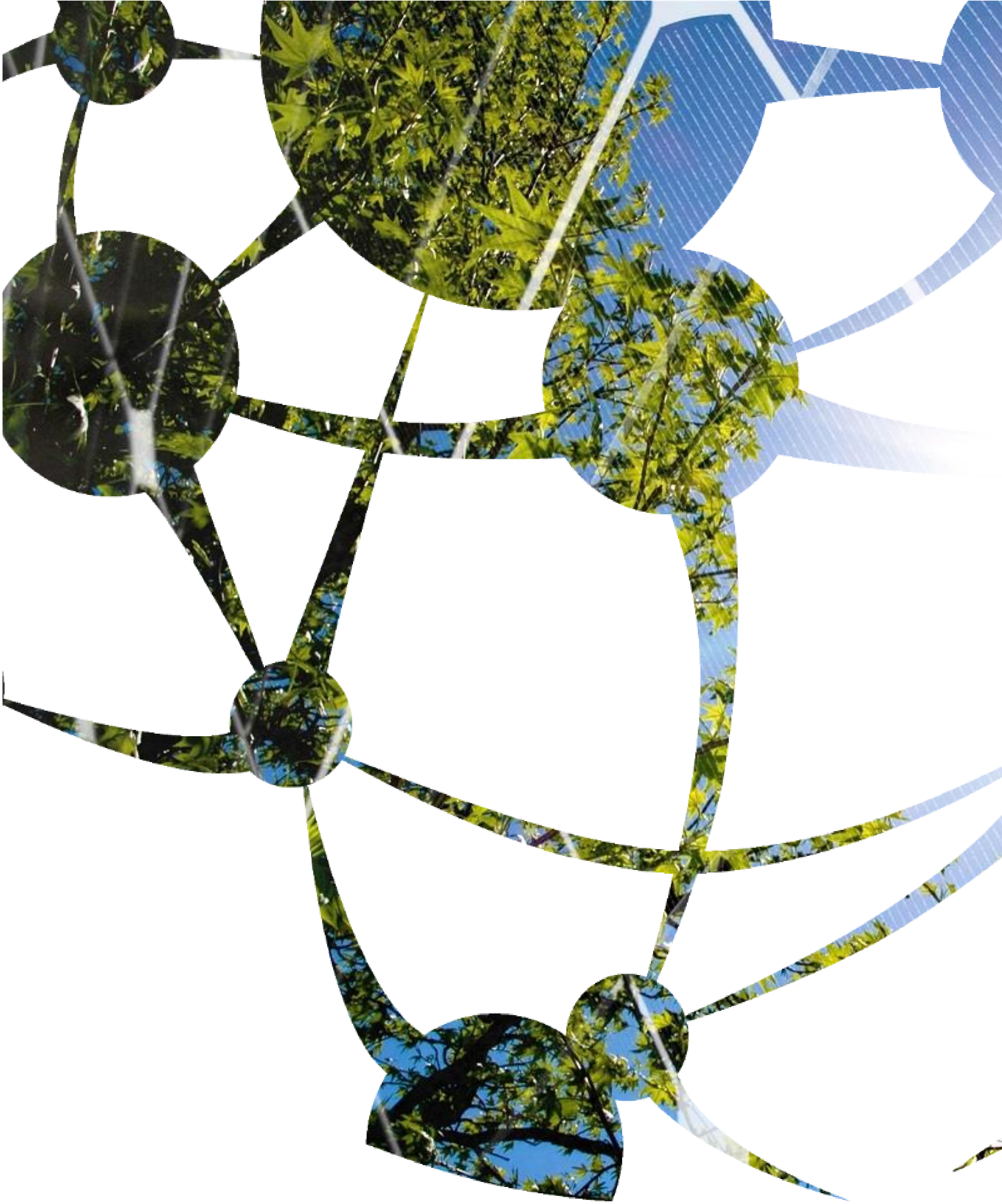

510121.000 EGLEY ROAD, WOKING
ENERGY STRATEGY REPORT
NOVEMBER 2019

elementa
Member of Integral Group

TABLE OF CONTENTS

DOCUMENT CONTROL

Issue	Description	Date	Prepared By	Signed Off
01	Draft	13-09-2019	MT	NM
02	For comments	27-09-2019	MT	RH
03	Final issue	25-11-2019	MT	AS

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1 EXECUTIVE SUMMARY

Elementa Consulting have been appointed to prepare the Energy Strategy in support of the Planning Application for the Egley Road, Woking development. The project includes the delivery of 36 new houses together with David Lloyd Health Club (a separate energy strategy is appended to this report for information).

The targets for the residential section of the development are to:

- Meet the requirements of Part L1A of the Building Regulations
- Satisfy local planning policy requirements stipulated by Woking Borough Council and in particular:
  - Achieve a minimum of 19% carbon emissions reduction against minimum building regulation compliance

The following energy hierarchy was adopted to help guide decisions about which energy measures are appropriate, and in order to optimise design solutions to maximise carbon reductions:

Be Lean: using less energy and utilising passive sustainable design measures
Be Clean: using Combined Heat and Power (CHP) system and district heating networks
Be Green: using renewable energy where possible, to further reduce carbon emissions

The measures listed in this report will ensure the residential section of the proposed development:

- Complies with part L1A approved documents of Building Regulations
- Achieves an overall 39.8% carbon emissions reduction against the building regulation minimum requirements

The updated SAP 10 carbon emission factors have been used as part of the energy calculations: 0.233 $kgCO_2/kWh$ for electricity and 0.210 $kgCO_2/kWh$ for mains gas. Further details on the reason of this choice are provided in *Section 1.2* of this report.

1.1 SUMMARY OF SYSTEMS INSTALLED

Space Heating and Domestic Hot Water will be provided through Air Source Heat Pumps with a capacity of either 11kW or 14kW per dwelling.

During the next stages of the design evolution, further improvements to the residential systems will be investigated to provide further carbon emissions reductions.

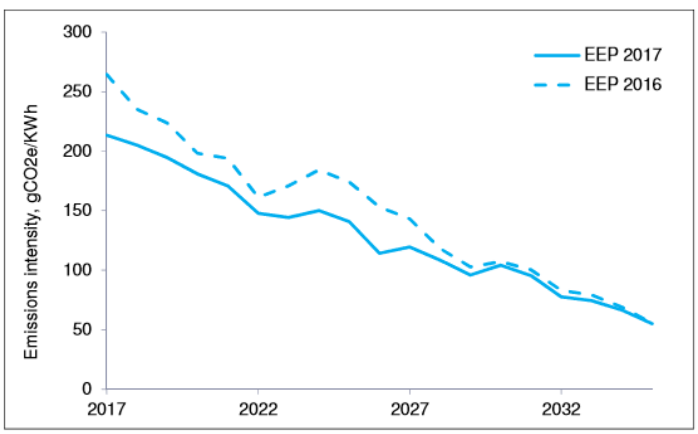
1.2 SAP 10 CARBON EMISSION FACTORS

Calculations for Part L of Building Regulation require the use of certain carbon factors, as outlined below. The latest best practice and guidance on preparing energy assessments, has recommended that SAP 10 carbon factors be used in these calculations. Although these are not yet reflected in regulatory and planning policy in Woking, Elementa Consulting believes that decision making should be based on SAP 10 carbon factors rather than historic and outdated carbon factors.

