Graven Hill, Redevelopment of MOD Bicester

Masterplan Energy Strategy and District Heating Feasibility Study
Rev F

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Audit Sheet

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Contents

1.0 Executive Summary

This report describes energy strategy scenarios for the proposed mixed-use development at the Graven Hill site. The site lies south east of Bicester Town Centre and north east of Junction 9 of the M40.

This study considers the opportunities and constraints influencing the proposed energy strategy for Graven Hill. This includes a review of the proposed energy profiles for the development and the feasibility of implementing a district heating and biomass energy source for the masterplan.

Passive Design and Energy Efficiency

The approach to energy efficient design at the Graven Hill development will have a great impact on the feasibility of implementing district heating at site, and on the carbon savings achievable from such a system. Two potential scenarios for energy efficient design are discussed within this report:

1. Code for Sustainable Homes Level 5 compliance for residential units, and Part L 2013 compliance for non-residential areas
2. Passivhaus standard for residential units, and Part L 2013 compliance for non-residential areas

The Code for Sustainable Homes includes mandatory requirements for 100% carbon savings over Part L (for regulated energy uses), as well as very demanding water efficiency and other technical requirements. These standards effectively mean that a substantial amount of renewable energy and water recycling would be required for all residences. This would be considered to be a technical challenge to individual house builders, and would also incur increased cost (estimated at £24,000-£40,000 for an average sized house compared to a Part L compliant dwelling, depending on the systems chosen to meet this requirement). The technical challenges of achieving Code level 5 for a self-builder encompass a range of design, procurement and construction implications that are not normal practice for self-builders. The commitment to achieve Code level 5 entails significant investment in the provision of specific construction management routines and control procedures, water recycling systems, biodiversity, acoustic improvements and certain material and design layout requirements etc. Evidence would have to be presented to a certified Code for Sustainable Homes assessor in order to validate that the range of Code level 5 measures have been achieved, which would be beyond the capacity of most self-builders.

As an alternative to meeting the Code level 5 standard, meeting the ‘Passivhaus’ standard is proven to result in ultra-low energy buildings that require little energy for space heating and cooling by the combination of a highly insulated envelope, very good air tightness and Mechanical Ventilation with Heat Recovery (MVHR). The ‘Passivhaus’ standard further imposes a maximum limit for overall energy use in a building. When compared to current (2010) UK Building Regulation standards, a ‘Passivhaus’ dwelling is estimated to achieve 25-35% savings in carbon emissions without the incorporation of CHP or renewables. There will be added cost to building a ‘Passivhaus’ home compared to a standard dwelling; depending on the specification this is estimated at approx. £15,000-£25,000 for a mid-size house, compared to a Part L 2010 compliant dwelling.

Overall, the Passivhaus standard offers many advantages to a Code level 5 standard, especially as the Passivhaus standard has a primary focus on energy demand reduction and is more cost effective.

District heating

The incorporation of a centralised energy centre with Combined Heat and Power has been considered for the Graven Hill development.

In the Passivhaus scenario, the most likely construction standard, the space heating demand will be very low. This will have a detrimental impact on the business case for district heating. It is therefore, as discussed in this report, not considered viable to invest in a district heating network, as the usage would be so low.

Further, the planned layout of the site (low density, leading to increased energy losses in pipework) and the development phasing does not provide optimum conditions for implementing a centralised energy centre. It should be noted here that it is expected that the heating demand in future housing will decrease as a result of upgrades to the building regulations, and therefore the case for district heating will diminish in any case, whether Passivhaus is adopted on site or not.

Renewable energy technology options

An initial review has been carried out into potential renewable technology options that could be considered for the Graven Hill development. The incorporation of renewables could deliver a final reduction to the site’s carbon emissions, and also potentially provide a visible statement of Bicester’s support for the promotion of sustainability, energy efficiency and innovation within the building sector.

Currently this study has undertaken a high level assessment of the following renewable technologies: Photovoltaic panels (PVs), solar hot water panels, wind turbines, heat pumps, and biomass boilers.

The most appropriate renewable energy sources, compatible with an energy efficient development built to passivhaus standards, is either solar water heating or solar power generation. Both options can be roof mounted and managed by each individual house holder. Since the buildings will be very energy efficient and have a low heating demand the case for biomass heating is not considered viable.

2.0 Introduction

Graven Hill is a large plot of land that currently forms part of MOD Bicester. As part of the MOD's mandate to increase operational efficiency, lower costs and rationalise its estates, Graven Hill and the neighbouring C Site have been proposed for redevelopment into a large residential community and employment land, located south of Bicester. The proposed redevelopment scheme has been awarded outline planning permission from the local planning authority, Cherwell District Council.

The existing site consists mainly of brownfield and military storage facilities. The proposed re-development of the north end of the site includes approx. 1,727 dwellings, consisting of 1,325 mixed sized houses, 402 apartments, a community centre, school, retail shops and offices. The majority of the residential Graven Hill site is proposed to be self-build. Plots of land with agreed development areas and build heights will be provided for people to design and build their own homes on the site. However it is envisaged that each self-build dwelling will be required to meet a set of agreed design criteria, which will form part of development's central strategy.

The south part of the Graven Hill Site, which is proposed to be developed as a later phase, will include commercial buildings and amenities, including offices, light industrial and warehouse buildings.

This energy strategy report investigates the predicted energy demand and operational CO_2 emissions of the Graven Hill site, and includes a district heat network feasibility study to assess the potential suitability of implementing this within the development.

Figure 2.1: North Graven Hill Site - Proposed Masterplan Development Plots

2.1 Proposed Re-development of Graven Hill

The redevelopment of Graven Hill is currently proposed to be undertaken over two phases, with the first phase land transfer planned for June 2015. This will include the majority of the residential plots and the school / community facilities. The site plan below shows the currently proposed phasing of the scheme.

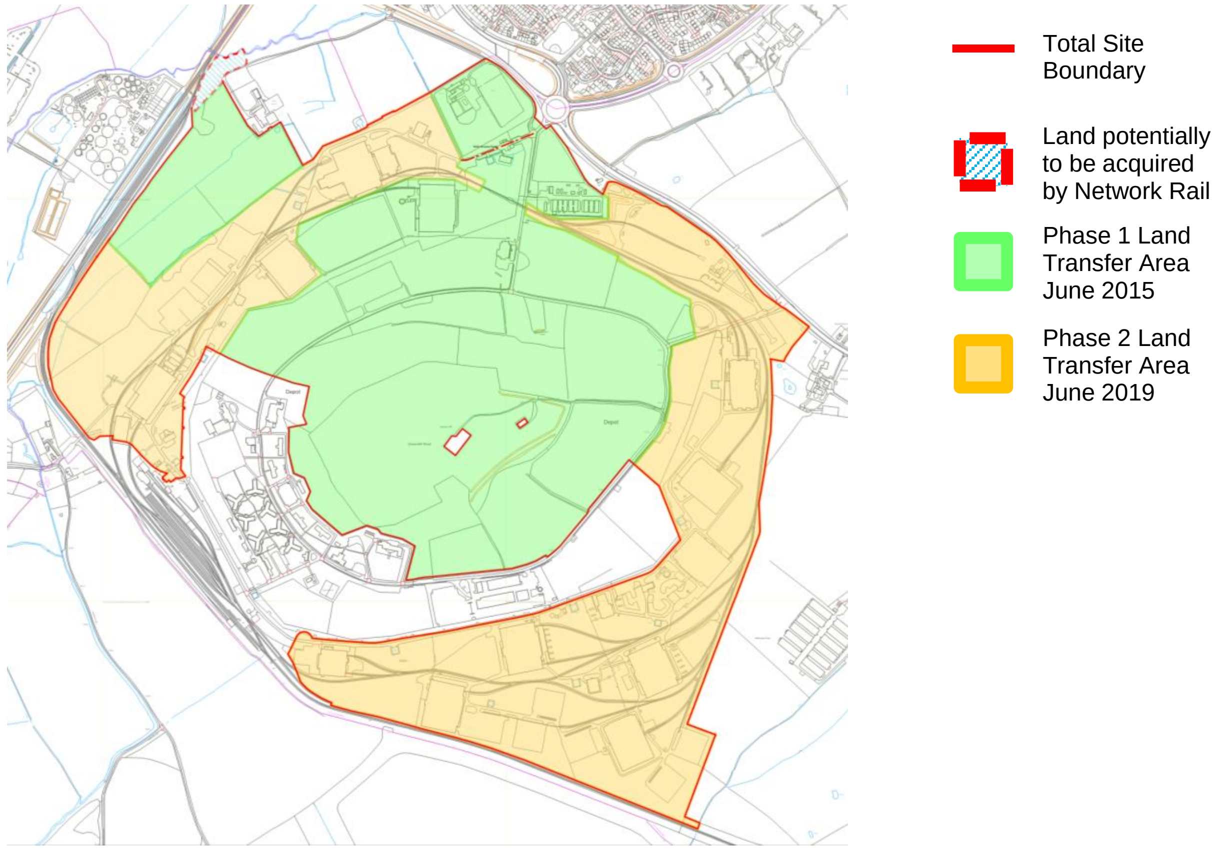


Figure 2.2: Graven Hill Land Transfer Phasing Areas

*Table 2.1 – Graven Hill Schedule of Accommodation**

Phase	Approx. Number of Units	Approx. Development Area GIA (m^2)
Residential (Houses)	1,325	~190,000
Residential (Apartments)	402	
School and Community	-	~2,700
B1 Office	-	~500
B1(b / c) Light / General Industrial	-	~23,000
B8 Storage	-	~67,000
Retail	**-**	~1,000
Hotel / Pub / Restaurant	**-**	~500
Total	**-**	**~195,000**

** Areas from Option 2 Plot Sizes issued 14.11.2013, and Energy Strategy issued Sep 2011*

3.0 Environmental Drivers and Energy Targets

3.1 Planning Drivers and Environmental Assessment

The proposed redevelopment of Graven Hill has been granted outline planning permission by the local authority, Cherwell District Council. The draft planning conditions for Graven Hill include a number of environmental targets that are required to be met by the proposed development.

