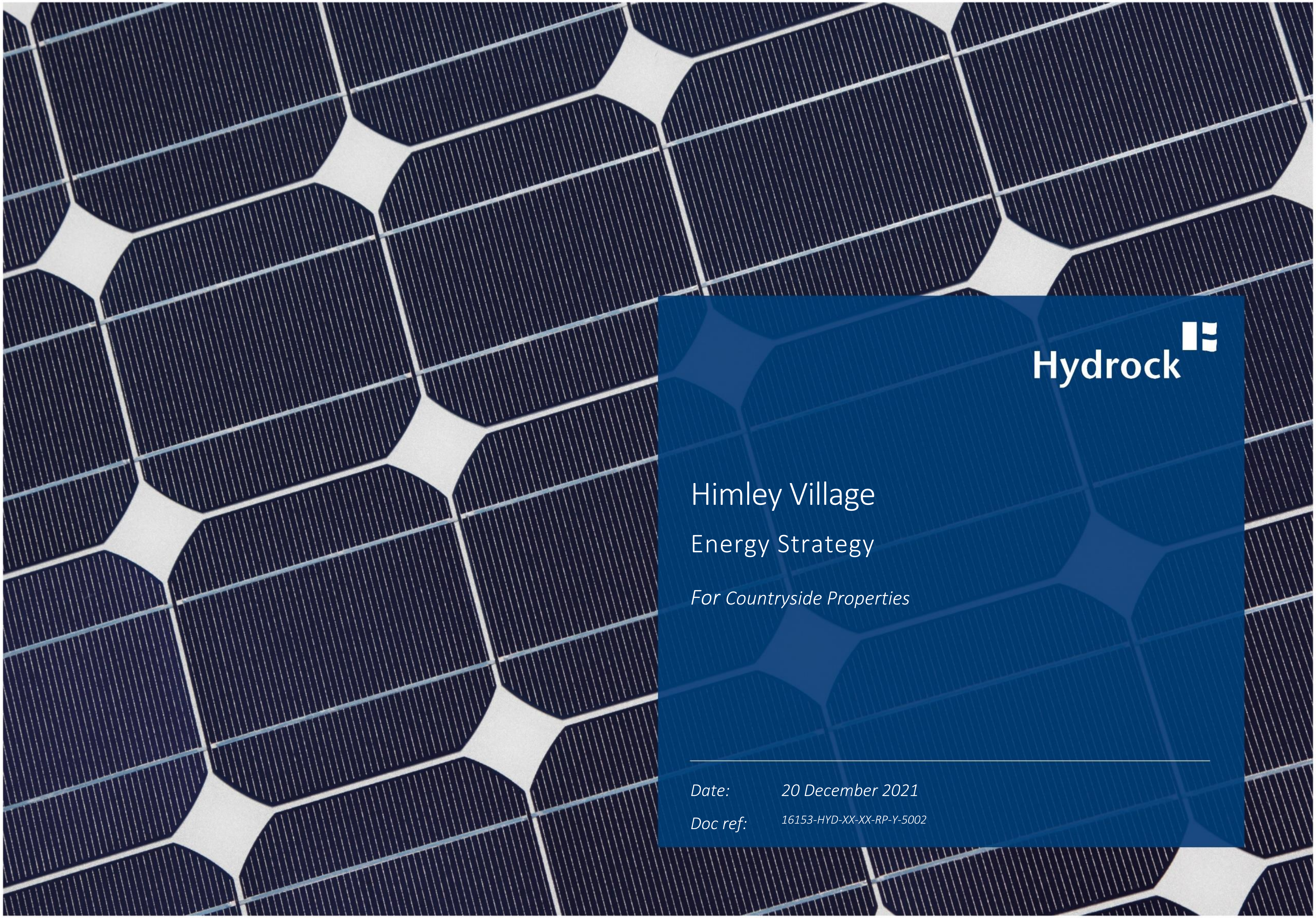

Hydrock

Himley Village

Energy Strategy

For Countryside Properties

Date: *20 December 2021*

Doc ref: *16153-HYD-XX-XX-RP-Y-5002*

DOCUMENT CONTROL SHEET

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Executive Summary

This report intends to provide an overview for the site wide energy strategy at Himley Village, Bicester. The proposed development will meet the planning requirements laid out in Policy Bicester I.

In addition, more detailed information is provided with respect to the proposed Phase 1 development parcel.

The site will meet operational zero carbon (including regulated and unregulated emissions) through a mixture of efficient fabric, air source heat pumps and roof and ground mounted PV.

The strategy has targeted an energy use intensity (EUI) value for each build out of the site, as EUIs allow a fixed target but can be achieved flexibly through fabric, form, orientation. Setting an EUI ensures a known scale required for renewable energy offsetting, to achieve net zero (based on assumed building mix and size).

During this period of energy transition and over a number of phases, an overly prescriptive fabric and services specification will not allow for future design flexibility and could ultimately lead to unintended consequences for new technology solutions or viability impacts for the site as it develops.

The energy and carbon strategy across the site is summarised graphically in Figure 1. For more detailed information on the site wide strategy please refer to the Site Wide Approach section.

Policy Bicester I: North West Bicester Eco-Town

A new zero carbon mixed use development including 6,000 homes will be developed on land identified at North West Bicester.

The definition of zero carbon in eco-towns is that over a year the net carbon dioxide emission from all energy use within the building on the eco-town development as a whole are zero or below.

Key site-specific design and place shaping principles for these sites include:

- High quality exemplary development and design standards including zero carbon development, and the use of low embodied carbon in construction materials as well as promoting the use of locally sourced materials.
- All new buildings designed to incorporate best practice on tackling overheating, taking account of the latest UKCP climate projections.
- Proposals should enable residents to easily reduce their carbon footprint to a low level and live low carbon life styles.
- Demonstration of climate change mitigation and adaptation measures including exemplary demonstration of compliance with the requirements of Policies ESD1-5.

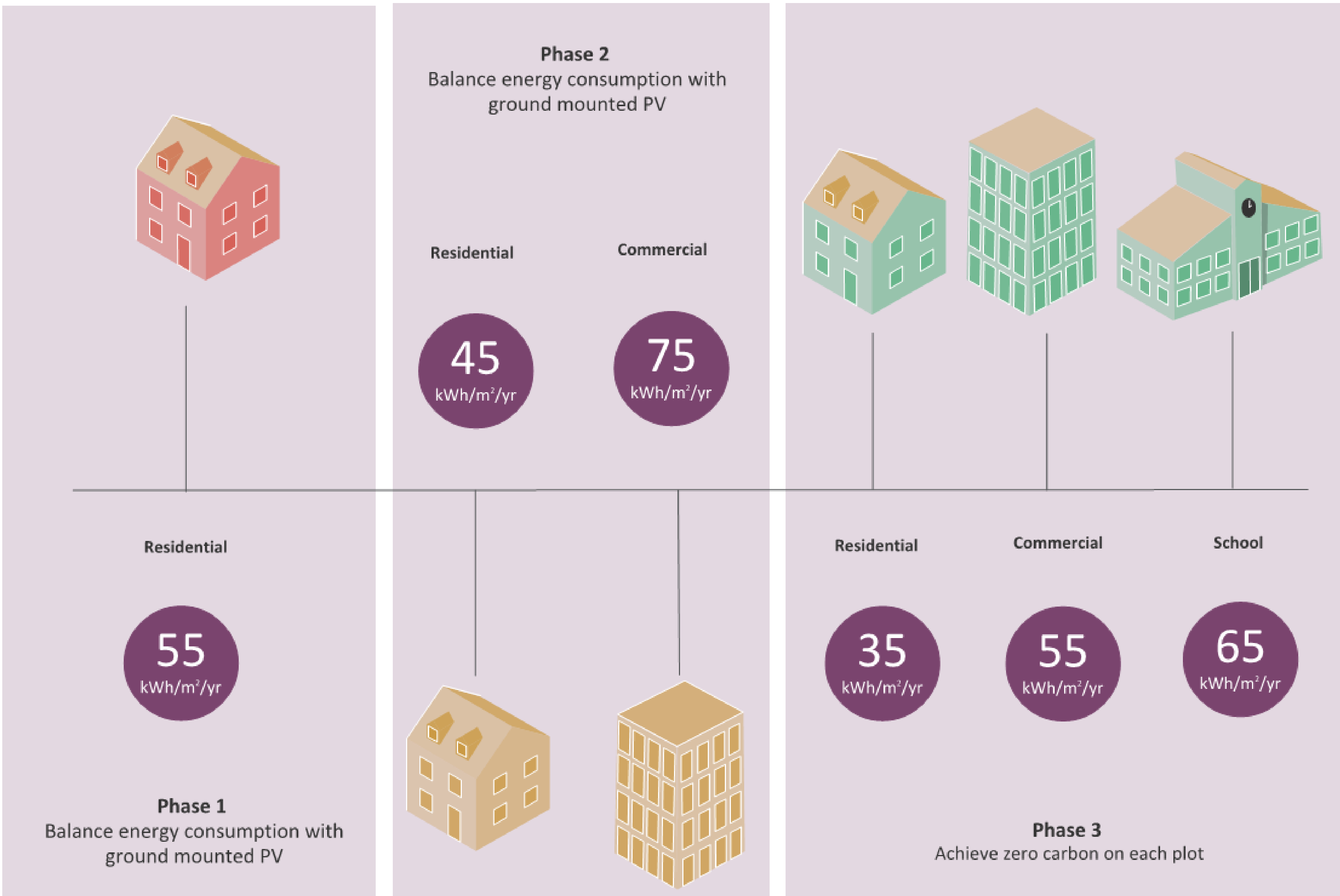

Figure 1 - EUI per Phase build out of the wider site

Himley Village, Bicester

Hydrock has been appointed by Countryside Properties to provide planning stage advisory services in relation to the proposed Himley Village development in Bicester, Oxfordshire.

This report will provide a comprehensive assessment of energy demand and carbon emissions associated with the proposed Phase 1 development as well as an overview of the energy and carbon strategy for the site as a whole

1. INTRODUCTION

1.1 Purpose of Report

This report has been produced predominantly to discharge Condition, 20 and of the Outline Permission 14/02121/OUT. In addition, to this the report seeks to also address the requirements of Conditions 13.

> *Condition 20*
>
> *No phase of development shall commence until a report has been submitted to and approved in writing by the Local Planning Authority outlining how carbon emissions from the construction process and embodied carbon within that phase will be minimised. The phase of development shall thereafter be carried out in accordance with the approved report.*

Throughout this report, carbon emissions are split into the following categories:

- Regulated: Emissions associated with heating, cooling, hot water, lighting and any other fixed building services equipment (those that are covered under Building Regulations Part L); and
- Unregulated: Emissions that are associated with small power and plug-in items and any other process or plant equipment (these are not covered by Building Regulations Part L).

This document will also provide the information required under Schedule 11 of the Section 106 agreement. This includes:

- Energy demand assessment using SAP/SBEM including regulated and unregulated energy;
- Energy demand reduction proposals;
- Energy generation strategy including anticipated outputs from any proposed technologies;
- Carbon balance using appropriate carbon factors (note S106 references DEFRA 2019, however carbon factors from SAP10.1 are proposed as these are more up to date.

Commentary is also be provided on upfront embodied carbon emissions reductions (those associated with the manufacturer and transport to site of building materials), however these are not included within the net zero carbon requirement for Himley Village and will not be quantified in the same manner as opertional Regulated and Unregulated carbon emissions and the net zero carbon requirement is applied only to opertional emissions at Himley Village

1.2 Project Description

The proposed Himley Village development consists of 500 dwellings and forms part of the wider Himley Village masterplan.

The Himley Village site falls within the remit of Cherwell District Council (CDC).

The wider masterplan will provide up to 1,700 homes, schools, and community facilities. The site itself is classified as an EcoTown and will seek to provide a zero-carbon ready development on the outskirts of Bicester.

Figure 2 - Proposed site masterplan

Regulations, Policy and Guidance

This section of the report highlights the relevant national regulations, local policy and guidance that are applicable to the Himley Village development.

2. NATIONAL PLANNING POLICY

2.1 National Planning Policy Framework (NPPF)

The National Planning Policy Framework (NPPF) was updated in 2021 and sets out government planning policy for England, removing all regional level planning policy at this time in favour of 'a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.'

All Local and Neighbourhood Plans must therefore align with the polices of the NPPF.

The NPPF states clearly that the purpose of planning is to help deliver sustainable development and defines three mutually dependent pillars that must be equally considered in order to achieve this:

- Economic
- Social
- Environmental

The NPPF focusses on:

- Promoting high-quality design for new homes and places.
- Offering stronger protection for the environment.
- Constructing the right number of homes in the right locations.
- Focusing on greater responsibility and accountability of councils and developers for housing delivery.

In terms of the environment, the NPPF seeks to further protect biodiversity by aligning the planning system with Defra's 25-year Environment Plan. Not only does this protect habitats, it also emphasises air quality protection in relation to development proposals.

2.2 Building Regulations Part L1A and L2A

All areas of the proposed development will need to meet Energy Performance standards are set for dwellings by Building Regulations Approved Document Part L1A and L2A, Conservation of Fuel and Power in New Dwellings and Buildings Other than Dwellings respectively.

It is the role of Part L of the Building Regulations to include a maximum level for regulated carbon emissions defined by the Target Emission Rate (TER) which relates to a 'Notional Building', automatically generated as part of the SAP (residential) and SBEM (non-residential) toolkits.