Table 1: Carbon Factor

Carbon Factor	Gas (kg CO2/kWh)	Electricity (kg CO2/kWh)
Current Part L of Bulding Regulations	0.216	0.519
SAP 10	0.210	0.233

The carbon emissions of the electricity grid are projected to continue to decrease over the next 20 years, as illustrated in the figure below.



Source: BEIS (2018)[1]

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/671187/Updated_energy_and_emissions_projections_2017.pdf

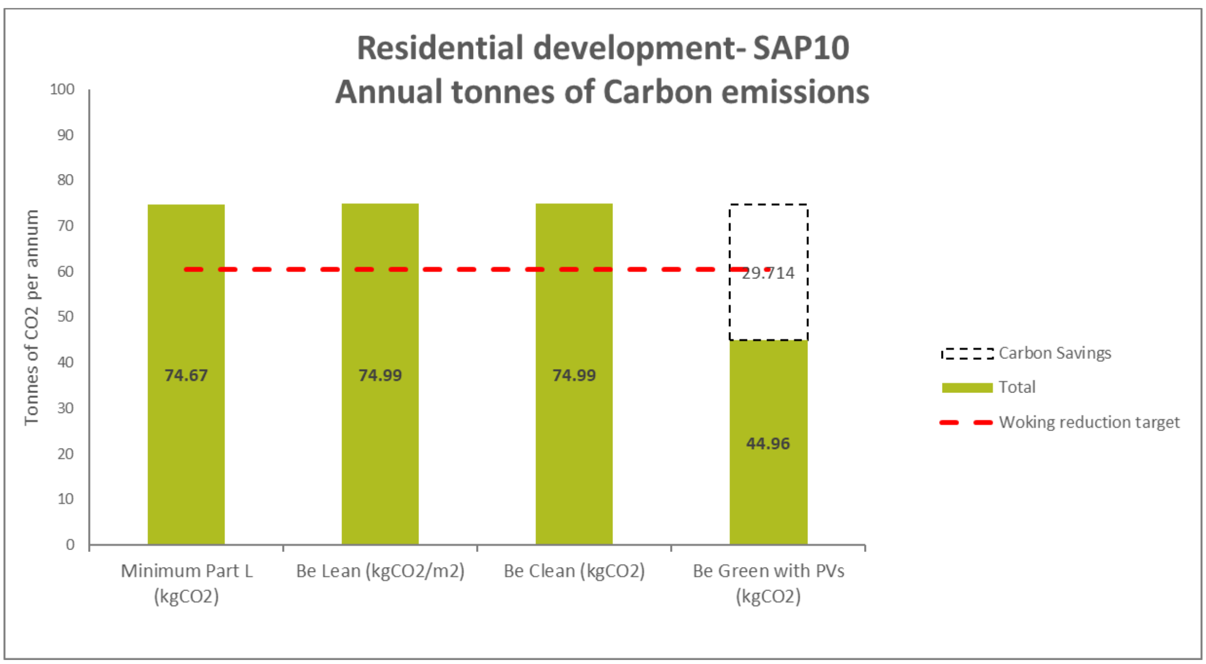
1.3 PROPOSED DEVELOPMENT RESULTS

The following table and graph summarise the carbon emissions calculations for site-wide development.

Table 2: Carbon Dioxide emissions and carbon saving after each stage of the Energy Hierarchy for residential development

Site-wide SAP10 carbon emissions (Tonnes CO_2 per annum)		
	Regulated	Unregulated
Part L 2013 of the Building Regulations compliant development	74.67	N/A
After energy efficient measures	74.99	N/A
After CHP and district heating	74.99	N/A
After renewable energy	44.96	N/A
Regulated carbon dioxide savings		
	Tonnes CO_2 per annum	% Improvement
Saving through passive design and energy efficient measures	-0.3	-0.4%
Savings through use of district heating schemes or CHP	0.0	0.0%
Savings through use of renewable energy	30.0	40.2%
Total cumulative savings	29.7	39.8%
Total target savings	14.19	

Figure 1: Residential development l Energy Hierarchy



2 INTRODUCTION

2.1 PLANNING SUBMISSION DESCRIPTION

Elementa Consulting has been appointed by Goldev Ltd to prepare the Energy Strategy report in support of the planning submission for Egley Road, Woking development. The project includes the delivery of 36 new houses and David Lloyd Health Club.

The Application Site is to the south of Woking town centre. It is bounded by Hoe Valley School to the north, an existing garden centre to the east, existing residences with extensive gardens to the south, and the railway line to the west.

2.2 ENERGY STRATEGY DEVELOPMENT

In line with the Energy Hierarchy outlined within the Woking Core Strategy, the effects of passive design and energy efficiency measures were first analysed (such as low construction u-values and high air-tightness, the use of energy efficient services, etc.) to understand their effect on the development's annual energy consumption and carbon emissions, to ensure that the development has an energy efficient baseline. A summary of these measures is provided within Section 3 of this report.

The next stage of the process was to consider the development's suitability to connect to existing district heat and electricity networks, and to look at the viability of utilising a combined heat and power (CHP) installation. A summary of these assessment is provided within *Section 4* of this report.

The final stage of the analysis was to select viable Low Zero Carbon Technology Options in order to meet the project's carbon reductions targets. A summary of this assessment is provided within *Section 5* of this report.

This report is based on the drawings plan produced by LRW Architects dated 30-07-2019.

2.3 PROJECT AND SITE DESCRIPTION

The development Design offers the potential to provide new high-quality family homes with private gardens along the residential boundary, create homes with largely southerly private amenity spaces, provide high quality public realm, provide residential units of all sizes and provide a private leisure facility to improve public amenities.

Figure 2: Proposed layout (from Design and Access Statements)

Figure 3: Aerial view (from Design and Access Statements)

2.4 PLANNING CONTEXT

2.4.1 Woking Core Strategy – Woking Borough Council (2012) + Climate Change Supplement Planning Document – Woking Borough Council (2013)

The following Core Strategies policies have been found to be relevant to the energy strategy and has been considered here for the development:

CS22 Sustainable Construction

- New residential developments required to achieve Code for Sustainable Homes level 5 requirements *(following the Housing Standard Review this requirement has been revised. See paragraph 2.4.2)*
    - New non-residential development of 1,000 sqm or more is required to comply with BREEAM very good standards
- CS23 Renewable and Low Carbon Energy Generation
    - All schemes should implement the energy hierarchy including passive fabric based measures, energy efficiency measures and decentralised energy and renewable power
    - The Council particularly encourages applications of community-based/owned projects
    - Applicants should take appropriate steps to mitigate any adverse impact of proposed development through careful consideration of location, scale design, and other measures

2.4.2 Guidance note for the implementation of policies in the Core Strategy following the Housing Standard Review (2016)

This note explains how certain parts of Core Strategy will be applied in light of the Government's Housing Standard Review and the introduction of 'new national technical standard'.

