Greggs Bakery / Twickenham

Energy Strategy

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GREGGS BAKERY SITE
TWICKENHAM
TW2 6RT

Energy Strategy and LZC Report

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1.0 EXECUTIVE SUMMARY

Development Description

Demolition of the existing commercial buildings serving the former Greggs Bakery site in Twickenham, London Borough of Richmond upon Thames, and the construction of 65 residential apartments, 51 houses and a 2 storey B1 commercial unit, together with associated car parking and cycle parking spaces, hard and soft landscaping and other ancillary works.

This report provides potential proposals for achieving the expectations laid down by the local authority for reducing energy consumption and employing Low Zero Carbon (LZC) energy sources to meet the following targets:

- To meet guidance wherever possible as defined in the GLA Energy Assessment Guidance dated October 2018
- To meet London Plan targets with respect to CO_2 emissions and other energy targets and methods.
- To minimise and eradicated overheating in dwellings in line with CIBSE standards.
- To consider LZC technologies to reduce energy consumption.
- To consider overheating in dwellings in line with GLA methodology for overheating risk analysis.
- Non-residential spaces – To achieve the mandatory number of ENE04 credits for an 'Excellent' BREEAM rating.

Current research into local heat networks within the Twickenham area, shows that no existing heat networks are within the vicinity of the site and there currently no proposals for any heat networks in consideration within the local area.

Planning stage analysis indicates that the installation LZC air source heat pumps and roof mounted photovoltaic cells in conjunction with high levels of insulation, good air tightness and good artificial lighting performance enables the project to meet the targets identified.

The application of general energy efficiency measures prior to consideration of LZC energy sources is crucial to meeting the expectations, as it has a multiple effect of reducing running costs, reducing baseline CO_2 emissions and reducing the absolute size of any renewable technologies / financial levies to be applied.

This concurs with The Energy Hierarchy:

1. *Use less energy;*
2. *Supply energy efficiently ;*
3. *Use renewable energy.*

In line with the above philosophy, the application of low energy lighting and passive improvements to building fabric are proposed.

For residential elements the baseline Carbon Dioxide emissions and LZC energy contribution, on which the %[1] reduction is based, have been calculated using approved SAP software which represents the latest calculation tool as required under The Building Regulations Part L1A 2013.

For non-residential elements the baseline Carbon Dioxide emissions and LZC energy contribution, on which the % reduction is based, have been calculated using approved DSM Level 5 IESVE 2015 software which represents the latest calculation tool as required under The Building Regulations Part L2A 2013. This software is also used for overheating analysis.

Analysis shows that that the development will meet Building Regulations compliance through energy efficient measures alone and then further reductions are achieved through use of air source heat pumps and PV's to beat the 35% improvement target.

Overall the site emissions provide a 37% improvement on combined building regulations L1 & L2 target emissions.

Further reductions in line with GLA requirements for zero carbon homes will be met by way of cash in lieu payment due to limitations at roof level for the placement of additional photovoltaic cells or other renewable technologies.

[1] The GLA calls for carbon reductions the equivalent of 10% (residential) & 15% (non-residential) over the Part L 2013 building regulations using passive measures only and 35% using renewable technologies as a minimum. 100% savings on residential dwellings are targeted.

Summary of Potential Proposals

Residential

Heating and tempered cooling system:	Minimised LTHW heating by means of centralised and de-centralised air sourced heat pumps to the residential buildings via convection radiators.
Domestic Hot Water:	Hot water by means of air sourced heat pumps and indirect un-vented hot water cylinders.
Ventilation:	System 4 MVHR mechanical supply and extract ventilation
Insulation:	Enhanced U-Values to all elements.
Air tightness:	APR = $3.0m^3$ / $m^2 \cdot h$ @ 50pa.
Lighting:	High efficiency lamps throughout.
On site LZC technology:	Air source heat pumps and Photovoltaics

Commercial office building

Heating and cooling system:	Variable refrigerant flow (VRF) Air conditioning
Domestic Hot Water:	Electric point of use hot water heaters
Ventilation:	Mechanical ventilation with heat recovery
Insulation:	Enhanced U-Values to all elements.
Air tightness:	APR = $3.0m^3$ / $m^2 \cdot h$ @ 50pa.
Lighting:	High efficiency lamps throughout.
On site LZC technology:	Air source heat pumps and Photovoltaics

Summary of Emissions

Standard Assesment procedure (SAP) 2012 and SAP 10 have both been used to demonstrate compliance with Building regulations approved document Part L 2013 and the GLA's current planning policy targets.

Residential – SAP 2012

Air Source heat pumps and Photovoltaics (PV)

To achieve a minimum 35% reduction over the TER with enhanced fabric U-Values and infiltration rate, using the 2012 Performance method, the residential apartments will be served by a centralised air source heat pump and condenser water loop connected to individual heat pumps within each apartment providing space heating, hot water generation and tempered cooling. The residential townhouses will be served by standalone air source heat pump systems, to provide space heating and hot water generation. PV's will be installed on each of the townhouses. The PV panels will be sized and the quantity selected to contribute to the site wide reduction in carbon dioxide emissions. The PV's will be sized to achieve a peak output of approximately 35kW$_e$. The impact on energy savings are highlighted in the table below.

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	174	-
After energy demand reduction (Be Lean)	156	-
After application of ASHP's (Be Clean)	120	-
After renewable energy (Be Green)	112	-

Table 1a - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	18	11%
Savings from ASHP's (Be Lean)	35	20%
Savings from renewable energy (Be Clean)	9	5%
Total Cumulative Savings (Be Green)	63	36%
Annual savings from offset payment	112	
Tonnes of CO_2		
Cumulative savings for offset payments	3,350	
Cash in-lieu contributions (£)	318,266	

Table 2a - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

Residential – SAP10

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	157	-
After energy demand reduction (Be Lean)	133	-
After application of ASHP's (Be Clean)	54	-
After renewable energy (Be Green)	50	-

Table 2b - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	24	15%
Savings from ASHP's	79	50%
Savings from renewable energy	4	3%
Total Cumulative Savings	107	68%
Annual savings from offset payment	50	
Tonnes of CO_2		
Cumulative savings for offset payments	1,504	
Cash in-lieu contributions (£)	142,883	

Table 2b - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

Final dwelling emissions rate incorporates energy efficiency, efficient supply of energy and renewable energy technologies. The following SAP analysis demonstrates RIBA stage 2 status and shall not be the final proposal due to design, build ability and cost considerations.

Non-Domestic – SAP 2012

Commercial Office

To achieve a minimum 35% reduction over the TER with enhanced fabric U-Values and infiltration rate, using the 2012 Performance method, the commercial office will be served by a variable refrigerant flow (VRF) system, providing simultaneous space heating and cooling, with mechanical ventilation with heat recovery to provide the fresh air requirements to the building. Hot water will be generated through electric point of use water heaters. LED lighting will be installed throughout the building. PV panels will be sized and the quantity selected to contribute to the site wide reduction in carbon dioxide emissions. The PV's will be sized to achieve a peak output of approximately 2.5kWe. The impact on energy savings are highlighted in the table below.

