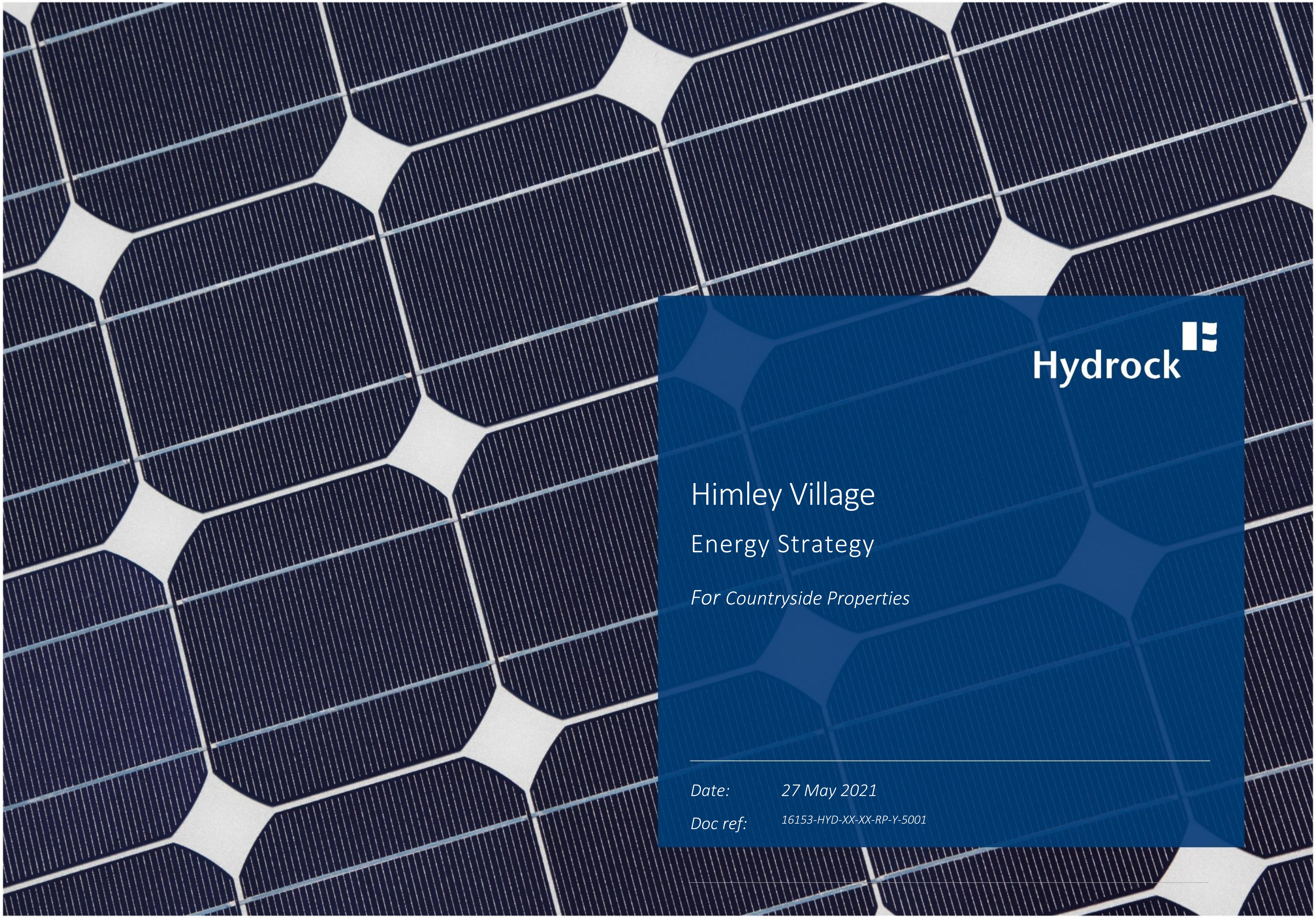

Hydrock

Himley Village

Energy Strategy

For Countryside Properties

Date: *27 May 2021*

Doc ref: *16153-HYD-XX-XX-RP-Y-5001*

DOCUMENT CONTROL SHEET

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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 development.

1. INTRODUCTION

1.1 Purpose of Report

This report has been produced to discharge Conditions 13, 20 and 38 of the Outline Permission 14/02121/OUT. 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).

Commentary will also be provided on embodied carbon emissions (those associated with the manufacturer and transport to site of building materials), however these will not be quantified in the same manner as Regulated and Unregulated carbon emissions.

1.2 Project Description

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

The wider masterplan will provide up to 1,500 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.

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

Regulations, Policy and Guidance

This section of the report highlights the relevant regulations, 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 first published on 27 March 2012 to set 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

A revised NPPF was published in July 2018, focusing on the following key areas:

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

In terms of the environment, the revised 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.

The revised NPPF was updated again on 19 February 2019 but this update included only minor changes to the text to provide additional clarity in some areas.

2.2 Building Regulations Part L1A

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

It is the role of Part L of the Building Regulations to include a minimum 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 toolkit.

The resulting Dwelling Emission Rate (DER) must be less 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 toolkit.

These changing national regulations will drive energy efficiency and carbon reduction improvements in new buildings. It was the intention via progressive changes to Part L to require zero carbon homes by 2016. However, in July 2015 the Government Productivity Plan ("Fixing the Foundations") announced that it would not proceed with the zero-carbon allowable solutions carbon offsetting scheme, or the proposed 2016 increase in on-site energy efficiency standards, committing instead to keeping standards 'under review'.

Recently, the Governments consultation response to the new Part L and Future Homes Standard has been released and urges 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 proposed Part L 2021 will require in a **31% reduction in CO_2** from new dwellings, compared to current standards. This is expected to come into play in 2022. There will be transitional arrangements but unlike previous iterations of Part L this will be on a dwelling by dwelling basis, so any dwellings where work has not started within a reasonable period will not be included within transitional arrangements and be expected to meet the updated Part L.

A consultation to make similar updates to Part L 2A for new non-domestic buildings is also expected in early 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 which will replace the existing figures in SAP 2012. The emissions 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) ($kgCO_{2e}/kWh$)	SAP 10.1 (Pending Part L update - 10/19) ($kgCO_{2e}/kWh$)
Electricity	0.519	0.136
Gas	0.216	0.210

3. LOCAL PLANNING POLICY

3.1 Cherwell Local Plan 2015

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.

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 emissions 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 wit the requirements of Policies ESD1-5.

4. OUTLINE PLANNING CONSENT

The proposed development is subject to outline planning consent 14/02121/OUT. The following Conditions are relevant to this report.

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.

6. ECO-TOWN PLANNING POLICY STATEMENT

This planning policy statement (PPS) provides the standard any eco-town has to adhere to. This was cancelled in March 2015 for all areas excluding North West Bicester.

This document includes standards for a number of key sustainability metrics, including:

- ET7 – Zero carbon in eco-towns
- ET8 – Climate change adaptation
- ET11 – Transport
- ET12 – Healthy lifestyles
- ET14 – Green infrastructure
- ET16 – Biodiversity
- ET17 – Water
- ET18 – Flood risk management

7. NORTH WEST BICESTER SUPPLEMENTARY PLANNING DOCUMENT (2016)

The NW Bicester SPD expands on the requirements of Policy Bicester 1 of the Cherwell Local Plan.

This includes further detail on zero carbon, climate change adaptation, and wider sustainability measures.

Baseline Energy Demand

The baseline energy demand refers to a Building Regulations Part L1A Compliant development. This is the level from which carbon emissions reduction will be measured. These emissions are calculated using the SAP methodology, and all equipment is based on the minimum requirements of Part L.

8. SAP ENERGY MODELLING

The dwellings on site have been assessed under Part L 2013 using the Government's Standard Assessment Procedure (SAP). The apartments have been assessed using Stroma FSAP software.

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

- Grantham
- Irwell
- Dee
- Ashop
- Avon

8.1 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. SAP also takes into account shading devices.