- Policy CS22
    - All new residential development will be required to achieve not less than a 19% improvement in the Dwelling Emission Rate (DER) over the Target Emission Rate (TER) as defined in Part L1A of the 2013 Building Regulation
    - Non-residential development must still comply with BREEAM standards in the policy

3 ENERGY EFFICIENT BUILDING

The first stage in reducing CO_2 emissions from the development is to reduce the energy required to service the building, through the implementation of passive design and active design measures.

To ensure that the development is inherently low in energy use, passive design measures were the initial point of focus.

- Efficient fabric to reduce heating and cooling demand, see *Table 3* for further information
- Appropriate glazing ratios to reduce solar gain during summer periods, limiting the risk of overheating in summer and reduce heat loss in winter
- Enhanced fabric airtightness that reduces infiltration heat losses

Active design measures included in the proposed development are outlined below; see *Tables 4-7* for further details.

- Providing energy efficient heating, cooling and mechanical ventilation plant
- Providing energy efficient lighting
- Providing adequate control of building services systems and lighting systems
- Providing training to building users to enable them to utilise the building efficiently

The following tables indicate how this development will reduce the baseline energy consumption required, through the implementation of passive design and energy efficient measures (i.e. Be Lean):

Table 3: Architectural 'Passive Design' Parameters for the development

Element	Average values proposed for residential
Wall U-Value (W/m^2.K)	0.13
Ground Floor U-Value (W/m^2.K)	0.13
Roof U-Value (W/m^2.K)	0.13
External Door U-Value (W/m^2.K)	1.6
External glazed Door U-Value (W/m^2.K)	1.6
External glazed Door G-Value	0.4
Natural ventilation louver U-value (W/m^2.K)	1.4
Window U-Value (W/m^2.K)	1.4

Glazing G-Value	0.4
Building Air Permeability ($m^3/h.m^2$)	3

Table 4: Mechanical Services 'Energy Efficient' Measures

Element	Description
Natural Ventilation	Natural ventilation option will be provided wherever feasible for resiliency
Mechanical Ventilation	For the residential development, mechanical ventilation with enhanced heat recovery will serve all dwellings. Duct sizes will be selected to reduce specific fan power and energy demand.
Mechanical Cooling	No mechanical cooling will be provided for the residential development.
Pumps and Motors	Variable speed, variable frequency, variable voltage drives to be provided on all pumps and motors to reduce energy consumption to minimum on variable flow systems.
Metering and Sub-Metering	Use of water and energy metering and direct sub-metering, together with automatic controls to identify area of unusual energy use and optimum operating times and durations. Use of a smart meter. Out of range monitoring and alarms to be provided via automatic control system.

Table 5: Mechanical Services 'Energy Efficient' Plant Design Parameters for non-residential development

Element	Typical Value Proposed for residential
Heat Generator Seasonal Efficiency: Gas boiler	89.5%* (Be Lean) 92%
Heat Exchanger Efficiency	As per selected MVHR unit
AHU Combined Specific fan power	As per selected MVHR unit

*So that improvements from energy efficiency alone can be understood as stipulated by the GLA guidance on preparing energy assessments the 'be lean' case assumes that heating is provided by gas boilers with an efficiency of 89.5% for residential development.

Other ‘Energy Efficient’ Design Measures:

In addition to the above energy efficient measures, a comprehensive commissioning programme shall be carried out, and full user training provided to ensure the building users understand how to utilise the building in an energy efficient manner, in accordance with the design intent.

3.1 ENERGY EFFICIENT BUILDING RESULTS

The following tables summarise the percentage improvement from the Part L 2013 compliant development. Detailed calculations have been carried out for the non-residential and residential section of the development.

In following best practice methodology, Elementa Consulting have used the Energy Strategy Calculation spreadsheet, released by the Greater London Authority in October 2018, to calculate carbon emissions with the new representative carbon factors.

Table 9: **Residential I** CO_2 emission reductions due to energy demand reduction measures (Be Lean)

Residential carbon dioxide emissions (Tonnes CO_2 per annum)		
	Regulated	Unregulated
Part L 2013 of the Building Regulations compliant development	74.67	N/A
After energy efficiency measures	74.99	
Regulated carbon dioxide savings		
	Tonnes CO_2 per annum	%
Savings from energy efficiency measures	-0.3	-0.4%

*Calculation Methodology from SAP Section 16

Disclaimer: The results are simulations of energy consumption and do not determine the consumption, emissions or costs of the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this standard, changes in carbon intensity of the electricity grid and precision of the calculation tool.

3.2 POTENTIAL FABRIC IMPROVEMENTS

The following actions should be considered at the next stage of design to improve the efficiency of the fabric envelope and related energy performance:

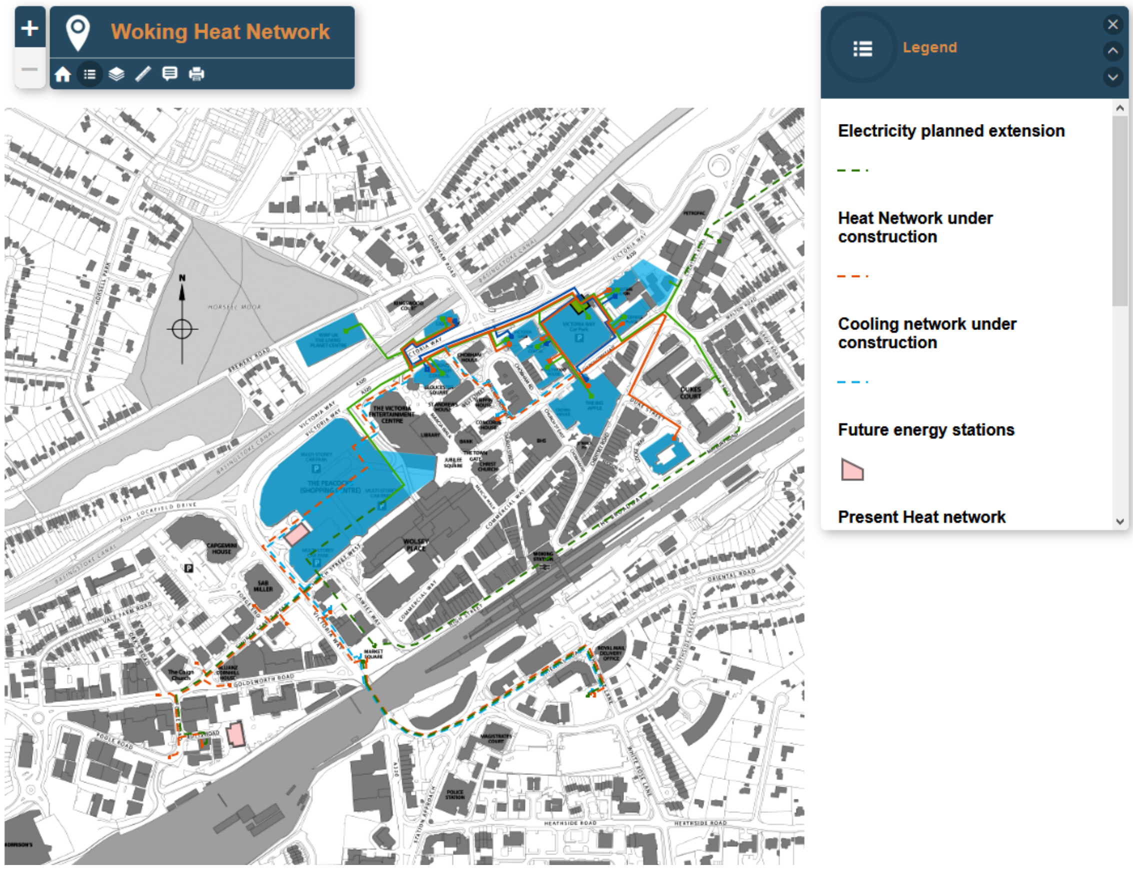
- Air pressure testing for all dwellings
- Consider reducing air infiltration rates through more air tight details
- Reduce construction u-values further
- Minimise heat losses related to thermal bridging, reducing dwelling thermal bridging (e.g. reducing global y-value from 0.1 to 0.07 or lower)

