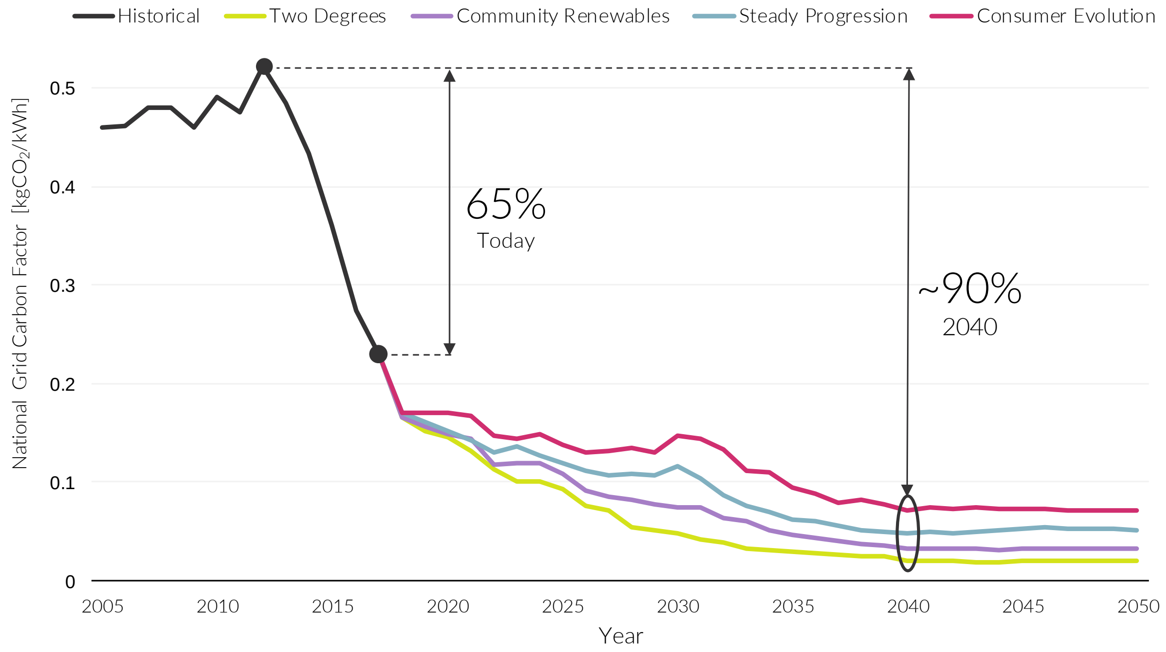


Figure 17: Historic and future projected carbon factor for the National Grid. 8% transmission and distribution losses are included. Sources: BEIS Green Book (historic carbon factors); National Grid Future Energy Scenarios (FES) 2018 (future projected carbon factors).

Shifting focus

As the carbon emissions associated with the generation of electricity continue to reduce, the proportion of the UK's overall greenhouse gas emissions for which the electricity sector is responsible will fall.

The carbon factor of natural gas is likely to remain relatively static. With 85% of homes in the UK relying on gas to supply their heating and hot water, as well as a significant proportion of commercial buildings, heating buildings and industry represents an ever-greater proportion of UK emissions – 32% in 2015 [HM Government, "Clean Growth Strategy," October 2017].

In order for the UK to maintain a trajectory sufficient to meet the 2050 Paris Agreement decarbonisation target of an 80% reduction in annual greenhouse gas emissions over 1990 levels, focus must necessarily shift to other contributors. The BEIS Clean Growth Strategy provides an indication of the direction the UK's energy policy is likely to take and "…sets out [the government's] proposals for decarbonising all sectors of the UK economy through the 2020s." This includes investing in infrastructure and mechanisms to facilitate a transition to low emission vehicles and strengthening the energy performance requirements of new and existing buildings.

As engineers and specialists in the built environment, staying abreast of this dynamism across all sectors is essential for Hoare Lea.

Updates to the Standard Assessment Procedure (SAP10)

In July 2018, the BRE released an update to the Standard Assessment Procedure (SAP) – used to assess dwellings' compliance with Building Regulations – for consultation. The following represents a brief summary of the changes to carbon factors over the current methodology, SAP2012.

Carbon factors

Many of the fuel types recognised in SAP have had their fuel types, carbon factors and primary energy factors amended following the decarbonisation of the grid and other national infrastructure changes. The table below shows the changes in carbon factor from SAP 2012 to SAP 10. It is worth noting the significant improvement for the electricity carbon factor (almost half of that used in 2012).

It is likely that that the next update to Building Regulations Part L will specify the SAP 10 carbon factors associated with natural gas and electricity.

Table 23: Current (SAP2012) and proposed (SAP10) carbon factors for natural gas and grid-supplied electricity.

Fuel	SAP 2012 Carbon Factor ($kgCO_2/kWh$)	SAP 10 Carbon Factor ($kgCO_2/kWh$)
Main Gas	0.216	0.210
Electricity	0.519	0.233

GLA Policy

This difference between national policy and reality means the emissions savings offered by all heat-raising plant are misrepresentative.

Figure 18 shows the percentage reduction in emissions over the GLA baseline for a variety of development types and servicing strategies using both the Part L 2013 and SAP10 carbon factors. Using the Part L 2013 carbon factor CHP offers substantial emissions savings in all scenarios (over 20%) whilst heat pumps offer a benefit in certain applications but a detriment in others. Direct electric is calculated to cause a net increase in emissions in all examples, over 60% in some circumstances.

However, using the SAP10 carbon factor, now specified within GLA energy assessment guidance (October 2018), the situation is markedly different. Heat pumps offer a significant benefit in all cases, with a minimum of a 20% reduction in regulated CO_2. CHP, on the other hand, now offer significantly less benefit, and actually cause over a 30% increase in net emissions in some applications where formerly they were strong. Direct electric is now better from an emissions perspective that the GLA gas boiler baseline in all scenarios.

However, whilst the updated SAP10 carbon factor is far closer to how the grid has been performing in recent years, the rate of progress is such that is may already be out of date. The Future Energy Scenarios 2018 report anticipated a carbon factor of 0.170$kgCO_2$/kWh by the end of 2018; a 28% reduction compared to the SAP10 carbon factor. Figure 19 shows how this difference affects the calculated emissions of a large-scale, mixed-use development for a variety of servicing strategies.

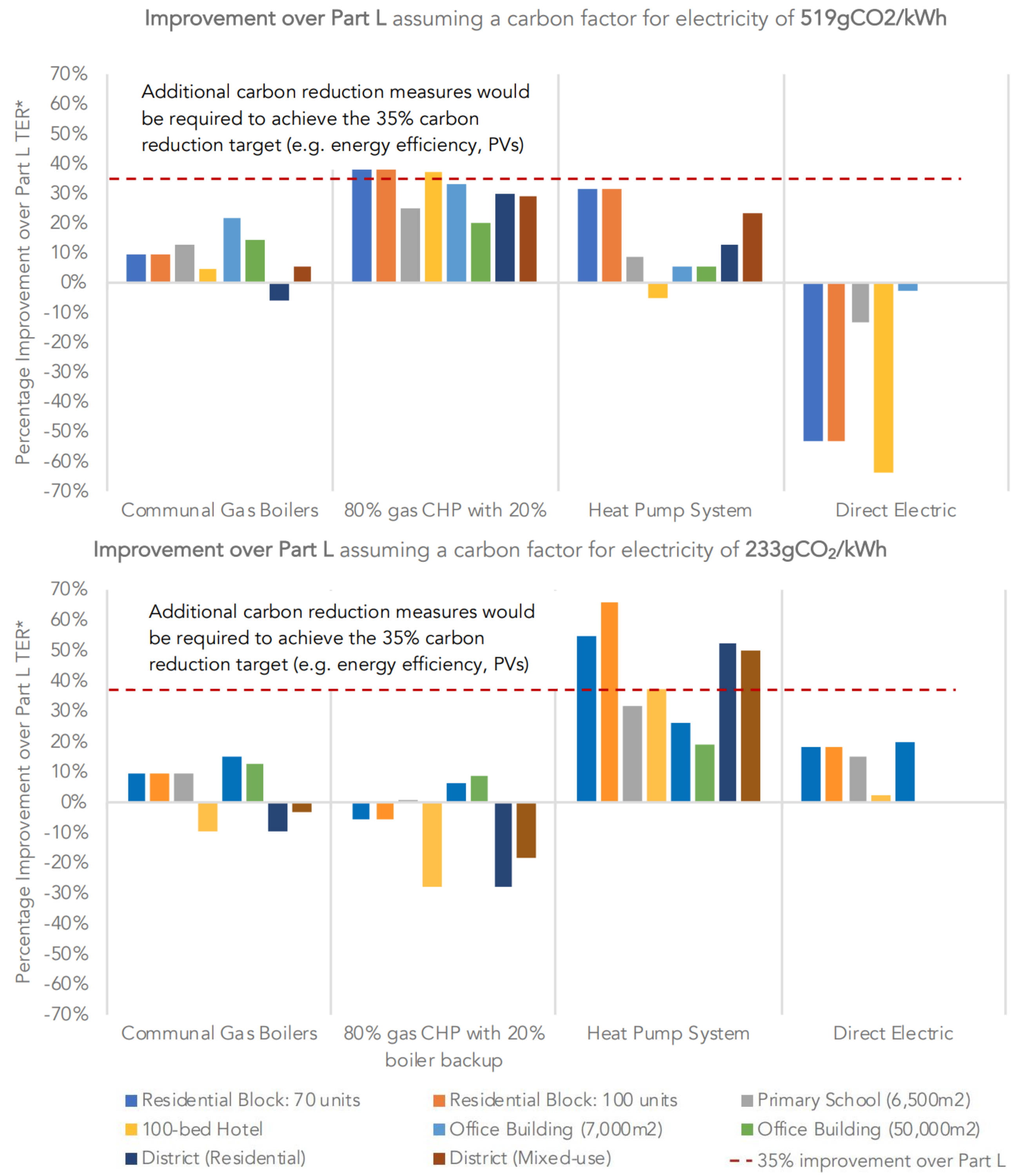


Figure 18: Percentage improvement over the baseline for a variety of development types and servicing strategies using both the current Part L 2013 carbon factor (top) and the updated SAP10 carbon factor (bottom) for electricity.