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	16	-
After energy demand reduction (Be Lean)	13	-
After application of ASHP's (Be Clean)	11	-
After renewable energy (Be Green)	9	-

Table 3a - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	20%
Savings from ASHP's (Be Lean)	3	15%
Savings from renewable energy (Be Clean)	2	13%
Total Cumulative Savings (Be Green)	8	48%

Table 4a - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	6	-
Shortfall	-2	-65
Cash in-lieu contributions (£)	-6,168	-

Table 5a – Shortfall in regulated carbon dioxide savings

Non-Domestic – SAP10

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	10	-
After energy demand reduction (Be Lean)	7	-
After application of ASHP's (Be Clean)	5	-
After renewable energy (Be Green)	4	-

Table 3b - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	33%
Savings from ASHP's (Be Lean)	2	19%
Savings from renewable energy (Be Clean)	1	9%
Total Cumulative Savings (Be Green)	6	62%

Table 4b - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	3	-
Shortfall	-3	0
Cash in-lieu contributions (£)	7,596	-

Table 5b – Shortfall in regulated carbon dioxide savings

Site Wide Emissions

SAP 2012

	Total regulated emissions (Tonnes CO_2 per annum)	CO2 Savings (Tonnes CO_2 per annum)	Percentage Savings (%)
Baseline: Part L 2013 of the Building Regulations Compliant Development	191	-	-
After energy demand reduction (Be Lean)	169	22	11%
After application of ASHP's (Be Clean)	131	38	20%
After renewable energy (Be Green)	120	11	6%
Total Cumulative Savings		71	37%
Off-set – Tonnes of CO2 over 30 years		3,285	-

Table 6a - Totalised Regulated carbon dioxide savings from each stage of the Energy Hierarchy

SAP10

	Total regulated emissions (Tonnes CO_2 per annum)	CO2 Savings (Tonnes CO_2 per annum)	Percentage Savings (%)
Baseline: Part L 2013 of the Building Regulations Compliant Development	167	-	-
After energy demand reduction (Be Lean)	140	27	16%
After application of ASHP's (Be Clean)	59	81	49%
After renewable energy (Be Green)	54	5	3%
Total Cumulative Savings		113	68%
Off-set – Tonnes of CO2 over 30 years		1,424	-

Table 6b - Totalised Regulated carbon dioxide savings from each stage of the Energy Hierarchy

As the electricity carbon emission factor is dramatically reduced in SAP 10, it is noticeable that the CO2 benefit of a heat pump system or electrically generated heat source is enhanced when compared to SAP 2012.

Introduction

This report provides preliminary proposals for achieving the expectations laid down by London Borough of Richmond and the planning requirement for reducing energy consumption below the basic statutory requirement laid down in the Building Regulations Part L1A & L2A 2013.

It is very important for energy efficiency as well as renewable energy to be considered for the development. Buildings that use less energy will therefore need to use a smaller amount of renewable energy to supply the expected proportion of the building's needs.

The reduction in carbon dioxide emissions is quantified as a proportion of baseline carbon emissions for the development (TER). Such reductions take into account energy efficient techniques and technologies such improved insulation, energy efficient lighting etc, before the inclusion of LZC technologies.

All calculations are based on limited planning stage information, for strategy purposes and as such are approximate.

Each LZC technology has been given an evaluation with regard to application to the new development.

2.0 RELEVANT POLICY AND TARGETS

2.1 London Plan AND London Borough of Richmond

As outlined in the Housing SPG, from 1 October 2016 the Mayor will apply a zero carbon standard to new residential development. The Housing SPG defines 'Zero carbon' homes as 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).

London Plan policy 5.2, 5.4

Where developments do not achieve the Mayor's carbon dioxide reduction targets set out in London Plan policy 5.2, the developer should make a contribution to the local borough's carbon dioxide off-setting fund.

14.4 *It should be noted that a cash in lieu payment should not be used as a cost comparison with delivering CO2 savings on-site. Policy 5.2 requires the carbon reductions to be achieved as far as possible on-site and a cash in lieu contribution will be considered acceptable only in instances where it has been clearly demonstrated that no further savings can be achieved onsite.*
In the case of the zero carbon target for homes, a minimum of 35% carbon savings are expected to be delivered on site. The remaining savings to reach zero carbon can be achieved either on site or via a cash in lieu contribution, although savings on site would be preferable.

GLA Energy Guidance Document 14 Carbon offsetting Guidance 2018
Once the GLA is satisfied that the CO2 reduction targets cannot feasibly or viably be met onsite, a commitment to ensure the shortfall is met off-site using the provision established by the borough must be provided.

Currently, the GLA's recommended price for offsetting carbon is £60 per tonne. This is a nationally recognised non-traded price of carbon and is also the Zero Carbon. However, The new draft London Plan includes a new recommended carbon offset price of £95 per tonne which was tested as part of the viability assessment. This is intended to be the price LPAs adopt, unless LPAs have set their own local price. The recommended GLA carbon offset price will be reviewed regularly.

London Borough of Richmond have confirmed the cash offsetting payment as follows:

The price for offsetting carbon is regularly reviewed and changes to the GLA's suggested carbon offset price will be updated in future guidance. A nationally recognised non-traded price of £95/tonne has been tested as part of the viability assessment for the London Plan, which this borough will use to collect offset payments.

GLA Documents confirm that the CO_2 payment is annually for a 30 year period and is also confirmed in section 2.5.13 of the GLA Sustainable Design and Construction SPG.

3.0 BASELINE EMISSIONS ASSESSMENT

3.1 Dwellings - Regulated Energy

Sample calculations with respect to the energy consumption and carbon emissions relating to the dwellings have been carried out using the Stroma FSAP 2012 Version: 1.0.4.16 (SAP 9.92) computer software, which has been tested by the BRE and is approved by the DCLG.

The primary data input to the calculations is given in the appendices.

All SAP calculations are based on the following architect's drawings and Accommodation Schedule.

Architect	Drawing/Document	Description	Revision	Date
Assael	A2871 200-R16 A2871 201-R16 A2871 202-R16 A2871 203-R15 A2871 204-R16 A2871 205-R16	Site Plans – Ground to Roof	-	01/02/19
Assael	A2871 401-R2 A2871 402-R2 A2871 601-R4 A2871 602-R4 A2871 603-R4 A2871 604-R4 A2871 605-R4 A2871 606-R4 A2871 607-R4 A2871 608-R4 A2871 609-R4 A2871 610-R1 A2871 611-R2 A2871 612-R3 A2871 613-R3 A2871 614-R3 A2871 615-R3 A2871 616-R3 A2871 617-R3 A2871 620-R1 A2871 621-R1 A2871 630-R2 A2871 631-R2	Site Elevations, Apartment layouts, sections and elevations. House type layouts, sections and elevations.	-	21/02/19

4.0 PASSIVE ENERGY REDUCTIONS (HIERACHY LEVEL 1)

The ethos of this project is to ensure that passive measures are adopted prior to the application of high efficiency or renewable technologies wherever feasible. The measures that have been included in the baseline emissions model are summarised below. All measures are quantified within the BER and DER/BER figures:

- Thermal Insulation;
- Air tightness;
- Maximised daylighting;
- Passive solar gain.