Condition 37

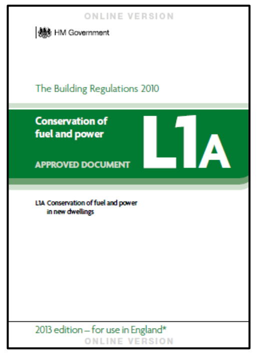
> *Prior to the commencement of development at Graven Hill, a feasibility assessment for district heating and/or combined heat & power to serve the site, including the consideration of bio mass, shall be carried out by a suitably qualified person and submitted to and approved in writing by the local planning authority.*

Condition 38

> *Should the feasibility study required by condition 37 identify the potential for district heating or combined heat and power, an energy plan shall be produced and be submitted to and approved in writing prior to the commencement of development. The plan shall thereafter be implemented to serve the development in accordance with the approved details.*

This document has been produced to satisfy the requirements of Planning Condition 37 and 38.

3.2 Building Regulations



Approved Documents Part L1 and Part L2 of the Building Regulations address the conservation of fuel and power in domestic and non-domestic buildings respectively. The current version of Part L was revised in October 2010; however this will be superseded by Part L 2013 in April 2014.

For the purposes of this feasibility study Part L 2010 compliance has been used as the baseline benchmark, since the calculation tools for Part L 2013 are not available at this stage.

Further reductions in CO2 emissions are expected to be required with future updates to Part L:

- All dwellings expected to have to be ‘zero carbon’ from 2016
- All non-residential development to be ‘zero carbon’ from 2019.

This is expected to result in, among other things, a greatly reduced heating demand from buildings.

3.3 Environmental Assessment Methods

Several environmental assessment methods are being considered for the site. Depending on the preferred passive design options chosen for the site, different methods may be best suited to individual parts of the development. An overview of the methods considered is given below.

Code for Sustainable Homes (CfSH)

The Code for Sustainable Homes (CfSH) is a benchmarking tool for setting standards for sustainable design and construction of new residential developments. It covers several sustainability categories, ranging from energy performance to materials selection and construction management. It aims to quantify and reduce the environmental impact of buildings by rewarding those designs that take positive steps to minimise their environmental impacts. The Code for Sustainable Homes awards credits in relation to various construction, design and procurement options; each design issue carrying a weighted percentage that contributes to the percentage score and final awarded rating. In accordance with draft planning condition 38 the dwellings at Graven Hill will be required to achieve CfSH Level 5 ratings.

Achieving Code for Sustainable Homes Level 5 – Minimum Mandatory Standards:

In order for a dwelling to be awarded a Code for Sustainable Homes Level 5 rating, both of the following requirements must be met:

- Achieve a minimum CfSH score of 84%
- Achieve all minimum mandatory standards required for Level 5:
    - Achieve zero carbon emissions (i.e. be 100% better than Building Regulations) for regulated energy uses (Credit Ene 1: Dwelling Emissions Rate). This is the most challenging standard that a dwelling must meet in order to be awarded a CfSH Level 5 rating. This must be entirely achieved through on-site measures and therefore cannot be offset with allowable solutions or off-site renewables. As maximising energy efficiency and passive design would generally not be able to provide much more than a 30% reduction in CO_2 over Part L 2010, it is essentially unavoidable that all CfSH Level 5 dwellings must have a substantial amount of on-site renewable technologies to offset the remaining carbon emissions. This could include a combination of a large area of photovoltaic panels, solar hot water (SHW) panels and a biomass boiler.
    - Achieve a Fabric Energy Efficiency <46kWh/m² for detached and semi-detached house, or <39kWh/m² for apartments and mid-terrace houses (Credit Ene 2: Fabric Energy Efficiency). It is estimated that a typical semi-detached house with best-practice energy performance levels would have a FEES of around 45kWh/m². It should be noted that dwellings which are shaped to have larger exposed surface areas will inherently have a worse FEES compared to more compact shaped dwellings.
    - Achieve a water consumption rate <80 litres/person/year (Credit Wat 1: Indoor Water Use). This must be achieved through a combination of very low flow rate water fittings and the incorporation of a greywater and / or rainwater recycling system, as a minimum for flushing WCs. It is not possible to meet this standard without incorporating greywater / rainwater recycling.

Apart from the above mandatory requirements, a CfSH level 5 rating also requires consideration of a number of further issues, with a heavy emphasis on the housebuilder to provide documentation to the certifying body, including, but not limited to:

- Environmental impact and responsible sourcing of materials
- Site run-off and ecology
- Waste storage
- NO_X emissions of heating system
- Compliance with Lifetime Homes
- Monitoring and reporting construction site impacts (energy use, water consumption, transport to and from site)
- Using contractors signed up to the Considerate Constructors' Scheme

All in all it is considered very onerous, and costly, for individual house builders to achieve Code Level 5 due to the complex requirements listed above. Depending on the approach taken to achieve this requirement it is currently estimated that the increased cost to each housebuilder would be £24,000-£40,000 for a mid-size dwelling, compared to a Part L 2010 compliant dwelling.

As the Graven Hill development is proposed as self-build plots it has been considered by the team whether a more appropriate assessment method would be Passivhaus, a voluntary and extremely rigorous standard for achieving energy efficient buildings. See the following page for a description of this standard for house building.

Figure 3.1: Code for Sustainable Homes Level 5 compliant dwelling in Newport, Wales, demonstrating the great amount of photovoltaics required to meet the standard. The development also includes a district energy system with CHP and biomass boilers

Passivhaus Standard

Designing and building to Passivhaus standards is proven to result in ultra-low energy buildings that require little energy for space heating by the combination of a highly insulated envelope, very good air tightness and Mechanical Ventilation with Heat Recovery (MVHR). Passivhaus further imposes a standard for overall energy use of a building, thereby restricting the energy use of the ventilation system, appliances etc.

The Passivhaus Standard can be applied to commercial, industrial and public buildings as well as residential buildings. The standard was developed in Germany in early 1990s by Prof. Bo Adamson of Sweden and Wolfgang Feist of Germany.

"Passivhaus is a building, for which thermal comfort can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality condition – without the need for additional recirculation of air."

The heating requirement in a Passivhaus is reduced to the point where a traditional heating system is no longer considered essential. The standard provides excellent indoor air quality – achieved by reducing the air infiltration rates and supplying fresh air which is filtered and post heated/cooled by the Mechanical Ventilation and Heat Recovery (MVHR) units.

Basic Principles:

a. Exemplar levels of insulation with minimal/eliminated thermal bridges
b. Utilising passive solar gains and internal heat sources
c. Exemplary level of air tightness
d. Good indoor air quality, provided by a highly efficient whole house mechanical ventilation system with heat recovery (MVHR).

When compared to current (2010) UK Building Regulations standards, a Passivhaus dwelling is estimated to achieve 25-35% savings in carbon emissions before the incorporation of CHP or renewables. The graph below shows actual measured heating energy consumption in Passivhaus dwellings compared to 'standard' low-energy dwellings. It is evident that the rigorous approach taken in Passivhaus dwellings helps to ensure consumption as calculated using the Passivhaus calculation tool (PHPP).

There will be added cost to building a Passivhaus compared to a standard dwelling. Depending on the specification this is estimated at approx. £15,000-£25,000 for a mid-size house, compared to a Part L 2010 compliant dwelling.