The resulting Dwelling Emission Rate (DER) or Building Emission Rate (BER) must be no more than the TER in order to comply. A benchmark Energy Performance Certificate (EPC), rated A (most efficient) through G (least efficient) will also be calculated as part of this assessment via comparison of each building assessed to a 'Reference Building', also automatically generated as part of the SAP and SBEM toolkits.

Recently, the Governments draft Part L 2021 and Future Homes Standard (to be implemented in 2025) have been released and urge developments at an early stage of design development to plan for compliance with the new Part L 2021 and give consideration to improved fabric efficiency and the use of low carbon heating via technologies such as heat pumps.

Developments currently in the design process should take the above into account when thinking about their heating and power strategies. The Interim Part L 2021 will require in a 35% reduction in CO_2 from new dwellings, compared to current standards from July 2022.

Whilst there will be transitional arrangements in place, unlike previous iterations of Part L these will be on a dwelling-by-dwelling basis, so any dwellings where work has not started within a reasonable period will be expected to meet the updated Part L.

A consultation to make similar updates to Part L 2A for new non-domestic buildings was carried out in January 2021 and developments should be aware of proposed changes and any transitional arrangements that may come into effect before works have started on site.

Also important is the changes to the carbon emissions within the new SAP10.1 which will replace the existing figures in SAP 2012. The emission factors demonstrate the significant decarbonisation of the national grid and confirm that natural gas will have a higher carbon factor than electricity going forward.

Table 1: Part L carbon factors 2013 vs. 2020.

Fuel	SAP 2012 (Part L 2013) (kgCO2e/kWh)	SAP 10.1 (Pending Part L update - 10/19) (kgCO2e/kWh)
Electricity	0.519	0.136
Gas	0.216	0.210

3. LOCAL PLANNING POLICY

3.1 Cherwell Local Plan, 2011-2031 Part 1 (2015)

The Local Plan for Cherwell District was adopted in 2015 and contains a number of policies relevant to energy and sustainability.

Whilst these policies are outlined below for reference, the expectation for net zero development at Himley Village goes beyond these requirements as a condition of outline planning consent, detail within the S106 agreement and the guidance within the North West Bicester SPD.

Policy ESD1: Mitigating and Adapting to Climate Change

Measures will be taken to mitigate the impact of development within the District on climate change. At a strategic level, this will include:

- Distributing growth to the most sustainable locations as defined in this Local Plan
- Delivering development that seeks to reduce the need to travel and which encourages sustainable travel options including walking, cycling, and public transport to reduce dependence on private cars
- Designing developments to reduce carbon emissions and use resources more efficiently, including water
- Promoting the use of decentalised and renewable or low carbon energy where appropriate.

The incorporation of suitable adaptation measures in new development to ensure that development is more resilient to climate change impacts will include consideration of the following:

- Taking into account the known physical and environmental constraints when identifying locations for development.
- Demonstration of design approaches that are resilient to climate change impacts including the use of passive solar design for heating and cooling
- Minimising the risk of flooding and making use of sustainable drainage methods; and
- Reducing the effects of development on the microclimate (through the provision of green infrastructure including open space and water, planting and green roofs).

Adaptation through design approaches will be considered in more locally specific detail in the Sustainable Buildings in Cherwell Supplementary Planning Document (SPD).

Policy ESD 2: Energy Hierarchy and Allowable Solutions

In seeking to achieve carbon emissions reductions, we will promote an 'energy hierarchy' as follows:

- Reducing energy use by the use of sustainable design and construction measures
- Supplying energy efficiently and giving priority to decentralised energy supply
- Making use of renewable energy
- Making use of allowable solutions (note allowable solutions have since been withdrawn).

Policy ESD 3: Sustainable Construction

All new residential development will be expected to incorporate sustainable design and construction technology to achieve zero carbon development through a combination of fabric energy efficiency, carbon compliance and allowable solutions in line with Government policy.

Cherwell District is in an area of water stress and as such the Council will seek a high level of water efficiency than required in the Building Regulations, with developments achieving a limit of 110 l/person/day.

The strategic site allocations identified in this Local Plan are expected to provide contribution to carbon emissions reductions and to wider sustainability.

All development proposals will be encouraged to reflect high quality design and high environmental standard, demonstrating sustainable construction methods including but not limited to:

- Minimising both energy demands and energy loss
- Maximising passive solar lighting and natural ventilation
- Maximising resource efficiency
- Incorporate the use of recycled and energy efficient materials
- Incorporating the use of locally sourced building materials
- Reducing waste and pollution and making adequate provision for the recycling of waste
- Making use of sustainable drainage methods
- Reducing the impact on the external environment and maximising opportunities for cooling and shading; and
- Making use of the embodied energy within buildings wherever possible and re-using materials where proposals involve demolition or development.

Policy ESD 4: Centralised Energy Systems

The use of decentralised energy systems, providing either heating (District Heating (DH)) or heating and power (Combined Heat and Power (CHP)) will be encouraged in all new developments.

A feasibility assessment for DH/CHP including consideration of biomass fuelled CHP will be required for:

- All residential development for 100 dwellings or more;
- All residential developments in off-gas areas for 50 dwellings or more;
- All applications for non-domestic developments above 1000sqm of floorspace.

Policy ESD 5: Renewable Energy

A feasibility assessment of the potential for significant on site renewable energy provision will be required for:

- All residential developments for 100 dwellings or more;
- All residential developments in off-gas areas for 50 dwellings or more;
- All applications for non-domestic developments above 1000sqm of floorspace.

Where feasibility assessments demonstrate that on site renewable energy provision is deliverable and viable, this will be required as part of the development unless an alternative solution would deliver the same or increased benefit.

4. OUTLINE PLANNING CONSENT

The proposed development is subject to outline planning consent 14/02121/OUT which includes the following Conditions:

Condition 13

Each reserved matters application shall be accompanied by a statement setting out how the design of buildings and the layout has taken account of future climate impacts, as identified in TSB research 'Future Climate Risks for NW Bicester', or any more recent assessment that has been published, and how the proposed development will be resilient to overheating, changing rainfall patterns and higher intensity storm events.

Condition 20

No phase of development shall commence until a report has been submitted to and approved in writing by the Local Planning Authority outlining how carbon emissions from the construction process and embodied carbon within that phase will be minimised. To ensure development achieves a reduced carbon footprint in accordance with Policy Bicester 1 of the Cherwell Local Plan and guidance contained with Government Eco Town PPS.

Condition 38:

Each dwelling hereby approved shall be provided with real time energy and travel information prior to its first occupation. Details of the provision for each phase shall be submitted to the Local Planning Authority and agreed in writing prior to the commencement of construction of dwellings above slab level."

5. SECTION 106 REQUIREMENTS

This document will also provide the information required under Schedule 11 of the Section 106 agreement. This includes:

- Energy demand assessment using SAP/SBEM including regulated and unregulated energy;
- Energy demand reduction proposals;
- Energy generation strategy including anticipated outputs from any proposed technologies;
- Carbon balance using appropriate carbon factors (note S106 references DEFRA 2019, however carbon factors from SAP10.1 are proposed as these are more up to date.

Baseline Energy Demand

The baseline energy demand is the level from which carbon emissions reduction will be measured for Phase 1.

6. OPERATIONAL ENERGY MODELLING

The dwellings within Phase 1 have been assessed under using IES VE. The proposals havebeen assessed using a TM54 based methodology which provides a more accurate representation of the energy usage in the dwellings than that provided using a Part L 2013 compliance approach

As the house types repeat across the site, a representative sample of house types have been assessed, this includes:

- Grantham
- Irwell
- Dee
- Ashop
- Avon

6.1 Solar Gains

Solar gains are calculated automatically by the modelling software and are based on the orientation of the building, the transmission coefficients of the glazing and the solar angles. IES VE also takes into account shading devices.

6.2 Internal gains

Gains from lighting, appliances, cooking and from the occupants are estimated from the floor area.

6.3 Building Fabric

The notional building fabric is shown in Table 2.

Table 2 - Notional building fabric properties

Building Element	Notional Building Fabric
Roof	0.13 W/m2k
External Wall	0.18 W/m2k
Glazing (g-value)	1.4 W/m2k (0.65)
Air Permeability	5 m3/m2/hr @ 50 Pa

6.4 Building Services

To calculate the baseline CO_2 emissions the dwellings are assumed to use a communal gas boiler system with heat interface units (HIU) for heating and hot water, and grid derived electricity for all lighting and power.

Dwellings are assumed to be naturally ventilated with mechanical extract for wet areas (kitchens and bathrooms). All equipment efficiencies match the case for a Part L notional building.

6.5 Weather data

Weather data is based on the climatic data provided by IES VE for the dwellings, the weather file used for the exercise is the London Test Reference Year (TRY) as required by the National Calculation Methodology (NCM).

6.6 Building Regulations Part L 2021

As the development will be built out during the transitional arrangements for the proposed update to Part L, it is proposed that the carbon factors associated with SAP 10.1 be used to assess the site. These are as follows:

- Electricity – 0.136 $kgCO_2/kWh$
- Gas – 0.210 $kgCO_2/kWh$

In addition, primary energy demand will be a key consideration, in the form of a baseline Energy Use Intensity metric for Interim Part L 2021 compliant development.

7. BASELINE CARBON EMISSIONS AND ENERGY USE

The baseline regulated carbon emissions for the Phase 1 development is **815,800 kgCO_2/yr**.

The baseline energy use for the development is also shown in the following graph.

The operational energy modelling for the development has been based on TM54 methodology. For details results for modelling dwellings please see Appendix A.

7.1 Unregulated Carbon Emissions

Unregulated emissions relate to any energy consuming activities that are not covered under Building Regulations Part L1A. For proposed development, this will include:

- Lifts;
- Small power –Computers and other electrical equipment.
- Kitchen equipment –fridges and dishwashers etc.
- Laundry equipment – washers and dryers.

The total unregulated carbon emissions baseline for the development is calculated using the BRE Domestic Energy Model (BREDEM) calculation at approximately (1,369,191 kWh/yr) **319,000 kgCO_2/yr.**

The proposed strategy includes measures that will reduce unregulated energy consumption though this is difficult to quantify via energy modelling for Part L.

7.2 Total Baseline Carbon Emissions (Phase 1)

The phase 1 carbon emissions rate for both regulated and unregulated energy is **1,134,800 kgCO_2/yr**

7.2.1 Baseline Energy Use Intensity

The baseline EUI for phase 1 is **120kWh/m^2.yr**.

Further details on Energy Use Intensity and its relevance to the net zero target are outlined in the site wide strategy in Section 22.

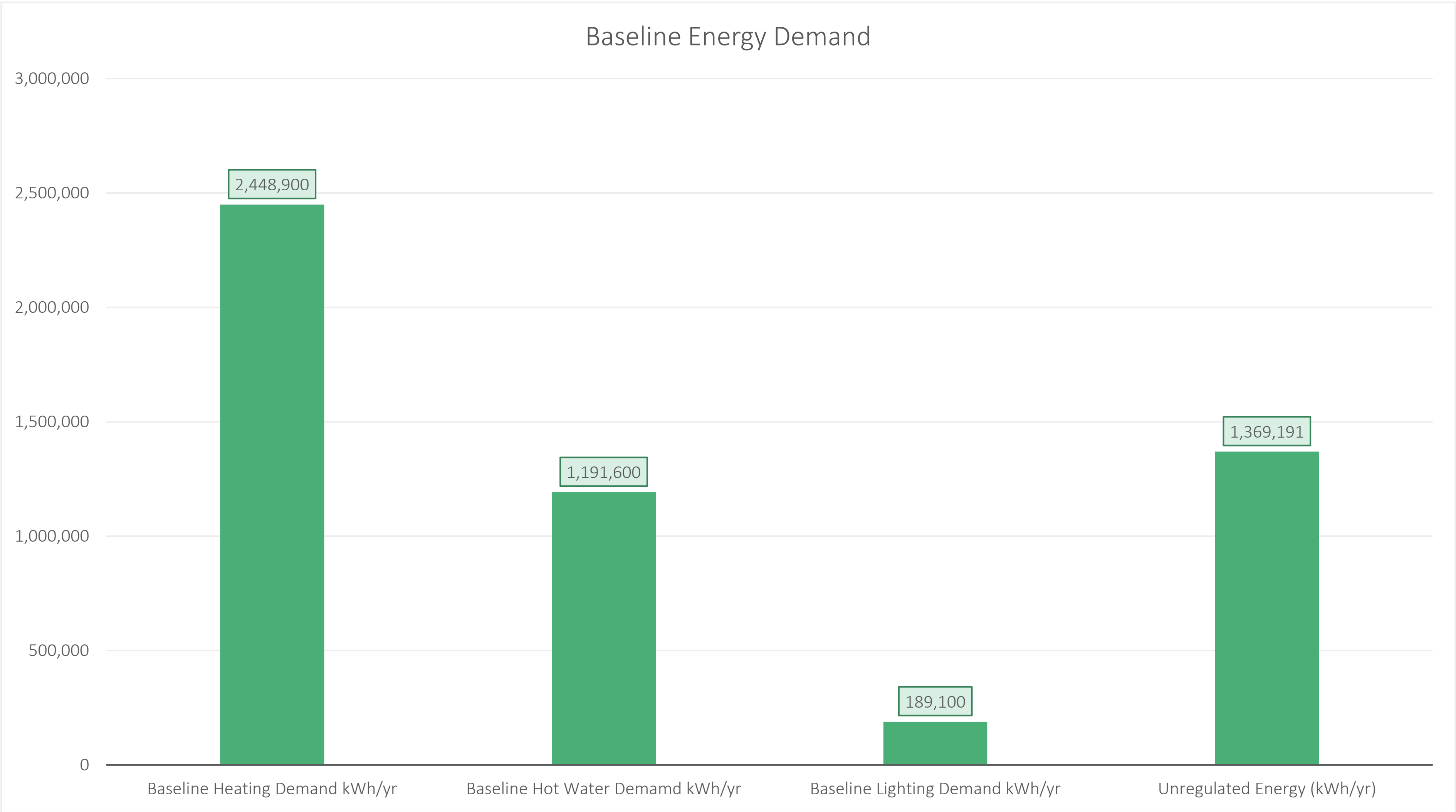

Figure 3 - Baseline energy demand for the development

Be Lean - Reducing the Demand for Energy

The first step in reduction carbon emissions from development is to reduce the demand for energy use through passive design and sustainable construction methods.