4.1 Building Fabric

The investment in thermal insulation to heated spaces will result in an improvement in heat losses and hence reduction in annual heating fuel consumption. All windows are based on aluminium frames.

Minimum Building constructions required to meet Building Regulations Part L 2013:

Building Element	U-Value
External Wall	0.35 W/m^2K
Roof	0.25 W/m^2K
Ground Floor	0.25 W/m^2K
Windows	2.2 W/m^2K

Proposed improved Building Constructions to exceed Building Regulations Part L 2013:

Building Element	U-Value
External Wall	0.15 W/m^2K
Roof	0.15 W/m^2K
Ground Floor	0.12 W/m^2K
Windows	1.3 W/m^2K G-value 0.4

All party walls are taken as U-value = 0 which requires a fully filled and sealed wall with no cavities. **It is important that the architect's details reflect this.**

The U-Values proposed above are indicative and are subject to change, due to the limited information available when carrying out the SAP calculations and preparing this report.

4.2 Infiltration and air tightness

To achieve the required result the buildings should be designed to achieve an air permeability of 3 $m^3/h/m^2$ at 50Pa.

5.0 EFFICIENT ENERGY DELIVERY (HIERARCHY LEVEL 2)

5.1 Existing District Heating

According to the London Heat Map, unfortunately there are no existing local district heat networks in operation, therefore there is no current opportunity to connect the site to a district heat network. The map is highlighted in appendix A.

5.2 Site based District Heating

The London Plan and London Borough of Richmond strongly encourage district heating. The scale of the development permits a district heating strategy to be considered. Although serving the townhouses from a central plant location at the north end of the site, within the central apartment block building, the pipework lengths required to serve all the townhouses will be extensive and will lead to high heat loses. Therefore the proposal is to only serve the apartment blocks with a centralised heating system.

The centralised plant will be made up of air source heat pumps, a dry cooler and a circulated condenser water loop distributed to all the apartments.

Key elements of centralised heating system:

- 2No. 240kW Air Source heat pumps,
- 1No. dry air cooler;
- 3m3 Buffer vessel;
- Heating Pressurisation Unit and Expansion Vessel;
- Low Loss Header;
- Circulating Pumps;
- Reverse cycle heat pump units in each dwelling with hot water cylinder;
- Control Panels;
- Chemical Dosing Pot;
- Louvres for Natural Ventilation to the Plantroom;
- Ancillary plant;
- Allocation for one set of double doors and separate escape door;
- Capped off connections for future external district heat distribution networks.

The on-site energy centre will be designed to circulate condenser water from the air source heat pumps and or dry air coolers to the apartments. The external plant will operate to maintain the condenser water at temperatures between 15oC - 25oC to serve as a heat sink for the reverse cycle heat pumps in the residential apartments. The centralised air source heat pump will operate when the external ambient temperature is below 15oC or above 25oC, the dry cooler will operate during the mid-band external ambient temperatures.

The tenants will utilise energy from the condenser water via the reverse cycle heat pumps installed in each apartment, energy usage will sub metered at the interface point.

It is envisaged that the landlord or an external metering and billing Company will be responsible for all metering and revenue collection.

From initial plant sizing and planning, the external plant will require a space allocation at roof level of approximately 14mL x 4.5mW x 3.0mH. The internal plant area housing the circulation pumps, buffer vessel, pressurisation unit, dosing plant, controls and connections to future district heating networks will be located at ground floor level of the central apartment block.

The mains condenser water pipe work connecting the central heat generation plant to each apartment would be owned and operated by the residential landlord / managing agent.

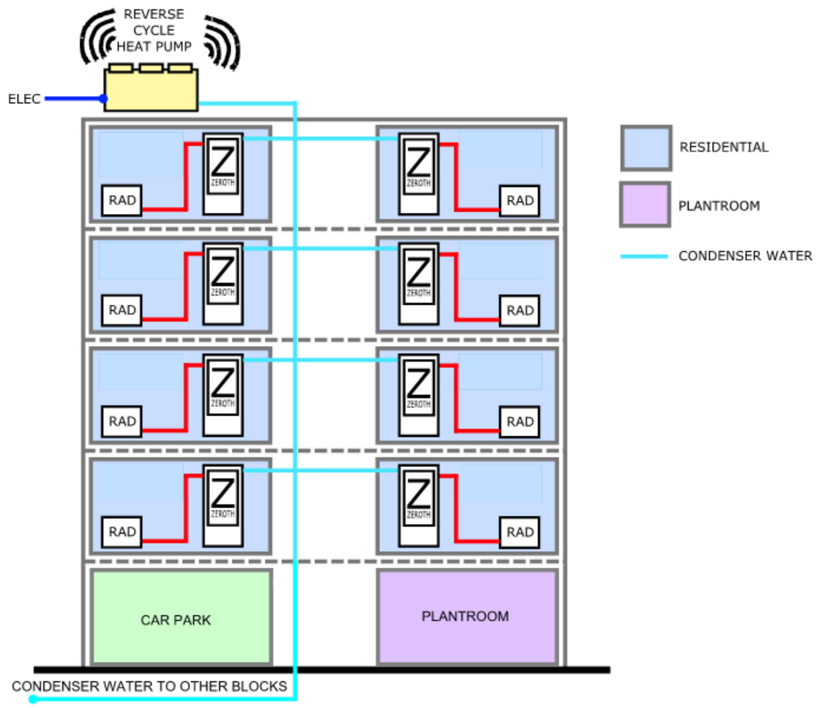


Figure 1 - Flat District Heating Philosophy

Apartment Internals

The heating system within each apartment will be ostensibly the same as a conventional system. The only obvious difference will be the way in which heat energy is delivered into the apartment. In a conventional system a gas fired boiler generates the heat that is delivered to the radiators and taps through low temperature hot water (LTHW) and domestic hot water (DHW) respectively. Metered gas is piped to the apartment. In the proposed system the boiler is replaced with an electric reverse cycle heat pump, which takes the heat out of the condenser water loop, which is maintained between 15oC and 25oC by the central plant, and further increases the temperature of the water up to 60oC and delivers it to the radiators and taps, via the hot water cylinder. No gas supply is required. Within each apartment the heat pump and hot water cylinder are installed within an internal cupboard.

Figure 2 – A heat pump and hot water cylinder within an apartment utility cupboard

Overheating Issues

There is a general consensus that site wide district heating can cause problems with overheating and thus energy inefficiencies across the development. Utilising lower water temperatures as proposed for the condenser water loop. The risk of overheating in corridors, caused by heat loss from distribution pipework is eliminated and energy inefficiencies across the development are minimised. The heat pump also has the facility to provide tempered cooling in the dwellings via fan assisted radiators to minimise the risk of overheating.

Billing Arrangements

The energy usage by each apartment is monitored by means of a heat meter which may be installed within the heat pump unit or within a meter cupboard located within the common area. This heat meter can be read directly by the managing agent or can be read remotely through either a connection to a data cable network system wired to a central monitoring point or by means of a wireless transmitter (Bluetooth). With the Bluetooth transmitter the meter can be read from outside the apartment by someone with a hand held receiver loaded with dedicated secure monitoring software. The overall cost of providing the heat is then apportioned to the occupiers by the managing agent based upon the heat meter readings.

