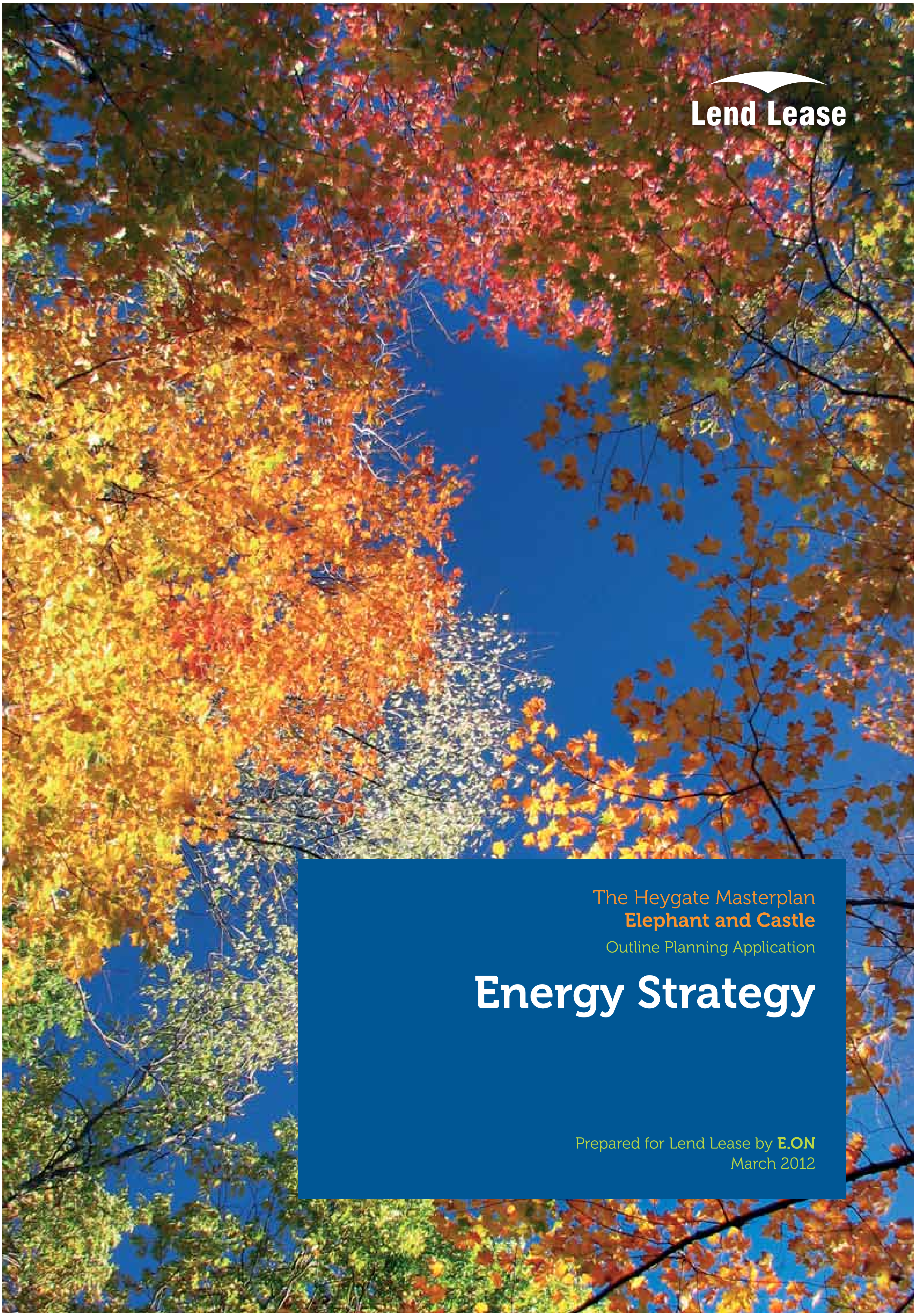
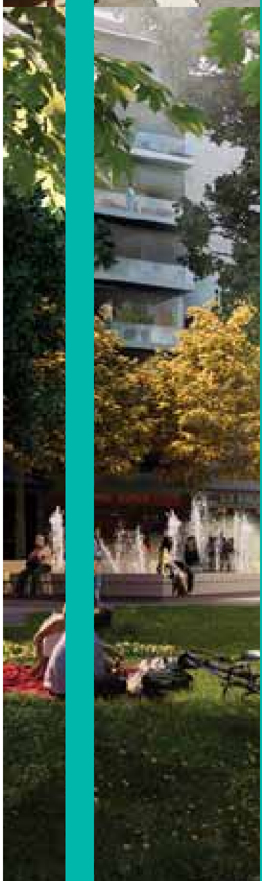
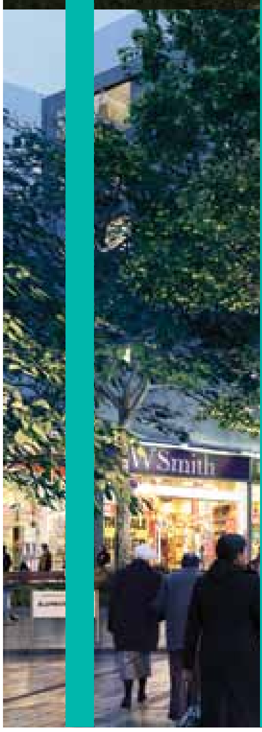


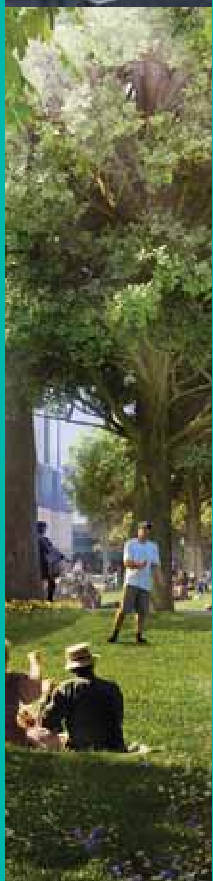
Lend Lease

The Heygate Masterplan
Elephant and Castle
Outline Planning Application

Energy Strategy

Prepared for Lend Lease by **E.ON**
March 2012





Lend Lease is **committed** to the successful regeneration of **Elephant and Castle**

Application Documents

- Parameter Plans
- Design Strategy Document
- Development Specification
- Design and Access Statement
- Environmental Statement
  - Non-Technical Summary
  - Main Text and Figures
    - Chapter 1 Introduction
    - Chapter 2 EIA Methodology
    - Chapter 3 Existing Land Uses and Activities
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- Vision and Destination Statement
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- Glossary of Terms

Contents

Prepared by	Duncan Child (Senior Carbon Consultant)
Authorised by	Richard Scott (Head of Carbon Consulting)
Date	27th March 2012
Version	6
Reference	CC/LEN002 Energy Strategy

Previous Versions

1	1st Draft	6th July 2011
2	2nd Draft	19th September 2011
3	3rd Draft	6th December 2011
4	4th Draft	21st December 2011
5	5th Draft	6th February 2012

Executive Summary

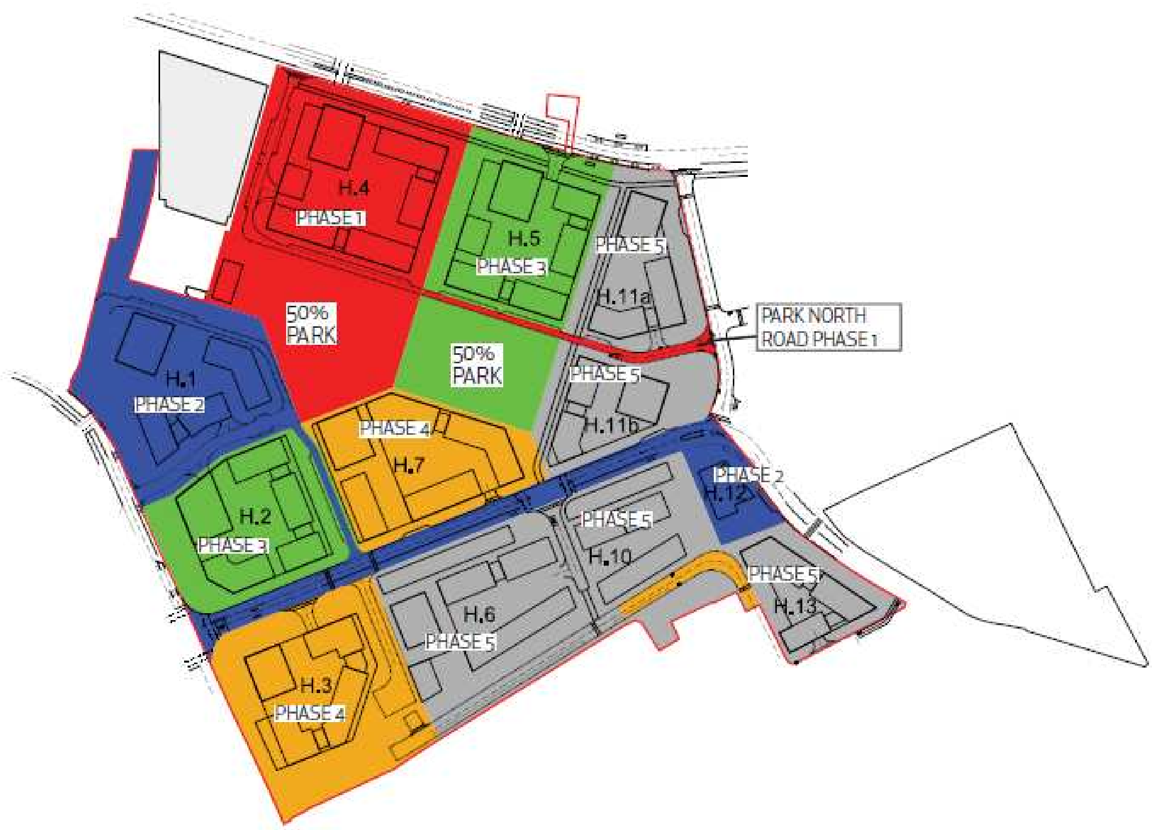
This Energy Strategy has been prepared and submitted by E.ON Energy Solutions Limited (E.ON Energy Solutions), on behalf of Lend Lease (Elephant and Castle) Limited (Lend Lease) (the "Applicant"), to support an outline planning application for The Heygate Masterplan in Elephant and Castle (the "Site").

The Site is located in Elephant and Castle, within the administrative boundary of Southwark Council (SC). The Site occupies an area of 9.71 hectares, and is bound by:

- New Kent Road (A201) to the north,
- Rodney Place and Rodney Road to the east,
- Wansey Street to the south; and
- Walworth Road (A215) and Elephant Road to the west.

Heygate Street bisects the site with junctions to Walworth Road to the west and Rodney Place and Rodney Road to the east.

The Heygate Masterplan will provide up to 2,462 new homes, as well as a maximum of 32,675m^2 of non-residential space consisting of predominantly retail space spread across 12 plots as shown. The assumed phasing is shown below for each plot and the Energy Strategy has been developed to be commensurate with this development programme.



Policy Compliance of the Energy Strategy

This proposed Energy Strategy complies with current energy-related planning policy from both a national, regional and local perspective for the Heygate Masterplan. It also advises on compliance with proposed changes to Building Regulations and other relevant legislation within the 13-year development timeline.

The UK Government's ambition to move towards a low carbon economy has seen the implementation of a number of national policies for new developments, which have been subsequently passed down through regional and local policies. As a result, this strategy is focused on meeting the relevant targets and requirements for each stage of the Heygate Masterplan, which will deliver Code for Sustainable Homes (CSH) Level 4 compliance as well as Zero Carbon Homes in 2016.

On a regional level, the London Plan was adopted in July 2011. One of its aims is to improve the environment and tackle climate change by reducing carbon dioxide (CO_2) emissions and heat loss from new developments. The Energy Strategy meets the applicable energy-specific policies and targets within the London Plan. It also contributes towards achieving an overall reduction in London's CO_2 emissions of 60% (below 1990 levels) by 2025 and meeting set targets for CO_2 emissions reduction in buildings.

The proposed Energy Strategy also meets the objectives of the Southwark Core Strategy 2011 in achieving at least 44% saving in CO_2 emissions above the Building Regulations 2006 from energy efficiency and efficient energy supply. It also complies with the requirements of the London Plan and SC in pursuing a decentralised energy strategy through the use of a district heat network (DHN). It is intended that this will be owned and/or operated by an energy services company (ESCo).

Consequently, the Energy Strategy seeks to achieve the following local, regional and national planning policies and SC's environmental aspirations.

Planning Policy Document	Policy	Forecast Achievement	Compliant?
Southwark Core Strategy	44% saving in CO_2 emissions above the Building Regulations 2010 from energy efficiency, efficient energy supply and renewable energy generation	54% reduction in CO_2 emissions vs. Building Regulations 2010	✓
Southwark Core Strategy	20% of remaining onsite CO_2 demand met by using on-site or local low and zero carbon sources of energy	20% CO_2 saving achievable with proposed biomethane solution	✓
London Plan 2011 Residential 2013 - 2016	40% reduction in CO_2 emissions vs. Building Regulations 2010	42% reduction in CO_2 emissions vs. Building Regulations 2010	✓
London Plan 2011 Residential 2016-2031	Zero Carbon	Comply with ZCH Guidance	✓
London Plan 2011 Non-residential 2013-2019	40% reduction in CO_2 emissions vs. Building Regulations 2010	40% reduction in CO_2 emissions vs. Building Regulations 2010	✓
Code for Sustainable Homes Level 4	25% reduction in CO_2 emissions vs. Building Regulations 2010	42% reduction in CO_2 emissions vs. Building Regulations 2010	✓
Zero Carbon Homes	Carbon Compliance limit of 15.0 $kgCO_2/m^2$ per year	Carbon Compliance of 12.3 $kgCO_2/m^2$ per year	✓

Aspirational Aim	Objective	Achievement	Compliant?
Net Zero Carbon Growth	Development to emit no more CO_2 than the existing 1,107 homes on the site	32% CO_2 saving achieved compared to existing 1,107 homes	✓

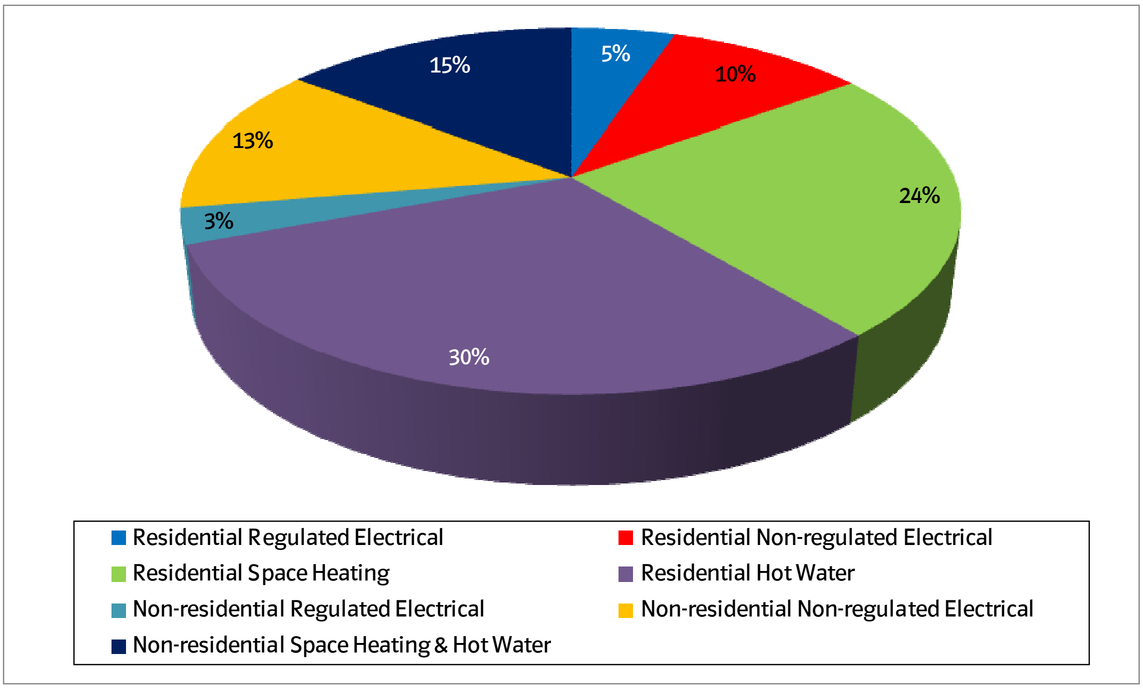
The net zero carbon growth aspiration of SC is also achievable as the Heygate Masterplan will emit no more carbon than the existing 1,107 homes on the site.

In addition to policy compliance the energy strategy seeks to put the Heygate Masterplan and Southwark at the forefront of innovative energy solutions for London. The proposed renewable energy option from offsite biomethane generation which is injected into the gas grid provides a holistic solution to sustainable policies.

Energy Hierarchy

The Energy Hierarchy applies the Be Lean (energy efficiency), Be Clean (on-site low carbon energy generation), Be Green (renewable energy generation) principles. The aspiration is to develop buildings that are as energy efficient as possible and then supply them with low and zero carbon energy.

The Heygate Masterplan seeks to improve thermal performance, thereby reducing space heat requirements and improving efficiency of building service elements. Space heat requirements will be reduced through high levels of insulation and air tightness. Some of the building services initiatives that will be considered in the detailed design stage include variable speed fans and pumps, demand controlled ventilation with heat recovery benefits, smart controls and smart meters. All these measures will assist in reducing both the electrical and space heat demand. The energy demand for the Heygate Masterplan once the fabric energy efficiency improvements have been made is shown below.



The Heygate Masterplan includes an on-site Energy Centre to supply low carbon energy to meet all the remaining heat demand and offset some of the electrical demand. The Energy Centre will comprise of gas Combined Heat and Power (CHP), high efficiency gas boilers and a thermal store to cope with peaks in demand. The equipment will be installed during the first phase of the Heygate Masterplan construction programme to ensure the initial heat demand is met.

A key element of the energy strategy is that the CHP will not be switched on until there is sufficient thermal demand. The most efficient strategy would be to have only one CHP engine that is turned on much later in the Heygate Masterplan. However understanding SC's aspiration for early low carbon energy, it is proposed that two smaller CHP engines are installed in line with the heat demand as development progresses. This arrangement reduces the potential for generating excess heat when operating the engine too soon in development phases. Therefore two CHP units will be provided, a $263kW_t$ unit being switched on during 2019 for the second phase of development, whilst a $985kW_t$ CHP will be switched on during 2021.

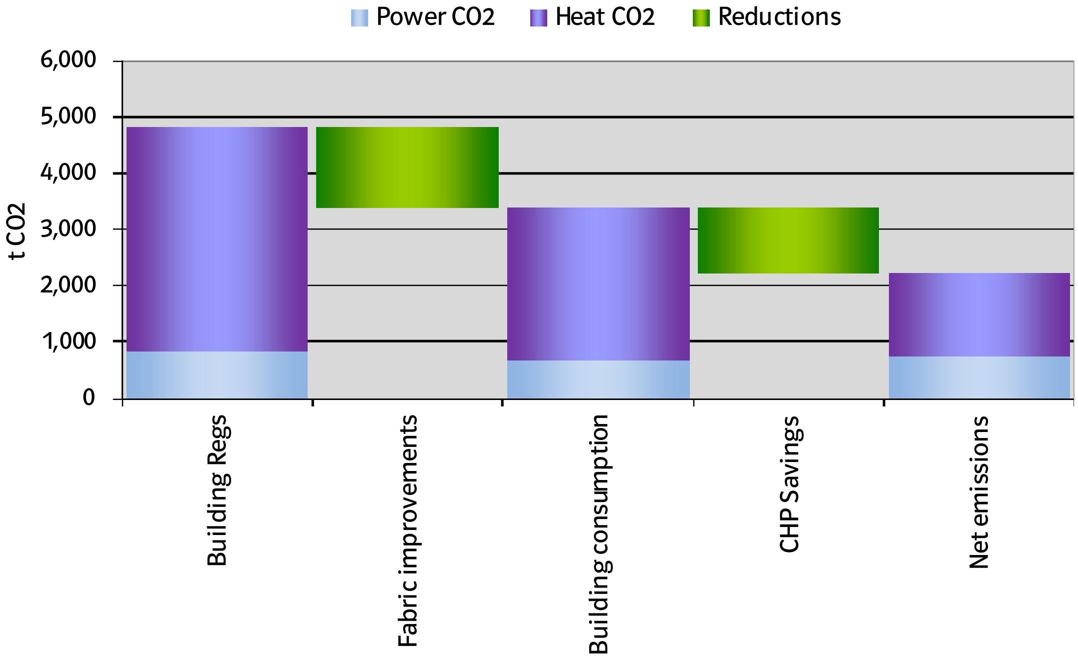
The London Plan sets out a requirement for onsite renewable energy generation, which is based on where site conditions make them feasible and where they contribute to the highest overall CO_2 savings. SC has also set a target that for all new build developments, 20% of the remaining CO_2 demand, (i.e. both regulated and unregulated), should be met by on-site renewable energy generation, after both energy efficiency and efficient energy supply measures have been applied.

It is the ambition for this site that part of the on-site gas usage will be sourced from biomethane and will be secured through the Green Gas Certification Scheme (GGCS) administered by the Renewable Energy Association (http://www.greengas.org.uk/). This is an on-site renewable energy source as defined within the recent Zero Carbon Homes guidance. The biomethane generation improves overall CO_2 reduction targets, achieves 20% renewable energy target and reduces the carbon intensity of the gas network. Biomethane generation also reduces the impact of transport movements in the area and minimises any impacts on air quality, both of which are important in the Low Emission Zone. By working with the GLA, SC and others to locate a biomethane generating plant in London, waste from the Heygate Masterplan could be used as an energy source – which would also help mitigate the impact of the waste generation in the wider community. Therefore the proposed strategy to meet the renewable energy target is to generate renewable energy through off-site biomethane. This is the most technically and commercially viable solution to meeting the renewable and CO_2 abatement objectives for the Heygate Masterplan, but also the solution with the greatest potential to provide greater CO_2 reductions in the wider area.

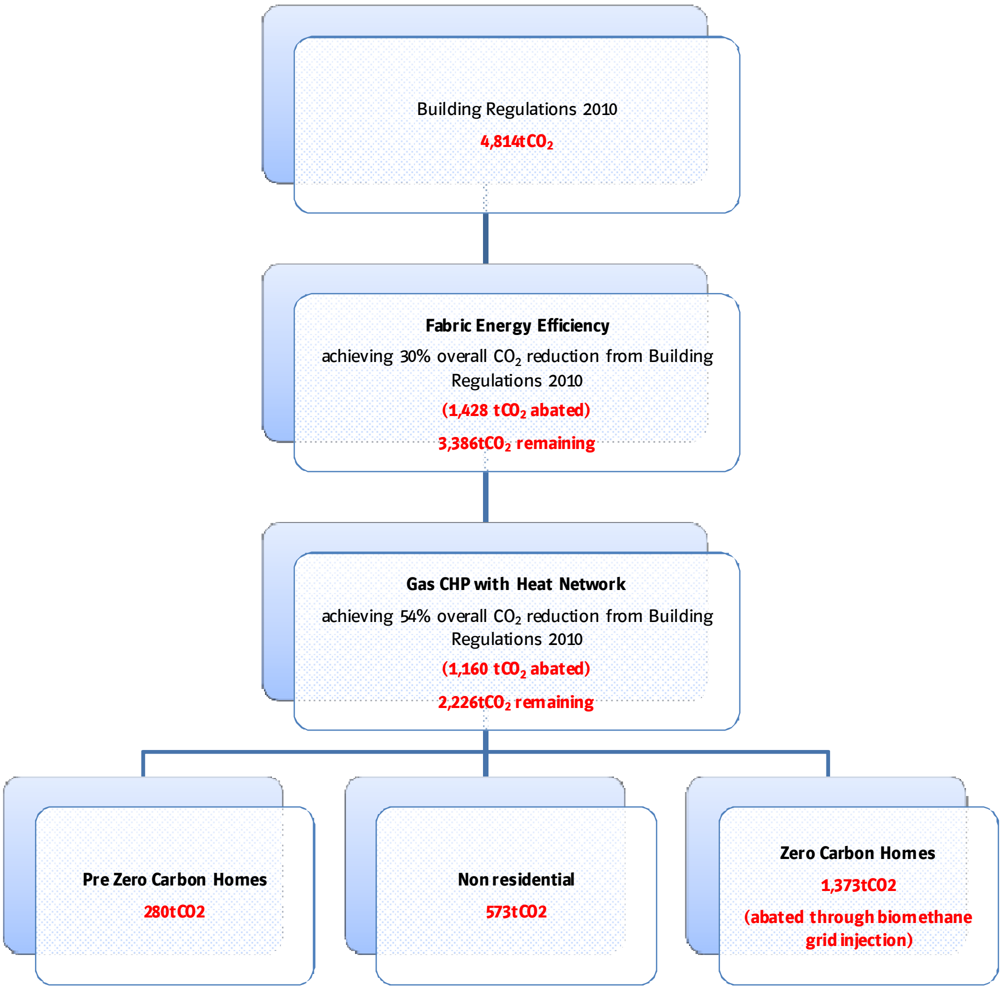
A number of other alternative renewable energy sources are considered in the strategy. However, they do not secure the quantum of CO_2 savings that are anticipated through biomethane and impact on the commercial viability. It was requested that alternatives ("Plan B") should be reviewed in the unlikely event that biomethane cannot be secured.

Solar PV is preferred over biomass boilers, as biomass introduces new forms of pollution, air quality impacts and road-safety concerns. However, solar PV is also the most expensive approach and yields considerably less CO_2 abatement (around 6% renewable energy) from the available roof/facade space then the renewable energy target. To further maximise the solar power opportunities, significant consideration of the facade design is required to include vertical solar panels. Within a challenging urban environment that is creating significant shading, even major building design changes may not yield the same environmental improvements as biomethane. To achieve the 20% renewables the PV would need to be supplemented with biomass. Biomass impacts on the Energy Centre sizing, transport network and noise and air quality, which means it is the least preferred solution of the other practical alternatives. Options will continue to be reviewed as technology changes throughout the development process.

In summary, by following the energy hierarchy principles, regulated CO_2 emissions are reduced by the Heygate Masterplan from 4,814 tonnes to 2,226 tonnes - a 54% CO_2 saving.



Of the 2,226 tonnes of remaining regulated emissions, 1,373 tonnes will be offset through the biomethane injection. The balance takes account of the remaining emissions from the pre-zero carbon plots and the non-residential buildings. The Heygate Masterplan will therefore achieve the recommended Zero Carbon Homes standards and set a benchmark for London.



Wider Community Benefits

The Energy Strategy recognises that there are a number of proposed and existing developments immediately adjacent to the Heygate Masterplan that have sufficient energy density to be worth considering connecting to the District Heating Network (DHN). Any early connection to these existing buildings (e.g. Phase 1 of the Heygate Regeneration on a site bounded by Rodney Road, Victory Place and Balfour Street) has the potential for enabling the CHPs to be switched on earlier, thereby improving carbon reduction for SC even further.

To allow for the potential for such future connections, the initial design of the Heygate Masterplan DHN and Energy Centre has sufficient flexibility to future proof the scheme for an increased thermal demand. It is estimated that the existing Energy Centre is able to accommodate the increase in generation plant that will be required to supply in the region of a further 1,000 apartment dwellings. For this to be achievable, detailed design and commercial modelling will be required as well as commitments from the developers or building owners. Discussions have already been made with a number of external developments to explore the opportunities to extend the network.

The Energy Strategy will be reviewed throughout the Heygate Masterplan. Thus alternative scenarios will be considered during the detailed design stages for the various plots.

