Gilston Area
Energy Statement

November 2016

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Summary

Purpose

This energy statement has been prepared by AECOM to support emerging proposals for development of 10,000 homes and associated schools, community, and village centre commercial uses on land owned by Places for People and City & Provincial Properties, referred to as Villages 1 to 7 of the Gilston Area Strategic Masterplan.

AECOM was commissioned by Places for People to explore the options for reducing the energy use and carbon emissions arising from development in the Gilston Area and to develop an energy strategy that would address national and local planning policy, deliver long term carbon savings, and reduce energy bills for future residents, while ensuring development is deliverable.

Given the scale and likely timeframes of development, the proposed energy strategy is also designed to be flexible, allowing alternative technology choices to be considered for later phases as carbon emission factors for grid electricity fall and as the relative efficiencies and costs of technologies change.

Policy review

This statement aims to respond to East Herts District Council local planning policy, including the emerging East Herts Draft District Plan, within the context of the National Planning Policy Framework and ministerial statements on planning policy. The energy strategy also aims to account for likely long term influences arising from UK commitments on climate change mitigation, the emerging EU agenda on 'nearly zero energy buildings', consequent trends in terms of future changes to Part L of the Building Regulations, and projected reductions in grid emission factors.

Targets

The energy strategy for the Gilston Area has been developed to meet the following targets:

- Overall Dwelling Emission Rates for homes to achieve the carbon emission rates consistent with achieving a Code Level 4 rating[1] – i.e. a reduction in regulated CO_2 emissions of 19% relative to Building Regulations Part L 2013 Target Emission Rates[2].

Energy & carbon baselines

A sample of homes – representative of those proposed for the site – was modelled to establish the baseline regulated emissions corresponding to a compliant development under Part L 2013 of the Building Regulations (i.e. based on Target Emissions Rates). Emissions for non-domestic buildings were also estimated based on recognised industry benchmarks.

Baseline regulated carbon emissions and additional unregulated emissions are calculated to be 19,882 tCO_2/year, and 20,028 tCO_2/year respectively.

Energy efficiency measures

The strategy assumes that new homes would be designed to a high standard of fabric energy efficiency. As an indication, AECOM modelled sample homes assuming a fabric energy efficiency specification consistent with the standard originally proposed by Zero Carbon Hub for the Fabric Energy Efficiency Standards[3] to support a UK zero carbon homes policy. This level of fabric efficiency goes beyond the minimum fabric U-

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[1] Noting that the Code was withdrawn in March 2013 and that performance in ENE1 Dwelling Emission Rate was only one aspect of achieving a Code rating, given the current lack of reference targets this standard remains useful as a comparative measure of sustainability performance.

[2] With an allowance for this criteria to be met on a block average basis for flats.

[3] *Fabric Energy Efficiency For Zero Carbon Homes A Flexible Performance Standard For Zero Carbon Homes.* Zero Carbon Hub, 2016; and *Defining A Fabric Energy Efficiency Standard Task Group Recommendations*. Zero Carbon Hub, November 2009.

values and air tightness required by Building Regulations and could meet Part L 2013 emissions targets through energy efficiency measures alone.

Decentralised energy

AECOM worked with HermeticaBlack to undertake an 'ESCo study' to identify options and appraise the viability of a heat network serving the Gilston Area. AECOM developed outline technical solutions and capital costs for two broad options for a Gilston Area heat network:

1. Independent heat networks served by a local energy centre in each Village; and
2. A single central energy centre serving all development in the Gilston Area.

For both options it was assumed that the primary heat generators would be gas-fired combined heat and power (CHP) engines, with gas-fired boilers to serve peak loads and provide backup. The cash flow analysis assumed energy prices paid by consumers would be controlled to remain equivalent to those for a conventional gas boiler system as is typical practice for district energy schemes.

Neither option produced an internal rate of return considered sufficient to attract a third party investor. This is due to the relatively low density of the development and low heat demands of energy efficient homes resulting in correspondingly low heat sales revenues relative to the network investment required.

AECOM also compared the carbon saving merits of a heat network served by gas-fired CHP with the savings from alternative carbon saving options, considering how relative carbon savings are likely to change over the course of a ~20-year development programme. This analysis found that equivalent or greater carbon savings could be delivered at lower cost via dwelling based solutions. The analysis also suggests, based on projected decarbonisation of the electricity grid, that carbon emissions from gas CHP will progressively rise – first to the point where they offer no savings against alternative heat pump options[4] before starting to exceed those of baseline gas boilers[5].

A decentralised energy solution based on a heat network served by gas-fired CHP is therefore not proposed for the development.

Renewable energy technologies

The options of applying air and ground source heat pumps, solar water heating and photovoltaics were appraised.

Biomass heating and wind turbines were ruled out on the basis of initial technical screening: biomass due to supply risks and likely air quality implications given the scale of development, and wind turbines due to lack of wind resource and disrupted wind patterns in urban fringe areas.

Proposed energy strategy

The proposed energy strategy for the development is:

1. Energy efficient fabric and buildings services designed such that on aggregate the site meets Building Regulations Part L 2013 Target Emissions Rates through energy efficiency alone;
2. PV or (for houses) solar water heating sized such that in combination with the efficiency measures all homes and blocks of flats achieve an emission rate reduction of at least 19% relative to Building Regulations Part L 2013 Target Emission Rates; and

Assuming that PV is the generally preferred solution and that efficient hybrid panels are specified and fitted at a tilt of 30 degrees to maximise energy output, this strategy results in site-wide peak installed capacity at full build-out of 4,476 kWp. This amount of PV would save 1,913 tCO_2/year, an emissions saving from renewables of 10.6% against the residual emissions after energy efficiency.

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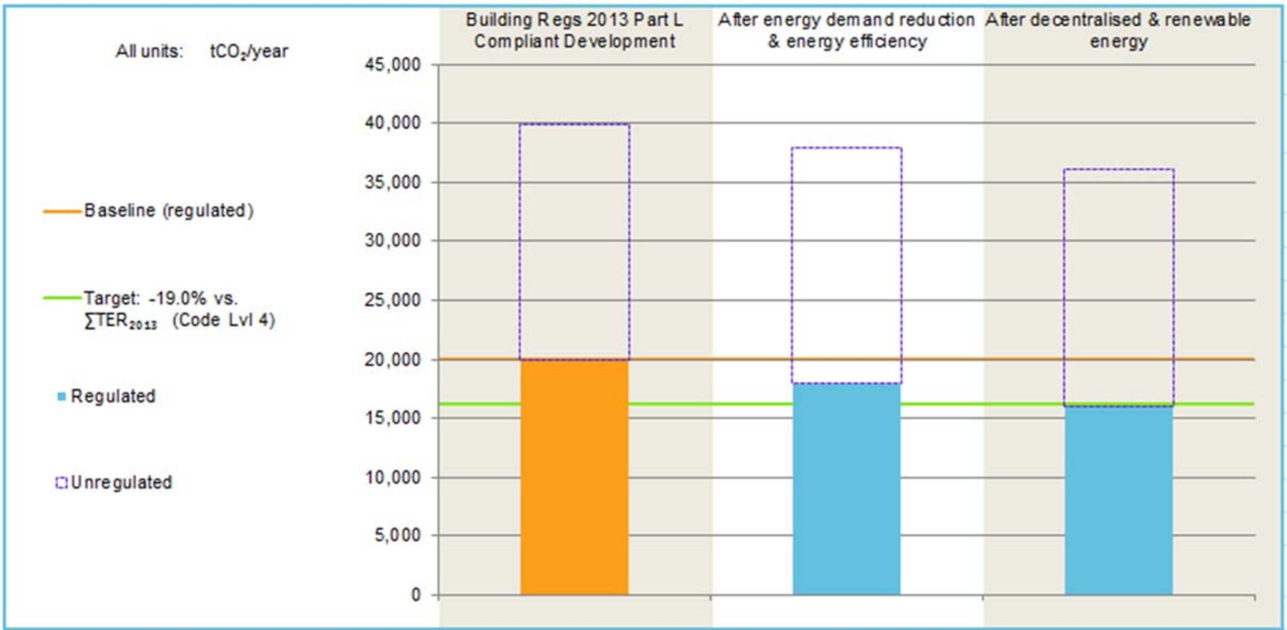
[4] At a grid carbon intensity ~400 gCO_2/kWh compared to the current 519 g/kWh

[5] At a grid carbon intensity ~300 gCO_2/kWh; for context, DECC's *Updated Energy and Emissions Projections 2015* expect grid carbon intensity to fall to ~100 gCO_2/kWh by around 2030.

Summary Figure 1 below shows the carbon baseline, emissions and savings for the proposed energy strategy, at each step in the energy hierarchy. Calculations at this stage suggest the proposed strategy would save 3,819 tCO_2/year, which is 19.2% of the baseline regulated emissions of 19,882 tCO_2/year.



			Building Regs 2013 Part L Compliant Development		After energy demand reduction & energy efficiency		After decentralised & renewable energy	
CO_2 Emissions								
	Unregulated	Site total	20,027.7		20,027.7		20,027.7	
	Regulated	Baseline			19,882.0			
		Site total	19,882.0		17,975.4		16,062.9	
		Target			16,104.4			
CO_2 savings								
	Regulated	Site total			1,906.6	9.6%	1,912.5	10.6%
		Cumulative			1,906.6	9.6%	3,819.0	19.2%

Summary Figure 1: Gilston Area proposed energy strategy: baseline CO_2 emissions & Energy Hierarchy savings.

It is proposed that flexibility is retained for later phases to deliver equivalent savings through alternative renewable technologies such as air and ground source heat pumps. These will become increasingly effective at reducing carbon emissions as the carbon intensity of grid electricity falls.

Introduction

01

1 Introduction

1.1 Purpose of this report

This energy statement has been prepared by AECOM to support emerging proposals for development of 10,000 homes and associated schools, community and commercial (village centre) uses on land owned by Places for People (PfP) and City & Provincial Properties (CPP), referred to as Villages 1 to 7 of the Gilston Area Strategic Masterplan.

The statement sets out the proposed energy strategy for development in the Gilston Area and the options reviewed for reducing CO_2 emissions through energy efficiency and low / zero carbon technologies.

1.2 Background

AECOM was commissioned to carry out a range of engineering and energy studies to inform the masterplan. This report focuses specifically on the proposed approach for reducing the energy demands and carbon emissions of the prospective development.

The following objectives have been considered in reviewing potential energy strategy options:

- To reduce the scheme's demand for energy;
- To utilise low carbon and renewable sources of energy supply;
- To reduce the scheme's carbon emissions as part of addressing national and global objectives for avoiding catastrophic climate change;
- To create homes that are comfortable, and affordable to heat and operate;
- To ensure that future residents can benefit from national incentives aimed at the more efficient use and production of energy;
- To identify a strategy that is sufficiently flexible to be able to adapt to future advances in technology and changes in policy and Government incentives likely to occur over a long build out programme; and
- To ensure proposals are deliverable both technically and financially.

1.3 The Proposed Scheme

The Gilston Area is located on land immediately to the north of the existing built up area of Harlow on the northern side of the River Stort, to the south east of the village of Hunsdon and to the west of the village of High Wych. It lies on the border of the counties of Essex and Hertfordshire. A small part of the site is within the Harlow Council boundary although the majority sits within East Herts.

The masterplan for the proposed development is still evolving but is likely to consist of a series of villages of varying density and character. Figure 1, Figure 2, and Figure 3 below show the emerging Strategic Masterplan[6], development densities[7], and illustrative phasing strategy[8] on which the analysis of energy options was based.

[6] Grimshaw / Rick Mather (3/9/2015).Gilston Area Strategic Masterplan (For information).

[7] Grimshaw / Rick Mather (10/7/2015). GPE Density Study – Developable Area (For information).

[8] Grimshaw / Mather (8/6/2015). Illustrative Phasing Strategy – Gilston Area.

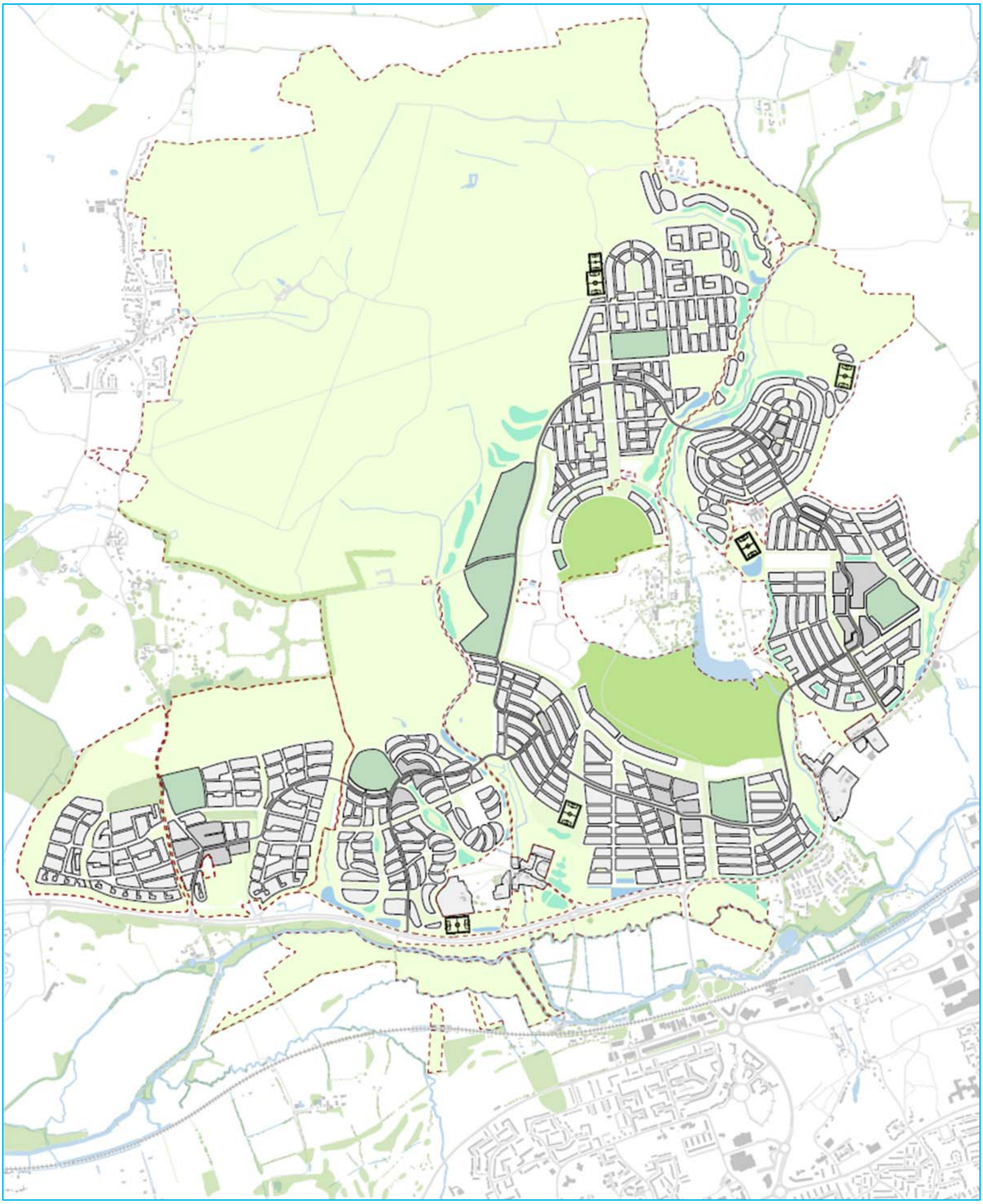


Figure 1 Gilston Area Strategic Masterplan (Grimshaw, Rick Mather, Figure Ground 11/2/2016).