This section of the report highlights the measures that will be included within the first phase of the Himley Village development to reduce energy demand and subsequent carbon emissions.

8. PASSIVE DESIGN MEASURES

Passive design options are those which utilise building form, massing and glazing ratios to exploit the natural surroundings of the site to help reduce energy demand. The proposed design includes the following:

- Optimising daylight through higher floor to ceiling heights or dual aspect buildings;
- Control of solar gain to benefit from heat when required without causing overheating in summer via the size and depth of windows on different elevations;
- Increased efficiency of building fabric, particularly the roof and walls to reduce heat loss;
- Maximising air tightness to minimise the impacts of uncontrolled air infiltration; and
- Strategic planting of trees to shelter lower level buildings from high winds and provide shading from the sun.

Passive design measures have been carefully considered within the development proposals as appropriate to the construction type and end use.

The houses have been orientated with respect to the sun path where possible maximize solar gain at the appropriate time of the year when required in cold climate and to minimise solar gain during summer months.

Glazing layout and specification has been strongly influenced by the passive design goals of the project, with windows placed to increase the amount of natural daylight and reduce the reliance on artificial lighting.

The design team have worked hard to improve the projects passive design performance, both the window and external wall U-values have been iteratively improved during the design

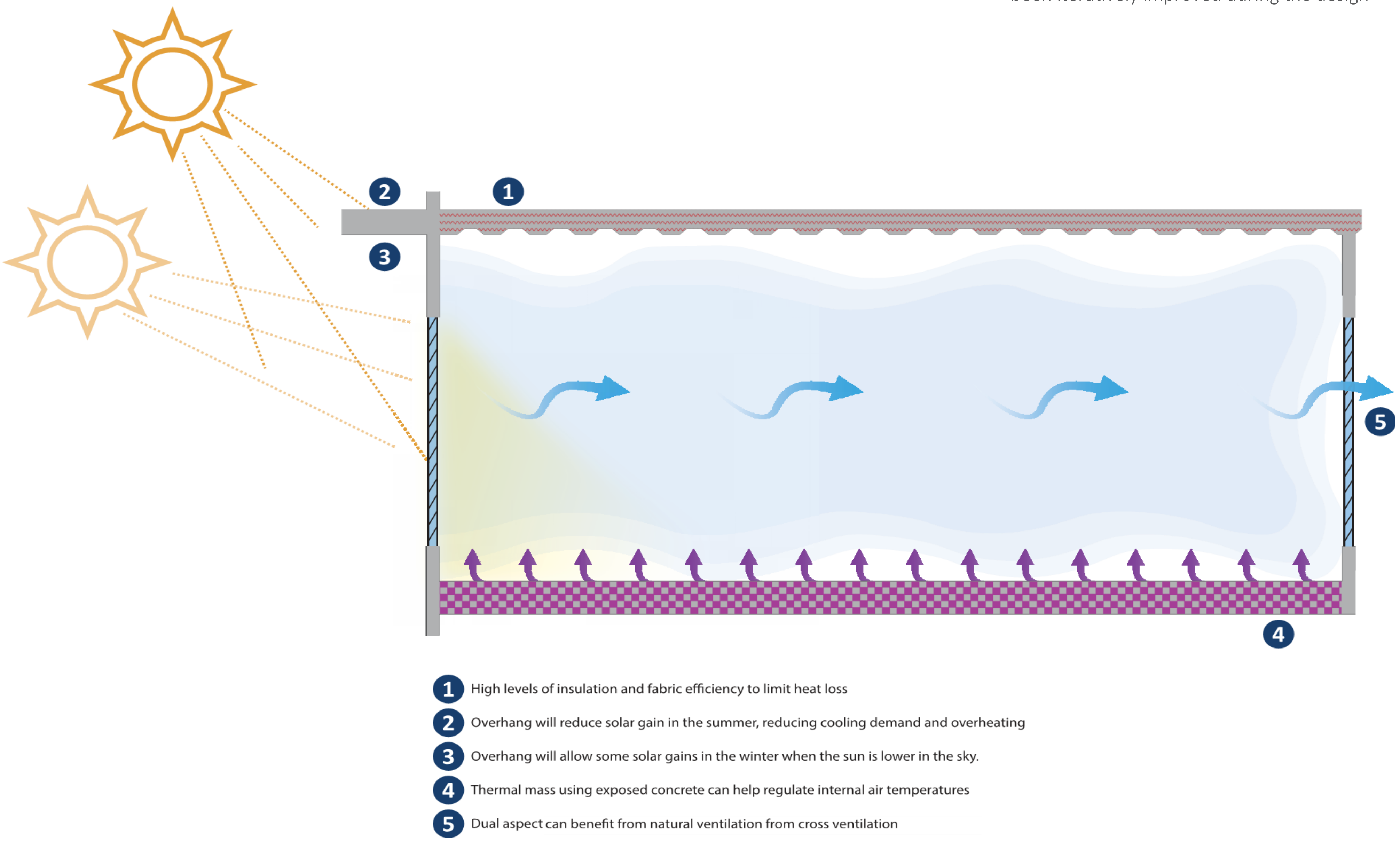

Figure 4 - Passive design measures

process. The final U-values for the floor, roof and glazing have also been confirmed as per Table 3 below.

Table 3 - Proposed building fabric properties both the dwellings and retail unit

Building Element	U-value
Roof	0.09 W/m^{2}k
Floor	0.14 W/m^{2}k
Walls	0.20 W/m^{2}k
Glazing	1.20 W/m^{2}k

Air permeability of 4 m^3/hr/m^2 at 50 Pa has been utilised at this stage within modelling for the actual building though this may be improved upon during detailed design with inputs from the principal contractor.

9. ACTIVE DESIGN MEASURES

Active design relates to energy efficiency measures that can be included within the building services specification to reduce energy consumption. All services will be designed to meet at least the minimum recommended performance requirements contained in the UK Government Domestic Building Services Compliance Guides (2013).

The following active design measures are recommended for inclusion within the scheme.

9.1 Regulated Energy

The heating system will ensure appropriate zoning and segregation of internal spaces to allow effective temperature control by residents as appropriate.

The heat emitters in all residential areas will be low surface temperature radiators. Hot water delivery will include high levels of insulation, coupled with efficient fittings to minimise water consumption and energy consumption. The system delivery efficiency is assumed at 91%.

Ventilation will be via openable windows, and positive input ventilation from the loft space. This will ensure a constant supply of fresh air into dwellings. Ventilation systems will be selected to ensure they have a low specific fan power to reduce energy use.

Generally, all equipment will be specified to achieve a high efficiency (e.g. high thermal conversion efficiency for heating equipment) and low distribution losses (low fan and pump power, insulation in accordance with relevant standards), with pumps utilising variable speeds.

To reduce energy, demand all lighting installed will be high efficiency LED type.

9.2 Unregulated Energy

The unregulated energy use will be mostly attributed to small power with plug-in devices and white goods providing the highest contribution. The most cost-effective way to reduce unregulated energy use in dwellings is to provide information to residents to encourage equipment to be switched off when not in use.

In addition, energy efficient equipment will be specified (where provided) to follow the principles outlined in CIBSE Guide TM50, where possible. For example, small domestic white goods (such as fridges where provided), will be specified to be A+ rated under the EU Energy Efficiency Labelling scheme.

Due to the high reliance on occupant behaviour patterns, it is difficult to predict the reduction in energy consumption and carbon emissions that can be achieved through the inclusion of these measures. However, it is estimated that a reduction in the region of 10% can be achieved.

9.2.1 Smart Metering – Real Time Data

To further reduce emissions associated with plug-in devices, all dwellings will be provided with a smart meter to provide real time energy use and cost data.

In line with Condition 38 of the outline consent, smart meters will be coupled with in-home energy display devices allowing residents to visualise their energy use in graphical and cost format will provide instant feedback on the energy and carbon implications of day to day plug-in equipment, and thermostat settings.

Be Clean – Supply Energy Efficiently

This section of the report will explore ways in which the developments heating and hot water could be provided via connection to any existing or planned district heating networks.

10. DISTRICT HEATING NETWORK

10.1 Himley Village Site Wide Heat Network

The outline planning application suggests that heating and hot water at the Himley Village development will be provided by a site wide district heating network. This would be served via a single energy centre building and powered by gas combined heat and power as the primary heat source.

No heat network is currently being brought forward by the wider Himley Village development. Furthermore, any heat network powered by gas CHP would be technologically out of date by the time the network became active and a decarbonisation plan would need to be introduced. To maximise the carbon reduction that can be achieved through efficient heating and hot water production, it is proposed that this plot on the Himley Village development would not connect to any site wide heat network.

10.2 Plot Wide Heat Network

As a site wide heat network is not currently being brought forward, a smaller heat network could be developed at plot level. The first plot consists of low-density housing and the annual heat load would not be sufficient to support a heat network. Furthermore, to align with the UK Government Future Homes Standard, it is the desire of the development to be gas free and all heat will be provided via electricity. To provide more control in the future to residents over how their heat is produced, heating and hot water infrastructure will be provided at a localised level.

11. PROPOSED HEATING AND HOT WATER GENERATION

Heating and hot water will be provided via individual air source heat pumps (ASHPs). ASHPs utilise the residual heat in external air to produce usable heat for heating and domestic hot water.

Heat pumps work by extracting thermal energy from a low-grade source (air, soil or water) to a heating element with a higher temperature. Heat pumps use a liquid refrigerant that is pumped into pipes which absorbs heat, that later is passed through a compressor where its further heated and moved to heating and hot water circuits.

Heat pumps operate with a typical Seasonal Coefficient of Performance (SCoP) of 2.5:1 to 5:1 (depending on heat source/sink); meaning that for every 1kW of electric in, 2.5kW of heat is generated (for ASHP) and up to 5kW (for some ground or water source heat pumps). This efficiency of a heat pump is governed by both the temperatures of the heat source and the heat emitter as shown below.

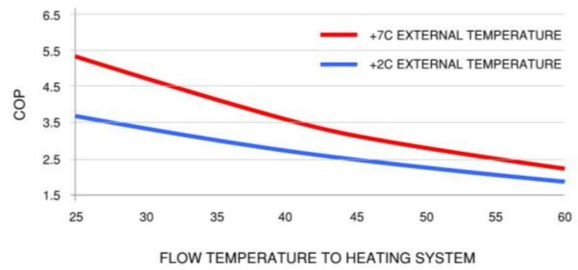

Figure 5: COP as a function of flow temperature for typical ASHP

Heat pumps are, therefore, best suited to low temperature systems such as underfloor heating. If radiators are used with heat pumps it is likely that they would be twice the as large as those used with conventional radiators.

Heat pumps are powered by electricity, so are considered low-carbon rather than zero-carbon/renewable, however, as the grid decarbonises, they will become more efficient.

The heat pump units will be sited externally to allow for air flow around the unit to maximise the coefficient and performance and subsequent carbon reduction. ASHPs are approximately 3.5 times more efficient than the equivalent direct electric heating, with one unit of power provided up to 3.5 units of heat (depending on final unit selection).

The use of ASHPs, along with efficient fabric will provide a 62% reduction in carbon emissions. Table 5 and figure 6 show the reduction in space energy demand through implementing these measures.