Centralised Air Sourced heat pumps & individual revers cycle heat pumps.	
Advantages	**Disadvantages**
Carbon savings are still good with current carbon emission factors for electricity.	Higher site wide electrical consumption could lead to additional substations and infrastructure reinforcement costs.
Carbon savings are predicted to increase when revised carbon factors are incorporated.	More roof space required (if ASHPs are utilised to maintain the condenser loop temperatures).
Renewable Heat Incentive available.	Landlord ASHP Plant can be noisy.
Low impact on air quality.	Large Utility Cupboards
Electricity generated on site.	Increased Maintenance requirements.
Predicted reduction in Landlord's plantroom requirements.	Lower life expectancy for Heat Pumps (10/15 years)
Capital Costs predicted to be lower	Auto de-frost function takes units off line for periods.
Limited distribution losses and negligible risk of overheating in corridors.	Controls need to be carefully considered as the Zeroth unit cannot offer simultaneous heating / cooling / DHW recharge.
Main energy billing to be electricity, therefore tenant can change provider.	Condenser Water pipework is predicted to be larger than district heating pipework due to the lower ΔT and diversity.
Less metering requirements.	Noise from the unit is currently an unknown. May need a higher spec of doors etc.
Immersion heater will act as a back-up for domestic hot water if the main plant fails.	Radiators would be oversized due to lower water temperatures.
2no. District Condenser Water pipes required rather than the 4no. pipes for options 2A and 2B.	

Table 3 - Advantages and Disadvantages of Air Source heat pumps combined with individual heat pumps.

5.3 Individual air source heat pump systems - Town houses

Air source heat pumps are proposed to be installed for the townhouses to provide both heating and tempered cooling, and hot water generation. The indoor unit will connect to fan assisted radiators, which provide sufficient output to offset the heat loses, with lower operating temperatures than traditional radiators. Air source heat pump systems operate most efficiently when coupled with low temperature heating systems. Therefore to maximise coefficients of performance such systems are typically adopted.
Each system can be stand alone and therefore all financial benefits associated with the system efficiencies will be passed on to the building occupier.

Such a system would typically comprise:

- An external air cooled condenser
- A Wall hung or floor mounted unit (internally mounted), commonly called a hydrobox.
- Refrigerant pipework connecting the condenser and hydrobox
- Hot water cylinder fed from the hydrobox, using LTHW pipework, typically installed in copper.
- Fan assisted radiators.
- Local control via a central time clock, and adjustable thermostats in each room.

The outdoor condenser unit shall be installed within an acoustic enclosure, on a raised flat concrete base, to allow condense water to drain away.

Fan assisted radiator

Condenser in an acoustic enclosure

The exact location and size of the ASHP outdoor units is subject to final unit selection and manufacturer however the rear gardens have been identified as the most suitable location.

5.4 Lighting and Metering

In the apartment blocks, lighting within the communal areas will be by means of wall and ceiling mounted compact fluorescent luminaires located within the stair cores and surface and recessed compact fluorescent luminaries within the corridors and foyer. The lighting levels will be designed to the Society of Light and Lighting (SLL) code for lighting. Automatic lighting control will be provided to minimise energy consumption.

System lighting to the all dwellings will be provided by means of a mixture of low energy down lights, low energy ceiling roses and low energy down lights, such that 100% of lighting shall be by low energy fittings.

Each apartment will have individual electricity metering from an appointed meter shipper which will be sited in the main riser cupboards at each block/floor level or in house meter cupboards. The Landlords areas will be separately metered and the cost of the energy used apportioned across the block by service charge.

The townhouses will be individually served with new supplies terminated near to the front elevation of each house, where electricity meter will be installed in line with the local DNO's requirements.

5.5 Mechanical Ventilation with Heat Recovery (MVHR)

A mechanical ventilation system with heat recovery captures heat energy from the outgoing air extracted from kitchens and bathrooms within the homes and warms the fresh air being blown into the home. Heat recovery on the background ventilation further reduces heat loss complementing the improvements in the building fabric. The heat exchanger shall be bypassed during the summer months to ensure that the general background ventilation provided through the MVHR assists in cooling the homes.

5.6 Heating and Cooling – Shell and Core Commercial Space

The shell and core commercial space will be provided with capped off incoming services. If cooling is required it is anticipated that this would be dealt with by heat pump technology. This will be provided by a packaged VRF cooling system. Such systems are electrically driven and utilise very good coefficient of performance to minimise running costs and CO2 emissions. The size and nature of the commercial units are well suited to this type of system and it is anticipated that proposed tenants would expect to install such a system as part of their fit out if required. Based on low density occupation and mechanical ventilation the provision of refrigerant based cooling is not anticipated unless fit out activities cause heat gains to necessitate such cooling.

5.7 Summary

The energy efficient measures that have been included in the baseline emissions model are summarised below.

- Centralised air source heat pumps combined with reverse cycle heat pumps in each of the apartments;
- Individual air source heat pumps serving the townhouses
- High efficiency mechanical ventilation with heat recovery;
- High efficiency lighting;
- Sub-metering to mechanical plant;
- Time-clock and temperature zone control of heating;
- Weather compensated control of heating.

The key efficiency data proposed is:

	Residential
Lighting	High efficiency
Heating seasonal efficiency	0.96
Cooling seasonal efficiency	N/A
Ventilation SFP	0.4
Ventilation heat recovery	91%
HWS efficiency	97% of LTHW

6.0 LZC ENERGY FEASIBILTY

LZC Energy Type	Application	Feasibility
Wind Turbine Power	Roof mounted small scale wind turbines for domestic and non domestic buildings. Wind speeds of 7m/s or above required for large scale therefore high level mounting only option.	Visual electromagnetic and environmental noise impact, and public opposition to such, may have negative effect on planning process. Electricity metering for domestic properties and responsibility for maintenance reduce the feasibility for this to be applied to residential. Vibration isolation required for building mounted turbines. Noise may affect natural ventilation feasibility for domestic properties. Wind study required to ensure conditions are correct. Feasibility for large scale not possible due to urban location. Appearance of turbines problematic. Low wind speeds at location increases number of turbines required.
Photovoltaics	PV panels integrated into building fabric, such as cladding, roof surface or brise soleil. Elevations south-east to south-west unshaded.	PV panels can be prone to vandalism in certain locations. Simple systems requiring little maintenance other than cleaning and repair. Individual connection to each dwelling required to permit maximum utilisation and FIT entitlement. Appearance can be unappealing where visible, however tile integrated PVs are less obtrusive. South facing roof space limited.
Ground Source Heating	Can be utilised individual systems with central or individual ground loop operation. Particularly suited to underfloor heating. Can preclude the need for gas distribution to individual properties.	Very costly More suited to individual systems, additional heating can be required to domestic hot water as typical temperatures are only 50°C.
Ground Source Heating		Borehole requirements and ground conditions may reduce the amount that could be implemented. Environment Agency Licence may be required.
River Source Heating	Can be utilised individual systems with central or individual operation.	Available source adjacent to site. Limited volume flow rate in river, therefore limited capacity. Environment Agency Licence would be required. Canal and River Trust licence required.