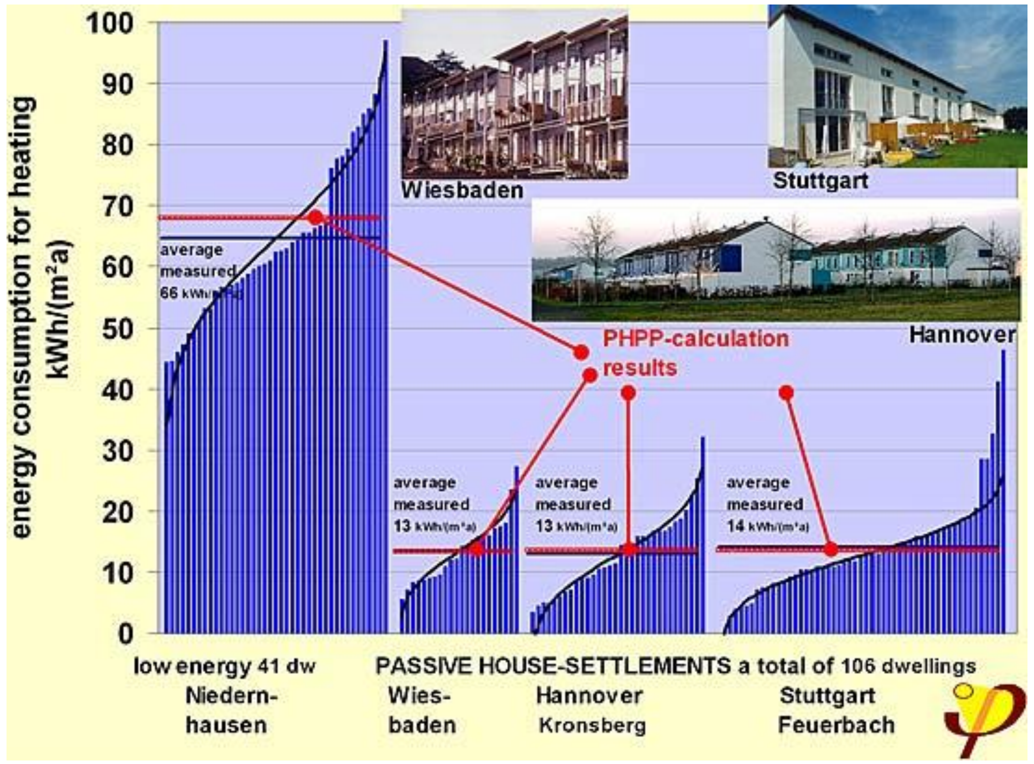


Figure 3.2: Measured heating energy consumption for Passivhaus dwellings compared to 'conventional' low energy dwellings.

Figure 3.3: Thermographic image of a Passivhaus between conventional houses, showing the extremely reduced heat loss

BREEAM

BREEAM is a voluntary environmental assessment benchmarking tool used to evaluate the design and construction of non-residential buildings. It aims to quantify and reduce the environmental impact of buildings by rewarding those designs that take positive steps to minimise their environmental impacts. BREEAM awards credits in relation to various construction, design and procurement options; each design issue carrying a weighted percentage that contributes to the BREEAM score and final awarded rating.

The requirement at Graven Hill is for all non-domestic areas of the development to achieve a BREEAM Excellent rating. There are several mandatory credits related to energy that must be achieved in order to achieve a BREEAM Excellent rating, in addition to achieving a minimum overall BREEAM score of 70%.

Achieving BREEAM 'Excellent' – Key Minimum Mandatory Standards:

Ene 01 Reduction of emissions (6 of 15 credits achieved)

BREEAM Excellent requires a minimum of 6 credits to be awarded, through achieving an Energy Performance Ratio (EPR) of 0.36 and a 25% reduction in CO_2 emissions arising from regulated building energy consumption (against Part L 2010)

Ene 02 Energy monitoring (1st Credit)

Major energy consuming systems (where present) must be monitored using either a Building Energy Management System (BEMS) or separate accessible energy sub-meters with a pulsed output to enable future connection to a BEMS. These include:

a Space Heating
b Domestic Hot Water
c Humidification
d Cooling
e Fans (major)
f Lighting
g Small Power (lighting and small power can be on the same sub-meter where supplies are taken at each floor/department).
h Other major energy-consuming items where appropriate (see Compliance notes).

The end energy consuming use must be identifiable to the building user through labelling or data outputs.

If achieving a BREEAM rating of Excellent were to be targeted, a number of additional credits would also become mandatory:

Ene 04 Low and zero carbon technologies (1st of 5 credits achieved)

1. A feasibility study must be carried out by an energy specialist to establish the most appropriate local (on-site or near-site) low or zero carbon (LZC) energy source for the building/development
2. A local LZC energy technology must be specified for the building/development in line with the recommendations of the above feasibility study
3. The feasibility study must be carried out at RIBA stage C (concept design) or equivalent procurement stage.

OR

1. The organisation that occupies the building has in place a contract with an energy supplier to provide electricity for the assessed building/development from a 100% renewable energy source

Further credits relating to Energy use

Specifically relating to the non-residential areas of Graven Hill, the following energy related credits are also applicable under BREEAM 2011 but are not mandatory minimum standards for a specific BREEAM rating:

Ene 03 External lighting

Ene 05 Energy efficient cold storage (where appropriate)

Ene 06 Energy efficient transportation systems

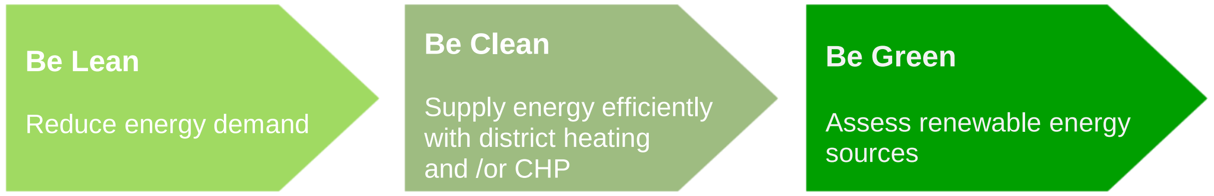
Ene 08 Energy efficient equipment

Pol 01 Impact of refrigerants

Pol 02 NO_X emissions

4.0 Approach to Energy Strategy

It is proposed that the strategic approach to the design of the Graven Hill redevelopment and its energy strategy will follow the Energy Hierarchy.



The energy hierarchy aims to reduce energy demand in the first instance prior to the integration of low and zero carbon energy sources, since controlling demand is the most effective way of reducing energy consumption and carbon dioxide emissions. After the energy demand has been minimised, the next step of the energy hierarchy is to incorporate low carbon technologies, therefore delivering the energy demand cleanly, before finally assessing the use of on-site renewable energy technologies.

A more detailed summary of these steps and the typical design strategies and measures that may be considered are provided below.

4.1 Passive and Energy Efficient Design Strategies

The buildings' thermal envelope and facades should be designed to minimise heating, cooling, and lighting requirements, prior to the incorporation of any low and zero carbon technologies.

Although it may not be feasible to prescribe particular design measures for a self-build scheme, it is intended that through the setting of appropriate environmental targets, all dwellings will achieve high levels of energy efficiency and ensure passive design principles are met.

For the non-residential / commercial buildings that are proposed as part of the site's central development, a high level of energy performance and passive design will also be targeted in line with their respective environmental targets.

4.2 Energy Efficient Design Strategies for Dwellings

The Graven Hill scheme includes mainly self-build houses in addition to a number of apartments. Targeting the following design strategies would help to ensure that the dwellings minimise their energy demand and achieve a high level of energy efficiency:

Proportion and location of transparent glazed elements

In order to help minimise the risk of excessive solar gains in the summer and reduce heat losses in the winter, it is recommended that the proportions of façade glazing are limited to approximately 50% of the façade area in apartments and 25-30% in houses (as seen from inside of rooms). Exceeding this is likely to result in greater winter heating loads, and increased risk of overheating in the summer. Placing glazing above table top height will provide a higher daylight factor than glazing placed below table top height. It is therefore recommended that glazing be placed predominantly above table top height where possible.

Solar control glazing, external shading, and cross ventilation

Incorporating external shading features such as overhangs, window recesses and shutters will help to reduce transmittance of solar gains in the summer, whilst still achieving good levels of daylight and allowing passive solar gains to warm the space in the winter. The intent of this design strategy is to help reduce mechanical cooling loads, improve occupant comfort and maintain a well daylit space. It is recommended that dwellings are designed as dual aspect where possible, to allow for cross-ventilation and thereby help mitigate potential summertime overheating.

Thermal insulation and air permeability

Heat losses and gains through the fabric can be further limited by the optimisation of building element U-values and fabric air permeability. Reducing thermal losses through the building envelope by increasing insulation and ensuring high levels of air tightness will help to significantly reduce heating demand, and therefore result in lower heating energy consumption. Moving towards more compact shapes will also help improve energy efficiency of dwellings by reducing heat loss through the fabric.

Depending on the level of fabric energy efficiency targeted by the dwellings, the below table gives examples of the indicative fabric parameters that would have to be targeted. The parameters are based on three potential scenarios:

1 **Part L 2010 Compliance**: The first scenario represents a typical dwelling that, when coupled with best practice building services, would achieve Part L 2010 compliance through energy efficiency and passive design alone. As it is expected that the first phase of construction would as a minimum to be built to Part L 2013 standards (at time of writing the approved calculation software is still to be released), this would result in the need to achieve a further 6% reduction in CO_2 emissions, as well as minimum targets for fabric efficiency. The Part L 2010 compliant scheme has been used as a baseline in this feasibility study.