Table 4 - EUI (kWh/m²/yr)breakdown after the implementation of PV

Energy Hierarchy Stage	Total Energy Use kWh/m²/yr	Heating Energy Use kWh/m²/yr	Hot Water Energy Use kWh/m²/yr	Lighting Energy Use kWh/m²/yr	Unregulated Energy Use kWh/m²/yr
Baseline	121.8	57.2	28.4	4.4	31.8
After Energy Efficient Measures	57.3	18.9	9.9	2.5	26.0
Total Energy Reduction	53%	67%	65%	44%	18%

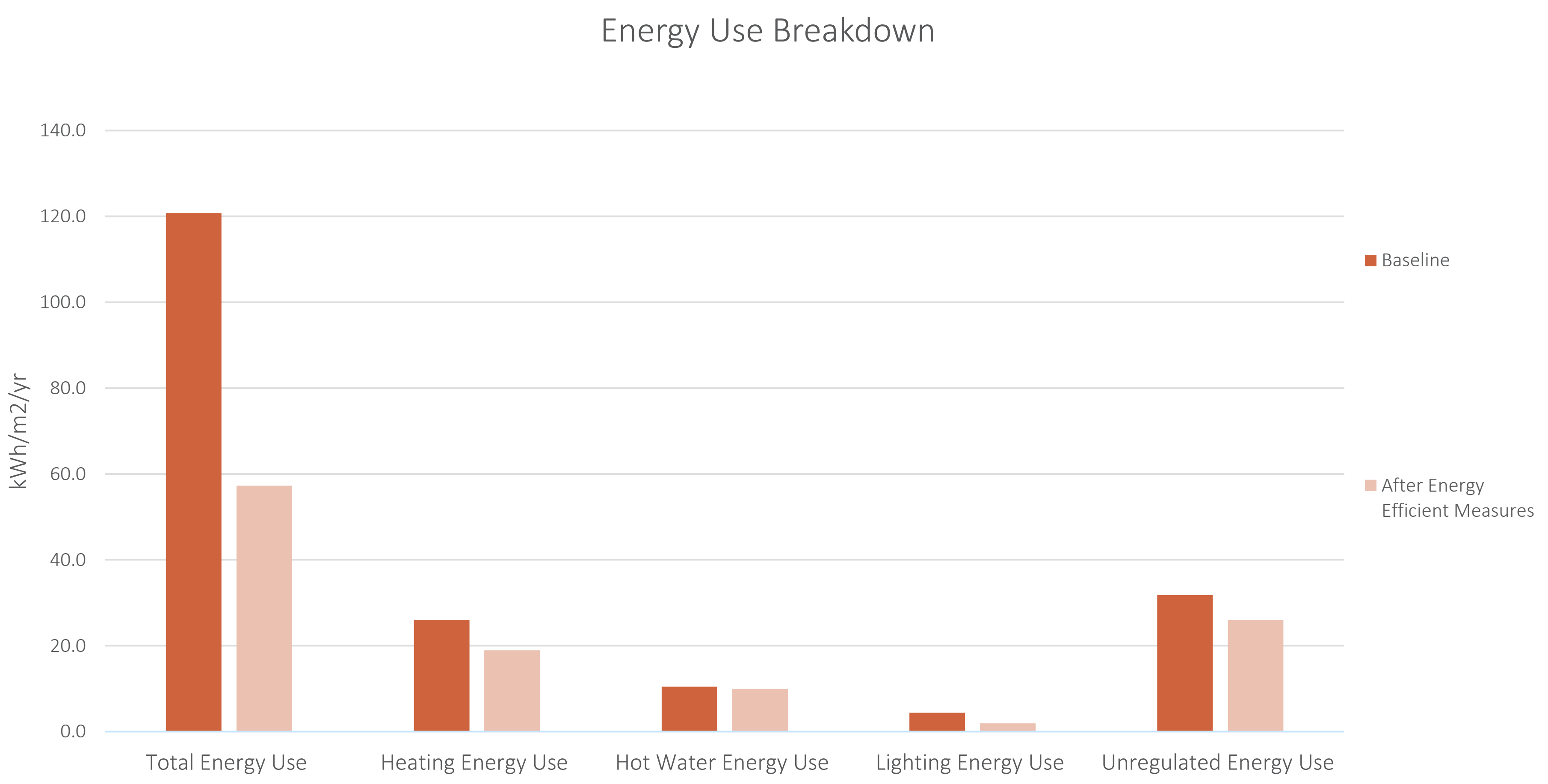

Figure 6 - Graph showing the EUI breakdown of the development against the Part L baseline

Be Green – Use Renewable Energy

This section of the report provides a summary of the potential and viable renewable technologies that could be installed at the Himley Village development. In order to meet the requirement of net zero carbon emissions across the year. In order to achieve this, an on-site reduction in carbon emissions (for both regulated and unregulated carbon), a carbon offset of 443,300 $kgCO_2/yr$ (approximately 880 $kgCO_2/yr$ per dwelling) will need to be achieved through the use of renewable or low carbon technologies.

12. RENEWABLE AND LOW CARBON TECHNOLOGY OPTIONS

To reduce carbon emissions further throughout the year, renewable technologies in addition to the use of ASHPs will be required. The following pages provide an initial options appraisal and highlight the technologies that will be included within the first plot at Himley Village.

Details of the chosen technology are provided in Section 14.

12.1 Photovoltaic Panels

Solar PV works by converting light into electricity using a semi-conductor material. PV panels don't need direct sunlight to work; electricity can still be generated on a cloudy day.

Solar irradiance, which is the power per unit area (W/m^2) received from the sun is measured annually. Monthly irradiation figures are shown in the following figures.

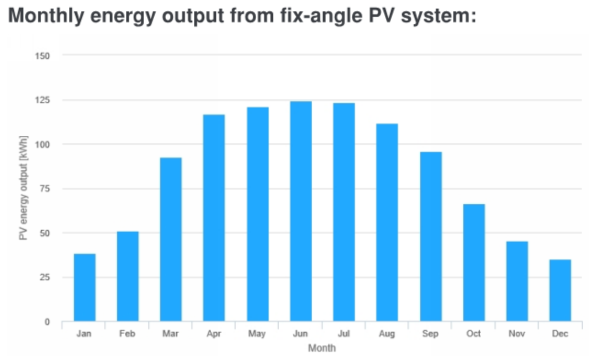

Figure 7: Monthly energy output from solar PV.

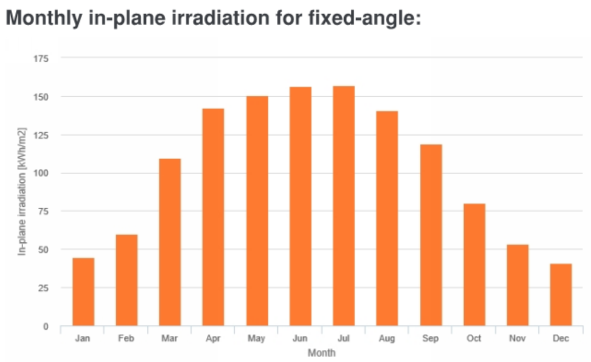

Figure 8: Monthly irradiation for solar PV.

It is anticipated that the site will receive approximately 900 $kWh/m^2/yr$ based on the UK irradiance chart, which makes a great case for installing solar.

PV panels themselves vary in efficiency from 15-20% (average) to 23% (most efficient). Panels should face between SE and SW, at an elevation of about 30° – 40° for maximum output. The spacing of rows of panels should minimise over-shading of each other and also account for maintenance space required.

In terms of location and orientation, there should be no overshadowing of the panels, as this reduces their overall efficiency. Even shading a small part of a PV panel could significantly reduce its efficiency and the efficiency of other PV panels connected in the string. Overshadowing can be caused by trees, other buildings, roofs of adjacent buildings, dormer windows, roof furniture, etc.

12.2 Solar Thermal Panels

Figure 9: Solar thermal hot water panels.

Solar thermal panels collect heat from the sun via a series of tubes, called collectors, that are filled with a heat transfer fluid. The warm fluid is then pumped through a coil in a water cylinder, warming the water; typically providing a 60°C output at the tap. Solar thermal is not as flexible as PV in terms of installation location; as it will require a roof. A double coiled hot water storage tank would also be required.

Typically, solar thermal is used in collaboration with a secondary heat source as it cannot provide all of a developments hot water; (typically 50-60%). A heat pump or boiler back-up would also be used to top up the temperature of the water if it isn't high enough, or to provide hot water at night.

Although heat from solar hot water collectors can be stored in hot water cylinders, during the summer, when hot water production will be at its peak, a high proportion of this can be wasted if there is not a dedicated heat sink.

Systems would be sized to meet peak summer hot water demand – for a typical dwelling at Himley Village this is expected to be approximately 150l/day, however, this may be increased for larger family houses.

12.3 Wind Turbines

Wind turbines can provide efficient and cost-effective renewable electricity generation. The annual output from wind turbines is highly dependent on the local wind speeds at the site, and are generally suited to unobstructed developments where good separation distances between turbines and residential dwellings can be achieved.

Whilst a wind turbine would provide a significant portion of the electricity demand at the Himley Village development, other issues associated with wind turbines need to be taken into account:

- Shadow flicker from rotating blades;
- Vibration and noise from generators;
- Environmental impact on local bird species.

13. PROPOSED RENEWABLE TECHNOLOGY

The development will utilise photovoltaic panels situated on all roofs that received sunlight (those that are oriented east through west).

During the course of design development, the site layout has been revised and rearranged to maximise the number of roof spaces that will be suitable for installing PV panels. Due to the roofs being pitched, panels can be installed without the need for spacing to account for overshadowing, increasing the overall roof area available.

The details of the proposed PV installation are shown in Table 6.

Table 5 - PV installation details

PV Installation Details	
Panel Efficiency	390 W
Total Installation kWp	1,420 kWp
Total PV Output	1,256,400 kWh/yr
Carbon Savings	292,700 $kgCO_2$/yr

This PV installation takes advantage of all suitable roof space within the development to maximise carbon emission reduction. The PV proposed will provide a carbon offset of approximately 292,700 $kgCO_2$/yr, this is equivalent to a 26% reduction in carbon emissions from PV alone (taking into account both regulated and unregulated carbon).

Please see Appendix B for PV detailed per dwelling.

13.1 Carbon Emissions Summary

The site wide carbon emissions for the first phase of the Himley Village development are shown in Table 7.

Table 6 - Reduction in carbon emissions after PV

	Regulated Carbon kgCO2/yr	Unregulated Carbon kgCO2/yr	Total Operational Carbon kgCO2/yr	Total Operational Carbon Reduction kgCO2/yr	Percentage Reduction
Baseline Carbon Emissions	815,800	319,000	1,134,800	NA	NA
After Be Green ASHP	182,500	233,900	416,400	718,400	63%
After Be Green PV	0	123,600	123,600	292,700	70%
Total				1,011,200	89%

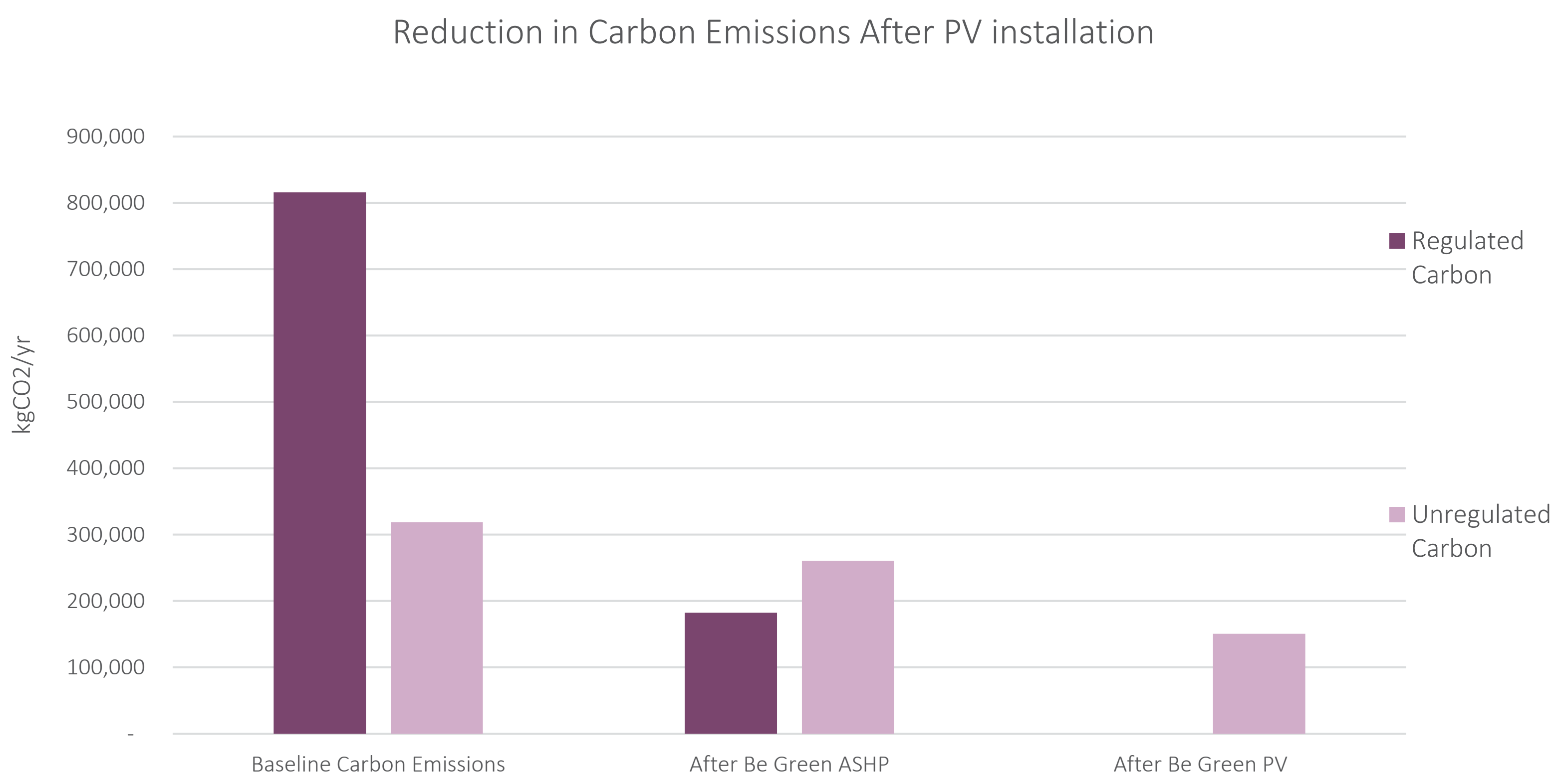

Figure 10 - Graph showing reduction in carbon emissions after PV installation

Climate Change Adaptation

This section of the report responds to Condition 13 which requires developments to set out how the dwellings will adapt to the changing climate.

For Himley Village, this specifically references the increased risk of overheating, changing rainfall patterns and higher intensity storm events.

14. CLIMATE CHANGE IMPACTS

Condition 13 of the outline application refers to the TSB document 'Future Climate Risks for NW Bicester'. This document refers to UK Climate Projectionss 2009 (UKCP09), these have since been updated to UKCP18, and the most up to date information from UKCP18 data is used as the basis of this assessment.