The Energy Strategy establishes high aspirations for the Heygate Masterplan in the reduction of carbon. By applying key principles of energy efficiency, low carbon and renewable energy generation, the Heygate Masterplan seeks to push the boundaries of conventional strategies. Working with SC and the Greater London Authority, Lend Lease will seek to extend the benefits of the energy strategy to the wider community within the Opportunity Area. The energy strategy complies with relevant policy and applies the energy hierarchy to deliver an innovative solution for both the Heygate Masterplan and the wider opportunity area.

1. Introduction

This Energy Strategy has been prepared and submitted by E.ON Energy Solutions, on behalf of Lend Lease (Elephant and Castle) Limited (Lend Lease) (the "Applicant"), to support an outline planning application for The Heygate Masterplan in Elephant and Castle (the "Site").

E.ON Energy Solutions has prepared this report to set out how the Heygate Masterplan complies with current energy related planning policy from both a national, regional and local perspective, as well as advising on compliance with anticipated future requirements from Building Regulations. In particular, this is related to the UK Government's ambition in moving towards zero carbon design for both residential buildings in 2016 and non-residential buildings in 2019.

1.1 Site and Surroundings

The Site is located in Elephant and Castle, within the administrative boundary of the SC. The Site occupies an area of 9.71 hectares, and is bound by:

- New Kent Road (A201) to the north,
- Rodney Place and Rodney Road to the east,
- Wansey Street to the south; and
- Walworth Road (A215) and Elephant Road to the west.

Heygate Street bisects the site with junctions to Walworth Road to the west; and Rodney Place and Rodney Road to the east.

1.2 Description of Development

This Section should be read in conjunction with the Development Specification, which is submitted in support of the application and defines and describes the principal components of the Heygate Masterplan.

The Heygate Masterplan comprises a single outline planning application for the demolition of all structures on the Site and its redevelopment for a mix of uses. Accordingly, planning permission is being sought for the following:

"Demolition of all existing structures and bridges and redevelopment to provide a mixed use development comprising residential (C3), retail (A1-A5), commercial (B1), leisure and community (D1 and D2), and energy centre (sui generis) uses, new landscaping, public park, and public realm, car parking, means of access, and other associated works."

The Heygate Masterplan will deliver a vibrant mix of uses to complement the new and existing and new residential community, such as shops, bars, cafes and restaurants, business, community, cultural and leisure uses.

The Heygate Masterplan will provide up to 2,462 new homes, as well as a maximum of 32,675m^2 of non-residential space consisting of predominantly retail space spread across 12 plots as shown in Figure 1. The indicative phasing for each plot and the Energy Strategy has been developed to be commensurate with this development programme.

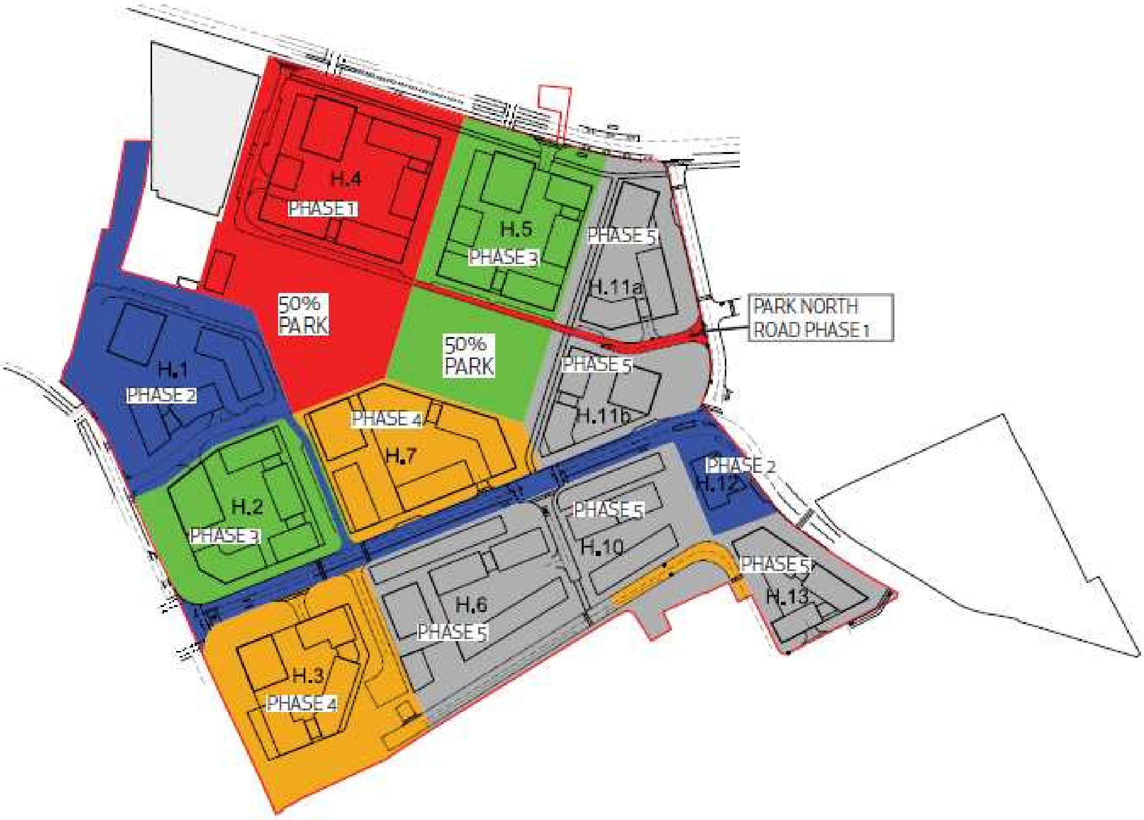


Figure 1 Assumed Phasing of Site

This Energy Strategy is purely focused on the first phase of the Heygate Masterplan though where appropriate, reference is made to Phase 1 of the Heygate Regeneration.

2. Policy Measures

The relevant national and local policies applicable to the Heygate Masterplan are stated within this section and compliance with the relevant policies is detailed in Section 5.

2.1 National Policy

Planning Policy Statement 1 (PPS1): Delivering Sustainable Development, 2005

PPS1 sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system, and states that:

> "Sustainable development is the core principle underpinning planning."

In order to achieve sustainable developments under PPS1, the following key principles are advocated:

- Pursue sustainable development in an integrated manner, ensuring positive outcomes in environmental, economic and social areas simultaneously;
- Development design should seek to optimise long-term function and impact of the development; and
- Developments should address the causes and potential impacts of climate change.

Planning Policy Statement: Planning and Climate Change - Supplement to Planning Policy Statement 1, 2007

This supplement to PPS1 encourages planning authorities to provide a framework that promotes and encourages renewable and low carbon energy generation. In particular, it recommends that local planning policies should be designed to promote and not restrict renewable and low-carbon energy and supporting infrastructure.

In particular, planning authorities should:

- "not require applicants for energy development to demonstrate either the overall need for renewable energy and its distribution, nor question the energy justification for why a proposal for such development must be sited in a particular location;
- ensure any local approach to protecting landscape and townscape is consistent with PPS22 and does not preclude the supply of any type of renewable energy other than in the most exceptional circumstances;
- expect a proportion of the energy supply of new development to be secured from decentralised and renewable or low-carbon energy sources."

Planning Policy Statement 22 (PPS22), 2009

PPS22 provides input to the London Spatial Development Strategy and states that:

"Increased development of renewable energy resources is vital to facilitating the delivery of the Government's commitments on both climate change and renewable energy. Positive planning which facilitates renewable energy developments can contribute to all elements of the Government's sustainable development strategy".

Draft National Planning Policy Framework, 2011

The aim of the draft framework is to make the planning system less complex, more accessible, and to promote sustainable growth. It therefore sets out planning's important role in tackling climate change, and moving to a low carbon economy. The draft framework recognises that effective planning can help local air quality through:

- "Choosing good locations and layouts for new development.
- Support for better energy efficiency in existing buildings, and
- Backing the delivery of renewable and low carbon energy, including community-led schemes."

Zero Carbon

The UK Government has set out an ambitious plan for all new homes to be zero carbon from 2016. This target will be reflected in future changes to the Building Regulations up to and including those in 2016.

In the March 2011 Budget announcement, details of the 2016 zero carbon new homes policy were clarified and zero carbon is now deemed to only include the regulated emissions covered by Building Regulations (heating, fixed lighting, hot water and building services). Therefore, unregulated emissions e.g. from cooking or from plug-in appliances such as computers and televisions, are excluded.

Therefore the regulated carbon emissions of a development are met by a combination of energy efficiency, onsite generation and allowable solutions as shown in Figure 2[1]. The energy efficiency measures and onsite generation comprise the Carbon Compliance phase of reaching zero carbon, whilst the remaining phase is termed Allowable Solutions as shown in Figure 2.

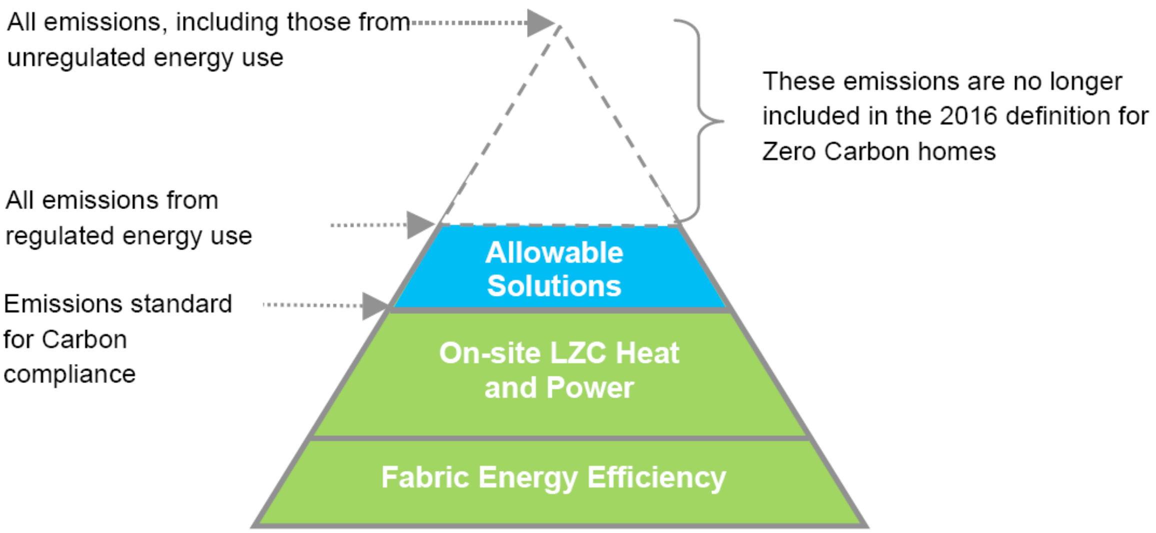


Figure 2 Zero Carbon Hierarchy

With the March 2011 Budget announcement that the definition of zero carbon was revised to exclude emissions from unregulated energy use, Allowable Solutions will need to contribute to a significant amount of emissions from a typical new home (estimated at 56% of emissions for flats).

As the concept of Allowable Solutions is relatively new to the market, the UK government (through a dedicated task force and devolved administrations) is still undertaking modelling and scenario testing around the proposed cost, acceptable solutions and many other details relating to Allowable Solutions. Allowable Solutions involve the developer making a payment to the Allowable Solutions provider, who will have the ultimate responsibility for ensuring the CO_2 savings are realised. The developer will have a choice as to which Allowable Solution to implement, ranging from onsite, near-site or off-site options, and a number of possible measures have been provided by the Zero Carbon Hub as detailed in Table 1.

"On-site" option	"Near-site" option	"Off site option"
Installation of smart appliances	Retrofitting of low/zero carbon technologies to local communal buildings	Investment in Energy from Waste plants
Use of grid-injected biomethane linked to Green Gas Certificates	Investment in local electric vehicle charging infrastructure	Investment in retrofitting of low carbon technologies to communal buildings
Home electric vehicle charging	Communal waste management solutions	Investment in low carbon cooling

Table 1 Allowable Solutions

[1] Ref: Allowable Solutions for Tomorrow's new homes: Towards a workable framework, Zero Carbon Hub, July 2011

The UK Government proposes to set the price of Allowable Solutions in line with the long term abatement cost of carbon, with a current proposed upfront cost equivalent to the cumulative cost of £50-100/CO_2 per annum for 30 years[2]. Whilst a case for passing back additional build costs to the occupant does exist, this is not being used in determining the price level of the Allowable Solutions.

2.2 Regional Policy

The London Plan, 2011

The London Plan aims to improve the environment and tackle climate change by reducing CO_2 emissions and heat-loss from new developments. Within the London Plan, the specific policies and targets that are applicable to the energy strategy for the Heygate Masterplan are:

- Policy 5.1 Climate change mitigation

  "The Mayor seeks to achieve an overall reduction in London's CO_2 emissions of 60% (below 1990 levels) by 2025. It is expected that regional agencies, London boroughs and other organisations will contribute to meeting this strategic reduction target, and the GLA will monitor progress towards its achievement annually."

- Policy 5.2 Minimising CO_2 emissions

  "The Mayor will work with boroughs and developers to ensure that major developments meet the following targets for CO_2 emissions reduction in buildings. These targets are expressed as minimum improvements over the Target Emission Rate (TER) outlined in the national Building Regulations leading to zero carbon residential buildings from 2016 and zero carbon non-residential buildings from 2019."

- Policy 5.6 Decentralised energy in development proposals

  "Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites."

Year	Residential	Non-residential
2010 – 2013	25% (CSH4)	25%
2013 – 2016	40%	40%
2016 – 2019	Zero carbon	As per building regulations requirements
2019 - 2031	Zero carbon	Zero carbon

Table 2 CO_2 Emission Savings

Climate Change Action Plan (CCAP), 2007

In February 2007, the Mayor of London produced his Climate Change Action Plan (CCAP) to deliver decisive action to cut CO_2 emissions in London. The Action Plan shows that, without any mitigation measures, London's CO_2 emissions will grow from 44 million tonnes per annum to 52 million tonnes per annum by 2025. Consequently, the CCAP sets a target of a 60% reduction in CO_2 emissions by 2025 on 1990 levels, but recognised that achieving this would be dependent on additional action by central government. Without that action, the CCAP state that it would be possible to achieve a 30% reduction through action in London alone. This means that by 2025 London must produce 33 million tonnes less of CO_2 than its current levels - an annual emissions reduction of 4% per annum.

Within the CCAP, the Mayor launched four programmes to form the basis of the Plan. One of these (the Green Energy Programme) sets a target to move a quarter of London's energy supply off the National Grid and on to more efficient, local energy systems by 2025.

2.3 Local Policy

In Southwark, energy use in buildings is responsible for 85% of the direct CO_2 emissions[3]. As such, the built environment is a key area for achieving CO_2 reduction, even though Southwark's emissions are slightly below the UK national average.

[2] Addendum to Carbon Compliance: Setting an appropriate limit for ZCH, February 2011, Updated cost of ZCH, April 2011
[3] Revitalise, Core Strategy, Southwark Council, April 2011, www.southwark.gov.uk/corestrategy

Southwark 2016: Sustainable Community Strategy

The Southwark 2016 plan sets a framework for promoting sustainable communities within Southwark and encourages key actions around the following broad principles:

- Reducing CO_2 gas emissions to the atmosphere from the burning of fossil fuels.
- Using local CHP plants to supply a significant proportion of Southwark's heating and electrical needs.
- Establishing an energy services company to deliver investment in sustainable energy systems.

The Southwark Core Strategy, 2011

The Southwark Core Strategy is a planning document that sets out how Southwark will change in the years up to 2026 to meet the aspirations as defined in the Southwark Sustainable Community Strategy. Within that Strategy, the overriding goal is to reduce CO_2 emissions across Southwark by 80% over 2005 levels by 2050.

In order to contribute to this overriding strategy, any new development will be expected to meet the following energy targets under the Southwark Core Strategy:

- Residential development should achieve at least CSH Level 4.
- Community facilities, including schools, should achieve at least BREEAM "Very Good".
- New health facilities must be BREEAM "Excellent" and any refurbishment should achieve BREEAM "Very Good".
- All other non-residential development should achieve at least BREEAM "Excellent".
- Major development should achieve a 44% saving in CO_2 emissions above the building regulations from energy efficiency, efficient energy supply and renewable energy generation.
- Major development must achieve a reduction in CO_2 of 20% from using on-site or local low and zero carbon sources of energy.

Sustainable Design and Construction, Supplementary Planning Document, Southwark Council, February 2009

The supplementary planning document (SPD) provides guidance on how new developments in Southwark should be designed and built so that it has a positive impact on the environment. Within the SPD, there is specific reference to energy use, minimising climate change and that energy issues need to be considered at the commencement of the design process. There is also an emphasis on prioritising the use of decentralised energy sources, in particular Combined Heat and Power (CHP) and DHN. It references that all developments should follow the three steps of the energy hierarchy:

- "First, use good design to minimise the development's energy needs;
- Then, make the most use of efficient energy, heating and cooling systems;
- Then, use renewable sources of energy".

The Southwark Plan (Unitary Development Plan), 2007

The saved policies in the Southwark Plan contain a key focus area for incorporating low carbon measures into new developments:

- Policy 3.4 Energy Efficiency
  "All developments must be designed to maximise energy efficiency and to minimise and reduce energy consumption and CO_2 emissions. Major developments will be required to provide an assessment of the energy demand of the proposed development (such as those contained within the BREEAM and EcoHomes Schemes). These should also demonstrate how the Mayor's energy hierarchy will be applied."

Elephant and Castle SPD/OAPF

This draft document, prepared by SC, provides detailed guidance which expands on the regeneration vision and objectives from new development in the Elephant and Castle Opportunity Area. It will become part of the Local Development Framework, and will be a material consideration in decisions made by the Council on all planning applications. It states that:

> "In 2006, Southwark adopted a climate change strategy that aims to reduce CO_2 emissions across the borough by 80% by 2050 and to pursue a decentralised energy strategy for the borough".

3. Energy Strategy

The energy strategy is based on the three elements of the energy hierarchy – reduce demand (be lean), efficient energy generation (be clean) and renewable energy (be green). [4] [5]

3.1 Reduce Demand (Be Lean)

3.3.1 Building Design

With respect to overall building design parameters that impact upon the energy demand of the Heygate Masterplan, this strategy assumes that in all cases regulatory compliance ‘minimum standards’ will be met and where viable they will be exceeded in order to deliver improved design and performance standards. Guidance and reference documents include:

- Building Regulations Part L (2010)
- Standard Assessment Procedure (SAP 2009)
- Building Research Establishment Environmental Assessment Methodology (BREEAM 2008)
- Code for Sustainable Homes (CSH 2010)
- Code for Sustainable Buildings (2019) – as and when introduced
- Zero Carbon Hub
- UK Green Building Council (UKGBC)

The strategy assumes that a high level of energy efficiency will be achieved from compliance with SAP (2009) and Building Regulations 2010 (Part L) baseline figures. For the residential buildings this will require higher levels of insulation and air tightness as detailed in Table 3, whilst for the non-residential buildings the energy efficiency will be related to the specific end-user profile.

From Building Regulation compliance for both residential and non-residential, it is considered that improved thermal performance will reduce space heating requirements and improved efficiency of building services elements e.g. variable speed fans and pumps, demand controlled ventilation with heat recovery benefits and smart controls, will all assist in reducing the electrical demand.

The building orientation and form is considered to ensure that the building envelope can act as a climate modifier, so that key considerations can be integrated and these will include:

- Ventilation to facilitate effective natural (passive) ventilation where possible and if supplemented by mechanical systems, then these will be high efficient mechanical ventilation incorporating heat recovery (MVHR) from relevant areas of the buildings e.g. kitchens, bathrooms, etc.
- Where non-residential cooling is to be required, the design will seek to maximise passive cooling by integrating ventilation strategies with window and façade design to facilitate where possible natural cooling delivery. This will require a range of considerations to ensure cooling loads are firstly reduced e.g. via high specification glazing properties (and/or solar control films applied to glazing), possible intelligent façade measures that will allow cooling energy (‘coolth’) capture during cooler night-time periods and released via specific fabric materials during peak temperature demands.

In all cases, the aim will be to avoid or in the worst case minimise the use of mechanical cooling equipment. Where mechanical cooling may be required, the most efficient units at time of design development will be specified based on cooling energy delivered. Primarily, the base design will play a key part in ensuring low energy cooling can be achieved e.g. building layout optimisation for effective use of ventilation and passive cooling measures appropriate to the prevailing design criterion.

- Natural lighting incorporated to maximise the daylight factor in order to reduce artificial lighting needs, which will also be commensurate with the occupant’s general health and wellbeing requirements.
- Installed artificial lighting loads are assumed to be beyond the minimum Building Regulations compliance by virtue of low energy lighting e.g. significant application of LED lighting and appropriate smart controls e.g. daylight controls to adjust lighting levels when daylight factor is high and PIR sensors to control lighting in low use/intermittent areas.
- Solar gains will be minimised by passive control measures within the design to prevent overheating during summer periods. This may integrate both passive and active measures dependant on final design layouts e.g. managing heat within buildings by due consideration of construction materials and surface design.
- Glazing type and configuration will be designed and applied so as to contribute directly to the ventilation, daylight and thermal strategies.

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[4] Sustainable design and construction, Supplementary planning document, February 2009, Southwark Council
[5] The London Plan, Spatial development strategy for Greater London, Greater London Authority, July 2011

- The dynamic thermal response of the building will be considered so as to support energy reduction by integration into the heating and cooling strategies.
- Reducing U Values, as detailed in Table 3, and reduction of thermal bridging in order to achieve CSH Level 4 prior to 2016 and zero carbon home (ZCH) post 2016.

Element	Part L (2010)	Post 2016 target
Roof U-Value (W/m^{2}K)	0.20	0.10
External Wall U-Value (W/m^{2}K)	0.30	0.10
Floor U-Value (W/m^{2}K)	0.25	0.10
Windows U-Value (W/m^{2}K)	2.00	0.80
Air Permeability (m^3/hr/m^2)	10[6]	3

Table 3 Fabric Design Values (Minimum Compliance Standard)

The use of smart metering and building management controls will be applied to determine measurement and verification protocol for proofing of the design from concept, through construction and into final occupancy. This should incorporate consideration of Building Regulation compliance (BR 2010 Part L Criterion 5) for information exchange on building controls to enable end-users to have sufficient knowledge and control capability. This will also directly support post occupancy reviews with full performance analysis from measured data.

It is recognised that there is a strong debate about the potential gap between the designed performance of new buildings and how they perform post occupancy. This is critical to meeting the relevant national and local environmental targets and is a key metric being considered by the Zero Carbon Hub. It is suggested that the Carbon Compliance limit should apply to post construction performance rather than designed performance.

A BREEAM 'Excellent' rating is to be achieved for all non-residential units above 1,000m^2 within the proposed Development. Although all units will benefit from CSH Level 4 thermal efficiency standard being applied across the Proposed Development, BREEAM for New Construction can accommodate mixed-use buildings and, more specifically, now includes a majority credit level of 30 credits for energy-related elements i.e. EN01 - ENO4. The Energy Strategy will cover as a minimum all of the EN01-04 elements directly by adherence to prevailing building regulations, CSH and other guiding frameworks including but not limited to the UKGBC and Zero Carbon Hub. In particular this includes reduction in CO_2 emissions through fabric efficiency improvements, use of sub-metering and building management information/control systems as appropriate to building design, consideration of LED street lighting and connection to DHN supplied by high efficiency gas CHP with biomethane injection.

It is also recognised that during the phasing of the proposed Development, the CO_2 emission factors for grid electricity are likely to change and this will impact the Carbon Compliance phase of the proposed Development. Where appropriate the impact of any change within the CO_2 emission factors will be factored in during the detailed design for each phase.

3.3.2 Energy Demand

The thermal demand profiling for the Heygate Masterplan takes into account the mix of property types and sizes, fabric efficiency levels, occupant behaviour patterns based on the anticipated occupancy demographic and the heating design. All the non-residential properties are located on the lower floors of their respective blocks, with the remaining floors being residential premises. The breakdown of property types based on the Illustrative Masterplan is as detailed in Table 4 and Table 5, whilst plot breakdown and thermal energy demand for each plot within the Heygate Masterplan is shown in Table 6 and Figure 3 respectively.

Property type	Number	%
1 bed	952	39
2 bed	1,261	51
3 bed	146	6
Town House	103	4
Total Residential	2,462	100

Table 4 Residential property breakdown – based on Illustrative Masterplan

[6] Air permeability would be expected to achieve 8 as a maximum with 2-5 being aspirational

Use Class	m²	%
A1-A5: Retail and Café/Restaurant	16,750	52
B1: Business	5,000	15
D2: Leisure	5,000	15
D1: Community	5,000	15
SG: Energy Centre	925	3
Total Commercial	32,675	100

Table 5 Non-residential property breakdown – based on maximum parameters

Plot	H4	H1	H12	H5	PAV	H2	H3	H7	H6	H10	H13	H11a	H11b
Completion	2018	2019	2019	2020	2020	2021	2021	2021	2023	2023	2024	2024	2025
Residential Property Numbers	349	256	0	270	0	347	176	347	168	75	72	231	171
Non-residential Floor Area (m² GEA)													
A1-A5: Retail & café/ restaurant	4,847	1,943	0	2,938	462	1,753	2,170	1,614	0	0	0	418	0
B1: Business	773	688	0	1,271	0	569	884	0	0	0	0	803	0
D2: Leisure	2,814	0	0	0	0	0	0	0	0	0	0	0	0
D1: Community	0	0	0	0	0	0	0	0	2,401	0	0	0	0
SG: Energy Centre	0	0	729	0	0	0	0	0	0	0	0	0	0

Table 6 Plot breakdown – based on maximum parameters

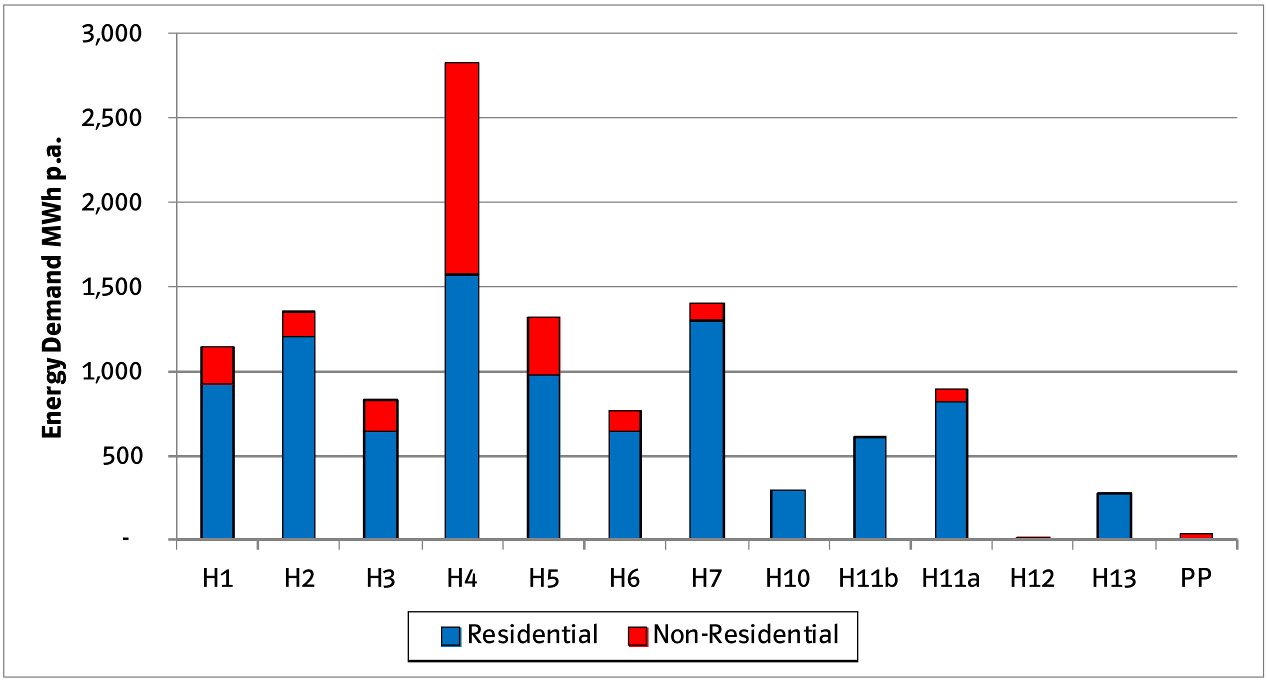


Figure 3 Thermal Energy Demand per Plot

The total thermal demand of the Proposed Development will increase throughout the phased construction from first block receiving heat in 2018 to full occupation in 2029 as shown in Figure 4.