8.2 Internal gains

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

8.3 Building Fabric

The notional building fabric is shown below :

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

Additionally, it has been assumed that the party walls between the apartments and communal corridors are cavity filled/ solid construction.

8.4 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 efficiencies match the case for the notional building.

8.5 Weather data

Weather data is based on the climatic data provided by SAP 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).

8.6 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

9. BASELINE CARBON EMISSIONS AND ENERGY USE

The baseline regulated carbon emissions for the development is **815,778 $kgCO_2$/yr**.

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

For details results for modelling dwellings please see Appendix A.

9.1 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) **319,022 $kgCO_2$/yr.**

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

9.2 Site Wide Baseline Carbon Emissions

The site wide baseline carbon emissions rate for both regulated and unregulated energy is **1,134,800 $kgCO_2$/yr**

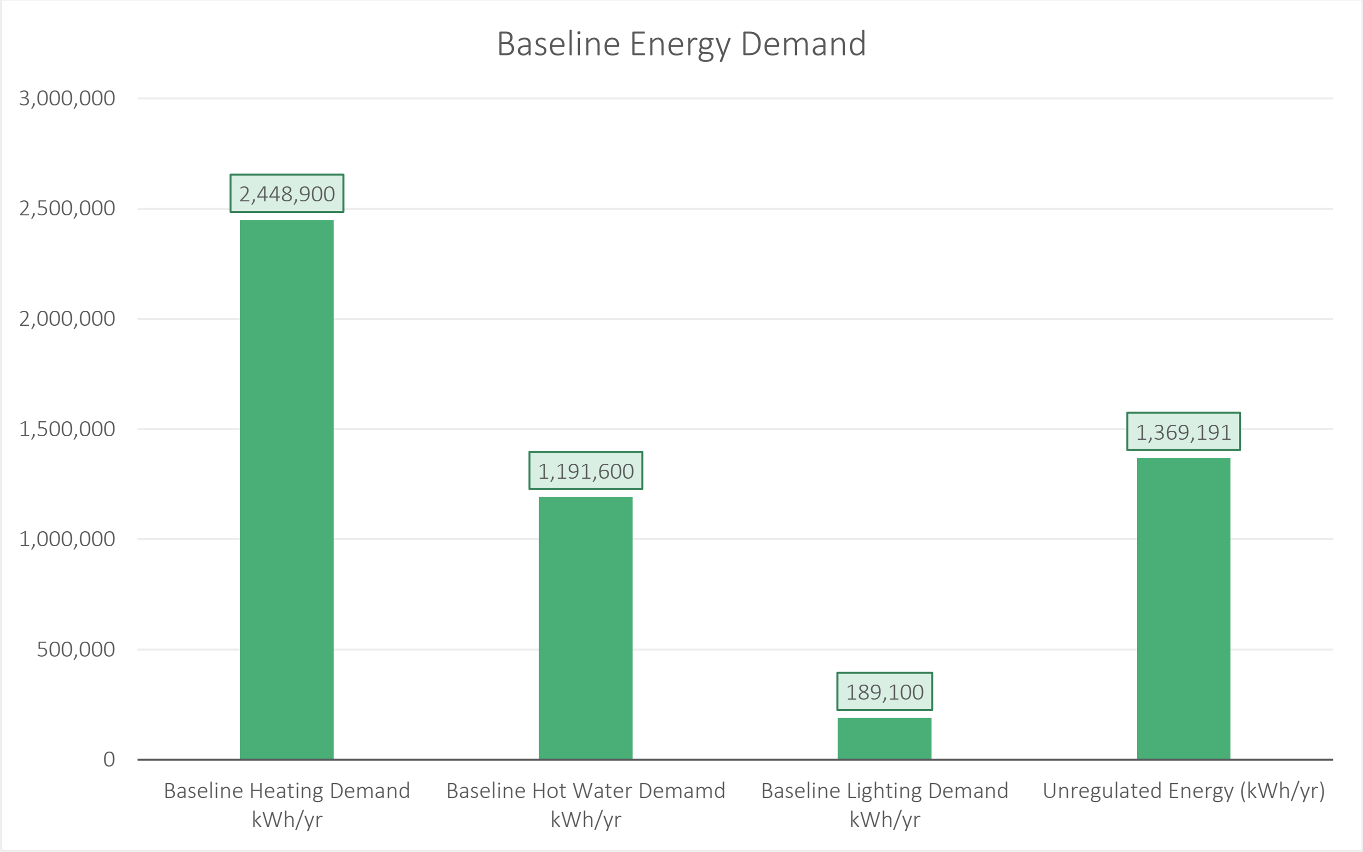

Figure 2 - Baseline energy demand for the development

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.

10. 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 process. The final U-values for the floor, roof and glazing have also been confirmed as per Table 5 below.

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

Building Element	U-value	Improvement over Notional Building
Roof	0.11 W/m^{2}k	15%
Floor	0.15 W/m^{2}k	0%
Walls	0.15 W/m^{2}k	17%
Glazing	1.00 W/m^{2}k	29%

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.

The above U-values are far in excess of the Part L notional building, and are broadly in line with the requirements of the Future Home Standard (with the exception of floor and window values).

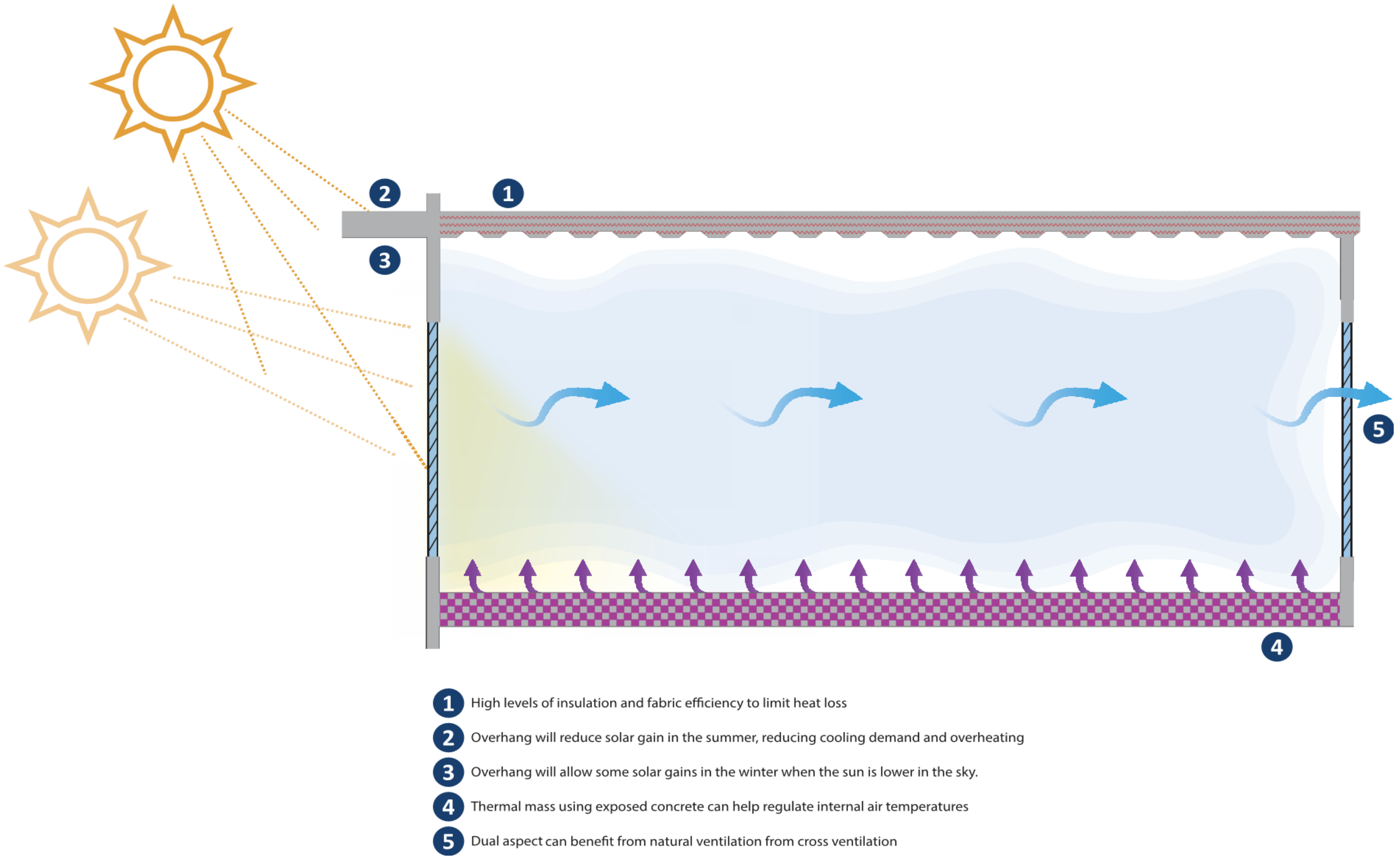

Figure 3 - Passive design measures

11. 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.