4 DISTRICT HEATING & CHP

4.1 DISTRICT HEATING NETWORKS

The proximity of existing, planned or potential District Heating networks has been investigated and no networks are available in the area to connect to and derive heat. .

A district heating network is currently active within Woking City Centre, but is around 1,000m from the proposed development. Due to the distance a connection to this network is not technically or financially viable as connecting to a network at such distance would be cost prohibitive.



4.2 COMBINED HEAT AND POWER (CHP)

The CHP would produce heat with a lower thermal efficiency and higher actual carbon footprint, when compared to an ASHP and its carbon emissions offset, due to electricity production will decrease while the national grid decarbonises, therefore its related carbon emissions will constantly increase.

In addition, a CHP unit will have a detrimental impact on the neighbourhood's environment worsening the air quality of the area. Therefore, the option to use CHP unit to produce heat and power has been excluded for the residential part of the development.

5 RENAWABLE ENERGY

5.1 OVERVIEW

Low and Zero Carbon (LZC) technologies that could be used for this development were evaluated.

5.2 PHOTOVOLTAICS

The feasibility of Photovoltaics (PV's) has been assessed. PV panels could potentially be installed on the roof area of the buildings.

Photovoltaics will be considered to further reduce carbon emissions of the development at the next stage of the design as the required carbon emissions saving will be achievable through ASHP technologies alone.

5.3 SOLAR THERMAL

Solar thermal technologies generate hot water from the sun's energy through the use of solar collectors. The sun's heat energy is accumulated by the solar cells and then water is pumped through these thus heating the water. The heated water is then stored or distributed for domestic use. These systems tend to be incorporated on to roof space so that they are clear of obstacles (obstructions on the roof can influence the solar array). Demand for domestic hot water from the non-domestic part will be minimal on the weekends, whereas there is a consistent demand for electricity.

Solar thermal will be considered to further reduce carbon emissions of the development at the next stage of the design as the required carbon emissions saving will be achievable through ASHP technologies alone.

5.4 GROUND SOURCE HEAT PUMP (GSHP)

Heat pumps use electricity to raise the temperature of water from a heat source, such as the ground, to a suitable level. Ground source heat pumps extract heat from the heat source via plastic piping (ground loops) containing a mixture of water and antifreeze, which is connected to a pump. Ground loops absorb low-grade heat from the heat source, which is delivered to the heat pump. Ground loops can either be horizontal pipes in trenches usually approximately 1.8m below ground (a slinky solution), or a series of boreholes, typically 100m to 150m deep. GSHP is not viable due to program and capacity issues.

GSHP will be considered to further reduce carbon emissions of the development at the next stage of the design as the required carbon emissions saving will be achievable through ASHP technologies alone.

5.5 AIR SOURCE HEAT PUMP

An air source heat pump (ASHP) works in a similar manner to a ground source heat pump, except the heat source is ambient air rather than the ground. In lieu of ground loops are fan-assisted heat exchangers, located in locations with a free air supply. Air is driven across the heat exchangers, and heat energy extracted. Like GSHPs, ASHPs can be reversed to provide cooling during summer operation.

ASHP technology is recommended and has been proposed for this site.

5.6 BIOMASS HEATING SYSTEM

Biomass is the burning of any plant-derived organic material (such as wood) that renews itself over a short period to generate energy. This fuel type is usually used for heating. Since the CO_2 released during the burning process is offset by the CO_2 absorbed during the life of the biomass source, biomass is considered to be close to carbon neutral.
Typically, a biomass system will burn wood in either a chip or pellet form instead of the conventional gas system. Biomass can save large amounts of carbon at a relatively low capital cost.

The combustion of biomass will lead to a degradation of air quality, not appropriate to the location of the development. Furthermore, the delivery and storage of fuel may cause significant issues of access and storage on a constrained site, therefore biomass is deemed not feasible.

5.7 WIND TURBINES

Wind turbines convert the kinetic energy of the wind into rotational mechanical energy using an aerodynamic rotor. This is then converted into electrical energy via a generator. There are two types of wind turbine available, smaller units which are roof mounted or fixed to the building, and larger free-standing turbines.

Due to the urban nature of the site, wind speeds are relatively low, and the wind is turbulent reducing the efficiency of the turbines. Therefore, it is deemed that wind turbines are not suitable for this development.

5.8 LZC CONCLUSIONS

The results of the Low and Zero Carbon (LZC) technologies analysis show PV is the most appropriate low and zero carbon technology that can help targeting the development's carbon reduction targets.

Table 10: LZC Technology Feasibility

LZC Technology	Technically Feasible	Recommended	Notes
Hydrogen Technology	No	No	Technology not yet economically viable
Tri-Generation	No	No	Structural limitations, height issues
CHP	Yes	No	No carbon savings due to decarbonisation of UK electricity Grid
ASHP	Yes	Yes	Recommended for this site
PV	Yes	No	To be considered to further reduce carbon emissions of the development. However, the required carbon emissions savings will be achieved through ASHP technologies
GSHP	Yes	No	To be considered to further reduce carbon emissions of the development. However, the required carbon emissions savings will be achieved through ASHP technologies
Wind Power	No	No	Not viable due to the urban nature of the development.
Solar thermal	Yes	No	To be considered to further reduce carbon emissions of the development. However, the required carbon emissions savings will be achieved through ASHP technologies
Biomass	No	No	Biomass heating will negatively impact air quality

5.9 RENEWABLE ENERGY RESULTS

The following carbon emission figures for the chosen combination of the LZC Technologies have been derived:

Table 11: Residential development carbon dioxide emission reductions due to energy efficiency measures and renewables

Non-residential carbon dioxide emissions (Tonnes CO_2 per annum)		
	Regulated	Unregulated
Part L 2013 of the Building Regulations compliant development	74.67	N/A
After energy efficiency measures	74.99	
After renewable energy	44.96	
Regulated carbon dioxide savings		
	Tonnes CO_2 per annum	% Improvement
Savings from energy efficiency measures	-0.3	-0.4%
Savings from renewable energy	30.0	40.2%
Cumulative savings	29.7	39.8%

Domestic

Space Heating and Domestic Hot Water will be provided through Air Source Heat Pumps with a capacity of either 11kW or 14kW per dwelling.