LZC Energy Type	Application	Feasibility
Air Source Heat Pumps	Particularly suited to water based heating and cooling systems. Particularly suited to underfloor heating or fan assisted radiators. Precludes the need for gas distribution to individual properties.	Significant roof or external compound space required. Outdoor units can be unsightly and generate background noise. Conventional heating and cooling delivery plant can still be utilised. Medium capital cost. Sufficient power supply required. Good maintenance support.
Solar Hot Water	Roof mounted solar collectors combined with local hot water calorifiers. Gas or electric back up system still required. Solar hot water is not a replacement of such systems.	Roof space availability for solar collectors subject to planning acceptance relating to visual appearance and height. Suitable for domestic and commercial properties. Limited load utilisation – difficult to achieve large saving. Oversized calorifier space required in each flat. Limited south facing roof space.
Biomass Heating	Central boiler installation for whole block. Wood chips used as primary fuel. Provides space heating and domestic hot water for whole site, or could be limited to residential only.	The necessary transportation of wood chips to site and ash from site using road reduces the carbon emission savings available. The proximity of wood chip sources and congested roads adds to the disadvantage. Wood chip and ash storage on site required. Very little space available for this. Back up gas installation required to ensure heat supply in the event of reliability problems or fuel availability problems. Only compatible with centralised systems.
Biomass CHP	CHP – Combined Heat and Power Adopts same principles as Biomass Heating, however part of the central plant will be utilised to provide power generation for the site and distribution back to the national Grid. Applicable to a commercial trigeneration system when used in conjunction with Biomass Fuel.	Feasibility issues as described above remain. CHP reduces the overall site carbon emissions due to very good efficiencies, therefore reducing the overall amount of renewable energy sources required for the site. Constant year round base load required to ensure generated heat is utilised. Does not suit proposed low operating temperatures.
Natural gas CHP	CHP – Combined Heat and Power Heat source for district heating system. Electrical output for landlord use or export.	Requires district heating for full load utilisation and maximisation of diversified heat load. CHP reduces the overall site carbon emissions due to very good efficiencies. No gas to site to proposed. Does not suit proposed low operating temperatures.

LZC Energy Type	Application	Feasibility
Natural gas CHP	CHP – Combined Heat and Power Micro CHP to each dwelling	Complex domestic machinery requires intensive maintenance. No external plant space required Low electrical output reduces carbon efficiency compared to centralised CHP. New gas supply through existing building required – impractical.

6.1 Feasibility Matrix

1 = poor
5 = excellent

Site suitability rating doubled to provide weighting

Where site application is less than 6 this option must be ruled out due to impracticalities.

Technology	Cost	Internal Plant Space	Roof space	Suitability of Site Application	Total
Turbines (Tower)	1	4	5	2	**12**
Turbines (Roof Mounted)	3	4	2	4	**13**
Photovoltaics	3	5	4	10	**22**
Solar Hot Water	4	1	1	10	**16**
Ground Source Heat Pumps	1	2	5	4	**12**
Air Source Heat Pumps	4	4	2	10	**20**
Centralised CHP	2	2	5	5	**14**
Biomass Boiler	2	2	5	5	**14**
Decentralised CHP	2	2	5	4	**13**

7.0 ENERGY ASSESSMENT

7.1 Low or Zero carbon Energy Assessment

The incorporation of 2No. 240kW air source heat pumps in combination with the individual reverse cycle heat pumps form the district heating system to serve the 65 apartments. Individual air source heat pump systems will serve the townhouses and will contribute to the 35% reduction on the building regulations L1 target emissions.

7.2 Renewable Energy Assessment

PV cells will be provided to the townhouses contributing to the site wide reduction in carbon dioxide emissions of 35%.

Tile PV panels are specified to provide the required Kwh/year output to achieve the energy target for the site.

SAP Assessments and PV design has led to the following provision:

Where roof space allows an array of 330W Mono Black panels are proposed on the roofs of all the townhouses, providing 35kW peak in total.

7.3 Summary of Emissions

To achieve a minimum 35% reduction over the TER with enhanced fabric U-Values and infiltration rate, Air source heat pumps will cater for the heating and hot water demand across the site. PV's will need to be sized for the townhouses to achieve a peak output of approximately 35kW$_e$. The impact on energy savings are highlighted in the table below.

When calculating the site wide carbon emissions, a provision 2.5kW peak output from PV panels was applied to the commercial space, as shown in the appended BRUKL report.

Residential – SAP 2012

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	**Unregulated**
Baseline: Part L 2013 of the Building Regulations Compliant Development	174	-
After energy demand reduction (Be Lean)	156	-
After application of ASHP's (Be Clean)	120	-
After renewable energy (Be Green)	112	-

Table 4a - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	18	11%
Savings from ASHP's (Be Lean)	35	20%
Savings from renewable energy (Be Clean)	9	6%
Total Cumulative Savings (Be Green)	63	36%
Annual savings from offset payment	112	
Tonnes of CO_2		
Cumulative savings for offset payments	3,350	
Cash in-lieu contributions (£)	318,266	

Table 2a - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

Residential – SAP10

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	157	-
After energy demand reduction (Be Lean)	133	-
After application of ASHP's (Be Clean)	54	-
After renewable energy (Be Green)	50	-

Table 5b - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	24	15%
Savings from ASHP's	79	50%
Savings from renewable energy	4	3%
Total Cumulative Savings	106	68%
Annual savings from offset payment	50	
Tonnes of CO_2		
Cumulative savings for offset payments	1,504	
Cash in-lieu contributions (£)	142,883	

Table 2b - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

Final dwelling emissions rate incorporates energy efficiency, efficient supply of energy and renewable energy technologies. The following SAP analysis demonstrates RIBA stage 2 status and shall not be the final proposal due to design, buildability and cost considerations.

Non-Domestic – SAP 2012

Commercial Office

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	16	-
After energy demand reduction (Be Lean)	13	-
After application of ASHP's (Be Clean)	11	-
After renewable energy (Be Green)	9	-

Table 3a - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	20%
Savings from ASHP's (Be Lean)	3	15%
Savings from renewable energy (Be Clean)	2	13%
Total Cumulative Savings (Be Green)	8	48%

Table 4a - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	6	-
Shortfall	-2	-65
Cash in-lieu contributions (£)	-6,168	-

Table 5a – Shortfall in regulated carbon dioxide savings

Non-Domestic – SAP10

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	10	-
After energy demand reduction (Be Lean)	7	-
After application of ASHP's (Be Clean)	5	-
After renewable energy (Be Green)	4	-

Table 3b - Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Regulated carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	33%
Savings from ASHP's (Be Lean)	2	19%
Savings from renewable energy (Be Clean)	1	9%
Total Cumulative Savings (Be Green)	6	62%

Table 4b - Regulated carbon dioxide savings from each stage of the Energy Hierarchy

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	3	-
Shortfall	-3	-80
Cash in-lieu contributions (£)	-7,596	-

