



Client	First Avenue Estates Ltd		
Development	Land to rear 303-313 Oxford Road and Adjacent 3 Western Elms Avenue, Reading, RG30 4AU		
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Land r/o 303-313 Oxford Road and adjacent 3 Western Elms Avenue, Reading, Berks RG30 4AU – Energy Strategy



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1. Site overview

This Energy Strategy has been produced to identify the measures and technologies necessary to exceed the requirements of Reading Borough Council as well as ensure the homes meet the need to reduce reliance on fossil fuels while reducing carbon emissions arising from new developments to slow the rate of climate change.

The application site which lies to the rear of 303-315 Oxford Road, and fronts Western Elms Avenue seeks permission for the construction 13 no apartments, 1 no flat or garage and associated parking and landscaping.

2. Planning targets

The Reading Borough Council Local Plan was adopted in November 2019 and sets out measures to respond to the climate emergency. A supporting Sustainable Design and Construction SPD was subsequently adopted in December 2019.

Policy H5 details the required standard for new housing, as detailed below.

"H5: STANDARDS FOR NEW HOUSING

New build housing should be built to the following standards, unless it can be clearly demonstrated that this would render a development unviable:

a. All new build housing outside the Central Area as defined on the Proposals Map will comply with the nationally-described space standard.

b. All new build housing will be built to the higher water efficiency standard under Regulation 36(3) of the Building Regulations⁷⁹.

c. All major new-build residential development should be designed to achieve zero carbon homes.

d. All other new build housing will achieve at a minimum a 19% improvement in the dwelling emission rate over the target emission rate, as defined in the 2013 Building Regulations.

e. All new build housing will be accessible and adaptable in line with M4(2) of the Building Regulations, unless it is built in line with M4(3) (see below).

f. On developments of 20 or more new build dwellings, at least 5% of dwellings will be wheelchair user dwellings in line with M4(3) of the Building Regulations. Any market homes provided to meet this requirement will be 'wheelchair adaptable' as defined in part M, whilst homes where the Council is responsible for allocating or nominating an individual may be 'wheelchair accessible'. "

This report intends to demonstrate how points (b) and (c) will be met in the context of the proposed development.

The supporting SPD further enhances on these requirements, in particular with regards to the requirement to achieve zero-carbon. Table 3.1 of the SPD states the following requirement for major developments (10 or more dwellings):

"Zero Carbon (or if unachievable, a minimum 35% improvement in the dwelling emission rate over the target emission rate, as defined in the 2013 Building Regulations and planning contribution to offset remaining carbon emissions to zero)"

2.1. Key Policy Targets

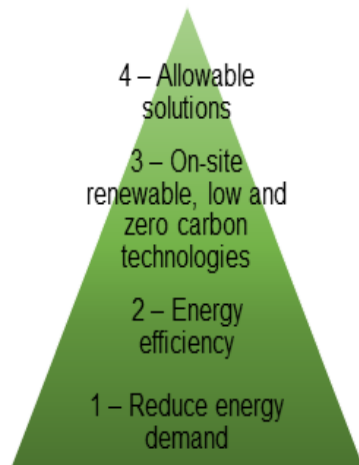
- To provide a water usage rate of under 110 Litres per person per day
- Achieve a minimum of 35% improvement in regulated emissions over the Target Emissions Rate in the 2013 Building Regulations.

3. Energy Efficiency – Demand Reduction

The developer aims to provide homes with as close to zero carbon emissions resulting from regulated energy usage (heating, hot water, ventilation and lighting) as possible. This is achieved by applying the energy hierarchy detailed below.

3.1. Methodology

This report uses the energy hierarchy to minimise onsite carbon emissions, the stages are:



Use Renewable Energy – assess the feasibility of renewable energy systems

Supply Energy Efficiently – Use low-carbon technology to significantly reduce energy consumption

Use less Energy – the incorporation of low energy design and passive measures to promise the reduction of energy use

Figure 1: The Energy Hierarchy

Indicative calculations have also been carried out using the SAP 10.1 carbon emissions for each fuel type. This is intended to demonstrate that the proposals remain consistent with the expectation of both current and future regulations.

3.1.1 Demand Reduction

A fabric first approach has been adopted to minimise energy demand as much as practical. The three main sources of heat loss have been addressed

- Thermal Envelope
- Thermal Bridging
- Uncontrolled Air Leakage

With each discussed in more detail below.

3.1.2 Thermal Envelope

The below table summarises the proposed performance of the thermal envelope. It is proposed that all areas significantly improve upon the minimum building fabric standards stated within the Part L 2013.

Thermal Element	Building Regulations (Part L 2013)	Proposed target values	Improvement over proposed 2013 Building Regulations Standard
Floors	0.25 W/m ² K	0.12 W/m²K	52%
External wall	0.30 W/m ² K	0.18 W/m²K	40%
Sheltered wall to communal area	0.30 W/m ² K	0.25 W/m²K	17%
Party wall	0.20 W/m ² K	Fully filled & sealed 0.00 W/m²K	100%
Roofs – Insulated at ceiling	0.20 W/m ² K	0.10 W/m²K	50%
Flat roof	0.20 W/m ² K	0.13 W/m²K	35%
Sloping roof	0.20 W/m ² K	0.15 W/m²K	25%
Windows & Glazed Doors	2.00W/m ² K	1.30 W/m²K	35%
Air permeability	10.00m ³ /(h.m ²) at 50 Pa	4.50m³/(h.m²) at 50 Pa	55%

Table 1: Proposed Fabric Standard

3.1.3 Thermal Bridging

Thermal bridging occurs at the junction between fabric elements, where the continuous insulation line is broken. Through careful detailing of junctions, it is possible to mitigate against the impact of thermal bridges.

It is proposed that the dwellings benefit from the use of enhanced thermal bridging detailing such as those provided by the LABC, Concrete Block Association (CBA) or Aircrete Product Association (APA). Specific detailing required will differ subject to the chosen method of construction, however, key junctions which require particular attention are the ground floor to wall junction and lintels, which can be addressed by incorporating thermal blockwork and thermally broken or independent lintels respectively or careful design of timber frame.

Balconies will be externally supported to ensure continuity of insulation is maintained.

3.1.4 Uncontrolled Air Leakage and Ventilation

As buildings become more heavily insulated, uncontrolled air leakage represents an increasing proportion of a dwellings heat loss. As such it is critical to ensure that any unwanted leakage is minimised.

To minimise energy demand, it is proposed that an airtightness of $3.00\text{m}^3/\text{hr}/\text{m}^2$ is targeted.

3.1.5 Mechanical Ventilation Heat Recovery

To assess the impact of introducing further energy efficiency measures, an MVHR has also been modelled. When designing very low energy buildings very high levels of air tightness are beneficial, which requires dedicated mechanical ventilation with heat recovery to maintain internal air quality.