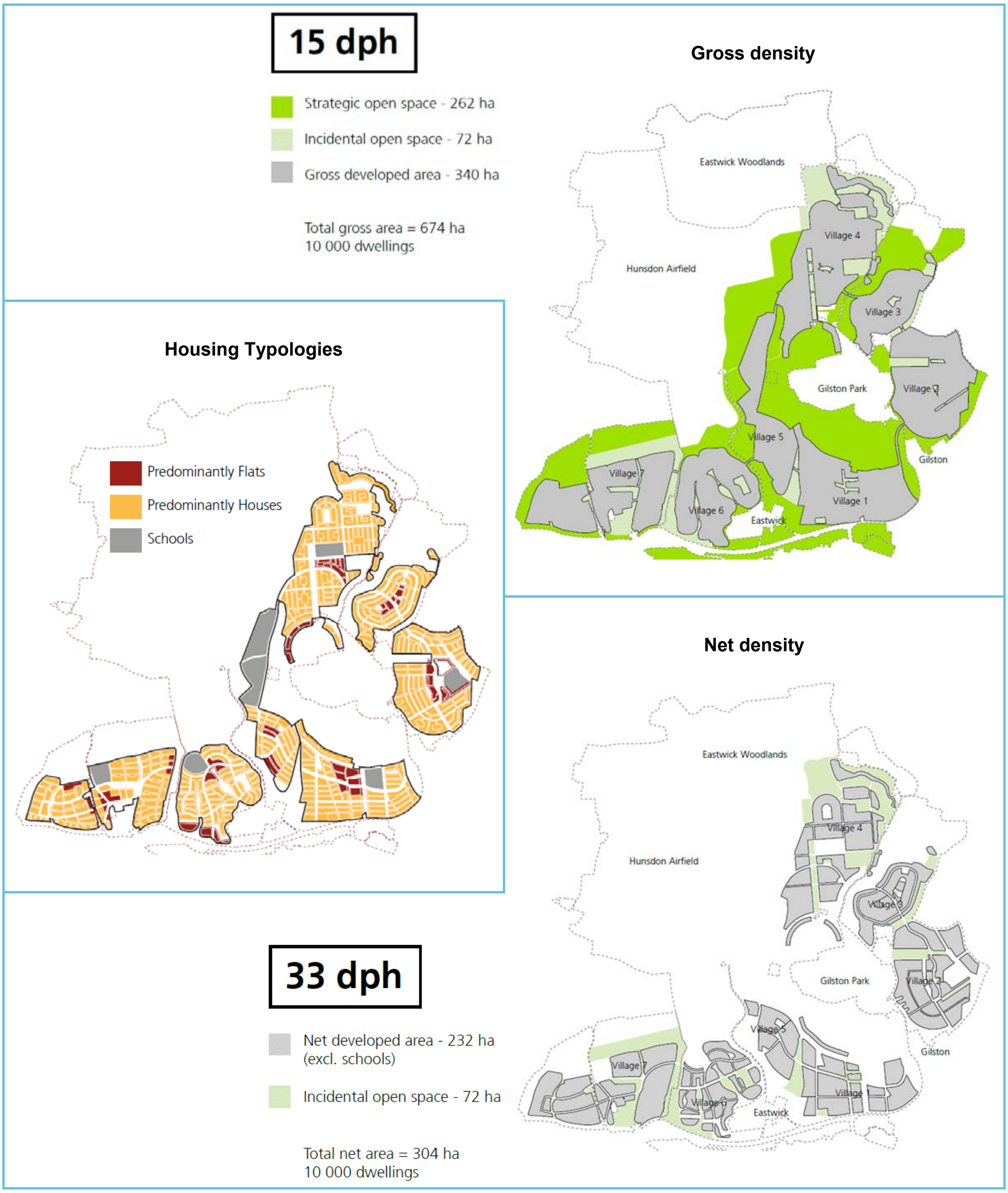


Figure 2 Gilston Area Density Note (Grimshaw, Rick Mather, Figure Ground February 2016) – housing typologies, gross and net density.

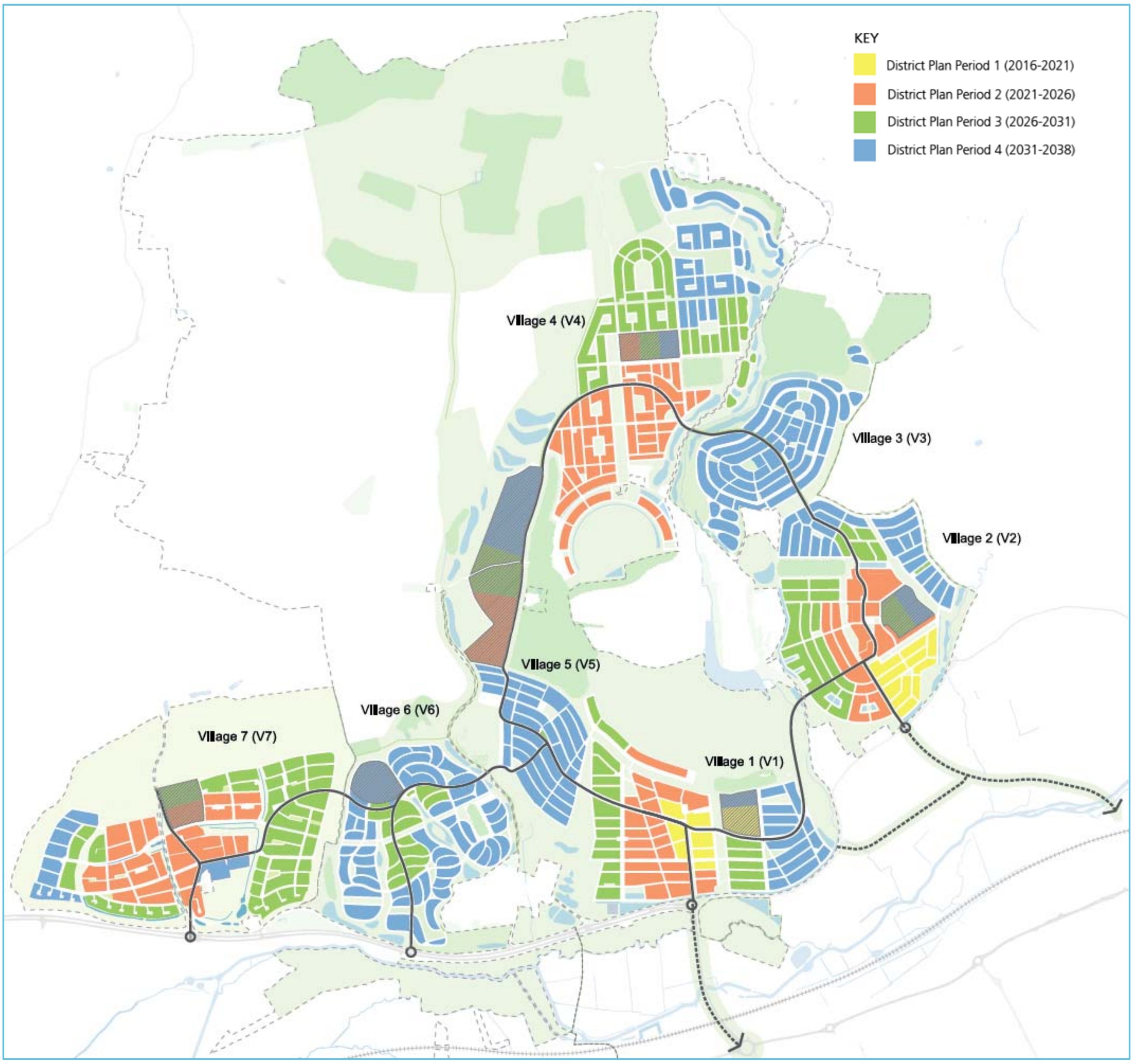


Figure 3. Gilston Area Phasing Plans. (Grimshaw / Mather / Figure Ground, 17/3/2016).

The illustrative mix of dwellings assumed for the purposes of establishing the site-wide carbon emissions for the baseline case and for considering energy strategy options is set out in Table 1. (Note that the illustrative mix presented in the table reflects what was modelled to calculate indicative energy demands and carbon emission and to develop the energy strategy set out in this report. The energy strategy is unlikely to be affected by minor changes in total dwelling numbers and mix during masterplan development. Current information on the masterplan is available from Places for People and City & Provincial Properties.)

Development data	Village 1	Village 2	Village 3	Village 4	Village 5	Village 6	Village 7	Total
Total residential units (#)	1,864 (18.3%)	1,805 (17.7%)	1,024 (10.1%)	1,940 (19.1%)	735 (7.2%)	1,213 (11.9%)	1,600 (15.7%)	10,181 (100.0%)
Gross density (dph)	36	31.6	31.2	24.5	38.5	25.6	24.4	28
Unit Types								

Cottages			176 (17.2%)				32 (2.0%)	208 (2.0%)
Bungalows				64 (3.3%)			16 (1.0%)	80 (0.8%)
Detached	10 (0.5%)	209 (11.6%)	212 (20.7%)	475 (24.5%)	74 (10.1%)	180 (14.8%)	224 (14.0%)	1,384 (13.6%)
Semi-detached	232 (12.4%)	379 (21.0%)	189 (18.5%)	423 (21.8%)	85 (11.6%)	275 (22.7%)	288 (18.0%)	1,871 (18.4%)
Townhouse	375 (20.1%)	126 (7.0%)	26 (2.5%)	90 (4.6%)	61 (8.3%)	99 (8.2%)	144 (9.0%)	921 (9.0%)
Terrace	555 (29.8%)	582 (32.2%)	138 (13.5%)	325 (16.8%)	295 (40.1%)	345 (28.4%)	416 (26.0%)	2,656 (26.1%)
Flats	692 (37.1%)	509 (28.2%)	283 (27.6%)	563 (29.0%)	220 (29.9%)	314 (25.9%)	480 (30.0%)	3,061 (30.1%)

Table 1 Masterplan illustrative unit numbers and mix used for energy and carbon modelling (in September 2015)

A range of non-domestic uses are also proposed as part of development in the Gilston Area including (at full build-out) five new primary schools up to 15-form entry, 1/2 secondary up to 14-form entry, and a mix of community and commercial buildings - healthcare, places of worship, amenities, food and non-food retail, etc. There is much greater variability in the design, energy use and carbon emission of non-domestic buildings than there is between different types of homes, and the total area and corresponding energy use and emissions arising from them will be small compared to those of the proposed homes. As such, the energy strategy accounts for the area of proposed non-domestic buildings on an aggregate basis.

Calculations for non-domestic buildings are based on an estimated total area of 39,521 m^2, of which ~30,000 m^2 relates to the proposed schools. Corresponding energy use and carbon emissions arising from non-domestic buildings are included in the baseline which determines the energy strategy targets. A conservative estimate of non-domestic heat demands was included in the study of decentralised energy and heat network options, and the appraisal of each renewables option includes a qualitative discussion of applicability to – and carbon savings contribution from – non-domestic buildings. However, while energy and carbon savings in non-domestic buildings would count towards meeting targets at the time of development, the energy strategy does not rely on any savings contributions from non-domestic buildings, which have been discounted due to the difficulty of undertaking meaningful calculations until more detailed design information for these buildings is available.

1.4 Energy statement structure

The remainder of this energy statement is structured as follows:

Section 2 sets out the **national and local policies** that have informed the energy strategy and which it aims to address, as well as the **energy and carbon targets** proposed for the Gilston Area.

Section 3 sets out how the **baseline CO_2 emissions** have been determined and the carbon savings achievable through **energy efficiency** measures.

Section 4 provides a summary of the analysis undertaken to explore the potential options for a **decentralised energy** scheme serving the Gilston Area.

Section 5 sets out the **renewable energy** options appraised and their potential contribution to energy and carbon savings.

Section 6 provides a summary and synthesis of the energy efficiency, decentralised energy, and renewables options considered and sets out a proposed energy strategy for the Gilston Area.

Policy and Targets

02

2 Policy and Targets

The energy strategy for the Gilston Area needs to respond to national and local planning policy as it currently stands, and should also have the flexibility to address broad changes in policy over an expected 20-year development period. The most relevant policies and related foreseeable trends are reviewed below. In light of this review, a set of energy and carbon objectives and targets are proposed for development in the Gilston Area.

2.1 National policy context and regulations

2.1.1 UK Commitments on Climate Change Mitigation & Renewable Energy

The Climate Change Act (2008) sets a legally binding target to reduce UK carbon emissions by 80% by 2050, against a 1990 baseline. The Committee on Climate Change advises the Government on the setting of binding 5-year carbon budgets on a pathway to achieving the 2050 target. The first four carbon budgets covering the period up to 2027 have been set in law. The current budget requires a 29% emissions reduction by 2017, while future budgets require reductions of 35% by 2020 and 50% by 2025.

The UK is committed to meeting the requirements of EU legislation designed to tackle climate change. The main piece of legislation affecting new buildings is the Energy Performance of Buildings Directive (EPBD). The majority of EPBD requirements – e.g. the setting of minimum energy performance standards and energy performance certification for new buildings – are implemented through Part L of the Building Regulations.

The UK is also committed to supplying 15% of all energy from renewable sources by 2020 as part of an EU target to supply 20% of energy from renewables by 2020. The UK Renewable Energy Strategy (2009) anticipates that renewables will need to contribute around 30% of electricity supply, 12% of heating energy and 10% of transport energy to meet this target.

2.1.2 National Planning Policy Framework

The National Planning Policy Framework was published in March 2012, replacing all previous Planning Policy Statements and guidance. Some of the key paragraphs relating to energy are set out below:

95. *To support the move to a low carbon future, local planning authorities should:*
    - *plan for new development in locations and ways which reduce greenhouse gas emissions;*
    - *when setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards.*
96. *In determining planning applications, local planning authorities should expect new development to:*
    - *comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and*
    - *take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.*
97. *To help increase the use and supply of renewable and low carbon energy, local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:*
    - *identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.*

In paragraph 95, reference to “the Government’s zero carbon buildings policy” now needs to be read in the context of the effective cancellation of 2016 zero carbon homes policy (see below), but could apply to the UK implementation of EU policy on “nearly zero energy buildings”. The nature of “nationally described standards” was addressed in the Housing Standards Review, summarised below.

The NPPF retains an emphasis on decentralised energy sources, and is careful to link this with viability.

2.1.3 Housing Standards Review and the Code for Sustainable Homes

In August 2013 the Department for Communities and Local Government published a Housing Standards Review Consultation. The aim of the Housing Standards Review was to rationalise the standards that housing developers are required to meet, to avoid duplication and conflicting standards while bringing forward new development. The intention of the review is to make the planning and compliance process more streamlined, therefore reducing some of the constraints that are currently considered to be hindering delivery of much needed housing. The intention was to set out a set of national standards, but with optional higher standards that can be adopted in local plans where this is justified by local circumstances.