The key effects of climate change anticipated for the NW Bicester area are:

- Change in summer temperature of 1.1degC – 5.8degC;
- Change in winter temperature of 0.7degC – 4.2degC;
- Increased intensity of rainfall and storm events (more instances of current 1 in 100 year event);
- Drier summers and wetter winters with more extreme weather events.

In line with the recommendations of the TSB research document, the climate change adaptation strategy for Phase 1 will focus on overheating, sustainable transport, flood risk and storm events and green infrastructure.

15. SUSTAINABLE TRANSPORT USE

To promote the sustainable use of transport, and minimise the greenhouse gas emission associated with private combustion engine car use, electric vehicle charging points will be provided throughout the development.

The Himley Village site forms part of the wider NW Bicester Eco-Town masterplan which includes a number of bus only roads to increase the use of public transport and reduce private car use. To further increase uptake of public transport, residents will be provided with virtual real-time public transport data.

Cycle paths are provided throughout the site, these will be of high quality to promote sustainable transport use.

16. OVERHEATING WITHIN DWELLINGS

To mitigate the risk of overheating, all residential buildings will be designed to meet the requirements of CIBSE TM59: Design Methodology for the Assessment of Overheating in Homes, including future climate scenarios.

Overheating modelling for the dwellings will be carried out using the Design Summer Year weather file for 2020s, high emissions, 50% percentile scenario. This will be done at the detailed design stage.

The risk of overheating has been reduced through the implementation of a number of passive design solutions. The building fabric has been specified to be better than the Part L1A notional building, this will help to regulate internal building temperature. Furthermore, the glazing ratios have been selected to provide good levels of internal daylight, whilst not being oversized to reduce solar gains and overheating risk.

The dwellings will be provided with PIV ventilation along with openable windows. The acoustic and air quality conditions at the site are such that openable windows can be used for ventilation purposes.

The development includes landscaping within street scenes. This includes low level shrubs and trees which will provide shading in the summer and passive cooling by evapotranspiration.

17. FLOOD RISK AND STORM EVENTS

The site is located in Environment Agency Flood Zone 1 - land that has a low probability of flooding from tidal and fluvial sources. However, the site will be subject to changes in average rainfall levels and experience more frequent intense rainfall events which will increase surface water runoff. This will increase the probability of localised flood events caused by overwhelmed local surface water drainage systems.

The widespread use of Sustainable Drainage Systems (SUDS) in the form of swales, wetlands and attenuation ponds will provide sustainable storm water management and create a sustainable resource from rainfall, whilst ensuring that flood risk is reduced for areas downstream and benefitting the local area.

This will also provide new wildlife corridors and spaces incorporating wetlands, ponds with a variety of flora and fauna, creating valuable open amenity areas whilst enhancing the local water environment. The SUDS system will comprise of linked SUDS components which complement one another, such as; rain gardens, swales, permeable paving with storage, attenuation ponds and ditches.

18. SUSTAINABLE WATER USE

All dwellings have been designed to achieve a potable water use of no more than 105 litres/person/day. This will be achieved through the specification of low flow fixtures and fittings including dual flush WCs and aerated shower heads/taps.

Rainwater collection via water butts has also been considered to provide water for irrigation purposes.

A water neutrality statement has been prepared as part of this application, please see document 16153-HYD-XX-XX-RP-Y-5004 for further details.

19. GREEN INFRASTRUCTURE

The inclusion of significant green infrastructure throughout the site will provide some degree of protection against increased rainfall and storm events, as well as providing shading and passive cooling to mitigate increased temperatures.

The Himley Village development includes pockets of green infrastructure that link with the proposed green corridors throughout the wider masterplan. These will be planted with drought resistant plants such as wild flowers, birch and beech trees to ensure they are suitable for the future climate.

Gardens to include porous surfaces such as lawn or permeable paving to reduce surface water run-off.

Embodied Carbon

Embodied carbon refers to all emissions relating to the extraction, processing, transport installation, repair, maintenance and end of life of materials and systems used within the construction of a building.

20. BACKGROUND

Historically, there has been little guidance and regulation with regards to embodied carbon, therefore, the level of information detail, accuracy and reliability can vary throughout these stages as the industry is still developing knowledge. For instance, data available for the maintenance (B2) and repair (B3) stages are still under development and may contribute to the performance gap between as built reality and the design estimation.

Figure 11 shows the RICS and BS EN 15978 defined stages for the whole life carbon. Other than operational energy (B6), all other whole life carbon emissions are associated with embodied carbon.

20.1 Building Elements

Following RICS elemental methodology, embodied carbon analysis within the built environment is broken down in to the following elements:

- Substructure: transfers the load of a building to the ground and isolates it horizontally from the ground. Substructures range from strip foundations through to large underground basements and are usually made from concrete, a highly emissive material. The substructure of a building is generally the element where structural performance is the largest design driver.
- Superstructure: the frame of the building required to support the suspended slabs, roof and internal finishes, providing stability.
- Façade: the external faces of a building.
- Building Services: these comprise the lighting, heating, cooling, ventilation, power supply, air conditioning plant any other building system

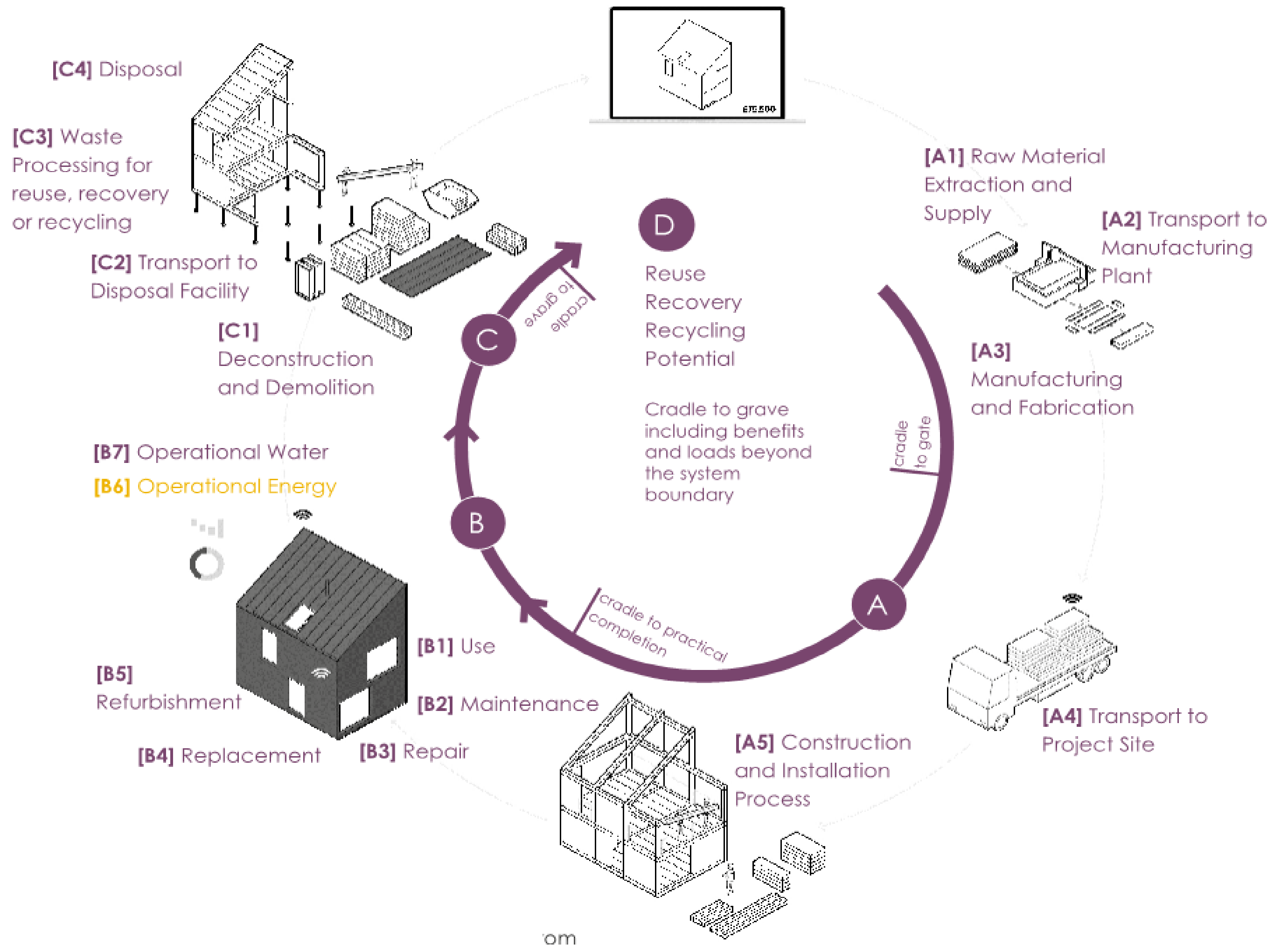

Figure 11 Whole life Carbon Stages (Adapted form LETI Embodied Carbon Primer)

- Building services have a relatively short lifespan compared to the building itself. Embodied carbon needs to be considered in parallel with operational carbon, lifespan, maintenance, comfort, health and safety, etc.
- Internal Finishes: the materials used on all exposed interior surfaces, such as floors, walls and ceilings. These are replaced more frequently and can require significant maintenance.
- External Works: This covers hard and soft landscaping on ground floor level, terraces, roofs and also below ground items such as irrigation tanks.

20.2 Benchmark Targets

At present, there are no benchmarks or guidance for embodied carbon covered by national legislation of policy. The London Energy Transformation Initiative (LETI) and the Greater London Authority (GLA) have produced benchmarks and targets for different buildings uses.

	Business as usual	2020 target
Residential	800 $kgCO_2e/m^2$	400-500 $kgCO_2e/m^2$

Figure 12 - LETI target values for embodied carbon in residential buildings

21. EMBODIED CARBON RESULTS

The embodied carbon of the houses within the development has been calculated using OneClick Life Cycle Assessment software.

In line with RICS methodology and ES 15978 all building elements in Section 23.1 have been assessed. Materials and construction information has been provided by the Client.

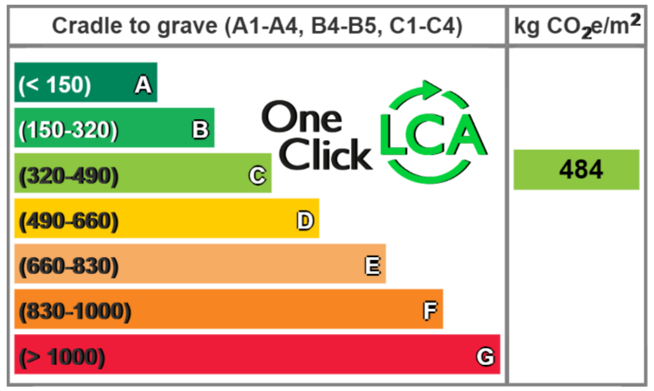

Figure 14 - Cradle to Grave embodied carbon emissions for the development

The embodied carbon emissions for the development are within the target range of 400-500 $kgCO_2e/m^2$ provide by LETI for 2020. This is a significant improvement over the 'business as usual' emissions of 800 $kgCO_2e/m^2$. One of the key drivers behind this level of performance, is the MMC (modern method of construction) timber frame system which will provide the structure and external wall system for the dwellings on site.