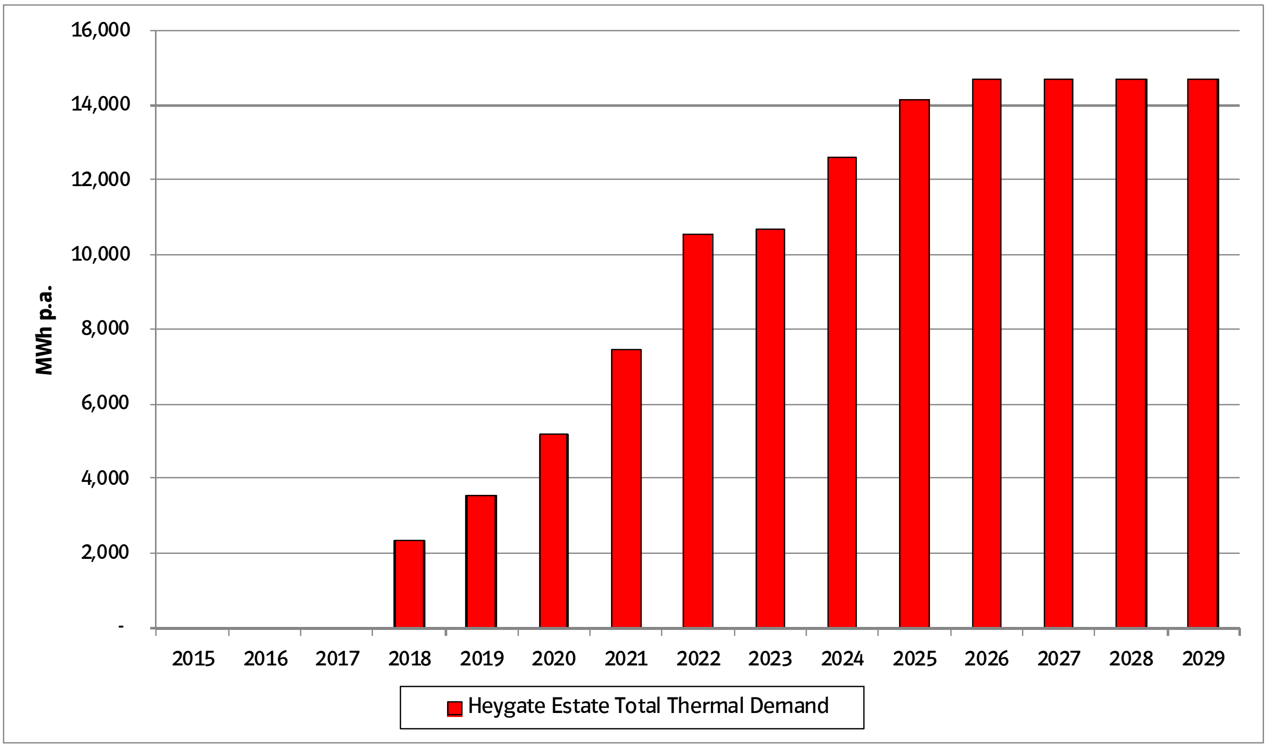


Figure 4 Thermal Energy Demand per Year

There is an estimated 28% reduction in energy demand of the proposed Development from the baseline as shown in Figure 5, which also shows both the regulated and non-regulated energy demand for the residential and non-residential properties within the Heygate Masterplan. The supporting SAP checklist and accompanying IES modelling output are shown in Appendix C and Appendix D respectively.

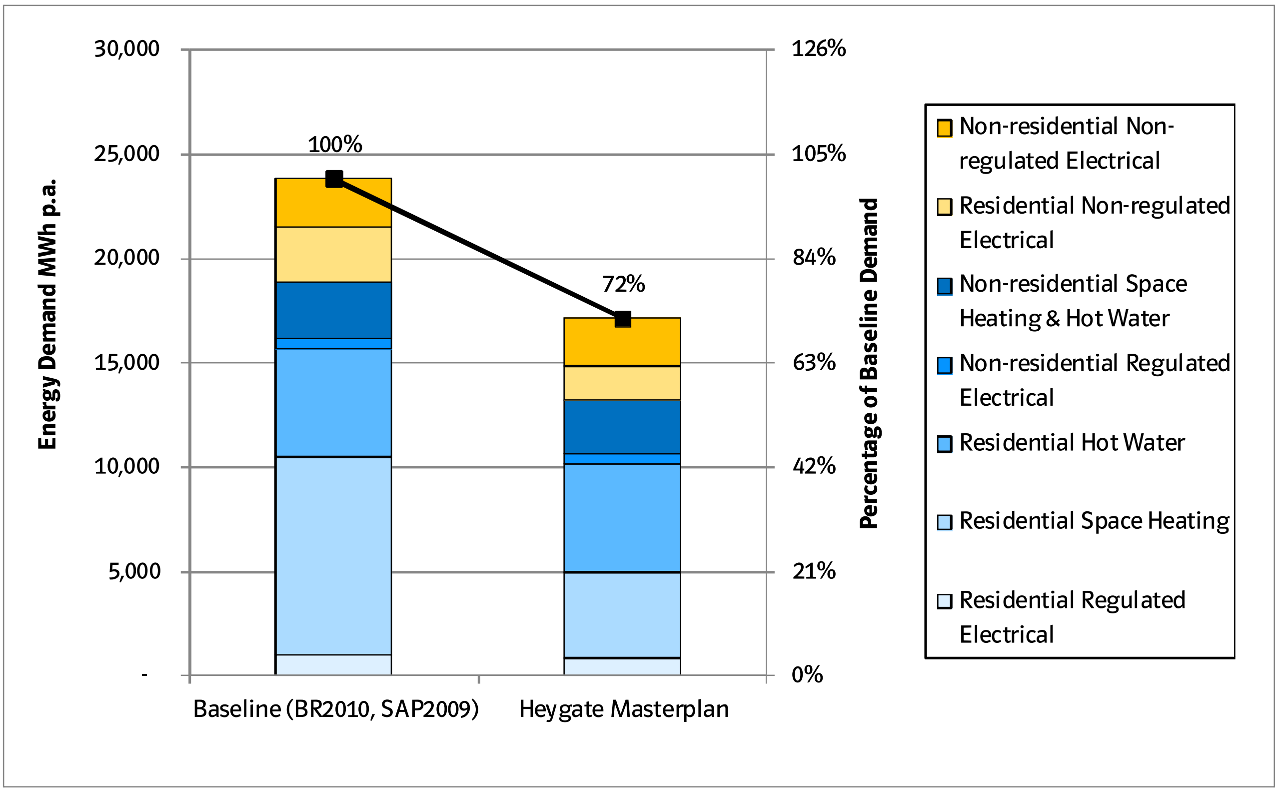


Figure 5 Reduction in Energy Demand

3.2 Efficient Energy Generation (Be Clean)

The mixed-use nature of the Heygate Masterplan, its phasing and ambition to be net zero carbon brings a requirement for a more holistic consideration of efficient energy generation, which moves away from the traditional approach of looking at energy generation on a building by building basis. Therefore the preferred energy-efficient generation technology is centralised gas CHP delivering both space heat and residential hot water via a low temperature hot water (LTHW) DHN to the proposed Development. The LTHW will be distributed to all properties by a series of heat substations located within each plot, with the exact location and numbers being determined at the detailed design stage.

A key element of the energy strategy is that the CHP will not be switched on until there is sufficient thermal demand. The most efficient strategy would be to have only one CHP engine that is turned on much later in the Proposed Development. However understanding SC's aspiration for early low carbon energy, it is proposed that two smaller CHP engines are installed in line with the heat demand as the proposed Development progresses. This reduces the potential for generating excess heat when operating the engine too soon in the Proposed Development phases. Therefore two CHP units will be provided, a 263kW$_t$ unit being switched on during 2019 for the second phase of Development, whilst a 985kWt CHP will be switched on during 2021.

This is within the requirements of the CSH guidelines, which indicates that for multi-phase developments, any centralised energy supply infrastructure should be operational before more than 60% of the dwellings are completed. Therefore in the early stages of each phase, buildings will be supplied heat from temporary high efficiency gas boilers that will be located in the Energy Centre. This guidance has been clarified with BRE, which advises: [7]

> "The 60% rule you refer to can be applied on a site-wide basis. To clarify, this exception within the technical guide for centralised energy systems allows a percentage of dwellings on a larger site to be completed/certified prior to the centralised system being in operation. The centralised energy system must be in place before 60% of the dwellings which will connect into this system, are complete. Note that the relevant infrastructure to allow for future connection to the system must be put in place in order for the relevant dwellings to gain credits. Evidence to confirm that this system will be operational before more than 60% of the dwellings are complete, will be required at the post construction stage for all dwellings, prior to the system being operational."

The two CHP units will be supplemented by gas boilers during periods of high demand and also for back-up provision. Therefore the two gas CHP units and gas boilers for back-up/stand-by provision will be located within a centralised Energy Centre.

The proposed DHN is designed to operate as a LTHW system, given that the DHN is fairly compact on the site giving low heat losses. The proposed temperature differential for the DHN will be determined at the detailed design stage in order to minimise distribution pipe sizes within the constraints of LTHW, whilst maintaining a mean water temperature sufficiently high to ensure good thermal transfer to the secondary heating circuits within each plot.

Within each apartment and commercial/retail unit there will be a heat interface unit (HIU) to distribute the heat for heating and hot water usage. The sizing of the HIU will be determined at the detailed design stage.

The plant sizing, as shown in Table 7, incorporates two CHPs, one for each stage of the proposed Development. The CHPs have been sized to meet the summer thermal demand (including DHN losses). The gas boilers will provide the variable load and also act as back up during down time and scheduled maintenance. The sizing philosophy is to install three boilers each capable of supplying 50% of the proposed Development peak demand.

Plant	Switch On Date	Thermal Output (kW)	Electrical Output (kW)	Annual Heat Output (GWh)	Annual Electrical Output (GWh)
CHP 1	2019	263	165	2.1	1.3
CHP 2	2021	985	809	5.7	4.7
Gas Boilers	2018	3 x 5,000	N/A	6.9	N/A
Total		16,248	974	14.7	6.0

Table 7 Generating technologies

The monthly variation in demand over the year for the completed proposed Development is shown in Figure 6. This demonstrates the plant sizing philosophy with the two CHP units providing the summer demand and the gas boilers providing the peak loading during the winter months.

[7] Personal communication, BRE, 25 August 2011

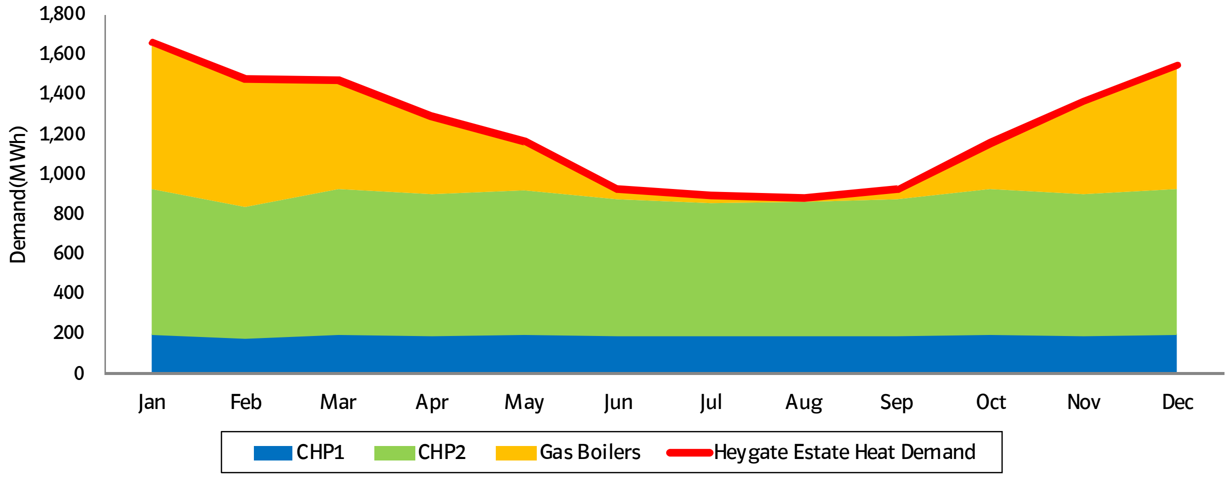


Figure 6 Monthly variation in Demand

CHP 1 and CHP 2 provide 4% and 20% respectively of the CO_2 savings for the Heygate Masterplan once the site is completed. The contribution of both the CHP and gas boilers towards the site energy demand is detailed in Appendix F.

It is recognised that there are a number of proposed and existing developments immediately adjacent to the Heygate Masterplan which have sufficient energy density to be worth considering connecting to the DHN at a later date. Any early connection to these existing buildings (e.g. Phase 1 of the Heygate Regeneration), have the potential for enabling the CHPs to be switched on earlier within each stage and any alternative scenario to the Heygate Masterplan will be considered in more detail at the detailed design stage.

An initial assessment of the opportunity to extend the DHN to neighbouring properties, indicates that there are a cluster of buildings of close proximity to the Heygate Masterplan area that have sufficient thermal demand to be worthy of further consideration. The indicative suitability of the buildings is detailed in Table 8 and their location in relation to the Heygate Regeneration area is shown in Figure 7.

Number	Property	Suitability (kWh/m)
2	Strata Tower	29,004
7	Oakmayne Plaza	14,115
12	1 Hampton Street	7,619
6	London Park hotel	6,101
13	St Marys	6,100
5	120-138 Walworth road	5,047
1	Amelia Street printworks	3,184
9	Eileen House	2,931
11	Stead Street	2,482
4	New Kent Road	2,083
10	89-93 Newington Causeway	828
8	Harper Road	813
3	Brandon Street	633

Table 8 Future DHN Connections

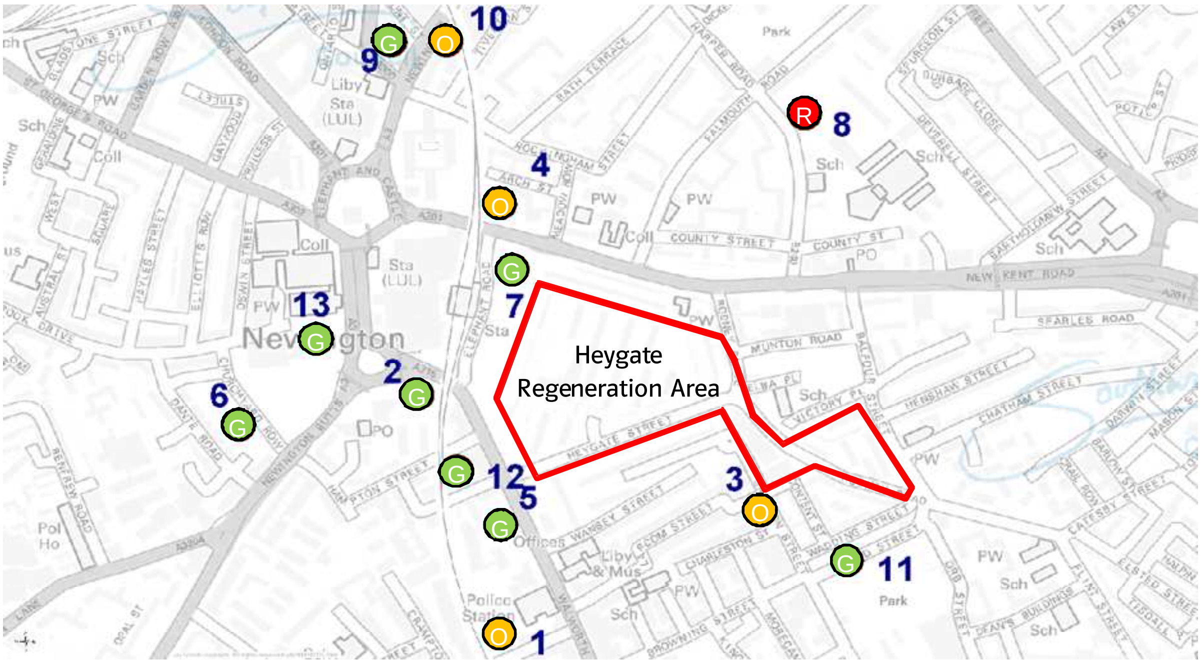


Figure 7 Future DHN Connections

To allow for the potential for such future connections, the initial design of the Heygate Masterplan DHN and Energy Centre has sufficient flexibility to future proof the scheme for an increased thermal demand. It is estimated that the existing Energy Centre is able to accommodate the increase in generation plant that will be required to supply in the region of a further 1,000 apartment dwellings, though this needs to be confirmed at the detailed design stage.

It also recognised that SC is actively encouraging the development of a DHN that will utilise the waste heat from the SELCHP energy recovery facility at South Bermondsey. From initial heat mapping of the opportunities within Southwark to connect to SELCHP, SC has recently published a detailed proposal to connect SELCHP to 3,000 residential properties in the vicinity of Southwark Park.[8] The provision of an Energy Centre at the Heygate Masterplan helps to facilitate the future opportunity to connect the Heygate Masterplan DHN to the SELCHP DHN should this be appropriate and feasible.

SC has set a target that every major development must achieve a reduction in CO_2 of 20% from using on-site or local low and zero carbon sources of energy after both energy efficiency and efficient energy supply measures have been applied.

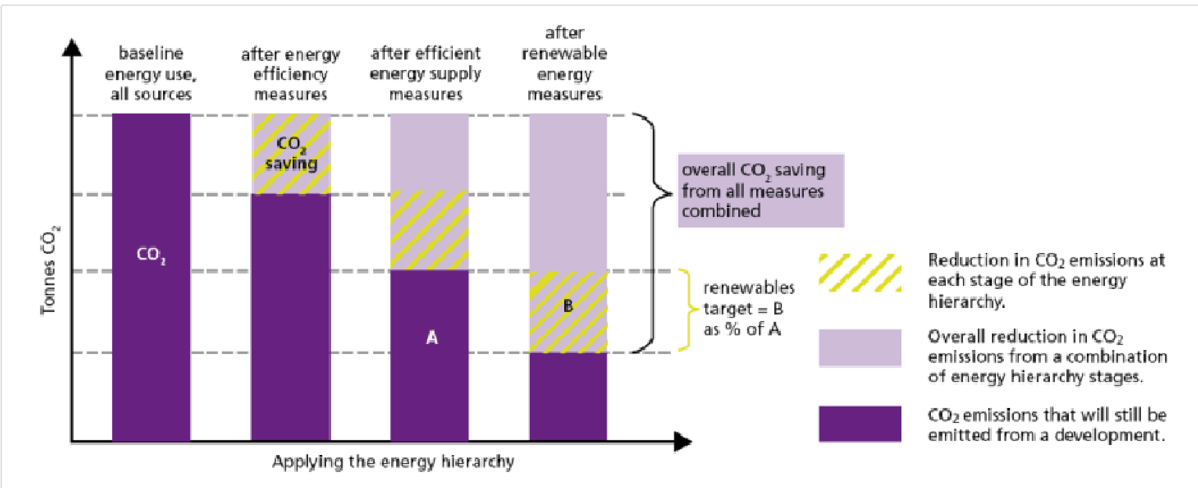


Figure 8 Applying the energy hierarchy

8 www.southwark.gov.uk/news/article/624/

For the Heygate Masterplan, after both the implementation of energy efficiency and energy supply measures there are 4,265 tonnes CO_2 remaining. Therefore in accordance with SC's Planning Policy, 20% of this (i.e. 853 tonnes CO_2) has to be met by renewable energy as shown in Figure 9.

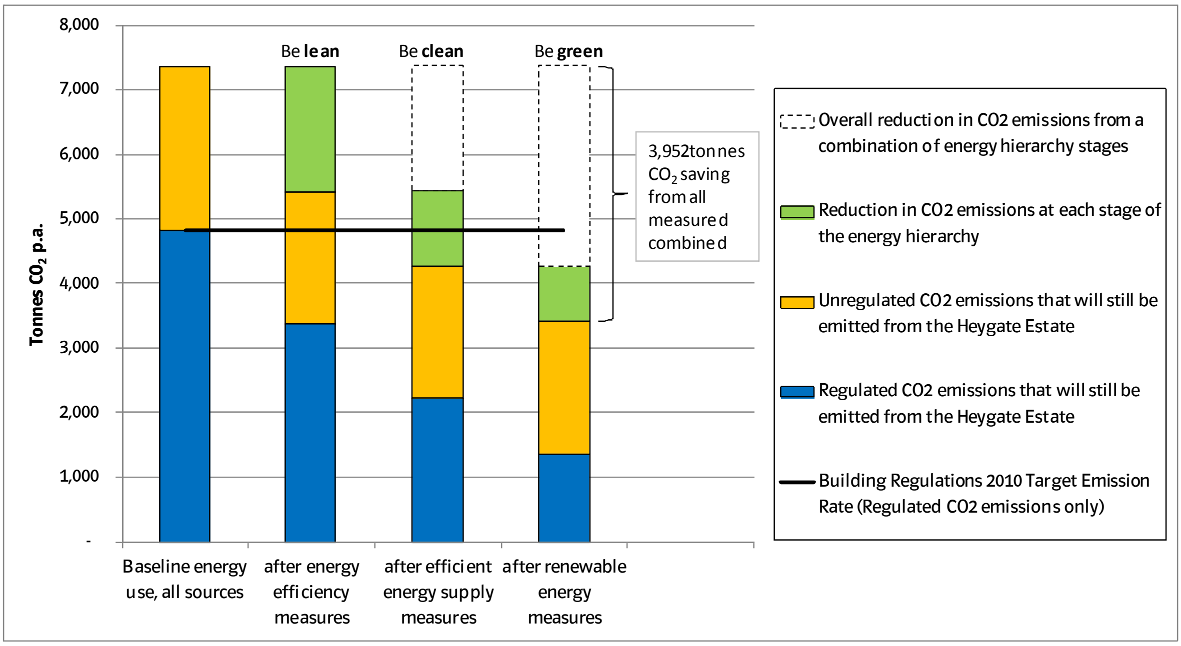


Figure 9 CO_2 Emission Reduction

3.3 Renewable Energy (Be Green)

Before arriving at the renewable energy generation solution, many different thermal and electrical energy generating technologies were evaluated for the Heygate Masterplan. The technologies considered the building locations, orientation, profiles and thermal and electrical demand profiles. The technologies reviewed are detailed in Table 9.

Energy	Solar PV	Solar Thermal	Biomethane CHP	Biomass Boiler	Biomass CHP	Wind Turbine	Ground Source Heat Pump	Air Source Heat Pump
Thermal	N/A	✓	✓	✓	✓	N/A	✓	✓
Electrical	✓	N/A	✓	N/A	✓	✓	N/A	N/A

Table 9 Technologies Considered in Review

The following subsections give an overview of each technology. The decision on whether a particular technology is appropriate for the Heygate Masterplan is determined from the options appraisal matrix in Section 3.3.9.

3.3.1 Solar PV

Solar PV panels can be installed on the roof of a building, on the side as a façade or mounted on the ground. They operate best when facing a southerly direction, and will operate effectively even when the sun is not shining, absorbing the sun's energy and converting it directly to electricity.

Benefits of solar PV include renewable and emission-free electricity generation, as well as revenue generation via the Feed-in-Tariff (FIT) and the avoided cost of imported electricity. The electricity generated from a solar PV array can be used to meet onsite demand or can be sold to the grid if generated at a time when there is insufficient on-site demand. Assuming that there is no shading from other buildings or trees etc., the annual energy output available for each 1kW of an array can be seen in Table 10.

Solar PV array	Roof Mounted[9]	Façade Mounted
Space required (m^2/kW)	20	6
Estimated Annual Energy Generation (kWh/kW)	900	637

Table 10 Expected Solar PV Generation and Revenue

It is estimated that 25% of the indicative roof area of the Heygate Masterplan could be made available for solar PV, making allowance for roof plant equipment, green roof areas, private/public space and access routes. This available area equates to an annual CO_2 saving of 268 tonnes CO_2 against grid imported electricity and a 6.3% CO_2 reduction for the proposed Development after energy efficiency measures. It is very unlikely that all of this roof space will be unshaded due to varying heights of adjacent buildings.

The opportunity for a solar PV façade at this stage is therefore limited as the available south facing unshaded area which is suitable for a PV façade will not be determined until the detailed design stage. Initial estimates indicate that to meet the remaining 13.7% CO_2 reduction to achieve SC's 20% renewable energy target a south facing unshaded façade area of 10,333m^2 is required. It is unlikely that this quantum of area would be available. Additionally, vertical PV is much less efficient and integrated façades that are aesthetic are not commercially available. Vertical PV is therefore not considered achievable from a technical and commercial standpoint in the current market.

Summary

Pros	Cons
Income stream through the feed in tariff increases commercial attractiveness.	Upgrade to the existing electrical infrastructure may be required for a large PV array.
Free or low cost electricity available to residents can reduce fuel bills and help alleviate fuel poverty.	Requires unshaded roof or façade areas – the Heygate Masterplan has the potential of shading from taller, adjacent buildings for roof top mounted arrays and shading from buildings located to the south for façade mounted arrays.
	Limited roof space is available therefore façades would be required to meet policy solely from PV. Table 10 show these to have lower output and income revenue per kW making them less viable
	Competes for roof space with green roofs and building plant.

Table 11 Solar PV Summary

3.3.2 Solar Thermal

Solar thermal collectors convert the power from the sun into useful heat by heating a fluid flowing through the collectors, which is then used to heat water through a coil in a water tank. This water can then be used for hot water, space heating, preheat for boilers or DHN return flow.

Individual System

A typical residential system in the UK produces 60% of the annual hot water requirement and requires two to three collectors. With a collector measuring between 1-2m^2 this represents a large area of space required at the Heygate Masterplan when multiplied by the number of units. Further to this external spatial requirement, a gas boiler would be required in each of the properties along with a hot water storage cylinder taking up valuable space in the apartments.

[9] Includes space between rows to prevent shading

Communal System

The alternative to individual systems is to combine a solar thermal system with a DHN. This is achieved by using the hot water from collectors to heat the return flow from the DHN before it enters the boilers or CHP. This arrangement reduces the temperature rise required by the boilers or CHP.

Summary

Pros	Cons
Solar thermal collectors can be used in conjunction with a communal heating system.	Due to the temperature of the hot water from the solar thermal collectors, an auxiliary heat source (e.g. gas boiler) is always required.
Income stream through the renewable heat incentive increases commercial attractiveness.	Individual systems require both external space for mounting collectors and internal space for a boiler and hot water cylinder.
	Competes for roof/façade space with green roofs and building plant.