On the 25 March 2015 Eric Pickles and DCLG published a Written Policy Statement to Parliament on Updates to Planning. This confirmed that following Royal Assent of the Deregulation Bill (which was subsequently granted on 26th March 2015) planning authorities should not set any additional local technical standards or requirements relating to the construction, internal layout or performance of new dwellings other than the proposed national standards or optional standards. Nor should planning permissions be granted requiring, or subject to conditions requiring, compliance with any technical housing standards other than for those areas where authorities have existing policies on access, internal space, or water efficiency. On the specific issue of energy performance the Policy Statement includes the following

> *[L]ocal planning authorities will continue to be able to set and apply policies in their Local Plans which require compliance with energy performance standards that exceed the energy requirements of Building Regulations until commencement of amendments to the Planning and Energy Act 2008 in the Deregulation Bill 2015.*
>
> *This is expected to happen alongside the introduction of zero carbon homes policy in late 2016. The government has stated that, from then, the energy performance requirements in Building Regulations will be set at a level equivalent to the (outgoing) Code for Sustainable Homes Level 4. Until the amendment is commenced, we would expect local planning authorities to take this statement of the government’s intention into account in applying existing policies and* ***not set conditions with requirements above a Code level 4 equivalent*** [emphasis added].

The Government has now withdrawn the Code, aside from the management of legacy cases.

2.1.4 UK Zero Carbon Homes policy

In July 2015 it was announced that

> *“the Government does not intend to proceed with the zero carbon Allowable Solutions carbon offsetting scheme, or the proposed 2016 increase in on-site energy efficiency standards, but will keep energy efficiency standards under review, recognising that existing measures to increase energy efficiency of new buildings should be allowed time to become established”.*

This announcement effectively interrupted the previous schedule to update energy efficiency standards for homes every 3 years (with standards having been updated in 2013 and the next update due in 2016) and cancelled the policy for new homes to be zero carbon from 2016.

In terms of implications for local planning policy, it is assumed that the situation established in the Planning Update Policy Statement of March 2015 continues to apply. I.e. planning authorities may continue to apply existing policies and set new planning policies on energy standards. However they should take account of the government’s stated policy intentions and not adopt new policies nor set conditions that are equivalent to a standard of energy performance above Code Level 4.

2.1.5 EU (EPBD) – Nearly Zero Energy Buildings

Directive 2010/31/EU (EPBD recast) Article 9 requires that "*Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings*".

A nearly zero-energy building is defined in Article 2 of the EPBD recast as "*a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby*".

While the Government cancelled the existing zero carbon policy and related delivery timetable, culminating in a 2016 Part L update, there is still the requirement under EU law to implement Article 9 in the UK through national legislation.

2.1.6 Building Regulations

Part L of Building Regulations is the key mechanism for implementing the EPBD in the UK and for implementing the Building Act (1984) with regard to the conservation of fuel and power in buildings.

The Building Regulations have been progressively tightened including updates in 2006, 2010 and 2013. With each improvement to Building Regulations Part L Target Emission Rates the scope to achieve further carbon savings becomes more limited. Part L 2013 came into force in April 2014, with an average 6% reduction in regulated CO_2 emissions for homes and 9% reduction for non-residential buildings compared with Part L 2010.

A key priority in previous updates to Building Regulations has been to maintain flexibility in how developers meet the required carbon reductions: enabling a choice between fabric enhancements to reduce demands, or investing in renewable technologies to supply energy demands through low carbon fuel sources. A key change in the 2013 update was the introduction of a new Target for Fabric Energy Efficiency (TFEE). This aimed to increase the attention given by developers to reducing the intrinsic heating demands of new homes and addresses a concern that carbon reductions were increasingly being delivered through low carbon or renewable energy supply options without sufficient focus on reducing the actual energy demands of homes. Meeting the TFEE is an additional requirement and developers are still required to achieve an overall CO_2 Target Emission Rate (TER).

2.2 Draft East Herts District Plan

The emerging East Herts District Plan has been considered in developing the energy strategy for the Gilston Area. Relevant policy excerpts are as follows:

> ***"Strategic Objectives***
>
> *1. To mitigate the effects of climate change by reducing carbon dioxide emissions, supporting decentralised, low carbon and renewable energy and reducing the risk of flooding."* [Chapter 2 Vision and Strategic Objectives]
>
> ***DES3 Design of Development***
>
> *I. All development proposals, including extensions to existing buildings, must be of a high standard of design and layout to reflect and promote local distinctiveness. Proposals will be expected to:*
>
> *(d) Encourage high quality innovative design, new technologies and construction techniques, including zero or low carbon energy and water efficient, design and sustainable construction methods;* [Chapter 17. Design and Landscape]

AECOM assumes that reference to "zero or low carbon energy…efficient design" in draft policy DES1 means the application of low carbon energy supply technologies (e.g. CHP) and renewables (e.g. PV), which are often referred to as low or zero carbon technologies, or LZCs.

"CC1 Climate Change Adaptation

All new development should:

(a) Demonstrate how the design, materials, construction and operation of the development would minimise overheating in summer and reduce the need for heating in winter;

CC2 Climate Change Mitigation

I. All new developments should demonstrate how carbon dioxide emissions will be minimised across the development site, taking account of all levels of the energy hierarchy. Achieving standards above and beyond the requirements of Building Regulations is encouraged.

II. Carbon reduction should be met on-site unless it can be demonstrated that this is not feasible or viable. In such cases effective offsetting measures to reduce on-site carbon emissions will be accepted as allowable solutions."

"CC3 Renewable and Low Carbon Energy

I. The Council will permit new development of sources of renewable energy generation, including community led projects, subject to assessment of the impacts upon:

(a) environmental and historic assets;

(b) visual amenity and landscape character;

(c) local transport networks;

(d) the amenity of neighbouring residents and sensitive uses;

(e) air quality and human health; and

(f) the safe operation of aerodromes.

III. In considering the impact of renewable technologies, the Council will attach particular importance to maintaining the special countryside character of the rural area, including the preservation of long-distance views from public rights of way." [Chapter 22. Climate Change]

2.3 East Hertfordshire Local Plan 2007

At the time of writing, the East Herts Local Plan 2007 saved policies remain part of the development plan used to determine planning applications. The key policies relevant to energy are:

"Policy SD3 Renewable Energy

The development of facilities for the harnessing of renewable energy sources is supported in principle. Particular emphasis will be placed on promoting energy generation from biomass fuels and solar power on both a small scale and commercially.

"Policy SD3 Renewable Energy - Supporting text:

2.4.9 …[O]n larger or other more spacious sites the District Council will expect proposals to be put forward which achieve renewable energy exploitation. For example, all new developments will be expected to include an active thermal solar system unless there are clear and exceptional reasons why this should not be the case."

While the supporting text places an emphasis on active solar thermal systems we have not seen evidence from recent applications that this is being rigorously enforced and we assume the local planning authority would accept alternative renewable sources such as PV.

"Policy ENV1 Design and Environmental Quality

– All development proposals, including extensions to existing buildings, will be expected to be of a high standard of design and layout and to reflect local distinctiveness. To those ends development proposals will be expected to:

(e) *incorporate sustainable initiatives in design, layout and construction methods including energy and water conservation and solar energy as an integral part of the design of the development;"*

2.4 Financial Incentives

At present FITs are available for PV generation in new homes and non-domestic buildings and Renewable Heat Incentive is available for use of renewable heat delivered to new homes via heat networks, and for renewable heat installed to serve non-domestic buildings. Renewable heat installations serving single new homes are ineligible for Renewable Heat Incentive. The levels of Government incentives for low carbon technologies have been subject to considerable change in recent years and it is reasonable to assume that further changes in incentives will occur over the build out period for the Gilston Area.

2.5 Future trends and the need for a flexible energy strategy

2.5.1 Electricity grid decarbonisation and fuel emission factors

The emission factor for grid supplied electricity is expected to fall progressively over time in response to a changing mix of generation capacity on the electricity network (including less coal, greater take up of renewable energy and a renewal of baseload nuclear power stations).

The emission factor for mains gas is on a small upward trend due to an increase in the importation of liquid natural gas and a reduction in North Sea gas supplies.

The impact of these changes is that over time the emissions associated with technologies that use electricity to produce heat or power will go down. This will make ground source heat pumps and air source heat pumps – that use mains power to 'extract' heat from local ambient heat sources, usually displacing gas heating fuel – more attractive in terms of net carbon emissions. Conversely the carbon savings benefits of combined heat and power (CHP), photovoltaics (PV) and fuel cells – that generate power locally, displacing grid electricity – will go down.

The carbon savings achieved by gas–fired CHP depend strongly on the difference between the emission factor of the gas fuel used in the engines and the electricity generated, displacing mains power. As such, the merits of CHP – relative to other carbon saving solution for new development – are particularly affected by the expected changes in carbon emission factors. Figure 4 compares the net CO_2 emissions associated with providing a unit of heat from market-ready low carbon heating technology options (vertical axis) at a range of emission factors for grid electricity (horizontal axis). (The heat pump efficiencies assumed in Figure 4 reflect data from Energy Saving Trust field trials [9] reports (March 2012), which are the default efficiencies used in SAP[10]. Gas fired CHP engines of the scale likely for any Gilston Area heat network would have an electrical efficiency of around 35%.)

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48327/5045-heat-pump-field-trials.pdf

[10] Average efficiencies for ASHP and GSHP reflect the default efficiencies in SAP when systems are fitted by a certified installer and assuming a 50%-50% split between space heating and hot water, typically found in flats. Houses typically have a higher proportion of space heating demand, for which heat pump efficiency is higher. So the assumed split is deliberately conservative as it underestimates average efficiency across a mix of houses and flats.

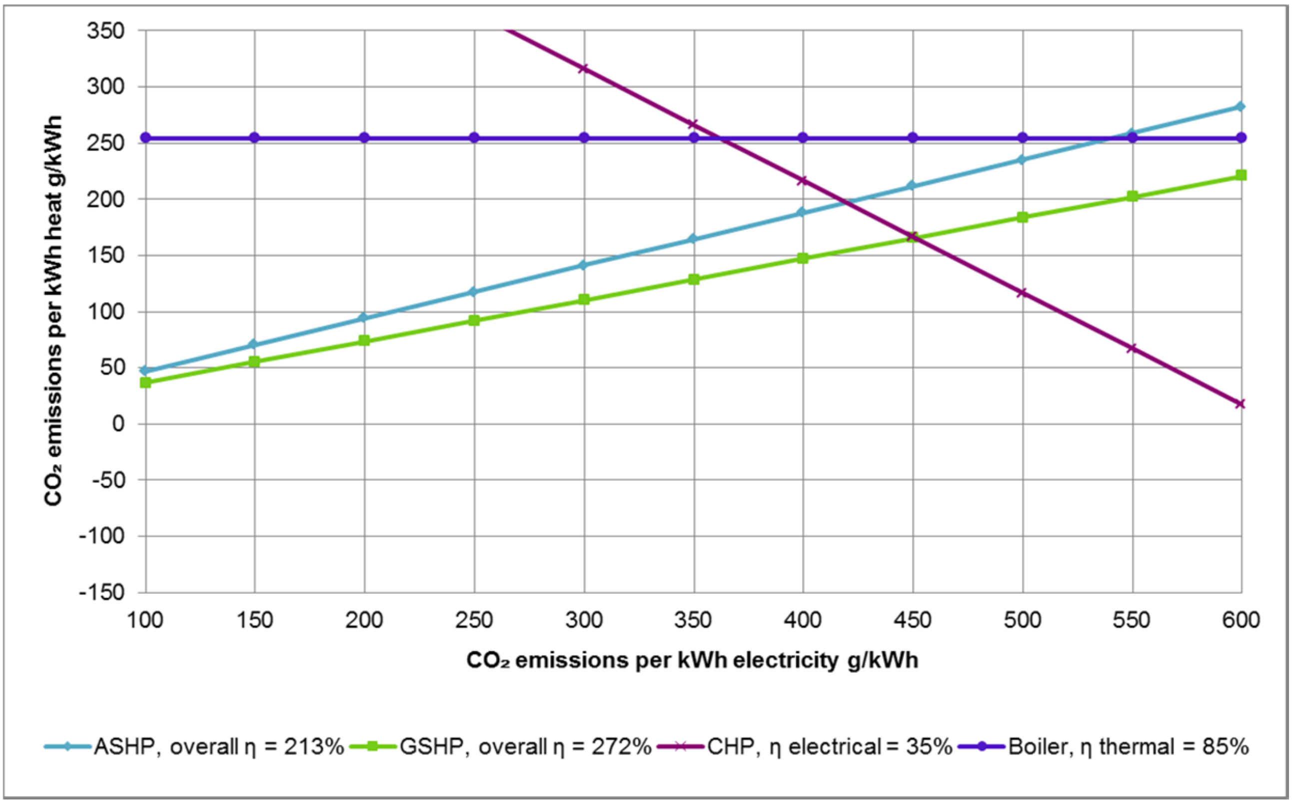


Figure 4 CO_2 emissions for heat from various sources against electricity emissions factor. (Note: gas emission factor 212 gCO_2/kWh; total thermal plus electrical CHP efficiency is 80 %.)

CO_2 emission factors used in the calculations for Building Regulations Part L compliance, and which in turn are typically used to demonstrate that planning policy targets are being addressed, are based on published figures set out in the Standard Assessment Procedure (SAP)[11].

The current grid emission factor used for Part L for both homes and non-domestic buildings is 519 gCO_2/kWh. DECC's *Updated Energy and Emissions Projections 2015*[12] expect grid carbon intensity to fall to ~127 gCO_2/kWh by around 2030. Figure 4 illustrates that, assuming a constant emission factor for gas, air source heat pumps have just passed the point (emission factor for electricity below ~530 gCO_2/kWh) where they offer a small carbon saving compared to an 85% efficient gas boiler[13]. The grid emission factor would need to drop to below ~420 gCO_2/kWh before air source heat pumps can provide heat at lower carbon emission rates than gas fired CHP.