Table 5b – Shortfall in regulated carbon dioxide savings

Site Wide Emissions

SAP 2012

	Total regulated emissions (Tonnes CO_2 per annum)	CO2 Savings (Tonnes CO_2 per annum)	Percentage Savings (%)
Baseline: Part L 2013 of the Building Regulations Compliant Development	191	-	-
After energy demand reduction (Be Lean)	169	22	11%
After application of ASHP's (Be Clean)	131	38	20%
After renewable energy (Be Green)	120	11	6%
Total Cumulative Savings		71	37%
Off-set – Tonnes of CO2 over 30 years		3,285	-

Table 6a - Totalised Regulated carbon dioxide savings from each stage of the Energy Hierarchy

SAP10

	Total regulated emissions (Tonnes CO_2 per annum)	CO2 Savings (Tonnes CO_2 per annum)	Percentage Savings (%)
Baseline: Part L 2013 of the Building Regulations Compliant Development	167	-	-
After energy demand reduction (Be Lean)	140	27	16%
After application of ASHP's (Be Clean)	59	81	49%
After renewable energy (Be Green)	54	5	3%
Total Cumulative Savings		113	68%
Off-set – Tonnes of CO2 over 30 years		1,424	-

Table 6b - Totalised Regulated carbon dioxide savings from each stage of the Energy Hierarchy

Final dwelling emissions rate incorporates energy efficiency, efficient supply of energy and renewable energy technologies. The SAP analysis demonstrates RIBA stage 2 status and shall not be the final proposal due to design, build ability and cost considerations.

8.0 CASH IN LIEU CARBON PAYMENT

To meet the zero carbon target for the **residential** element of the development a cash in lieu payment can be made, as quoted below:

GLA Energy Guidance Document 14 Carbon offsetting Guidance 2018
Once the GLA is satisfied that the CO2 reduction targets cannot feasibly or viably be met onsite, a commitment to ensure the shortfall is met off-site using the provision established by the borough must be provided.

Currently, the GLA's recommended price for offsetting carbon is £60 per tonne. This is a nationally recognised non-traded price of carbon and is also the Zero Carbon. However, The new draft London Plan includes a new recommended carbon offset price of £95 per tonne which was tested as part of the viability assessment. This is intended to be the price LPAs adopt, unless LPAs have set their own local price. The recommended GLA carbon offset price will be reviewed regularly.

London Borough of Richmond have confirmed the cash offsetting payment as follows:

The price for offsetting carbon is regularly reviewed and changes to the GLA's suggested carbon offset price will be updated in future guidance. A nationally recognised non-traded price of £95/tonne has been tested as part of the viability assessment for the London Plan, which this borough will use to collect offset payments.

GLA Documents confirm that the CO_2 payment is annually for a 30 year period and is also confirmed in section 2.5.13 of the GLA Sustainable Design and Construction SPG.

Therefore based upon the planning stage energy strategy calculations in this document the following order of payment levels should be expected where renewables are not incorporated:

Richmond's total cost per tonne is £95 over 30 years

In our Stage 2 SAP summary, a carbon dioxide shortfall of 3285 tonnes over 30 years is estimated (see Carbon Emissions table above), and this will therefore result in a carbon offsetting cash payment in the order of **£312,075**.

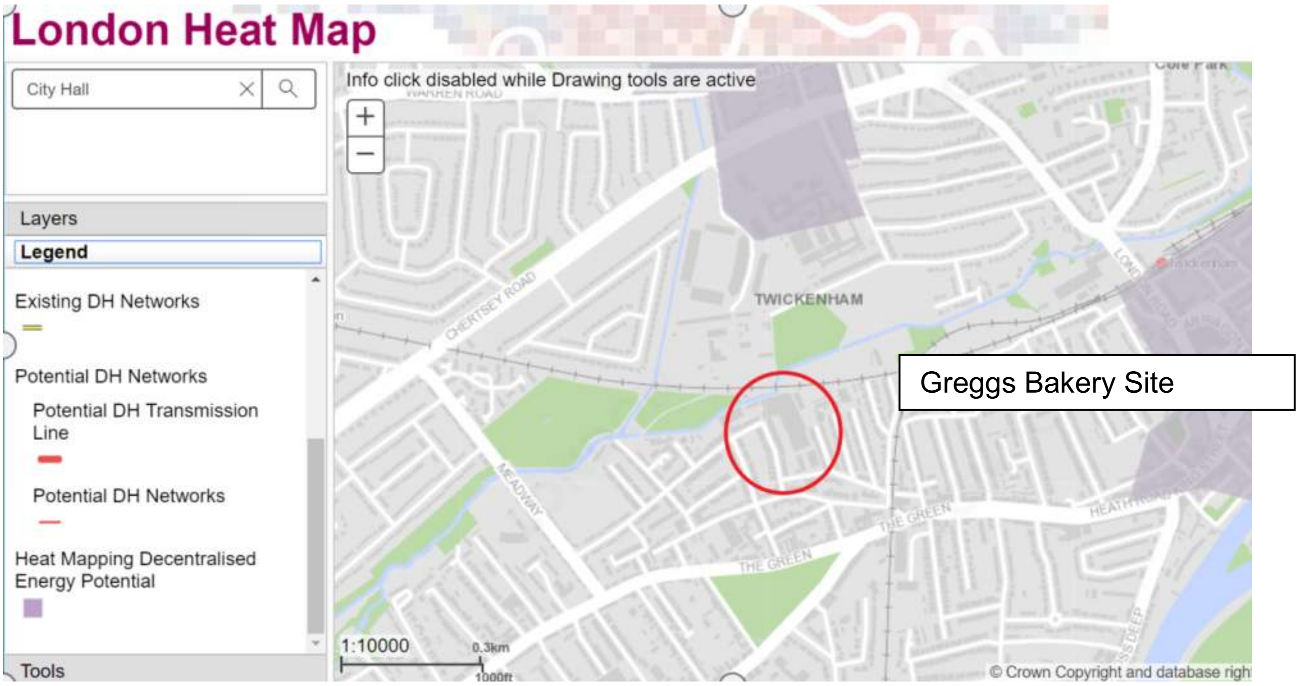
The above calculations are based on pre planning stage 2 apartment layouts and are therefore estimates. Figures will need to be refined as the design progresses and when final design stage SAP calculations are submitted during RIBA design stage 4.

9.0 APPENDIX A – LOCAL HEAT NETWORKS

The extract below shows the current heat map for the surrounding area as accessed from https://maps.london.gov.uk/heatmap/

The grey shaded areas shows identified decentralised heat potential.

There are currently no local heat networks within the area surrounding the site.