In this instance we have modelled a Nuaire MRXBOXAB- ECO2 model, however detailed design and selection of an appropriately sized system would be necessary.

MVHR units do require additional maintenance with filters needing to be replaced annually.

3.2. Energy Efficiency

The following efficiency measures are proposed for the development.

Lighting

Internal lighting will be specified with a minimum efficacy of 60 lumens per circuit watt. External lighting will be designed to minimise light spill and have efficient lights and appropriate automatic controls.

Appliances

Where supplied, any white goods will achieve the following ratings (or better) under the EU Energy Efficiency Labelling Scheme:

1. Fridges, fridge-freezers: A+ rating
2. Washing machines: A++ rating
3. Dishwashers: A+ rating
4. Washer-dryers: A rating
5. Tumble-dryers: A rating (Where possible external drying lines will be included to reduce the need for tumble dryers)

Where not provided as part of the build specification, guidance regarding energy-efficient appliances will be provided to the occupant.

3.3. Water Efficiency

In accordance with policy H5(b) it is proposed that all dwellings achieve a minimum water efficiency standard of 110 litres/person/day as set out in Building Regulations Part G. It is recommended that maximum water consumption criteria, as stated in table 2.2 of approved document Part G be followed, summarised below.

Water Fitting	Maximum Consumption
WC	4/2.6 litres dual flush
Shower	8 l/min
Bath	170 litres
Basin Taps	5 l/min
Sink Taps	6 l/min
Dishwasher	1.25 l/place setting
Washing Machine	8.17 l/kilogram dry load

Table 2: (Part G2 Table 2.2) Maximum fittings consumption optional requirement level

4. Supply Energy Efficiently

Over recent years, the electricity grid had undergone the process of de-carbonisation with coal power stations being decommissioned and generation moving to cleaner fuel sources and renewable energy such as wind and solar.

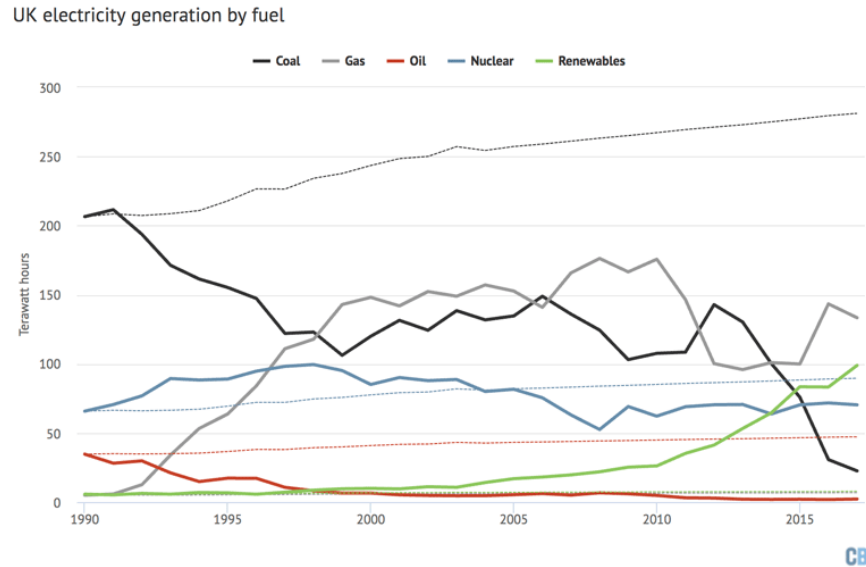


Figure 2: UK electricity generation by fuel (source: Carbon Brief 2019)

SAP 10.1 is the first version of SAP which reflects this, with emissions from grid electricity being quarter of what they were previously, which removes the significant benefit that a fossil fuel natural gas heated dwelling used to benefit from. This will encourage a move to alternative low-carbon heating systems such as heat pumps.

Fuel	CO ₂ (SAP 2012)	CO ₂ (SAP 10.1)	
Mains Gas	0.216	0.21	-3%
Oil	0.298	0.298	0%
LPG	0.241	0.241	0%
Electric	0.519	0.136	-74%
Electric sold to grid	0.519	0.136	-74%
Wood logs	0.019	0.028	47%

Table 3: Carbon emissions factors for fuels in SAP 10.1

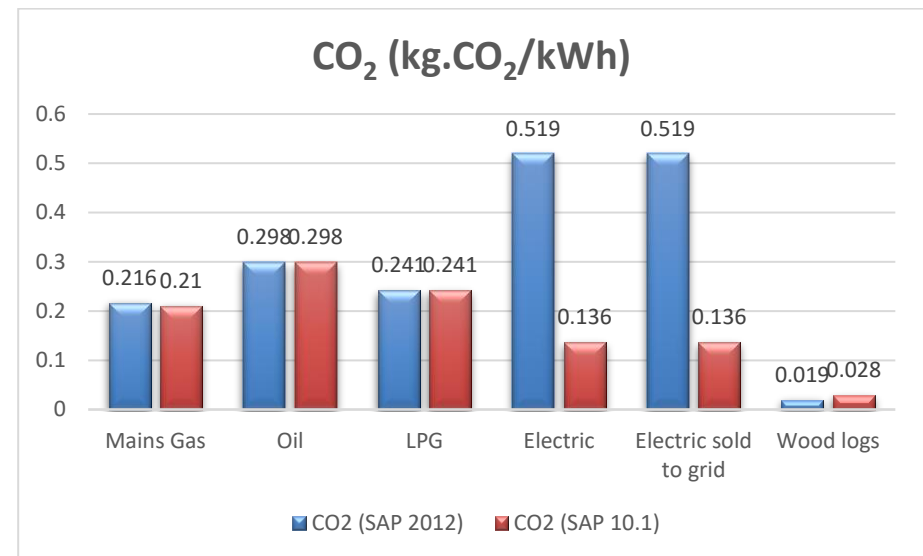


Figure 3: Carbon emissions factors for fuels in SAP 10.1

Energy strategy options using both mains gas and grid electricity are presented within this report.

5. Energy Strategy Options

A number of energy strategy options have been identified, which are capable of meeting and exceeding the requirements of national and local planning policy whilst also offering future proofing by remaining viable under future Building Regulations.

5.1. Option 1 – Gas Combination Boilers & Photovoltaics

Despite grid electricity slowly being considered to be the cleaner fuel type, high efficiency gas condensing combination boilers remain a compelling option for providing a reliable and low costing with few compromises.

The main building offers good ability to install solar photovoltaics (PV) on the upper most flat roof. Installing panels at a low pitch would ensure that shading is minimised, and panels are subject to direct solar radiation throughout the day. For the flat over garage building, PV panels could be located on the west elevation which should offer the opportunity to generate electricity for most of the day. Distribution and location of PV panels to be confirmed at design stage.