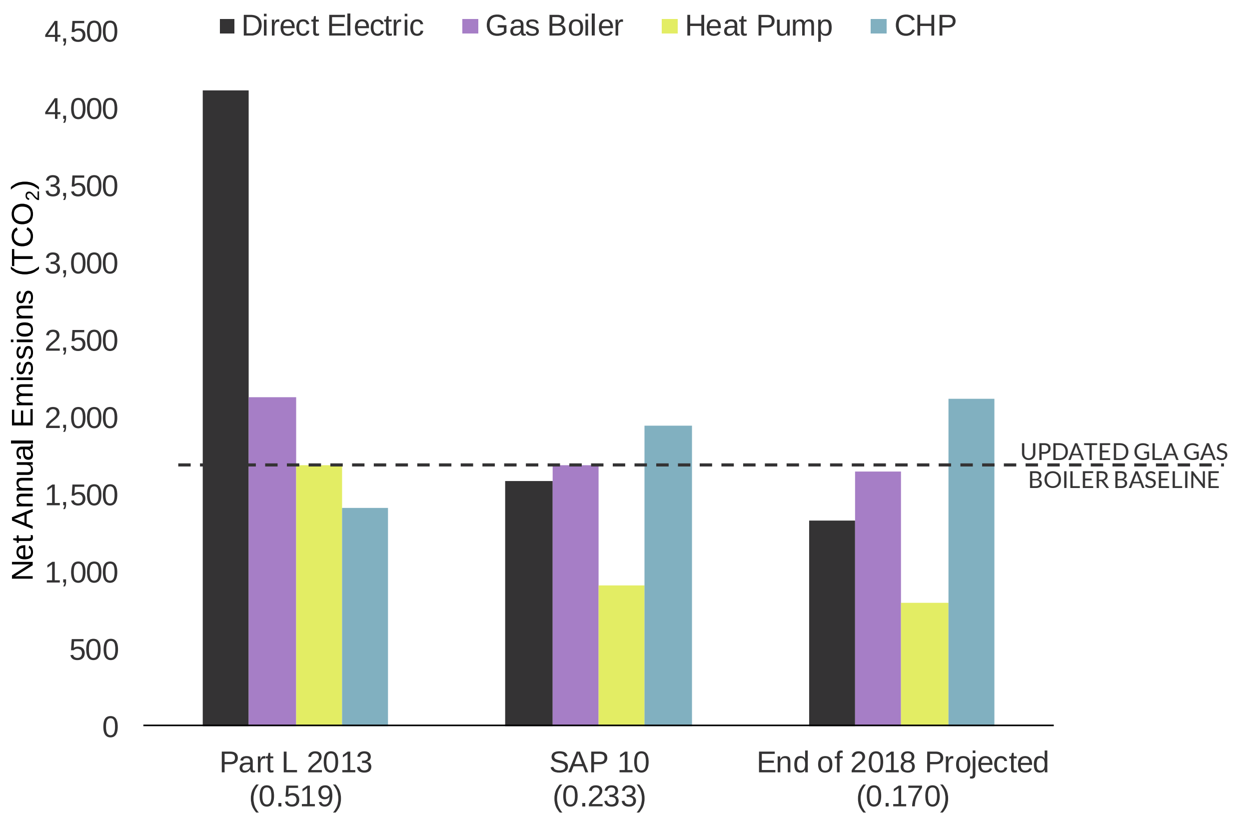
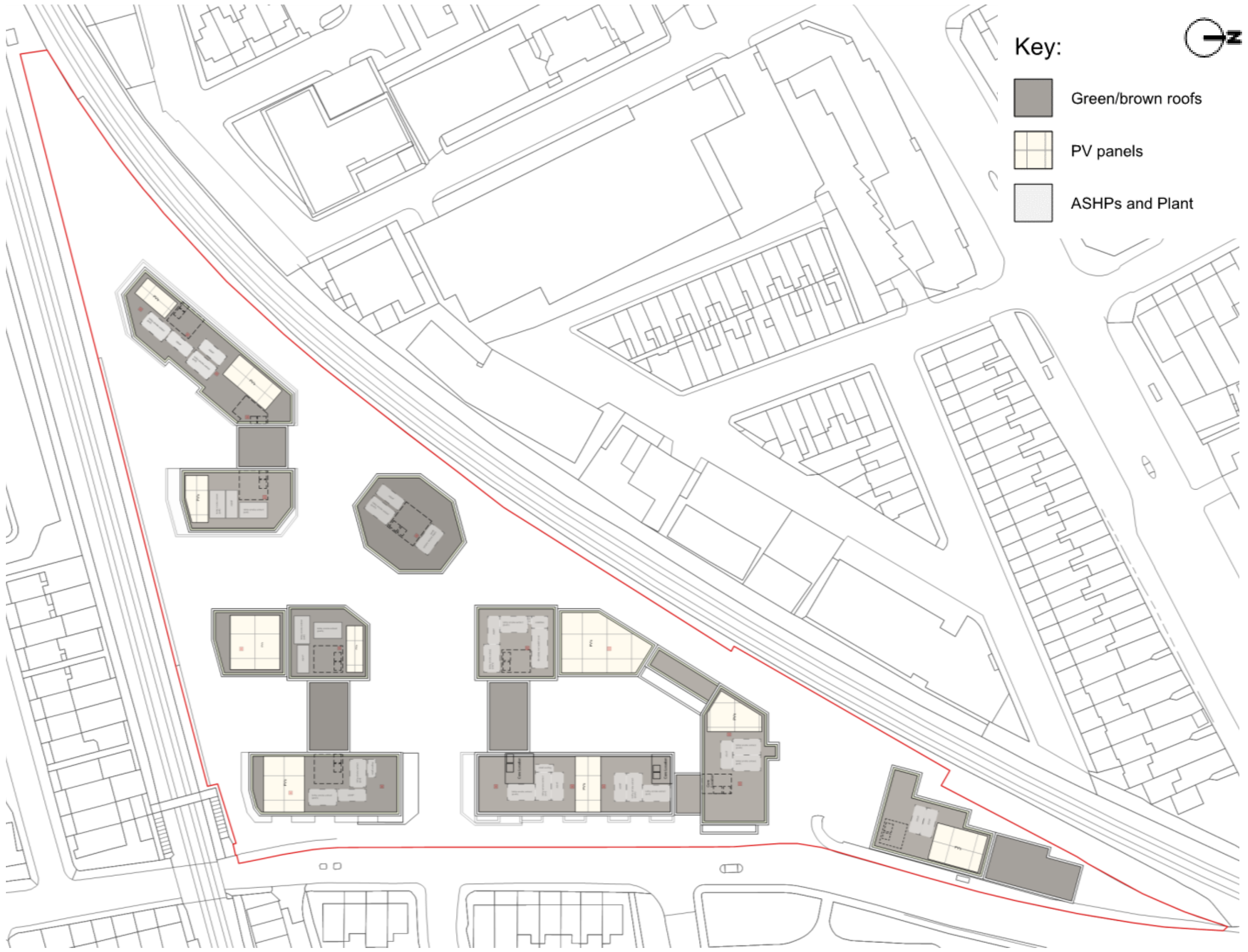
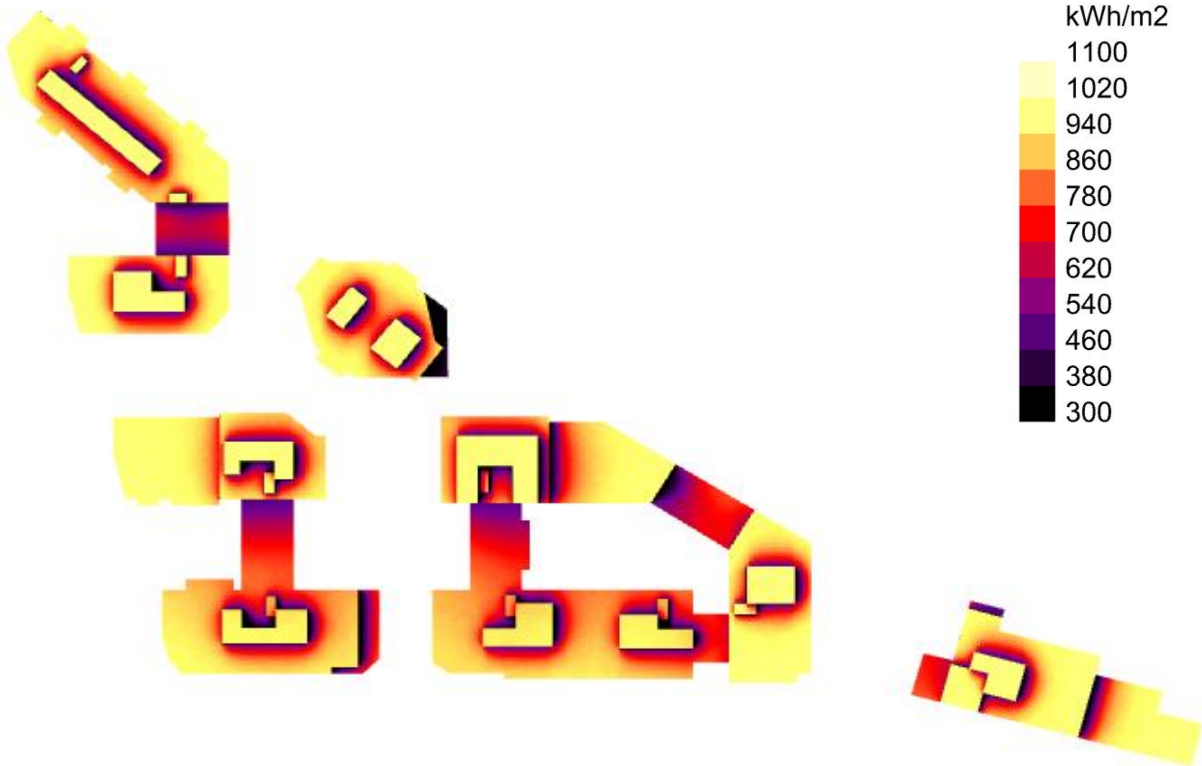