11.1 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.

11.2 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.

11.2.1 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. 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.

Figure 4 - Smart meter graphic

12. SUMMARY OF CARBON EMISSIONS

The carbon emissions after the Be Lean stage of the energy hierarchy are shown in the following table and graphics. These include both regulated and unregulated carbon emissions.

Table 4 - Carbon emissions after passive and active design measures (SAP 10.1 carbon factors unregulated and regulated carbon emissions included)

Energy Hierarchy Stage	Carbon Emissions $kgCO_2$/yr	Carbon Reduction $kgCO_2$/yr	Percentage Reduction
Baseline Carbon Emissions	1,134,799	NA	NA
After Be Lean	1,017,241	117,559	10%

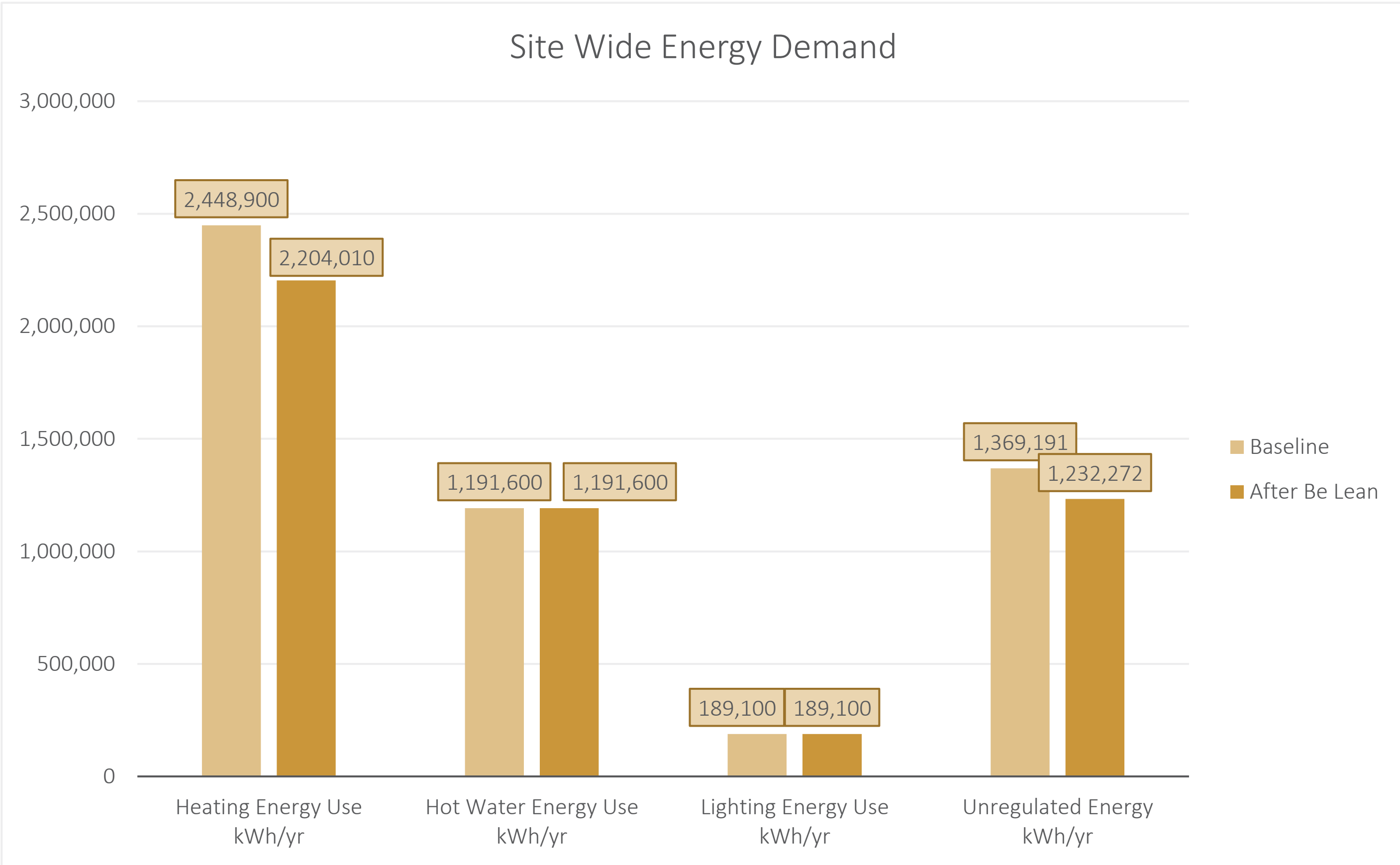

Figure 6 - Site wide energy use after demand reduction

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.

13. DISTRICT HEATING NETWORK

13.1 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.

13.2 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.

14. 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.

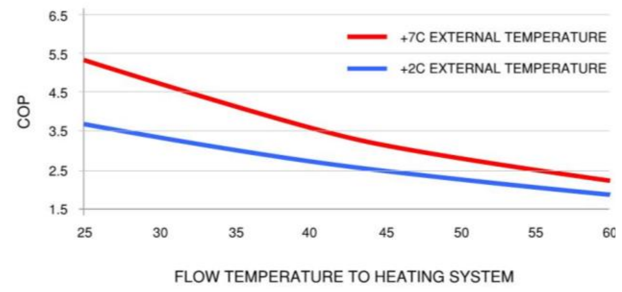

Figure 8: COP as a function of flow temperature for typical ASHP

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 will provide an additional 45% reduction in carbon emissions. This is shown in the following table and graph.

Table 5 - Carbon emissions after the Be Clean stage of the energy hierarchy (Regulated and unregulated energy included)

Energy Hierarchy Stage	Carbon Emissions $kgCO_2/yr$	Carbon Reduction $kgCO_2/yr$	Percentage Reduction
Baseline Carbon Emissions	1,134,799	NA	NA
After Be Lean	1,017,241	117,559	10%
After Be Clean	508,126	509,115	45%