Table 12 Solar Thermal Summary

The most viable location for a solar thermal system is on the Energy Centre roof to provide a preheat for the DHN return water and initial estimates suggest an investment cost of £5,500/tonne CO_2 for a 40 tonne CO_2 saving. This will be considered at the detailed design stage of the Energy Centre. As the hot water design for the Heygate Masterplan DHN is based on instantaneous hot water there is no provision for a hot water storage cylinder within the properties, therefore solar thermal is not a viable solution for the apartment blocks.

3.3.3 Biomass Boiler

Biomass boilers run most efficiently at high load therefore are suited to providing the base load of a development. The combustion of biomass releases a large number of pollutants compared to the combustion of natural gas increasing the emissions control requirements. At the Heygate Masterplan where there are multiple tall buildings, this could mean a very tall flue and extra requirements for measures to reduce the pollutant content of the flue gases e.g. utilising high efficiency burners.

Factors to be considered when using biomass boilers are the increased traffic due to deliveries, extra space required for biomass storage and associated flue emissions. The extra space required within the Energy Centre would mean that within the maximum parameter plans the potential for external connections to the DHN would be reduced.

Within an urban location wood pellets are the preferred fuel. Although the biomass boiler and the pellets themselves are generally more expensive than for wood chips, the delivery and storage requirements are much less for pellets. Furthermore, burning pellets poses far fewer maintenance issues than chips.

Summary

Pros	Cons
Income stream through the renewable heat incentive increases commercial attractiveness.	Increased access requirement and volume of traffic due to biomass deliveries.
Lower maintenance costs than gas CHP.	Increased traffic noise due to both biomass deliveries and offloading of the biomass
Increased carbon savings over a gas boiler due to lower carbon intensity of biomass.	Conflicts with CHP for providing the baseline thermal demand.
	Additional space requirements in the Energy Centre mean that less external developments could be connected
	Increased requirements for flue system due to pollutants in exhaust gases.

Table 13 Biomass Boiler Technology Summary

3.3.4 Biomass CHP

Similar to a gas CHP unit, a biomass CHP unit produces both heat and electricity in its operation. There are two types of technology available for a biomass CHP, gasification and steam turbine.

Though gasification is a combustion process to turn biomass wood fuel into a hydro-carbon gas (wood gas), which is then used to drive a gas CHP engine, it is not yet fully established as a technically and commercially proven solution at a suitable size for the Heygate Masterplan.

A biomass steam turbine CHP system uses more proven technologies. Steam is raised through combustion of biomass, which is then fed into a steam turbine which drives an electrical generator. Due to the requirement for a steam turbine, this technology is only suited to very large developments.

Both types of technology are suited to producing baseline thermal energy demand due to their operational characteristics. Therefore, similar to gas CHP, run hours must be maximised to ensure commercial viability.

Summary

Pros	Cons
Income stream through the renewable obligation certificate increases commercial attractiveness	Gasification biomass CHP system is not a proven technology.
Generates electricity and heat giving low net carbon emissions.	Larger volumes of biomass required than a biomass boiler increasing store requirements and volume of traffic from deliveries.
Electricity generated can be sold via private wire or to the national grid.	Increased traffic noise, congestion and pollution due to biomass deliveries.
Increased carbon savings over a gas CHP due to lower carbon intensity of biomass.	Increased requirements for flue system due to pollutants in exhaust gases.
	Significantly increased Energy Centre area required compared to biomass boilers and gas CHP units which is not available in the Heygate Masterplan.
	Conflicts with gas CHP and biomass boiler for providing the baseline thermal demand.
	High capital cost

Table 14 Biomass CHP Technology Summary

3.3.5 Biomethane

An alternative fuel source to natural gas that is rapidly gaining recognition within the UK as a renewable energy source is biomethane. Biomethane is simply biogas generated from the anaerobic digestion of sewage, waste or crops and then cleaned to remove other gases to create a gas that is approximately 98% methane. The biomethane can then be injected into the gas network and gain accreditation under the Green Gas Certification Scheme (GGCS), which is administered by the Renewable Energy Association (http://www.greengas.org.uk/).

Biomethane grid injection is already recognised by DECC as a renewable fuel within the Renewable Heat Incentive (RHI) scheme, whilst OFGEM regard connection of biomethane to the gas network as a key performance metric for gas distribution network operators. It is also presently identified as one of the on site technology solutions within the ZCH consultation on Allowable Solutions. Further a recent report by National Grid, estimates that 15% of residential gas demand can be met by biomethane by 2020.[10] The biomethane supply chain within the UK is rapidly developing with significant investment and interest from the major energy companies as detailed in Table 15.

[10] The potential for Renewable Gas in the UK, National Grid, January 2009

Energy Company	Description
British Gas/Bio Group	£5m anaerobic digester with biomethane upgrade and injection facility in Stockport due to open in April 2012. Will supply 1,400 homes using 250,000 tonnes of food waste.
British Gas/Thames Water/Scotia Gas Networks	200 homes supplied with biomethane from Thames Water sewage treatment works in Didcot.
British Gas/National Grid/Adnams Bio Energy	235 homes supplied with biomethane from 12,500 tonnes of brewery and food waste.
RWE	2 biomethane injection plants in Germany
E.ON	13 biomethane injection plants (12 in Germany, 1 in Sweden). Roll out programme planned for UK.

Table 15 Biomethane development

It is therefore anticipated that during the lifetime of this project, biomethane through the GGCS will become an Allowable Solution and that there will be full transparency with regards to carbon emission factors – see Appendix K and Appendix L for more detail.

Summary

Pros	Cons
Increased carbon savings over a gas CHP due to lower carbon intensity of biomethane.	Yet to be fully recognised as an Allowable Solution by UK govt.
Increased carbon savings over a gas CHP due to lower carbon intensity of biomethane.	
Fuel is transported through existing gas network, therefore no increased transportation on the Heygate Masterplan.	
Low emissions compared to biomass.	
No onsite fuel storage requirements.	
Able to be used within standard gas fuelled boilers and CHPs without modification.	

Table 16 Biomethane Technology Summary

3.3.6 Wind

The extraction of power from the wind through wind turbines has become an established industry in recent years, with turbine sizes ranging from a few kW to the large offshore turbines which are now several MW in size.

As the power output from a wind turbine is proportional to the cube of the wind speed, a doubling of the wind speed results in the power output increasing by a factor of eight. Consequently, the correct siting of wind turbines is critical to maximize the availability of the prevailing wind and hence the power output.

The key aspects determining the electricity generated from a wind turbine are the wind speed, the height of the wind turbine and the swept area. The wind speed is the main variable and this is very site specific. To provide an indication of the wind speed at the Heygate Masterplan, we have used published average wind speed figures for the local grid reference and these are detailed in Table 17.[11]

[11] Source: NOABLE wind speed database

Measure height above ground level (m)	NOABL Wind Speed (m/s)
10	4.7
25	5.5
45	6.0

Table 17 Indicative wind speed

The opportunity to install wind turbines is severely limited in the densely populated urban environment of the Heygate Masterplan. The wind will be heavily affected by the height of the surrounding canopy, which can reduce the wind speeds by up to 50%. Since the power produced from a wind turbine is proportional to the cube of the wind speed, a 50% reduction in wind speed reduces the annual generation by over 87%.

Summary

Pros	Cons
Income stream through the feed in tariff increases commercial attractiveness.	Both roof mounted and free-standing wind turbines generate most efficiently in an undisturbed wind which is hard to achieve in a dense urban area such as the Heygate Masterplan.
Wind turbines can be used as a source for science based educational programmes.	If free standing, then topple distance must be considered. This is typically 1.5 times the total height of the turbine and may make it difficult to gain planning permission for a turbine in a densely populated area.
	High visual impact to local residents.
	Potential increase in background noise.

Table 18 Wind Technology Summary

3.3.7 Ground Source Heat Pump

Ground source heat pumps (GSHP) act as a central heating and cooling system by pumping heat to or from the ground. Using the earth as a heat source in the winter and a heat sink in the summer improves efficiency and reduces operational costs of a heating/cooling system. GSHP harvest heat absorbed at the Earth's surface from solar energy, capitalising on the stable temperature underground.

Open loop borehole GSHP, otherwise known as water source heat pumps (WSHPs), draw hot water from an underground well, pass it through a heat exchanger forming part of the heat pump and then discharge it back into the well. WSHPs are well suited to locations where there is a majority of porous rock. The initial survey indicated that the ground underneath the Heygate Masterplan is reasonable for an underlying chalk aquifer with an estimated capacity of 300kW per extraction borehole, just 2% of the total thermal demand.

The space heating design for the Heygate Masterplan is based on a DHN which typically will have an operating temperature of (c.85^{O}C flow and 55^{O}C return). GSHP run at maximum efficiency at lower output temperatures and are therefore more suited to underfloor heating systems.

Summary

Pros	Cons
Stable well temperatures allowing for a stable heating output.	Heat pump driven by electricity therefore marginal cost and carbon savings seen.
Typical heat pump efficiencies of 250-400% depending on the required output temperature.	At least 2 boreholes required – depth is dependant on the location of the well. This would have to be established with a detailed geological survey.

	Drilling boreholes can be costly – up to £100/m - with two boreholes required, and depths up to several hundred metres.
	Only 2% of the total thermal demand can be satisfied by a pair of boreholes.

Table 19 GSHP Technology Summary

3.3.8 Air Source Heat Pump

An air source heat pump (ASHP) takes thermal energy from the surrounding air to provide space heating and hot water. ASHPs work like fridges in reverse by absorbing the low grade heat from the air through a refrigerant within the heat pump. ASHP typically have an efficiency of 150-300%.

For an apartment block system, multiple ASHP units are mounted on the roof of the apartment block or on the ground beside it. As an ASHP has a relatively small output (low kW scale) multiple units would be required to provide the demand for each of the apartment blocks within the Heygate Masterplan.

Heat is delivered from the ASHP to the apartments within the block via riser and lateral pipe work inside the building. ASHP operate most efficiently with a lower output (35-40^{0}C) temperature, which requires an underfloor heating system rather than a radiator system. ASHP are less suited to providing hot water as this must be able to be heated to 60^{0}C to prevent legionella. Though it is possible to combine an ASHP with an auxiliary heat source e.g a gas boiler or electric immersion heater, this adds to the cost and complexity of the system.

The space heating design for the Heygate Masterplan is based on a DHN which typically will have an operating temperature of (c.85^{O}C flow and 55^{O}C return). ASHP run at maximum efficiency at lower output temperatures and are therefore more suited to underfloor heating systems.

Summary

Pros	Cons
No boreholes required, reducing capital cost compared with other heat pump technologies.	Output inversely proportional to demand i.e. reduced output at high demand when external air temperature is low.
Higher efficiency than gas or biomass boilers.	Efficiency and output dependant on external air temperature.
	Relatively low output therefore multiple units required to provide the total demand at the Heygate Masterplan.
	Issues with legionella in the hot water storage cylinder if no auxiliary heat source is utilised.
	More efficient at lower output which will preclude some traditional heating systems..
	Heat pump driven by electricity therefore marginal cost and carbon savings seen.

Table 20 ASHP Technology Summary

3.3.9 Options Appraisal

To provide an objective assessment of the most suitable renewable energy generating technologies for the Heygate Masterplan, the technologies described in Sections 3.3.1 – 3.3.8, have been evaluated across a range of key criteria:

- Financial implications — Revenue streams, CAPEX costs and available incentives
- Technological risk — Maturity of technology and infrastructure upgrades required
- Security of supply risk — Likelihood that residents will be left without energy
- Technology combination — Suitability of technology to be combined with other solutions
- Operational risk — Control, maintenance and security considerations
- Future proofing of technology — Suitability of technology for future CO_2 abatement
- Spatial requirements — Consideration of onsite space requirements
- Site applicability — Additional considerations for site

Within the evaluation, a scoring metric has been used for assessing each of the technologies against each of the key criteria based on a scale of 1-5. Where a technology is considered least suitable to the Heygate Masterplan for a particular criteria it is scored 1; where it is most suitable, it is scored 5. The technologies are then ranked with the highest scoring and therefore most suitable technologies at the top of the options appraisal matrix as shown in Table 21.

	Financial implications		Technological risk		Security of supply		Technology combination		Operational risk		Future proofing opportunity		Spatial requirements		Site applicability		Total Score
Gas boiler fuelled with biomethane	May be slight uplift on gas price	3	Biomethane production an emerging technology Supply chain being developed	3	GGCS	5	Standby capacity meets peak demand	5	Minimal. as standard gas technology	5	Could be fuelled from hydrogen	4	No additional space requirements and no major renovations required	5	Highly applicable as standby/peak heating provision	5	35
Gas CHP fuelled with biomethane	May be slight uplift on gas price Electricity sale revenue stream	4	Biomethane production an emerging technology Supply chain being developed	3	GGCS	5	Conflicts with biomass technologies for providing baseline thermal demand	2	Increased control requirement	4	Could be fuelled from hydrogen Change to fuel cell CHP	4	Larger footprint area required than gas boiler	4	High associated CO2 achieved	5	31
Solar PV	FIT revenue stream but high capex	2	Possible electrical infrastructure upgrade required	4	Weather dependent – therefore intermittent	3	Competes for roof space with solar thermal	3	Degradation Damage to solar façade	4	Minimal. Expected improvements is in cost reduction rather than increased efficiency	2	South facing unshaded roofs/facades Competes for roof space with building plant	3	Not sufficient roof space available. Will require solar PV facades	3	24
Biomass Boiler	RHI revenue stream	3	Mature technology	5	Frequent fuel deliveries required. Market Maturity	3	Conflicts with CHP technology for providing baseline thermal demand	2	Availability of biomass as market matures in the UK	3	Minimal. Expected improvements is in cost reduction rather than increased efficiency	2	Increased energy centre size due to associated biomass fuel store	3	Increased access requirements, traffic movements and traffic noise	2	23

	Financial implications		Technological risk		Security of supply		Technology combination		Operational risk		Future proofing opportunity		Spatial requirements		Site applicability		Total Score
Solar Thermal	RHI revenue stream	3	Requires hot water storage tank	4	Weather dependent – therefore intermittent	3	Competes for roof space with solar PV. Auxiliary heat source required.	3	Requires hot water storage Damage to solar facade	3	Minimal. Expected improvements is in cost reduction rather than increased efficiency	2	South facing unshaded roofs/facades Internal space for hot water cylinder Competes for roof space with building plant	2	Limited to energy centre roof	2	22
GSHP	RHI revenue but high capex for boreholes	1	High proven efficiencies of 250-400%	5	Low risk due to a stable heating output	5	Auxiliary heat source required	4	Marginal cost/CO_2 savings as electrically driven	2	Minimal. Expected improvements is in cost reduction rather than increased efficiency	2	At least 2 boreholes required per unit, with depths up to several 100m	2	Unsuitable, due to compact nature of site	1	22
ASHP	No boreholes required, reducing costs compared to other heat pump technologies	3	Higher efficiencies than gas or biomass boilers	4	Efficiency and output highly dependent on external air temperature	3	Auxiliary heat source required	4	Output inversely proportional to demand	2	Minimal. Expected improvements is in cost reduction rather than increased efficiency	2	More efficient at lower output temperatures which requires an under-floor heating system rather than radiators.	2	Relatively low output, therefore thermal store required to ensure thermal comfort	2	22
Wind Turbine	FIT revenue stream	3	Possible electrical infrastructure upgrade	3	Weather dependent – therefore intermittent	2	Independent energy system, therefore combines well with other proposed technologies	5	High visual impact Shadow flicker Noise	3	Minimal. Expected improvements is in cost reduction rather than increased efficiency	2	Consideration of topple distance for free standing turbine. Land ownership issues. Roof mounted turbines compete for roof space with building plant	1	Densely populated urban environment	1	20

Table 21 Renewable Energy Options Appraisal Matrix

3.3.10 Recommended Option

From the renewable energy options appraisal matrix, the use of biomethane within both the gas CHP and gas boilers as a renewable fuel source has the highest score and is therefore the recommended renewable energy option for the Heygate Masterplan.[12]

With this option, biomethane will be supplied to the gas CHPs and gas boilers within the Energy Centre through the existing gas network. This arrangement has the least impact on the surrounding area as it simply displaces some of the existing gas supply to the proposed Development, requires no fuel storage, provides no increase in local transportation, is not visually intrusive, minimises impact on air quality, uses standard technology and provides the highest CO_2 savings. It also future proofs the on-site energy generation allowing the incorporation of less disruptive changes to both the fuel supply (e.g. hydrogen injection) and the generating technology (e.g. fuel cell CHP – see Appendix N).

The use of biomethane as a renewable fuel can meet SC's 20% renewable energy target and in doing so provide a reduction in on-site CO_2 emissions of 853 tonnes. This equates to displacing 27% of the Heygate Masterplan site demand for natural gas for the gas CHP and boilers with biomethane. However if all gas required at the Energy Centre is displaced by biomethane as shown in Figure 10, this reduces the regulated emissions to zero and the net CO_2 emissions of the proposed Development to 1,129 tonnes CO_2.

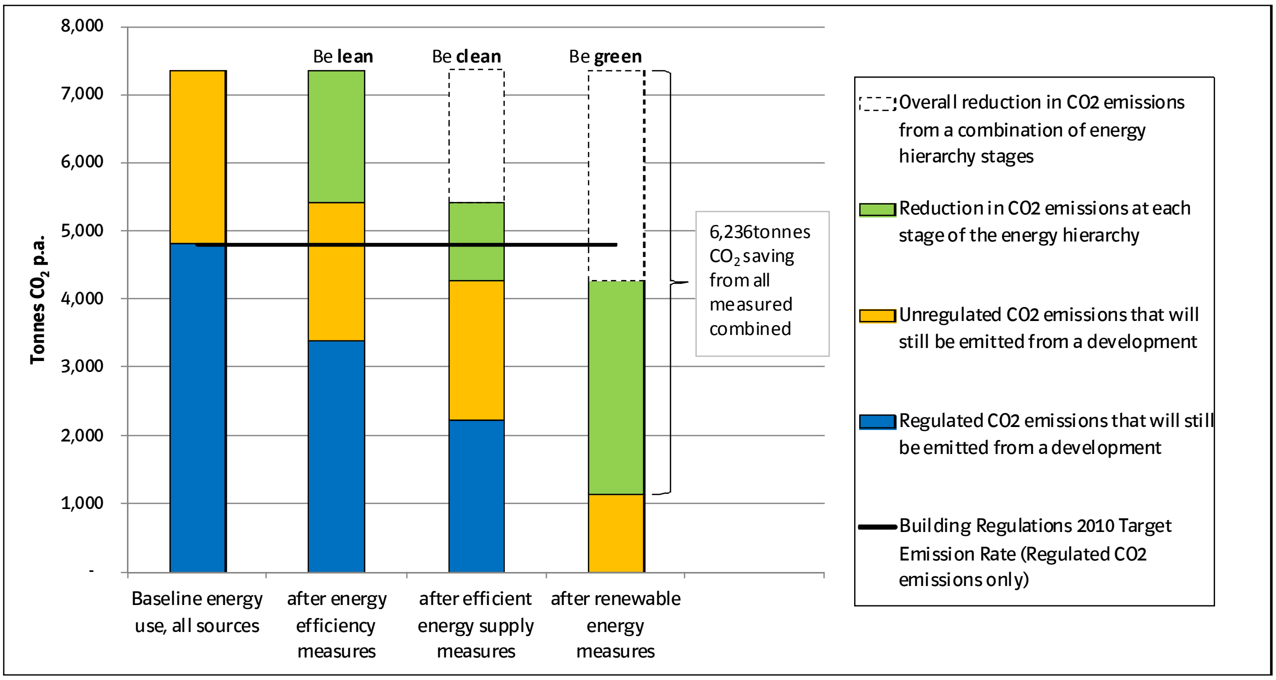


Figure 10 Zero Regulated Emissions

The first demand for biomethane as an Allowable Solution will be on completion of the first ZCH plot H1, which is planned for 2019.

[12] For clarity, the use of biomethane within both gas boilers and gas CHP, is considered as a single renewable energy technology

3.3.11 Plan B

SC has requested that the energy strategy considers potential "Plan B" alternatives to biomethane as it is still to be officially recognised as an Allowable Solution by the UK Government. In the first instance solar PV would be considered as the initial Plan B option, with subsequent consideration of biomass.

Solar PV

The initial estimate is that there is about 25% of the roof area available for roof mounted solar PV, and for this available roof space a 708kW solar PV array could be installed which will generate 518MWh p.a. and provide an annual CO_2 saving against grid imported electricity of 268 tonnes CO_2. For this indicative array size, the investment cost is £8,699/tonnes CO_2. The renewable energy contribution from a roof mounted solar PV array will be 6.3%.

To meet the remainder of SC's 20% onsite renewable energy target (i.e. 13.7%) a 10,333m^2 solar PV façade will be required. This façade area will accommodate a 1.7MW solar PV array which will generate 1,105MWh p.a. and provide an annual CO_2 saving against grid imported electricity of 584 tonnes CO_2. For this indicative array size, the investment cost is £9,800/tonnes CO_2. The availability of this amount of façade area for solar PV façade is unable to be confirmed at this stage and will therefore be considered at the detailed design stage.

Biomass

In order to achieve SC's 20% onsite renewable energy target, 4,612MWh of heat would have to be delivered from biomass boilers rather than gas boilers. However the maximum size of biomass boiler that can be installed alongside the gas CHP units which is technically and commercially viable is a 500kW biomass boiler. This size of boiler would generate 2,604MWh of heat which equates to an annual CO_2 saving of 268 tonnes CO_2 and an 11.3% CO_2 reduction for the proposed Development after efficient energy efficiency measures have taken place. For this boiler size the investment cost is £560/tonnes CO_2.

For the 500kW boiler, the estimated biomass consumption for one year is 542 tonnes. This is equivalent to an average of a 10 tonne delivery of wood pellets nearly every week from a standard 4 axle lorry. It is good practice to have sufficient capacity to store two weeks worth of biomass fuel on the site in case of fuel supply interruption or particularly cold weather increasing consumption. This equates to approximately 40m^3 storage required at the Energy Centre which would require a further 20m^2 of floor area for a typical store height of 2m.

Though the existing Energy Centre could accommodate a 500kW biomass boiler and associated fuel storage as shown in Appendix J, there will be a reduction in the space available for the café and visitor centre or expansion for potential external connections. The design of the Energy Centre will also need to consider the impacts of biomass on air quality, emissions, noise and traffic management safety.

3.3.12 Option Summary

A summary of the cost and CO_2 abatement potential for the biomethane, solar PV and biomass options are shown in Table 22. It can be seen that with a zero marginal installation cost and the ability to achieve the entirety of SC's 20% renewable energy target, biomethane is clearly the most suitable technology option for the Heygate Masterplan.

Renewable Energy Solution	Size (kW)	Marginal Cost (£±20%)	Annual CO_2 abatement potential (tonnes CO_2)	CO_2 reduction after efficient energy supply measures (%)	Marginal Abatement Cost (£/tCO_2)
Biomethane	N/A	None	853	20	Potential uplift in fuel price
Solar PV	708kW	2,300k	268	6.3	8,582
Biomass	500kW	405k	482	11.3	560

Table 22 Renewable Energy Options

Biomethane is the most suitable approach to meeting the renewable and CO_2 abatement objectives of the Heygate Masterplan and therefore is the recommended renewable energy solution. It will deliver on the renewable energy policy and maximises the CO_2 savings with an appropriate level of investment. Biomethane grid injection is recognised by DECC within the RHI scheme, OFGEM regard it as a key performance metric for gas distribution network operators and it is identified as one of the on site technology solutions within the ZCH consultation on Allowable Solutions. It is also estimated that 15% of the UK residential gas demand can be met by biomethane by 2020.[13] Biomethane is also being implemented across other countries as detailed in Appendix M. Lend Lease will seek to work with the GLA, SC and others to locate a biomethane generating plant in London. This could mean that waste from the proposed Development could be used as an energy source. This would also help mitigate the impact of the waste generation in the wider community.

Within a challenging urban environment, even major building design changes may not yield the same environmental improvements as biomethane and, in such circumstances for "Plan B" where the onsite 20% renewable energy target is not feasible to be met by solar PV alone, a combination of solar PV and biomass may be required along with the potential for investment in local renewable energy projects.

[13] The potential for Renewable Gas in the UK, National Grid, January 2009

4 Phasing Strategy

The Energy Centre is proposed to be sited on plot H12 and the phasing allows the development of the DHN to be co-ordinated with the assumed Development phasing. The DHN is, at this stage, illustrative and will be co-ordinated via the detailed design of the Heygate Masterplan. The indicative DHN route from the Energy Centre to each of the Heygate Masterplan plots is shown in Figure 11.

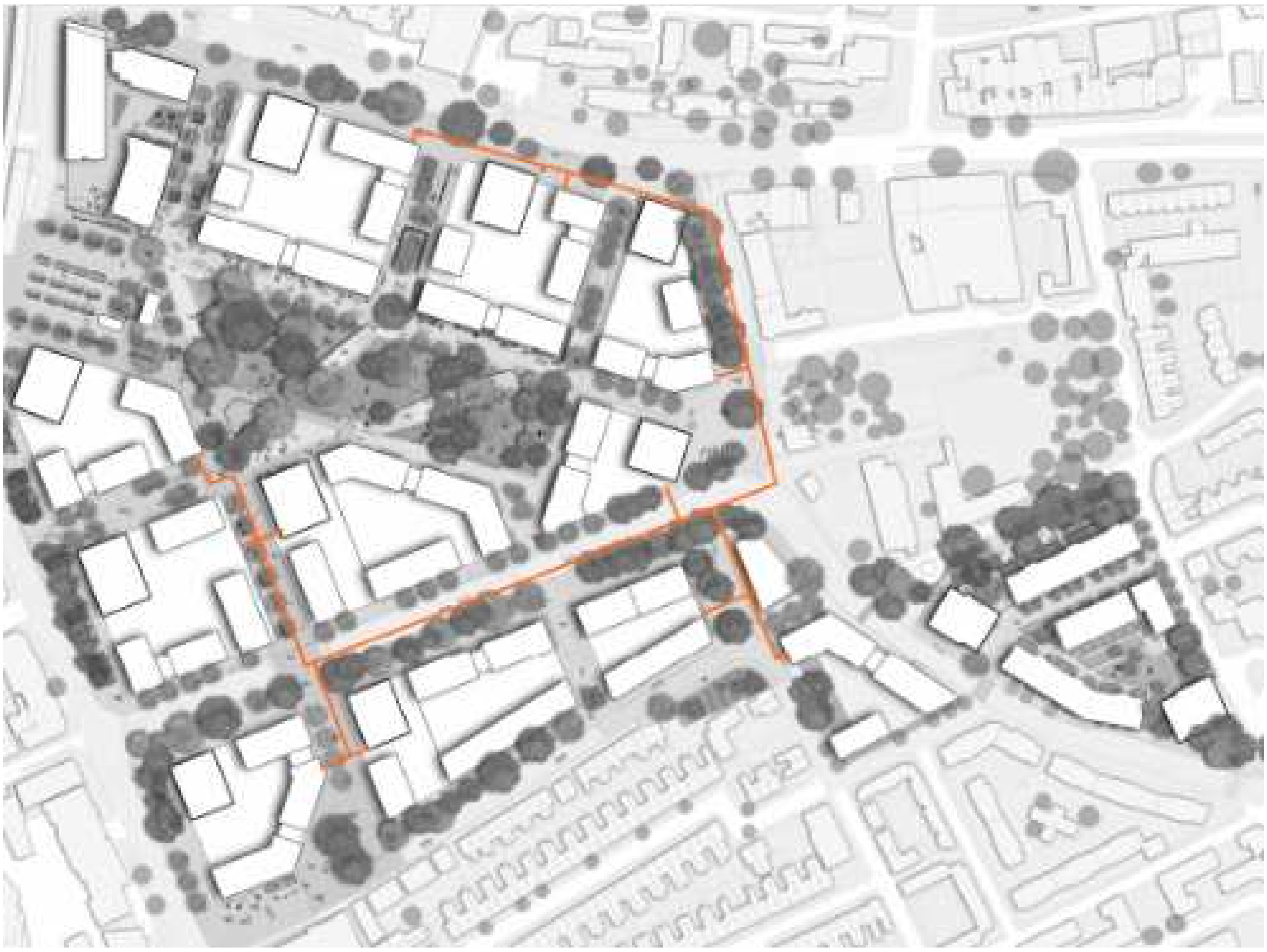


Figure 11 Indicative DHN Route

Initially interim high efficiency gas boilers will be used to supply heat until there is sufficient thermal demand to justify the switching on of the gas CHP for phase 2 in 2019. Similarly, interim gas boilers will provide the thermal demand until the threshold for switching on of the second gas CHP is reached in 2021. Two thermal stores will be utilised to balance and optimise the run hours of both the CHPs. To comply with the renewable energy requirements for the Proposed Development, the intention is that the existing gas CHPs will subsequently be fuelled in part or in total from biomethane. The biomethane forms part of the existing gas supply, in a similar way to green electricity.