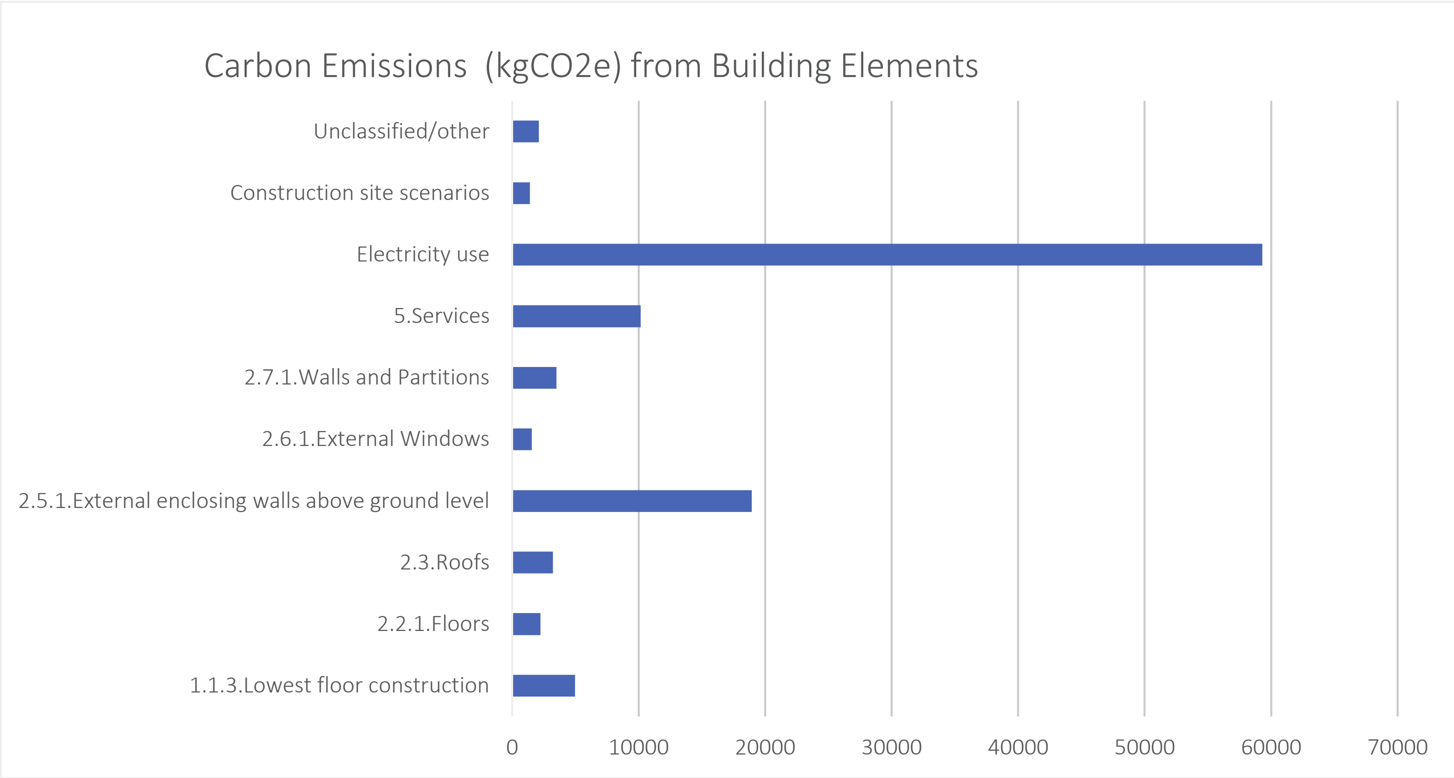

Figure 13 - Carbon emission from building elements

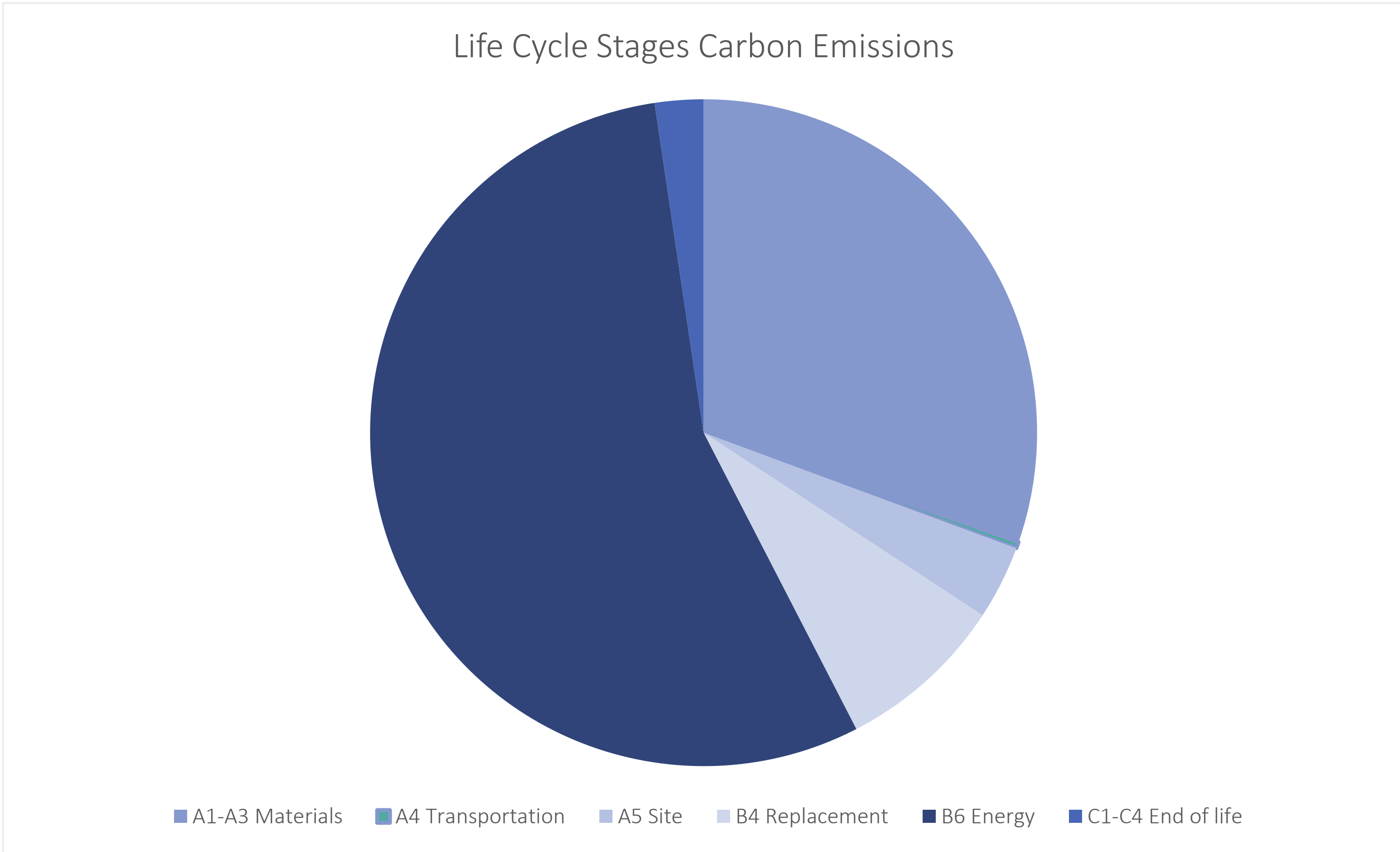

Figure 15 - Life cycle stages carbon emissions

Delivering Net Zero at Himley Village - Site Wide Approach

The section details the proposed strategy across the site to ensure that the Himley Village proposals as a whole will meet the net zero carbon requirement.

22. IMPORTANCE OF ENERGY USE INTENSITY

Energy efficiency is vital for a rapid transition to zero carbon as it reduces energy demand and therefore, the energy generation capacity required.

Currently, Building Regulations use carbon as the key metric to assess the energy efficiency and sustainability of a building but there are a number of problems with this:

- Carbon factor values used in current Building Regulations are out of date, they do not account for decarbonisation of the grid;
- Carbon factor for electricity is fixed – in reality this fluctuates dependent on power generation technologies at any one time;
- Energy consumption calculations are over-simplified and under-estimate in use consumption;
- Comparison of the predicted performance of a building with its in-use performance is not possible without bespoke metering arrangements.

Energy Use Intensity (EUI) measured in kilowatt hours per m^2 per year (kWh/m^2/annum) is the total amount of energy consumed by a building on an annual basis divided by floor area which allows easy and direct comparison of building performance.

EUI removes 'carbon intensity' which has less relevance as fossil fuels are removed for heating and is widely adopted by best practice guidance for achieving Operational Net Zero.

In relation to Net Zero, the EUI of a building is counterbalanced with renewable generation of electricity equal to the Energy use, commonly referred to as the Net Zero Energy Balance. As EUI is easily measured in-use by totalling the annual energy consumption from utility bills (in kWh), the EUI of a building can be set at the design stage, compared with the in-use values and dynamic energy modelling (where available) to obtain an accurate prediction of energy use in operation.

Using EUI as a metric allows the development to not only reduce carbon emissions, but also provide a robust approach to tackling issues such as:

- Net zero
- Grid capacity
- Fuel cost to residents and alleviation of fuel poverty
- Operational efficiency (performance gap)
- Long term asset value (ESG criteria)
- Autonomy over supply and resilience (ability to manage and offset grid pricing fluctuations etc).

Table 7 - Himley Village EUI breakdown comparison to Part L and RIBA 2030.

Domestic EUI	Heating	Hot Water	Lighting	Unregulated energy	**Target EUI per phase**
	(kWh/m^2/yr)				
Part L 2021	78.1	20.4	0.9	20.6	**120.0**
RIBA 2025	11.4	14.0	1.5	33.0	**60.0**
Phase 1	18.9	9.9	2.5	23.3	**54.6**
Phase 2	8.6	10.5	1.1	24.8	**45.0**
Phase 3 - LETI	6.6	8.2	0.9	19.3	**35.0**

Table 8 – Non-domestic EUI comparisons

Non-domestic EUI	Heating	Hot Water	Cooling	Lighting	Unregulated energy	Total
	(kWh/m^2/yr)					
Part L	7.9	16.2	37.5	6.9	61.6	130
RIBA 2025	14.5	8.6	4.3	5.9	41.8	75
RIBA 2030	10.7	6.3	3.1	4.4	27.2	55

23. COMPARING AGAINST INDUSTRY BENCHMARKS

23.1 Energy Efficiency Requirements

RIBA 2030 guidance has broken down how both residential and non-domestic developments can achieve zero carbon on plot (see Table 7 and Table 8).

23.2 Green Skills Gap

Employers are learning that many of the high-performance green buildings built over the last decade are not living up to their energy efficiency potential because there is a green skills gap amongst building operators and building technicians. Without a skilled workforce, these buildings will not provide the environmental or the financial return on investment as expected.

LETI Climate Emergency Design Guides[1] states that, for each dwelling to achieve zero carbon 'on plot' the total EUI (Energy Use Intensity) must be 35kWh/m^2/yr, or lower. However, due to the current green skills gap for 'passivhaus' level performing fabric, this EUI is extremely difficult to achieve in practice and at scale where optimal orientation to reduce demand may also not be possible for every home.

Although the first phases of the site will need extra ground mount PV to meet zero carbon, the later build out of the site will be able to target a lower EUI due to the industry's increased construction of building fabric which align with RIBA 2030 and LETI standards along with the construction industry taking the necessary steps to meet the skills required to build to this standard.

On this basis, a phased reduction of EUI is proposed across the development to align with LETI requirements at (or before Phase 3). The overall target EUI per phase will be met to ensure a known requirement for additional energy generation to ensure overall net zero is met across Himley Village.

An indicative breakdown is provided of how these EUI targets can be met (Phase 1 is supported by the energy modelling work undertaken specific to this first phase of development) but it is key to the future design flexibility of the wider site that these can be achieved utilising alternative specifications and technologies.

Further detail is provided over the following sections to ensure CDC understand the proposed route and the additional off plot generation required for earlier phases.

24. INCREASED RENEWABLE ENERGY OPPORTUNITY

The wider Himley site will include commercial buildings a school and community spaces. These buildings are typically designed to have flat roofs, which means, there will be a larger proportion of available roof area for PV installation.

As the wider site will be able to produce a higher kilowatt peak through PVs per plot, there may be an incentive to include batteries in the design. This will bridge the gap between demand and supply for energy and ensure all energy produced by the PVs is used on site first before exporting to the grid.

[1] LETI Climate Emergency Design Guide [2020]

25. PHASE BUILD OUTS

As the site will be built out over a few years, the buildings will be able to target lower EUIs over time.

Phase 1 includes the first 500 homes for Himley Village which will use the fabric and system efficiencies laid out in this report. The energy demand will be balanced through both roof mounted and nearby ground mount PV installation. Any residual emissions which cannot be accommodated due to land availability within the Himley site may be addressed via an offset method agreed with the Council.

Phase 2 of the site will target RIBA 2025 benchmarks for commercial buildings whilst further improving on the current EUI target for the dwellings. This phase will still require the energy demand to be balanced through both roof mounted and ground mounted PV. However, the kilowatt peak per square metre required to be generated through the ground mounted PV will be reduced. The offsetting method agreed in phase 1 can be used in phase 2 if the land provided does not have space for the required PV.

Phase 3 of the site will target LETI standards for dwellings, commercial buildings and schools. The energy will be balanced through roof installed PV alone. Phase 3 will be any part of the site built after 2025.

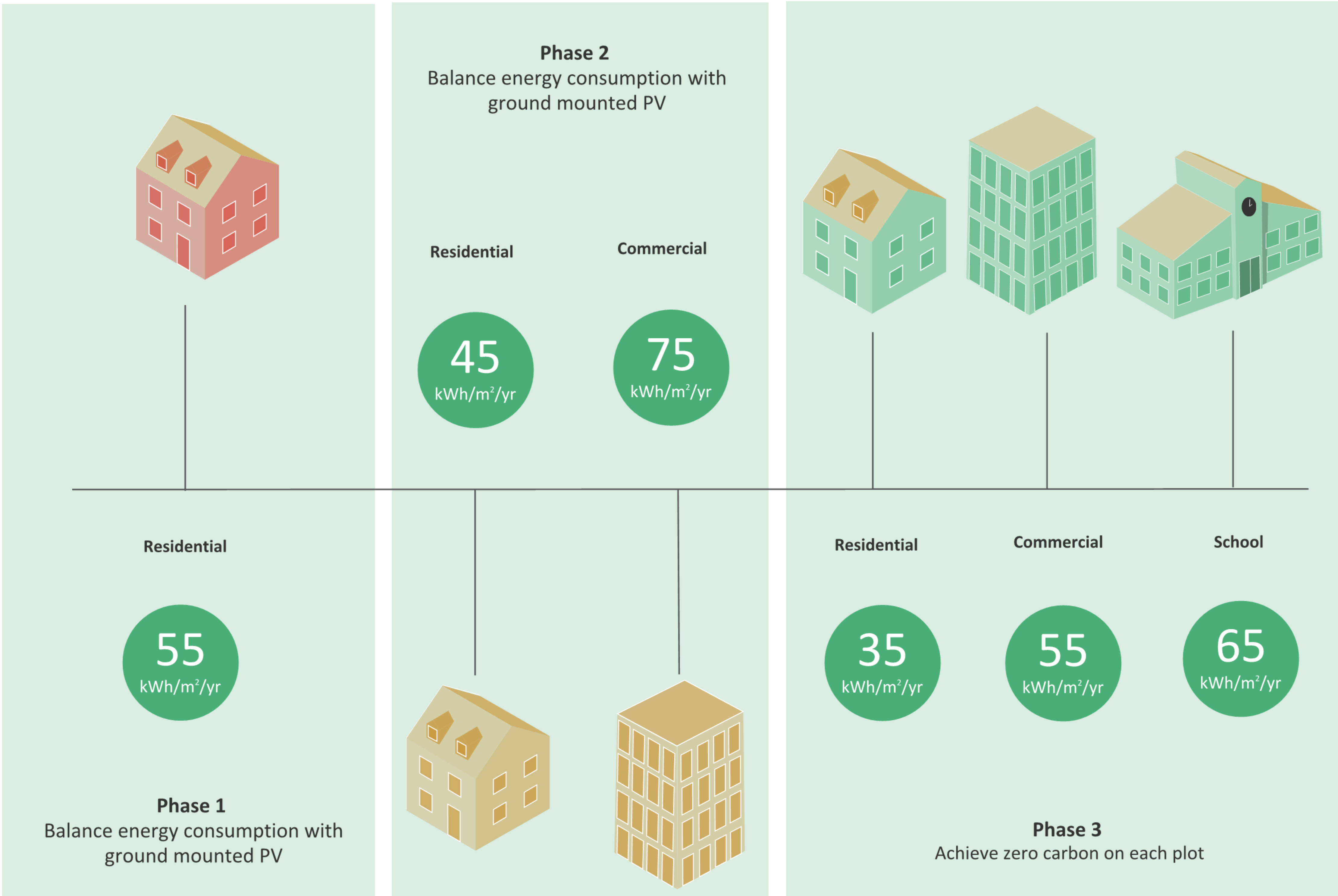

Figure 16 - EUI per Phase build out of the wider site

25.1.1 Lowering the EUI

Each phase will need to introduce new design criteria to reach the target EUI. Figure 17 shows the steps required to reduce the EUI from Part L standards to the LETI target of 35kWh/m².yr