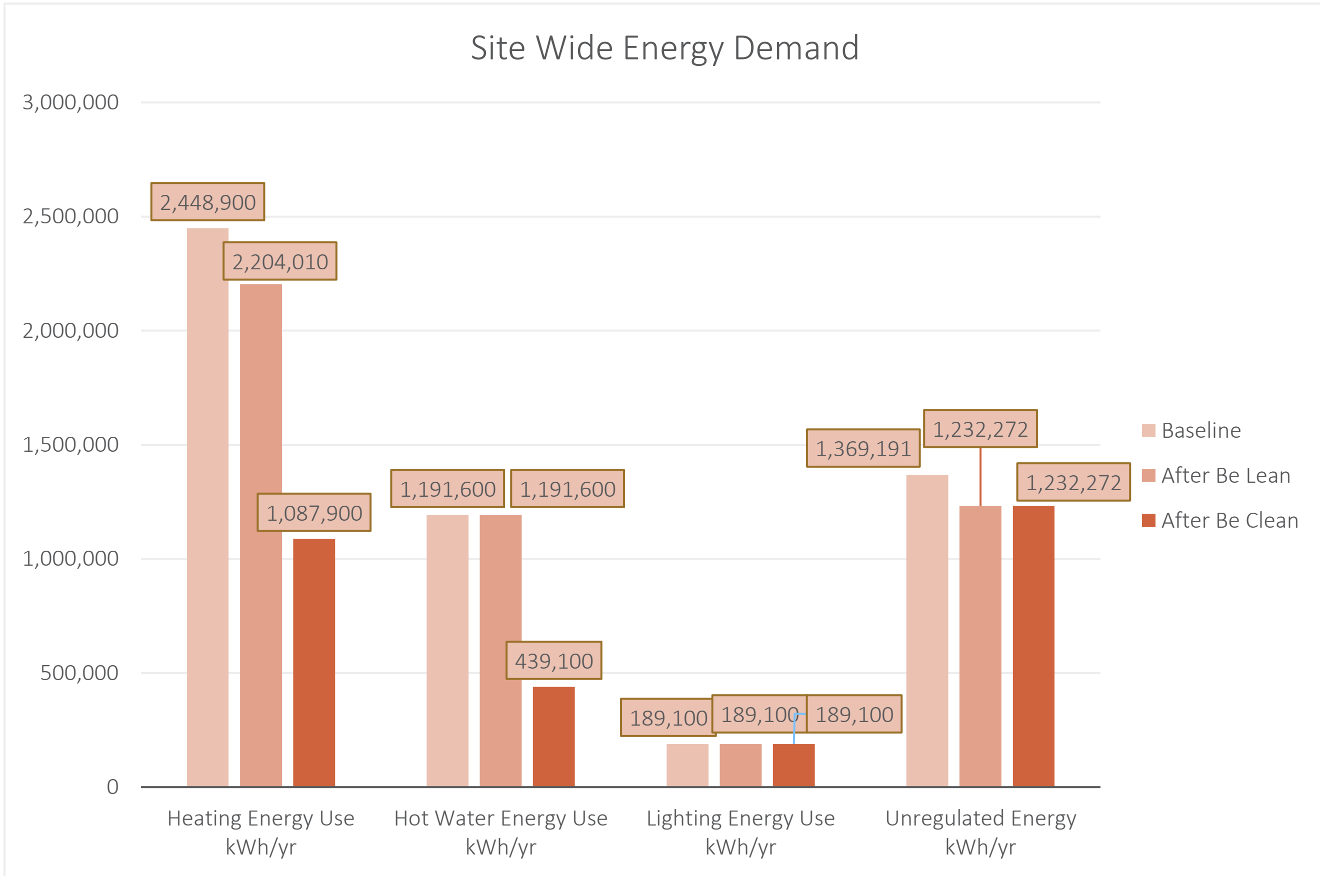

Figure 7 - Energy use for the site after the use of ASHPs

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 508,126 $kgCO_2/yr$ (approximately 1,016 $kgCO_2/yr$ per dwelling) will need to be achieved through the use of renewable or low carbon technologies.

15. 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.

15.1 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.

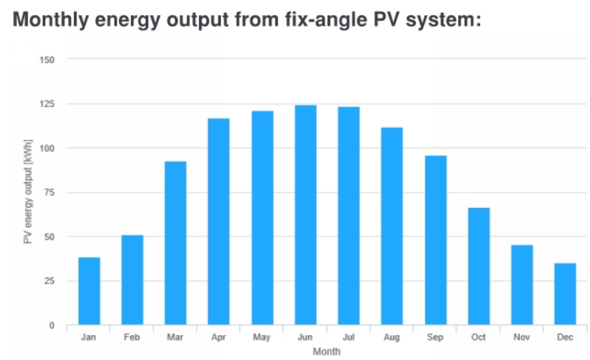

Figure 9: Monthly energy output from solar PV.

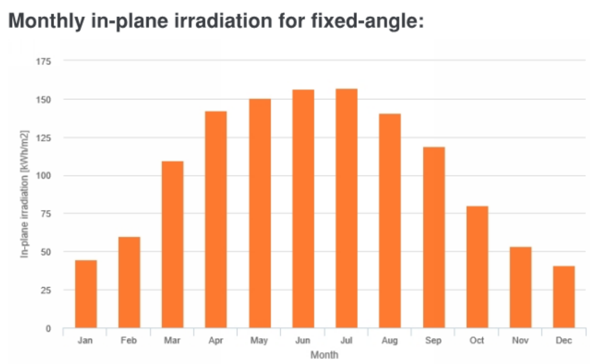

Figure 10: Monthly irradiation for solar PV.

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 15-18% (average) to 21% (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.

15.2 Solar Thermal Panels

Figure 11: 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.

15.3 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.

16. 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 6 - PV installation details

PV Installation Details	
Panel Efficiency	330 W
Total Installation kWp	1092 kWp
Total PV Output	966,459 kWh/yr
Carbon Savings	225,184 $kgCO_2/yr$

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 225,184 $kgCO_2/yr$, this is equivalent to a 20% reduction in carbon emissions from PV alone (taking into account both regulated and unregulated carbon).

Please see Appendix B for PV detailed per dwelling.

16.1 Carbon Emissions Summary

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

Table 7 - Carbon emissions after the implementation of PV (unregulated and regulated emissions included)

Energy Hierarchy Stage	Carbon Emissions $kgCO_2/yr$	Carbon Reduction $kgCO_2/yr$	Percentage Reduction
Baseline Carbon Emissions	1,134,799	NA	NA
After Be Lean	1,017,241	117,559	10%
After Be Clean	508,126	509,115	45%
After Be Green	282,941	225,185	20%