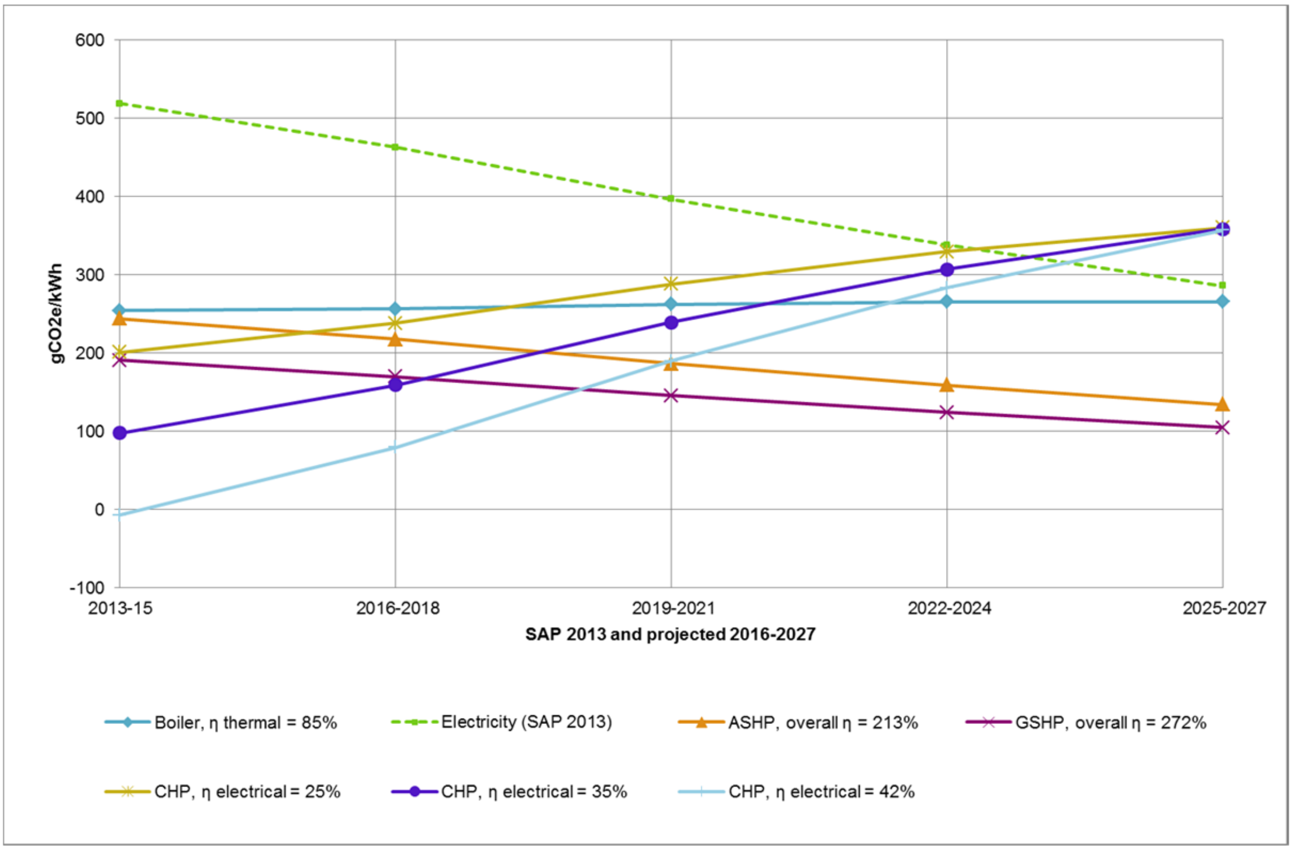


Figure 5 CO_2 emissions for heat from various sources against predicted future electricity emissions factors (as published in SAP 2012 consultation (Note: gas emissions factor increases over time. CHP efficiency relates to electrical efficiency; total CHP efficiency (i.e. thermal plus electrical) is 80%.))

11 http://www.bre.co.uk/sap2012/page.jsp?id=2759

12 https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal#history. Data Table 1. September 2015

13 The EST Condensing Boiler trials identified that few condensing gas boilers are installed in a system with low enough return temperatures to enable condensing operation. 85%-86% is the maximum efficiency achievable without condensing operation.

Figure 5 plots the predicted future gas and electricity emission factors as reported in the 'Technical Papers' supporting SAP2012[14] and the impact on the CO_2 emissions per kWh of heat. Based on these emission factor projections and including distribution losses at 22% of the heat delivered, gas CHP could offer a carbon saving over a gas condensing boiler until around 2022, over an ASHP with an average efficiency of 213% until around 2019 and over a GSHP with an average efficiency of 272% until around 2016. By 2025 there is predicted to be little difference between the carbon emissions associated with heat from CHP and heat from direct electricity.The projected phasing for development in the Gilston Area runs from 2016 – 2038 therefore it is likely that the preferred technological solution for homes will change over time with an initial preference for gas boilers and PV trending towards heat pumps as the grid decarbonises.

Another implication of grid decarbonisation is that it will increase the attractiveness of mechanical ventilation with heat recovery in delivering carbon savings to properties heated by any fuel except electricity. At present the CO_2 emissions associated with fan power for operating MVHR negates part of the benefit of the heat saved. This issue will reduce as the grid decarbonises.

2.5.2 Home energy costs

Energy costs are an increasing proportion of household budgets and an important issue for home owners and residents, in particular those on low incomes. Helping to control those costs is a key part of the energy strategy.

Variability in annual household energy bills depends almost entirely on how much energy is used for heating, the forms in which heating energy is delivered, and the price of that energy. It is very difficult to project fuel prices into the future but the recent trend has been gas prices rising faster than power.

Reducing energy demands through improved fabric efficiency will reduce the energy costs for residents regardless of the heating fuel and is therefore a key consideration for the energy strategy. It is also difficult to improve efficiency standards once homes are built. Renewable technologies such as PV and solar water heating provide a source of free energy which typically displaces grid electricity use or fossil fuel heating respectively, leading to reductions in running costs for residents.

Alternative heating sources such as district heating with CHP tend to offer limited potential for running cost benefits for residents in new schemes. The need to recover upfront infrastructure costs means that price control mechanisms intended to protect consumers, are often designed to ensure that in aggregate the standing charges and unit charges for heat do not exceed the charges that would normally be paid for annual maintenance and energy costs for a standalone gas boiler, but not to offer a saving.

2.5.3 Implications for the Gilston Area

A key observation from these trends is that the attractiveness of heat networks served by gas CHP relative to electricity based heating systems will decrease over time as the grid decarbonises. This is significant given the high up-front cost of installing district heating networks. It might be possible to switch the heat source for a network from gas-fired CHP engines to large scale electric heat pumps, for example, as the grid decarbonises. However, the carbon saving and financial merits and the household energy bill implications of a heat network served by gas-fired CHP in the medium to long term are issues that require close attention in arriving at an energy strategy that can deliver energy and carbon-related policy targets both now and in the future.

[14] STP11/CO204 Proposed Carbon Emission and Primary Energy Factors for SAP 2012, Section 5.1, Table 2, p.14. BRE. http://www.bre.co.uk/filelibrary/SAP/2012/STP11-CO204_emission_factors.pdf

2.6 Energy and carbon-related objectives and targets for the Gilston Area

A key objective of the energy strategy is to develop proposals which deliver significant ongoing energy and carbon savings without compromising the viability or deliverability of the proposed scheme. There is also a need to demonstrate that current and likely future minimum standards can be met. Based on this general objective, and the specific planning expectations identified in the policy review above, the energy strategy for the Gilston Area has been developed to reduce the heating demands of the homes and to meet the following target:

- Overall Dwelling Emission Rates for homes to achieve the carbon emission rate consistent with achieving Code for Sustainable Homes Level 4 rating[15] - i.e. an aggregate reduction of 19% relative to Building Regulations Part L 2013 Target Emission Rates;

Given the desire to develop an energy strategy prior to masterplan fix, a range of energy efficiency and low carbon and renewable energy supply options have been appraised against the energy strategy targets for a number of typical housing typologies that are representative of the range of densities that are likely to be accommodated within the masterplan.

[15] While noting that the Code was withdrawn in March 2013 and that performance in ENE1 Dwelling Emission Rate was only one aspect of achieving a Code rating, given the current lack of reference targets this standard remains useful as a comparative measure of sustainability performance.

Baseline Annual Energy Use

03

3 Baseline annual energy use, CO_2 emissions and energy efficiency

3.1 Site-wide energy demand and carbon emissions calculations for homes

Home energy use, Dwelling Emission Rates (DERs) and corresponding baseline Target Emission Rates (TERs) were calculated according to the Standard Assessment Procedure SAP version 9.92 using NHER Plan Assessor version 6.2.0.

3.1.1 Representative dwellings for energy modelling

Six basic dwelling forms were selected for use in estimating base case energy demands and the potential improvements from energy efficiency and the use of low and zero carbon technologies. In reality the Gilston Area will contain a greater variety of dwelling types but AECOM believes these are a sufficient basis for establishing a proposed energy strategy at this stage. The six dwelling types selected for modelling, are set out in Table 2.

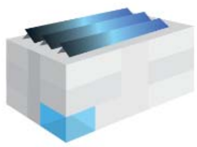
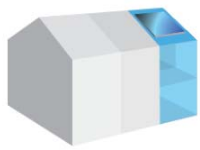
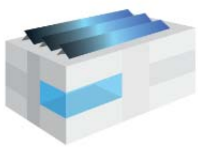
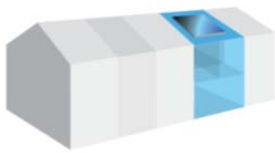
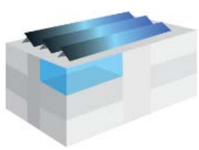
Flats		Houses	
	1 bed ground floor flat Total floor area: 43m^2		2 bed end terrace or semi Total floor area: 76m^2
	2 bed flat (mid-floor) Total floor area: 67m^2		3 bed mid terrace house Total floor area: 101m^2
	2 bed flat (top floor) Total floor area: 67m^2		4 bed detached house Total floor area: 128m^2

Table 2: The 6 dwelling types used for energy modelling

As part of later analysis of available roof areas for PV, it is assumes that each apartment block is four storeys in height and contains 8 – four 2-bed and four 1-bed – apartments on each floor, i.e. 32 apartments per block.

Table 3 shows the number of units allocated to each model to estimate the total energy demand and carbon emissions from homes on the site.

Unit description	Unit ID	TFA (m²)	No. of units
1-bed ground floor flat	1b GFFL	50.01	612
2-bed mid-floor flat	2b MFFL	66.05	1,837
2-bed top-floor flat	2b TFFL	66.05	612
2-bed end-terrace house or semi	2b ETH/S	83.76	3,042
3-bed mid-terrace townhouse	3b MTTH	105.39	2,256
4-bed end-terrace or detached house	4b ET/DH	135.38	1,822
	Total		**10,181**

Table 3. Allocation of number of dwellings to representative SAP models.

3.1.2 Building fabric specification

The six typical homes set out above were modelled with an 'Improved fabric' energy efficiency specification, shown in Table 4, and compared to a Part L 2013 base case.

Element	Notional building	'Improved fabric' design (proposed)	Zero Carbon Hub indicative FEES
Insulation U-values [W/m².K]			
Walls	0.18	0.13	0.15 – 0.18
Floors	0.13	0.13	0.13 – 0.15
Roof	0.13	0.13	0.13
Windows	1.4	1.2	1.2 – 1.4
Doors	1.2	1.2	1.0 – 1.4
Solar transmittance g-values			
Glazing	0.63	0.45	-
Envelope performance			
Air permeability [m³/h.m² @ 50Pa]	5	3	5 – 5.2
Thermal bridging	Thermal bridges for the representative dwellings were calculated individually. The corresponding allowance for the notional building is calculated automatically based on reference psi values as set out in Table R2 of the SAP documentation, (SAP 2012 version 9.92 (BRE, October 2013).		0.04 – 0.07 W/m^{2}K (Note: defined prior to change in SAP method so not directly comparable.)

Table 4. Fabric specification assumptions for SAP modelling of homes.

The 'Improved fabric' specification broadly corresponds to the specification proposed by Zero Carbon Hub for meeting the Fabric Energy Efficiency Standard (FEES) they had recommended for the 2016 zero carbon homes policy[16].

[16] Fabric Energy Efficiency For Zero Carbon Homes A Flexible Performance Standard For Zero Carbon Homes 2016. also: Defining A Fabric Energy Efficiency Standard Task Group Recommendations. Zero Carbon Hub. November 2009.

3.1.3 Building services

Services specification assumptions made for SAP modelling of homes are presented in Table 5.

System efficiency parameter	Notional building	'Improved fabric' design (proposed)
Boiler efficiency	89.5%	89.5%
Low-energy lights as a % of fixed (i.e. regulated) lighting	100%	100%
Ventilation	Natural ventilation	Whole house extract ventilation

Table 5. Services specification assumptions for dwellings

3.1.4 Energy demands and carbon emissions for baseline and 'Improved fabric' homes

Table 6 sets out the baseline delivered energy (fuel) demands for each of the sample dwelling types, the corresponding baseline TER, the Dwelling Emission Rate (DER) after energy efficiency, i.e. after the application of the 'Improved fabric' design set out above, and the percentage carbon saving, i.e. DER vs. TER. The final part of the table presents the total annual regulated emissions for the baseline, the savings from applying energy efficiency and the residual regulated emissions after energy efficiency.

Improved energy efficiency	1-bed ground floor flat	2-bed mid-floor flat	2-bed top-floor flat	2-bed end-terrace or semi	3-bed mid-terrace townhouse	4-bed detached house
Dwelling treated floor area [m²]	50.0	66.1	66.1	83.8	105.4	135.4
Baseline delivered energy (fuel) demands						
Total household electricity demand (after energy efficiency) [kWh/year]	2,290.7	2,850.4	2,850.4	3,390.6	3,909.2	4,446.1
Total household gas demand (after energy efficiency) [kWh/year]	3,321.4	4,035.7	4,532.1	6,166.4	6,890.0	8,657.5
Regulated emission rate – DER & savings vs. TER baseline						
TER, individual gas heating baseline [$kgCO_2$/year]	18.0	19.2	20.9	20.6	18.5	18.1
DER after energy efficiency [$kgCO_2/m^2$]	17.5	16.1	17.8	18.7	16.7	16.1
% Reduction vs. TER after energy efficiency	2.8%	16.1%	14.9%	9.5%	9.4%	10.7%
Annual regulated emissions – savings and residual emissions						
Baseline dwelling emissions [$kgCO_2$/year]	898.7	1,270.1	1,377.8	1,728.8	1,944.4	2,447.7
Savings vs. baseline after energy efficiency [$kgCO_2$/year]	25.3	204.1	204.5	164.0	183.5	262.5
Residual emissions after energy efficiency [$kgCO_2$/year]	873.3	1,066.0	1,173.3	1,564.9	1,761.0	2,185.2

Table 6 Baseline energy demand, emission rates and emissions for Improved energy efficiency standard vs. baseline for the sample dwelling types.

The results for sample homes were used to calculate the site-wide delivered energy demands, carbon emissions, and carbon savings from energy efficiency that are set out in Table 7.

3.2 Non- domestic Buildings

Building designs for non-residential buildings have yet to be developed. The energy demands for non-domestic buildings have therefore been estimated based on benchmarks.

Without detailed building models it is not possible to accurately assess the energy efficiency improvements for non-residential buildings, however, as non-residential buildings make up a very small proportion of the overall development the savings potential will be small in relation to the residential development. In bringing forward the non-residential elements the following measures will be promoted:

- Improved insulation standards for walls, roofs, glazing and floors and improved air-tightness and cold bridging details.
- Use of narrow plan form to increase the perimeter zone benefiting from daylight and to reduce demand for artificial lighting.
- Increasing the size of air-distribution and air-handling plant to reduce pressure drops and fan power and incorporate heat recovery.
- Use of the most efficient variable speed fan technology with electronic commutation.
- Use of the most efficient chillers with magnetic bearings and COPs greater than 4.
- Use of effective lighting control systems incorporating manual on with automatic absence detection or automatic dimming down in response to daylight.
- Using high efficacy lighting equipment with efficient lamps and luminaires with high light output ratios.
- Use of effective façade design including fixed external shading where appropriate, adjustable internal shading and use of glazing with high light transmittance and low solar heat gain factors.
- Use of effective control of heating and air-conditioning systems to allow mechanical cooling at peak periods of the year only.
- Consideration of night ventilation to pre-cool building structures requiring window and shutter arrangements that allow ventilation at night without compromising security.

3.3 Site-wide passive design measures

The following passive design measures will also be promoted across the site, where possible:

- Use of dual aspect apartments and homes to promote daylighting and cross ventilation;
- Use of narrow plan non-residential buildings for improved daylighting and ventilation;
- Extensive use of vegetation and deciduous trees to provide shade, evaporative transpiration and reduce heat build-up on adjacent surfaces in summer, while also allowing solar gain in winter;
- Use of permeable paving surfaces to trap moisture for further evaporative cooling benefit;
- Use of materials with high albedo (light coloured) to reduce heat build-up;
- Adjustable external solar shading (shutters, roller blinds, louvers etc.) to reduce solar gains in summer;
- Large areas of openable glazing, with ground floor windows or louvers designed to provide large free ventilation areas while retaining security; and
- Use of thermal mass in living areas but not in bedrooms.