Figure 19: Net annual emissions for a large scale, mixed-use development for a variety of servicing strategies under Part L 2013, using the updated SAP10 carbon factor, and the projected carbon factor for the end of 2018 respectively.

Appendix G: Roof area appraisal.

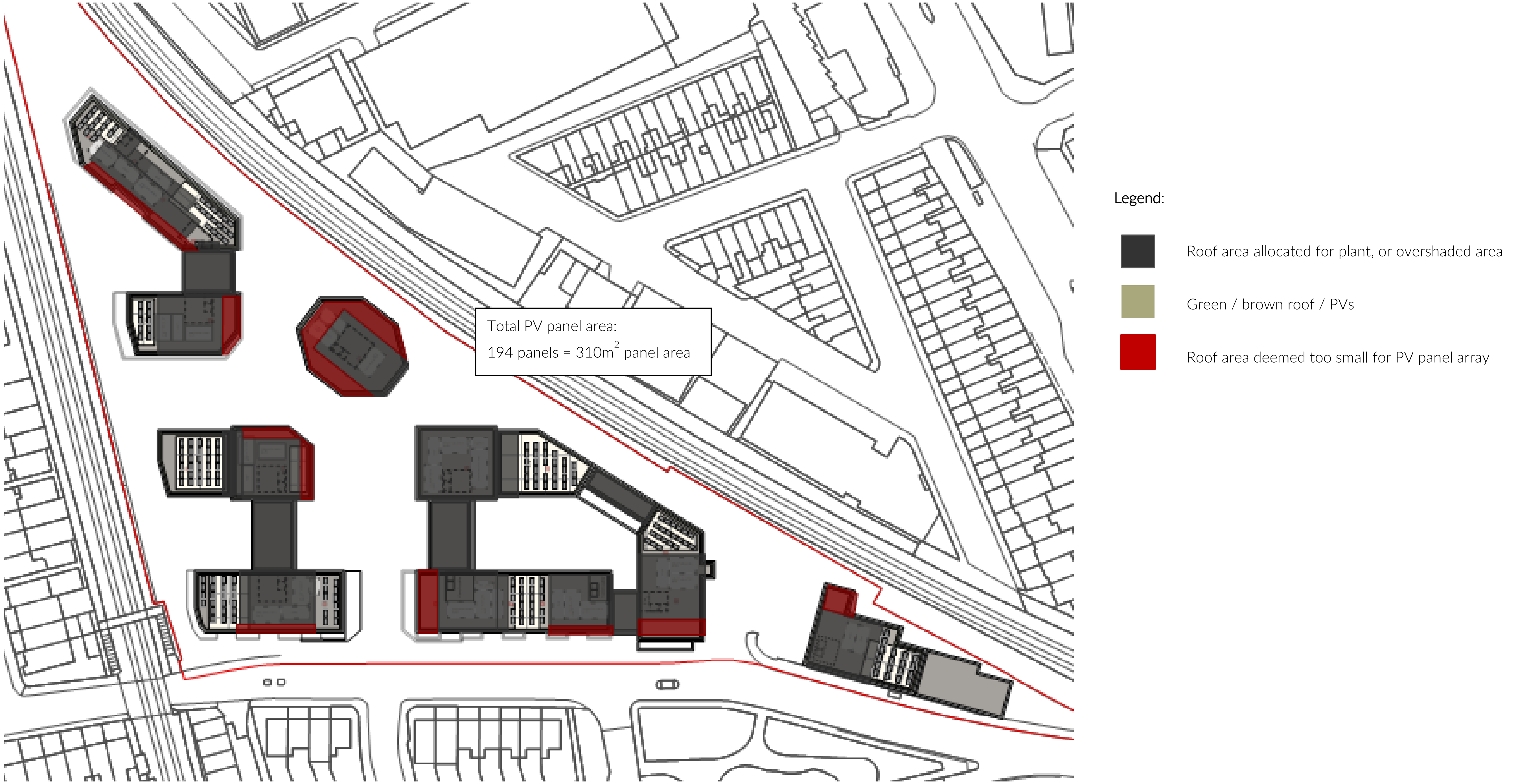


Proposed Development Roof Plan (source: Assael Architecture)



Annual solar irradiance on roofs

Total PV panel area:
194 panels = 310m^2 panel area



Resulting Proposed PV array

Appendix H: SAP worksheets.

Be Lean example data sheet – DER & TER

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	Miss Michelle Wang	Assessor number	2018
Client		Last modified	23/10/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		70.28	(1a)	x	2.65	(2a)	=	186.24	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	70.28	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			186.24	(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	2	(19)
Shelter factor 1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor (18) x (20) =	0.13	(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	0.16	0.16	0.16	0.14	0.14	0.12	0.12	0.12	0.13	0.14	0.14	0.15	(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]	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(24a)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(25)

BSI SAP

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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	
Window			21.01	x	1.33	=	27.85			(27)
External wall			39.72	x	0.15	=	5.96			(29a)
External wall			5.37	x	0.01	=	0.05			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.10							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	33.87	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		100.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		11.02	(36)
Total fabric heat loss	(33) + (36) =	44.89	(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)	17.21	17.02	16.82	15.84	15.65	14.67	14.67	14.47	15.06	15.65	16.04	16.43	(38)
Heat transfer coefficient, W/K (37)m + (38)m	62.10	61.90	61.71	60.73	60.53	59.55	59.55	59.36	59.94	60.53	60.92	61.31	
Average = ∑(39)1...12/12 =												60.68	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	0.88	0.88	0.88	0.86	0.86	0.85	0.85	0.84	0.85	0.86	0.87	0.87	
Average = ∑(40)1...12/12 =												0.86	(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	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(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)	96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
∑(44)1...12 =												1052.48	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
∑(45)1...12 =												1379.96	(45)
Distribution loss 0.15 x (45)m	21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.61	(48)
Temperature factor from Table 2b	0.60	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.97	(50)
Enter (50) or (54) in (55)	0.97	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(57)

Primary circuit loss for each month from Table 3

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	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	196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	(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	196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	
∑(64)1...12 =												2006.45	(64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]	90.14	80.05	85.50	78.62	78.48	72.19	71.29	75.52	74.54	81.43	83.62	88.64	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(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)	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)	121.15	119.13	114.92	109.20	105.49	100.26	95.81	101.51	103.53	109.45	116.14	119.14	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	393.54	391.60	379.29	359.45	339.39	319.97	307.28	312.89	323.02	343.05	366.09	383.28	(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	
SouthEast	0.77	x	5.25	x	36.79	x 0.9 x	0.40	x	0.90	=	48.19	(77)
SouthWest	0.54	x	3.68	x	36.79	x 0.9 x	0.40	x	0.90	=	23.69	(79)
SouthWest	0.77	x	5.78	x	36.79	x 0.9 x	0.40	x	0.90	=	53.06	(79)
NorthWest	0.77	x	6.30	x	11.28	x 0.9 x	0.40	x	0.90	=	17.73	(81)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	142.67	248.91	356.22	467.60	547.69	554.25	529.98	468.62	394.54	279.32	171.96	121.40	(83)
Total gains - internal and solar (73)m + (83)m	536.22	640.51	735.51	827.05	887.08	874.22	837.26	781.51	717.56	622.37	538.05	504.69	(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)												