Number of panels	20
Approximate surface area per Panel	1.75m ²
Approximate panel surface area required	35m ²
Panel Output (Wp)	370
Total Output (kWp)	7.4
Total Output (kWh/year)	5627.7

Table 4: Indicative Photovoltaic Array

In the context of the application site, when combined with a high-performance fabric and renewable energy generation in the form of solar can achieve

significant reduction in energy demand and achieve at least 35% emissions reduction as required by policy H5.

5.1.1 Considerations

Pros:

- Low capital cost
- Low running costs
- Low space requirements
- Low NO_x emissions
- Low visual impact

Cons:

- Reliance on fossil fuels
- Boiler flues need to discharge externally, routes and ventilation of ceilings should be considered accordingly.
- emissions on site

5.1.2 Results

	Part L 2013 TER Energy Demand (kWh/year)	Predicted Energy Demand (kWh/year)	Energy Demand Reduction (kWh/year)	Demand Reduction (%)
Option 1 - Gas Combi + PV	62259.17	43647.78	18611.38	29.9%
	Part L 2013 TER Emissions (kg.CO ₂ /year)	Predicted CO2 emissions (kg.CO ₂ /year)	CO2 emissions reduction (kg.CO ₂ /year)	CO2 emissions reduction (%)
Option 1 - Gas Combi + PV	14834.85	9542.07	5292.78	35.7%

5.2. Option 2 - Air Source Heat Pump (ASHP)

An air to water heat pump extracts heat from the external air and upgrades it using a compressor to provide useful heat for space and water heating. The efficiency of an ASHP is measure in Coefficient of Performance (CoP) and can achieve a CoP more than 3 (300%) in favorable conditions, which means for every unit of energy consumed 3 units of energy is produced by the heat pump. This makes the running cost of heat pumps significant cheaper than a direct electric heat source such as panel heaters as at a CoP it consumes just a third of the energy.

Air source heat pumps are not able to deliver the flow temperatures typically associate with boilers, and as such require emitters to be specifically designed to operate at the temperatures a heat pump can deliver. Underfloor heating, low temperature fan convactor radiators or traditional radiators oversized to account for the lower temperatures are such emitters. Traditional radiators may need to be sized to provide double up to double the output required for a conventional heating system, however due to high levels of insulation seen in new build dwellings it remains possible keep radiator sizes sensible.

It is important for occupants to be made aware of the slower heat up time they may experience with an ASHP and that for maximum efficiency, they should allow the ASHP to provide a steady amount out heating during the heating period, rather than simply switching heating on and off as might have been the case with a boiler, as once the building structure has lost its retained heat it would take a while for an air source heat pump to heat the entire building back up.

In this instance an induvial ASHPs are modelled alongside a high-performance fabric. For the purposes of the SAP modelling, an indicative Samsung ASHP has been modelled (detail sizing will be required at design stage)

The upper most flat roof areas could be utilised to accommodate the external condenser units for the apartment block. Clearance requirements vary between manufacturers however the below illustration demonstrates that ASHP can be located away from the edge of the flat roof minimizing the visual impact.

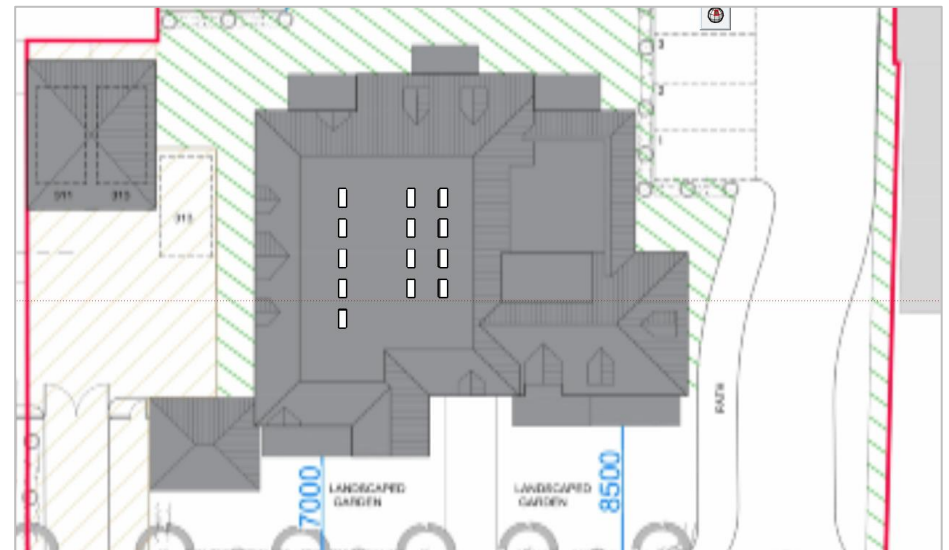


Figure 4: Indicative condenser locations

5.2.1 Considerations

Pros:

- Reduce energy demand and carbon emissions
- No emissions on-site
- Low running cost
- Currently eligible for the Renewable Heat Incentive (RHI)

- Significantly lower emissions when calculated using updated SAP 10.1 emissions factors

Cons:

- Higher capital cost
- Space for water heater required within apartment
- Potential noise impact
- Potential visual impact
- Structural considerations to ensure roof can accommodate additional loadings
- Roof access required for inspection of condenser units

5.2.2 Results

	Part L 2013 TER Energy Demand (kWh/year)	Predicted Energy Demand (kWh/year)	Energy Demand Reduction (kWh/year)	Demand Reduction (%)
Option 2 - ASHP	62259.17	25622.34	36636.83	58.8%
	Part L 2013 TER Emissions (kg.CO ₂ /year)	Predicted CO2 emissions (kg.CO ₂ /year)	CO2 emissions reduction (kg.CO ₂ /year)	CO2 emissions reduction (%)
Option 2 - ASHP	21687.48	13298.00	8389.48	38.7%

5.3. Option 3 - Electric Panel Heaters, Heat Pump Water Heaters and Photovoltaics

As an alternative a conventional wet heating system, an electric panel heater (which operate at 100% efficiency) can be used to heat new dwellings and can achieve the required carbon emissions targets where a high-performance fabric and other technologies are installed. Due to the higher cost of electricity compared to gas, they can be a more expensive form of heating, which make it even more important to ensure a high level of thermal efficiency, and onsite energy generation to offset the higher running costs.

They are however very low maintenance, and very simple to use.

5.3.1 Heat Pump Hot Water Cylinder

Relatively new to the market, heat pump water heaters use the same technology as an air source heat pump to provide stored hot water for use in the home. A system such as the Dimplex Edel 200L, would be highly efficient and more cost effective to run than a conventional cylinder heated with an immersion heater.