These measures will contribute to reducing heat build-up, providing greater resilience to the now unavoidable rise in average and peak summer temperatures that will occur over the coming decades and hence help to avoid the use of mechanical cooling.

3.4 Site-wide baseline energy demands and carbon emissions, and efficiency savings

The site-wide baseline delivered energy demands and carbon emissions, and the site-wide carbon emissions and savings with ‘Improved fabric’ for homes are set out in Table 7.

Location	Numbers of units	Delivered energy (fuel) demand (MWh/year)			Residual site-wide emissions (tCO_2/year)			'Improved efficiency' savings	
		Total heating fuel demand	Regulated electricity	Unregulated electricity	Regulated baseline	Regulated, after energy efficiency	Unregulated emissions	tCO_2/year	%
Village 1	1,864	10,626	831	5,418	3,056	2,727	3,155	329.1	10.8%
Village 2	1,805	10,947	837	5,437	3,130	2,799	3,167	330.7	10.6%
Village 3	1,024	6,775	507	3,264	1,937	1,726	1,902	210.6	10.9%
Village 4	1,940	12,205	923	5,975	3,491	3,115	3,481	375.7	10.8%
Village 5	735	4,420	340	2,206	1,265	1,131	1,285	134.2	10.6%
Village 6	1,213	7,518	571	3,704	2,146	1,920	2,158	226.1	10.5%
Village 7	1,600	9,805	749	4,854	2,806	2,506	2,828	300.1	10.7%
Homes	**10,181**	**62,296**	**4,758**	**30,859**	**17,832**	**15,925**	**17,977**	**1,906.6**	**10.7%**
Non-domestic	39,521 m²	4,743	1,976	3,952	2,050	2,050	2,051	0.0	0.0%
Gilston Area		**67,039**	**6,734**	**34,811**	**19,882**	**17,975**	**20,028**	**1,906.6**	**9.6%**

Table 7. Summary of energy and carbon results for the baseline and application of energy efficient design to individual dwelling types.

3.5 Summary

The ‘Improved fabric’ specification modelled enables the representative homes to achieve Part L 2013 Target Emission Rate criteria through energy efficiency measures alone. Based on the sample calculations conducted to date and the illustrative mix of homes assessed it is calculated that a 10.7% reduction in regulated CO_2 emissions would be achieved for the homes and that if the estimated baseline emissions for non-residential buildings are added this saving would be around 9.6% overall.

The proposed strategy is to apply the ‘Improved fabric’ specification, or specifications with equivalent performance, throughout the Gilston Area. Plot developers would be free to exceed this standard based on optimising the trade-off between making additional efficiency savings or investing in renewables..

Decentralised Energy

04

4 Decentralised Energy

4.1 Options for a heat network served by gas-fired CHP

To assess the potential for decentralised energy, two heat network options were considered in detail to determine their carbon savings, and potential financial viability. The two broad options considered were:

1. Independent heat networks served by a local energy centre in each of the seven Villages; and
2. A single central energy centre serving all development in the Gilston Area.

For each option, sample SAP calculations were used to develop the heat demands and profiles for homes, and benchmark figures were used to determine the heat demands for non-residential uses on a plot by plot basis. The plot based energy demands were used to determine the required capacity of the heat network and hence sizing of heat mains. Heat network layouts were developed to determine pipework lengths and hence the overall heat capacity of the network. Heat demands and their build up over four indicative five-year phasing periods were used to determine energy centre plant sizing and the phasing over which energy centre plant and the district network would need to be delivered.

The energy centre plant sizes identified were used to determine the anticipated heat and power efficiencies of the gas CHP engines required to serve the network and these were then inputted into the SAP calculations to inform the calculation of carbon savings. The heat losses for the primary district heating network were calculated from proposed network pipe layouts and insulation standards and an allowance for secondary network losses of 15% was allowed based on meeting good practice heat losses recommended in the CIBSE/ADE District Heating Code of Practice[17].

Key assumptions and calculated data for the network are set out in Table

Heat network Option 1: technical information	Phase 1 (2016 - 2021)	Phase 2 (2021 - 2026)	Phase 3 (2026 - 2031)	Phase 4 (2031 - 2038)	Option 1 Total
Total peak heat load incl. losses (kW)	5,100	18,538	15,175	20,887	59,700
Distribution losses (primary network) (%)	7.1%	6.3%	6.4%	6.3%	6.3%
Total heat demand (Space, DHW, distribution losses) (MWh)	6,828	24,521	20,276	27,546	79,171
Number of CHP units	3	4	2	3	12
CHP thermal capacity (kWth)	782	4,218	4,120	4,103	13,222
CHP electrical capacity (kWe)	759	4,333	4,315	3,612	13,019
Number of boiler units	3	4	2	3	12
Top-up boiler capacity (kW)	3,998	14,223	11,507	16,369	46,096
CHP TOTAL electricity output (MWh)	3,705	16,429	16,431	14,305	50,870
Total energy centre fuel consumption (MWh)	13,308	52,624	48,693	53,049	167,673
Total primary pipework, Ø 80-250mm (m)	4,320	12,199	14,691	19,412	50,622
Total secondary pipework, Ø 25 - 40mm (m)	4,875	16,468	12,595	18,195	52,133

Table 8. Heat network with gas-fired CHP Option 1 - Heat demand (incl. primary losses), generator and network sizing – additions per phase.

[17] Heat networks: Code of Practice for the UK – Raising the Standards for heat supply. CIBSE and ADE. 2015.

Heat network Option 2: technical information	Phase 1 (2016 - 2021)	Phase 2 (2021 - 2026)	Phase 3 (2026 - 2031)	Phase 4 (2031 - 2038)	Option 2 Total
Total peak heat demand incl. losses (kW)	5,088	17,635	14,416	19,657	56,796
Distribution losses (primary network) (%)	26.4%	9.6%	6.1%	4.0%	4.0%
Total heat demand (Space, DHW, distribution losses)	8,615	23,898	18,945	25,832	77,290
Number of CHP units	1	1	1	1	4
CHP thermal capacity (kWth)	988	3,237	3,683	3,683	11,591
CHP electrical capacity (kWe)	834	3,349	4,029	4,029	12,241
Number of boiler units	1	1	1	1	4
Top-up boiler capacity (kW)	4,100	14,398	11,721	19,211	49,430
CHP TOTAL electricity output (MWh)	3,940	14,658	15,304	13,593	47,495
Total energy centre fuel consumption (MWh)	15,736	48,681	43,584	49,424	157,426
Total primary pipework, Ø 80-250mm (m)	8,577	12,721	12,704	18,559	52,562
Total secondary pipework, Ø 25 - 40mm (m)	4,875	16,468	12,595	18,195	52,133

Table 9. Heat network with gas-fired CHP Option 2 - Heat demand (incl. primary losses), generator and network sizing – additions per phase.

4.2 Carbon savings for a heat network with gas-fired CHP

4.2.1 Carbon savings for representative dwelling types

Table 10 sets out the annual carbon savings calculated for each sample dwelling types assuming it is connected to a district heating network served by gas CHP engines with efficiencies and heat losses as shown. It can be seen that carbon savings are 22-23% relative to the residual emissions after applying the efficiency standards set out in section 3. It is worth noting that the carbon savings from supplying individual dwellings with 60% of their total heat demands for space heating and hot water via a heat network served by gas-fired CHP are comparable to the savings achieved by applying solar water heating (see section 5.3) and which are achievable with modestly sized PV installations (see section 5.2). One of the reasons that savings from gas CHP are relatively modest is because space heating demands are already low because of improved fabric energy efficiency.

Heat network served by gas-fired CHP	1-bed ground floor flat	2-bed mid-floor flat	2-bed top-floor flat	2-bed end-terrace or semi	3-bed mid-terrace townhouse	4-bed detached house
Technology sizing						
Fraction of heat supplied by gas-fired CHP	0.6	0.6	0.6	0.6	0.6	0.6
CHP total efficiency [%]	71%	71%	71%	71%	71%	71%
CHP heat to power ratio	0.9	0.9	0.9	0.9	0.9	0.9
Gas boiler efficiency [%]	85%	85%	85%	85%	85%	85%
Distribution loss factor for community heating system	1.28	1.28	1.28	1.28	1.28	1.28
Regulated emission rate – DER & savings vs. TER baseline						
TER, heat from district network [$kgCO_2/m^2$]	25.9	27.6	30.1	29.8	26.6	26.3
DER with gas CHP [$kgCO_2/m^2$]	15.0	13.6	15.0	15.7	14.1	13.7
% Reduction vs. TER with gas CHP	15.9%	27.7%	26.6%	21.9%	21.8%	22.9%
Annual regulated emissions – savings and residual emissions						
Residual emissions after energy efficiency [$kgCO_2$/year]	873.3	1,066.0	1,173.3	1,564.9	1,761.0	2,185.2
Savings vs. after efficiency with gas CHP [$kgCO_2$/year]	124.0	168.0	184.0	247.0	277.4	335.3
Residual emissions with gas CHP [$kgCO_2$/year]	749.3	898.1	989.3	1,317.9	1,483.6	1,849.8
% savings vs. after efficiency with gas CHP	14.2%	15.8%	15.7%	15.8%	15.7%	15.3%

Table 10 CO_2 savings for sample dwellings assuming connection to district heating network

4.2.2 Site-wide carbon savings

Table 11 sets out the site wide carbon emissions calculated assuming all homes and associated non-domestic buildings housing schools and local amenities are connected to a heat network. Savings are shown against both the regulated baseline (sum of Building Regulations Part L 2013 TERs) and the residual emissions after the application of the energy efficiency measures set out in section 3.1.2 have been implemented.

Location	Total gas CHP thermal capacity [kWth]	Residual site-wide emissions (tCO_2/year)			Heat network with gas-fired CHP savings			
		Regulated baseline	Regulated, after energy efficiency	With gas CHP	tCO_2/year vs. baseline	% vs. baseline	tCO_2/year after efficiency	% after efficiency
Village 1	2,033	3,056	2,727	2,300	756.0	24.7%	426.9	15.7%
Village 2	2,136	3,130	2,799	2,362	768.3	24.5%	437.6	15.6%
Village 3	968	1,937	1,726	1,459	478.3	24.7%	267.7	15.5%
Village 4	4,489	3,491	3,115	2,630	860.7	24.7%	485.0	15.6%
Village 5	668	1,265	1,131	954	311.0	24.6%	176.9	15.6%
Village 6	1,611	2,146	1,920	1,620	526.1	24.5%	299.9	15.6%
Village 7	2,341	2,806	2,506	2,115	691.2	24.6%	391.0	15.6%
Homes		**17,832**	**15,925**	**13,440**	**4,391.6**	**24.6%**	**2,485.0**	**15.6%**
Non-domestic	-	2,050	2,050	1,601	448.6	21.9%	448.6	21.9%
Gilston Area	**14,246**	**19,882**	**17,975**	**15,042**	**4,840.2**	**24.3%**	**2,933.7**	**16.3%**

Table 11: Site-wide summary results for heat network with gas-fired CHP – Option 1.

4.3 Potential for a Gilston Area heat network served by gas-fired CHP

The main considerations when evaluating the potential for a heat network to serve development in the Gilston Area are the levels of heat demand and density, the scale and longevity of carbon savings for a network served by gas-fired CHP and the costs, financing options, and deliverability of a network.

4.3.1 Heat demand and density

Looking at the overall masterplan for the Gilston Area – seven villages spaced along the Eastwick Road and a new 'ribbon road' around a central park and woodland – it is clear that the gross density of development will be low; the plan is not to create a dense urban environment. There is a range of net densities for individual plots, but 55% of homes are expected to be developed in blocks at densities above benchmark thresholds for feasibility of heat networks served by gas-fired CHP (based on numbers of homes in blocks at >50 dwellings per hectare). The average net density is circa 33 dwellings per hectare, which is below the threshold rule of thumb for heat network feasibility. The combination of relatively low development densities and low household space heating demands (due to improved fabric energy efficiency), mean that heat density and overall heat demand within the boundaries of the Gilston Area Strategic Masterplan are low.

The River Stort and the West Anglia Main Line railway line are barriers to connecting remote heat loads on the fringes of Harlow, which lies to the south, to any Gilston Area heat network. As well as being physical obstacles to pipework, the river and railway ensure long minimum distances to potential offsite customers.

4.3.2 Carbon savings and the impact of projected grid decarbonisation

CHP-related carbon savings critically depend on the emissions savings from displaced electricity demand – i.e. the electricity generated by the CHP – offsetting emissions increases from higher heat demand (due to heat losses in the heat distribution network) and increased gas demand (due to generating both heat and power on site). The net carbon emissions and savings presented above were calculated using the SAP methodology, assuming current Building Regulations Part L 2013 carbon emission factors for gas and electricity. Current savings from gas CHP are not significantly different from the savings achievable with solar water heating, PV and ground source heat pumps. As discussed in section 2.5.1, Government projections suggest that the emission factor for grid electricity will fall over time, with the result that carbon savings for gas-fired CHP will progressively fall relative to both a Building Regulations Part L baseline – individual gas fired boilers and reference fabric – and to the savings achievable by applying competing technologies such as heat pumps. The expectation is that the grid emission factor should fall to ~100 gCO_2/kWh by around 2030. This is well below the level at which carbon savings from air source heat pumps outstrip those of gas CHP (~420 gCO_2/kWh) and, significantly, also beyond the level at which gas CHP ceases to offer savings relative to baseline gas boilers (~360 gCO_2/kWh). Even if grid emission factors fall more slowly and less markedly than projected, installing gas CHP risks locking in a technology that offers low net lifetime carbon savings for the Gilston Area compared to other options.

4.3.3 Costs and viability

Cost analysis by AECOM determined the additional capital cost to deliver a Gilston Area heat network served by gas-fired CHP to be ~£63 million or around £6,300 / dwelling, compared with a baseline option assuming individual gas boilers. This additional cost accounts for the avoided costs of providing gas infrastructure to each home under the baseline situation. The development appraisal found that development is no longer viable if this cost were to be met by the scheme developers.

A separate analysis was then undertaken, by AECOM working with HermeticaBlack, to determine whether there would be a sufficient rate of return on investment to attract a third party – i.e. a specialist Energy Services Company – to invest in the delivery of the heat network infrastructure, recouping that investment through long term heat sales and network operation. A detailed cash flow analysis was developed for each heat network options taking into account the timing of network and plant investment and revenues generated from connection charges and sale of heat and power.

In terms of projecting costs and revenues for the cash flow analysis, development was treated as coming forward in four phases corresponding to the East Herts Draft District Plan periods as follows:

- Phase 1: 2016-21,
- Phase 2: 2021-26,
- Phase 3: 2026-31, and
- Phase 4: 2031-2038.

This analysis found that it is unlikely to be possible to attract a commercial investor to deliver a Gilston Area district heating scheme as the projected internal rate of return is less than the 10% typically considered to make such a scheme ‘investment grade’ at this stage.

An additional cost-related consideration is the implication of a heat network for household energy bills. The cash flow analysis referred to above assumed that price control mechanisms were in place to ensure that consumers paid no more in aggregate for heat and servicing than they could expect to pay for an individual gas boiler system, but that there would be no saving.