The majority of energy saving will come in the first phase, through the use of heat pumps and improved building fabric. The next phases continue to push the energy efficiency through tighter building fabric and increased heat pump efficiencies. The unregulated energy will see savings through increasingly low energy plug ins. Smart meters will also be installed to provide users with real time data. This will help to inform their decisions and reduce usage, where feasible.

Figure 18 shows that the main change between phase 1 and 3 is the heating demand. This will be improved by the closing of the green skills gap.

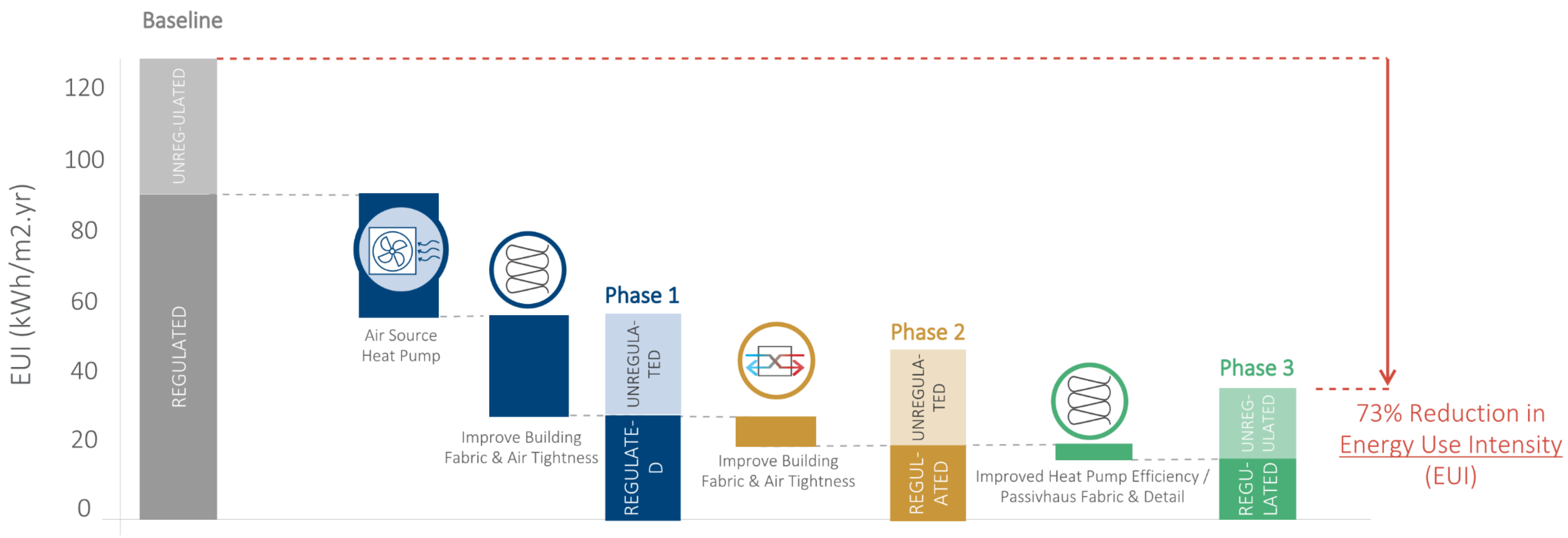

Figure 17 - EUI Step down graph

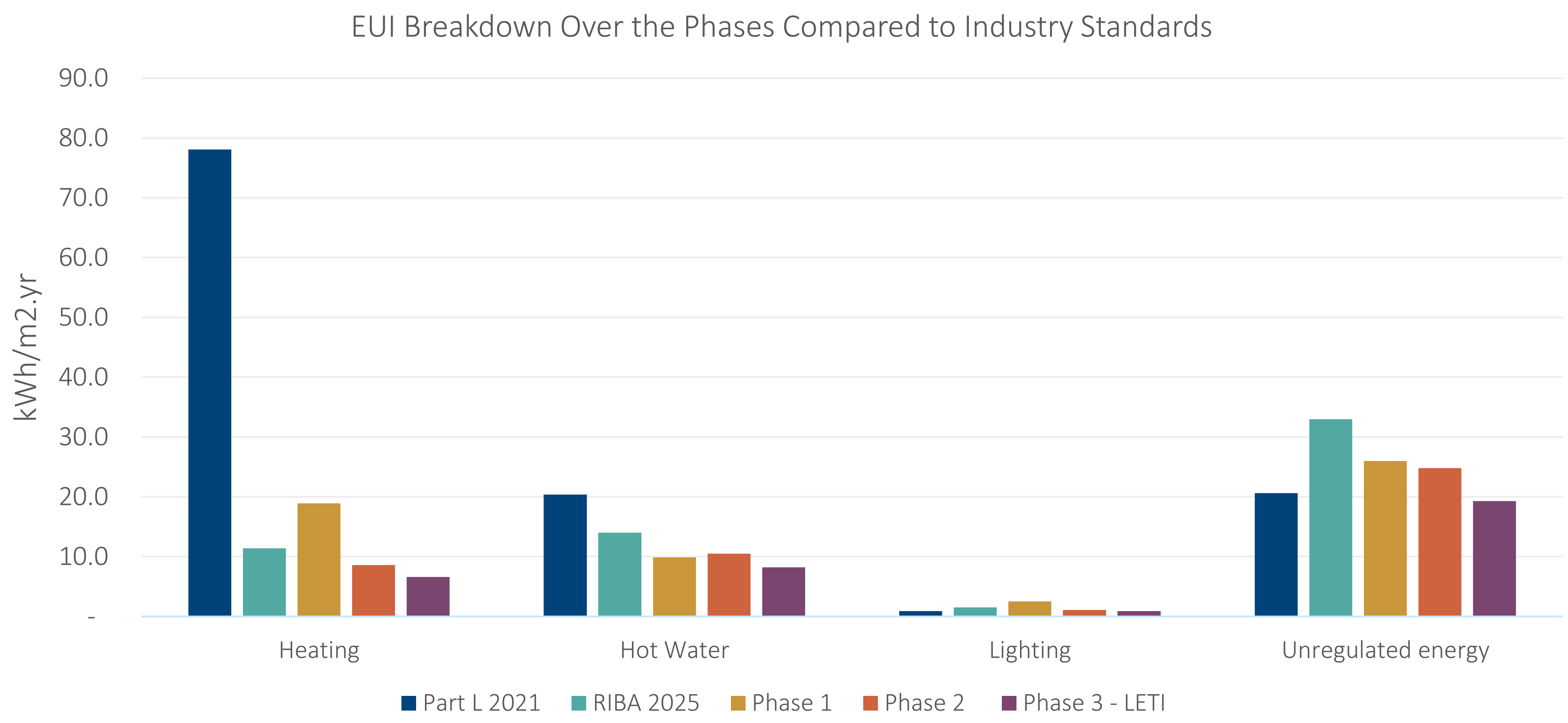

Figure 18 - EUI Breakdown over the phases compared to Industry Standards

Conclusions

This report has provided an overview of the calculated carbon emissions for the first phase of the Himley Village development, and the measures in place to reduce on-site carbon emissions.

The development has been designed to minimise on-site energy use and carbon emissions in line with the energy hierarchy, and has sought to meet the requirements of Policy Bicester 1 of the Cherwell Local Plan.

26. PASSIVE DESIGN

The design team have worked to incorporate passive design principles into the scheme from the outset of the project. Building fabric has been specified in excess of the current Part L Notional Building, and is broadly in line with the proposed standards contained within the Future Homes Standard. As the development will likely be built out during transitional arrangements for the updated to Part L that will be brought in during 2022, all carbon emissions figures have been calculated using the carbon factors proposed within SAP 10.1 These provide a more accurate picture of the actual carbon emissions for the development compared to those currently used for SAP12 and Part L1A calculations.

In addition to good levels of building fabric efficiency, dwellings have been oriented to have south facing aspects where possible to maximise solar gains and reduce heating demands. Tree planting and green infrastructure throughout the site will provide shading during the summer months to mitigate overheating risk.

Table 9 - Carbon emissions at each stage of the energy hierarchy

	Regulated Carbon kgCO2/yr	Unregulated Carbon kgCO2/yr	Total Operational Carbon kgCO2/yr	Total Operational Carbon Reduction kgCO2/yr	Percentage Reduction
Baseline Carbon Emissions	815,778	319,022	1,134,799	NA	NA
After Be Green ASHP	182,538	233,850	416,388	718,411	63%
After Be Green PV	0	123,648	123,648	292,740	70%
Total				1,011,152	89%

Table 10 - Energy use intensity at each stage of the energy hierarchy

Energy Hierarchy Stage	Total Energy Use kWh/m2/yr	Heating Energy Use kWh/m2/yr	Hot Water Energy Use kWh/m2/yr	Lighting Energy Use kWh/m2/yr	Unregulated Energy Use kWh/m2/yr
Baseline	120.8	56.9	27.7	4.4	31.8
After Energy Efficient Measures	54.6	18.9	9.9	2.5	23.3
Total Energy Reduction	55%	67%	64%	44%	27%

27. HEATING AND HOT WATER GENERATION

To be fully aligned with the Future Homes Standard, and to take advantage of the rapid decarbonisation of the national grid, the development will be gas free and all heating and hot water generation will be provided by air source heat pumps (ASHPs).

ASHPs will be provided at an individual dwelling level, and will be sited external to the dwellings to allow for air circulation around the unit. The ASHPs will be sized to provide 100% of the heating and hot water demand, with an electric immersion heater provided for top up if required.

28. POWER GENERATION AND RENEWABLES

Following the use of ASHPs, carbon emissions will be reduced further by the installation of photovoltaic panels. The design team have provided iterative updates to the site layout to maximise the number of available roof spaces. All roofs that are facing east, south east, south, south west and west will have PV panels installed, this equates to a total installed capacity of 1,420 kWp. The PV array will provide a total of 1,256,397 kWh/yr in renewable electricity for the development.

29. SUMMARY OF ENERGY USE AND CARBON EMISSIONS REDUCTION

A summary of the carbon emissions at each stage of the energy hierarchy are shown in Tables 8 and 9.

Whilst the development is committed to meeting the net zero carbon requirement outlined in Condition 20 of the outline planning permission, it is not feasible to achieve zero carbon through roof mounted PV alone. The initial site will make up the rest of the carbon emissions through a local offset method agreed by the council of either a utilising local land for ground mounted PV or an offset fund via section 106 which will be deploy more renewables in later phases.

To meet the energy demand for phase 1, the ground mount PV will need to generate 600 kWp, which will need approximately 2.1 acres of land. This will ensure that the first build out of the site achieves zero carbon.

The latter stages of the masterplan will consist of higher density residential developments, commercial, health and education uses. Medium to high density residential developments can significantly outperform low rise houses in terms of their carbon performance with similar building fabric and heating systems installed as flatted developments are better at retaining heat than semi-detached and detached properties.

The non-residential uses within the wider masterplan will be equipped with large, flat roofed areas. There will be significant opportunity here to maximise the installation of PV across these buildings. The later build outs of the wider site will also benefit from improvements the closing green skills gap, enabling the site to target lower building fabric.

30. CLIMATE CHANGE ADAPTATION

In order to adapt to the future climate, the development has included a number of mitigation measures. This includes:

- Designing dwellings in line with CIBSE TM59 requirements for future climate scenarios. This will be achieved through passive design and natural ventilation via openable windows;
- SUDs will be provided throughout the site to provide attenuation and storage of rainwater to adapt to future precipitation levels.
- Significant green infrastructure to provide shading to pedestrianised areas and passive cooling, along with wellbeing and biodiversity benefits.

31. EMBODIED CARBON

The development has sought to reduce carbon emissions embodied within construction products and processes. The embodied carbon emissions for the development have been calculated in line with RICS and EN 15978 methodology using construction details and information provided by the Client.