Figure 5: Dimplex EDEL water heater

Installation requirements are minimal, just requiring an electrical input and 2 number ducts to an outside wall for intake and exhaust air. Placement of the duct outlets would need to maintain typical

clearances from any other openings or services penetrations. Further documentation has been provided within the appendices.

As with Option 1, solar photovoltaic panels are necessary to satisfy planning requirements, the below table summarises the PV array modelled.

Number of panels	16
Approximate surface area per Panel	1.75m ²
Approximate panel surface area required	28m ²
Panel Output (Wp)	370
Total Output (kWp)	5.92
Total Output (kWh/year)	4502

Table 5: Indicative Photovoltaic Array

5.3.2 Considerations

Pros:

- Reduce energy demand and carbon emissions
- No emissions on-site
- Low running cost
- Significantly lower emissions when calculated using updated SAP 10.1 emissions factors
- Low maintenance

Cons:

- Slightly higher running cost compared to option 1 and 2 due to higher cost of electricity and high heat demand respectively
- Space for water heater required within apartments
- Compressor built into water heater may emit some noise

- Supply and exhaust ductwork require consideration to ensure ceiling heights are not significantly impacted and to avoid clash with other services such as the MVHR ductwork
- External air inlets and outlets required, consideration should be given to minimise visual impact

5.3.3 Results

	Part L 2013 TER Energy Demand (kWh/year)	Predicted Energy Demand (kWh/year)	Energy Demand Reduction (kWh/year)	Demand Reduction (%)
Option 3 - Panel + EDEL + PV	62259.17	26834.18	35428.99	56.9%
	Part L 2013 TER Emissions (kg.CO ₂ /year)	Predicted CO2 emissions (kg.CO ₂ /year)	CO2 emissions reduction (kg.CO ₂ /year)	CO2 emissions reduction (%)
Option 3 - Panel + EDEL + PV	21687.48	13925.38	7762.09	35.8%

5.4. Option 4 - Nilan Compact P - 2 Stage Exhaust Air Heat Pump with Heat Recovery

For dwellings with very low energy demand, an exhaust air heat pump such as the Nilan Compact P can provide significant levels of performance.

This technology incorporates an air-to-air heat pump, mechanical ventilation heat recovery and hot water cylinder into a single package, as heating is provided via the air distribution ductwork it also removes the need for a wet heating system.

This system operates most effectively when allowed to maintain the dwelling at a steady temperature, recovering and upgrading to the latent heat within extract air to provide space and water heating. Due to the small heat output capacity, it is necessary to install a supplementary panel heater sized for dwelling peak heat loss within the main living spaces to aid rapid heat up for particularly cold days or when the dwelling has been allowed to cool down significantly, however once the dwelling is up to temperature little input from the panel heaters should be required.



Figure 6: Exhaust Air Heat Pump with MVHR (Source: Nilan UK)

5.4.1 Considerations

Pros:

- Reduce energy demand and carbon emissions
- No emissions on-site
- Low running cost
- Significantly lower emissions when calculated using updated SAP 10.1 emissions factors
- Low maintenance
- Combines heating, water heater and ventilation in one unit, removing the need for a separate MVHR system.

Cons:

- This system is larger than a typical water heater, therefore requiring larger cupboards, which may impact space standards
- Operates in an unconventional manner, occupants should be informed and advised on how to operate such as system efficiently.
- Compressor built into water heater may emit some noise

5.4.2 Results

	Part L 2013 TER Energy Demand (kWh/year)	Predicted Energy Demand (kWh/year)	Energy Demand Reduction (kWh/year)	Demand Reduction (%)
Option 4 - NILAN	62259.17	22517.79	39741.38	63.8%

	Part L 2013 TER Emissions (kg.CO ₂ /year)	Predicted CO2 emissions (kg.CO ₂ /year)	CO2 emissions reduction (kg.CO ₂ /year)	CO2 emissions reduction (%)
Option 4 - NILAN	21687.48	11686.73	10000.74	46.1%

6. Comparison of Results

6.1. Energy Demand

As demonstrated in figure 7 below, all the presented options offer a significant reduction in energy demand relative to Part L 2013 Target Emission Rate (TER) baseline, options which utilise heat pumps for either space or water heating yield the greater improvement due to the high co-efficient if performance.

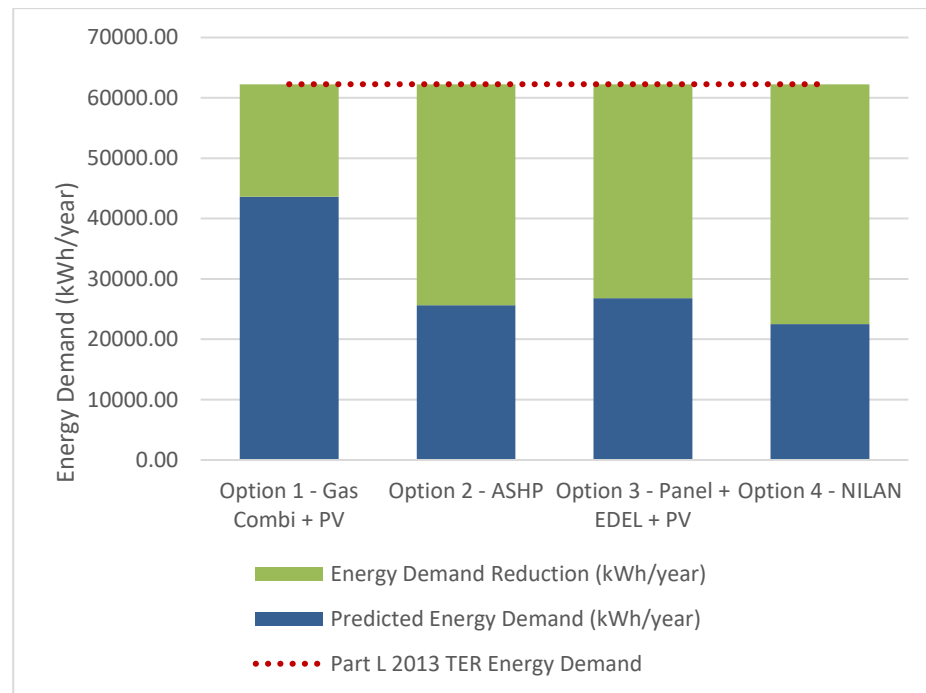


Figure 7: Part L 2013: Energy Demand Reduction

6.2. Carbon Emissions

Part L 2013 uses an adjusted calculation for TER where electric is being used as primary heating source, as such this is reflected in figure 8 opposite. Due to

electricity having a higher carbon factor than mains gas under part L 2013 methodology, options 2, 3 and 4 which use electricity all have higher overall emissions compared to option 1 which uses a gas boiler.