CHP 1 will be switched on during 2019 at completion of the second phase of the Heygate Masterplan when 605 (25%) properties are completed. CHP 2 will be switched on during 2021 at completion of Phase 3 when 1,222 (50%) of properties are completed. If, however there is an increase in the thermal demand due to other developments connecting to the DHN (e.g. Phase 1 of the Heygate Regeneration), then this is likely to enable CHP 1 to be switched on earlier than 2019.

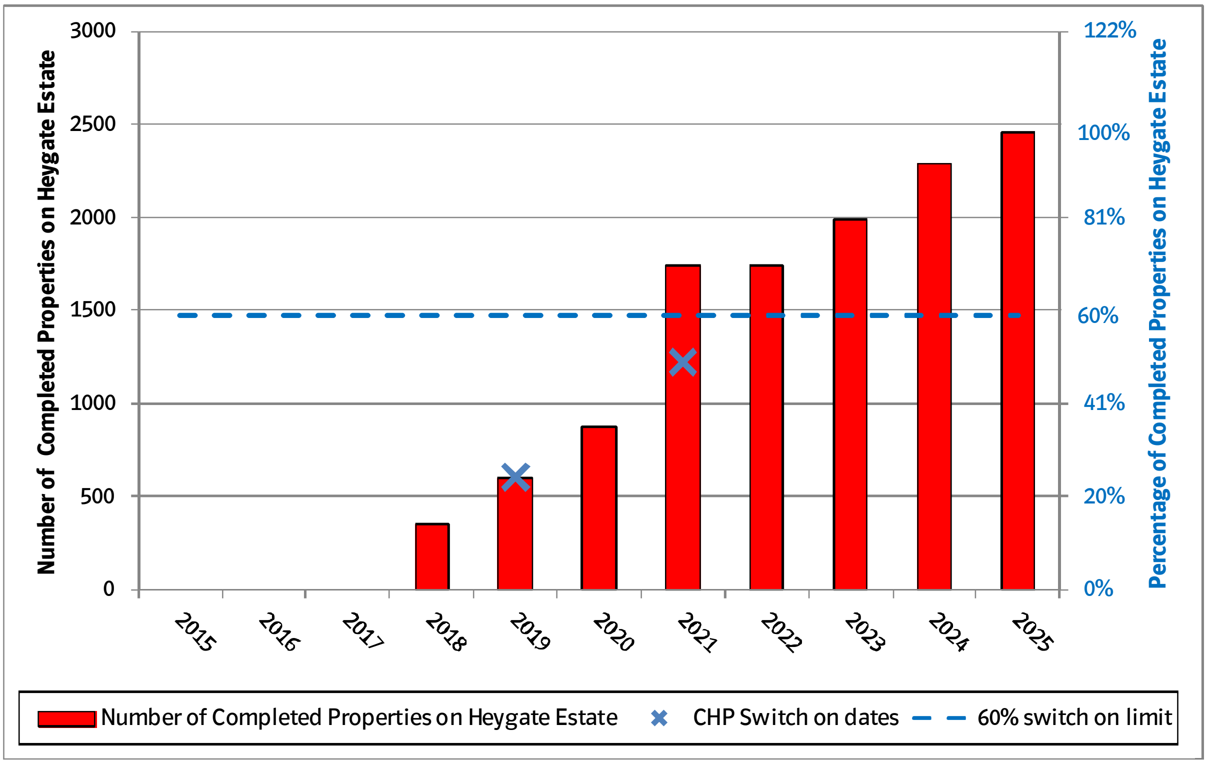


Figure 12 CHP Phasing

The full phasing of the plots along with the associated property numbers, heat and electrical demand and CO_2 emissions can be seen in Appendix E. This table includes the energy demand and CO_2 emissions from both regulated and unregulated energy consumption.

Within the Energy Centre, as the thermal generation is based on a gaseous fuel, the intention is that future changes to the fuel type (i.e. from natural gas to biomethane) will not require any additional plant. Future changes to the generating plant (e.g. from gas CHP to fuel cell CHP) can be accommodated within the existing footprint area and be incorporated through the planned plant replacement schedule.

5 Compliance

The relevant national, regional and local policies applicable to the Heygate Masterplan are as stated in Section 2. Compliance with the relevant policies for the proposed Development is demonstrated in this section.[14]

Within the policy measures described in Section 2 there are multiple targets and reporting requirements concerned with CO_2 emissions.

Many of these, for example the CSH and ZCH, are targets based only on regulated emissions. That is, emissions from:

- Space heating
- Hot water
- Lighting
- Pumps and fans

Also house builders are only accountable for those emissions that are covered by Building Regulations.[15]

However, a significant proportion of total carbon emissions from a development use can come from unregulated emissions. That is, emissions from:

- Plug in appliances (computers, televisions, lamps etc)
- Cooking (gas or electric)

Therefore, where required, this strategy demonstrates compliance to all emissions targets both regulated and non-regulated.

5.1 CSH Level 4

In order to meet the national criteria for planning, properties which are due to start on site prior to 2016 must meet the mandatory CO_2 reduction requirements for CSH4. This is a 25% reduction in regulated CO_2 emissions against a baseline of Building Regulations 2010.[16]

The space heating demand for the baseline case was calculated using internal modelling of Building Regulations 2010 and both the baseline and the 'as designed' cases account for only regulated emissions as stated in the CSH Technical Guidance November 2010. As shown in Figure 13, the residential properties achieve a 42% reduction in CO_2 emissions from the 2010 Building Regulations baseline demonstrating compliance with the CSH4 mandatory CO_2 reduction requirements.

[14] All of the compliance carbon calculations include for 5% heat loss as per the SAP2009 calculation methodology, however for plant sizing we have increased this to 20% heat losses as our experience shows that this is a more realistic figure.
[15] HM Treasury & BIS Plan for Growth, March 2011.
[16] Previously 44% against a baseline of Building Regulations 2006 – see Appendix B for rebasing explanation.

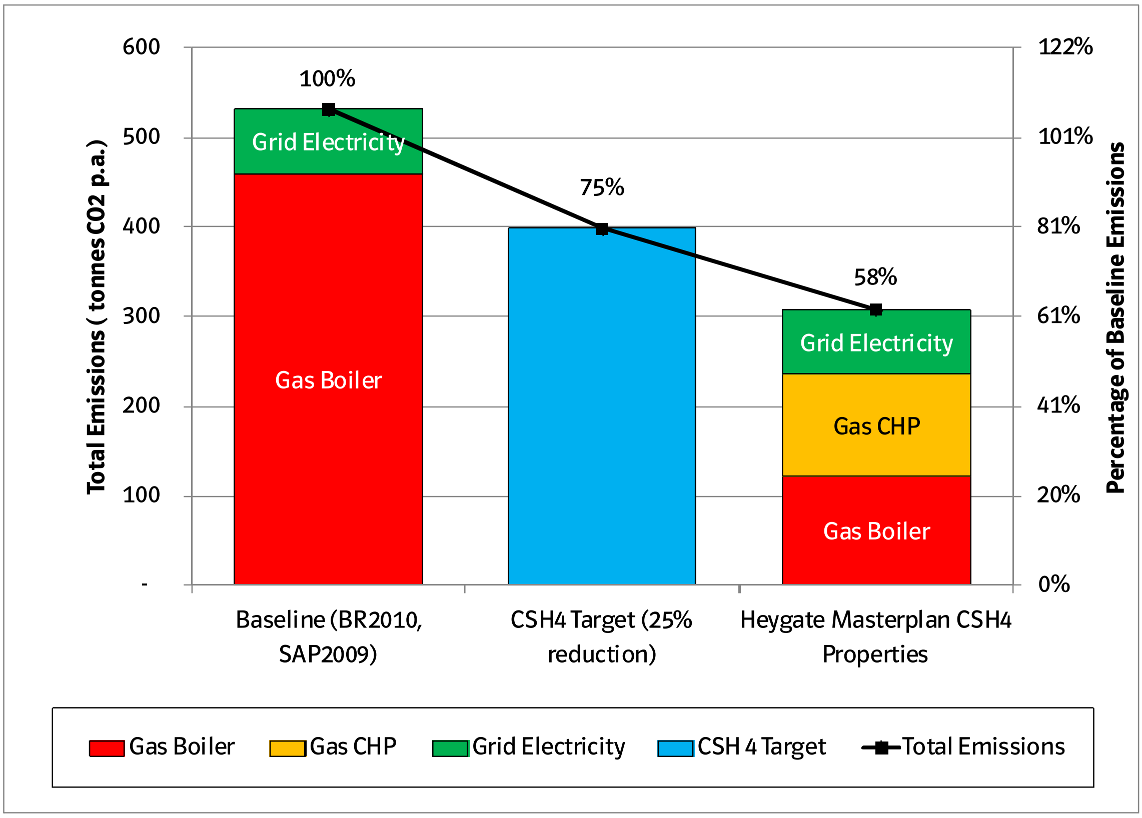


Figure 13 CSH Level 4 Compliance

5.2 Zero Carbon Homes

It is anticipated that Building Regulations 2016 will include the recommendations from the Zero Carbon Hub for ZCH in that a limit is set of the maximum amount of CO_2 that can be emitted from a ZCH.

For the low rise residential buildings (fewer than five storeys), the present guidance is that this will be set at 14 $kgCO_2/m^2$.[17] [18] At present there is no suggested limit for high rise buildings, however following guidance from the Zero Carbon Hub the limit for the Heygate Masterplan for ZCH has been set to 15 $kgCO_2/m^2$.[19]

Also the present guidance allows for the ZCH compliance to be averaged across the Proposed Development:

> "It should not be necessary for each individual dwelling on a development site to achieve the Carbon Compliance limit, so long as the aggregate limit is achieved by the development as a whole."[20]

For example, although the one-bed studio apartments have a Carbon Compliance limit of greater than the 15$kgCO_2/m^2$ limit as shown in Figure 14, the indicative average for the proposed Development is 12.3$kgCO_2/m^2$ demonstrating overall improvement from the guidelines. This may change over the course of the proposed Development dependent on the building mix, but will be no more than 15$kgCO_2/m^2$. As for the CSH, and in line with the latest guidance from the ZCH, this absolute target is only applied to regulated emissions. The allowable solutions payment also only covers regulated emissions.

[17] This is based on the internal floor area.
[18] As a comparison, figures for a detached house are 10 $kgCO_2/m^2$ and both semi-detached and terraced housing are 11 $kgCO_2/m^2$.
[19] This needs to be confirmed by /GLA.
[20] Carbon Compliance – Setting an Appropriate Limit for Zero Carbon New Homes, Zero Carbon Hub, February 2011.

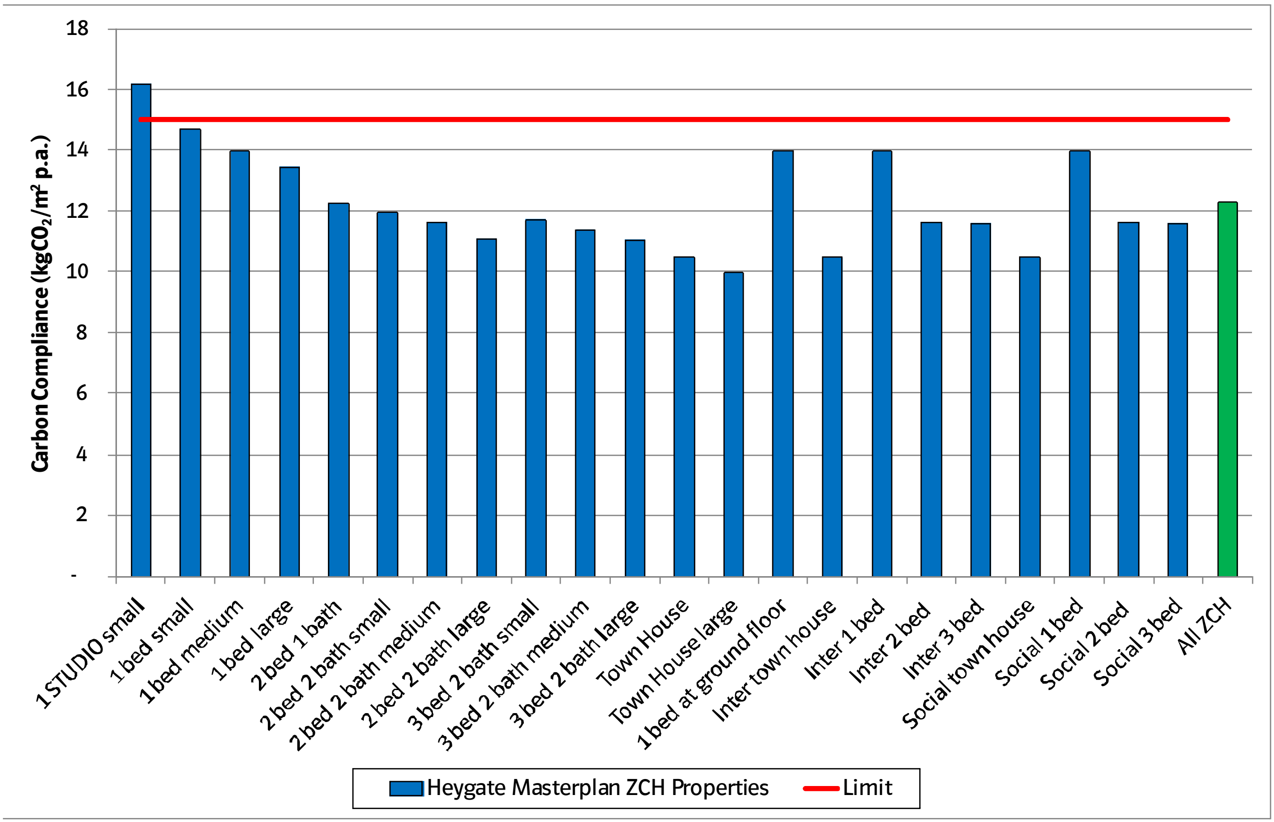


Figure 14 Zero Carbon Homes Compliance

5.3 Allowable Solutions

Allowable Solutions, as described within the Zero Carbon Hierarchy in Section 2.1, accounts for measures that will be available to developers to mitigate the remaining carbon emissions following the Carbon Compliance phase.[21] Therefore the intention for this proposed Development is to utilise biomethane grid injection linked to the site through the GGCS as the on-site Allowable Solution.

The Allowable Solutions will therefore contribute a maximum of 46% of the regulated CO_2 emissions, whilst the fabric energy efficiency and on-site LZC Heat and Power within the Carbon Compliance phase of the Zero Carbon hierarchy, will contribute 30% and 24% respectively.

5.4 London Plan 2011

As described in Section 2, the London Plan sets specific targets for minimum improvement over the Target Emissions Rate for both residential and non-residential buildings.[22] It also specifies that both energy demand and CO_2 emissions covered by Building Regulations (regulated emissions) and other (non-regulated emissions) should be reported.

Residential

The non-residential targets for the London Plan are as follows:

- 2013-2016 40% reduction based on 2010 Building Regulations
- 2016-2031 Zero Carbon

As was shown in Figure 12, the properties which are due to start on site before 2016 achieve a 40% emissions reduction against a baseline of 2010 Building Regulations.

As demonstrated in Section 5.3, the absolute emission from all properties where building commences after 2016 is 12.3kgCO_2/m^2. Since this is below the allowed limit of 15.0kgCO_2/m^2, these properties comply with the ZCH guidelines.

[21] The proposed Allowable Solutions, have at time of writing, yet to be approved by UK Govt.
[22] Minimising CO2 Emissions, Policy 5.2, London Plan 2011

Non-residential

The non-residential targets for the London Plan are as follows:

- 2013-2016 40% reduction based on 2010 Building Regulations
- 2016-2019 As per building regulation requirements
- 2019-2031 Zero Carbon

Though there is no information available at present about the expected requirements of the 2016 Building Regulations or Zero Carbon guidelines for non-residential buildings, this strategy shows that all non-residential buildings where construction is due to commence prior to 2019, achieve a 40% emissions reduction as shown in Figure 15.

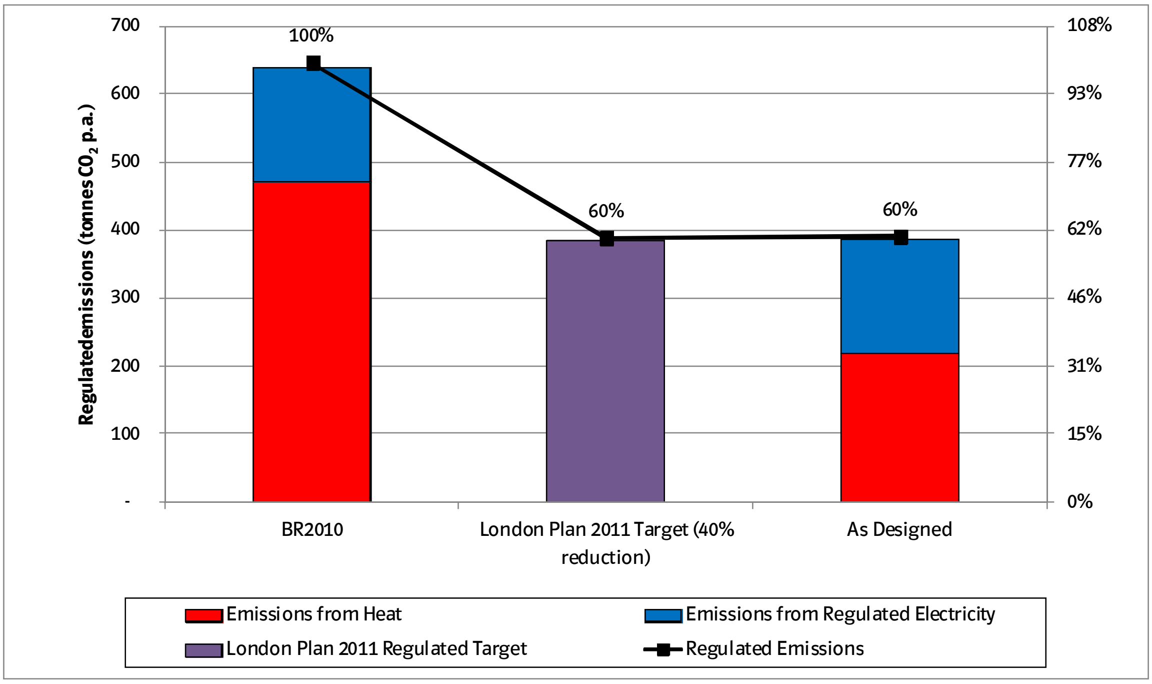


Figure 15 Non-residential Regulated Emissions

Total Site

Policy 5.2 Part D of the London Plan 2011 states that:
"As a minimum, energy assessments should include the following details:

a. Calculation of the energy demand and CO_2 emissions covered by the Building Regulations and, separately, the energy demand and CO_2 emissions from any other part of the development, including plant or equipment, that are not covered by Building Regulations at each stage of the energy hierarchy."

Therefore, Table 23 summarises regulated and non-regulated energy demands and emissions from both residential and non-residential properties within the proposed Development once it is completed.

		Residential	Non-Residential	Total Development
Regulated Energy	MWh p.a.	10,156	3,032	13,188
Non Regulated Energy	MWh p.a.	1,700	2,246	3,946
Total Energy	**MWh p.a.**	**11,856**	**5,278**	**17,134**
Regulated CO_2	tonnes CO_2 p.a.	1,633	594	2,226
Non Regulated CO_2	tonnes CO_2 p.a.	879	1,161	2,040
Total CO_2	**tonnes CO_2 p.a.**	**2,512**	**1,755**	**4,266**

Table 23 CO_2 Emission Summary

5.5 Net Zero Carbon Growth

The existing Heygate Estate on the Application Site contains 1,107 residential units. To achieve the Lend Lease aspirational aim for the Heygate Masterplan of net zero carbon growth, the proposed Development should emit no more CO_2 than these 1,107 flats in operation. The exact nature of the building fabric of the flats is uncertain; therefore we have conservatively modelled them as a 1990 standard building fabric with an average floor area of $80m^2$ for each flat. Compliance with this target is demonstrated in Figure 16, which shows a 32% reduction in emissions from both regulated and unregulated energy use.

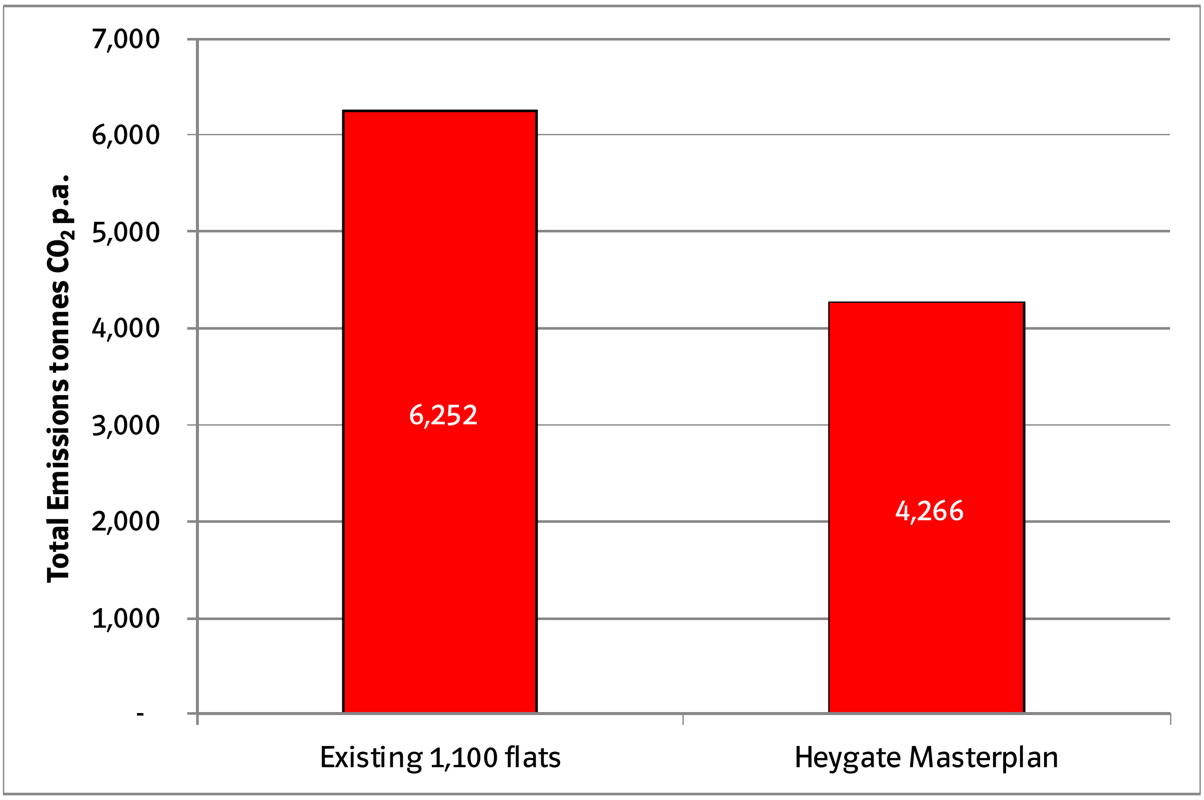


Figure 16 Net Zero Carbon Growth Compliance.

5.6 CO_2 Saving

Only the regulated emissions for residential and non-residential properties need to be reported for Building Regulations in assessing CO_2 savings. Therefore when comparing the centralised gas CHP Energy Centre and DHN proposed in this energy strategy with the same development of properties built to 2010 Building Regulations and individual gas boilers, regulated CO_2 emissions are reduced by 54% from 4,814 tonnes to 2,226 tonnes as shown in Figure 17.

Of this amount, 1,373 tonnes are eligible for Allowable Solutions under the present guidance from the ZCH, as shown in Figure 18. The remaining balance is accounted for by emissions from the pre-zero carbon homes also the non-residential buildings.