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	0.93	0.89	0.83	0.71	0.57	0.42	0.31	0.34	0.53	0.76	0.90	0.94	(86)
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)	19.50	19.81	20.19	20.59	20.84	20.96	20.99	20.98	20.90	20.56	19.97	19.44	(87)
Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)	20.18	20.18	20.19	20.20	20.20	20.21	20.21	20.21	20.21	20.20	20.20	20.19	(88)
Utilisation factor for gains for rest of dwelling n2,m	0.92	0.88	0.81	0.68	0.53	0.37	0.25	0.29	0.48	0.73	0.88	0.93	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)	18.17	18.61	19.15	19.70	20.02	20.17	20.20	20.20	20.11	19.68	18.86	18.10	(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2	18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(92)
Apply adjustment to the mean internal temperature from Table 4e where appropriate	18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.91	0.86	0.79	0.68	0.54	0.39	0.28	0.31	0.50	0.73	0.87	0.92	(94)
Useful gains, ηmGm, W (94)m x (84)m	487.02	552.42	583.41	564.02	481.32	343.16	235.12	244.69	357.84	453.98	466.36	463.94	(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]	903.03	886.28	813.22	683.18	528.69	355.44	238.25	249.13	384.49	576.79	750.84	893.76	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	309.52	224.35	170.98	85.80	35.24	0.00	0.00	0.00	0.00	91.37	204.82	319.78	

∑(98)1...5, 10...12 = 1441.87 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) 20.52 (99)

8c. Space cooling requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat loss rate Lm	0.00	0.00	0.00	0.00	0.00	559.78	440.68	451.10	0.00	0.00	0.00	0.00	(100)
Utilisation factor for loss ηm	0.00	0.00	0.00	0.00	0.00	0.94	0.96	0.95	0.00	0.00	0.00	0.00	(101)
Useful loss ηmLm (watts) (100)m x (101)m	0.00	0.00	0.00	0.00	0.00	526.03	424.47	430.53	0.00	0.00	0.00	0.00	(102)
Gains	0.00	0.00	0.00	0.00	0.00	1102.90	1057.93	992.99	0.00	0.00	0.00	0.00	(103)
Space cooling requirement, whole dwelling, continuous (kWh) 0.024 x [(103)m - (102)m] x (41)m	0.00	0.00	0.00	0.00	0.00	415.35	471.29	418.47	0.00	0.00	0.00	0.00	

∑(104)6...8 = 1305.12 (104)

Cooled fraction — cooled area ÷ (4) = 0.51 (105)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Intermittency factor (Table 10)	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.00	0.00	0.00	0.00

∑(106)6...8 = 0.75 (106)

Space cooling requirement (104)m x (105) x (106)m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	0.00	0.00	0.00	0.00	0.00	52.61	59.70	53.01	0.00	0.00	0.00	0.00

∑(107)6...8 = 165.32 (107)

Space cooling requirement kWh/m²/year — (107) ÷ (4) = 2.35 (108)

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		1.05	(306)

Space heating

Annual space heating requirement	1441.87			(98)
Space heat from boilers		(98) x (304a) x (305) x (306) =	1513.96	(307a)

Water heating

Annual water heating requirement	2006.45			(64)
Water heat from boilers		(64) x (303a) x (305a) x (306) =	2106.77	(310a)
Electricity used for heat distribution		0.01 × [(307a)...(307e) + (310a)...(310e)] =	36.21	(313)
Cooling System Energy Efficiency Ratio			4.05	(314)
Space cooling (if there is a fixed cooling system, if not enter 0)		(107) ÷ (314)	40.82	(315)
Electricity for pumps, fans and electric keep-hot (Table 4f)				
mechanical ventilation fans - balanced, extract or positive input from outside	174.96			(330a)
Total electricity for the above, kWh/year			174.96	(331)
Electricity for lighting (Appendix L)			311.66	(332)
Total delivered energy for all uses		(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	4148.17	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from boilers	1513.96	x	4.24	x 0.01 =	64.19	(340a)
Water heating from boilers	2106.77	x	4.24	x 0.01 =	89.33	(342a)
Space cooling	40.82	x	13.19	x 0.01 =	5.38	(348)
Pumps and fans	174.96	x	13.19	x 0.01 =	23.08	(349)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(350)
Additional standing charges					120.00	(351)
Total energy cost				(340a)...(342e) + (345)...(354) =	343.09	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.25	(357)
SAP value	82.56	
SAP rating (section 13)	83	(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		89.50					(367a)
CO2 emissions from boilers	[(307a)+(310a)] x 100 ÷ (367a) =	4045.52	x	0.216	=	873.83	(367)
Electrical energy for community heat distribution		36.21	x	0.519	=	18.79	(372)
Total CO2 associated with community systems						892.62	(373)
Total CO2 associated with space and water heating						892.62	(376)
Space cooling		40.82	x	0.519	=	21.19	(377)
Pumps and fans		174.96	x	0.519	=	90.80	(378)
Electricity for lighting		311.66	x	0.519	=	161.75	(379)
Total CO_2, kg/year					(376)..(382) =	1166.36	(383)
Dwelling CO_2 emission rate					(383) ÷ (4) =	16.60	(384)
EI value						86.44	
EI rating (section 14)						86	(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		89.50					(367a)
Primary energy from boilers	[(307a)+(310a)] x 100 ÷ (367a) =	4045.52	x	1.22	=	4935.53	(367)
Electrical energy for community heat distribution		36.21	x	3.07	=	111.16	(372)
Total primary energy associated with community systems						5046.69	(373)
Total primary energy associated with space and water heating						5046.69	(376)
Space cooling		40.82	x	3.07	=	125.32	(377)
Pumps and fans		174.96	x	3.07	=	537.11	(378)
Electricity for lighting		311.66	x	3.07	=	956.79	(379)
Primary energy kWh/year						6665.91	(383)
Dwelling primary energy rate kWh/m2/year						94.85	(384)

TER 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	Miss Michelle Wang	Assessor number	2018
Client		Last modified	23/10/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		70.28	(1a)	x	2.65	(2a)	=	186.24	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	70.28	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			186.24	(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	3	x 10 =	30	(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) =	30	÷ (5) =	0.16	(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	5.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)	0.41	(18)
Number of sides on which the dwelling is sheltered	2	(19)
Shelter factor 1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor (18) x (20) =	0.35	(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	0.45	0.44	0.43	0.38	0.38	0.33	0.33	0.32	0.35	0.38	0.39	0.41	(22b)

Calculate effective air change rate for the applicable case:

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
d) natural ventilation or whole house positive input ventilation from loft	0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(24d)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)	0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(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	
Window			17.57	x	1.33	=	23.29			(27)
External wall			48.50	x	0.18	=	8.73			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.07							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	32.02	(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		5.69	(36)
Total fabric heat loss	(33) + (36) =	37.71	(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)	36.83	36.59	36.36	35.27	35.07	34.12	34.12	33.94	34.48	35.07	35.48	35.91	(38)
Heat transfer coefficient, W/K (37)m + (38)m	74.54	74.31	74.07	72.98	72.78	71.83	71.83	71.65	72.20	72.78	73.19	73.62	
Average = ∑(39)1...12/12 =												72.98	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	1.06	1.06	1.05	1.04	1.04	1.02	1.02	1.02	1.03	1.04	1.04	1.05	
Average = ∑(40)1...12/12 =												1.04	(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	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(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)	96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
∑(44)1...12 =												1052.48	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
∑(45)1...12 =												1379.96	(45)
Distribution loss 0.15 x (45)m	21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.62	(48)
Temperature factor from Table 2b	0.54	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.88	(50)
Enter (50) or (54) in (55)	0.88	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(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)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
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	193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	(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	193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	
∑(64)1...12 =												1973.70	(64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]	87.91	78.04	83.28	76.47	76.26	70.03	69.06	73.30	72.39	79.21	81.47	86.41	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(69)
Pump and fan gains (Table 5a)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	(70)
Losses e.g. evaporation (Table 5)	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)	118.16	116.14	111.93	106.21	102.50	97.27	92.82	98.52	100.54	106.46	113.15	116.15	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	393.55	391.61	379.30	359.46	339.40	319.98	307.29	312.90	323.03	343.06	366.10	383.29	(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	
SouthEast	0.77	x	4.39	x	36.79	x 0.9 x	0.63	x	0.70	=	49.36	(77)
SouthWest	0.54	x	3.08	x	36.79	x 0.9 x	0.63	x	0.70	=	24.29	(79)
SouthWest	0.77	x	4.84	x	36.79	x 0.9 x	0.63	x	0.70	=	54.42	(79)
NorthWest	0.77	x	5.26	x	11.28	x 0.9 x	0.63	x	0.70	=	18.14	(81)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	146.21	255.08	365.02	479.10	561.11	567.82	542.96	480.13	404.26	286.23	176.23	124.42	(83)
Total gains - internal and solar (73)m + (83)m	539.77	646.69	744.31	838.56	900.51	887.80	850.25	793.03	727.29	629.30	542.32	507.71	(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	0.98	0.95	0.87	0.71	0.51	0.37	0.41	0.66	0.91	0.98	1.00	(86)

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

20.04	20.24	20.50	20.79	20.94	20.99	21.00	21.00	20.97	20.75	20.34	20.00	(87)

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

20.03	20.04	20.04	20.05	20.05	20.06	20.06	20.07	20.06	20.05	20.05	20.04	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.99	0.98	0.94	0.83	0.65	0.44	0.29	0.33	0.58	0.88	0.98	0.99	(89)

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

18.76	19.06	19.43	19.82	20.00	20.06	20.06	20.07	20.04	19.79	19.22	18.72	(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

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

19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37	(92)

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

19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37	(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	0.94	0.84	0.67	0.48	0.33	0.37	0.62	0.89	0.98	0.99	(94)
Useful gains, ηmGm, W (94)m x (84)m	534.28	630.63	698.39	706.21	607.11	422.26	282.43	295.73	448.15	559.29	529.87	503.83	(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]	1126.31	1096.35	998.21	832.70	638.98	426.11	282.86	296.53	462.91	704.11	928.54	1117.04	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	440.46	312.97	223.07	91.07	23.71	0.00	0.00	0.00	0.00	107.75	287.04	456.23	