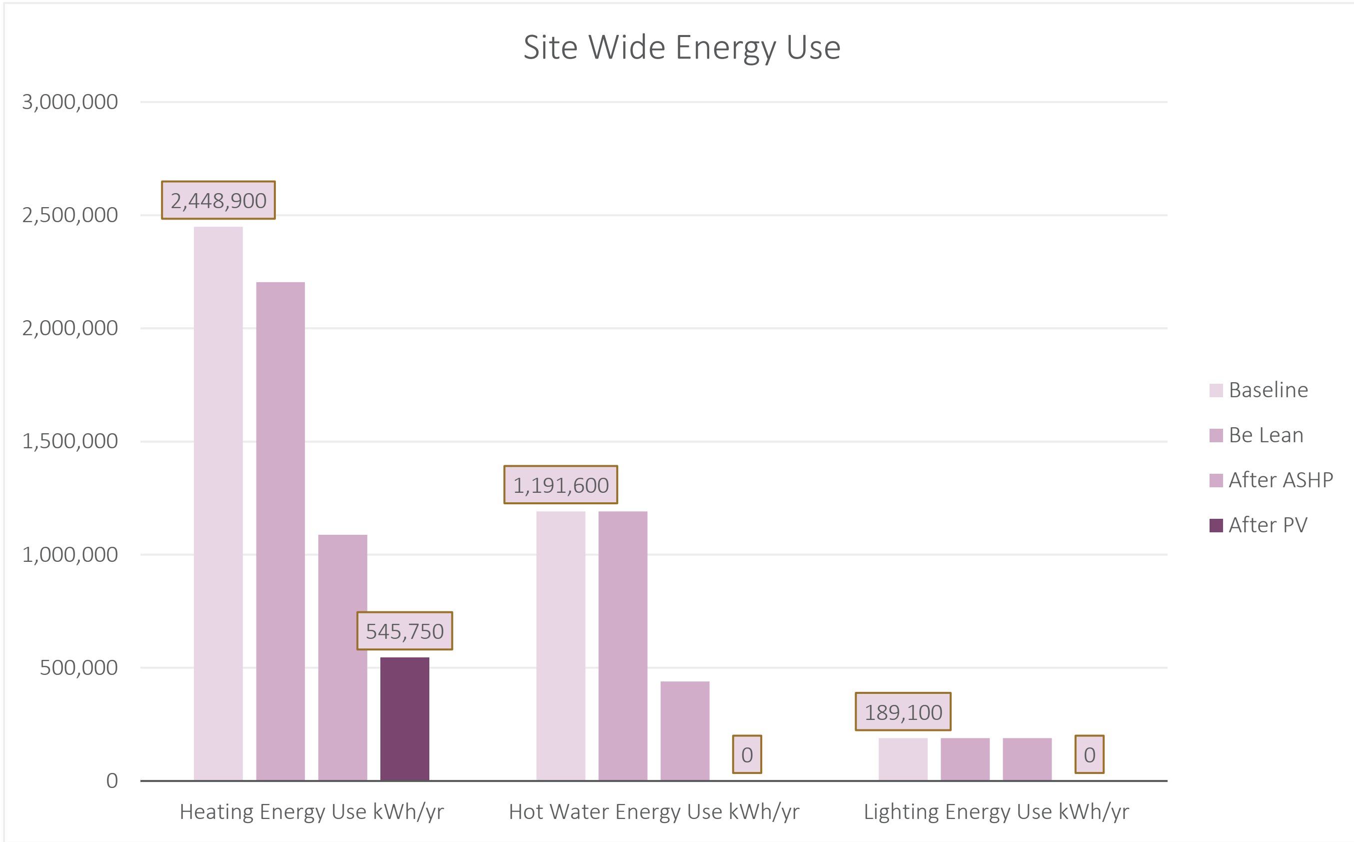

Figure 12 - Site wide energy use after PV (for this calculation PV is assumed to offset lighting, domestic hot water and 50% of the heating demand)

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.

17. 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 Projects 2009 (UKCP09), these have since been updated to UKCP18, which have been 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 will focus on overheating, sustainable transport, flood risk and storm events and green infrastructure.

18. 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.

19. 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.

20. 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.

21. 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.

22. 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.

Hydrock

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.

23. 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 2 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.

23.1 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

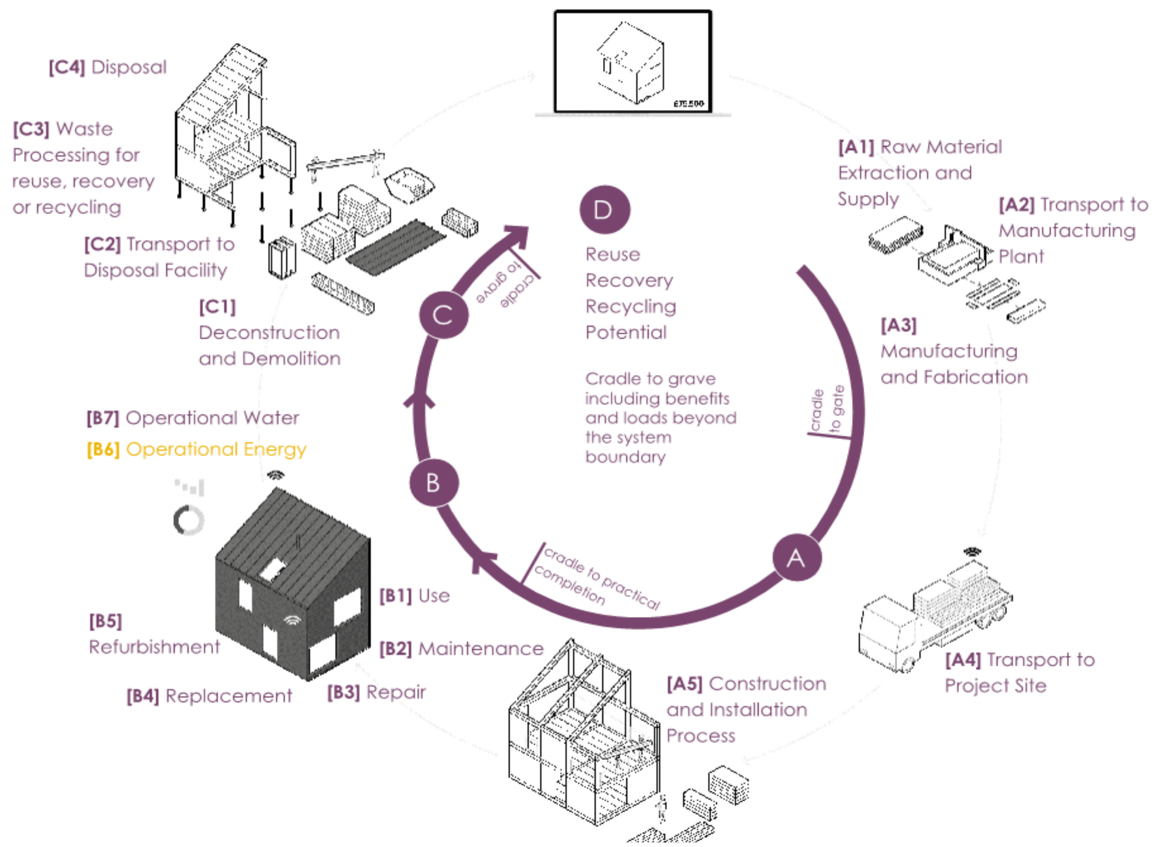

Figure 13 Whole life Carbon Stages (Adapted form LETI Embodied Carbon Primer)

- 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.

23.2 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 kgCO₂e/m²	400-500 kgCO₂e/m²

Figure 14 - LETI target values for embodied carbon in residential buildings

24. 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.

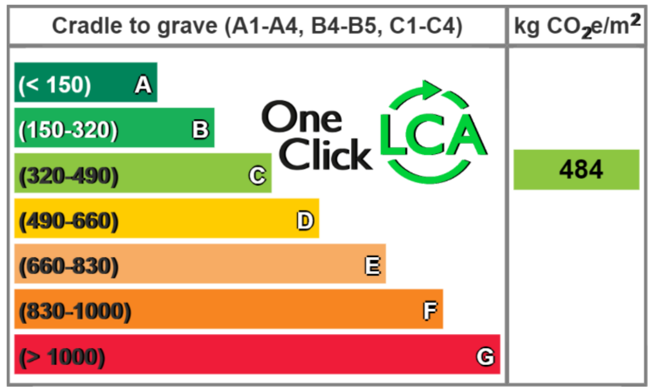

Figure 16 - Cradle to Grave embodied carbon emissions for the development

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.