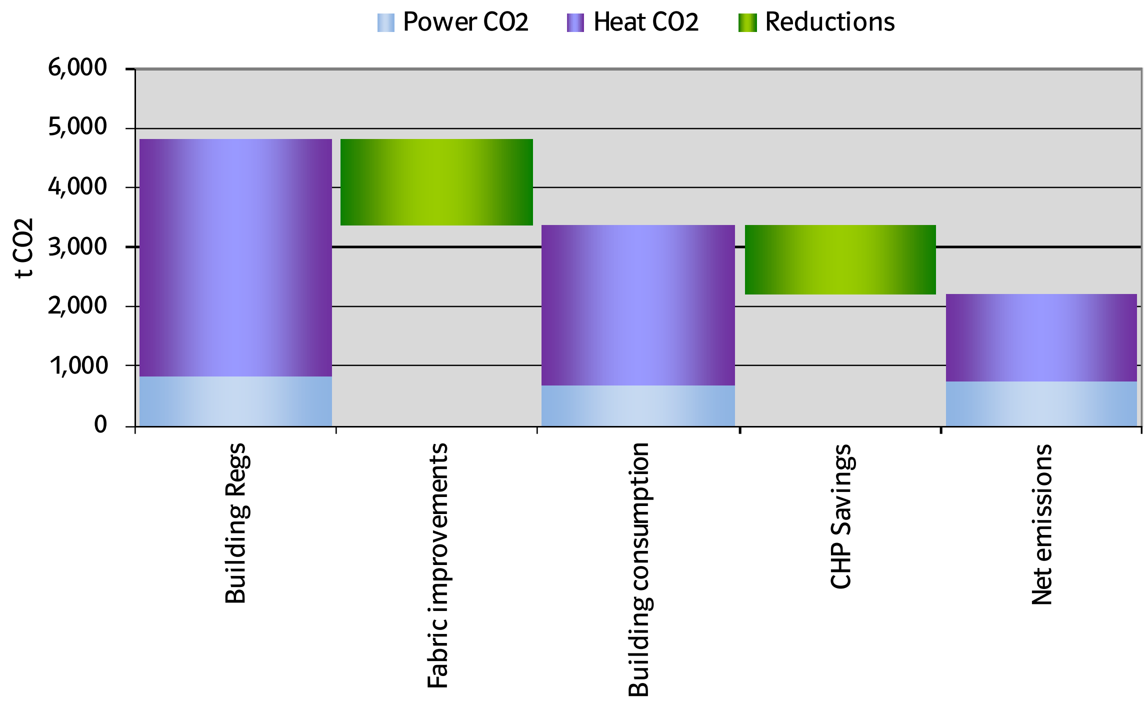


Figure 17 CO_2 savings

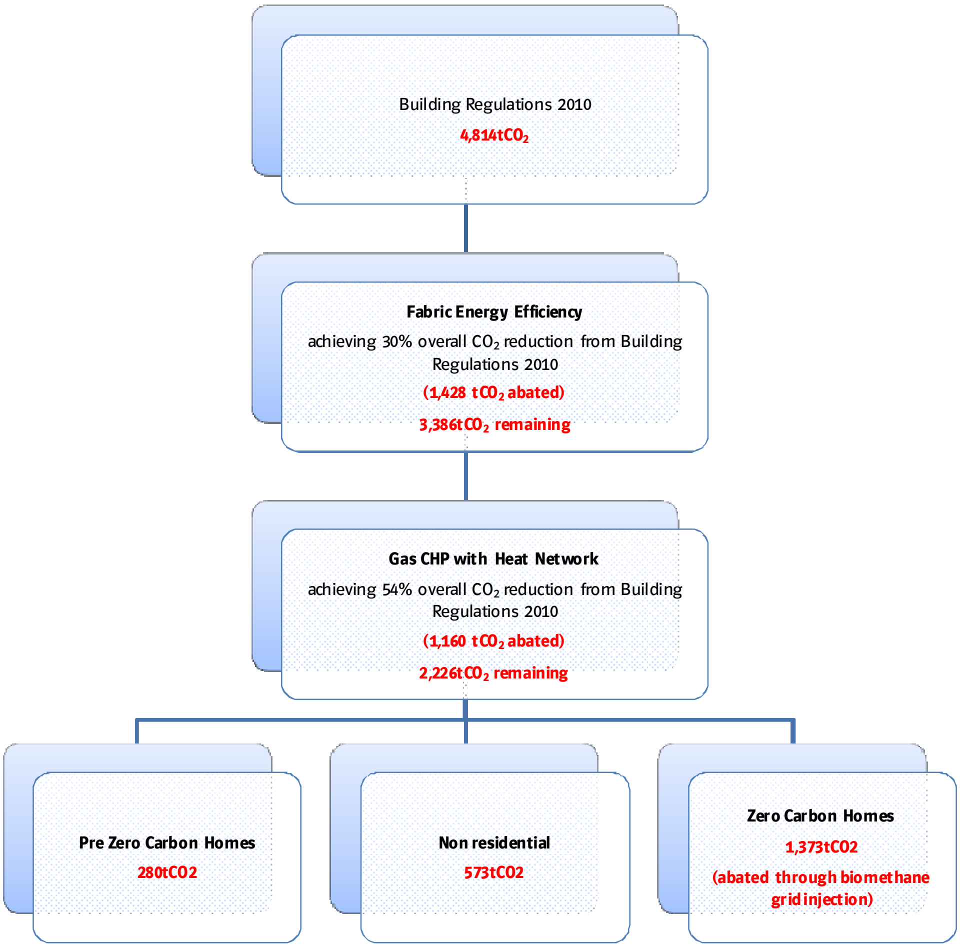


Figure 18 CO_2 savings as per Energy Hierarchy

6 Conclusion

This Energy Strategy shows compliance with current energy-related planning policy from both a national, regional and local perspective for the Heygate Masterplan. In particular the energy strategy complies with the requirements of SC and the London Plan in pursuing a decentralised energy strategy for the Heygate Masterplan, utilising CHP through a DHN.

It is recognised that there will be changes to Building Regulations and other relevant legislation within the build-out of the proposed Development and any material changes which impact on this energy strategy will therefore be accommodated during the detailed design for each phase.

The Energy Centre has been sized to future proof the Heygate Masterplan against not just an increase in thermal demand from opportunities to extend the DHN system beyond the site boundary to adjacent sites, but also through changes to fuel supply and generating technology during the proposed build-out.

The Energy Strategy is based on the energy hierarchy – be lean, be clean, be green approach. This approach ensures that fabric efficiency and energy reduction measures are implemented prior to the installation of onsite or low carbon generation technologies. In turn this minimises the size of the renewable energy provision and therefore provides the foundation for a technically, commercially and environmentally robust energy strategy that is in line with the low/zero carbon regulatory framework of both SC and the GLA.

The energy strategy complies with the requirement from SC that every major development must achieve a reduction in CO_2 of 20% from using on-site or local low and zero carbon sources of energy after both energy efficiency and efficient energy supply measures have been applied.

For the Heygate Masterplan, this renewable energy contribution will be from offsite biomethane injection into the gas grid. It benefits the proposed Development by maximising the carbon savings from an equivalent level of investment, requires no fuel storage, no increases in local transportation, is not visually intrusive, uses standard technology and provides the highest CO_2 savings. It also future proofs the on-site energy generation through any fuel supply and generating technology changes.

If there is any concern over securing biomethane, then the Plan B for the project would be the consideration of roof mounted solar PV. In this circumstance it would not be possible to achieve 20% renewables from PV alone and as such the Energy Centre will have to include biomass boilers. This is considered less than optimal for the proposed Development due to the other environmental impacts caused by biomass.

Planning Policy Document	Policy	Achievement	Compliant?
Southwark Core Strategy	44% saving in CO_2 emissions above the Building Regulations 2010 from energy efficiency, efficient energy supply and renewable energy generation	54% reduction in CO_2 emissions vs. Building Regulations 2010	✓
Southwark Core Strategy	20% of remaining onsite CO_2 demand met by using on-site or local low and zero carbon sources of energy	20% CO_2 saving achievable with biomethane	✓
London Plan 2011 Residential 2013 - 2016	40% reduction in CO_2 emissions vs. Building Regulations 2010	42% reduction in CO_2 emissions vs. Building Regulations 2010	✓
London Plan 2011 Residential 2016-2031	Zero Carbon	Comply with ZCH Guidance	✓
London Plan 2011 Non-residential 2013-2019	40% reduction in CO_2 emissions vs. Building Regulations 2010	40% reduction in CO_2 emissions vs. Building Regulations 2010	✓
Code for Sustainable Homes	25% reduction in CO_2 emissions vs. Building Regulations 2010 for properties built to CSH Level 4	42% reduction in CO_2 emissions vs. Building Regulations 2010	✓
Zero Carbon Homes (post 2016)	Carbon Compliance limit of 15.0 $kgCO_2/m^2$ per year	Carbon Compliance of 12.3 $kgCO_2/m^2$ per year	✓
Net Zero Carbon Growth	Development to emit no more CO_2 than the existing 1,107 homes on the site	32% CO_2 saving achieved	✓

Table 24 Compliance Summary

Appendix A Assumptions

Residential Properties

- The number and size of properties was taken from the residential yield schedule – maximum parameters.
- Gross internal area of the properties was taken from the Illustrative Masterplan.
- The space heat energy demand for residential properties is in line with the guidelines of the CSH and the Zero Carbon Hub.
- Peak and annual space heating determined from IES modelling.
- Peak and annual domestic hot water benchmark data determined from BSRIA and Plumbing Engineering Services Design Guides.

Property Type	Space Heating CSH4 Properties (kWh/m^2)	Space Heating ZCH Properties (kWh/m^2)	Domestic Hot Water (kWh/m^2)	Space Heating CSH4 Properties (W/m^2)	Space Heating ZCH Properties (W/m^2)	Domestic Hot Water (W/m^2)
1 studio small	42	28	48	44	36	35
1 bed small	42	28	39	44	36	35
1 bed medium	42	28	36	44	36	35
1 bed large	42	28	32	44	36	35
2 bed 1 bath	37	21	35	41	29	40
2 bed 2 bath small	37	21	33	41	29	40
2 bed 2 bath medium	37	21	31	41	29	40
2 bed 2 bath large	37	21	28	41	29	40
3 bed 2 bath small	38	22	30	43	30	40
3 bed 2 bath medium	38	22	28	43	30	40
3 bed 2 bath large	38	22	26	43	30	40
Town House	38	22	23	43	30	40
Town House large	38	22	20	43	30	40
1 bed at ground floor	42	28	36	44	36	35
Inter town house	38	22	23	43	30	40
Inter 1 bed	42	28	36	44	36	35
Inter 2 bed	37	21	31	41	29	40
Inter 3 bed	38	22	29	43	30	40
Social town house	38	22	23	43	30	40
Social 1 bed	42	28	36	44	36	35
Social 2 bed	37	21	31	41	29	40
Social 3 bed	38	22	29	43	30	40

Table 25 Residential Properties Assumptions

- The hot water strategy has been assumed to be instantaneous hot water.
- The space heating and hot water usage patterns have been calculated using internal profiles based on property type and occupation demographic.
- Diversification factors based on S-Curve analysis for heating and hot water have been applied to the residential areas of the Proposed Development.

Non-Residential Properties

- The gross external floor areas were taken from the Illustrative Masterplan non-residential yield schedule
- A factor of 99% was assumed to calculate the gross internal floor area
- BSRIA Blue Book 2011 and CIBSE TM46 2008 Benchmarks were used for the commercial properties.
- The benchmarks have been reduced by an aggregate 32% to allow for the 2013 Building regulations update and a further 25% for the 2016 Building Regulations update.

Land Use Class	Thermal Demand (kWh/m^2)	Electrical Demand (kWh/m^2)	Space Heating (W/m^2)	Domestic Hot Water (W/m^2)
A1-A5: Retail & cafe/ restaurant 2010	82	118	100	35
B1: Business 2010	82	86	70	32
D2: Leisure 2010	286	135	100	3.4
D1: Community 2010	72	36	100	3.4
SG: Energy Centre & ancillary visitors/cafe 2010	82	118	100	35
A1-A5: Retail & cafe/ restaurant 2019	62	106	100	35
B1: Business 2019	62	77	70	32
D2: Leisure 2019	214	122	100	3.4
D1: Community 2019	53	32	100	3.4
SG: Energy Centre & ancillary visitors/cafe 2019	62	106	100	35

Table 26 Non residential Properties Assumptions

CO_2 emission factors

SAP (2009) CO2 emission factors have been used for CSH4 compliance and carbon reduction calculations[23]

- 0.517 $kgCO_2/kWh$ imported electricity
- -0.529 $kgCO_2/kWh$ exported electricity
- -0.529 $kgCO_2/kWh$ onsite generated electricity
- 0.198 $kgCO_2/kWh$ natural gas
- 0.013 $kgCO_2/kWh$ heat from boilers – biomass (Community heating schemes)
- 0.049 $kgCO_2/kWh$ biomethane gas (TBC)

SAP (2009) CO_2 emission factors rebased to 2016 have been used for ZCH compliance calculations[24]

- 0.527 $kgCO_2/kWh$ imported electricity
- -0.527 $kgCO_2/kWh$ exported electricity
- -0.527 $kgCO_2/kWh$ onsite generated electricity
- 0.227 $kgCO_2/kWh$ natural gas

[23] Table 12 SAP2009, BRE, May 2010
[24] Modelling 2016 using SAP 2009 – Technical Guide, Zero Carbon Hub, March 2011

Appendix B Rebasing targets to Building Regulations 2010

The 2010 edition of Part L1a Conservation of fuel and power in new dwellings states that: [25]
"The annual CO_2 emission rate of the completed dwelling is now calculated using SAP2009 and must not exceed the target set by reference to a notional dwelling with an additional overall improvement of 25% relative to 2006 standards."

This overall approach allows all targets previously quoted against 2006 Building Regulations to be rebased to 2010 Building Regulations by applying a 25% overall improvement in the annual CO_2 emissions.

For example, CSH Level 4 has a requirement of 44% CO_2 saving on 2006 Building Regulations which equates to a 25% saving on 2010 Building Regulations. An example where a building built to 2006 Building Regulations has emissions of 100kgCO_2 p.a. is shown in Figure 19.

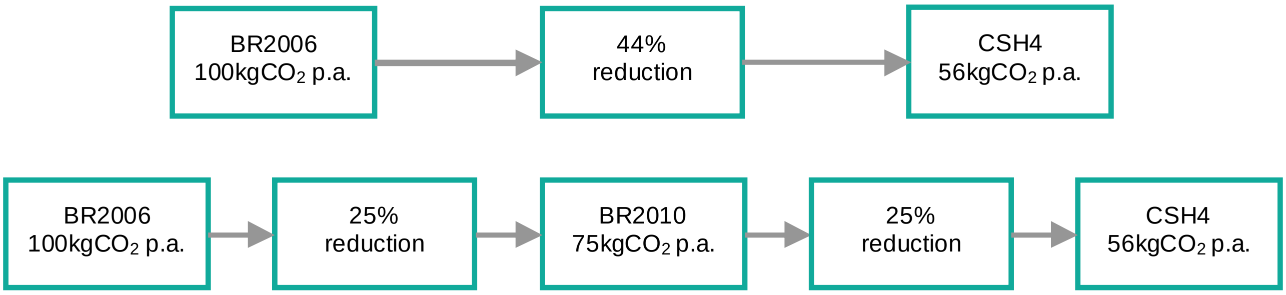


Figure 19 Rebasing Targets to BR2010

A summary of the key policy targets applicable to the Heygate Masterplan rebased to 2010 Building Regulations can be seen in Table 27.

Policy	Years of Effect	Mandatory CO_2 Reduction from 2006 Building Regulations	Mandatory CO_2 Reduction from 2010 Building Regulations
CSH Level 3	2010 – 2013	25%	0%
CSH Level 4	2013 – 2016	44%	25%
London Plan 2011	2010 – 2013	44%	25%
London Plan 2011	2013 – 2016	55%	40%

Table 27 Policy Targets rebased to BR2010

[25] HM Government, The Building Regulations 2000 Conservation of fuel and power, 2010 edition

Appendix C SAP Checklist

Regulations Compliance Report

Approved Document L1A 2010 edition assessed by Stroma FSAP 2009 program, Version: 1.4.0.54
Printed on 27 February 2012 at 08:53:46

Project Information:

Assessed By:	()	**Building Type:**	Enclosed end Flat

Dwelling Details:

NEW DWELLING DESIGN STAGE

Site Reference :	Compliant 2 Bed Unit Type A	**Plot Reference:**	Compliant 2 Bed Unit Type A
Address :	Wallace Whittle Ltd, 18 Buckingham Gate, LONDON, SW1E 6LB		

Client Details:

Name:
Address :

This report covers items included within the SAP calculations.
It is not a complete report of regulations compliance.

1 TER and DER

Fuel for main heating system:		
Target Carbon Dioxide Emission Rate (TER)	15.89 kg/m²	
Dwelling Carbon Dioxide Emission Rate (DER)	11.18 kg/m²	OK

2 Fabric U-values

Element	Average	Highest	
External wall	0.10 (max. 0.30)	0.10 (max. 0.70)	OK
Party wall	0.00 (max. 0.20)	-	OK
Floor	(no floor)		
Roof	0.00 (max. 0.20)	0.00 (max. 0.35)	OK
Openings	0.80 (max. 2.00)	0.80 (max. 3.30)	OK

3 Design air permeability

Design air permeability at 50 pascals	3.00	
Maximum	10.0	OK

DRAFT

4 Heating efficiency

Main Heating system:	Community heating schemes - mains gas
Secondary heating system:	None

5 Cylinder insulation

Hot water Storage:	No cylinder

6 Controls

Space heating controls	Charging system linked to use of community heating, programmer and TRVs	OK
Hot water controls:	No cylinder	

7 Low energy lights

Percentage of fixed lights with low-energy fittings	100.0%	
Minimum	75.0%	OK

8 Mechanical ventilation

Continuous supply and extract system	
Specific fan power:	0.4

Regulations Compliance Report

Maximum	1.5	OK
MVHR efficiency:	90%	
Minimum	70%	OK
9 Summertime temperature		
Overheating risk (South England):	Not assessed	?
10 Key features		
Design air permeablility	3.0 m³/m²h	
Windows U-value	0.8 W/m²K	
External Walls U-value	0.1 W/m²K	
Community heating, heat from boilers – mains gas		

DRAFT

Stroma FSAP 2009 Version: 1.4.0.54 (SAP 9.90) - http://www.stroma.com Page 2 of 2

Figure 20 SAP Checklist

Appendix D IES Modelling

Best practice dynamic thermal simulation modelling (IES) has been used to determine the predicted annual space heating demand and electrical energy demand based on the proposed design criteria. The output from this modelling is shown below in graphical form:

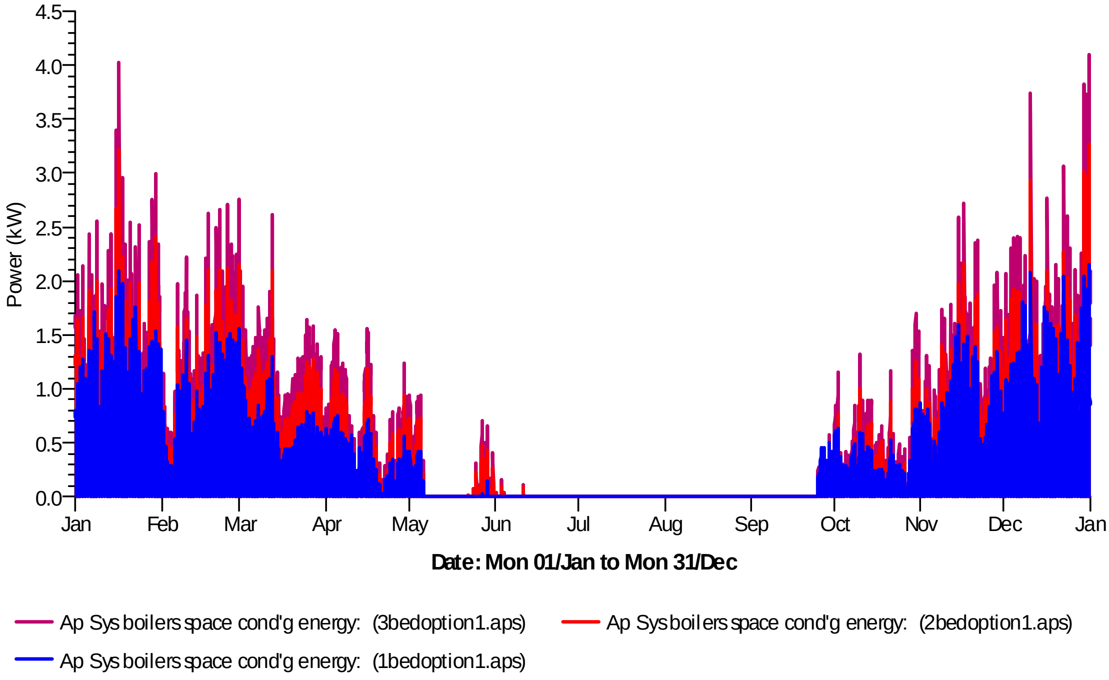


Figure21 Predicted annual space heating demand for 1 to 3 bedroom apartments – Up to 2016

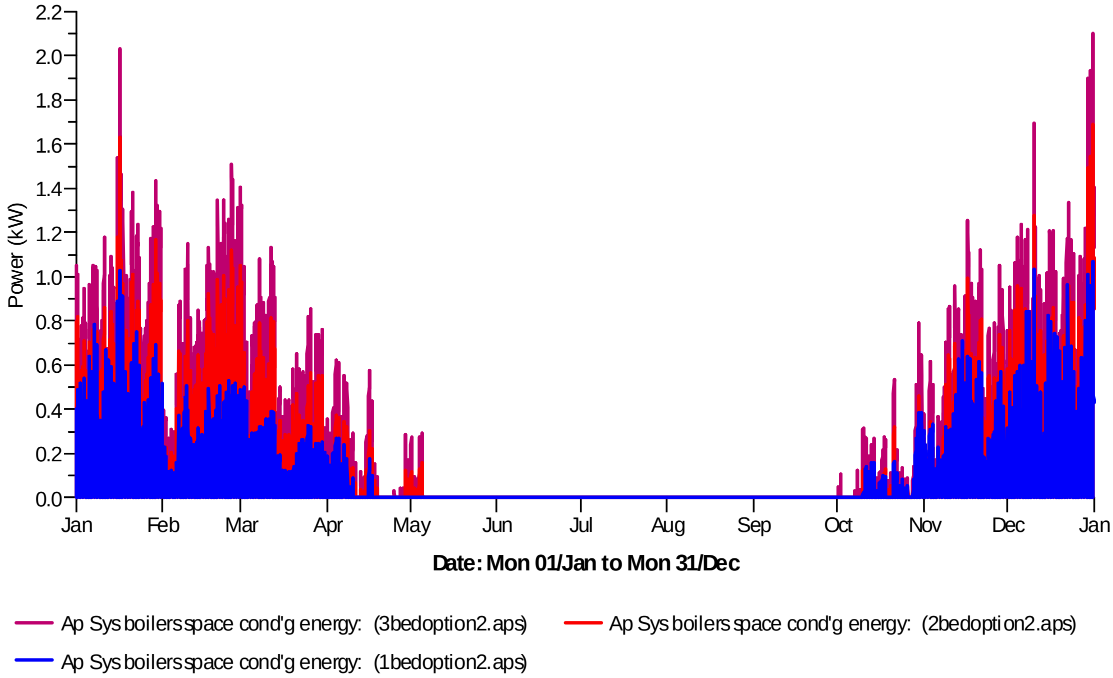
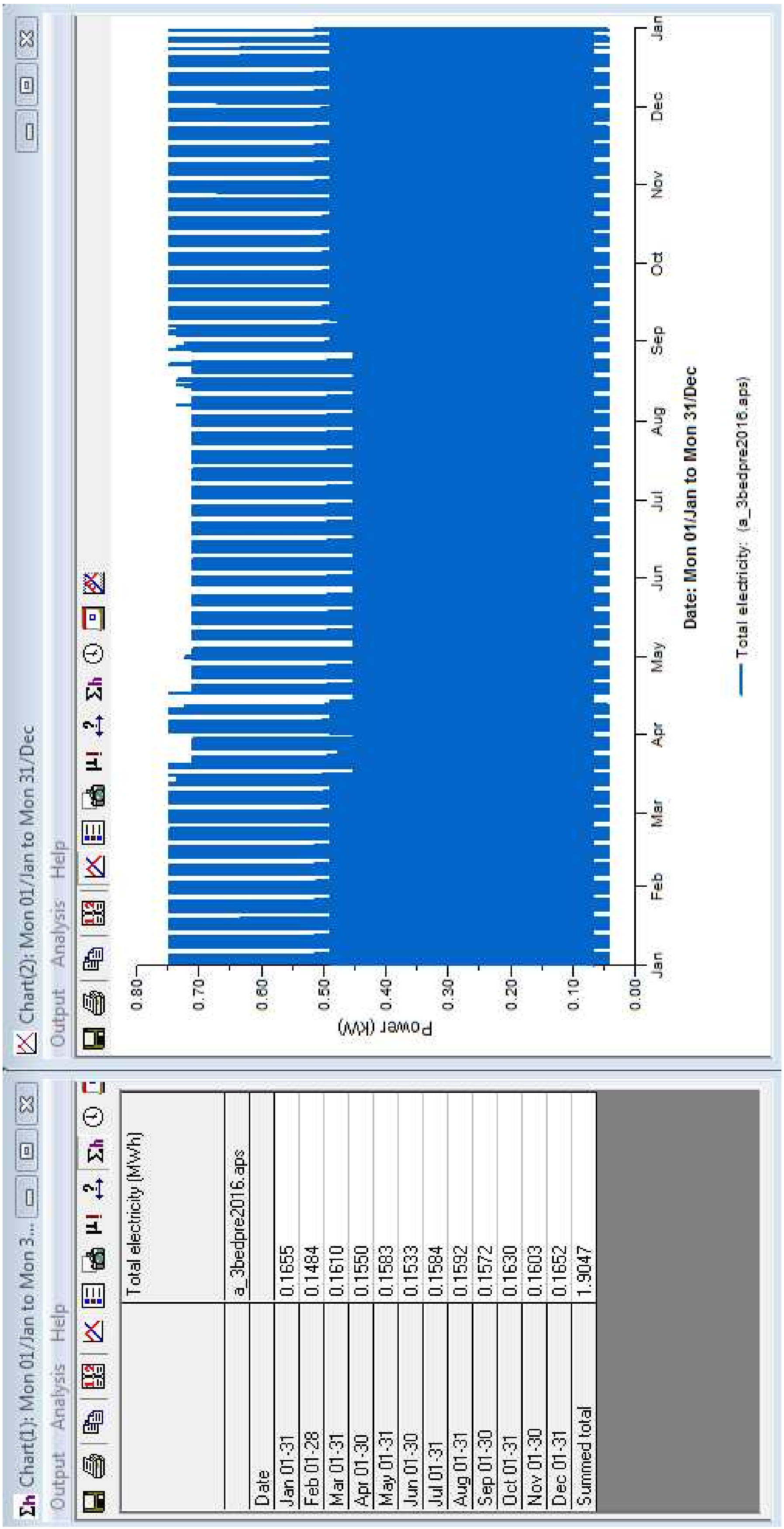
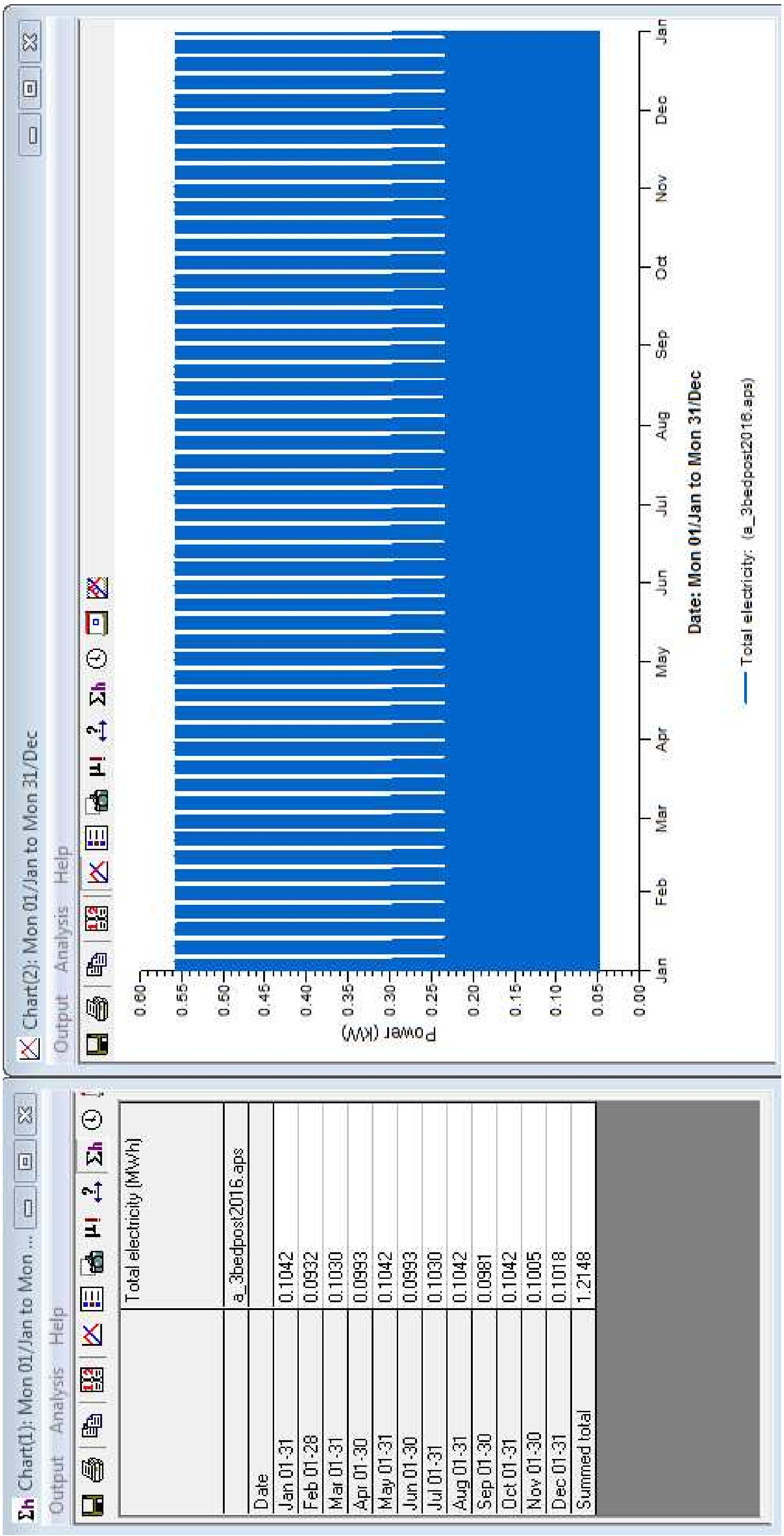