	∑(98)1...5, 10...12 =	1942.29	(98)
Space heating requirement kWh/m²/year	(98) ÷ (4)	27.64	(99)

9a. Energy requirements - individual heating systems including micro-CHP

Space heating

Fraction of space heat from secondary/supplementary system (table 11)		0.00	(201)
Fraction of space heat from main system(s)	1 - (201) =	1.00	(202)
Fraction of space heat from main system 2		0.00	(202)
Fraction of total space heat from main system 1	(202) x [1- (203)] =	1.00	(204)
Fraction of total space heat from main system 2	(202) x (203) =	0.00	(205)
Efficiency of main system 1 (%)		93.50	(206)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating fuel (main system 1), kWh/month	471.08	334.72	238.57	97.40	25.36	0.00	0.00	0.00	0.00	115.24	307.00	487.95	

∑(211)1...5, 10...12 = 2077.32 (211)

Water heating

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Efficiency of water heater	86.94	86.41	85.39	83.36	81.05	79.80	79.80	79.80	79.80	83.68	86.11	87.08	(217)
Water heating fuel, kWh/month	222.56	197.52	210.26	193.60	195.50	177.96	171.43	187.40	186.84	199.96	204.86	217.03	

∑(219a)1...12 = 2364.91 (219)

Annual totals

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SAP version 9.92
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Space heating fuel - main system 1			2077.32	
Water heating fuel			2364.91	
Electricity for pumps, fans and electric keep-hot (Table 4f)				
central heating pump or water pump within warm air heating unit	30.00			(230c)
boiler flue fan	45.00			(230e)
Total electricity for the above, kWh/year			75.00	(231)
Electricity for lighting (Appendix L)			311.66	(232)
Total delivered energy for all uses		(211)...(221) + (231) + (232)...(237b) =	4828.89	(238)

10a. Fuel costs - individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	2077.32	x	3.48	x 0.01 =	72.29	(240)
Water heating	2364.91	x	3.48	x 0.01 =	82.30	(247)
Pumps and fans	75.00	x	13.19	x 0.01 =	9.89	(249)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(250)
Additional standing charges					120.00	(251)
Total energy cost				(240)...(242) + (245)...(254) =	325.59	(255)

11a. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	1.19	(257)
SAP value	83.45	
SAP rating (section 13)	83	(258)
SAP band	B	

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	2077.32	x	0.216	=	448.70	(261)
Water heating	2364.91	x	0.216	=	510.82	(264)
Space and water heating				(261) + (262) + (263) + (264) =	959.52	(265)
Pumps and fans	75.00	x	0.519	=	38.93	(267)
Electricity for lighting	311.66	x	0.519	=	161.75	(268)
Total CO_2, kg/year				(265)...(271) =	1160.20	(272)
Dwelling CO_2 emission rate				(272) ÷ (4) =	16.51	(273)
EI value					86.51	
EI rating (section 14)					87	(274)
EI band					B	

13a. Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	2077.32	x	1.22	=	2534.33	(261)
Water heating	2364.91	x	1.22	=	2885.20	(264)
Space and water heating				(261) + (262) + (263) + (264) =	5419.53	(265)
Pumps and fans	75.00	x	3.07	=	230.25	(267)
Electricity for lighting	311.66	x	3.07	=	956.79	(268)
Primary energy kWh/year					6606.57	(272)
Dwelling primary energy rate kWh/m2/year					94.00	(273)

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Be Green example data sheet – DER & TER

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	Miss Michelle Wang	Assessor number	2018
Client		Last modified	05/11/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		70.28	(1a)	x	2.65	(2a)	=	186.24	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	70.28	(4)						
Dwelling volume							(3a) + (3b) + (3c) + (3d)...(3n) =	186.24	(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		2	(19)
Shelter factor	1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.13	(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	0.16	0.16	0.16	0.14	0.14	0.12	0.12	0.12	0.13	0.14	0.14	0.15	(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]	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(24a)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)	0.28	0.28	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25	0.26	0.27	(25)

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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	
Window			21.01	x	1.33	=	27.85			(27)
External wall			39.72	x	0.15	=	5.96			(29a)
External wall			5.37	x	0.01	=	0.05			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.10							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	33.87	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		100.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		11.02	(36)
Total fabric heat loss	(33) + (36) =	44.89	(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)	17.21	17.02	16.82	15.84	15.65	14.67	14.67	14.47	15.06	15.65	16.04	16.43	(38)
Heat transfer coefficient, W/K (37)m + (38)m	62.10	61.90	61.71	60.73	60.53	59.55	59.55	59.36	59.94	60.53	60.92	61.31	
Average = ∑(39)1...12/12 =												60.68	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	0.88	0.88	0.88	0.86	0.86	0.85	0.85	0.84	0.85	0.86	0.87	0.87	
Average = ∑(40)1...12/12 =												0.86	(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	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(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)	96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
∑(44)1...12 =												1052.48	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
∑(45)1...12 =												1379.96	(45)
Distribution loss 0.15 x (45)m	21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.61	(48)
Temperature factor from Table 2b	0.60	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.97	(50)
Enter (50) or (54) in (55)	0.97	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	29.95	27.05	29.95	28.98	29.95	28.98	29.95	29.95	28.98	29.95	28.98	29.95	(57)

Primary circuit loss for each month from Table 3

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	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	196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	(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	196.28	173.19	182.33	164.07	161.23	144.70	139.58	152.32	151.79	170.10	179.09	191.77	
∑(64)1...12 =												2006.45	(64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]	90.14	80.05	85.50	78.62	78.48	72.19	71.29	75.52	74.54	81.43	83.62	88.64	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(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)	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)	121.15	119.13	114.92	109.20	105.49	100.26	95.81	101.51	103.53	109.45	116.14	119.14	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	393.54	391.60	379.29	359.45	339.39	319.97	307.28	312.89	323.02	343.05	366.09	383.28	(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	
SouthEast	0.77	x	5.25	x	36.79	x 0.9 x	0.40	x	0.90	=	48.19	(77)
SouthWest	0.54	x	3.68	x	36.79	x 0.9 x	0.40	x	0.90	=	23.69	(79)
SouthWest	0.77	x	5.78	x	36.79	x 0.9 x	0.40	x	0.90	=	53.06	(79)
NorthWest	0.77	x	6.30	x	11.28	x 0.9 x	0.40	x	0.90	=	17.73	(81)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	142.67	248.91	356.22	467.60	547.69	554.25	529.98	468.62	394.54	279.32	171.96	121.40	(83)
Total gains - internal and solar (73)m + (83)m	536.22	640.51	735.51	827.05	887.08	874.22	837.26	781.51	717.56	622.37	538.05	504.69	(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)												

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0.93	0.89	0.83	0.71	0.57	0.42	0.31	0.34	0.53	0.76	0.90	0.94	(86)

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

19.50	19.81	20.19	20.59	20.84	20.96	20.99	20.98	20.90	20.56	19.97	19.44	(87)

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

20.18	20.18	20.19	20.20	20.20	20.21	20.21	20.21	20.21	20.20	20.20	20.19	(88)

Utilisation factor for gains for rest of dwelling n2,m

0.92	0.88	0.81	0.68	0.53	0.37	0.25	0.29	0.48	0.73	0.88	0.93	(89)

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

18.17	18.61	19.15	19.70	20.02	20.17	20.20	20.20	20.11	19.68	18.86	18.10	(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

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

18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(92)

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

18.84	19.22	19.68	20.15	20.43	20.57	20.60	20.60	20.51	20.13	19.42	18.78	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.91	0.86	0.79	0.68	0.54	0.39	0.28	0.31	0.50	0.73	0.87	0.92	(94)
Useful gains, ηmGm, W (94)m x (84)m	487.02	552.42	583.41	564.02	481.32	343.16	235.12	244.69	357.84	453.98	466.36	463.94	(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]	903.03	886.28	813.22	683.18	528.69	355.44	238.25	249.13	384.49	576.79	750.84	893.76	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	309.52	224.35	170.98	85.80	35.24	0.00	0.00	0.00	0.00	91.37	204.82	319.78	

∑(98)1...5, 10...12 = 1441.87 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 20.52 (99)

8c. Space cooling requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat loss rate Lm	0.00	0.00	0.00	0.00	0.00	559.78	440.68	451.10	0.00	0.00	0.00	0.00	(100)
Utilisation factor for loss ηm	0.00	0.00	0.00	0.00	0.00	0.94	0.96	0.95	0.00	0.00	0.00	0.00	(101)
Useful loss ηmLm (watts) (100)m x (101)m	0.00	0.00	0.00	0.00	0.00	526.03	424.47	430.53	0.00	0.00	0.00	0.00	(102)
Gains	0.00	0.00	0.00	0.00	0.00	1102.90	1057.93	992.99	0.00	0.00	0.00	0.00	(103)
Space cooling requirement, whole dwelling, continuous (kWh) 0.024 x [(103)m - (102)m] x (41)m	0.00	0.00	0.00	0.00	0.00	415.35	471.29	418.47	0.00	0.00	0.00	0.00	

∑(104)6...8 = 1305.12 (104)

Cooled fraction — cooled area ÷ (4) = 0.51 (105)

Intermittency factor (Table 10)