Further improvements to the system will be investigated to minimise carbon emissions at next stage of design.

The results documented above demonstrate that through the implementation of passive design, energy efficiency measures, and through the provision of heating through ASHP the CO_2 reductions will enable the development to:

- Comply with Part L1A approved documents of Building Regulations
- Achieve a 39.8% carbon emissions reduction for the residential section of the development

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6 CONCLUSIONS

The measures listed in this report will ensure the proposed development to:

- Comply with part L1A approved documents of Building Regulations
- Achieving an overall 39.8% carbon emissions reduction against the building regulation minimum requirements

7 APPENDICES

7.1 APPENDIX A – THERMAL MODELLING METHODOLOGY

INTRODUCTION

SAP modelling of typical dwelling units – chosen among the most representative of the whole residential development - was carried out using JPA Designer 6.04a1 Build 026 approved software.

For information, please find details relating to the accredited energy assessor and the dynamic simulation software utilised to generate this report:

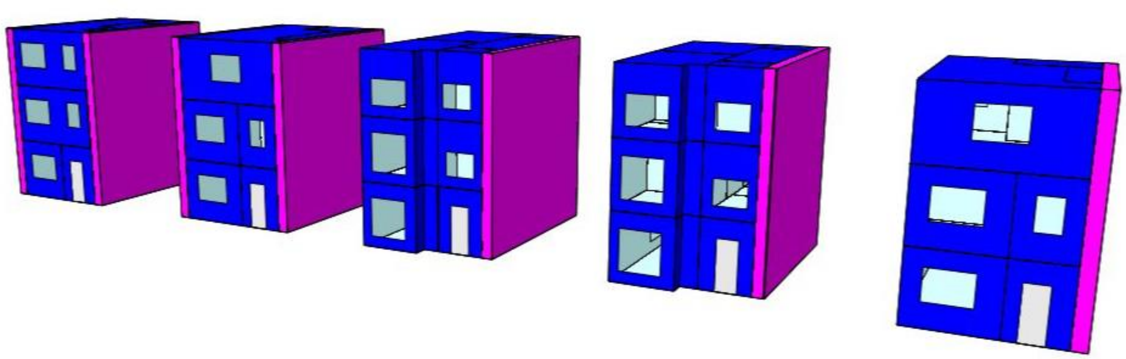
Dynamic Simulation Software	-	IES Version 2019.0.1.0
Energy Assessor	-	Adeel Ahmed of Elementa Consulting Ltd.
Energy Assessors Accreditation Body	-	CIBSE
Energy Assessors Accreditation Number	-	LCEA125791
Energy Assessor Status	-	Level 3, Level 4 and Level 5 EPC and DEC
Energy Assessor Qualifications	-	BEng, MSc, CIBSE Low Carbon Consultant

METHODOLOGY

IES Virtual Environment software, provided by Integrated Environmental Solutions (IES) version 2019.0.1.0 has been used to create the geometry of the dwellings. And then JPA Designer 6.04a1 Build 026 approved software has been used to demonstrate compliance with Part L1A of building regulation.

Figure 4: Modelling of dwellings within IESVE

Residential modelled typologies (exported into JPA Designer software for SAP calculations)



FABRIC ENVELOPE

JPA Designer software requires other building data to be input, which includes:

- Air permeability. This relates to how well sealed the building is and is expressed in m3/m2/hour@50Pa
- Constructions U-values W/m²K

SYSTEM DESCRIPTION

- The user then specifies building specific data for the systems such as:
- Extent of servicing (heating only, heating with mechanical ventilation, etc.)
- The system efficiencies associated with the anticipated installations of heating, cooling and domestic hot water
- Controls for heating, cooling and domestic hot water
- Specific fan power and heat recovery efficiency of mechanical ventilation where appropriate

ACTUAL AND REFERENCE BUILDING MODELS

The user inputs all the above information into the model to produce the "actual" building model. From this, JPA creates the notional/target building model which will be used to benchmark the actual building against. The dwelling emission rate (DER) from the actual building must be lower than that of the target emission rate (TER) from the notional/target building, in order to satisfy Part L1A of the Building Regulations.

7.2 APPENDIX B - LZC TECHNOLOGIES OVERVIEW

Appendix C provides an overview of the various low and zero carbon technologies that are currently available.

GROUND SOURCE HEAT PUMPS (GSHP)

Heat pumps use electricity to raise the temperature of water from a heat source, such as the ground, to a suitable level. Ground source heat pumps extract heat from the heat source via plastic piping (ground loops) containing a mixture of water and antifreeze, which is connected to a pump. Ground loops absorb low-grade heat from the heat source, which is delivered to the heat pump. Ground loops can either be horizontal pipes in trenches usually approximately 1.8m below ground (a slinky solution), or a series of boreholes, typically 100m to 150m deep. In both cases, the exact ground loop design depends on the soil/geological conditions and required plant duty.

This heat can then be utilised to heat the building. A heat pump operates more efficiently with a higher heat source temperature. The ground is typically 10°C at 1 metre below the surface throughout the year, and so during the heating season acts as a better source of heat than air, where the heat source temperature in winter can drop to/below freezing.

The heating cycle can be reversed in summer to provide cooling via a low grade heat sink. Using GSHP's in this way is generally recommended in order to replenish the grounds heat store

GSHP systems can provide heat or coolth to either a wet secondary side (e.g. LTHW heating or chilled water circuit), or to a refrigerant based secondary side (i.e. a refrigerant-based VRF system, serving fan coil units).

For a GSHP serving an LTHW heating system, it is best utilised in conjunction with underfloor heating (UFH) coils, due to the relatively low temperatures that UFH systems operate at, therefore improving system efficiency.

The extraction of heat from the heat source requires electrical energy to drive the compressor and pumps of the GSHP equipment. The ratio of electrical energy supplied to the heat energy delivered is known as the Coefficient of Performance (COP). The seasonal COP of a GSHP system is dependent on a number of factors but is generally in the region of 4.5.

A GSHP system can be designed to supply space heating only, or it can be designed to supply the space heating and to generate domestic hot water.

In the case of the domestic hot water generation, a GSHP system will only be able to provide a pre-heat to a conventional gas boiler system. The COP of the GSHP drops below an acceptable level if temperatures of over 45ºC are required, thus it can heat the hot water to 45ºC but above this temperature it is more efficient to utilise gas.

GSHP systems need to be sized carefully to work within the constraints of the site.

GSHP systems represent an unobtrusive technology, with no active external plant required. It should be noted that there is little noise associated with GSHP's systems, with the only source being from the heat pumps compressor, which can be minimised by taking appropriate attenuation measures (i.e. locating the plant within an indoor plantroom, on anti-vibration mountings).