2 **CfSH Level 5**: The second scenario represents the fabric efficiency performance standards that would need to be achieved for a Code for Sustainable Level 5 dwellings, in order to meet the minimum mandatory fabric energy efficiency standard of ≤39 kWh/m²/yr for apartments/mid-terrace houses and ≤46kWh/m²/yr for semi-detached and detached houses. It should be noted that CfSH Level 5 also requires the dwelling to be zero carbon, which would normally require a substantial amount of on-site renewable technologies to be incorporated.

3 **Passivhaus**: The third scenario represents an example of the fabric efficiency performance standards required for the dwellings to be built to Passivhaus standards. This is an exemplar practice scenario in terms of energy efficiency and minimising the energy demand of the development, in line with the Passivhaus standard.

Table 4.1: Indicative Fabric Energy Performance Standards

Fabric Specification	Unit	Part L 2010 Compliant	CfSH Level 5	Passivhaus
External Wall U-value	W/m²K	0.23	0.15	0.1
Ground Floor U-value	W/m²K	0.18	0.15	0.1
Roof U-value	W/m²K	0.15	0.13	0.1
Windows U-value	W/m²K	1.5	1.2	0.8
Sheltered Wall U-value	W/m²K	0.25	0.17	0.13
Doors U-value	W/m²K	1.5	1.0	0.8
Air Permeability	m^3/m^2.hr @50Pa	5	3	1
Calculated Thermal Bridging y-value	W/m²K	0.08	0.05	0.03
Type of Ventilation		Natural	MVHR	MVHR
MVHR – Heat Recovery Efficiency and Specific Fan Power (SFP)		-	90% 0.6W/l/s	93% 0.5-0.6W/l/s

Natural Daylighting

The glazing proportions, window arrangements and glazing specifications should be designed to ensure good levels and uniformity of daylighting, helping to reduce lighting energy consumption and enhance occupant wellbeing.

Energy efficient light fittings

Best practice low energy light fittings should be specified throughout each dwelling. This will help to ensure that energy consumption from lighting is minimised.

Energy-efficient boilers

Highly efficient condensing boilers are recommended for the development. This will help to reduce fuel / energy consumption and CO_2 emissions associated with space heating and domestic hot water.

Efficient ventilation system

Whole house Mechanical Ventilation with Heat Recovery (MVHR) systems are recommended for dwellings in the scheme. A heat recovery efficiency of approx. 90+% and a specific fan power of 0.6 W/l/s should be targeted. This can provide significant energy benefits compared to using a natural ventilation strategy by helping to reduce the demand for space heating. A best practice system will be fitted with insulated, rigid ductwork in order to minimise the pressure drop and thermal losses through the ductwork.

Minimising the use of mechanical cooling

Although the inclusion of comfort cooling will be the individual decision of each house builder, it is encouraged that mechanical cooling systems are not specified. Summer thermal comfort can be achieved more energy efficiently through passive design strategies such as solar shading/control, effective ventilation and exposed thermal mass.

Enhanced pipework thermal insulation

It is recommended that all thermal distribution networks are insulated beyond the requirements of the relevant standards in order to reduce distribution losses.

Energy metering

All dwellings should be equipped with an energy display device that displays electricity and primary heating fuel consumption.

Un-regulated Energy

Overall there is limited design control over unregulated energy use at the development. An effort should be made to reduce unregulated energy uses (e.g. small power, security lighting etc.), such as through the following measures:

External lighting

All external lighting and lighting in communal areas should be designed to be energy efficient and incorporate relevant controls (i.e. passive infra-red, timers etc.) that will ensure that they are not switched on at times when not required.

Energy-efficient white goods

All white goods and kitchen equipment should be energy efficient products (i.e. A-rated EPC or better, where products are available, otherwise Class B).

4.3 Energy Efficient Design Strategies for non-domestic areas

Improvement on Part L 2010 Building Regulations to meet requirements for BREEAM Excellent (25% improvement in CO_2 emissions compared with Part L 2010) is estimated to result in the need for the following design requirements for non-residential areas of the development:

- Very good levels of insulation
- Double or triple glazing
- Whole wall U-value of ~1.0-1.2 W/m^2K OR opaque element U-value of 0.15 W/m^2K
- Very airtight envelope (~ 3 $m^3/m^2/hr$ @50 Pa)
- Very efficient lighting (~2W/m^2 per 100 lux in open plan office areas and main retail areas, 2.5-3W/m^2 elsewhere)
- Very good display lighting lamp efficacy (>80 lamp lumens / circuit Watt)
- Very efficient boilers (SEER > 92%)
- Very efficient chillers (SEER > 4.5), and utilisation of free cooling where possible
- Very efficient ventilation system
- Hot water fed from main boiler where possible and viable (especially for areas with high Domestic Hot Water loads, e.g. retail A3 units)
- It is recommended that a high level of energy sub-metering is provided within all buildings being developed on the site.
- Consideration of:
  - Cooling towers
  - Displacement / Mixed-mode ventilation
  - Chilled beams
  - External shading

Shell and core performance

It is not likely to be possible to reach the targeted performance of all shell-and-core areas until tenants are on board to fit out any shell-and-core areas on site.

The performance at this stage for these areas must be estimated using default assumptions for lighting and ventilation systems, and other items to be installed by the tenant.

It is therefore estimated at this point that shell-and-core commercial units will achieve Part L compliance at the shell-and-core stage, but may only reach the target of 25% better than Part L (as required for BREEAM Excellent) at the final fit-out stage.

For the sake of this feasibility study it has been assumed that all commercial areas will achieve Part L 2013 compliance.

Small commercial units

It should be noted here that the requirement for achieving BREEAM Excellent is very onerous on small commercial units. As stated above, it has been assumed for the sake of this feasibility study that all commercial areas will be Part L 2013 compliant, and it is recommended that it is looked into whether the goal of BREEAM Excellent is realistic for small individual units.

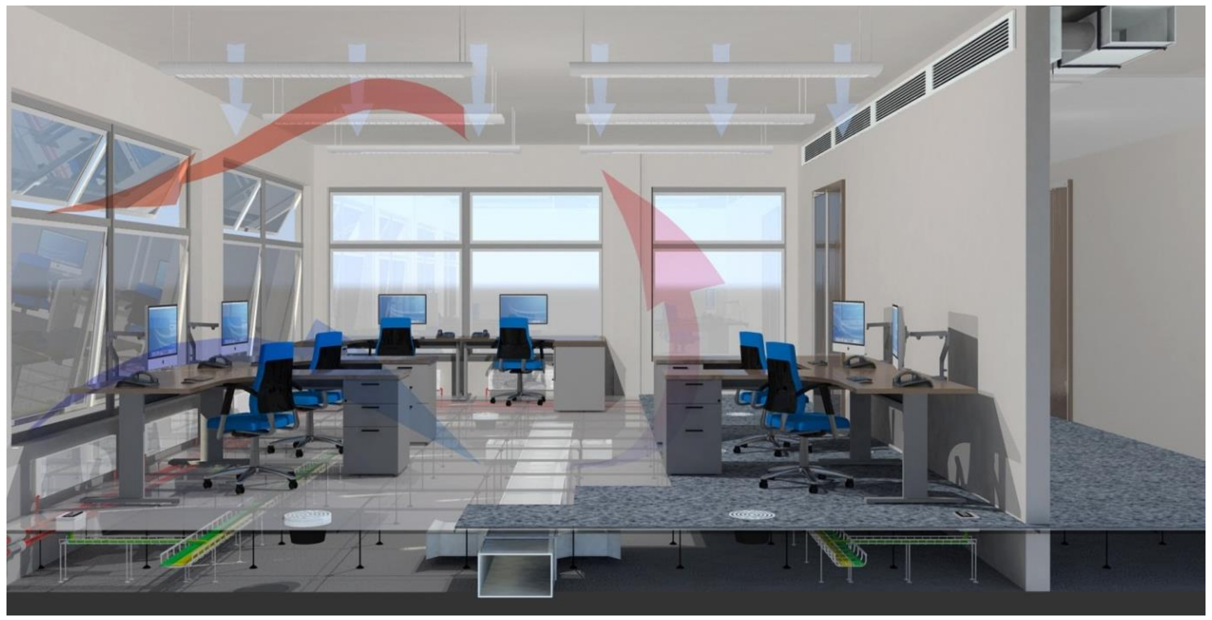


Figure 4.1: Example office development incorporating displacement ventilation in combination with chilled beams and openable windows at high level

5.0 Energy Demand Assessment - Benchmarking

An initial energy demand assessment has been carried out for the proposed Graven Hill site. The predicted energy consumption of the residential areas of the site has been estimated using indicative SAP calculations, and non-domestic areas have been estimated using industry approved energy consumption benchmarks.