4.3.4 Conclusions on the potential for a Gilston Area heat network

Based on the analysis undertaken, the energy strategy does not propose the provision of a district heating network for the Gilston Area. Low heat density and hence low income from heat sales relative to high up-front network infrastructure costs (~£63 million) make investment in a Gilston Area heat network financially unattractive.

The carbon saving potential of heat networks served by gas-fired CHP is set to fall as the electricity supply system is decarbonised. The government intends for the grid to be largely decarbonised (to at or below 100 gCO_2/kWh) by 2030. Regardless of the uncertainties around the pace of decarbonisation or the appropriate marginal emission factor to use for carbon saving calculations where gas-fired CHP displaces grid electricity, it is unlikely that a heat network served by gas CHP would save carbon once average grid emission factors fall to the levels planned from ~2030 onwards. Over the development timeframes for the Gilston Area, the carbon benefits of district heating served by gas CHP will diminish to the point where the CO_2 emissions per unit of heat will be higher than alternative dwelling based systems such as gas boilers or air source heat pumps.

The proposed 19% CO_2 emission reduction targets for the scheme can be delivered at substantially reduced cost through the use of energy efficiency standards and PV. A dwelling based carbon reduction strategy is also expected to reduce running costs for residents compared with a district heating solution.

Renewables

05

5 Renewables

5.1 Introduction

This section summarises the appraisal of renewable energy technology options for development in the Gilston Area.

5.1.1 Renewable options studied

The following technologies were considered:

- Photovoltaics,
- Solar water heating,
- Ground and air source heat pumps,
- Biomass heating, and
- Small wind turbines.

First each technology was screened on the basis of practical constraints, and established rules of thumb that generally indicate whether technologies are likely to make technical and financial sense. Annual energy and carbon savings are then calculated for any technologies that pass the screening phase.

5.1.2 Technology options excluded from analysis

Technologies that were discounted from the analysis and the rationale for their exclusion are listed below

- **Large Scale Wind** – discounted based on previous exploratory work. Key blocks were found to be in the proximity of Stanstead Airport flight paths with implications for radar. Large areas of land would be made inaccessible to avoid health and safety risks associated with blade shed and ice shed in a built up area.
- **Biomass CHP** – a large scale biomass power station was previously considered to be the lowest cost solution to meeting an earlier definition of zero carbon policy. With the redefining of zero carbon policy and the need to ensure a deliverable strategy, relying on third party delivery of a power station with limited ability to engage with wider stakeholders would impact the deliverability of the proposals. The alternative of using local smaller scale biomass CHP biomass gasification plant has been ruled out as plant at the required scale has yet to be demonstrated successfully in the UK.
- **Fuel Cells** – discounted due to high cost and limited market experience of technology in operation, although it is recognised the strategy should be sufficiently flexible not to preclude their future use.

5.2 Photovoltaics

5.2.1 PV options appraisal

AECOM explored the potential CO_2 savings achievable for PV and the sizes of PV systems that would be required to meet the proposed site-wide targets for the development.

Through SAP modelling using NHER software, AECOM established the energy generated by a 1 kWp PV system. Panels were assumed to be installed facing South East (orientation = 45 degrees) at a tilt (inclination from horizontal) of 30 degrees, for which the annual energy generated and carbon savings calculated by SAP are 823.3 kWh/year and 427.3 $kgCO_2$/year respectively. The energy generated and carbon savings are directly proportional to the area of panel installed, allowing the savings for any system with the same orientation and tilt to be identified through extrapolation.

In determining whether sufficient PV could be accommodated to meet proposed CO2 reduction and renewables targets the following assumptions were made.

Houses – panel area limited to 40% of roof / building footprint area

It was assumed that typically homes would be able to accommodate an area of PV equivalent to up to 40% of the home’s footprint area. This is consistent with assumptions made in wider studies including Zero Carbon Hub’s ‘Carbon Compliance for Tomorrows New Homes’.

Flats – panel area limited to 50% of roof area

For apartments it was assumed that the maximum area of PV would be equivalent to 50% of the home’s footprint area. This reflects the increased flexibility to arrange panels on racks in the absence of a pitched roof construction, but also allows for the access needed to maintain panels and ensure spacing between panels to avoid self-shading. The total footprint / roof area of blocks takes account of additional internal circulation space.

Photovoltaic panels – installation assumptions

Conservative assumptions were made about the efficiency and optimisation of PV applied to homes in the development. This should ensure that the savings calculated can be met in practice, as the assumptions leave room for optimisation of the system to account for any unforeseen constraints. It was assumed that PV panels of medium to high efficiency are selected, with an area of panel required per kW of peak output of 7.5m^2/kWp. The most efficient ‘hybrid’ panels require only 6.5 – 7 m^2/kWp, i.e. a potential increase in energy generation and carbon savings of 7 – 15% with the same panel area. Where panels are oriented due south rather than the assumed South East, energy and carbon emissions savings would increase by around 5%.

The installed peak output of PV required for each dwelling type ‘to meet all the applicable targets’ was calculated based on meeting either 10% renewables or an overall carbon saving of 19% vs. the Part L 2013 Target Emission Rate, whichever requires the greater amount of PV.

For flats, the amount of PV proposed for each flat is the exact amount needed to meet the targets for that flat (calculated as if each flat were connected to its corresponding individual rooftop PV array). The assignment of areas to specific flat types is entirely notional. In practice the PV systems serving flats are expected to be connected to the common (‘landlord’) supply. This difference has no effect on assessing whether targets are met as the 10% renewables carbon saving target is calculated on a development-wide basis and the 19% total carbon saving target is calculated for flats on a block average basis. For houses, it is likely to be cost-efficient to install a standard PV system for all homes so the system size capable of meeting targets in the dwelling type requiring greatest area of PV (~3.8 m^2 / 0.5 kWp for the detached house) was applied to all homes.

A summary of the roof area constraints calculation, the corresponding maximum peak output of PV that could be installed, the quantity of PV required to meet the targets set out in section 2.4, proposed PV sizes and corresponding energy generation and carbon savings are set out in Table 12.

PV	1-bed ground floor flat	2-bed mid-floor flat	2-bed top-floor flat	2-bed end-terrace or semi	3-bed mid-terrace townhouse	4-bed detached house
Technology sizing						
Max solar collector as % of total roof area	50%	50%	50%	40%	40%	40%
Max solar collector area per home [m²]	6.9	9.1	9.1	16.8	16.9	27.1
PV peak output per unit area installed [kWp/m²]	7.5	7.5	7.5	7.5	7.5	7.5
Max PV peak output per home [kWp]	0.9	1.2	1.2	2.2	2.2	3.6
Minimum PV required to meet all applicable targets [kWp]	0.34	0.25	0.27	0.39	0.44	0.51
'Target-optimal' nominal output of installed PV [kWp]	0.34	0.25	0.27	0.51	0.51	0.51
PV installed aperture area proposed [m²]	2.6	1.9	2.1	3.8	3.8	3.8
PV proposed as % of max PV	37%	21%	23%	23%	23%	14%
Energy generated / saved						
PV annual energy yield per kWp installed (SE/SW at 30°) [kWh/kWp]	823.3	823.3	823.3	823.3	823.3	823.3
Electricity generated / saved by PV [kWh/year]	280.1	205.4	226.1	317.0	358.4	421.0
Regulated emission rate – DER & savings vs. TER baseline						
TER, individual gas heating baseline [kgCO_2/year]	18.0	19.2	20.9	20.6	18.5	18.1
DER with 'Target-optimal' nominal output of installed PV [kgCO_2/m²]	14.6	14.5	16.0	16.1	14.6	14.5
% Reduction vs. TER with 'Target-optimal' nominal output of installed PV	19%	24%	23%	22%	21%	20%
Annual regulated emissions – savings and residual emissions						
Residual emissions after energy efficiency [kgCO_2/year]	873.3	1,066.0	1,173.3	1,564.9	1,761.0	2,185.2
Savings vs. after efficiency with 'Target-optimal' nominal output of installed PV [kgCO_2/year]	145.4	106.6	117.3	218.5	218.5	218.5
Residual emissions with 'Target-optimal' nominal output of installed PV [kgCO_2/year]	727.9	959.4	1,055.9	1,346.3	1,542.5	1,966.6
% Renewables with 'Target-optimal' nominal output of installed PV	17%	10%	10%	14%	12%	10%

Table 12: Summary of PV application to individual dwelling types

The results of scaling up PV application to the Gilston Area are summarised in Table 13.

Location	'Target-optimal' nominal output of installed PV [kWp]	Residual site-wide emissions (tCO_2/year)			'Target-optimal' PV savings			
		Regulated baseline	Regulated, after energy efficiency	With 'Target-optimal' nominal output of installed PV	tCO_2/year vs. baseline	% vs. baseline	tCO_2/year after efficiency	% renewables
Village 1	788	3,056	2,727	2,390	665.9	21.8%	336.7	12.3%
Village 2	802	3,130	2,799	2,457	673.2	21.5%	342.5	12.2%
Village 3	456	1,937	1,726	1,532	405.5	20.9%	194.9	11.3%
Village 4	858	3,491	3,115	2,749	742.2	21.3%	366.5	11.8%
Village 5	323	1,265	1,131	993	272.3	21.5%	138.2	12.2%
Village 6	545	2,146	1,920	1,687	459.2	21.4%	233.0	12.1%
Village 7	704	2,806	2,506	2,206	600.8	21.4%	300.7	12.0%
Homes	**4,476**	**17,832**	**15,925**	**14,013**	**3,819.0**	**21.4%**	**1,912.5**	**12.0%**
Non-domestic	-	2,050	2,050	2,050	0.0	0.0%	0.0	0.0%
Gilston Area		**19,882**	**17,975**	**16,063**	**3,819.0**	**19.2%**	**1,912.5**	**10.6%**

Table 13: Site-wide photovoltaics application summary

5.2.2 Potential to incorporate PV on the site

The initial options appraisal suggests that installation of an average of 0.27 kWp (2 m^2) per flat and 0.51 kWp (3.5 m^2) per house of roof-mounted PV would – in combination with the 'Improved' standard of fabric energy efficiency – be a technically feasible option for meeting the energy targets established for development in the Gilston Area. In total across the development, this aggregates to an installed nominal output of PV of 4,476 kWp that would save 1,913 tCO_2/year, which is a renewables saving of 10.6% of residual site-wide emissions after savings from energy efficiency have been taken into account.

PV is an inherently flexible and scalable carbon saving option. The figures in Table 12 for 'PV proposed as % of max PV' show that the proposed areas of PV can easily be accommodated within the scheme.

It is expected that PV on non-domestic buildings will be able to make an additional, small contribution to overall carbon savings.

With the exception of limited competition with solar water heating for roof space (discussed in section 5.3) PV is compatible with fabric energy efficiency, decentralised energy and other individual renewable energy options. So PV can contribute to energy and carbon savings alongside almost all other energy strategy options.

In terms of the implications for householders, PV systems in new homes are eligible for Feed In Tariff payments, albeit at tariff rates that are lower than in the past and which are expected to reduce progressively over time. Even without Feed In Tariffs PV installed on houses will reduce the use of imported grid electricity resulting in reduced running costs for residents.

Roof space for PV in non-domestic buildings tends to be more constrained due to competition for roof space from other uses such as rooftop amenity space, building services plant, light wells/atria, lift motor equipment, etc. Where PV can be installed in non-domestic buildings, the percentage carbon savings – on an individual building basis – will tend to be lower than for individual homes both because of the constraints on panel area and hence peak output installable, and because the baseline carbon intensity of non-domestic buildings is generally higher. Nevertheless, it is likely to be possible to make further carbon savings by installing PV on non-domestic buildings. All such savings would be in addition to the 10.6% overall savings achievable from PV installed on homes.

5.3 Solar water heating

5.3.1 Solar water heating options appraisal

AECOM studied the option of fitting solar water heating systems with solar collectors on the roofs of homes in the proposed development. The area of rooftop collectors required for solar water heating systems is determined by hot water demand which depends on the number of people in a household. At this stage, the number of occupants is assumed to be related to dwelling size (using the SAP occupancy formula). Having estimated the number of occupants per home, the collector area (2 – 6 m^2) and related thermal store size (180 – 280 L) were selected based on supplier guidance and AECOM's previous experience. The carbon savings per home were established by SAP modelling of the solar thermal system using NHER software assuming panels are installed facing South East (orientation = 45 degrees) at a tilt (inclination from horizontal) of 30 degrees.

A summary of the solar water heating system sizing assumptions and corresponding useful heat generation and carbon savings are set out in Table 14.

Solar water heating	1-bed ground floor flat	2-bed mid-floor flat	2-bed top-floor flat	2-bed end-terrace or semi	3-bed mid-terrace townhouse	4-bed detached house
Technology sizing						
Collector type	Flat plate, glazed	Flat plate, glazed	Flat plate, glazed	Flat plate, glazed	Flat plate, glazed	Flat plate, glazed
Roof area of solar panel [m²]	2.2	3.3	3.3	3.3	4.4	6.7
Ratio of aperture area to gross area	0.9	0.9	0.9	0.9	0.9	0.9
Aperture area of solar panel [m²]	2.0	3.0	3.0	3.0	4.0	6.0
Dedicated solar store volume [L]	180	180	180	180	250	280
Energy generated / saved						
Useful heat supplied by solar water heating system [kWh/year]	748.3	911.7	911.7	930.9	1,065.6	1,179.4
Regulated emission rate – DER & savings vs. TER baseline						
TER, individual gas heating baseline [$kgCO_2$/year]	18.0	19.2	20.9	20.6	18.5	18.1
DER with solar water heating [$kgCO_2/m^2$]	13.5	12.5	14.1	15.8	14.1	13.9
% Reduction vs. TER with solar water heating	25%	35%	32%	24%	24%	23%
Annual regulated emissions – savings and residual emissions						
Residual emissions after energy efficiency [$kgCO_2$/year]	873.3	1,066.0	1,173.3	1,564.9	1,761.0	2,185.2
Savings vs. after efficiency with solar water heating [$kgCO_2$/year]	198.6	241.4	240.1	243.7	278.5	306.4
Residual emissions with solar water heating [$kgCO_2$/year]	674.7	824.7	933.1	1,321.1	1,482.5	1,878.8
% Renewables with solar water heating	23%	23%	20%	16%	16%	14%

Table 14: Summary of solar water heating application to individual dwelling types

The results of scaling up solar water heating application to the Gilston Area are summarised in Table 15.