10.0 APPENDIX B – SAP ANALYSIS

Block A – Be Lean

													kgCO$_2$/m^2/yr	kgCO$_2$/m^2/yr		kgCO$_2$/yr		kWh/year	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^{2}K	Wall U-value W/m^{2}K	Floor U-Value W/m^{2}K	Window U-Value W/m^{2}K	Thermal Bridging	APR	Primary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER	TFEE	DFEE
A	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	922	802	51.0	42.8
A	Ground	Apartment	61.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1124	978	51.0	42.8
A	First	Apartment	57.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1091	969	54.6	46.9
A	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1378	1224	54.6	46.9
A	Second	Apartment	57.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1091	969	54.6	46.9
A	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1378	1224	54.6	46.9

Block D – Be Lean

													kgCO$_2$/m^2/yr	kgCO$_2$/m^2/yr		kgCO$_2$/yr		kWh/year	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^{2}K	Wall U-value W/m^{2}K	Floor U-Value W/m^{2}K	Window U-Value W/m^{2}K	Thermal Bridging	APR	Primary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER	TFEE	DFEE
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2054	1868	56.8	48.9
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2054	1868	56.8	48.9
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2054	1868	56.8	48.9
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2054	1868	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2087	1897	56.8	48.9

Block C - Be Lean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)	TFEE (kWh/year)	DFEE (kWh/year)
C	Townhouse	Townhouse	110.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1807	1643	56.8	48.9
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1774	1614	56.8	48.9
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1774	1614	56.8	48.9
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1774	1614	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2185	1987	56.8	48.9
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	2185	1987	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
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C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
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C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1840	1673	56.8	48.9

Block E - Be Lean

													kgCO$_2$/m^2/yr	kgCO$_2$/m^2/yr		kgCO$_2$/yr		kWh/year	
Block	**Floor**	**Dwelling Type**	**Area m^2**	**Roof U -value W/m^{2}K**	**Wall U-value W/m^{2}K**	**Floor U-Value W/m^{2}K**	**Window U-Value W/m^{2}K**	**Thermal Bridging**	**APR**	**Primary Heating**	**Ventilation**	**Lighting**	**TER**	**DER**	**% imp**	**TER**	**DER**	**TFEE**	**DFEE**
E	**Ground**	**Apartment**	55.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1014	882	51.0	42.8
E	**Ground**	**Apartment**	55.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1014	882	51.0	42.8
E	**First**	**Apartment**	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9
E	**First**	**Apartment**	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9
E	**Second**	**Apartment**	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9
E	**Second**	**Apartment**	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9

Block F – Be Lean

													$kgCO_2/m^2/yr$	$kgCO_2/m^2/yr$		$kgCO_2/yr$		kWh/year	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER	TFEE	DFEE
F	Ground	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1309	1138	51.0	42.8
F	Ground	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	995	866	51.0	42.8
F	Ground	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1327	1154	51.0	42.8
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	922	802	51.0	42.8
F	Ground	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1309	1138	51.0	42.8
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	922	802	51.0	42.8
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	922	802	51.0	42.8
F	Ground	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	18.4	16.0	13.0%	1235	1074	51.0	42.8
F	First	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9
F	First	Apartment	99.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1895	1683	54.6	46.9
F	First	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1053	935	54.6	46.9
F	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1378	1224	54.6	46.9
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	First	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1034	918	54.6	46.9
F	First	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	First	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1282	1139	54.6	46.9
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1378	1224	54.6	46.9
F	Second	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9
F	Second	Apartment	99.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1895	1683	54.6	46.9
F	Second	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1053	935	54.6	46.9
F	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1378	1224	54.6	46.9
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Second	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1034	918	54.6	46.9
F	Second	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Second	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1282	1139	54.6	46.9
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1378	1224	54.6	46.9
F	Third	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	Third	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1340	1190	54.6	46.9
F	Third	Apartment	75.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1436	1275	54.6	46.9
F	Third	Apartment	53.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1014	901	54.6	46.9
F	Third	Apartment	75.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1436	1275	54.6	46.9
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Third	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1034	918	54.6	46.9
F	Third	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Third	Apartment	95.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1818	1615	54.6	46.9
F	Fourth	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1034	918	54.6	46.9
F	Fourth	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1359	1207	54.6	46.9
F	Fourth	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	957	850	54.6	46.9
F	Fourth	Apartment	80.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired combination Boiler	MVHR System	All Low Energy	19.1	17.0	11.2%	1531	1360	54.6	46.9

Block G – Be Lean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)	TFEE (kWh/year)	DFEE (kWh/year)
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1298	1180	56.8	48.9
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1298	1180	56.8	48.9
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1298	1180	56.8	48.9
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1298	1180	56.8	48.9

Block H – Be Lean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)	TFEE (kWh/year)	DFEE (kWh/year)
H	Townhouse	Townhouse	84.0	0.15	0.15	0.12	1.30	Approved	3	Gas Fired System Boiler	MVHR System	All Low Energy	16.4	14.9	9.1%	1380	1255	56.8	48.9

Block A – Be Clean

														kgCO_2/m^2/yr			kgCO_2/yr	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^{2}K	Wall U-value W/m^{2}K	Floor U-Value W/m^{2}K	Window U-Value W/m^{2}K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER
A	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
A	Ground	Apartment	61.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1124	670
A	First	Apartment	57.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1091	676
A	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
A	Second	Apartment	57.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1091	676
A	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854

Block D – Be Clean

														kgCO_2/m^2/yr			kgCO_2/yr	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^{2}K	Wall U-value W/m^{2}K	Floor U-Value W/m^{2}K	Window U-Value W/m^{2}K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2054	1543
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2054	1543
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2054	1543
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2054	1543
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2087	1567

Block C - Be Clean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	$kgCO_2/m^2/yr$ TER	$kgCO_2/m^2/yr$ DER	% imp	$kgCO_2/yr$ TER	$kgCO_2/yr$ DER
C	Townhouse	Townhouse	110.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1807	1357
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1774	1333
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1774	1333
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1774	1333
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2185	1641
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2185	1641
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2185	1641
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2185	1641
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2185	1641
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	2185	1641
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1840	1382

Block E - Be Clean

Block	Floor	Dwelling Type	Area m²	Roof U -value W/m²K	Wall U-value W/m²K	Floor U-Value W/m²K	Window U-Value W/m²K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)
E	Ground	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1014	604
E	Ground	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1014	604
E	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
E	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
E	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
E	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830

Block F – Be Clean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	$kgCO_2/m^2/yr$ TER	$kgCO_2/m^2/yr$ DER	% imp	$kgCO_2/yr$ TER	$kgCO_2/yr$ DER
F	Ground	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1309	780
F	Ground	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	995	593
F	Ground	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1327	791
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
F	Ground	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1309	780
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
F	Ground	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1235	736
F	First	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
F	First	Apartment	99.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1895	1174
F	First	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1053	652
F	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	First	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1282	795
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	Second	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
F	Second	Apartment	99.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1895	1174
F	Second	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1053	652
F	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	Second	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1282	795
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	Third	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Third	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
F	Third	Apartment	75.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1436	890
F	Third	Apartment	53.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1014	629
F	Third	Apartment	75.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1436	890
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Third	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	Third	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Third	Apartment	95.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1818	1127
F	Fourth	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	Fourth	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Fourth	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Fourth	Apartment	80.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1531	949

Block G – Be Clean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1298	975
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1298	975
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1298	975
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1298	975

Block H – Be Clean

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)
H	Townhouse	Townhouse	84.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	12.3	24.9%	1380	1037

Block A – Be Green

														kgCO$_2$/m^2/yr			kgCO$_2$/yr	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^{2}K	Wall U-value W/m^{2}K	Floor U-Value W/m^{2}K	Window U-Value W/m^{2}K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER
A	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
A	Ground	Apartment	61.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1124	670
A	First	Apartment	57.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1091	676
A	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
A	Second	Apartment	57.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1091	676
A	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854