GSHP installations are classified as a qualifying technology under the RHI scheme, which is a potential source of funding.

AIR SOURCE HEAT PUMPS (ASHP)

An air source heat pump works in a similar manner to a ground source heat pump, except the heat source is ambient air rather than the ground. In lieu of ground loops are fan-assisted heat exchangers, located in locations with a free air supply. Air is driven across the heat exchangers, and heat energy extracted. Like GSHP's, ASHP's can be reversed to provide cooling during summer operation.

ASHP have a significant advantage over GSHP in that no ground loop is required. This leads to reduced capital costs and the "peace of mind" that no equipment is buried. It also removes the risk of unknown ground conditions at the time of design and installation. However, the performance of GSHP's is now well understood, whereas the performance of ASHP, particularly for large installations, is less certain.

The coefficient of performance (COP) of GSHP and ASHP systems is critical to the success of the installation. The COP is reduced as the difference between external temperature and delivered heat temperature increases. Therefore, during the coldest parts of the year, the efficiency of the ASHP will drop as air temperature falls.

In comparison, the COP of a GSHP will only fall slightly because the ground temperature remains more or less constant. In addition to this, the external heat exchangers will, during winter, frequently reduce the air temperature to sub-zero. This causes condensation in the air stream which freezes on to the heat exchanger; unless this is removed the system will cease to operate.

The solution to this is to pass heat back into the heat exchanger. This use of energy further reduces the ASHP COP. The extent of the effect of this problem will differ from situation to situation; the commonly quoted COP figure provided by manufacturers of ASHP equipment is generally approximately 3.5. However, with the provision of high efficiency plant, higher COP's are achievable.

The compressor/s and fan/s located within the external unit/s of an ASHP system generate some noise, so the location of the external plant compound therefore needs to be carefully considered during the early design stages, to ensure that the noise emitted does not create any issues. If necessary, attenuation measures can be applied to the external units, to ensure noise levels are kept at an acceptable level.

ASHP installations do not currently qualify for potential funding under the RHI. However, 'Enhanced Capital Allowances' can be claimed for air to air (e.g. variable refrigerant flow systems) and air to water systems. In order to qualify for ECA's, the ASHP plant needs to be present on the 'Energy Technology List'. This will enable the Client to claim 100% of first year capital gain allowances on their spending on qualifying plant and/or machinery.

WIND TURBINES

Wind turbines convert the kinetic energy of the wind into rotational mechanical energy using an aerodynamic rotor. This is then converted into electrical energy via a generator. The UK is the windiest country in Europe, and therefore wind power is one of the UK's most promising technologies.

There are two types of wind turbine available, smaller units which are roof mounted or fixed to the building, and larger free standing turbines.

The roof mounted units are limited in size due to wind induced stresses which are transmitted to the building structure. Most roof mounted turbines currently on the market are approximately 2m diameter and are capable of producing 1-1.5kW each, and produce significant levels of noise locally. However, electrical output is dependent on the surrounding obstructions and local wind speed (wind turbines work best with laminar wind flows). In developed urban areas, outputs can be greatly reduced. Small scale wind turbines would not make any meaningful impact on a site such as this.

Large free standing turbines are capable of producing hundreds of kilowatts of electrical energy which makes them a more attractive proposition in terms of energy generation. However, there are problems with noise, obtrusiveness and shadow flicker which means that generally large wind turbines need to be located at least 300m from any residential properties.

PHOTOVOLTAIC (PV) SYSTEM

Photovoltaic cells, or solar cells as they are often referred to, are silicon semi-conductor devices that convert light energy emitted by the sun into direct current (DC) electricity.

Groups of PV cells are electrically configured into modules and arrays which form the building block of solar arrays. With the use of appropriate power conversion equipment (inverters), PV systems convert the generated DC current into alternating current (AC) compatible with conventional operating appliances, and operate in parallel with the utility grid.

PV systems require only daylight to generate electricity (although more is produced with more sunlight); therefore, energy can be produced in overcast or cloudy conditions and are successfully utilised in all parts of the UK.

Arrays would normally be formed of panels mounted on the roof, and preferable face between South-East and South-West at an elevation of 20° to 40° to horizontal for maximum efficiency.

PV's require minimal maintenance during the period of their life, normally estimated at 25 years, and carbon emissions associated with PV are considered to be zero.

From a noise perspective, PV's produce virtually no noise at all (only negligible sound from the inverter fan/s), and if roof-mounted require no additional land take.

Photovoltaics have traditionally represented a relatively expensive form of renewable technology, although installed costs have reduced significantly over the last couple of years.

SOLAR THERMAL

Solar thermal technologies generate hot water from the sun's energy through the use of solar collectors. The sun's heat energy is accumulated by the solar cells and then water is pumped through these thus heating the water. The heated water is then stored or distributed for domestic use. These systems tend to be incorporated on to roof space so that they are clear of obstacles (obstructions on the roof can have an effect on the solar cell array). As with photovoltaic panels, the solar collectors are more effective if they are in a south-facing position.

There are two main types of solar thermal system; flat panel and thermal vacuum (evacuated) tubes. Flat panels consist of a flat "radiator" absorber, covered by glass and insulated. Their efficiency depends on the insulation properties and type of construction. More expensive double-glazed units have a better efficiency, so that a smaller area of solar thermal panels is required; a compromise would need to be made between efficiency and cost. Solar thermal panels are especially worth considering for new buildings, since they can be effectively built into roof structures during the construction stage.
Thermal vacuum tubes are a more recently developed technology designed for obtaining heat from the sun. These have been developed over the last thirty years into units that are now up to 90% efficient. Water is passed through an evacuated tube, which contains a black absorber plate. Vacuum tubes are more efficient and therefore a smaller area of collector is required. Solar vacuum tubes are capable of operating at higher working temperatures than flat plate collectors. Thermal losses for vacuum tubes also tend to be lower than those of flat plate collectors due to improved heat insulation. The vacuum provides insulation, and this allows the water to be heated to higher temperatures, and remain very effective even on cloudy days.

In the UK, solar thermal is most effective during the summer months, when space heating is not normally required, hence solar thermal systems are normally utilised to provide a heating source for domestic hot water.

From a noise perspective, solar thermal systems produce virtually no noise at all (only negligible sound from the associated water circulation pump), and if roof-mounted require no additional land take.

Solar thermal installations are classified as a qualifying technology under the RHI scheme, which is a potential source of funding.

BIOFUEL

Biomass is the burning of any plant-derived organic material (such as wood) that renews itself over a short period to generate energy. This fuel type is usually used for heating.
Since the CO_2 released during the burning process is offset by the CO_2 absorbed during the life of the biomass source, biomass is considered to be close to carbon neutral.

Typically, a biomass system will burn wood in either a chip or pellet form instead of the conventional gas system. Biomass can save large amounts of carbon at a relatively low capital cost.

Non-domestic biomass boilers mainly use either wood pellet or wood chip burners. Wood pellets are comprised of wood chips and sawdust that are compacted into smaller volumes.