Figure 22 Predicted annual space heating demand for 1 to 3 bedroom apartment – Post 2016



Date	Total electricity (MWh) a_3bedpre2016.aps
Jan 01-31	0.1655
Feb 01-28	0.1484
Mar 01-31	0.1610
Apr 01-30	0.1550
May 01-31	0.1583
Jun 01-30	0.1533
Jul 01-31	0.1584
Aug 01-31	0.1592
Sep 01-30	0.1572
Oct 01-31	0.1630
Nov 01-30	0.1603
Dec 01-31	0.1652
Summed total	1.9047

Figure 23 Predicted annual electrical demand for 3 bedroom apartment – Up to 2016



Date	Total electricity (MWh) a_3bedpost2016.aps
Jan 01-31	0.1042
Feb 01-28	0.0932
Mar 01-31	0.1030
Apr 01-30	0.0993
May 01-31	0.1042
Jun 01-30	0.0993
Jul 01-31	0.1030
Aug 01-31	0.1042
Sep 01-30	0.0981
Oct 01-31	0.1042
Nov 01-30	0.1005
Dec 01-31	0.1018
Summed total	1.2148

Figure 24 Predicted annual electrical demand for 3 bedroom apartment – Post 2016

Appendix E Phasing Table

Phasing													
Stage	1	2											
Residential Building Standards	CSH4	Zero Carbon Homes											
Non-residential Building Standards	BREEAM "Excellent"				Code for Sustainable Buildings								
Phase	1	2		3			4		5				
Plot	H4	H12	H1	H5	PP	H2	H3	H7	H6	H10	H13	H11a	H11b
Completion Year	2018	2019	2019	2020	2020	2021	2021	2021	2023	2023	2024	2024	2025
Residential Property Numbers													
Number of Residential Properties	349	0	256	270	0	347	176	347	168	75	72	231	171
Cumulative Residential Properties	*349*	*349*	*605*	*875*	*875*	*1,222*	*1,398*	*1,745*	*1,913*	*1,988*	*2,060*	*2,291*	*2,462*
Non-residential Floor Area (m^2 GEA)													
A1-A5: Retail & café/restaurant	4,847	0	1,943	2,938	462	1,753	2,170	1,614	0	0	0	418	0
B1: Business	773	0	688	1,271	0	569	884	0	0	0	0	803	0
D2: Leisure	2,814	0	0	0	0	0	0	0	0	0	0	0	0
D1: Community	0	0	0	0	0	0	0	0	2,401	0	0	0	0
SG: Energy Centre & ancillary visitors/cafe	0	729	0	0	0	0	0	0	0	0	0	0	0
Non-residential floor area (m^2 GEA)	8,434	729	2,631	4,209	462	2,322	3,054	1,614	2,401	0	0	1,221	0
Cumulative non-residential floor area (m^2 GEA)	*8,434*	*9,163*	*11,794*	*16,003*	*16,465*	*18,787*	*21,841*	*23,455*	*25,856*	*25,856*	*25,856*	*27,077*	*27,077*
Heat Demand (MWh p.a.)													
Residential Units	1,568	0	926	979	0	1,210	637	1,302	644	300	280	816	612
Non-residential Units	1,253	20	213	341	37	143	188	99	126	0	0	75	0
Total (MWh)	**2,820**	**20**	**1,139**	**1,320**	**37**	**1,353**	**825**	**1,401**	**770**	**300**	**280**	**891**	**612**
Cumulative thermal demand (MWh)	*2,820*	*2,840*	*3,979*	*5,300*	*5,337*	*6,690*	*7,514*	*8,916*	*9,685*	*9,985*	*10,265*	*11,156*	*11,768*
Electricity Demand (MWh p.a.)													
Residential Regulated	*141*	*0*	*76*	*81*	*0*	*97*	*53*	*112*	*57*	*27*	*25*	*68*	*51*
Residential un-regulated	*354*	*0*	*162*	*172*	*0*	*205*	*112*	*232*	*115*	*54*	*51*	*138*	*106*
Residential total	494	0	238	252	0	302	165	343	172	81	76	206	157
Non-residential Regulated	*841*	*71*	*233*	*368*	*45*	*204*	*264*	*153*	*53*	*0*	*0*	*93*	*0*
Non-residential un-regualted	*167*	*14*	*52*	*83*	*9*	*23*	*30*	*16*	*24*	*0*	*0*	*12*	*0*
Non-residential total	1,008	85	285	451	54	227	295	169	77	0	0	105	0
Heat Distribution	30	0	12	14	0	14	9	15	8	3	3	9	6
Total (MWh)	**1,531**	**85**	**535**	**717**	**54**	**543**	**468**	**527**	**258**	**84**	**79**	**320**	**164**
Cumulative electrical demand (MWh)	*1,531*	*1,617*	*2,152*	*2,869*	*2,924*	*3,467*	*3,935*	*4,462*	*4,719*	*4,804*	*4,883*	*5,202*	*5,366*
Emissions (tonnes CO_2 p.a.)													
Heat	358	3	144	167	5	172	105	178	98	38	36	113	78
Cumulative Heat	*358*	*360*	*505*	*672*	*677*	*848*	*953*	*1,130*	*1,228*	*1,266*	*1,301*	*1,414*	*1,492*
Electricity	792	44	277	371	28	281	242	273	133	44	41	165	85
Cumulative Electricity	*792*	*836*	*1,113*	*1,483*	*1,512*	*1,792*	*2,034*	*2,307*	*2,440*	*2,484*	*2,524*	*2,690*	*2,774*
Total (tonnes CO_2 p.a.)	**1,149**	**47**	**421**	**538**	**33**	**452**	**346**	**450**	**231**	**82**	**76**	**278**	**162**
Cumulative CO_2 per plot	*1,149*	*1,196*	*1,617*	*2,155*	*2,188*	*2,640*	*2,987*	*3,437*	*3,668*	*3,749*	*3,826*	*4,104*	*4,266*

Table 28 Indicative Plot Phasing Summary

Appendix F Plant Operation

Phases Completed		1	2	3	4	5
No. of residential properties		349	256	617	523	717
First Year of Operation		2018	2019	2021		
Development Demand						
Development heat demand	MWh p.a.	3,525	4,974	8,362	11,144	14,710
Development electrical demand	MWh p.a.	1,671	2,206	3,467	4,462	5,366
CHP Details						
Total CHP installed capacity	kW_{th}		263	1,248	1,248	1,248
CHP 1 capacity	kW_{th}		263	263	263	263
CHP 1 annual operating hours	hrs p.a.		6,727	7,555	7,774	7,940
CHP 1 electrical generation	MWh p.a.		1,110	1,247	1,283	1,310
CHP 1 useful heat supply	MWh p.a.		1,769	1,987	2,045	2,088
CHP 1 gas consumption	MWh p.a.		3,902	4,382	4,509	4,605
Number of CHP 1 starts per year			96	21	14	7
CHP 2 capacity	kW_{th}		0	985	985	985
CHP 2 annual operating hours	hrs p.a.		0	4,690	5,329	5,805
CHP 2 electrical generation	MWh p.a.		0	3,794	4,309	4,696
CHP 2 useful heat supply	MWh p.a.		0	4,619	5,247	5,718
CHP 2 gas consumption	MWh p.a.		0	10,285	11,682	12,731
Number of CHP 2 starts per year			0	135	88	73
Auxiliary Plant Details						
Boiler heat supplied	MWh p.a.	3,525	3,205	1,756	3,853	6,903
Boiler gas consumption	MWh p.a.	4,147	3,771	2,066	4,533	8,122
Thermal Store 1 Capacity	m^3	0	30	30	30	30
Thermal Store 2 Capacity	m^3	0	0	100	100	100

Table 29 Plant Operation

Appendix G Thermal Demand Profiling

The CHP sizing and operation modelling was carried out based on the thermal demand for the Proposed Development with the CHP units being run heat led to ensure efficient operation with no heat dumping in order to ensure CHPQA Good Quality status.

Phase 1 of the Heygate Masterplan

Over the entire year, the average hourly demand for each hour of each month is shown in Figure 25.

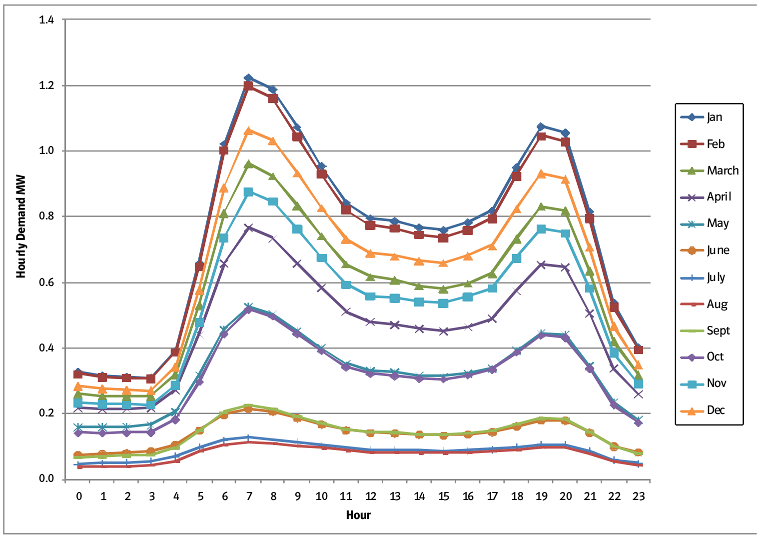


Figure 25 Phase 1 Average Hourly Demand per Month

An example of an individual daily profile, 1st January is shown in Figure 26.

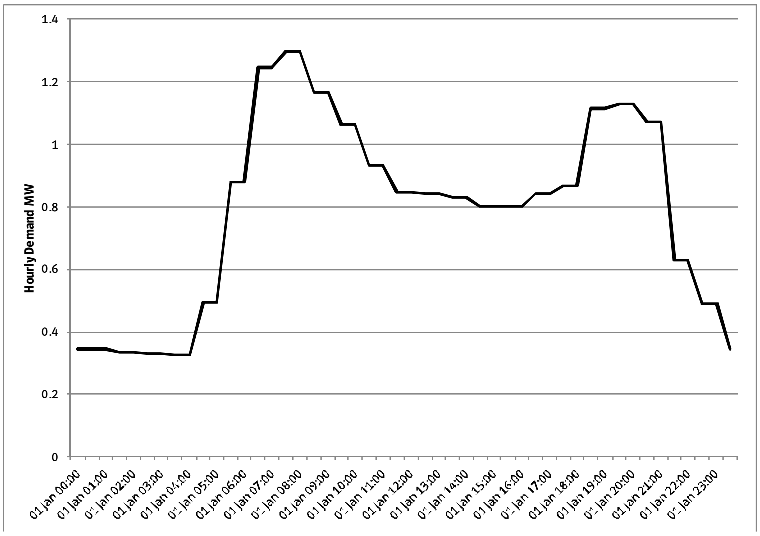


Figure 26 Phase 1 Development Daily Profile – 1st January

The maximum, minimum and average hourly demands are shown in Table 30.

	1.9
Development Minimum Hourly Demand MW	0.1
Development Average Hourly Demand MW	0.4

Table 30 Phase 1 Hourly Demand Summary

Phase 2 of the Heygate Masterplan

Over the entire year, the average hourly demand for each hour of each month is shown in Figure 27.

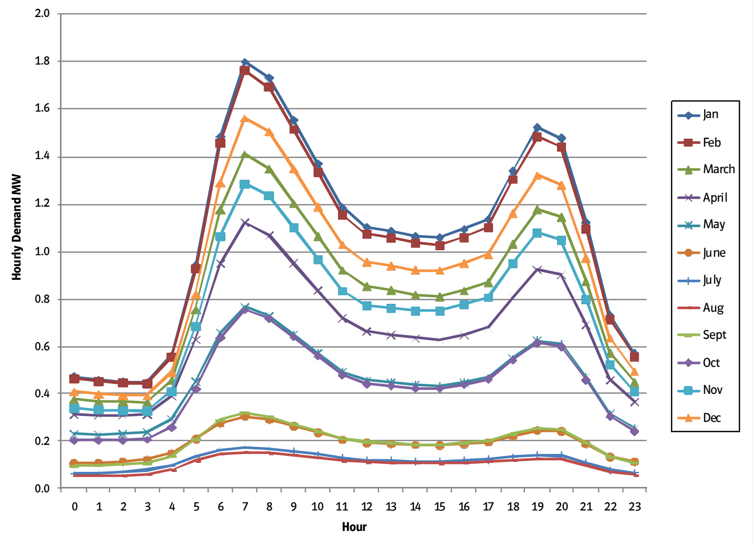


Figure 27 Phase 2 Average Hourly Demand per Month

An example of an individual daily profile, 1st January is shown in Figure 28.

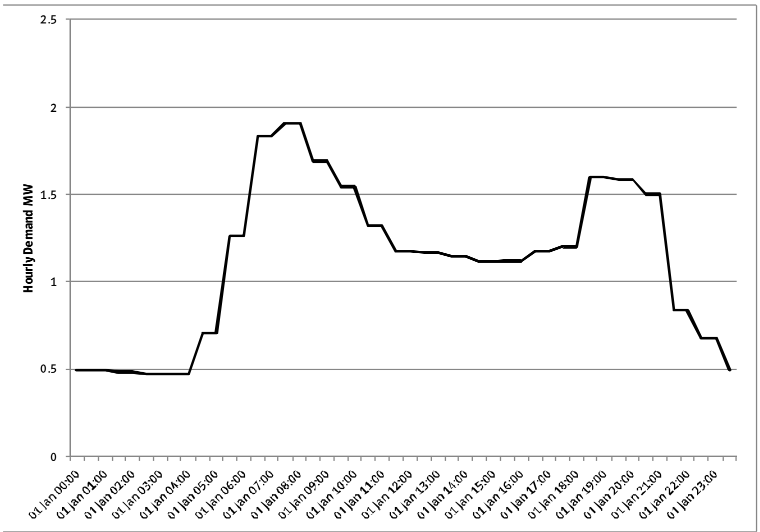


Figure 28 Phase 2 Development Daily Profile – 1st January

The maximum, minimum and average hourly demands are shown in Table 31.

Development Maximum Hourly Demand MW	2.8
Development Minimum Hourly Demand MW	0.2
Development Average Hourly Demand MW	0.6

Table 31 Phase 2 Hourly Demand Summary

Phase 3 of the Heygate Masterplan

Over the entire year, the average hourly demand for each hour of each month is shown in Figure 29.

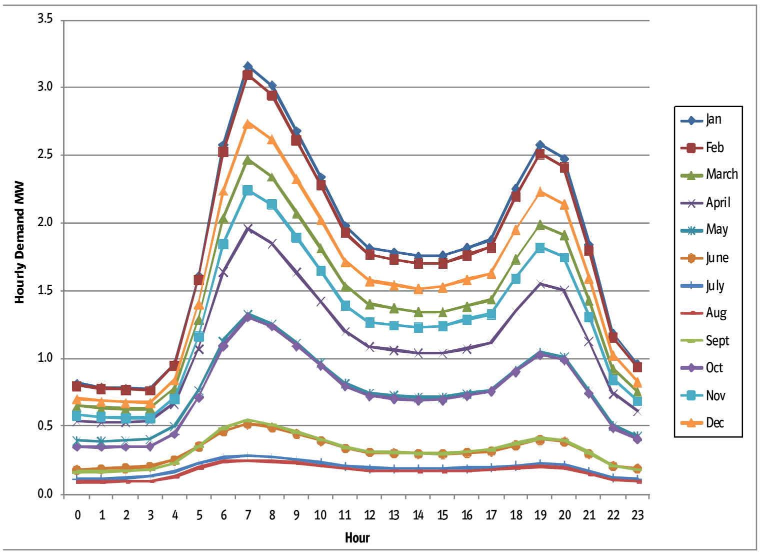


Figure 29 Phase 3 Average Hourly Demand per Month

An example of an individual daily profile, 1st January is shown in Figure 30.

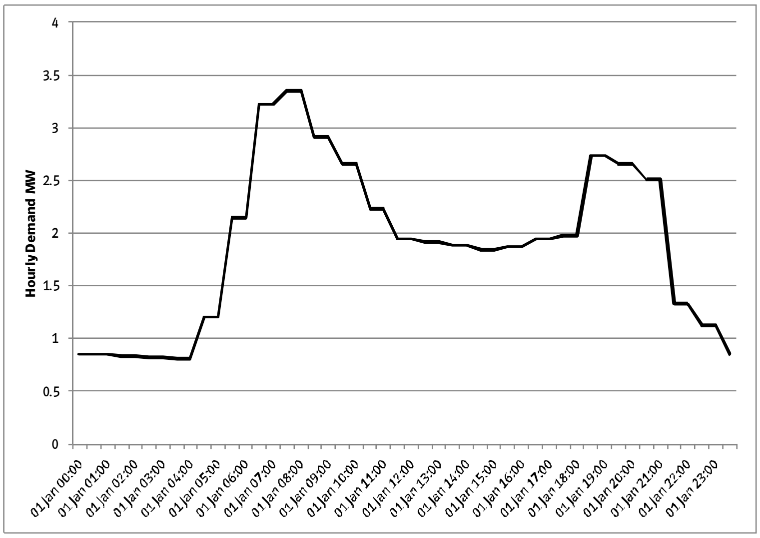


Figure 30 Phase 3 Development Daily Profile – 1st January

The maximum, minimum and average hourly demands are shown in Table 32.

Development Maximum Hourly Demand MW	4.9
Development Minimum Hourly Demand MW	0.1
Development Average Hourly Demand MW	1.0

Table 32 Phase 3 Hourly Demand Summary

Phase 4 of the Heygate Masterplan

Over the entire year, the average hourly demand for each hour of each month is shown in Figure 31.

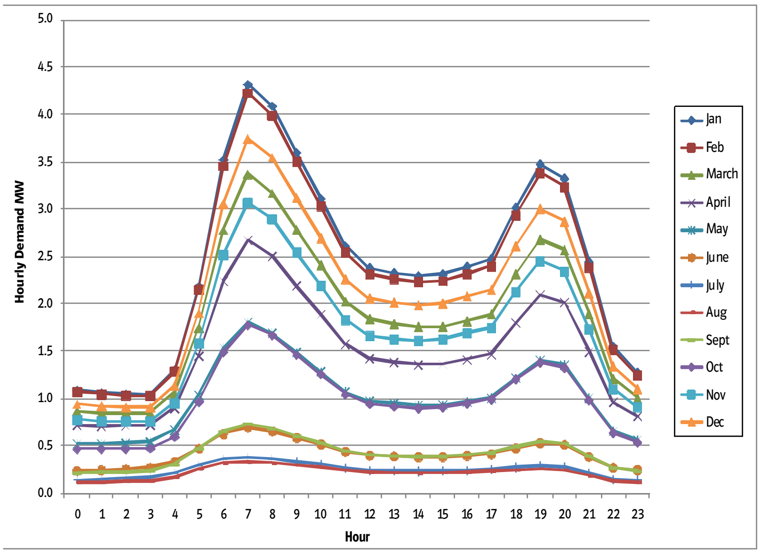


Figure 31 Phase 4 Average Hourly Demand per Month

An example of an individual daily profile, 1st January is shown in Figure 32.

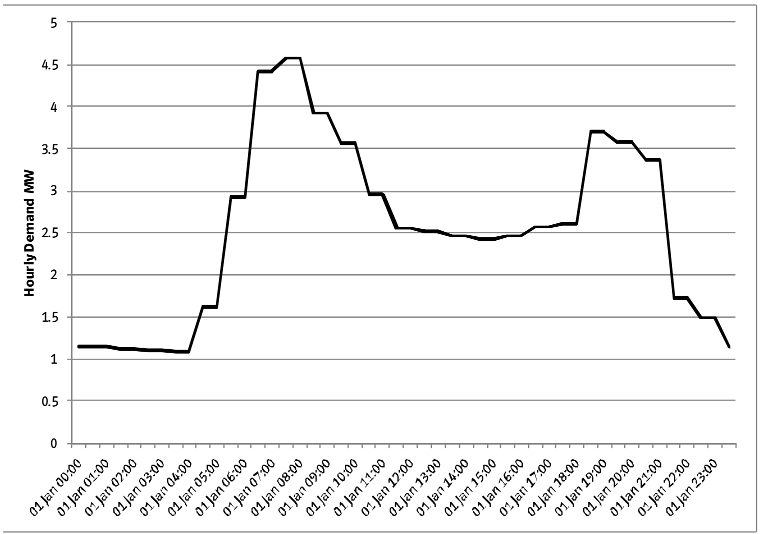


Figure 32 Phase 4 Development Daily Profile – 1st January

The maximum, minimum and average hourly demands are shown in Table 33.

Development Maximum Hourly Demand MW	6.6
Development Minimum Hourly Demand MW	0.1
Development Average Hourly Demand MW	1.3

Table 33 Phase 4 Hourly Demand Summary

Phase 5 of the Heygate Masterplan

Over the entire year, the average hourly demand for each hour of each month is shown in Figure 33.

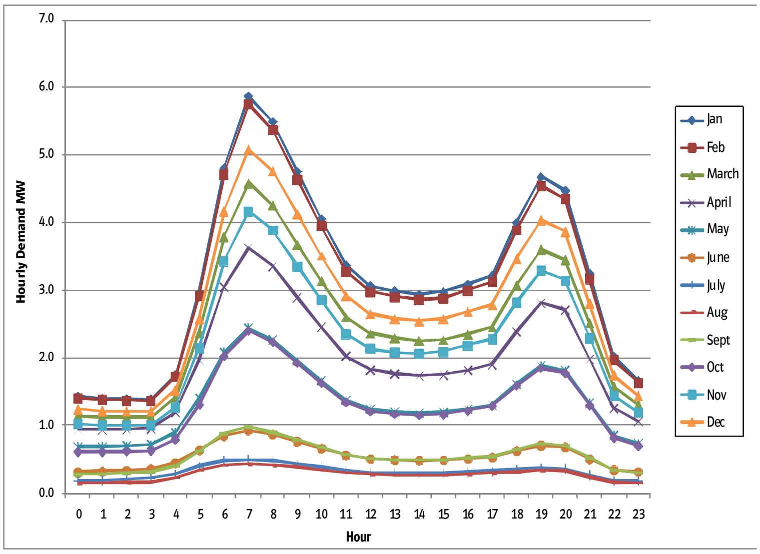


Figure 33 Phase 5 Average Hourly Demand per Month

An example of an individual daily profile, 1st January is shown in Figure 34.

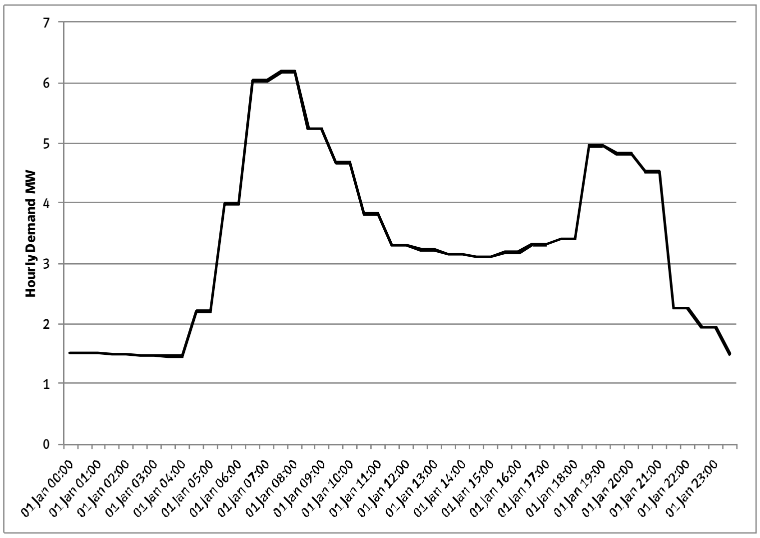


Figure 34 Phase 5 Development Daily Profile – 1st January

The maximum, minimum and average hourly demands are shown in Table 34.

Development Maximum Hourly Demand MW	9.0
Development Minimum Hourly Demand MW	0.1
Development Average Hourly Demand MW	1.7

Table 34 Phase 5 Hourly Demand Summary

Appendix H Indicative Daily CHP Operation

1st January

Demand sufficient to run both CHP units for full day. Gas boilers provide peak loading.

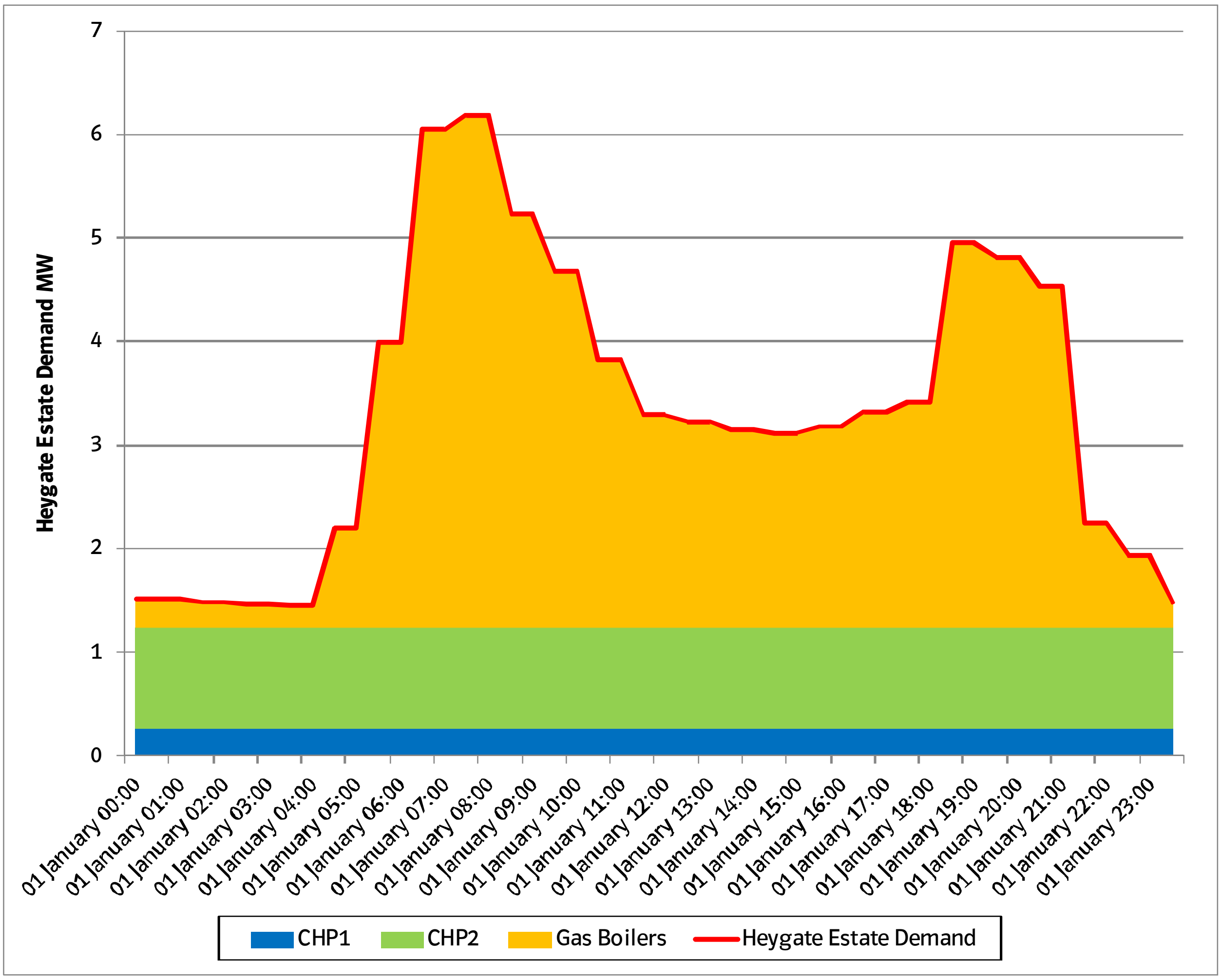


Figure 35 Daily CHP Operation – 1st January

1st April

Sufficient demand for CHP 1 to run constantly. CHP 2 also runs constantly by charging the thermal store overnight while demand is lower and then discharging during the morning peak, reducing the amount of gas boiler required. Gas boilers provide the majority of the peak loading.