5.1 Estimated Energy Consumption of Dwellings using SAP

SAP (Standard Assessment Procedure) is the Government approved methodology for predicting the energy consumption and CO_2 emissions of new dwellings, primarily for the purpose of demonstrating compliance with Part L1A of the building regulations. In order to provide a detailed estimate of the energy consumption and CO_2 emissions from the residential part of the development, a number of different sizes and types of dwellings were modelled in SAP. As Graven Hill is proposed to be a self-build site and no standard dwelling designs were available, indicative plot unit sizes from EC Harris's and Glenn Howells were used to create a set of typical dwellings in SAP.

It should be noted that the tested sample of dwellings does not include every single type of dwelling proposed for the site; however it the sample was considered adequate for the purposes of establishing principles of design and estimated site-wide energy consumption. SAP calculations were carried out for the following unit types:

Table 5.1: Units Types Assessed using SAP

Dwelling Type	Indicative Size	No. of Storeys	Proportion of Glazing (relative to internal façade area)
1 Bed Semi-Detached	76m²	2	25%
2 Bed Semi-Detached	87m²	2	25%
3 Bed Semi-Detached	96m²	2	25%
4 Bed Detached	132m²	3	25%
5 Bed Detached	192m²	3	25%
1 Bed Apartment	50m²	1	50%
2 Bed Apartment	70m²	1	40%

The results from the SAP calculations were then area weighted across the scheme in order to estimate the average energy consumption of the residential parts of Graven Hill.

As described in section 4.2 above, three different potential passive design scenarios have been tested for dwellings:

1 Part L 2010 Compliance (for use as baseline)

2 CfSH Level 5 compliance

3 Passivhaus standards

*Table 5.2: **Part L 2010 Compliant Scheme** Energy Consumption Benchmarks*

	Space Heating kWh/m²	Domestic Hot Water kWh/m²	Regulated Electricity other than Cooling kWh/m²	Cooling Electricity kWh/m²	Unregulated / Process Electricity kWh/m²
Houses	49.87	19.77	4.69	0.00	29.40
Apartments	44.58	33.17	6.69	0.00	39.27

*Table 5.3: **Code for Sustainable Homes Level 5** Energy Consumption Benchmarks (from efficiency only)*

	Space Heating kWh/m²	Domestic Hot Water kWh/m²	Regulated Electricity other than Cooling kWh/m²	Cooling Electricity kWh/m²	Unregulated / Process Electricity kWh/m²
Houses	27.17	19.99	7.23	0.00	29.40
Apartments	20.85	33.66	9.16	0.00	39.27

*Table 5.4: **Passivhaus Standard** Energy Consumption Benchmarks*

	Space Heating kWh/m²	Domestic Hot Water kWh/m²	Regulated Electricity other than Cooling kWh/m²	Cooling Electricity kWh/m²	Unregulated / Process Electricity kWh/m²
Houses	12.48	20.30	7.23	0.00	29.40
Apartments	6.89	34.25	9.16	0.00	39.27

Thermal profiles for each of these scenarios have been produced – see figures 5.1-5.3. It is evident from these profiles that the space heating demand diminishes greatly with increased thermal performance of the dwellings – especially for the Passivhaus scenario.

5.2 Estimated Energy Consumption of non-domestic areas using benchmarks

The energy consumption of non-domestic areas has been estimated based on industry approved energy consumption benchmarks as described in the below table:

Table 5.5: Energy Consumption Benchmarks for non-domestic areas of the Graven Hill development

Area	Benchmark used (assumed equivalent to Part L 2006 compliance)	Carbon emission reduction to convert to Part L 2010 compliance (in accordance with Part L 2010 Implementation Stage Impact Assessment)	Further carbon emission reduction to convert to Part L 2013 compliance (in accordance with Part L 2013 Implementation presentation)
School and Community	CIBSE Guide F – Secondary School 'Good Practice'	27%	9%
B1 Office	CIBSE Guide F - Air conditioned, standard, 'Good Practice'.	25%	13% (Assumed shallow plan office)
B1(c) and B2 Light Industrial	CIBSE Guide F table 20.1 - industrial buildings post 1995 >5000m2	25%	3%
B8 Warehouse	CIBSE Guide F table 20.5 - distribution warehouse.	34%	4%
Retail	CIBSE Guide F - Small Food Shop (A1) (75% of area)	21%	9%
	CIBSE Guide F - Fast food restaurants (A3) (25% of area)	21%	9%
Hotel / Pub / Restaurant	CIBSE Guide F - Hotel type 3 - business or holiday (50% of area)	26%	12%
	CIBSE Guide F - Sports and Recreation Fitness Centre. Split between energy uses is estimated (50% of area)	25%	9%

*Table 5.6: **Non-domestic areas** Energy Consumption Benchmarks*

	Space Heating kWh/m²	Domestic Hot Water kWh/m²	Regulated Electricity other than Cooling kWh/m²	Cooling Electricity kWh/m²	Unregulated / Process Electricity kWh/m²
School and Community	70.0	7.2	11.3	0.0	10.0
B1 Office	64.4	4.5	42.8	11.9	49.0
B1(c) and B2 Light Industrial	58.0	8.3	9.9	0.0	39.8
B8 Warehouse	60.3	9.3	8.0	0.0	39.8
Retail A1	63.8	4.5	67.5	12.8	22.0
Retail A3	96.0	216.0	86.1	20.0	672.0
Hotel / Pub / Restaurant	112.0	45.0	28.0	1.7	38.0
Leisure	56.0	108.9	56.6	8.0	30.0

5.3 Results and thermal profiles

The three tested scenarios are expected to result in the following indicative carbon emission savings, from passive design and energy efficiency alone (i.e. before the incorporation of low or zero carbon technologies):

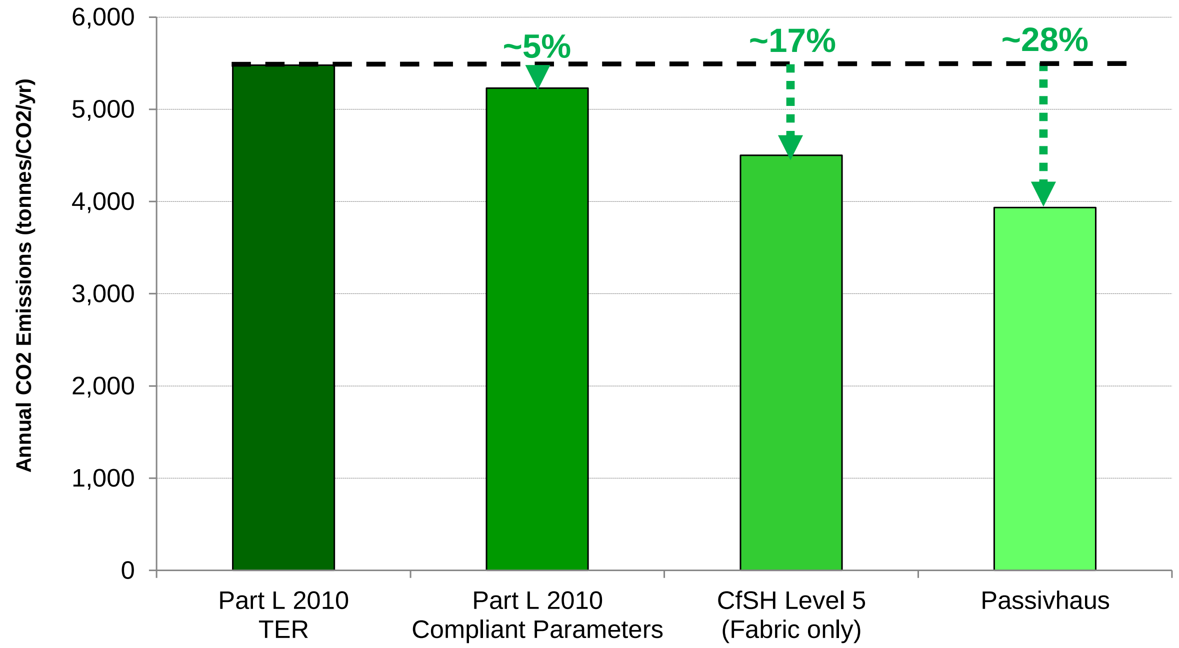


Figure 5.1: Indicative carbon emission savings from passive design and energy efficiency for different scenarios at the Graven Hill development

Based on the information given in sections 5.1 and 5.2 thermal profiles have been developed for the development for each of these scenarios (see figures 5.1-5.3 on the following page).

As can be seen from the thermal profiles, the increased thermal performance of buildings – especially dwellings – means that the energy demand for heating decreases.

Due to this decreasing space heating demand of future residences the case for district heating will diminish, most notably in the Passivhaus scenario. Further, the planned layout of the site (low density, leading to increased energy losses in pipework) and the development plan in several phases does not provide optimum conditions for implementing a centralised energy centre.