0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.00	0.00	0.00	0.00

∑(106)6...8 = 0.75 (106)

Space cooling requirement (104)m x (105) x (106)m

0.00	0.00	0.00	0.00	0.00	52.61	59.70	53.01	0.00	0.00	0.00	0.00

∑(107)6...8 = 165.32 (107)

Space cooling requirement kWh/m²/year — (107) ÷ (4) = 2.35 (108)

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 heat pump		1.00	(303a)
Fraction of total space heat from community heat pump	(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		1.07	(306)

Space heating

Annual space heating requirement	1441.87			(98)
Space heat from heat pump		(98) x (304a) x (305) x (306) =	1542.80	(307a)

Water heating

Annual water heating requirement	2006.45			(64)
Water heat from heat pump		(64) x (303a) x (305a) x (306) =	2146.90	(310a)
Electricity used for heat distribution		0.01 × [(307a)...(307e) + (310a)...(310e)] =	36.90	(313)
Cooling System Energy Efficiency Ratio			4.05	(314)
Space cooling (if there is a fixed cooling system, if not enter 0)		(107) ÷ (314)	40.82	(315)
Electricity for pumps, fans and electric keep-hot (Table 4f)				
mechanical ventilation fans - balanced, extract or positive input from outside	174.96			(330a)
Total electricity for the above, kWh/year			174.96	(331)
Electricity for lighting (Appendix L)			311.66	(332)
Total delivered energy for all uses		(307) + (309) + (310) + (312) + (315) + (331) + (332)...(337b) =	4217.14	(338)

10b. Fuel costs - community heating scheme

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating from heat pump	1542.80	x	4.24	x 0.01 =	65.41	(340a)
Water heating from heat pump	2146.90	x	4.24	x 0.01 =	91.03	(342a)
Space cooling	40.82	x	13.19	x 0.01 =	5.38	(348)
Pumps and fans	174.96	x	13.19	x 0.01 =	23.08	(349)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(350)
Additional standing charges					120.00	(351)
Total energy cost				(340a)...(342e) + (345)...(354) =	346.01	(355)

11b. SAP rating - community heating scheme

Energy cost deflator (Table 12)	0.42	(356)
Energy cost factor (ECF)	1.26	(357)
SAP value	82.41	
SAP rating (section 13)	82	(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 heat pump	180.00					(367a)
CO2 emissions from heat pump [(307a)+(310a)] x 100 ÷ (367a) =	2049.84	x	0.519	=	1063.86	(367)
Electrical energy for community heat distribution	36.90	x	0.519	=	19.15	(372)
Total CO2 associated with community systems					1083.01	(373)
Total CO2 associated with space and water heating					1083.01	(376)
Space cooling	40.82	x	0.519	=	21.19	(377)
Pumps and fans	174.96	x	0.519	=	90.80	(378)
Electricity for lighting	311.66	x	0.519	=	161.75	(379)
Total CO_2, kg/year				(376)..(382) =	1356.75	(383)
Dwelling CO_2 emission rate				(383) ÷ (4) =	19.30	(384)
EI value					84.23	
EI rating (section 14)					84	(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 heat pump	180.00					(367a)
Primary energy from heat pump [(307a)+(310a)] x 100 ÷ (367a) =	2049.84	x	3.07	=	6292.99	(367)
Electrical energy for community heat distribution	36.90	x	3.07	=	113.27	(372)
Total primary energy associated with community systems					6406.27	(373)
Total primary energy associated with space and water heating					6406.27	(376)
Space cooling	40.82	x	3.07	=	125.32	(377)
Pumps and fans	174.96	x	3.07	=	537.11	(378)
Electricity for lighting	311.66	x	3.07	=	956.79	(379)
Primary energy kWh/year					8025.49	(383)
Dwelling primary energy rate kWh/m2/year					114.19	(384)

TER 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	Miss Michelle Wang	Assessor number	2018
Client		Last modified	05/11/2019
Address	Manor Road Richmond Block 1, Richmond, TW9		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		70.28	(1a)	x	2.65	(2a)	=	186.24	(3a)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	70.28	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			186.24	(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	3	x 10 =	30	(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) =	30	÷ (5) =	0.16	(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		5.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.41	(18)
Number of sides on which the dwelling is sheltered		2	(19)
Shelter factor	1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.35	(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	0.45	0.44	0.43	0.38	0.38	0.33	0.33	0.32	0.35	0.38	0.39	0.41	(22b)

Calculate effective air change rate for the applicable case:

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
d) natural ventilation or whole house positive input ventilation from loft	0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(24d)
Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)	0.60	0.60	0.59	0.57	0.57	0.56	0.56	0.55	0.56	0.57	0.58	0.58	(25)

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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	
Window			17.57	x	1.33	=	23.29			(27)
External wall			48.50	x	0.18	=	8.73			(29a)
Party wall			33.79	x	0.00	=	0.00			(32)
Total area of external elements ∑A, m²			66.07							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	32.02	(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		5.69	(36)
Total fabric heat loss	(33) + (36) =	37.71	(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)	36.83	36.59	36.36	35.27	35.07	34.12	34.12	33.94	34.48	35.07	35.48	35.91	(38)
Heat transfer coefficient, W/K (37)m + (38)m	74.54	74.31	74.07	72.98	72.78	71.83	71.83	71.65	72.20	72.78	73.19	73.62	
Average = ∑(39)1...12/12 =												72.98	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	1.06	1.06	1.05	1.04	1.04	1.02	1.02	1.02	1.03	1.04	1.04	1.05	
Average = ∑(40)1...12/12 =												1.04	(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	2.25	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	87.71	(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)	96.48	92.97	89.46	85.95	82.44	78.94	78.94	82.44	85.95	89.46	92.97	96.48	
∑(44)1...12 =												1052.48	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	143.07	125.13	129.13	112.57	108.02	93.21	86.37	99.12	100.30	116.89	127.59	138.56	
∑(45)1...12 =												1379.96	(45)
Distribution loss 0.15 x (45)m	21.46	18.77	19.37	16.89	16.20	13.98	12.96	14.87	15.04	17.53	19.14	20.78	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	194.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.62	(48)
Temperature factor from Table 2b	0.54	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.88	(50)
Enter (50) or (54) in (55)	0.88	(55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water storage loss calculated for each month (55) x (41)m	27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)	27.16	24.54	27.16	26.29	27.16	26.29	27.16	27.16	26.29	27.16	26.29	27.16	(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)

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
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	193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	(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	193.50	170.68	179.55	161.38	158.45	142.01	136.80	149.54	149.10	167.32	176.39	188.99	
∑(64)1...12 =												1973.70	(64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]	87.91	78.04	83.28	76.47	76.26	70.03	69.06	73.30	72.39	79.21	81.47	86.41	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	112.65	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	17.65	15.67	12.75	9.65	7.21	6.09	6.58	8.55	11.48	14.58	17.01	18.14	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	197.95	200.00	194.83	183.81	169.90	156.82	148.09	146.04	151.21	162.23	176.14	189.22	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	34.26	(69)
Pump and fan gains (Table 5a)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	(70)
Losses e.g. evaporation (Table 5)	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	-90.12	(71)
Water heating gains (Table 5)	118.16	116.14	111.93	106.21	102.50	97.27	92.82	98.52	100.54	106.46	113.15	116.15	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m	393.55	391.61	379.30	359.46	339.40	319.98	307.29	312.90	323.03	343.06	366.10	383.29	(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	
SouthEast	0.77	x	4.39	x	36.79	x 0.9 x	0.63	x	0.70	=	49.36	(77)
SouthWest	0.54	x	3.08	x	36.79	x 0.9 x	0.63	x	0.70	=	24.29	(79)
SouthWest	0.77	x	4.84	x	36.79	x 0.9 x	0.63	x	0.70	=	54.42	(79)
NorthWest	0.77	x	5.26	x	11.28	x 0.9 x	0.63	x	0.70	=	18.14	(81)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains in watts ∑(74)m...(82)m	146.21	255.08	365.02	479.10	561.11	567.82	542.96	480.13	404.26	286.23	176.23	124.42	(83)
Total gains - internal and solar (73)m + (83)m	539.77	646.69	744.31	838.56	900.51	887.80	850.25	793.03	727.29	629.30	542.32	507.71	(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	0.98	0.95	0.87	0.71	0.51	0.37	0.41	0.66	0.91	0.98	1.00	(86)

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)	20.04	20.24	20.50	20.79	20.94	20.99	21.00	21.00	20.97	20.75	20.34	20.00	(87)
Temperature during heating periods in the rest of dwelling from Table 9, Th2(˚C)	20.03	20.04	20.04	20.05	20.05	20.06	20.06	20.07	20.06	20.05	20.05	20.04	(88)
Utilisation factor for gains for rest of dwelling n2,m	0.99	0.98	0.94	0.83	0.65	0.44	0.29	0.33	0.58	0.88	0.98	0.99	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)	18.76	19.06	19.43	19.82	20.00	20.06	20.06	20.07	20.04	19.79	19.22	18.72	(90)

Living area fraction — Living area ÷ (4) = 0.51 (91)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2	19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37	(92)
Apply adjustment to the mean internal temperature from Table 4e where appropriate	19.41	19.65	19.98	20.31	20.48	20.53	20.54	20.54	20.51	20.27	19.79	19.37	(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	0.94	0.84	0.67	0.48	0.33	0.37	0.62	0.89	0.98	0.99	(94)
Useful gains, ηmGm, W (94)m x (84)m	534.28	630.63	698.39	706.21	607.11	422.26	282.43	295.73	448.15	559.29	529.87	503.83	(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]	1126.31	1096.35	998.21	832.70	638.98	426.11	282.86	296.53	462.91	704.11	928.54	1117.04	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	440.46	312.97	223.07	91.07	23.71	0.00	0.00	0.00	0.00	107.75	287.04	456.23	