This means that they have lower moisture content and they can be produced in a consistent size. However, wood pellet fuel is more expensive costing around 4.5p/kWh (price varies with required load). Wood chips are a cheaper source of fuel costing around 2.5p/kWh (price varies with required load).

Biomass boilers tend to be larger and more expensive than their gas equivalents. This is due to the higher temperatures required for efficient combustion which requires a larger fire box. Fuel storage and handling is less simple than for conventional oil or gas fuels. Fuel is typically delivered by truck and is generally stored in a bunker adjacent to the boiler room, or a silo within the respective boiler room. This has implications for delivery as lorries need to be able to draw up alongside the store to deliver the fuel. If fuel delivery from a reliable source within a reasonable distance of the site can be achieved and the logistics surrounding lorry deliveries can be overcome, then this can be a viable option to serve a proportion of the heating and hot water requirements of the site.

It is worth noting that in common with other types of combustion appliances, biomass boilers are potentially a source of air pollution. Pollutants associated with biomass combustion include particulate matter (PM_{10}/$PM_{2.5}$) and nitrogen oxides (NOx) emissions. These pollution emissions can have an impact on local air quality and affect human health.

The operation of a biomass boiler and its associated ancillary plant (e.g. fuel supply system) will generate noise, which will need to be carefully considered throughout all stages of the design process. Effective management of delivery schedules will help to minimise any potential noise issues associated with fuel supply.

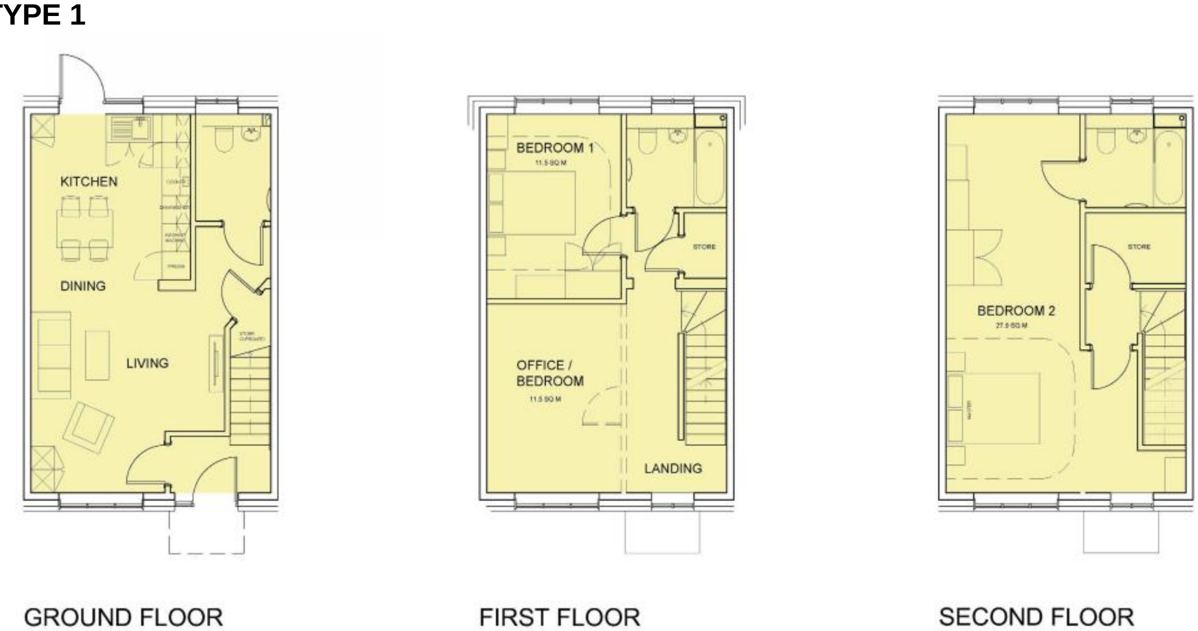
The land take of a biomass boiler will be more than that of a comparable floor-mounted boiler providing a similar thermal duty. Additional space will also be required for the associated fuel storage and fuel distribution requirements.

Biomass installations are classified as a qualifying technology under the RHI scheme, which is a potential source of funding.

7.3 APPENDIX C – SAP MODELLING METHODOLOGY

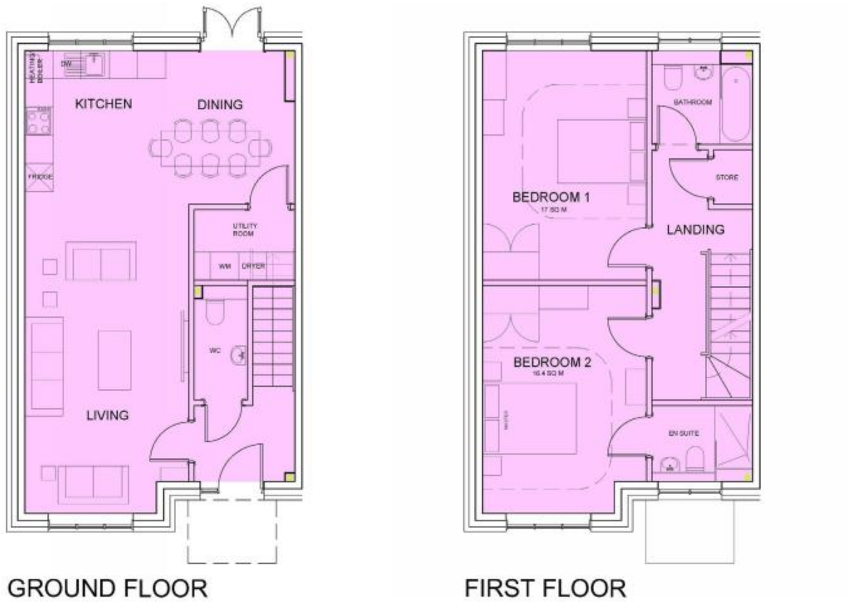
The following 3 typologies and additional variations have been modelled for a total of 36 units. A weighted average (based on area) TER and DER (for Be Lean and BE Green) has been calculated for each typology and projected for the whole development based on each typology dwellings total area within the development. The total carbon emissions have been derived based on the above methodology.