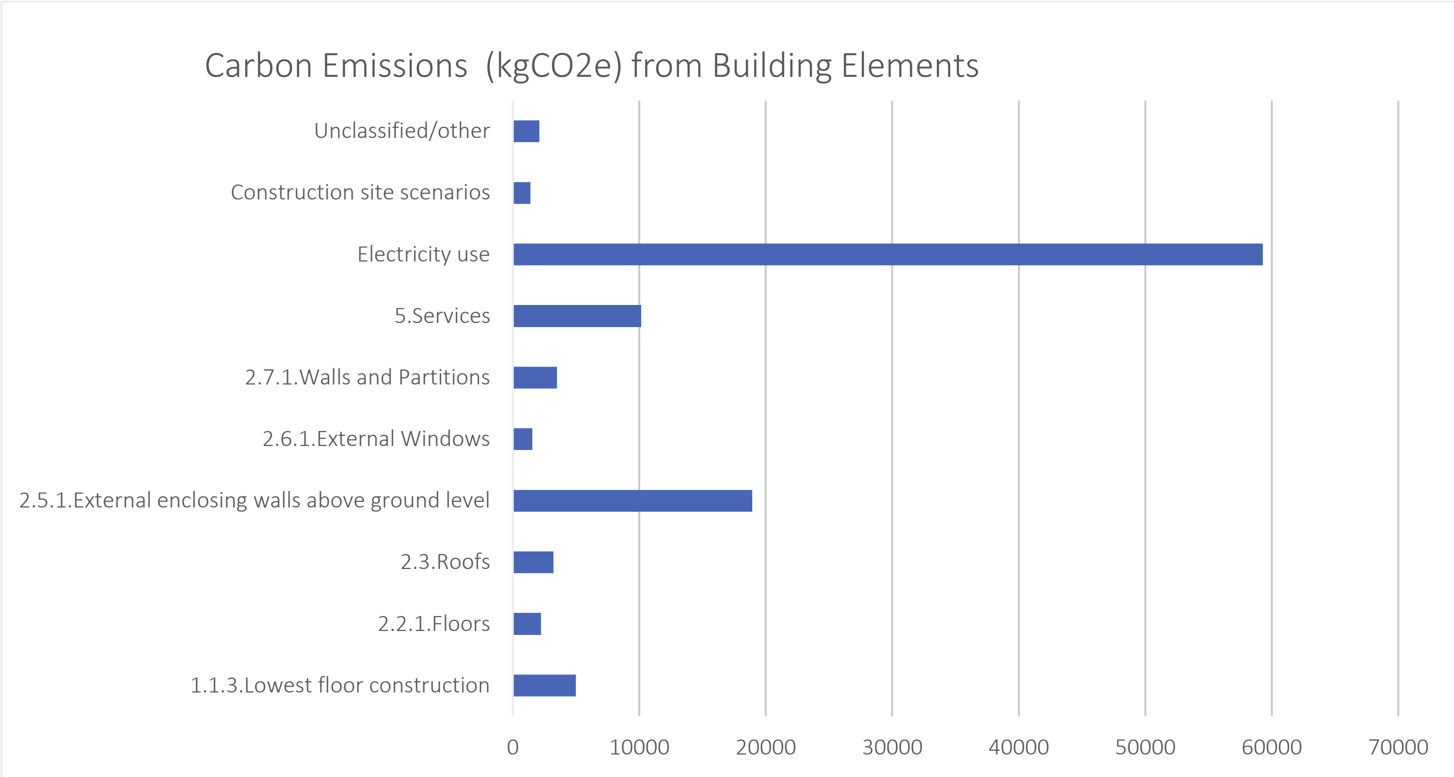

Figure 15 - Carbon emission from building elements

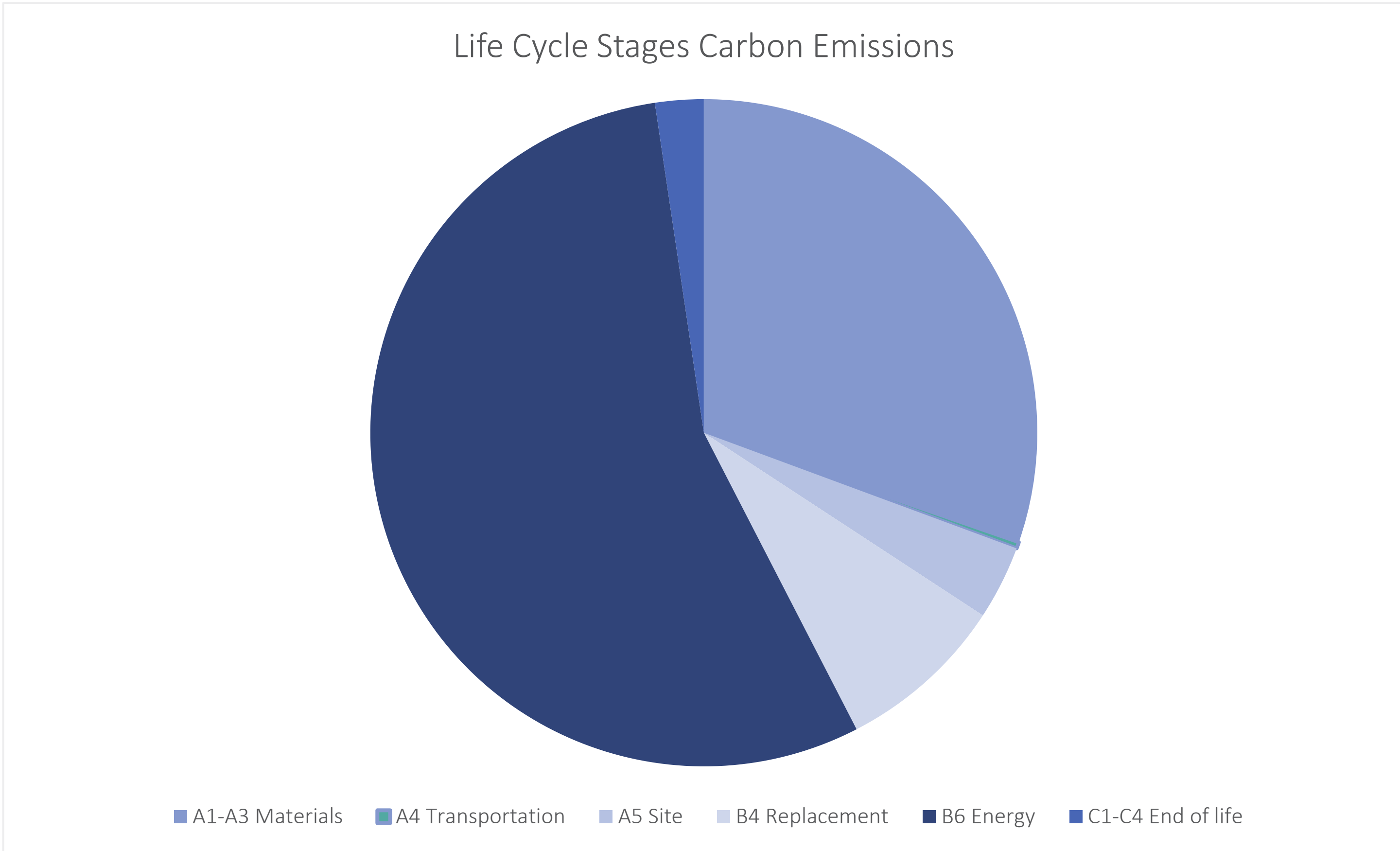

Figure 17 - Life cycle stages carbon emissions

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.

25. 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 SAP9 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.

26. 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.

27. 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 1,092 kWp. The PV array will provide a total of 966,459 kWh/yr in renewable electricity for the development.

28. 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, this is not feasible on this portion of the overall Himley Village masterplan when taking both regulated and unregulated carbon emissions into account. The proposed strategy of good fabric, highly efficient building services with low carbon heating, and significant renewable technologies in the form of PV results in the development achieving a 100% reduction in carbon emissions associated with regulated energy (carbon emissions assessed under Part L of the UK building regulations). 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 out perform 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 rest of the site would need to allow for the remaining 282,941kgCO_2/yr from our site (approximately 300kgCO_2 per dwelling not taking into account the non-residential uses on the rest of the site). This is a reasonable amount and across the remainder of the site would result in approximately 1,000 kWp of PV. Which is approximately 1kWp per dwelling (circa 3 additional PV panels).

The design team for the first phase of the Himley Village development proposed that the remaining carbon reduction be achieved via measures included in the remaining development plots.

Table 8 - Carbon emissions at each stage of the energy hierarchy

Energy Hierarchy Stage	Carbon Emissions kgCO_2/yr	Carbon Reduction kgCO_2/yr	Percentage Reduction
Baseline Carbon Emissions	1,134,799	NA	NA
After Be Lean	1,017,241	117,559	10%
After Be Clean	508,126	509,115	45%
After Be Green	282,941	225,185	20%
Total		**851,859**	**75%**

Table 9 - Energy use at each stage of the energy hierarchy

Energy Hierarchy Stage	Total Energy Use kWh/yr	Heating Energy Use kWh/yr	Hot Water Energy Use kWh/yr	Lighting Energy Use kWh/yr	Unregulated Energy Use kWh/yr
Baseline	5,281,741	2,448,900	1,191,600	189,100	1,369,191
After Be Lean	4,816,982	2,204,010	1,191,600	189,100	1,232,272
After Be Clean	3,043,322	1,087,900	439,100	189,100	1,232,272
After Be Green	1,214,338	0	0	0	1,214,338
Total Energy Reduction	77%	100%	100%	100%	

29. 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.