The embodied carbon emissions rate for the development is 484 $kgCO_2e/m^2$, which is in line with the 2020 target values provided by LETI, and a significant improvement on the ‘business as usual’ case.

Appendix A Carbon and energy use figures per modelled unit type

SAP 10.1 Carbon Factors (Not including PV, this has been calculated on a site wide basis not plot by plot)

House Type	Area (m2)	TER (kgCO2/m2)	DER (kgCO2/m2)
Irwel	61.5	21.96	5.2
Grantham	77.76	19.86	4.5
Ashop	86.92	19.49	4.1
Dee	99.12	18.63	3.8
Avon	105.2	18.32	3.6
Average		19.7	4.2
Site Wide		846,091	182,538

Baseline Energy Use kWh/yr

House Type	Area (m2)	Heating and DHW Energy Demand kWh/yr	Lighting Energy Demand kWh/yr	Unregulated Energy Demand kWh/yr	Total Energy Demand kWh/yr
Irwel	61.5	5,264	271	1,956	7,492
Grantham	77.76	6,656	343	2,473	9,472
Ashop	86.92	7,440	383	2,764	10,588
Dee	99.12	8,485	437	3,152	12,074
Avon	105.2	9,005	464	3,346	12,815
Average		7,370	380	2,738	10,488
Site Wide		3,685,028	189,931	1,369,191	5,244,151

After Be Green ASHP Energy Use kWh/yr

House Type	Area (m2)	Heating and DHW Energy Demand kWh/yr	Lighting Energy Demand kWh/yr	Unregulated Energy Demand kWh/yr	Total Energy Demand kWh/yr
Irwel	61.5	1,773	151	1,599	3,523
Grantham	77.76	2,242	191	2,022	4,454
Ashop	86.92	2,506	213	2,260	4,979
Dee	99.12	2,858	243	2,577	5,678
Avon	105.2	3,033	258	2,735	6,026
Average		2,482	211	2,239	4,932
Site Wide		1,241,140	105,586	1,119,300	2,466,026

Appendix B PV Details Per Dwelling

House No	No. Roof	Area space	Configeration	No. Modules	Orientation	kWp p.plot	Total kWp	kWh p.a.	Total kWh p.a.
1	1	4400 x 5900	Portrait	10.0	110	4	4	825	3,218
2	1	3700 x 6200	Portrait	12	110	5	5	825	3,861
3+4	2	5000 x 6700	Portrait	10	200	4	8	952	7,426
5+6	2	4800 x 4500	Portrait	8	200	3	6	952	5,940
7+8	2	2500 x 9500	Landscape	10	110	4	8	825	6,435
9+10+11+12	4	4400 x 4500	Portrait	8	200	3	12	952	11,881
13	1	2600 x 8700	Landscape	10	110	4	4	825	3,218
14+15	2	5000 x 7900	Portrait	14	110	5	11	825	9,009
16+17+18+19+20+21	6	4400 x 5700	Portrait	10	110	4	23	825	19,305
22+27	2	2600 x 6300	Landscape	6	110	2	5	825	3,861
23+24	2	4600 x 6300	Portrait	12	200	5	9	952	8,911
25+26	2	4500 x 4100	Portrait	8	200	3	6	952	5,940
28+29	2	4500 x 4100	Portrait	8	110	3	6	825	5,148
30+31	2	4500 x 4100	Portrait	8	110	3	6	825	5,148
32+33	2	4300 x 5400	Portrait	10	110	4	8	825	6,435
34+35	2	4300 x 5400	Portrait	10	110	4	8	825	6,435
36	1	9200 x 6700 (H)	Portrait	10	200	4	4	952	3,713
38+41	2	4800 x 4500	Portrait	8	200	3	6	952	5,940
39+40	2	2800 x 9700	Landscape	10	200	4	8	952	7,426
42	1	2800 x 8700	Landscape	10	110	4	4	825	3,218
43-46	1	3200 x 18700	Landscape	22	110	9	9	825	7,079
47	1	2800 x 8700	Landscape	10	110	4	4	825	3,218
48+49	2	4800 x 4400	Portrait	8	200	3	6	952	5,940
51	1	2600 x 6300	Landscape	6	200	2	2	952	2,228
52	3	4300 x 5400	Portrait	10	110	4	12	825	9,653
53+54	2	4500 x 4100	Portrait	8	110	3	6	825	5,148
55	1	2600 x 6300	Portrait	6	110	2	2	825	1,931
56+57+57+59	4	4300 x 5400	Portrait	10	185	4	16	960	14,976
60	1	2600 x 6300	Landscape	6	185	2	2	960	2,246
61+62+63+64	4	4300 x 5400	Portrait	10	100	4	16	811	12,652
65	1	2600 x 6300	Landscape	6	185	2	2	960	2,246
66-71	1	3200 x 18700	Landscape	22	110	9	9	825	7,079
66-71	1	9200 x 3300	Landscape	10	200	4	4	952	3,713
73+76+77+79+82+83+86+88+89	9	4800 x 4500	Portrait	8	200	3	28	952	26,732
75+81+85+87+91	5	2800 x 9700	Landscape	10	110	4	20	825	16,088
92+93+94	3	5500 x 7800	Portrait	12	110	5	14	825	11,583
95+96+97	3	4800 x 4500	Portrait	8	110	3	9	825	7,722
98 +100	2	2800 x 9700	Landscape	10	110	4	8	825	6,435

House No	No. Roof	Area space	Configeration	No. Modules	Orientation	kWp p.plot	Total kWp	kWh p.a.	Total kWh p.a.
99	1	4800 x 4500	Portrait	8	110	3	3	825	2,574
102+103+104	3	4800 x 4500	Portrait	8	110	3	9	825	7,722
105+106+107	3	4500 x 4100	Portrait	8	110	3	9	825	7,722
108+109+110+111+112+113	6	4800 x 4500	Portrait	8	110	3	19	825	15,444
114	1	2800 x 9700	Landscape	10	185	4	4	960	3,744
115 + 17	2	2800 x 9700	Landscape	10	110	4	8	825	6,435
116	1	4800 x 4500	Portrait	8	200	3	3	952	2,970
118+119+120+121	4	4500 x 4100	Portrait	8	110	3	12	825	10,296
122	1	2800 x 9700	Landscape	10	110	4	4	825	3,218
123+124	2	4800 x 4500	Portrait	8	200	3	6	952	5,940
125+129	2	2800 x 9700	Landscape	10	200	4	8	952	7,426
126+127+128+139+140+141	6	4800 x 4500	Portrait	8	110	3	19	825	15,444
130+132+134+150+152	5	2800 x 9700	Landscape	10	110	4	20	825	16,088
144+143+142	3	4800 x 4500	Portrait	8	100	3	9	811	7,591
138+137+136	3	4800 x 4500	Portrait	8	110	3	9	825	7,722
146+147	2	4800 x 4500	Portrait	8	175	3	6	960	5,990
148	1	2800 x 4500	Landscape	10	100	4	4	825	3,218
159	1	3300 x 9200	Landscape	10	110	4	4	825	3,218
156+157+161+162+168+169	6	4800 x 4500	Portrait	8	200	3	19	952	17,821
159	1	2800 x 9700	Landscape	10	110	4	4	825	3,218
165+166+172+173+174+175+178+177+179+180	10	4800 x 4500	Portrait	8	185	3	31	960	29,952
171	1	3300 x 9200	Landscape	10	200	4	4	952	3,713
181-184	1	6600 x 9400	Portrait	24	100	9	9	825	7,722
185-190	1	6600 x 9400	Portrait	24	200	9	9	952	8,911
195+213+216	3	2800 x 9700	Landscape	10	200	4	12	952	11,138
194+214+215+216+217+208+201+202	8	4800 x 4500	Portrait	8	200	3	25	952	23,762
196+197+198+199+210+211+212+205+206+203+204	11	4800 x 4500	Portrait	8	185	3	34	960	32,947
191+192+193	3	4800 x 4500	Portrait	8	225	3	9	912	8,536

House No	No. Roof	Area space	Configeration	No. Modules	Orientation	kWp p.plot	Total kWp	kWh p.a.	Total kWh p.a.
262+261+260+259+254+253+251+250	8	4800 x 5400	Portrait	10	225	4	8	912	7,114
255	1	3600 x 9700	Landscape	10	135	3	6	912	5,691
257	1	3600 x 9700	Landscape	10	165	3	19	825	15,444
269+268	2	4800 x 5400	Portrait	10	110	4	4	825	3,218
267+268	2	Hips	Portrait	6	110	3	6	960	5,990
285	1	3600 x 9700	Landscape	10	185	4	4	960	3,744
284+283	2	Hips	Portrait	6	200	4	8	912	7,114
282+281+280+279+269+270+271	7	4800 x 4500	Portrait	8	200	3	6	825	5,148
278+277	2	Hips	Portrait	6	185	4	8	825	6,435
276	1	3600 x 9700	Landscape	10	185	4	8	912	7,114
274+275	2	4800 x 5400	Portrait	10	100	4	8	912	7,114
273	1	2800 X 9700	Landscape	10	135	2	9	912	8,536
300+301+302+303	4	4800 x 4500	Portrait	8	110	3	6	912	5,691
299+296	2	4800 x 4500	Portrait	10	110	4	4	912	3,557
297+298	2	3600 x 9700	Landscape	10	200	4	4	912	3,557
294	1	4800 x 4500	Portrait	10	200	4	31	912	28,454
293+290	2	4800 x 4500	Portrait	10	200	4	4	912	3,557
307+306+305+304	4	4800 x 5400	Portrait	10	200	4	4	888	3,463
309+310+311+312+316+317	6	4800 x 4500	Portrait	8	110	4	8	825	6,435
313+314	2	Hips	Portrait	6	200	2	5	825	3,861
315	1	3300 x 9700	Landscape	10	200	4	4	960	3,744
316+319	2	4800 x 5400	Portrait	10	135	2	5	952	4,455
327+328+329+330	4	4800 x 4500	Portrait	8	225	3	22	952	20,792
320+321	2	4800 x 5400	Portrait	10	135	2	5	825	3,861
322	1	Hips	Portrait	6	135	4	4	960	3,744
323	1	3300 x 9700	Landscape	10	135	4	8	811	6,326
324+325	2	3300 x 9700	Landscape	10	225	4	4	913	3,561
331+334+341	3	3300 x 9700	Landscape	10	225	3	12	828	10,333
332+333	2	4800 x 5400	Portrait	10	135	4	8	825	6,435
335	1	Hips	Portrait	6	225	4	8	952	7,426

House No	No. Roof	Area space	Configeration	No. Modules	Orientation	kWp p.plot	Total kWp	kWh p.a.	Total kWh p.a.
361	1	3300 x 9700	Landscape	10	240	4	20	912	17,784
363+368	2	4800 x 5400	Portrait	10	135	4	8	912	7,114
365+367	2	2700 x 9700	Landscape	8	135	4	8	912	7,114
370	1	3300 x 9700	Landscape	10	185	4	4	912	3,557
388+389+390	3	4800 x 4500	Portrait	8	240	4	4	912	3,557
391+392	2	4800 x 4500	Portrait	8	135	2	5	912	4,268
393	1	4800 x 5400	Portrait	10	135	4	4	912	3,557
395+396+397+398	4	Hips	Portrait	6	110	4	4	912	3,557
399	1	3300 x 9700	Landscape	10	200	4	8	912	7,114
377+378+360+382+384	5	4800 x 4500	Portrait	8	200	4	8	825	6,435
361+388	2	4800 x 4500	Portrait	8	185	4	8	912	7,114
402+405+406+407+408+411+417	7	4800 x 5400	POrtrait	10	110	4	27	825	22,523
403+404+409+410	4	Hips	Portrait	6	110	4	4	912	3,557
414+415+416	2	7700 x 5500	Portrait	12	110	4	4	912	3,557
412	1	3300 x 9700	Landscape	10	200	4	8	912	7,114
413	1	Hips	Portrait	6	200	3	6	912	5,691
434	1	3300 x 9700	Landscape	10	225	4	4	960	3,744
435	1	4800 x 4500	Portrait	8	225	3	9	825	7,722
436+437+438+439+418+419+420	7	3300 x 9700	Landscape	10	110	3	6	912	5,691
421	1	4800 x 4500	Portrait	8	110	4	4	912	3,557
424	1	4800 x 5400	Portrait	10	225	2	9	825	7,722
425+426+430+432+429	5	4800 x 5400	Portrait	10	110	4	4	952	3,713
431+428+427	3	Hips	Portrait	6	110	3	16	952	14,851
440-443	1	3300 x 9300	Landscape	10	225	3	6	960	5,990
440-443	1	3300 x 6500	Landscape	6	135	4	27	825	22,523
444-447	1	3300 x 6500	Landscape	6	110	2	9	825	7,722
452+453+454+455+456+461	6	4800 x 5400	Portrait	10	200	5	9	825	7,722
457+458+459+450	4	Hips	Portrait	6	200	4	4	952	3,713
462	1	3300 x 9700	Landscape	10	200	2	2	952	2,228
451+450+449+448	4	4800 x 4500	Portrait	8	110	4	4	912	3,557
500+499+498+497+496+489+488	7	4800 x 5400	POrtrait	10	110	3	3	912	2,845
480+481+482+483	4	3300 x 9700	Landscape	10	200	4	27	825	22,523
484+493+492	3	4800 x 5400	Portrait	10	110	3	3	825	2,574
494+490+485	3	3300 x 9700	Landscape	10	110	4	4	912	3,557