Location	Numbers of units	Aperture area of solar panel [m²]	Residual site-wide emissions (tCO_2/year)			Solar water heating savings			
			Regulated baseline	Regulated, after energy efficiency	With solar water heating	tCO_2/year vs. baseline	% vs. baseline	tCO_2/year after efficiency	% renewables
Village 1	1,864	6,288	3,056	2,727	2,256	800.4	26.2%	471.3	17.3%
Village 2	1,805	6,483	3,130	2,799	2,334	795.6	25.4%	464.9	16.6%
Village 3	1,024	4,328	1,937	1,726	1,451	486.2	25.1%	275.6	16.0%
Village 4	1,940	7,513	3,491	3,115	2,607	884.4	25.3%	508.6	16.3%
Village 5	735	2,628	1,265	1,131	942	323.4	25.6%	189.2	16.7%
Village 6	1,213	4,481	2,146	1,920	1,605	541.2	25.2%	315.1	16.4%
Village 7	1,600	5,932	2,806	2,506	2,091	715.3	25.5%	415.1	16.6%
Homes	**10,181**	**37,654**	**17,832**	**15,925**	**13,286**	**4,546.4**	**25.5%**	**2,639.9**	**16.6%**
Non-domestic	39,521 m²	-	2,050	2,050	2,050	0.0	0.0%	0.0	0.0%
Gilston Area		**37,654**	**19,882**	**17,975**	**15,336**	**4,546.4**	**22.9%**	**2,639.9**	**14.7%**

Table 15: Site-wide solar water heating application summary

5.3.2 Potential to incorporate solar water heating on the site

There are no significant constraints on solar water heating systems for houses as the fixed areas of panel required are small compared to total roof area. For flats, the number of storeys determines the degree of constraint, and for the 4 storey blocks of 1- and 2-bed flats considered, there is sufficient roof space to fit the required size of solar collectors and leave space for PV (with a reduced maximum size of PV array). Solar water heating does pose a design challenge in blocks of flats due to the need to distribute hot water from the rooftop solar collectors down to each home. Multiple vertical pipe runs for individual solar systems reduce net usable space, systems serving lower floors are less efficient due to heat distribution losses, and heat gains to common areas may contribute to summer overheating. Communal solar water heating systems are possible, but are generally avoided in homes for private sale, and developers generally prefer not to serve flats more than two floors below the roof with individual solar systems. A 4 storey block is at the limit of feasibility and application is likely to be problematic for any taller blocks.

The initial options appraisal suggests that installation of solar water heating, sized appropriately in accordance with anticipated household occupancy and corresponding hot water demand, would – in combination with the ‘Improved’ standard of fabric energy efficiency – be a technically feasible option for meeting the energy targets established for development in the Gilston Area. In total across the development, this aggregates to an installed solar collector area of 37,654 m^2 that would save 2,640 tCO_2/year, which is a renewables saving of 14.7% of residual site-wide emissions after savings from energy efficiency. In practice, solar water heating is more likely to be considered a good option for houses, with PV being the preferable solar technology for blocks of flats, avoiding the difficulties of distributing hot water from collectors to individual flats.

5.4 Ground and air source heat pumps

5.4.1 Heat pumps screening

AECOM considered the application of ground and air source heat pumps as the main heating and hot water systems for homes in the development. The appraisal of site-wide application of air and ground source heat pumps to homes is presented in the sections below. Heat pumps could also be applied to non-domestic buildings, and reversible heat pumps could be used in cases where both heating and cooling are required. However, the savings from such applications have not been calculated at this stage.

5.4.2 Heat pump options appraisal

AECOM undertook SAP modelling using NHER to calculate the carbon emissions and the savings (relative to the TER for an electrically heated reference building) from applying ground source and air source heat pumps to each of the six representative house types.

Ground source heat pumps

The key heat pump inputs, Target and Dwelling Emission Rates, and percentage reduction in emission rates for GSHPs are set out in Table 16. The final part of the table summarises the residual annual emissions per dwelling type and the absolute and percentage annual savings relative to the residual emissions after energy efficiency. The latter is the percentage renewables saving from applying GSHPs.

Ground source heat pumps	1-bed ground floor flat	2-bed mid-floor flat	2-bed top-floor flat	2-bed end-terrace or semi	3-bed mid-terrace townhouse	4-bed detached house
Technology sizing						
Space heating efficiency with flow temperature <=35°C [%]	320%	320%	320%	320%	320%	320%
Water heating efficiency with flow temperature <=35°C [%]	224%	224%	224%	224%	224%	224%
Hot water storage volume [L]	120.0	120.0	120.0	120.0	180.0	180.0
Regulated emission rate – DER & savings vs. TER baseline						
TER, electric heating [kgCO_2/m²]	25.9	27.6	30.1	29.8	26.6	26.3
DER with GSHP [kgCO_2/m²]	15.0	13.5	14.7	15.1	13.5	12.8
% Reduction vs. TER with GSHP	42%	51%	51%	49%	49%	51%
Annual regulated emissions – savings and residual emissions						
Residual emissions after energy efficiency [kgCO_2/year]	873.3	1,066.0	1,173.3	1,564.9	1,761.0	2,185.2
Savings vs. after efficiency with GSHP [kgCO_2/year]	123.7	171.7	201.4	300.3	343.6	449.6
Residual emissions with GSHP [kgCO_2/year]	749.6	894.3	971.9	1,264.6	1,417.4	1,735.5
% Renewables with GSHP	14%	16%	17%	19%	20%	21%

Table 16: Summary of GSHP application to individual dwelling types

The results of scaling up GSHP application to the Gilston Area are summarised in Table 17.

Location	Residual site-wide emissions (tCO_2/year)			GSHP savings			
	Regulated baseline	Regulated, after energy efficiency	With GSHP	tCO_2/year vs. baseline	% vs. baseline	tCO_2/year after efficiency	% renewables
Village 1	3,056	2,727	2,220	835.5	27.3%	506.4	18.6%
Village 2	3,130	2,799	2,269	860.7	27.5%	530.1	18.9%
Village 3	1,937	1,726	1,392	545.1	28.1%	334.6	19.4%
Village 4	3,491	3,115	2,519	971.7	27.8%	596.0	19.1%
Village 5	1,265	1,131	918	347.8	27.5%	213.6	18.9%
Village 6	2,146	1,920	1,554	592.0	27.6%	365.9	19.1%
Village 7	2,806	2,506	2,030	776.0	27.6%	475.8	19.0%
Homes	**17,832**	**15,925**	**12,903**	**4,928.9**	**27.6%**	**3,022.3**	**19.0%**
Non-domestic	2,050	2,050	2,050	0.0	0.0%	0.0	0.0%
Gilston Area	**19,882**	**17,975**	**14,953**	**4,928.9**	**24.8%**	**3,022.3**	**16.8%**

Table 17: Site-wide summary results for ground source heat pumps application.

Air source heat pumps

The key heat pump inputs, Target and Dwelling Emission Rates, and percentage reduction in emission rates for ASHPs are set out in Table 18. The final part of the table summarises the residual annual emissions per dwelling type and the absolute and percentage annual savings relative to the residual emissions after energy efficiency. The latter is the percentage renewables saving from applying ASHPs.

Air source heat pumps	1-bed ground floor flat	2-bed mid-floor flat	2-bed top-floor flat	2-bed end-terrace or semi	3-bed mid-terrace townhouse	4-bed detached house
Technology sizing						
Space heating efficiency with flow temperature <=35°C [%]	250%	250%	250%	250%	250%	250%
Water heating efficiency with flow temperature <=35°C [%]	175%	175%	175%	175%	175%	175%
Hot water storage volume [L]	120.0	120.0	120.0	120.0	180.0	180.0
Regulated emission rate – DER & savings vs. TER baseline						
TER, electric heating [$kgCO_2/m^2$]	25.9	27.6	30.1	29.8	26.6	26.3
DER with ASHP [$kgCO_2/m^2$]	18.3	16.5	18.0	18.6	16.5	15.8
% Reduction vs. TER with ASHP	29%	40%	40%	38%	38%	40%
Annual regulated emissions – savings and residual emissions						
Residual emissions after energy efficiency [$kgCO_2$/year]	873.3	1,066.0	1,173.3	1,564.9	1,761.0	2,185.2
Savings vs. after efficiency with ASHP [$kgCO_2$/year]	-43.0	-24.8	-16.7	11.1	22.8	51.8
Residual emissions with ASHP [$kgCO_2$/year]	916.3	1,090.8	1,190.0	1,553.8	1,738.2	2,133.4
% Renewables with ASHP	-5%	-2%	-1%	1%	1%	2%

Table 18: Summary of ASHP application to individual dwelling types

The results of scaling up air source heat pump application to the Gilston Area are summarised in Table 19

Location	Residual site-wide emissions (tCO_2/year)			ASHP savings			
	Regulated baseline	Regulated, after energy efficiency	With ASHP	tCO_2/year vs. baseline	% vs. baseline	tCO_2/year after efficiency	% renewables
Village 1	3,056	2,727	2,722	333.9	10.9%	4.8	0.2%
Village 2	3,130	2,799	2,783	346.4	11.1%	15.8	0.6%
Village 3	1,937	1,726	1,708	228.8	11.8%	18.2	1.1%
Village 4	3,491	3,115	3,091	399.8	11.5%	24.1	0.8%
Village 5	1,265	1,131	1,125	139.9	11.1%	5.8	0.5%
Village 6	2,146	1,920	1,907	239.4	11.2%	13.3	0.7%
Village 7	2,806	2,506	2,491	315.7	11.2%	15.5	0.6%
Homes	**17,832**	**15,925**	**15,828**	**2,004.0**	**11.2%**	**97.4**	**0.6%**
Non-domestic	2,050	2,050	2,050	0.0	0.0%	0.0	0.0%
Gilston Area	**19,882**	**17,975**	**17,878**	**2,004.0**	**10.1%**	**97.4**	**0.5%**

Table 19: Site-wide summary results for air source heat pumps application.

5.4.3 Potential to incorporate heat pumps on the site

In general terms, heat pumps are applicable in most building types on most sites. Potential constraints relate to the space required for heat exchange and heat rejection equipment and, specifically for ground source, the ground conditions and available footprint for installation of the ground heat exchange loop. The cost of the ground loop makes ground source systems significantly more expensive than air source and baseline gas-fired boiler systems in homes. The barrier to uptake of air source heat pumps is that they currently offer only marginal carbon savings, although these will increase as the electricity grid decarbonises.

For these reasons, currently heat pumps are not generally a first choice for making carbon savings in homes. They are likely to become more attractive over time as the electricity grid decarbonises, at which point they are likely to be more widely adopted as a proven technology for supplying low carbon heat.

It is very likely that non-domestic buildings will use air source heat pumps – in the form of chillers or split units – as a standard part of their heating, ventilation and air conditioning systems. These will make an increasing contribution to reducing carbon emissions as the electricity grid decarbonises, but are not generally counted as renewables. Ground source heat pumps may be a feasible option for low carbon heating and cooling in non-domestic buildings, and their merits relative to alternative renewables should be assessed on an individual building basis later in the development and building design process.

5.5 Biomass

5.5.1 Biomass screening

Biomass boilers are a mature and proven technology and biomass is inherently the heating solution (for individual homes) with the lowest carbon emissions, due to the very low emission factors of biomass fuels. Even so, biomass is not typically considered alongside gas boilers and heat pumps as a feasible development-wide option for individual main heating systems in on-grid homes, for the following reasons:

Householder considerations

Gas-fired central heating has been ubiquitous in on-grid homes for several decades and is the norm by which householders will judge alternative options. Modern gas fired central heating systems in new homes are familiar and 'hassle-free' and the related markets of gas supply and maintenance companies are well-established and reasonably competitive. Although gas prices are on a long-term upward trend, gas sets the benchmark for heating fuel price comparisons and is consistently cheaper than most realistic alternatives.

By contrast, modern biomass heating is unfamiliar, implies increased management of the fuel supply by the householder (compared to buying mains gas or electricity), and requires more consistent boiler maintenance. The biomass fuel supply and equipment maintenance markets are less mature and more fragile than the equivalents for gas and electricity. Biomass heating – assuming the most likely fuel option is wood pellets that allow automatic boiler feeding and relatively simple fuel transport, delivery and storage – is more expensive than heating with gas or electric heat pumps and installations in new homes do not qualify for Renewable Heat Incentive payments. (One comparison suggests the price per kWh of heat from a wood pellet boiler is currently around 25% higher than from a gas boiler, 47% higher than from a ground source heat pump, and 14% higher than from an air source heat pump[18].)

A proportion of households will be content with the practical implications of biomass heating (or attracted to it for sustainability or other reasons) and ready to 'opt in' to biomass as a main or secondary heating system. However, it is likely that given a choice, the majority of households would opt for a home with gas central heating.

Fuel delivery and storage impacts

Biomass would require regular fuel deliveries, increasing goods vehicle movements on the road network serving the development. It would also be necessary to design the on-site road network to enable access by delivery vehicles to all customers, potentially increasing land take for road to ensure adequate turning and manoeuvring space. Furthermore, each property with biomass heating would require a fuel store, adding to gross area and/or cutting net internal space.

Supply chain risks

Were biomass to be used, the source would ideally need to be a local one, and one that does not result in over exploitation of forest land. Suitable suppliers of sustainable biomass fuel are inherently less secure sources (to have underpinning an essential household utility) than the heating fuel suppliers for the baseline and alternative low carbon and renewable heating options, i.e. established and regulated gas and electricity suppliers.

Air quality impacts

Biomass would be likely to have significant air quality implications in terms of particulates (smoke) and NOx emissions.

5.5.2 Potential to incorporate individual biomass heating on the site

Assuming air quality and fuel transport-related impacts are acceptable, biomass offers very low carbon heat but at a cost to householders in both financial and practical terms. Given the barriers and risks set out above, AECOM decided not to undertake a detailed study of site-wide individual biomass heating at this stage. Log or pellet stoves for secondary heating may be attractive to some householders and house designs that enable this option could be considered in later design stages.

5.6 Small wind turbines

5.6.1 Wind turbine screening

A rule of thumb is that to make operational and financial sense micro-wind systems need to be sited in locations with an annual average wind speed of at least 5 m/s. AECOM checked whether this condition is met on the site.

Research into micro wind turbines in urban and urban fringe areas by BRE suggests that a scaling factor should be applied to the wind resource assumed to be available to account for urban 'roughness' that reduces the effective available wind resource. The BRE report measured the scaling factor for 5 locations in Manchester (large inland city, -40%), Portsmouth (large coastal city, -10%) and Wick (small coastal

[18] Energy cost comparison for December 2015. http://www.nottenergy.com/energy_cost_comparison. Nottingham Energy Partnership. Accessed 2 February 2016.

town, -13%). AECOM assumes that the results for Manchester are the closest match for conditions in the Gilston Area, inland at the edge of the urban area of Harlow. The -40% scaling factor was applied to site wind speeds before assessing the wind resource against the rule of thumb.

AECOM obtained the annual average wind speed for the site from the Windspeed Database maintained by the Department of Energy and Climate Change[19]. The unmodified database results and the results scaled to account for urban roughness are shown in Table 20.

Height agl	Annual average wind speed (unmodified)	Annual average wind speed (scaling factor -40%)
45m	6.0	3.6
25m	5.5	3.3
10m	4.8	2.9

Table 20. Windspeed database query results (agl = above ground level)

The hub height of small turbines mounted on the ground or fixed to houses or flats would be in the range 10 - 25 m above ground level. The scaled annual average wind speeds at that hub height could be somewhere between 2.9 – 3.3 m/s.

5.6.2 Potential to incorporate wind turbines on the site

The scaled available wind resource falls short of the levels considered necessary to make such systems sensible. On this basis AECOM judged that no further assessment of wind feasibility was warranted.