Block D – Be Green

														kgCO$_2$/m^2/yr			kgCO$_2$/yr	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^{2}K	Wall U-value W/m^{2}K	Floor U-Value W/m^{2}K	Window U-Value W/m^{2}K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2054	1335
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2054	1335
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2054	1335
D	Townhouse	Townhouse	125.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2054	1335
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356
D	Townhouse	Townhouse	127.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2087	1356

Block C - Be Green

														$kgCO_2/m^2/yr$			$kgCO_2/yr$	
Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER	DER	% imp	TER	DER
C	Townhouse	Townhouse	110.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1807	1175
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1774	1153
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1774	1153
C	Townhouse	Townhouse	108.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1774	1153
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2185	1420
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2185	1420
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2185	1420
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2185	1420
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2185	1420
C	Townhouse	Townhouse	133.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	2185	1420
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196
C	Townhouse	Townhouse	112.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1840	1196

Block E - Be Green

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)
E	Ground	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1014	604
E	Ground	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1014	604
E	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
E	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
E	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
E	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830

Block F – Be Green

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	$kgCO_2/m^2/yr$ TER	$kgCO_2/m^2/yr$ DER	% imp	$kgCO_2/yr$ TER	$kgCO_2/yr$ DER
F	Ground	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1309	780
F	Ground	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	995	593
F	Ground	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1327	791
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
F	Ground	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1309	780
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
F	Ground	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	922	550
F	Ground	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	18.4	11.0	40.4%	1235	736
F	First	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	First	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
F	First	Apartment	99.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1895	1174
F	First	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1053	652
F	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	First	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1282	795
F	First	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	First	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	Second	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Second	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
F	Second	Apartment	99.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1895	1174
F	Second	Apartment	55.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1053	652
F	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	Second	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	67.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1282	795
F	Second	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Second	Apartment	72.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1378	854
F	Third	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Third	Apartment	70.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1340	830
F	Third	Apartment	75.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1436	890
F	Third	Apartment	53.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1014	629
F	Third	Apartment	75.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1436	890
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Third	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	Third	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Third	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Third	Apartment	95.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1818	1127
F	Fourth	Apartment	54.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1034	640
F	Fourth	Apartment	71.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1359	842
F	Fourth	Apartment	50.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	957	593
F	Fourth	Apartment	80.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump	Reverse cycle heat pumps	MVHR System	All Low Energy	19.1	11.9	38.0%	1531	949

Block G – Be Green

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1298	844
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1298	844
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1298	844
G	Townhouse	Townhouse	79.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1298	844

Block H – Be Green

Block	Floor	Dwelling Type	Area m^2	Roof U -value W/m^2K	Wall U-value W/m^2K	Floor U-Value W/m^2K	Window U-Value W/m^2K	Thermal Bridging	APR	Primary Heating	Secondary Heating	Ventilation	Lighting	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% imp	TER ($kgCO_2/yr$)	DER ($kgCO_2/yr$)
H	Townhouse	Townhouse	84.0	0.15	0.15	0.12	1.30	Approved	3	Air source heat pump (split)	None	MVHR System	All Low Energy	16.4	10.7	35.0%	1380	897

11.0 APPENDIX C – BE LEAN BRUKL REPORT FOR COMMERCIAL UNIT

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name **Shell and Core**

01PL1823_ Be Lean

As designed

Date: Fri Feb 15 11:37:13 2019

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.9

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.9

BRUKL compliance check version: v5.4.a.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	27.9
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	27.9
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	22.2
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	SH000003:Surf[1]
Floor	0.25	0.12	0.12	SH000003:Surf[0]
Roof	0.25	0.15	0.15	SH000000:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.3	1.3	SH000002:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a-Limit}$ = 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

12.0 APPENDIX D – BE CLEAN BRUKL REPORT FOR COMMERCIAL UNIT

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name **Shell and Core**

02PL1823_ Be Clean As designed

Date: Fri Feb 15 13:56:43 2019

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.9

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.9

BRUKL compliance check version: v5.4.a.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	20.3
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	20.3
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	18
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	SH000003:Surf[1]
Floor	0.25	0.12	0.12	SH000003:Surf[0]
Roof	0.25	0.15	0.15	SH000000:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.3	1.3	SH000002:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

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

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

13.0 APPENDIX E – BE GREEN BRUKL REPORT FOR COMMERCIAL UNIT

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name **Shell and Core**

03PL1823_ Be Green As designed

Date: Fri Feb 15 13:54:36 2019

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.9

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.9

BRUKL compliance check version: v5.4.a.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	20.3
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	20.3
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	14.5
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	SH000003:Surf[1]
Floor	0.25	0.12	0.12	SH000003:Surf[0]
Roof	0.25	0.15	0.15	SH000000:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.3	1.3	SH000002:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

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

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

14.0 APPENDIX F – GLA SUMMARY TABLES

SAP 2012 PERFORMANCE

DOMESTIC

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	174	
After energy demand reduction	156	
After heat network / CHP	120	
After renewable energy	112	

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	18	11%
Savings from heat network / CHP	35	20%
Savings from renewable energy	9	5%
Cumulative on site savings	**63**	**36%**
Annual savings from off-set payment	112	-
	(Tonnes CO2)	
Cumulative savings for off-set payment	**3,350**	-
Cash in-lieu contribution (£)	**201,010**	

NON-DOMESTIC

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	16	
After energy demand reduction	13	
After heat network / CHP	11	
After renewable energy	9	

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	20%
Savings from heat network / CHP	3	15%
Savings from renewable energy	2	13%
Total Cumulative Savings	**8**	**48%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	6	-
Shortfall	-2	-65
Cash in-lieu contribution (£)	**-3,896**	-

SITE-WIDE

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	191		
Be lean	169	22	11%
Be clean	131	38	20%
Be green	120	11	6%
	-	CO2 savings off-set (Tonnes CO2)	-
Off-set	-	3,285	-

SAP10 PERFORMANCE

DOMESTIC

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	157	
After energy demand reduction	133	
After heat network / CHP	54	
After renewable energy	50	

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	24	15%
Savings from heat network / CHP	79	50%
Savings from renewable energy	4	3%
Cumulative on site savings	**106**	**68%**
Annual savings from off-set payment	50	-
	(Tonnes CO2)	
Cumulative savings for off-set payment	**1,504**	-
Cash in-lieu contribution (£)	**90,242**	

NON-DOMESTIC

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	10	
After energy demand reduction	7	
After heat network / CHP	5	
After renewable energy	4	

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	33%
Savings from heat network / CHP	2	19%
Savings from renewable energy	1	9%
Total Cumulative Savings	**6**	**62%**

Table 5: Shortfall in regulated carbon dioxide savings

	Annual Shortfall (Tonnes CO_2)	Cumulative Shortfall (Tonnes CO_2)
Total Target Savings	3	-
Shortfall	-3	-80
Cash in-lieu contribution (£)	**-4,798**	-

SITE-WIDE

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	167		
Be lean	140	27	16%
Be clean	59	81	49%
Be green	54	5	3%
	-	CO2 savings off-set (Tonnes CO2)	-
Off-set	-	1,424	-