30. 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	Description	Area (m2)	TER (kgCO2/m2)	TER (kgCO2)	DER (kgCO2/m2)	DER (kgCO2)	Percentage Reduction
Irwel	Detached	61.5	21.96	1351	6.50	400	70%
Irwel	Semi Detached	61.5	20.44	1257	6.20	381	70%
Grantham	Detached	77.76	19.86	1545	5.60	435	72%
Grantham	Semi Detached	77.76	19.86	1545	5.40	420	73%
Ashop	Detached	86.92	19.49	1694	5.20	452	73%
Ashop	Semi Detached	86.92	18.45	1604	5.10	443	72%
Dee	Detached	99.12	18.63	1846	4.80	476	74%
Dee	Semi Detached	99.12	17.50	1734	4.70	466	73%
Avon	Detached	105.2	18.32	1928	4.50	473	75%
Avon	Semi Detached	105.2	17.23	1812	4.50	473	74%
Average			19.17	1632	5.25	442	73%

Baseline Energy Use kWh/yr

House Type	Description	Area (m2)	Baseline Energy Demand kWh/yr	Baseline Heating Demand kWh/yr	Baseline Hot Water Demamd kWh/yr	Baseline Lighting Demand kWh/yr
Irwel	Detached	61.5	6,472	3,859	2,172	285
Irwel	Semi Detached	61.5	6,028	3,410	2,177	285
Grantham	Detached	77.76	7,632	4,797	2,341	338
Grantham	Semi Detached	77.76	7,301	4,475	2,335	334
Ashop	Detached	86.92	8,099	5,147	2,409	387
Ashop	Semi Detached	86.92	7,766	4,774	2,350	387
Dee	Detached	99.12	8,816	5,746	2,471	443
Dee	Semi Detached	99.12	8,282	5,169	2,513	443
Avon	Detached	105.2	9,202	6,077	2,530	440
Avon	Semi Detached	105.2	8,653	5,524	2,534	440
Average			7,825	4,898	2,383	378
Site Wide			3,912,550	2,448,900	1,191,600	189,100

Be Lean Energy Use kWh/yr

House Type	Description	Area (m2)	Be Lean Energy Demand kWh/yr	Heating Energy Use kWh/yr	Hot Water Energy Use kWh/yr	Lighting Energy Use kWh/yr
Irwel	Detached	61.5	5,930	3,473	2,172	285
Irwel	Semi Detached	61.5	5,531	3,069	2,177	285
Grantham	Detached	77.76	6,996	4,317	2,341	338
Grantham	Semi Detached	77.76	6,697	4,028	2,335	334
Ashop	Detached	86.92	7,428	4,632	2,409	387
Ashop	Semi Detached	86.92	7,034	4,297	2,350	387
Dee	Detached	99.12	8,085	5,171	2,471	443
Dee	Semi Detached	99.12	7,608	4,652	2,513	443
Avon	Detached	105.2	8,439	5,469	2,530	440
Avon	Semi Detached	105.2	7,946	4,972	2,534	440
Average			7,169	4,408	2,383	378
Site Wide			3,584,710	2,204,010	1,191,600	189,100

Be Clean Energy Use kWh/yr

House Type	Description	Area (m2)	Be Clean Energy Demand kWh/yr	Be Clean Heating Demand kWh/yr	Be Clean Hot Water Demamd kWh/yr	Be Clean Lighting Demand kWh/yr
Irwel	Detached	61.5	3,430	2,169	786	285
Irwel	Semi Detached	61.5	3,193	1,927	791	285
Grantham	Detached	77.76	3,565	2,169	868	338
Grantham	Semi Detached	77.76	3,406	2,033	848	334
Ashop	Detached	86.92	3,728	2,257	895	387
Ashop	Semi Detached	86.92	3,625	2,150	898	387
Dee	Detached	99.12	3,888	2,337	918	443
Dee	Semi Detached	99.12	3,755	2,200	922	443
Avon	Detached	105.2	3,875	2,319	926	440
Avon	Semi Detached	105.2	3,756	2,197	930	440
Average			3,622	2,176	878	378
Site Wide			1,811,050	1,087,900	439,100	189,100

Be Green Energy Use kWh/yr

House Type	Description	Area (m2)	Be Clean Energy Demand kWh/yr	Be Clean Heating Demand kWh/yr	Be Clean Hot Water Demamd kWh/yr	Be Clean Lighting Demand kWh/yr
Irwel	Detached	61.5	3,430	2,169	786	0
Irwel	Semi Detached	61.5	3,193	1,927	791	285
Grantham	Detached	77.76	3,565	2,169	868	338
Grantham	Semi Detached	77.76	3,406	2,033	848	334
Ashop	Detached	86.92	3,728	2,257	895	387
Ashop	Semi Detached	86.92	3,625	2,150	898	387
Dee	Detached	99.12	3,888	2,337	918	443
Dee	Semi Detached	99.12	3,755	2,200	922	443
Avon	Detached	105.2	3,875	2,319	926	440
Avon	Semi Detached	105.2	3,756	2,197	930	440
Average			3,622	2,176	878	350
After PV				545,750	0	0

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	3	3	825	2475
2	1	3700 x 6200	Portrait	12	110	3.6	3.6	825	2970
3+4	2	5000 x 6700	Portrait	10	200	3	6	952	5712
5+6	2	4800 x 4500	Portrait	8	200	2.4	4.8	952	4569.6
7+8	2	2500 x 9500	Landscape	10	110	3	6	825	4950
9+10+11+12	4	4400 x 4500	Portrait	8	200	2.4	9.6	952	9139.2
13	1	2600 x 8700	Landscape	10	110	3	3	825	2475
14+15	2	5000 x 7900	Portrait	14	110	4.2	8.4	825	6930
16+17+18+19+20+21	6	4400 x 5700	Portrait	10	110	3	18	825	14850
22+27	2	2600 x 6300	Landscape	6	110	1.8	3.6	825	2970
23+24	2	4600 x 6300	Portrait	12	200	3.6	7.2	952	6854.4
25+26	2	4500 x 4100	Portrait	8	200	2.4	4.8	952	4569.6
28+29	2	4500 x 4100	Portrait	8	110	2.4	4.8	825	3960
30+31	2	4500 x 4100	Portrait	8	110	2.4	4.8	825	3960
32+33	2	4300 x 5400	Portrait	10	110	3	6	825	4950
34+35	2	4300 x 5400	Portrait	10	110	3	6	825	4950
36	1	9200 x 6700 (H)	Portrait	10	200	3	3	952	2856
38+41	2	4800 x 4500	Portrait	8	200	2.4	4.8	952	4569.6
39+40	2	2800 x 9700	Landscape	10	200	3	6	952	5712
42	1	2800 x 8700	Landscape	10	110	3	3	825	2475
43-46	1	3200 x 18700	Landscape	22	110	6.6	6.6	825	5445
47	1	2800 x 8700	Landscape	10	110	3	3	825	2475
48+49	2	4800 x 4400	Portrait	8	200	2.4	4.8	952	4569.6
51	1	2600 x 6300	Landscape	6	200	1.8	1.8	952	1713.6
52	3	4300 x 5400	Portrait	10	110	3	9	825	7425
53+54	2	4500 x 4100	Portrait	8	110	2.4	4.8	825	3960
55	1	2600 x 6300	Portrait	6	110	1.8	1.8	825	1485
56+57+57+59	4	4300 x 5400	Portrait	10	185	3	12	960	11520
60	1	2600 x 6300	Landscape	6	185	1.8	1.8	960	1728
61+62+63+64	4	4300 x 5400	Portrait	10	100	3	12	811	9732
65	1	2600 x 6300	Landscape	6	185	1.8	1.8	960	1728
66-71	1	3200 x 18700	Landscape	22	110	6.6	6.6	825	5445
66-71	1	9200 x 3300	Landscape	10	200	3	3	952	2856
73+76+77+79+82+83+86+88+89	9	4800 x 4500	Portrait	8	200	2.4	21.6	952	20563.2
75+81+85+87+91	5	2800 x 9700	Landscape	10	110	3	15	825	12375
92+93+94	3	5500 x 7800	Portrait	12	110	3.6	10.8	825	8910
95+96+97	3	4800 x 4500	Portrait	8	110	2.4	7.2	825	5940
98 +100	2	2800 x 9700	Landscape	10	110	3	6	825	4950
99	1	4800 x 4500	Portrait	8	110	2.4	2.4	825	1980