∑(98)1...5, 10...12 = 1942.29 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) = 27.64 (99)

9a. Energy requirements - individual heating systems including micro-CHP

Space heating

Fraction of space heat from secondary/supplementary system (table 11)		0.00	(201)
Fraction of space heat from main system(s)	1 - (201) =	1.00	(202)
Fraction of space heat from main system 2		0.00	(202)
Fraction of total space heat from main system 1	(202) x [1- (203)] =	1.00	(204)
Fraction of total space heat from main system 2	(202) x (203) =	0.00	(205)
Efficiency of main system 1 (%)		93.50	(206)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Space heating fuel (main system 1), kWh/month	471.08	334.72	238.57	97.40	25.36	0.00	0.00	0.00	0.00	115.24	307.00	487.95

∑(211)1...5, 10...12 = 2077.32 (211)

Water heating

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Efficiency of water heater	86.94	86.41	85.39	83.36	81.05	79.80	79.80	79.80	79.80	83.68	86.11	87.08	(217)
Water heating fuel, kWh/month	222.56	197.52	210.26	193.60	195.50	177.96	171.43	187.40	186.84	199.96	204.86	217.03	

∑(219a)1...12 = 2364.91 (219)

Annual totals

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Space heating fuel - main system 1		2077.32	
Water heating fuel		2364.91	
Electricity for pumps, fans and electric keep-hot (Table 4f)			
central heating pump or water pump within warm air heating unit	30.00		(230c)
boiler flue fan	45.00		(230e)
Total electricity for the above, kWh/year		75.00	(231)
Electricity for lighting (Appendix L)		311.66	(232)
Total delivered energy for all uses	(211)...(221) + (231) + (232)...(237b) =	4828.89	(238)

10a. Fuel costs - individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	2077.32	x	3.48	x 0.01 =	72.29	(240)
Water heating	2364.91	x	3.48	x 0.01 =	82.30	(247)
Pumps and fans	75.00	x	13.19	x 0.01 =	9.89	(249)
Electricity for lighting	311.66	x	13.19	x 0.01 =	41.11	(250)
Additional standing charges					120.00	(251)
Total energy cost				(240)...(242) + (245)...(254) =	325.59	(255)

11a. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	1.19	(257)
SAP value	83.45	
SAP rating (section 13)	83	(258)
SAP band	B	

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	2077.32	x	0.216	=	448.70	(261)
Water heating	2364.91	x	0.216	=	510.82	(264)
Space and water heating				(261) + (262) + (263) + (264) =	959.52	(265)
Pumps and fans	75.00	x	0.519	=	38.93	(267)
Electricity for lighting	311.66	x	0.519	=	161.75	(268)
Total CO_2, kg/year				(265)...(271) =	1160.20	(272)
Dwelling CO_2 emission rate				(272) ÷ (4) =	24.02	(273)
EI value					86.51	
EI rating (section 14)					87	(274)
EI band					B	

13a. Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	2077.32	x	1.22	=	2534.33	(261)
Water heating	2364.91	x	1.22	=	2885.20	(264)
Space and water heating				(261) + (262) + (263) + (264) =	5419.53	(265)
Pumps and fans	75.00	x	3.07	=	230.25	(267)
Electricity for lighting	311.66	x	3.07	=	956.79	(268)
Primary energy kWh/year					6606.57	(272)
Dwelling primary energy rate kWh/m2/year					94.00	(273)

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Appendix I: BRUKL summary

Be lean BRUKL

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Manor Road - Retail A1 (Lean) As designed

Date: Fri Jan 25 17:34:01 2019

Administrative information

Building Details

Address: Richmond, London, TW9

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: Avanton Richmond Development Ltd.

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address: , ,

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	43.8
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	43.8
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	33.6
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.15	00000001:Surf[2]
Floor	0.25	0.13	0.13	00000001:Surf[0]
Roof	0.25	0.16	0.16	00000001:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.4	1.4	00000001:Surf[3]
Personnel doors	2.2	1.4	1.4	00000001:Surf[4]
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

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

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

Air Permeability	Worst acceptable standard	This building
m³/(h.m²) at 50 Pa	10	3

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	434.5	434.5
External area [m²]	965.6	965.6
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	311.82	399.49
Average U-value [W/m²K]	0.32	0.41
Alpha value* [%]	10	10

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

Building Use

% Area	Building Type
100	**A1/A2 Retail/Financial and Professional services**
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	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	11.55	13.15
Cooling	5.88	8.82
Auxiliary	16.97	17.66
Lighting	37.77	53.7
Hot water	1.86	1.86
Equipment*	20.26	20.26
TOTAL**	**74.04**	**95.19**

* 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]	127.99	161.17
Primary energy* [kWh/m²]	197.83	258.32
Total emissions [kg/m²]	33.6	43.8

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

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Be green BRUKL

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Manor Road - Retail A1 (Green)

As designed

Date: Fri Jan 25 17:39:38 2019

Administrative information

Building Details

Address: Richmond, London, TW9

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: Avanton Richmond Development Ltd.

Telephone number:

Address: , ,

Certifier details

Name:

Telephone number:

Address: , ,

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	36
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	36
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	27.3
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

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

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.15	0.15	00000001:Surf[2]
Floor	0.25	0.13	0.13	00000001:Surf[0]
Roof	0.25	0.16	0.16	00000001:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.4	1.4	00000001:Surf[3]
Personnel doors	2.2	1.4	1.4	00000001:Surf[4]
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

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

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

Air Permeability	Worst acceptable standard	This building
m³/(h.m²) at 50 Pa	10	3

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Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	434.5	434.5
External area [m²]	965.6	965.6
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	311.82	399.49
Average U-value [W/m²K]	0.32	0.41
Alpha value* [%]	10	10

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

Building Use

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

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	1.98	4.43
Cooling	5.32	8.82
Auxiliary	7.13	3.06
Lighting	37.77	53.7
Hot water	1.7	1.86
Equipment*	20.26	20.26
TOTAL**	**53.9**	**71.88**

* 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]	127.99	161.17
Primary energy* [kWh/m²]	167.27	224.88
Total emissions [kg/m²]	27.3	36

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

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Appendix J: Boiler and ASHP operational cost analysis

	Communal gas boiler			**ASHP + local storage with immersion**			**ASHP + local storage with immersion**		
	Communal gas boiler			**Building-by-building ASHP**			**Building-by-building ASHP**		
	Equivalent heat price	p/kWh	**4.0**	Equivalent heat price (inc. RHI)	p/kWh	**2.4**	Equivalent heat price (excl. RHI)	p/kWh	**5.2**
System Inputs	Tenant heat demand	kWh/yr	1	Tenant heat demand	kWh/yr	1	Tenant heat demand	kWh/yr	1
	Proportion of demand is space heat	-	0.50	Proportion of demand is space heat	-	0.33	Proportion of demand is space heat	-	0.33
	Proportion of demand is DHW	-	0.50	Proportion of demand is DHW	-	0.67	Proportion of demand is DHW	-	0.67
	Communal distribution heat losses	-	0.30	Building by Building distribution heat losses	-	0.11	Building by Building distribution heat losses	-	0.11
	Communal storage heat losses	-	0.00	Communal storage heat losses	-	0.00	Communal storage heat losses	-	0.00
	Gas boiler efficiency	-	0.95	Gas boiler efficiency	-	-	Gas boiler efficiency	-	-
	Pumping energy % of heat generated	-	0.01	Pumping energy % of heat generated	-	0.01	Pumping energy % of heat generated	-	0.01
	Cold water flow temp	C	10	Cold water flow temp	C	10	Cold water flow temp	C	10
	Hot water storage temp	C	-	Hot water storage temp	C	60	Hot water storage temp	C	60
	Communal distribution flow temp	C	70	Communal distribution flow temp	C	55	Communal distribution flow temp	C	55
	Communal distribution return temp	C	40	Communal distribution return temp	C	30	Communal distribution return temp	C	30
				Electric heating efficiency	-	1.00	Electric heating efficiency	-	1.00
				ASHP heating efficiency	-	2.90	ASHP heating efficiency	-	2.90
Calculation	Heat generated	kWh/yr	1.429	Percentage of communal hot water	-	0.90	Percentage of communal hot water	-	0.90
				Percentage of local storage hot water	-	0.10	Percentage of local storage hot water	-	0.10
				ASHP heat generated	kWh/yr	1.049	ASHP heat generated	kWh/yr	1.049
				Electric heat generated	kWh/yr	0.067	Electric heat generated	kWh/yr	0.067
Output (heat system)	Landlord gas consumption	kWh/yr	1.504	Landlord gas consumption	kWh/yr	0.000	Landlord gas consumption	kWh/yr	0.000
	Landlord electricity consumption	kWh/yr	0.014	Landlord electricity consumption	kWh/yr	0.372	Landlord electricity consumption	kWh/yr	0.372
	Tenant electricity consumption	kWh/yr	0.000	Tenant electricity consumption	kWh/yr	0.067	Tenant electricity consumption	kWh/yr	0.067
	Total net energy consumption	kWh/yr	1.518	Total net energy consumption	kWh/yr	0.439	Total net energy consumption	kWh/yr	0.439
	Landlord gas consumption	p	3.865	Landlord gas consumption	p	0.000	Landlord gas consumption	p	0.000
	Landlord electricity consumption	p	0.158	Landlord electricity consumption	p	4.108	Landlord electricity consumption	p	4.108
	Landlord RHI	p	0.000	Landlord RHI	p	-2.821	Landlord RHI	p	0.000
	Tenant gas consumption	p	0.000	Tenant gas consumption	p	0.000	Tenant gas consumption	p	0.000
	Tenant electricity consumption	p	0.000	Tenant electricity consumption	p	1.099	Tenant electricity consumption	p	1.099
	Total energy consumption	p	4.022	Total energy cost	p	2.386	Total energy cost	p	5.207

Table 24: Boiler & ASHP operational cost analysis inputs and results

Appendix K: Centralised vs decentralised analysis

Centralised vs decentralised energy strategy analysis.
Manor Road, Richmond.