All presented options achieve 35% improvement over the relevant of Part L 2013 TER as required by policy H5, however electrically based options have the greatest residual carbon emission therefore attracting greater contribution to achieve zero carbon.

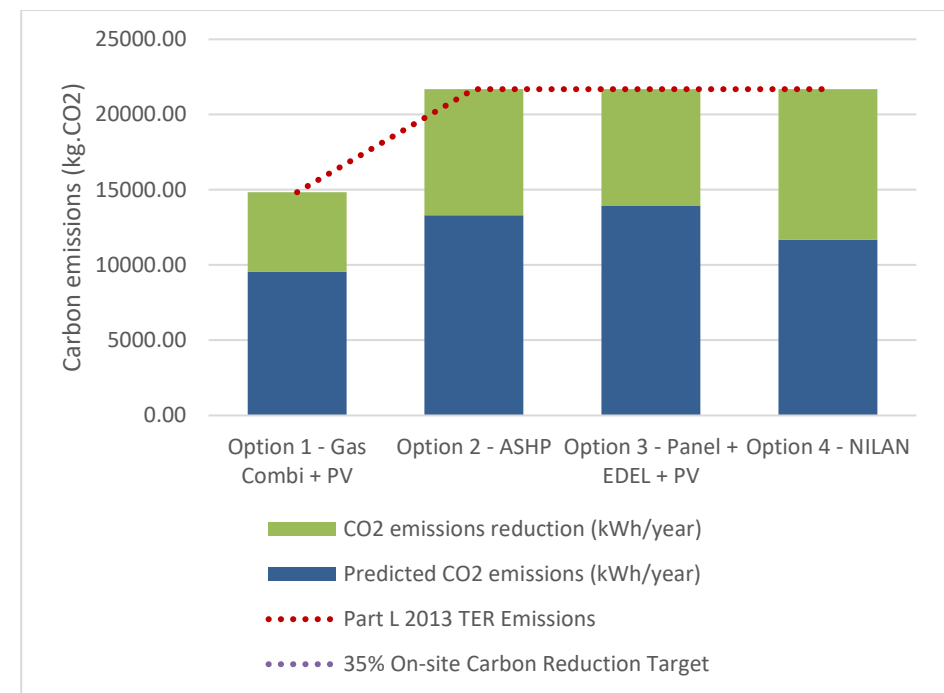


Figure 8: Part L 2013: Carbon Emissions Reduction

6.3. SAP 10.1

As detailed in section 4, upcoming regulations are expected to utilise updated carbon factors which better reflect the higher proportion of green and renewable energy generation now taking place and being utilised on the electricity network.

Figure 9 below, presents adjusted results using the carbon factors proposed within the draft version of Part L. The new Part L also proposes a TER approximately 31% better than current regulation, this has been transposed below for reference.

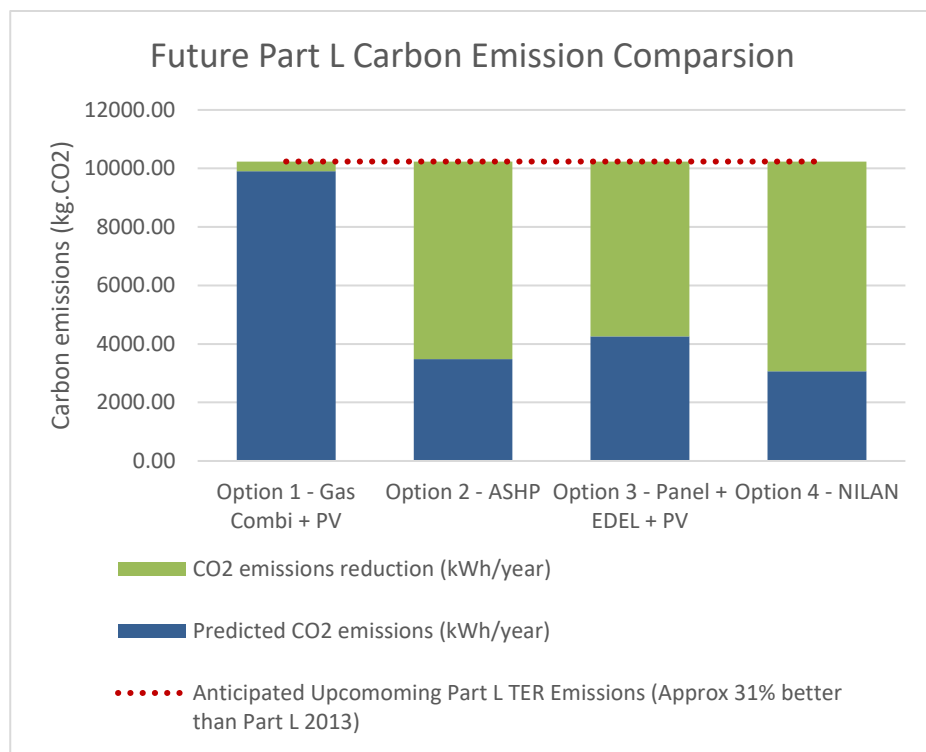


Figure 9: SAP 10.1 Emissions Comparison

In contrast to current regulations, electrically based heating scenarios are considered to have significantly lower carbon emissions associated with them. The benefit of electrically based systems is expected to extend further as green generations continues to grow and the carbon factor associated with grid electricity trends towards zero.

As the upcoming part L and associated SAP calculation remain in consultation, should the development not be registered prior to the new regulations coming into force (currently expected June 2022) or not commenced within the 1-year transitional arrangement period, all results presented here are indicative and for guidance only. Should this be the case, the energy strategy should be reviewed to ensure compliance with the relevant regulations.

7. Conclusion

Reading Borough Council require that new major developments (over 10 dwellings) achieve zero-carbon emissions, with a minimum 35% reduction in carbon emissions to be delivered through energy efficiency and renewable energy on-site and the balance of emissions being offset through a carbon offset contribution.

SAP calculations have been carried out for several energy strategy options and a number of viable energy strategy identified which are capable of meeting the requirements of the planning policy.

Four options are presented (Section 5), each with their own merits, and are fully capable of satisfying the planning policy as necessary:

- Option 1 – High Performance Building Fabric, Gas Combi Boiler & PV
- Option 2 – High Performance Building Fabric and ASHP
- Option 3 - High Performance Building Fabric, Panel Heaters, Heat Pump Water Heater & PV
- Option 4 – 2 Stage exhaust air heat pump with heat recovery ventilation.

Each of these options will be review in more detail at detailed design stage for technical and economic feasibility, at which point one or a combination of the strategies will be selected.