TYPE 1



TYPE 2

TYPE 3


KITCHEN
DINING
LIVING
GROUND FLOOR
BEDROOM 1
LANDING
BEDROOM 2
FIRST FLOOR
BEDROOM 3
LANDING
BEDROOM 2
SECOND FLOOR

TYPE 4


KITCHEN
DINING
LIVING
HALL
GROUND FLOOR
BEDROOM 1
BEDROOM 2
BEDROOM 3
LANDING
FIRST FLOOR
BEDROOM 4
LANDING
BEDROOM 5
SECOND FLOOR

The spreadsheet including the calculations methodology is attached below for reference:

EGLEY ROAD												
NAME	% of total	Area	Be Lean						Be Green			
			SAP 2012			SAP 10			SAP 2012		SAP 10	
			TER	DER	%	TER	DER	%	DER	%	DER	%
House Type 1	13.89%		15.69	16.99	**8.2%**	13.98	14.48	**3.6%**	17.08	**8.8%**	7.68	**-45.1%**
TYPE1_2BEDTH_SE	2.78%	124.8	15.62	16.93	8.4%	13.90	14.40	3.6%	16.98	8.7%	7.60	-45.3%
TYPE1_2BEDTH_NW	11.11%	124.8	15.71	17.00	8.2%	14.00	14.50	3.6%	17.10	8.8%	7.70	-45.0%
House Type 2	30.56%		15.17	15.95	**5.2%**	13.54	13.34	**-1.5%**	16.14	**6.4%**	7.24	**-46.5%**
TYPE2A_3BEDTH_SE	13.89%	146.6	15.10	15.91	5.4%	13.50	13.30	-1.5%	16.10	6.6%	7.20	-46.7%
TYPE2A_3BEDTH_NW	11.11%	146.6	15.28	16.02	4.8%	13.60	13.40	-1.5%	16.20	6.0%	7.30	-46.3%
TYPE2A_3BEDTH_S	5.56%	146.6	15.10	15.91	5.4%	13.50	13.30	-1.5%	16.10	6.6%	7.20	-46.7%
House Type 2B	5.56%		16.49	17.83	**8.1%**	14.96	15.06	**0.7%**	21.57	**30.8%**	7.60	**-49.2%**
TYPE2_3BEDTH_NW	5.56%	146.6	17.03	18.49	8.6%	15.40	15.90	3.2%	16.90	-0.8%	7.60	-50.6%
House Type 3	44.44%		16.43	17.75	**8.0%**	14.90	14.95	**0.3%**	22.15	**34.9%**	9.90	**-33.6%**
TYPE3_4BEDTH_SE	22.22%	163.7	16.35	17.78	8.7%	14.80	15.00	1.4%	22.20	35.8%	9.90	-33.1%
TYPE3_4BEDTH_NW	22.22%	163.7	16.50	17.71	7.3%	15.00	14.90	-0.7%	22.10	33.9%	9.90	-34.0%
House Type 4	5.56%		16.14	17.67	**9.5%**	14.70	15.20	**3.4%**	21.50	**33.2%**	9.70	**-34.0%**
TYPE4_5BEDTH_S	5.56%	163.7	16.14	17.67	9.5%	14.70	15.20	3.4%	21.50	33.2%	9.70	-34.0%

SAP 2012			
Total Target Emissions (kgC02)	Total CO2 Emission Be Lean (kgC02)	Total CO2 Emission excluding PV (kgC02)	% reduction
82876.94	88940.97256	101678.40	22.69%
SAP 10			
Total Target Emissions (kgC02)	Total CO2 Emission Be Lean (kgC02)	Total CO2 Emission excluding PV (kgC02)	% reduction
74661.68	74994.14611	44955.05	-39.8%

7.4 APPENDIX D – SUPPORTING SAP OUTPUT DOCUMENTS

Appended to this report the following output documents:

- x9 SAP output documents for residential development (Be Lean)
- x9 SAP output documents for residential development (Be Green)

7.5 APPENDIX E – DAVID LLOYD HEALTH CENTER ENERGY STRATEGY

The David Lloyd Health Center Energy Strategy is appended to this report for information. This has been prepared by others.

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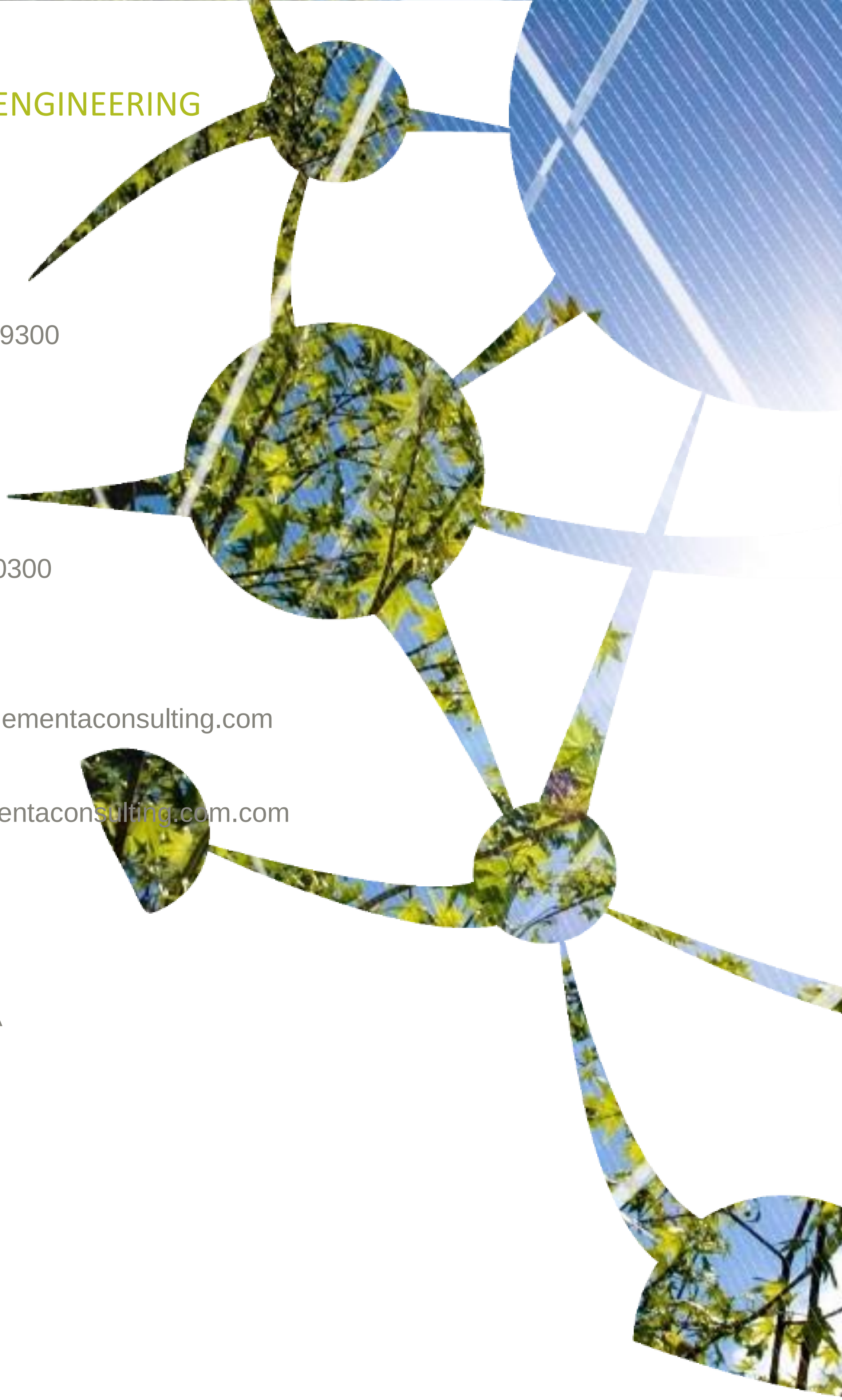

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