Introduction.

This report has been produced on behalf of Avanton Richmond Development Ltd to assess the implications of providing a centralised district heating network for the proposed development at Manor Road, Richmond.

The energy strategy is based upon a number of decentralised air source heat pumps, which are utilised to generate the heating and hot water for the residential elements of the development.

This report assesses the approximate additional heat losses and power consumption involved in providing a district network, and discusses how a future district heating network could be planned for within the development.

Development proposals.

The proposal for the development is to provide a decentralised energy strategy, with a 'bank' of heat pumps per core. This is primarily due to the absence of a single roof area which can accommodate the heating requirements for the whole development. This is demonstrated in Figure 1. In addition, centralising the heating generation would have other planning implications, including massing, views and acoustics. The heat pump configuration is generally modular, and as such limited benefit is gained from utilising larger central plant.

Therefore, the current proposed strategy includes space allocation which has been made for future plate heat exchangers at the ground floor to each building, and the pipework in all risers appropriately sized to be able to serve each building bottom-up in future, in addition to the current top-down arrangement. It is further proposed to include full trenching between all buildings, with space allocation made for future district heating pipework. A further space allocation has been made for a plate heat exchanger at the ground floor near to the site entrance, so that a future potential district energy network would only require one connection point. Pipework sleeves will be included through the building envelope at the location of each future plate heat exchanger to further ease future connection, should a viable option become available in the vicinity of the site in future. This is shown in Figure 2.

Figure 1: Approximate centralised ASHP plant space requirements

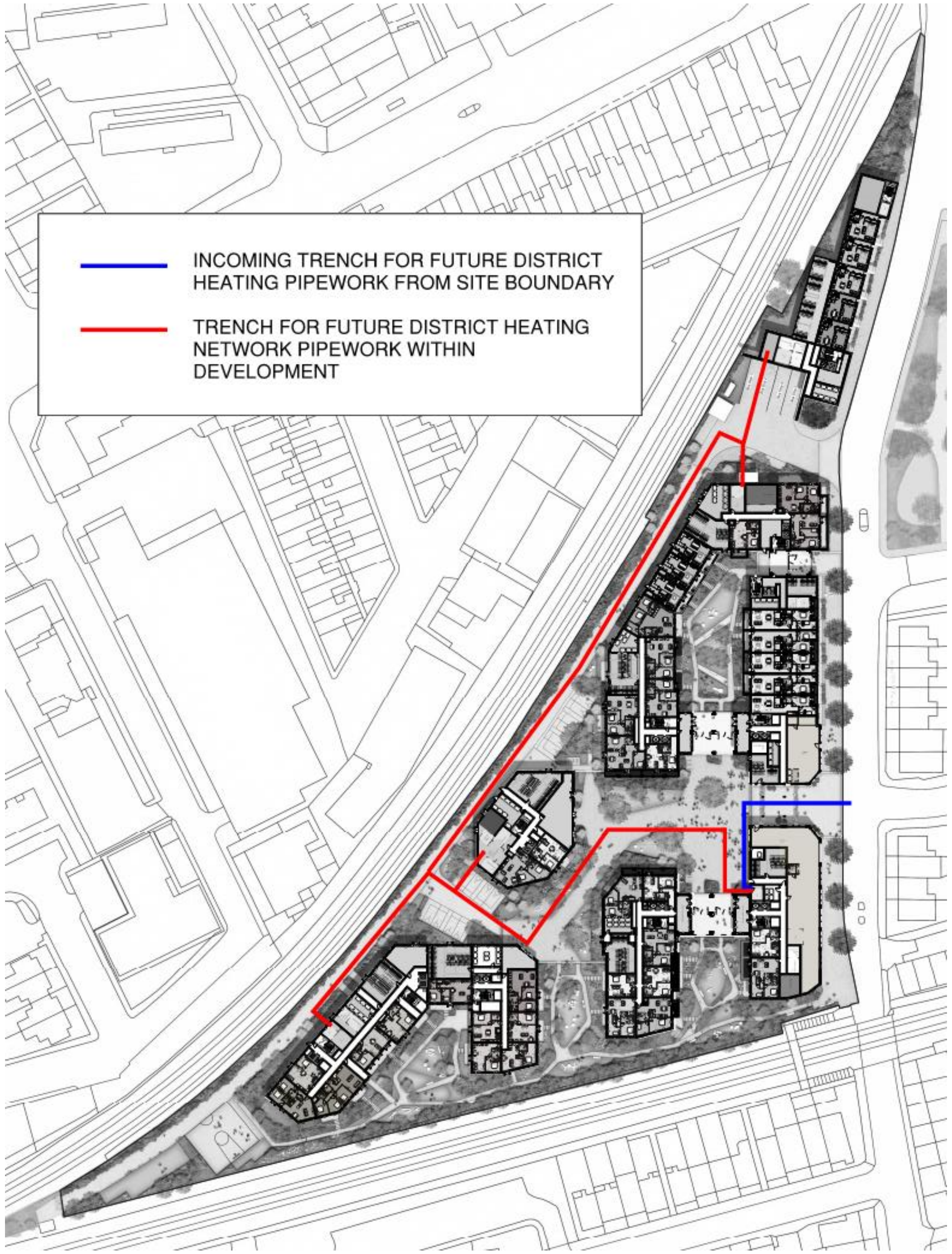

Figure 2: Indicative trench route for future district heating pipework

District network assessment.

This section assesses the viability and the implications of providing a district heating network at day one.

Inter-connectivity

A route has been planned through the development which would allow inter-connectivity between each of the blocks, which would facilitate connection to a district heating network.

A pre-built trench has been planned and safeguarded from the site boundary which allows a single point of connection from a future district heat network to a central future plate heat exchanger. Trenching has been allowed between each of the future district heating plate heat exchangers, which would allow interconnectivity of the blocks in the event of a district network coming on line. Additionally, builderswork has been considered at the boundary of each building, and it is proposed that pre-cast/ pre-installed sleeves will be provided, to allow the pipework to enter the building with minimal disruption, and minimum additional cost incurred to a future network energy provider.

Hydraulic considerations.

It has been considered whether connecting capped pipework between all buildings could be provided at day one. However, this option has been disregarding for the following reasons:

- the risk that the pipework may never be used, therefore the embodied carbon associated with the installed pipework would be spent at no additional benefit to the scheme
- the difficulty in stopping the pipework corroding/ deteriorating over time
- potential warranty issues with connecting to the pipework when it has been left unused for a period of time.

Additional energy consumption

It has also been considered whether connecting, 'live' distribution pipework between all buildings could be provided at day one. However, this option has been disregarding for the following reasons:

Owing to the nature of air source heat pumps being located locally at roof level of each building, for the reasons outlined in the previous section, providing interconnecting pipework at day one will not yield a saving in terms of energy or carbon emissions. The below summary table shows the approximate additional heat and energy demand to the scheme that would be expected to result from inter-connecting the buildings.

Also, given there is very limited non-domestic uses at this development, there is little likelihood of achieving an energy-sharing scenario.

In summary, this would mean that the additional energy lost in the distribution pipework would not be expected to be made up for by any savings from a sitewide connection.

Building Distribution Heat Losses		
Estimated Heat Loss per metre (vertical pipework)	6	W
Estimated Heat Loss per metre (lateral pipework)	4	W
Estimated Annual Heat Loss per core	12089	kWh
Estimated Annual Heat Loss	120888	kWh
District Network Distribution Heat Losses		
Estimated Buried Pipework Length	800	m
Estimated Heat Loss per metre	15	W
Estimated Heat Loss per PHX	750	W
Total Annual Heat Loss	137970	kWh
Estimated additional pump power	5000	W
Total Annual Energy Loss	181770	kWh
Estimated annual total heat demand	1670400	kWh
Estimated district heating distribution losses (without centralised network)	7%	
Estimated district heating distribution losses (with centralised network)	18%	

Table 1: Summary of energy losses in centralised and decentralised distribution networks

Summary

In summary, it is expected that the operational energy lost in any installed distribution pipework would not be counter-acted by any savings resulting from such a sitewide connection.

It is also not proposed to install capped pipework on day one, as it is known from experience that such pipework often is not fit for purpose once it may come to be used. Further, additional embodied carbon would be expected to result from installing such district energy pipework.

Instead it is proposed to make allocations for heat exchangers, full trenching, and pipework sleeves as described above, in order to facilitate a future energy network connection at minimal disruption to residents, and minimal cost to the installer.

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