	Estimated Demand Reduction (%)	Estimated CO2 emissions reduction (%)
Option 1 - Gas Combi + PV	29.9%	35.7%
Option 2 - ASHP	58.8%	38.7%
Option 3 - Panel + EDEL + PV	56.9%	35.8%
Option 4 - NILAN	63.8%	46.1%

Table 6: Summary of Results

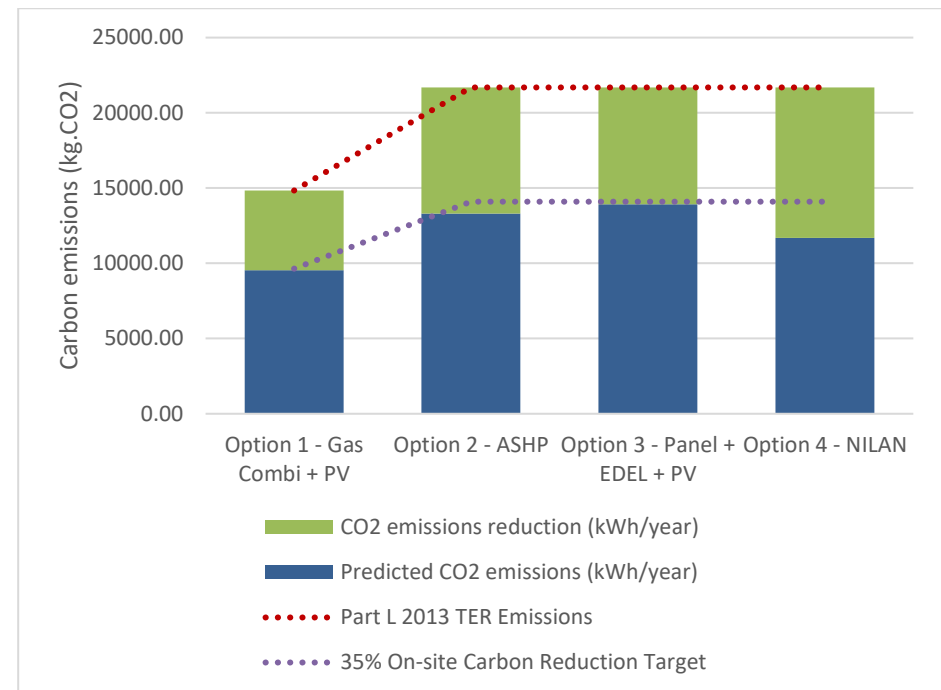


Figure 10: Part L 2013: Carbon Emissions Reduction

It is considered that the proposed energy strategies are consistent with the National Planning Policy Framework and the policies of the Reading Borough Council and local authority and when implemented will provide an efficient and low carbon development.

Appendix A – Energy and Emissions Calculations

Energy Calculation - TER Baseline										
Dwelling Type	Sample Floor Area	Represented Floor Area	Space Heating		Hot Water		Pumps Fans		Lighting	
			Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)
Plot 4 - 1 Bed Ground Floor	39.56	173.60	1928.61	416.58	1734.02	374.55	75.00	38.93	191.02	99.14
Plot 5 - 2 Bed Ground Floor	61.24	122.80	2714.13	586.25	2108.09	455.35	75.00	38.93	302.96	157.23
Plot 9 - 1 Bed Mid Floor	39.56	118.60	1493.00	322.49	1743.96	376.70	75.00	38.93	191.02	99.14
Plot 10 - 2 Bed Mid Floor	61.24	122.80	2101.16	453.85	2119.99	457.92	75.00	38.93	302.96	157.23
Plot 12 - 2 Bed Top Floor	72.99	75.00	3270.91	706.52	2286.62	493.91	75.00	38.93	347.57	180.39
Plot 13 - 2 Bed Top Floor	61.24	107.30	2488.40	537.49	2112.04	456.20	75.00	38.93	302.96	157.23
Total Floor Area (m₂) (SAP Box 5)	335.83	720.10								
Space Heating Fuel			Mains Gas							
Total space heating (kWh/year) (SAP Box 85)			30315.93							
SAP 2012 CO₂ from space heating (kg/year) (SAP Box 101)			6548.24							
SAP 10.1 CO₂ from space heating (kg/year)			6366.35							
Water Heater Fuel			Mains Gas							
Total hot water (kWh/year) (SAP Box 86a)			27366.12							
SAP 2012 CO₂ from hot water (kg/year) (SAP Box 103)			5911.08							
SAP 10.1 CO₂ from hot water (kg/year)			5746.89							
Total electricity for pumps and fans (kWh/year) (SAP Box 87)			1063.23							
SAP 2012 CO₂ from electricity for pumps and fans (kg/year) (SAP Box 108)			551.81							
SAP 10.1 CO₂ from electricity for pumps and fans (kg/year)			247.7318951							
Total electricity for lighting (Kwh/year) (SAP Box 53)			3513.89							
SAP 2012 CO₂ from electricity for lighting (kg/year) (SAP Box 109)			1823.71							
SAP 10.1 CO₂ from electricity for lighting (kg/year)			818.74							
Energy saving/generation technologies (kWh/year)										
Total Energy demand from development (kWh/year)			62259.17							
SAP 2012 CO₂ saving/generation technologies (kg/year)										
SAP 2012 Total CO₂ emissions from development (kg/year)			14834.85							
SAP 10.1 CO₂ saving/generation technologies (kg/year)										
SAP 10.1 Total CO₂ emissions from development (kg/year)			13179.70							



Energy Calculation - TER Baseline (Electric)										
Dwelling Type	Sample Floor Area	Represented Floor Area	Space Heating		Hot Water		Pumps Fans		Lighting	
			Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)
Plot 4 - 1 Bed Ground Floor	39.56	173.60	1928.61	416.58	1734.02	374.55	75.00	38.93	191.02	99.14
Plot 5 - 2 Bed Ground Floor	61.24	122.80	2714.13	586.25	2108.09	455.35	75.00	38.93	302.96	157.23
Plot 9 - 1 Bed Mid Floor	39.56	118.60	1493.00	322.49	1743.96	376.70	75.00	38.93	191.02	99.14
Plot 10 - 2 Bed Mid Floor	61.24	122.80	2101.16	453.85	2119.99	457.92	75.00	38.93	302.96	157.23
Plot 12 - 2 Bed Top Floor	72.99	75.00	3270.91	706.52	2286.62	493.91	75.00	38.93	347.57	180.39
Plot 13 - 2 Bed Top Floor	61.24	107.30	2488.40	537.49	2112.04	456.20	75.00	38.93	302.96	157.23
Total Floor Area (m₂) (SAP Box 5)	335.83	720.10								
Space Heating Fuel			Mains Gas							
Total space heating (kWh/year) (SAP Box 85)			30315.93							
SAP 2012 CO₂ from space heating (kg/year) (SAP Box 101)			10149.77							
SAP 10.1 CO₂ from space heating (kg/year)			6366.35							
Water Heater Fuel			Mains Gas							
Total hot water (kWh/year) (SAP Box 86a)			27366.12							
SAP 2012 CO₂ from hot water (kg/year) (SAP Box 103)			9162.18							
SAP 10.1 CO₂ from hot water (kg/year)			5746.89							
Total electricity for pumps and fans (kWh/year) (SAP Box 87)			1063.23							
SAP 2012 CO₂ from electricity for pumps and fans (kg/year) (SAP Box 108)			551.81							
SAP 10.1 CO₂ from electricity for pumps and fans (kg/year)			144.5988744							
Total electricity for lighting (Kwh/year) (SAP Box 53)			3513.89							
SAP 2012 CO₂ from electricity for lighting (kg/year) (SAP Box 109)			1823.71							
SAP 10.1 CO₂ from electricity for lighting (kg/year)			477.89							
Energy saving/generation technologies (kWh/year)										
Total Energy demand from development (kWh/year)			62259.17							
SAP 2012 CO₂ saving/generation technologies (kg/year)										
SAP 2012 Total CO₂ emissions from development (kg/year)			21687.48							
SAP 10.1.1 CO₂ saving/generation technologies (kg/year)										
SAP 10.1.1 Total CO₂ emissions from development (kg/year)			12735.72							