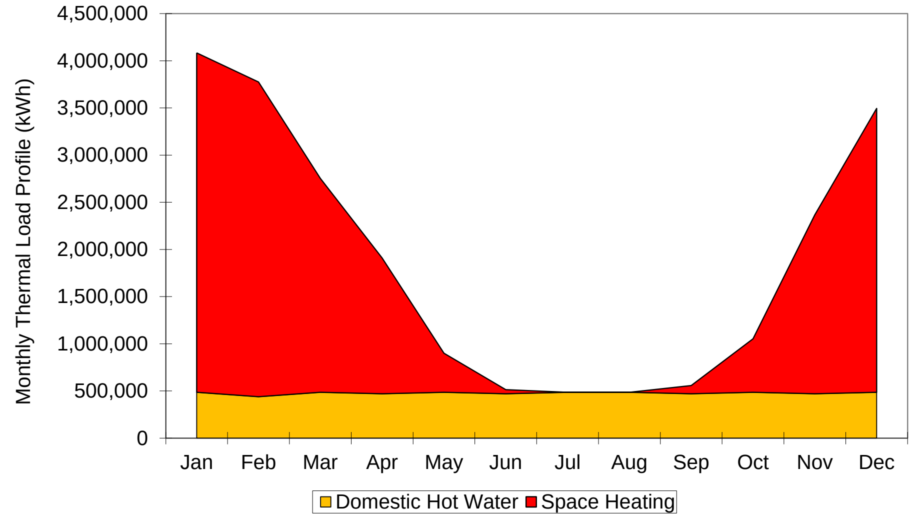


Figure 5.1: Thermal profile – Baseline Part L 2010 Compliant Fabric Parameters for dwellings, Part L 2010 compliance for non-domestic areas

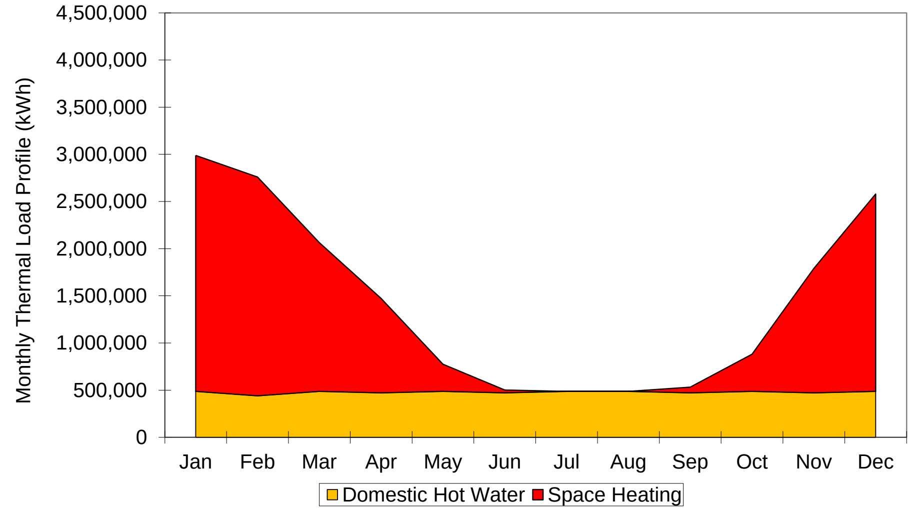


Figure 5.2: Thermal profile – CfSH Level 5 Compliant Fabric Parameters for dwellings, Part L 2013 compliance for non-domestic areas

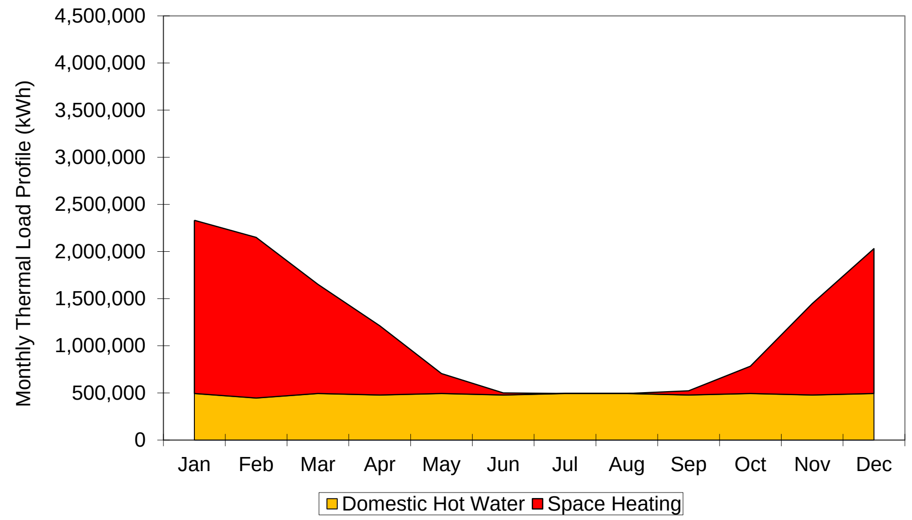


Figure 5.3: Thermal profile – Passivhaus Fabric Parameters for dwellings, Part L 2013 compliance for non-domestic areas

6.0 District Heating and Combined Heat and Power (CHP)

As explained above, due to the decreasing space heating demand of future residences the case for district heating will diminish, most notably if the homes are built to the Passivhaus standard. Further, the planned layout of the site (low density, leading to increased energy losses in pipework) and the development plan in several phases does not provide optimum conditions for implementing a centralised energy centre. It should be noted here that it is expected that the heating demand in future housing will decrease as a result of upgrades to the building regulations, and therefore the case for district heating will diminish in any case, whether Passivhaus is adopted on site or not.

6.1 Centralised Services & District Energy Networks

Locating building services plant (heating, cooling, ventilation, hot water, etc.) in a central location is common place in current building design. It provides an opportunity to reduce the number of plant units servicing any given building as well as rationalising flues. Energy can also be saved by avoiding regular ignition processes on multiple plant allowing the system to be run in a much more efficient manner.

District energy networks expand on this principle and provide greater savings through the provision of energy (heat, coolth, power) to multiple buildings. Through this method it is also possible to reduce the demand on the national grid and reduce transmission losses associated with electrical power distribution.

The most common form of district energy in the UK is district heating in which heat is delivered to multiple buildings from a local plant via a network of insulated pipes buried in the ground. This approach brings a range of benefits, such as;

- Reduce the energy lost in transmission networks
- Increased flexibility for energy generation to match local demand patterns for electricity and heat
- Increased use of renewable and low carbon sources of fuel
- Reduced disruption when servicing/replacing plant
- Future proofing - district energy networks allow a range of fuel sources to be considered and ‘bolted’ into a scheme at a later stage when new technologies and fuel supply chains are more mature

District Energy Networks also allow an ability to capture the waste heat from energy generation and use it nearby if plant such as Combined Heat & Power (CHP) or biomass is implemented.

Procurement, management and implications

The procurement of a district energy system on a site such as Graven Hill would have to be done in stages, and would be expected to need the involvement of an Energy Services Company (ESCO) to implement, run and maintain the system. For an ESCO to have a reasonable business case, as a rule of thumb they would need at least 500 dwellings connected on the system.

In order to implement a district energy network at Graven Hill in an energy-efficient manner, a phased approach would have to be taken. The full amount of plant cannot be implemented from phase 1 since it would not be efficient to run large systems at low efficiencies, whilst waiting for full capacity to be reached. It is expected that a phased approach to the energy centre would involve temporary plant, to be replaced or upgraded once further capacity is needed. This temporary plant can either be placed in the final energy centre (this would involve investing in the building for the energy centre as part of phase 1), or the plant can be placed in a temporary structure, and the final energy centre built when the site is at / near full capacity.

Due to the low-density nature of the scheme, there is a risk of increased pipe losses for the scheme. It should be noted here that for a scheme such as Graven Hill very well-insulated pipework would be needed, at an increased cost to the ESCO in implementation – and ultimately to the consumer.

6.2 Combined Heat & Power (CHP)

CHP describes a combined process that produces both useful electricity and heat.

CHP has a higher overall efficiency compared to sourcing electricity from the grid, as the heat generated by the CHP whilst producing the electricity can be utilised onsite. This has the further benefit of the electricity not having to travel great distances over the national grid before use, thus minimising transmission losses.

CHP systems can operate at ~80% overall efficiency whereas a traditional system would typically operate at ~55% efficiency. Thus an improvement in overall efficiency of ~25% can be potentially achieved by using a CHP engine. Figure 5.2 compares the efficiency of a CHP engine relative to traditional energy sources.