[19] http://www.decc.gov.uk/en/windspeed/default.aspx

5.7 Summary and comparison of renewables options

Table 21 sets out a summary of the site-wide carbon saving results for the renewable options considered and a comparison with the estimated savings for a Gilston Area heat network served by gas-fired CHP. (These options should be considered as alternatives as the cost of combining

	Individual dwelling carbon savings		Site-wide carbon savings				Scalability*	
Renewables option	% reduction vs. TER	% renewables	% reduction vs. baseline	% renewables	tCO_2/year vs. baseline	tCO_2/year after efficiency	% of maximum savings	Carbon savings trend**
'Target-optimal' nominal output of installed PV	19.0% to 24.5%	10.0% to 16.6%	19.2%	10.6%	3,819.0	1,912.5	34%	↓
Solar water heating	23.2% to 35.0%	14.0% to 22.7%	22.9%	14.7%	4,546.4	2,639.9	~95%*	↔
Ground source heat pumps	42.2% to 51.3%	14.2% to 20.6%	24.8%	16.8%	4,928.9	3,022.3	~95%*	↑
Air source heat pumps	29.4% to 40.1%	-4.9% to 2.4%	10.1%	0.5%	2,004.0	97.4	~100%	↑
Individual biomass heating	screened out due to concerns about: household acceptability; supply chain risk; transport and air quality impacts							
Small scale wind turbines	screened out due to insufficient wind resource							
For comparison	(heat network serves homes and non-domestic; '% renewables' –> '% after efficiency')							
Heat network served by gas CHP	15.9% to 27.7%	14.2% to 15.8%	24.3%	16.3%	4,840.2	2,933.7	~100%	↓
* Scalability notes:	There is significant scope to increase the nominal output of PV installed; the 'target optimal' amount of PV is around a third of the maximum installable area on homes. Solar water heating and GSHPs could be applied to non-domestic buildings, which make up ~5% of heat demand. ASHPs are already widely used in non-domestic buildings, where they are not generally counted as renewables.							
** Carbon savings trend notes:	Carbon savings for low carbon technologies that displace electricity (PV, and gas CHP) will fall as the electricity grid decarbonises. Conversely, savings for technologies that use electricity and displace fossil fuel heating (heat pumps) will rise. Solar water heating savings will rise only slightly due to the gradual upward trend in the gas emission factor, which also contributes to the fall in carbon savings for heat networks served by gas-fired CHP.							

Table 21: Summary of site-wide carbon saving results for renewable options and comparison with gas CHP.

The summary shows that the application of any one of PV, solar water heating or ground source heat pumps can meet the energy strategy targets proposed for the Gilston Area: 19% reduction in dwelling emission rate vs. the TER equivalent to the requirement for Code Level 4. Each – or a mix – of these dwelling-based renewables applied site-wide can achieve carbon savings equal to those for a Gilston Area heat network served by gas-fired CHP.

The SAP emission factor for grid electricity is currently 519 gCO_2/kWh; grid carbon intensity is projected to fall to ~100 gCO_2/kWh by around 2030. Savings from applying PV will fall as the electricity grid decarbonises, but there is scope to offset this by scaling up PV installation, i.e. using more of the available roof area up to the established practical limits of 40% for houses and 50% for flats. The 'target-optimal' amounts of installed PV for which results are presented above represent around a third of the maximum PV area installable. Savings from heat pumps are expected to rise markedly, and carbon savings from cheaper air source heat pumps start to outstrip those of gas CHP when grid carbon intensity drops below ~420 gCO_2/kWh to.

Summary

06

6 Summary and proposed energy strategy

6.1 Proposed Targets

The energy strategy for the Gilston Area has been developed to reduce energy demands and to meet the following target:

- Overall Dwelling Emission Rates for homes to achieve the carbon emission consistent with achieving Code for Sustainable Homes Level 4 rating[20] - i.e. a reduction of 19% (on aggregate for blocks of flats) relative to Building Regulations Part L 2013 Target Emission Rates;

A range of energy efficiency and low carbon and renewable energy supply options have been appraised against the energy strategy targets for a number of typical housing typologies that are representative of the range of densities and forms that are likely to be accommodated in the Gilston Area. The energy and carbon savings have also been aggregated for an illustrative mix of homes at full build out.

The options appraised included both decentralised, district energy options and dwelling based solutions.

6.2 Fabric energy efficiency

It is proposed that homes are built to high standards of fabric energy efficiency. The analysis has explored the energy savings that would be achieved for an improved fabric specification based on specifications proposed by Zero Carbon Hub for meeting efficiency standards they had recommended for use in relation to Government zero carbon policy[21].

Element	‘Improved fabric’ design (proposed)
Insulation U-values [W/m².K]	
Walls	0.13
Floors	0.13
Roof	0.13
Windows	1.2
Doors	1.2
Solar transmittance g-values	
Glazing	0.45
Envelope performance	
Air permeability [m³/h.m² @ 50Pa]	3
Thermal bridging	Thermal bridges for the representative dwellings were calculated individually assuming the use of Approved Construction Details, where available.

Table 22. Proposed ‘Improved fabric’ specification for homes.

This specification would currently mean that all homes meet Part L 2013 through efficiency measures alone – and deliver additional savings beyond the minimum Part L 2013 requirements – before any further savings from low carbon and renewable technologies are taken into account. Calculations based on a sample of homes show a reduction in annual regulated CO_2 emission of 10.7% against a Part L 2013 Building Regulations baseline when aggregated across all homes. It is proposed that homes in the Gilston Area are

[20] While noting that the Code was withdrawn in March 2013 and that performance in ENE1 Dwelling Emission Rate was only one aspect of achieving a Code rating, given the current lack of reference targets this standard remains useful as a comparative measure of sustainability performance.

[21] The Government issued a statement in July 2015 to the effect that the introduction of zero carbon homes policy, planned for the update to Part L of the Building Regulations in 2016, had been cancelled.

delivered to this improved fabric specification or an equivalent fabric specification delivering similar carbon savings.

In the absence of detailed designs for non-residential buildings it has not been possible to assess the efficiency savings for non-residential buildings in detail. Savings will be assessed and reported as part of future detailed designs, having regard to:

- Improved insulation standards for walls, roofs, glazing and floors and improved air-tightness and cold bridging details
- Use of narrow plan form to increase the perimeter zone benefiting from daylight and to reduce demand for artificial lighting. This will be important for all buildings naturally ventilated, mixed mode and air-conditioned.
- Increasing the size of air-distribution and air-handling plant to reduce pressure drops and fan power and incorporate heat recovery
- Use of the most efficient variable speed fan technology with electronic commutation.
- Use of the most efficient chillers with magnetic bearings and COPs greater than 4.
- Use of effective lighting control systems incorporating manual on with automatic absence detection or automatic dimming down in response to daylight.
- Using high efficacy lighting control equipment with high efficiency lamps and luminaires with high light output ratios and efficacy higher than the national calculation method.
- Use of effective façade design including where appropriate fixed external shading, adjustable internal shading and use of glazing with high light transmittance and low solar heat gain factors.
- Use of effective control of heating and air-conditioning systems to allow mechanical cooling at peak periods of the year only.
- Consideration of night ventilation to pre-cool building structures requiring window and shutter arrangements that allow ventilation at night without compromising security.

6.3 Decentralised or District Heating systems

In developing the energy strategy for the Gilston Area a detailed assessment was carried out of the carbon savings and viability of delivering a district heating network served by gas CHP engines.

For the representative homes considered, the potential regulated annual CO_2 savings compared to Part L 2013 Target Emission Rates were calculated to be between 15.9 and 27.7% depending on dwelling type and size. On aggregate for all homes and non-domestic buildings in the illustrative masterplan, the savings were calculated to be 24.3% against the baseline. These savings are based on the current SAP 2012 CO_2 emission factors that are used in Part L 2013. As set out in section 2.5.1, Government projections suggest the emission factors for grid supplied electricity will fall sharply over the coming decades, resulting in reduced savings for gas CHP under future regulations.

Taking account of distribution losses (estimated at 22% of the heat delivered) and projected declining grid electricity emission factors, gas CHP was shown to offer a carbon saving over a gas condensing boiler until around 2022, over an ASHP with an average efficiency of 213%[22] until around 2019 and over a Ground Source Heat Pump (GSHP) with an average efficiency of 272% until around 2016. Whatever the eventual rate of grid decarbonisation, the clear trend is that net CO_2 emissions for district heating served by gas CHP will increase over time and its savings potential will be overtaken by heating options based on electricity.

Two broad heat network options were studied: one with separate energy centres serving local district heating networks in each village, the other with a single energy centre serving all seven villages. For both options it

[22] Average efficiencies for ASHP and GSHP reflect the default efficiencies in SAP when systems are fitted by a certified installer and assuming a 50%-50% split between space heating and hot water, typically found in flats. Houses typically have a higher proportion of space heating demand, for which heat pump efficiency is higher. So the assumed split is deliberately conservative as it underestimates average efficiency across a mix of houses and flats.

was found that if the costs had to be met by the scheme developers this would render development in the area unviable. Additional analysis explored whether heat network infrastructure costs could be met by attracting investment from a specialist third party Energy Services Company, e.g. on the basis of a long term exclusive concession agreement to supply heat in the Gilston Area. This analysis showed that revenues from future heat sales were likely to be insufficient relative to infrastructure costs for an investor to achieve a commercial rate of return. This supports the conclusions of a rule of thumb technical assessment which suggests that the relatively low housing densities proposed, combined with high fabric efficiency standards results in heat densities that are too low to justify the high up-front costs of heat network infrastructure.

Alternative energy centre heating plant such as large scale heat pumps or biomass boilers could help to address the projected fall in CO_2 savings for gas CHP. However, at current prices such alternative heat generators would further increase capital and operational costs, worsening the financial outcomes. Other options such as biomass CHP or fuel cells are unproved in the UK.

It is clear from the analysis of heat network options that it would be hard to finance the required heat network infrastructure, carbon savings from any initially installed gas CHP engines are likely to fall rapidly, and that alternative heat generation plant is relatively expensive and risky. Further study and effort to implement a heat network might be warranted if it offered significantly greater or longer lasting carbon savings than other alternatives. However, comparison with dwelling based solutions suggests that packages of measures combining high fabric energy efficiency standards and renewable energy technologies offer equivalent carbon savings that are more robust in the medium to long term, and at lower up-front capital costs than a solution based on district heating.

Given the results of the study of heat network options, a district heating network is not proposed as part of the energy strategy for the Gilston Area.

6.4 Renewable energy options

Table 23 sets out a summary of the site-wide carbon saving results for the renewable options considered and a comparison with the estimated savings for a Gilston Area heat network served by gas-fired CHP

	Individual dwelling carbon savings		Site-wide carbon savings				Scalability*	
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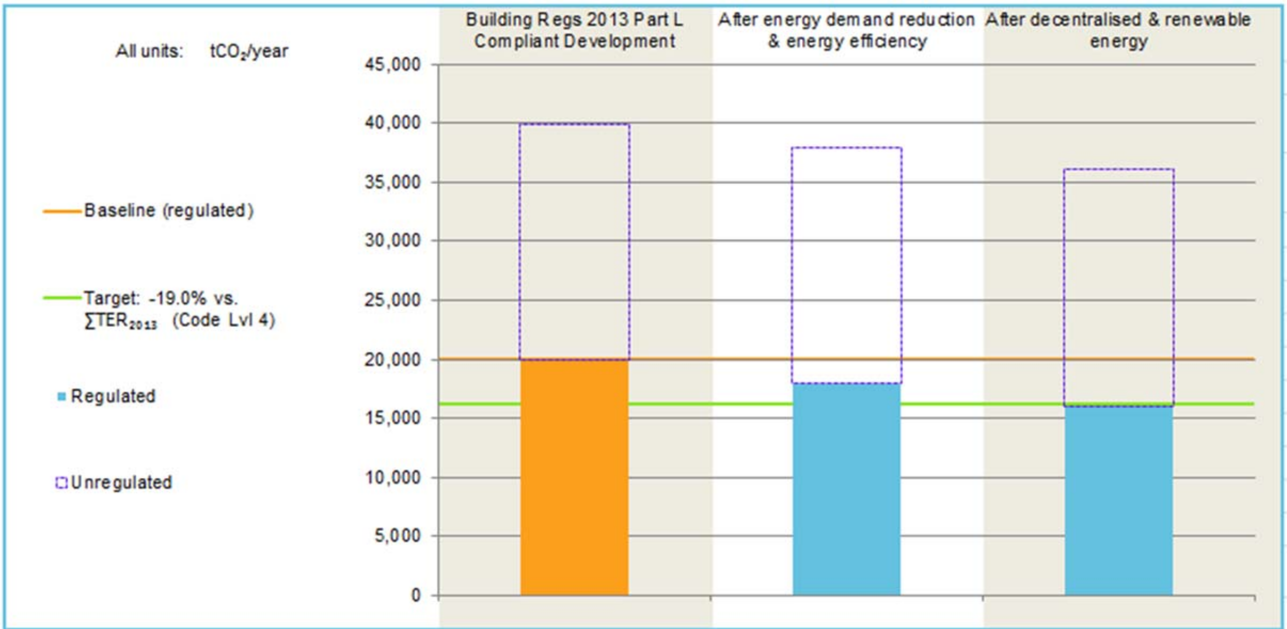
6.5 Proposed energy strategy

The proposed energy strategy for the Gilston Area is:

1. Energy efficient fabric and buildings services designed such that on aggregate the site meets Building Regulations Part L 2013 Target Emissions Rates through energy efficiency alone;
2. PV, solar water heating (for houses), or another carbon saving technology, sized such that in combination with the efficiency measures all homes and blocks of flats achieve an emission rate reduction of at least 19% relative to Building Regulations Part L 2013 Target Emission Rates.

In the case that PV is the preferred solution and that efficient hybrid panels are specified and fitted at a tilt of 30 degrees to maximise energy output, this strategy results in site-wide peak installed capacity at full build-out of 4,476 kWp. This amount of PV would save 1,913 tCO_2/year, an emissions saving from renewables of 10.6% against the residual emissions after energy efficiency.

Summary Figure 6 below shows the carbon baseline, emissions and savings for the proposed energy strategy, at each step in the energy hierarchy. Calculations at this stage suggest the proposed strategy would save 3,819 tCO_2/year, which is 19.2% of the baseline regulated emissions of 19,882 tCO_2/year.



			Building Regs 2013 Part L Compliant Development	After energy demand reduction & energy efficiency		After decentralised & renewable energy	
CO_2 Emissions							
	Unregulated	Site total	20,027.7	20,027.7		20,027.7	
	Regulated	Baseline		19,882.0			
		Site total	19,882.0	17,975.4		16,062.9	
		Target		16,104.4			
CO_2 savings							
	Regulated	Site total		1,906.6	9.6%	1,912.5	10.6%
		Cumulative		1,906.6	9.6%	3,819.0	19.2%

Summary Figure 6: Gilston Area proposed energy strategy: baseline CO_2 emissions & Energy Hierarchy savings.

It is proposed that flexibility is retained, allowing equivalent savings to be delivered through alternative renewable technologies such as air and ground source heat pumps. These will become increasingly effective at reducing carbon emissions as the carbon intensity of grid electricity falls.

6.6 Considerations for design

The projected reduction in grid electricity emission factors underlines the need to maintain flexibility to allow each phase of development to adopt the most effective package of technologies at the time it comes forward.

In the early phases, good fabric energy efficiency standards, solar water heating and PV represent a cost effective approach to meeting the proposed carbon targets. As such it is likely that developers will seek to apply solar technologies to most homes and buildings. Design guidelines should seek to ensure that suitable amounts of unshaded roof area for PV will be available, either in banks on flat roofs or on roofs with an orientation within 45 degrees of south and inclination close to 30 degrees.

If the grid decarbonises as projected, a good standard of fabric energy efficiency along with air source heat pumps will become an increasingly attractive solution. In that scenario, design guidelines should seek to ensure that there is space for heat rejection equipment to be fitted outside the treated dwelling space and in locations that avoid visual impacts on the public realm.