Energy Calculation - Option 1 Gas Combi + PV										
Dwelling Type	Sample Floor Area	Represented Floor Area	Space Heating		Hot Water		Pumps Fans		Lighting	
			Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)
Plot 4 - 1 Bed Ground Floor	39.56	173.60	1559.66	336.89	1379.67	298.01	153.43	79.63	191.02	99.14
Plot 5 - 2 Bed Ground Floor	61.24	122.80	2105.47	454.78	1641.44	354.55	196.41	101.94	302.96	157.23
Plot 9 - 1 Bed Mid Floor	39.56	118.60	960.44	207.45	1384.65	299.08	153.43	79.63	191.02	99.14
Plot 10 - 2 Bed Mid Floor	61.24	122.80	1299.81	280.76	1647.39	355.84	196.41	101.94	302.96	157.23
Plot 12 - 2 Bed Top Floor	72.99	75.00	2309.52	498.86	1768.76	382.05	219.70	114.03	347.57	180.39
Plot 13 - 2 Bed Top Floor	61.24	107.30	1624.47	350.89	1644.83	355.28	196.41	101.94	302.96	157.23
Total Floor Area (m₂) (SAP Box 5)	335.83	720.10								
Space Heating Fuel			Mains Gas							
Total space heating (kWh/year) (SAP Box 85)			21771.30							
SAP 2012 CO₂ from space heating (kg/year) (SAP Box 101)			4702.60							
SAP 10.1 CO₂ from space heating (kg/year)			4571.97							
Water Heater Fuel			Mains Gas							
Total hot water (kWh/year) (SAP Box 86a)			21499.77							
SAP 2012 CO₂ from hot water (kg/year) (SAP Box 103)			4643.95							
SAP 10.1 CO₂ from hot water (kg/year)			4514.95							
Total electricity for pumps and fans (kWh/year) (SAP Box 87)			2490.83							
SAP 2012 CO₂ from electricity for pumps and fans (kg/year) (SAP Box 108)			1292.74							
SAP 10.1 CO₂ from electricity for pumps and fans (kg/year)			338.7522399							
Total electricity for lighting (kWh/year) (SAP Box 53)			3513.89							
SAP 2012 CO₂ from electricity for lighting (kg/year) (SAP Box 109)			1823.71							
SAP 10.1 CO₂ from electricity for lighting (kg/year)			477.89							
Energy saving/generation technologies (kWh/year)			5628							
Total Energy demand from development (kWh/year)			43647.78							
SAP 2012 CO₂ saving/generation technologies (kg/year)			2920.932							
SAP 2012 Total CO₂ emissions from development (kg/year)			9542.07							
SAP 10.1 CO₂ saving/generation technologies (kg/year)			1311.324							
SAP 10.1 Total CO₂ emissions from development (kg/year)			9903.57							



Energy Calculation - Option 2 ASHP										
Dwelling Type	Sample Floor Area	Represented Floor Area	Space Heating		Hot Water		Pumps Fans		Lighting	
			Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)
Plot 4 - 1 Bed Ground Floor	39.56	173.60	890.43	462.13	592.65	307.59	78.43	40.70	191.02	99.14
Plot 5 - 2 Bed Ground Floor	61.24	122.80	1027.74	533.40	678.23	352.00	121.41	63.01	302.96	157.23
Plot 9 - 1 Bed Mid Floor	39.56	118.60	596.88	309.78	592.65	307.59	78.43	40.70	191.02	99.14
Plot 10 - 2 Bed Mid Floor	61.24	122.80	689.50	357.85	678.23	352.00	121.41	63.01	302.96	157.23
Plot 12 - 2 Bed Top Floor	72.99	75.00	1043.29	541.47	719.51	373.43	144.70	75.10	347.57	180.39
Plot 13 - 2 Bed Top Floor	61.24	107.30	823.79	427.55	678.23	352.00	121.41	63.01	302.96	157.23
Total Floor Area (m₂) (SAP Box 5)	335.83	720.10								
Space Heating Fuel			Grid Electricity							
Total space heating (kWh/year) (SAP Box 85)			11655.75							
SAP 2012 CO₂ from space heating (kg/year) (SAP Box 101)			6049.33							
SAP 10.1 CO₂ from space heating (kg/year)			1585.18							
Water Heater Fuel			Grid Electricity							
Total hot water (kWh/year) (SAP Box 86a)			9025.11							
SAP 2012 CO₂ from hot water (kg/year) (SAP Box 103)			4684.03							
SAP 10.1 CO₂ from hot water (kg/year)			1227.41							
Total electricity for pumps and fans (kWh/year) (SAP Box 87)			1427.60							
SAP 2012 CO₂ from electricity for pumps and fans (kg/year) (SAP Box 108)			740.92							
SAP 10.1 CO₂ from electricity for pumps and fans (kg/year)			194.1533655							
Total electricity for lighting (kWh/year) (SAP Box 53)			3513.89							
SAP 2012 CO₂ from electricity for lighting (kg/year) (SAP Box 109)			1823.71							
SAP 10.1 CO₂ from electricity for lighting (kg/year)			477.89							
Energy saving/generation technologies (kWh/year)			0							
Total Energy demand from development (kWh/year)			25622.34							
SAP 2012 CO₂ saving/generation technologies (kg/year)			0							
SAP 2012 Total CO₂ emissions from development (kg/year)			13298.00							
SAP 10.1 CO₂ saving/generation technologies (kg/year)			0							
SAP 10.1 Total CO₂ emissions from development (kg/year)			3484.64							