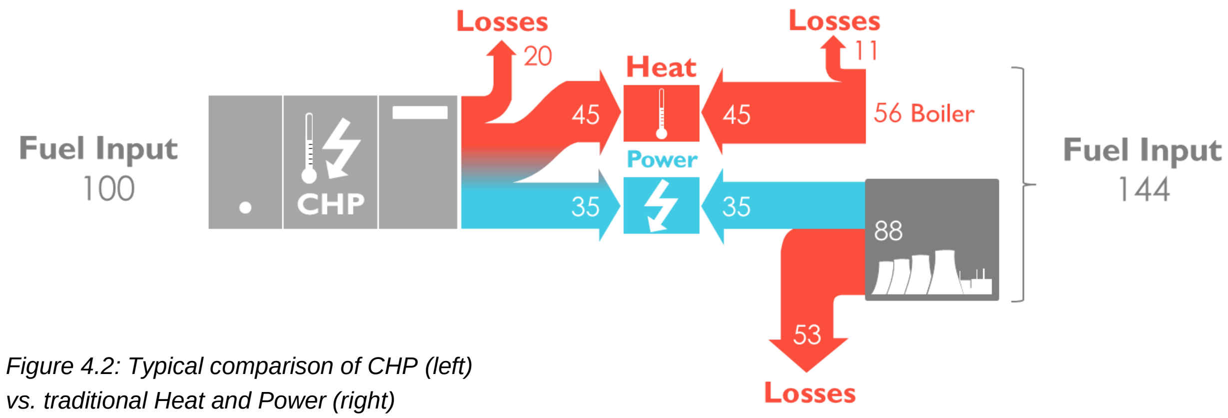


Figure 4.2: Typical comparison of CHP (left) vs. traditional Heat and Power (right)

Combined Heat and Power devices can be fuelled by mains gas, however the opportunity to provide fuel via biomass or biogases should also be investigated as this could be provide further carbon savings (see section 7.0 for further details regarding this option).

It is currently estimated that a unit size of ~2 MW_e / 2.17 MW_{th} (running max. 20h/day) would be needed to provide all of the domestic hot water and 30% of the space heating on site. As an approximation for this feasibility study it has been estimated that if all areas on site are connected to this system the cost of the pipework and trenches for the district heating network to the northern part of the site alone would be £3,000,000 – a cost that would initially have to be covered by the developer of the site (see appendix A).

7.0 Assessment of Renewable Energy Sources

Once measures to reduce the overall energy demand of the development have been investigated, the integration of on-site renewable energy sources should be examined to deliver the energy required in the most carbon conscious way possible. Attention should be paid to make sure low carbon and renewable technologies do not compete for the same energy provision as this would negate any potential savings. Potential technologies to provide renewable energy are as follows:

Solar Hot Water

Solar thermal panels operate by capturing solar energy and transferring this via glycol to a thermal store to maintain hot water. Panels can operate efficiencies up to ~75% and therefore a high energy yield can be derived from relatively small plant area. They would typically be used to meet a proportion of the domestic hot water load.

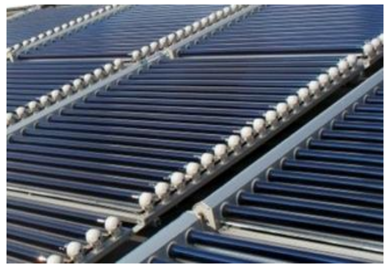


Figure 4.4: Solar Hot Water Panels

Solar hot water panels are eligible for a government subsidy under the Renewable Heat Incentive (RHI). The RHI scheme provides a payment for each kWh of heat generated.Solar hot water panels are relatively simple to install and run, and therefore a good option for self-builders. It is recommended that they should be sized to meet a proportion (~80%) of the hot water load in summer when the panels are at their highest yield in order not to over-size the system.

Photovoltaic Electricity Generation

Photovoltaic (PV) modules capture solar radiation and convert it to electricity. They can be installed as single modules or as grouped arrays. Typically they are roof mounted at an angle of around 30°, providing typical system efficiency range of 13 - 18%. PV systems can operate year-round with a potential seasonal yield of ~100kWh/m^2.

Figure 4.5: Photovoltaic Panels

It is currently estimated that, for a mid-size house, 20-40m2 of PV panels could be needed in order to reach the required carbon savings for CfSH level 5 (depending on which other carbon reduction technologies would be implemented on site).

Wind Turbines

Wind turbines use the force of the wind to turn a rotor which in turn generates electricity. Wind power is used in large scale wind farms, generating electricity and contributing to the national grid as well as in small, mast-mounted or building integrated turbines. They can be categorised into two groups, Horizontal axis wind turbines (HAWT) and Vertical axis wind turbines (VAWT). Small scale wind turbines could potentially be permitted however there is evidence of their limited effectiveness due to the turbulent nature of air flow close to and around buildings. Wind power is much more effective at the larger scale, using 2 MW or 3MW turbines with overall heights above 120m.

Heat Pumps

Heat Pumps work by extracting heat from the air (Air Source Heat Pumps), ground (Ground Source Heat Pumps) or water (Water Source Heat Pumps).

Figure 4.6: Ground Source Heat Pump System

Generally, GSHPs are more efficient as the ground temperature is more stable over the course of the year relative to air or water temperature. GSHPs have three common varieties:

- Horizontal, closed loop
- Vertical, closed loop, and
- Vertical, open loop

The performance characteristics and technical requirements of each variety varies. Typically, vertical, open loop systems operate at the highest efficiencies and are capable of producing the most thermal output. The efficiencies of the systems are highest when providing heat at relatively low temperatures, and coolth at relatively high temperatures. It is therefore considered that these types of system are best placed to provide space heating rather than hot water heating. Open loop systems require an abstraction license from the Environment Agency. In order to gain a licence, a scheme typically is required to operate in a balanced heating and cooling mode such that over the year, the amount of heat extracted from the ground is equivalent to the amount of heat rejected to the ground. Open-loop systems would most likely be considered too expensive for single dwellings, and it is also unlikely that a balanced load could be achieved, but the system could be a viable solution for non-domestic parts of the scheme. Implementation on open-loop systems would always rely on a specialist assessment of the ground conditions and aquifer in order to ascertain whether a sufficient amount of water can be extracted to make the system viable. Horizontal closed-loop systems could be a viable option for some house builders, as most of the plots at Graven Hill have garden space under which the system could be placed. It should be considered though, depending on the passive performance of the dwelling, that only very little heating may be needed for each individual dwelling.

The use of heat pumps to generate heat is eligible for a government subsidy under the Renewable Heat Incentive (RHI). The RHI scheme provides a payment for each kWh of heat generated by the heat pumps.

Another key issue relating to the energy strategy is the availability of power for the new development. Investigations into the capacity of regional electricity supply has shown that there are power constraints for the new development and it would take a number of years for a large supply of electricity to be diverted to the site. Heat pump systems, such as air source heat pumps or ground source heat pumps should be discouraged as these can increase the demand for power supplies and would not be suitable in the medium term, until future supply constraints are relieved.

Biomass

Biomass boilers use biomass material as a fuel source to heat water in a similar way to a conventional gas-fired boiler. Suitable biomass materials include a range of land and water based vegetation, with the most common being wood chips and wood pellets. Since biomass boilers are fuelled using a natural replenishable resource, it is generally considered as a renewable energy source.

Figure 4.7: Biomass Fuel Pellets

The carbon dioxide emitted from burning biomass is approximately balanced by the carbon absorbed during the fuel's production, so biomass heating approaches a carbon neutral process. However it should be noted that the harvesting, processing and transportation of the biomass fuel will inevitably involve the burning of fossil fuels, therefore it will have some carbon emissions associated with it. Biomass boilers require space for fuel storage adjacent to the boiler, and fuel must be delivered on a regular basis.

If biomass was implemented into the district energy system it would result in over-all carbon savings for the development, which each individual house builder would then benefit from when they tap into the system. This would make it slightly easier for the individual house builder to reach the onerous requirements for carbon savings required to achieve CfSH level 5.

It is currently estimated that a unit size of ~5 MW_{th} (running max. 20h/day) would be needed to provide all of the Domestic hot Water space heating on site. As an approximation for this feasibility study it has been estimated that all areas on site would be connected to this system.

The following factors need to be considered to determine the appropriateness of biomass boilers for the Graven Hill development.

- Biomass heating would need to be integrated centrally (for example within a centralised energy centre) and would provide a contribution to the site's thermal demand. As it has been established that a centralised energy system would be viable only in the CfSH Level 5 scenario, therefore biomass heating is also considered viable only for this scenario
- Biomass fuel storage would need to be provided within the energy centre, near to the boiler For a 5 MW unit it is estimated that 150 m^2 of storage could be needed (based on delivery once per month – more storage space needed for less frequent delivery) if the more space-efficient wood pellets are used (if woodchip is used more storage space would be needed).
- Fuel supply sources and local availability will need to be established
- Air quality issues would arise from the combustion of biomass on site
- Requirement to secure delivery contract for wood chips or wood pellets
- The delivery of wood chips or pellets is likely to create additional traffic, air and noise pollution on and around the site

The use of biomass is eligible for a government subsidy under the Renewable Heat Incentive (RHI). The RHI scheme provides a payment for each kWh of heat generated by the biomass boiler.