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	2.4	2.4	825	1980
102+103+104	3	4800 x 4500	Portrait	8	110	2.4	7.2	825	5940
105+106+107	3	4500 x 4100	Portrait	8	110	2.4	7.2	825	5940
108+109+110+111+112+113	6	4800 x 4500	Portrait	8	110	2.4	14.4	825	11880
114	1	2800 x 9700	Landscape	10	185	3	3	960	2880
115 + 17	2	2800 x 9700	Landscape	10	110	3	6	825	4950
116	1	4800 x 4500	Portrait	8	200	2.4	2.4	952	2284.8
118+119+120+121	4	4500 x 4100	Portrait	8	110	2.4	9.6	825	7920
122	1	2800 x 9700	Landscape	10	110	3	3	825	2475
123+124	2	4800 x 4500	Portrait	8	200	2.4	4.8	952	4569.6
125+129	2	2800 x 9700	Landscape	10	200	3	6	952	5712
126+127+128+139+140+141	6	4800 x 4500	Portrait	8	110	2.4	14.4	825	11880
130+132+134+150+152	5	2800 x 9700	Landscape	10	110	3	15	825	12375
144+143+142	3	4800 x 4500	Portrait	8	100	2.4	7.2	811	5839.2
138+137+136	3	4800 x 4500	Portrait	8	110	2.4	7.2	825	5940
146+147	2	4800 x 4500	Portrait	8	175	2.4	4.8	960	4608
148	1	2800 x 4500	Landscape	10	100	3	3	825	2475
159	1	3300 x 9200	Landscape	10	110	3	3	825	2475
156+157+161+162+168+169	6	4800 x 4500	Portrait	8	200	2.4	14.4	952	13708.8
159	1	2800 x 9700	Landscape	10	110	3	3	825	2475
165+166+172+173+174+175+178+177+179+180	10	4800 x 4500	Portrait	8	185	2.4	24	960	23040
171	1	3300 x 9200	Landscape	10	200	3	3	952	2856
181-184	1	6600 x 9400	Portrait	24	100	7.2	7.2	825	5940
185-190	1	6600 x 9400	Portrait	24	200	7.2	7.2	952	6854.4
195+213+216	3	2800 x 9700	Landscape	10	200	3	9	952	8568
194+214+215+216+217+208+201+202	8	4800 x 4500	Portrait	8	200	2.4	19.2	952	18278.4
196+197+198+199+210+211+212+205+206+203+204	11	4800 x 4500	Portrait	8	185	2.4	26.4	960	25344
191+192+193	3	4800 x 4500	Portrait	8	225	2.4	7.2	912	6566.4

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	3	24	912	21888
255	1	3600 x 9700	Landscape	10	135	3	3	912	2736
257	1	3600 x 9700	Landscape	10	165	3	3	888	2664
269+268	2	4800 x 5400	Portrait	10	110	3	6	825	4950
267+268	2	Hips	Portrait	6	110	1.8	3.6	825	2970
285	1	3600 x 9700	Landscape	10	185	3	3	960	2880
284+283	2	Hips	Portrait	6	200	1.8	3.6	952	3427.2
282+281+280+279+269+270+271	7	4800 x 4500	Portrait	8	200	2.4	16.8	952	15993.6
278+277	2	Hips	Portrait	6	185	1.8	3.6	825	2970
276	1	3600 x 9700	Landscape	10	185	3	3	960	2880
274+275	2	4800 x 5400	Portrait	10	100	3	6	811	4866
273	1	2800 X 9700	Landscape	10	135	3	3	913	2739
300+301+302+303	4	4800 x 4500	Portrait	8	110	2.4	9.6	828	7948.8
299+296	2	4800 x 4500	Portrait	10	110	3	6	825	4950
297+298	2	3600 x 9700	Landscape	10	200	3	6	952	5712
294	1	4800 x 4500	Portrait	10	200	3	3	952	2856
293+290	2	4800 x 4500	Portrait	10	200	3	6	952	5712
307+306+305+304	4	4800 x 5400	Portrait	10	200	3	12	952	11424
309+310+311+312+316+317	6	4800 x 4500	Portrait	8	110	2.4	14.4	825	11880
313+314	2	Hips	Portrait	6	200	1.8	3.6	952	3427.2
315	1	3300 x 9700	Landscape	10	200	3	3	952	2856
316+319	2	4800 x 5400	Portrait	10	135	3	6	912	5472
327+328+329+330	4	4800 x 4500	Portrait	8	225	2.4	9.6	912	8755.2
320+321	2	4800 x 5400	Portrait	10	135	3	6	912	5472
322	1	Hips	Portrait	6	135	1.8	1.8	912	1641.6
323	1	3300 x 9700	Landscape	10	135	3	3	912	2736
324+325	2	3300 x 9700	Landscape	10	225	3	6	912	5472
331+334+341	3	3300 x 9700	Landscape	10	225	3	9	912	8208
332+333	2	4800 x 5400	Portrait	10	135	3	6	912	5472
335	1	Hips	Portrait	6	225	1.8	1.8	912	1641.6

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	3	3	912	2736
363+368	2	4800 x 5400	Portrait	10	135	3	6	912	5472
365+367	2	2700 x 9700	Landscape	8	135	2.4	4.8	912	4377.6
370	1	3300 x 9700	Landscape	10	185	3	3	960	2880
388+389+390	3	4800 x 4500	Portrait	8	240	2.4	7.2	825	5940
391+392	2	4800 x 4500	Portrait	8	135	2.4	4.8	912	4377.6
393	1	4800 x 5400	Portrait	10	135	3	3	912	2736
395+396+397+398	4	Hips	Portrait	6	110	1.8	7.2	825	5940
399	1	3300 x 9700	Landscape	10	200	3	3	952	2856
377+378+360+382+384	5	4800 x 4500	Portrait	8	200	2.4	12	952	11424
361+388	2	4800 x 4500	Portrait	8	185	2.4	4.8	960	4608
402+405+406+407+408+411+417	7	4800 x 5400	POrtrait	10	110	3	21	825	17325
403+404+409+410	4	Hips	Portrait	6	110	1.8	7.2	825	5940
414+415+416	2	7700 x 5500	Portrait	12	110	3.6	7.2	825	5940
412	1	3300 x 9700	Landscape	10	200	3	3	952	2856
413	1	Hips	Portrait	6	200	1.8	1.8	952	1713.6
434	1	3300 x 9700	Landscape	10	225	3	3	912	2736
435	1	4800 x 4500	Portrait	8	225	2.4	2.4	912	2188.8
436+437+438+439+418+419+420	7	3300 x 9700	Landscape	10	110	3	21	825	17325
421	1	4800 x 4500	Portrait	8	110	2.4	2.4	825	1980
424	1	4800 x 5400	Portrait	10	225	3	3	912	2736
425+426+430+432+429	5	4800 x 5400	Portrait	10	110	3	15	825	12375
431+428+427	3	Hips	Portrait	6	110	1.8	5.4	825	4455
440-443	1	3300 x 9300	Landscape	10	225	3	3	912	2736
440-443	1	3300 x 6500	Landscape	6	135	1.8	1.8	912	1641.6
444-447	1	3300 x 6500	Landscape	6	110	1.8	1.8	825	1485
452+453+454+455+456+461	6	4800 x 5400	Portrait	10	200	3	18	952	17136
457+458+459+450	4	Hips	Portrait	6	200	1.8	7.2	952	6854.4
462	1	3300 x 9700	Landscape	10	200	3	3	952	2856
451+450+449+448	4	4800 x 4500	Portrait	8	110	2.4	9.6	825	7920
500+499+498+497+496+489+488	7	4800 x 5400	POrtrait	10	110	3	21	825	17325
480+481+482+483	4	3300 x 9700	Landscape	10	200	3	12	952	11424
484+493+492	3	4800 x 5400	Portrait	10	110	3	9	825	7425
494+490+485	3	3300 x 9700	Landscape	10	110	3	9	825	7425