Energy Calculation - Option 3 Panel Heater + Heat Pump Water Heater + PV										
Dwelling Type	Sample Floor Area	Represented Floor Area	Space Heating		Hot Water		Pumps Fans		Lighting	
			Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)
Plot 4 - 1 Bed Ground Floor	39.56	173.60	1452.90	754.05	393.98	204.47	78.43	40.70	191.02	99.14
Plot 5 - 2 Bed Ground Floor	61.24	122.80	1955.68	1015.00	460.47	238.99	121.41	63.01	302.96	157.23
Plot 9 - 1 Bed Mid Floor	39.56	118.60	907.32	470.90	393.98	204.47	78.43	40.70	191.02	99.14
Plot 10 - 2 Bed Mid Floor	61.24	122.80	1221.78	634.10	460.47	238.99	121.41	63.01	302.96	157.23
Plot 12 - 2 Bed Top Floor	72.99	75.00	2137.35	1109.28	492.56	255.64	144.70	75.10	347.57	180.39
Plot 13 - 2 Bed Top Floor	61.24	107.30	1517.29	787.47	460.47	238.99	121.41	63.01	302.96	157.23
Total Floor Area (m₂) (SAP Box 5)	335.83	720.10								
Space Heating Fuel			Grid Electricity							
Total space heating (kWh/year) (SAP Box 85)			20322.03							
SAP 2012 CO₂ from space heating (kg/year) (SAP Box 101)			10547.13							
SAP 10.1 CO₂ from space heating (kg/year)			2763.80							
Water Heater Fuel			Grid Electricity							
Total hot water (kWh/year) (SAP Box 86a)			6069.66							
SAP 2012 CO₂ from hot water (kg/year) (SAP Box 103)			3150.15							
SAP 10.1 CO₂ from hot water (kg/year)			825.47							
Total electricity for pumps and fans (kWh/year) (SAP Box 87)			1427.60							
SAP 2012 CO₂ from electricity for pumps and fans (kg/year) (SAP Box 108)			740.92							
SAP 10.1 CO₂ from electricity for pumps and fans (kg/year)			194.1533655							
Total electricity for lighting (kWh/year) (SAP Box 53)			3513.89							
SAP 2012 CO₂ from electricity for lighting (kg/year) (SAP Box 109)			1823.71							
SAP 10.1 CO₂ from electricity for lighting (kg/year)			477.89							
Energy saving/generation technologies (kWh/year)			4502							
Total Energy demand from development (kWh/year)			26831.18							
SAP 2012 CO₂ saving/generation technologies (kg/year)			2336.538							
SAP 2012 Total CO₂ emissions from development (kg/year)			13925.38							
SAP 10.1 CO₂ saving/generation technologies (kg/year)			1048.966							
SAP 10.1 Total CO₂ emissions from development (kg/year)			4261.31							



Energy Calculation - Option 4 2-Stage Exhaust Air Heat Pump										
Dwelling Type	Sample Floor Area	Represented Floor Area	Space Heating		Hot Water		Pumps Fans		Lighting	
			Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)	Energy (kWh/year)	CO ₂ (kg/year)
Plot 4 - 1 Bed Ground Floor	39.56	173.60	584.04	303.12	630.77	327.37	83.30	43.23	191.02	99.14
Plot 5 - 2 Bed Ground Floor	61.24	122.80	764.17	396.60	750.43	389.47	69.51	36.08	302.96	157.23
Plot 9 - 1 Bed Mid Floor	39.56	118.60	367.71	190.84	630.77	327.37	90.68	47.06	191.02	99.14
Plot 10 - 2 Bed Mid Floor	61.24	122.80	481.25	249.77	750.43	389.47	78.74	40.87	302.96	157.23
Plot 12 - 2 Bed Top Floor	72.99	75.00	834.32	433.01	808.16	419.43	62.61	32.49	347.57	180.39
Plot 13 - 2 Bed Top Floor	61.24	107.30	594.50	308.55	750.43	389.47	73.90	38.36	302.96	157.23
Total Floor Area (m₂) (SAP Box 5)	335.83	720.10								
Space Heating Fuel			Grid Electricity							
Total space heating (kWh/year) (SAP Box 85)			8061.57							
SAP 2012 CO₂ from space heating (kg/year) (SAP Box 101)			4183.95							
SAP 10.1 CO₂ from space heating (kg/year)			1096.37							
Water Heater Fuel			Grid Electricity							
Total hot water (kWh/year) (SAP Box 86a)			9813.83							
SAP 2012 CO₂ from hot water (kg/year) (SAP Box 103)			5093.38							
SAP 10.1 CO₂ from hot water (kg/year)			1334.68							
Total electricity for pumps and fans (kWh/year) (SAP Box 87)			1128.50							
SAP 2012 CO₂ from electricity for pumps and fans (kg/year) (SAP Box 108)			585.69							
SAP 10.1 CO₂ from electricity for pumps and fans (kg/year)			153.4754575							
Total electricity for lighting (kWh/year) (SAP Box 53)			3513.89							
SAP 2012 CO₂ from electricity for lighting (kg/year) (SAP Box 109)			1823.71							
SAP 10.1 CO₂ from electricity for lighting (kg/year)			477.89							
Energy saving/generation technologies (kWh/year)			0							
Total Energy demand from development (kWh/year)			22517.79							
SAP 2012 CO₂ saving/generation technologies (kg/year)			0							
SAP 2012 Total CO₂ emissions from development (kg/year)			11686.73							
SAP 10.1 CO₂ saving/generation technologies (kg/year)			0							
SAP 10.1 Total CO₂ emissions from development (kg/year)			3062.42							



Appendix B – Calculation of Indicative Zero Carbon Contribution

The below table calculates the excess CO₂ emissions annually and details the indicative S106 contribution which would be due for each of the presented energy strategy options calculated in accordance with the methodology stated within Reading Borough Councils Sustainable Design and Construction SPD.

Figures are indicative only, and performance will be re-assessed at as-built stage through the submission of as built SAP calculations to account for the performance gap between a building as designed and as occupied.

	Option 1 - Gas Combi + PV	Option 2 - ASHP	Option 3 - Panel + EDEL + PV	Option 4 - NILAN
TER as defined in the Building Regulations 2013 (fuel factor = 1.0)	14834.85			
TER as defined in the Building Regulations 2013 (fuel factor = 1.55)		21687.48	21687.48	21687.48
Sitewide total excess CO ₂ emissions annually (kg.CO ₂ /year)	9542.07	13298.00	13925.38	11686.73
Sitewide total excess CO ₂ emissions annually (tonnes CO ₂ /year)	9.54	13.30	13.93	11.69
Annual excess CO ₂ emissions x £1800 = S106 contribution	£17,175.72	£23,936.39	£25,065.69	£21,036.12



Appendix C – Dimplex Edel – Heat Pump Water Heater



Appendix D – Nilan Compact P



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