Figure 4.8: Example of biomass fuel storage: Internal masonry store

Figure 4.9: Example of biomass fuel storage: External pellet silo

8.0 Energy strategy appraisal and summary of options

Based on the scenarios for passive design assessed, a district heating system with CHP or biomass heating system are not considered viable.

Code for Sustainable Homes (CfSH) level 5 vs Passivhaus

A CfSH assessment will require all dwellings to reach 100% carbon reduction over Part L from on-site measures. Further, mandatory water reduction requirements will mean that rainwater or greywater recycling must be installed in all dwellings.

Apart from the above mandatory requirements, a CfSH level 5 rating also requires consideration of a number of further issues, with a heavy emphasis on the housebuilder to provide documentation to the certifying body, including, but not limited to:

- Environmental impact and responsible sourcing of materials
- Site run-off and ecology
- Waste storage
- NOX emissions of heating system
- Compliance with Lifetime Homes
- Monitoring and reporting construction site impacts (energy use, water consumption, transport to and from site)

All in all it is considered very onerous, and costly, for individual house builders to achieve Code Level 5 due to the complex requirements listed above. Depending on the approach taken to achieve this requirement it is currently estimated that the increased cost to each housebuilder would be £24,000-£40,000 for a mid-size dwelling, compared to a Part L 2010 compliant dwelling.

It is the understanding that the Passivhaus approach would be both less complicated and less costly for both the site developer and the individual house builders, as this option would eradicate the need for a district heating system, and would not require housebuilders to implement a host of add-on technologies.

Designing and building to Passivhaus standards is proven to result in ultra-low energy buildings that require little energy for space heating by the combination of a highly insulated envelope, very good air tightness and Mechanical Ventilation with Heat Recovery (MVHR). Passivhaus further imposes a standard for overall energy use of a building, thereby restricting the energy use of the ventilation system, appliances etc.

When compared to current (2010) UK Building Regulations standards, a Passivhaus dwelling is estimated to achieve 25-35% savings in carbon emissions before the incorporation of CHP or renewables.

There will be added cost to building a Passivhaus compared to a standard dwelling. Depending on the specification this is estimated at approx. £15,000-25,000 for a mid-size house, compared to a Part L 2010 compliant dwelling.

Implications of incorporating a district energy network on the Graven Hill site

The procurement of a district energy system on a site such as Graven Hill would have to be done in stages, and would be expected to need the involvement of an Energy Services Company (ESCO) to implement, run and maintain the system. For an ESCO to have a reasonable business case, as a rule of thumb they would need at least 400-500 dwellings connected on the system. However, given the passive design strategy proposed for the buildings the development does not offer a sufficient heat load and neither centralised CHP or biomass heating is considered viable.

For information, it is currently estimated that the cost of the pipework and trenches for the district heating network to the northern part of the site alone would be £3,000,000 – a cost that would initially have to be covered by the developer of the site (see appendix A). This would be an unnecessary burden for the development and not offer sufficient operational benefits.

9.0 Conclusion and recommendations

This study has been carried out to investigate the potential opportunities and constraints that are expected to influence the proposed energy strategy for Graven Hill. This includes a review of the proposed energy profiles for the development (as a result of requirements connected to environmental assessment methods) and the feasibility of implementing a district heating and biomass energy source for the masterplan. In conclusion there are several options available for the site, with options for the residential areas specifically discussed in this document as dwellings are expected to consume the majority of the site's thermal load.

It is highlighted that the Passivhaus standard is more deliverable and cost effective than a Code level 5 standard development.

9.1 Passive Design and Energy Efficiency

The passive design strategy chosen for dwellings at the Graven Hill development will have a great impact on the feasibility of implementing district heating on site, and on the carbon savings achievable from such a system.

Two potential scenarios for passive design are considered within this report:

1. Code for Sustainable Homes Level 5 compliance for residential units, and Part L 2013 compliance for non-residential areas
2. Passivhaus standard for residential units, and Part L 2013 compliance for non-residential areas

Code for Sustainable Homes

The greatest challenge for a Code 5 development would be in reaching the zero carbon emission target (i.e. the need to be 100% better than Building Regulations compliance- Credit Ene 1: Dwelling Emissions Rate). This would have to be achieved through on-site measures and therefore cannot be offset with allowable solutions or off-site renewables.

There is a mandatory requirement under CfSH to achieve a water consumption rate of less than 80 litres/person/year (Credit Wat 1: Indoor Water Use). It is not possible to meet this standard without incorporating greywater / rainwater recycling. This type of system will be expensive, and potentially complicated, for individual house builders to install and maintain.

It is currently estimated that the requirements for reaching Code Level 5 would be a great technical challenge to individual house builders, and would also incur substantial increased cost (estimated at £24,000-£40,000 for a mid-size house compared to a Part L 2010 compliant dwelling, depending on the systems chosen to meet this requirement).

Passivhaus option

The more viable option is to require house builders to design to Passivhaus standards instead. Designing and building to Passivhaus standards is proven to result in ultra-low energy buildings that require little energy for space heating and cooling by the combination of a highly insulated envelope, very good air tightness and Mechanical Ventilation with Heat Recovery (MVHR). Passivhaus further imposes a maximum limit for overall energy use in a building. When compared to current (2010) UK Building Regulations standards, a Passivhaus dwelling is estimated to achieve 25-35% savings in carbon emissions before the incorporation of low and zero carbon technologies. There will be added cost to building a Passivhaus compared to a standard dwelling; depending on the specification this is estimated to be approx. £15,000-25,000 for a mid-size house, compared to a Part L 2010 compliant dwelling.

This would leave more flexibility for the individual house builder, while still achieving exemplar carbon performance across the residential parts of the development.

As the heating requirement in a Passivhaus is reduced to the point where a traditional heating system is no longer considered essential, dwellings could be served by either small, efficient combination boilers or solar hot water heating with a small condensing boiler for top-up.

The Passivhaus option would therefore not require a district heating system to be implemented on site, and the installation of expensive renewable options could also be minimised.

BREEAM Excellent

Another requirement which impacts on the over-all energy strategy and viability of district heating for the site is the draft planning requirement for all non-residential areas to achieve a BREEAM rating of Excellent. This would require savings in carbon emissions of at least 25% over Part L 2010 requirements.

This requirement is particularly onerous for shell-and-core development (as fit-out works for these would not be carried out as part of the proposed works) and smaller commercial units, both of which types are expected to be present on site.

For the purposes of this feasibility study it has therefore been assumed at this stage that all commercial units will achieve Part L 2013 compliance, and it is recommended that it should be looked into whether the goal of BREEAM Excellent is realistic for all commercial units on site.

9.2 Supply energy efficiently

After the incorporation of energy efficiency and passive design measures, the incorporation of a centralised energy centre with Combined Heat and Power has been considered for the Graven Hill development.

The planned layout of the site (low/medium density) and the development programme being in several phases does not provide optimum conditions for implementing a centralised energy centre. The increased risk of pipe losses for the scheme would result in the need for very well-insulated pipework, at an increased cost to implementation – and ultimately to each housebuilder.

A site-wide district heating and CHP system is therefore considered not viable for the development.

Another key issue relating to the energy strategy is the availability of power for the new development. Investigations into the capacity of regional electricity supply has shown that there are power constraints for the new development and it would take a number of years for a large supply of electricity to be diverted to the site. Heat pump systems, such as air source heat pumps or ground source heat pumps should be discouraged as these can increase the demand for power supplies and would not be suitable in the medium term, until future supply constraints are relieved.

9.3 Renewable energy sources

An initial review has been carried out into potential renewable technology options that could be considered for the Graven Hill development. The incorporation of renewables would deliver a final reduction to the site's carbon emissions, and also potentially provide a visible statement of Bicester's support for the promotion of sustainability, energy efficiency and innovation within the building sector. However this should be held up against the cost to the individual house builder on site, as financial viability could become threatened by these requirements.

Currently this study has undertaken a high level assessment of the following renewable technologies: Photovoltaic panels (PVs), solar hot water panels, wind turbines, heat pumps, and biomass boilers.

In the Passivhaus scheme, as the heating requirement is very low for this type of dwelling, and as there is not a requirement to be 'zero carbon' for this assessment method, these dwellings could be served by a small heart source supplemented by solar thermal or solar PV systems for each dwelling. Both solar energy options can be roof mounted and managed by each individual house holder.

Since the buildings will be very energy efficient and have a low heating demand the case for biomass heating is not considered viable.

10.0 Appendix A: District Heating Network estimated layout and cost of pipework and trenching

The below image depicts an option for a district heating network of trenching in relation to the location of the proposed energy centre. The pipe network is shown by the thick red line. This network equates to approximately 4,000m in length and (assuming a capital cost of £750/m for district heating trench) would cost in the vicinity £3,000,000 as a very rough estimate.