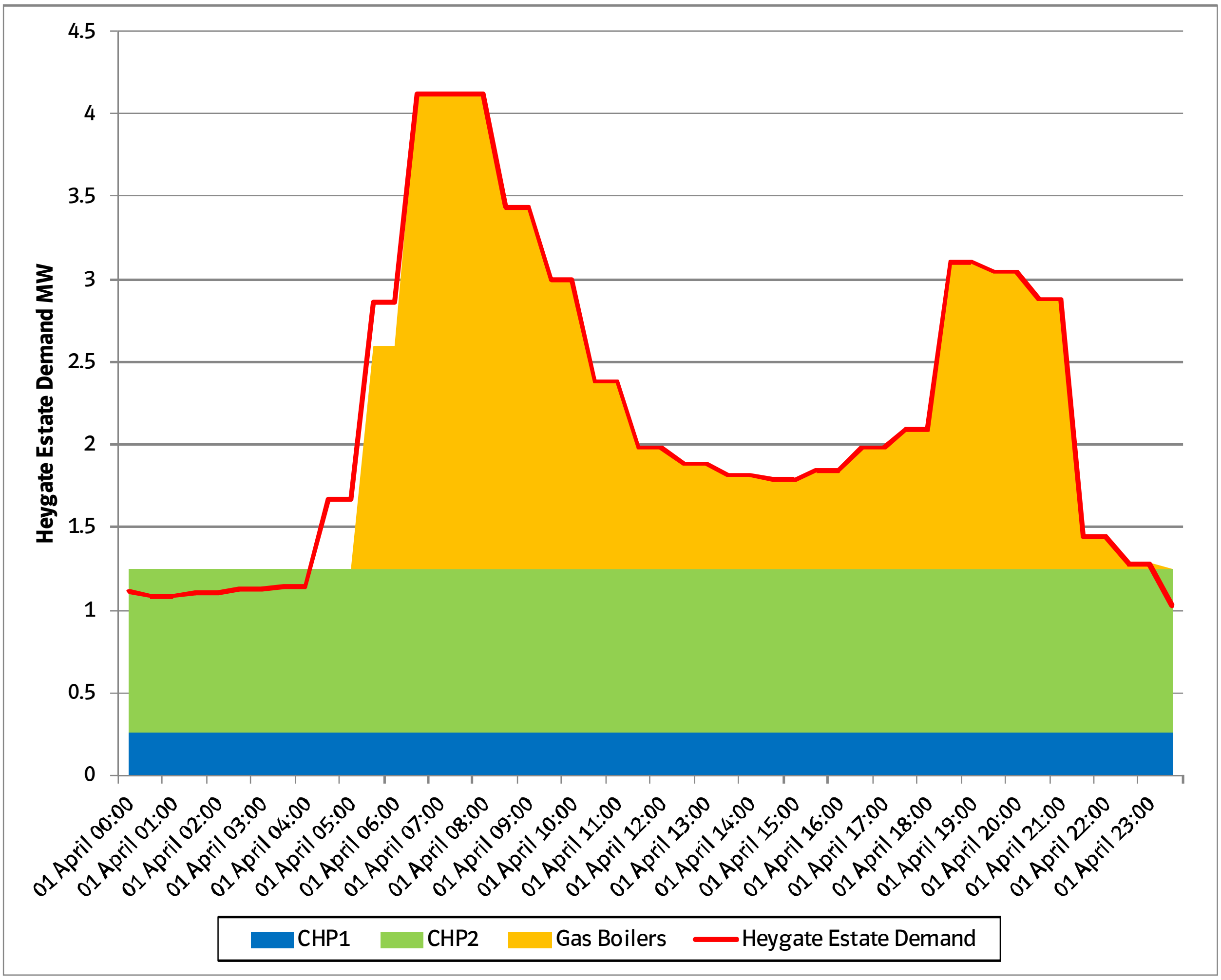


Figure 36 Daily CHP Operation – 1st April

1st June

CHP 1 runs for the duration of the day. Initially there is insufficient demand to switch on CHP 2 so the gas boilers provide the overnight load and early morning increased load. Once this demand rises sufficiently, CHP 2 turns on and starts to charge the thermal store as well as supplying the peak demand.

At the height of the morning peak, the thermal store starts discharging and the gas boilers provide additional top up. CHP2 continues to run during the day recharging the thermal store which is then discharged at the end of the day.

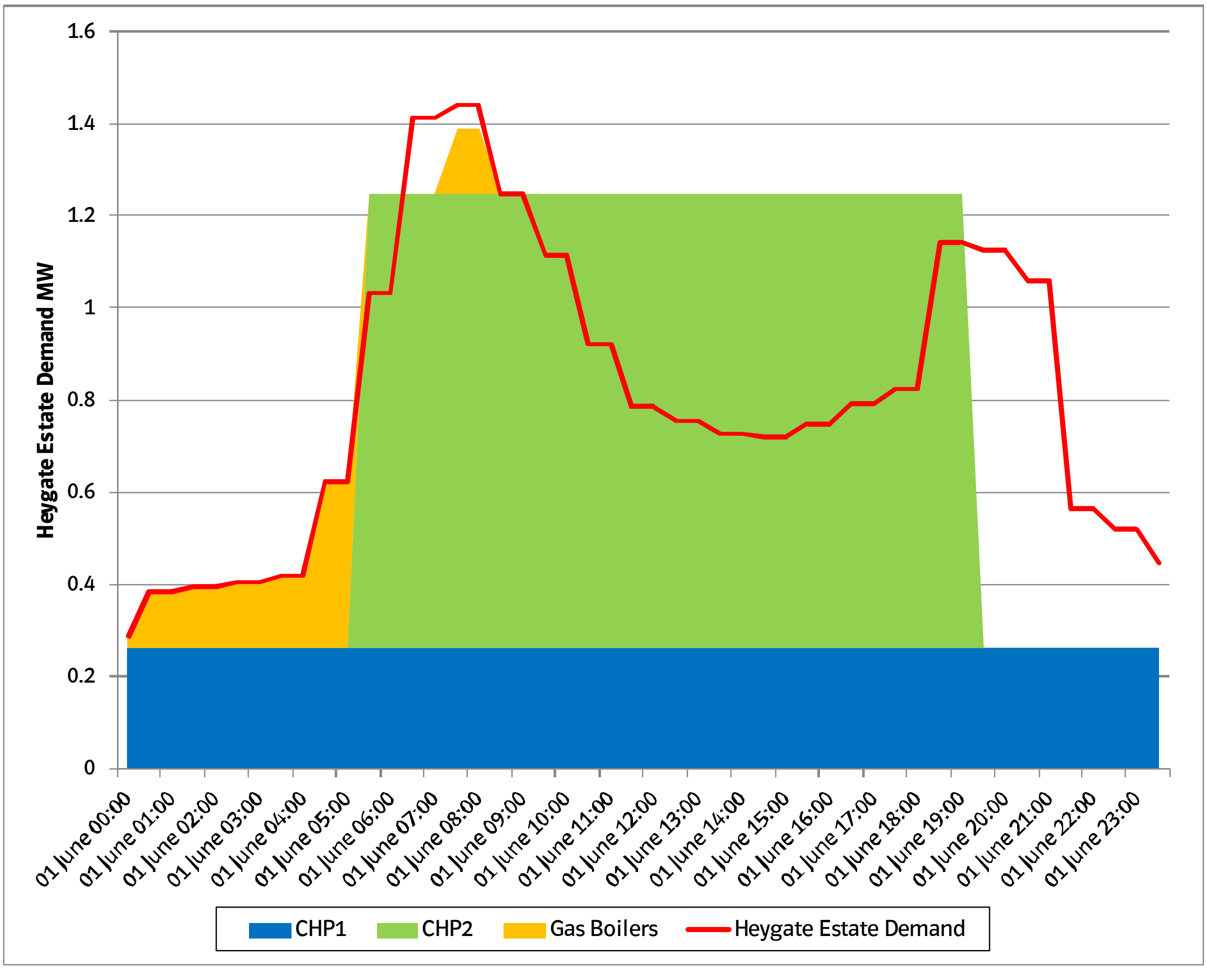


Figure 37 Daily CHP Operation – 1st June

1st September

CHP 1 turns on right at the start of the day and starts charging the thermal store as well as delivering the overnight demand. CHP1 continues to run whilst additional load is supplied by discharging the thermal store at the beginning of the morning peak. Once this is fully discharged at 6am, the gas boilers turn on to meet the peak demand for the reminder of the morning. During the afternoon CHP 1 slowly charges the thermal store and provides the small peak load required during the evening.

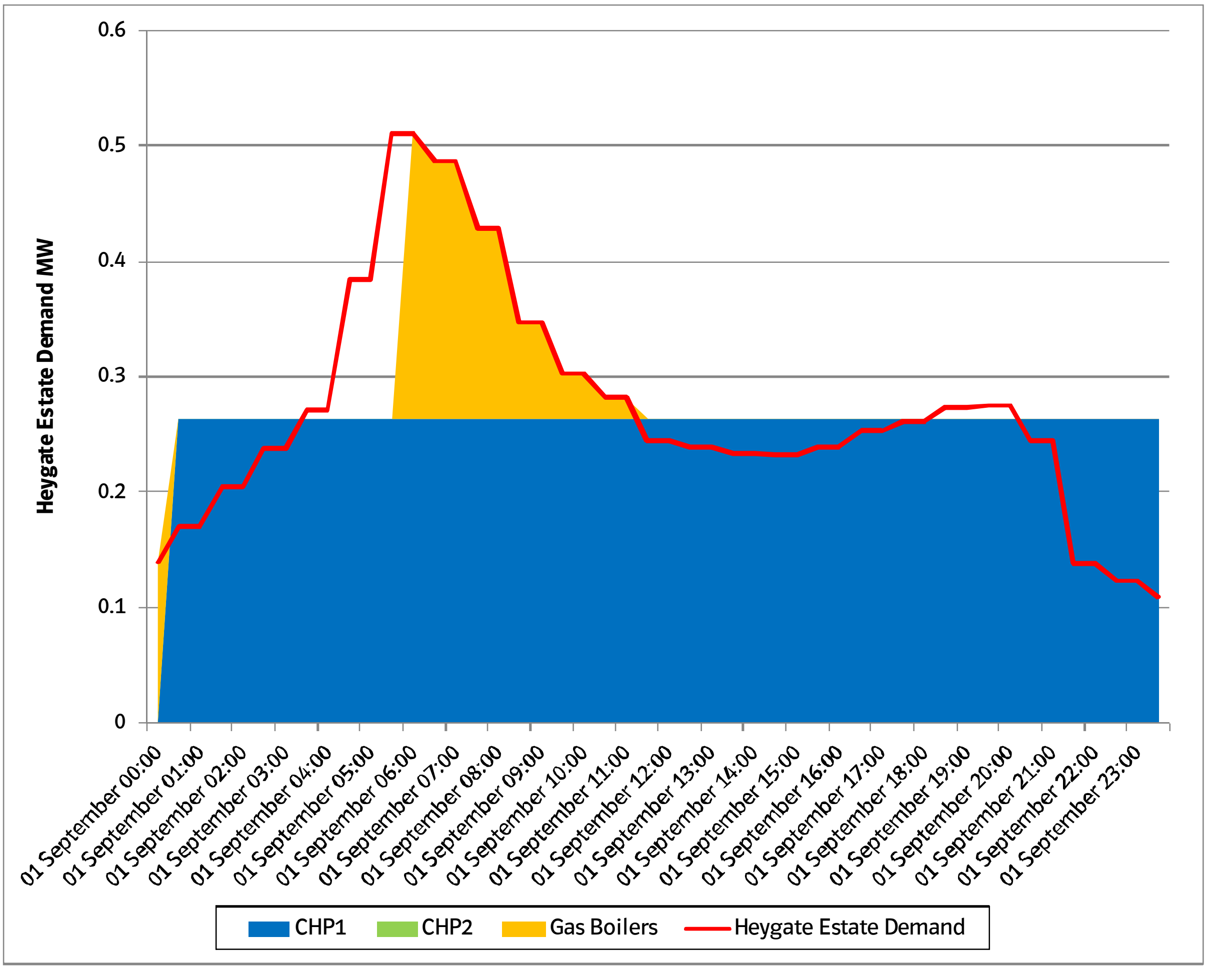


Figure 38 Daily CHP Operation – 1st September

Appendix I Indicative Energy Centre Layout

Though the Energy Centre layout is based on the present thermal demand for the Heygate Masterplan, there is sufficient flexibility within the Energy Centre design to allow for future technology changes and potential extension of the DHN to properties adjacent to the Heygate Masterplan, where appropriate.

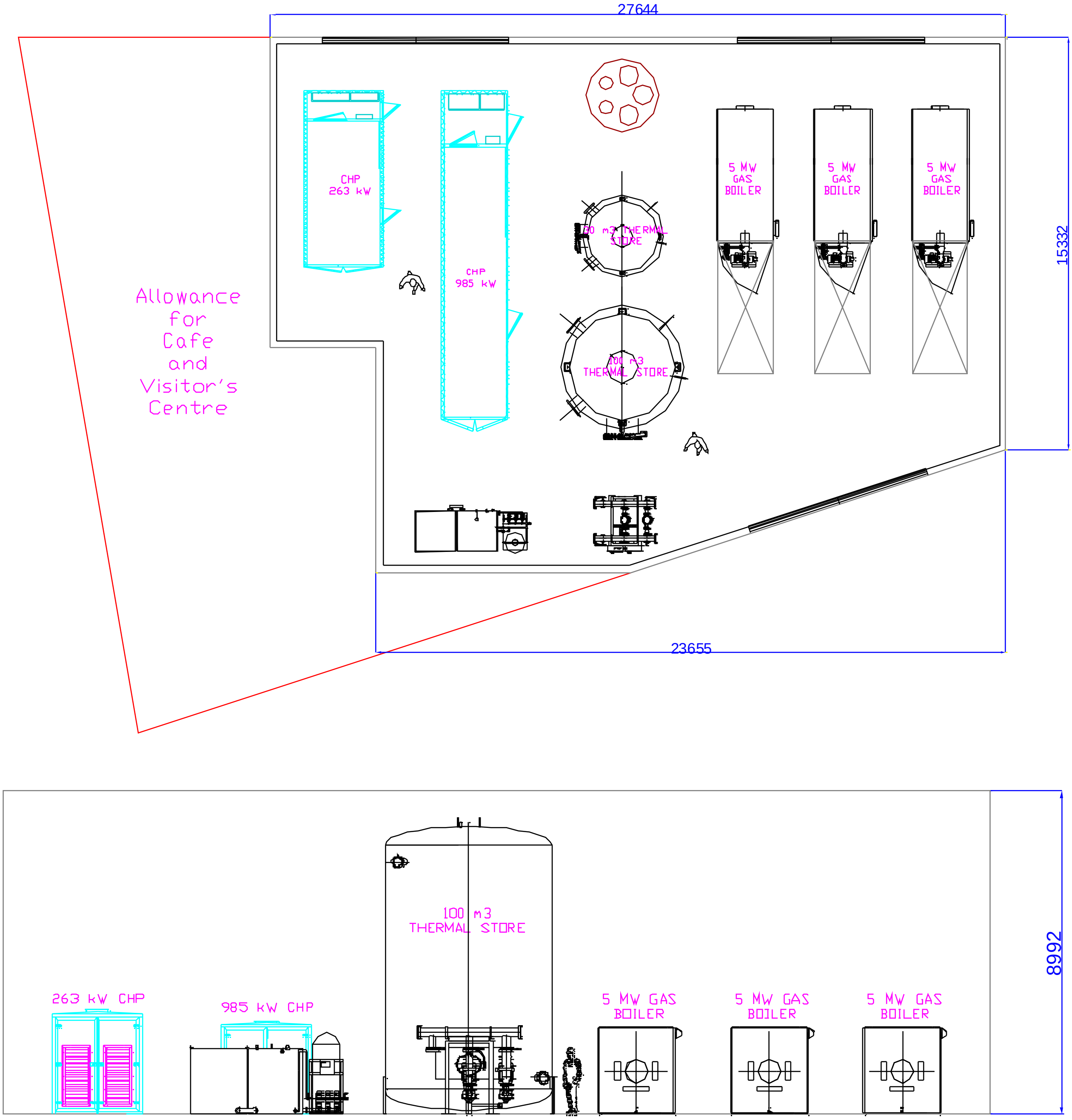


Figure 39 Indicative Energy Centre Layout

Appendix J Indicative Plan B Energy Centre Layout

This indicative Energy Centre design incorporates the biomass boiler that would be required if biomass is to be implemented within a Plan B scenario.

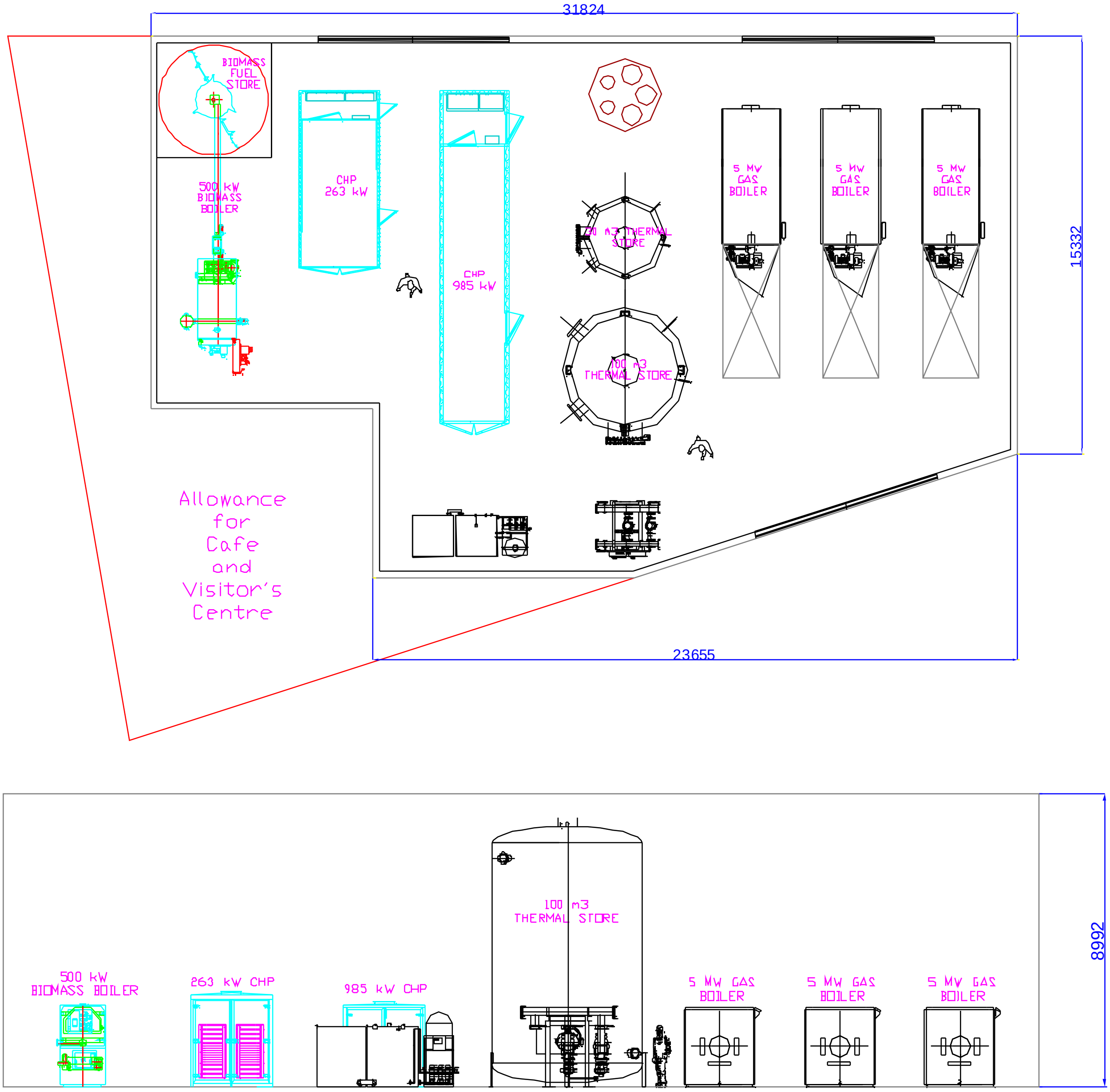


Figure 40 Indicative Plan B Energy Centre Layout

Appendix K Biomethane

Biogas, generated from a source such as anaerobic digestion of sewage, waste or crops is typically a mixture of approximately 50-70% methane and 50-30% other gases including a large proportion of CO_2. It has a lower energy content than natural gas and therefore, before it can be injected into the gas network as biomethane and gain accreditation under the GGCS, it must be cleaned to remove the other gases thereby creating a gas which is approximately 98% methane. Propane is also added to increase the calorific value to bring it in line with the requirement of the National Grid Network Entry Agreement.

Currently there are two operational biomethane injection plants in the UK at Didcot Sewage Works, Oxfordshire and Adnams Brewery, Suffolk.

The current status of financial, fiscal and carbon incentives of biomethane injection is as follows:

- RHI is paid to the biomethane producer
- Any heat added to the gas producing process and any propane added in the clean up process (typically 5-12% by energy) must be netted off the kWh of biomethane injected to calculate the RHI revenue
- ROCs/FITs/RHI cannot be claimed by the deemed combustor of the biomethane
- There is no carbon credit attached to the injection or combustion of biomethane – the emissions factor to be used is that for natural gas

However, many interested parties, including E.ON are working closely with DECC to drive an increase in the demand market through:

- Accrediting biomethane injection as an allowable solution under ZCH definition
- Establishing a biomethane carbon emissions factor (a study of large scale plants in Europe has shown that biomethane injection emits 49kgCO_2/MWh – a large saving over natural gas)
- Introducing financial and fiscal incentives for combusting biomethane, either through tax exemption or a payment for heat/electricity produced

This will lead to a competitive market for biomethane with attached financial and carbon benefit.

Appendix L Green Gas Certification Scheme

The GGCS is in its very early stages and is constantly developing. The key points of the scheme are as follows:

- Each kWh of biomethane 'green gas' is labelled electronically with a unique identifier known as a Renewable Gas Guarantee of Origin (RGGO). This identifier contains information about where, when and how it was produced. When consumers buy green gas the RGGO is their guarantee that the gas is authentic and has not been sold to any-one else.
- Anyone involved in the green gas supply chain can take part in the GGCS. The key participants are green gas producers who register the gas they've injected to the grid, and suppliers and other traders who register gas sale contracts they've agreed.
- Aims to give a guarantee to customers of green gas tariffs. Each customer will receive a certificate that tracks any contractual trading of the injected gas, providing them with evidence that the gas they use is matched by an equivalent amount of green gas going into the grid.

Appendix M Biomethane Grid Injection Case Study

Pratteln Anaerobic Digestion Facility, Switzerland

LONDON

Summary of Key Operational Parameters	Pratteln is an innovative facility where separately collected food and kitchen waste from households, along with separately collected food wastes from industry are fed into dry anaerobic digestion (AD) vessels. Biogas generated by the AD process is cleaned and upgraded for both injection into the natural gas network and for use as vehicle fuel. A limited amount of digestate from the AD process is used as liquid fertiliser but most is composted prior to use in agriculture.
Technology Providers for Key Capex Equipment	Kompogas (digestion vessels) Genosorb® (gas cleaning/upgrade equipment to remove CO_2 and H_2S) Biopower Nordwestschweiz AG / IST (sterilization equipment) Leureko AG / Biopower Nordwestschweiz AG (in-vessel composting)
Operator(s)	BioPower Nordwestschweiz AG / Leureko AG
Year of Commencement of Full Operation	2006
Overarching Policy and Cultural Environment	The Swiss Government has long supported source-separated means of treating organic wastes, and has put in a series of mechanisms (as detailed below) to ensure such methods are implemented.
Key Regulatory / Policy Mechanisms	There is an existing standard for biogas for injection into gas network in Switzerland, which requires 96% methane content, along with limit values for a range of other contaminants. Renewable 'feed-in' tariff of €0.10/kWh of electricity (which, following a implementation of a new Bill for Renewable Energy, will increase to €0.15/kWh) Landfill ban on combustible wastes effective since 2002
Design Capacity and Throughput	The facility has 16,000tpa design capacity and is currently receiving: Industrial 'catering' waste – 4-6,000tpa Mixed food and garden waste from households – 8-12,000tpa
Business model	The facility was financed on the basis of future gate fee receipts from the local municipal authority and industry. BioPower Nordwestschweiz AG, the special purpose vehicle set up to develop the facility is owned by 3 Swiss energy companies: Elektra Baselland (EBL), IWB and EBM. Leureko is the site operator and is also responsible for marketing the outputs from the facility. A limited amount of digestate from the AD process is used as liquid fertiliser but most is composted prior to use in agriculture.
Local Waste Collection Techniques and Logistics	The collection from households is through the fortnightly collection of co-mingled kitchen and garden waste using wheeled bins. Catering waste from industry (including food retailers) is also collected in wheeled bins.

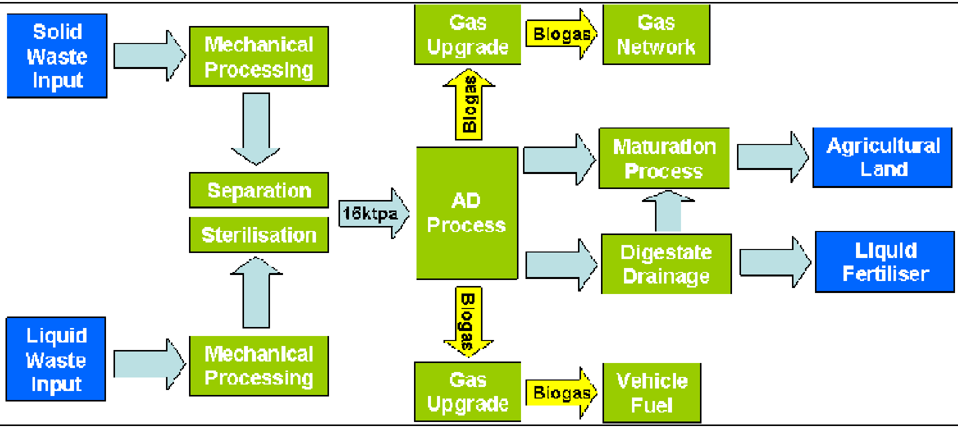
Waste flow (including output destinations)	
Energy Inputs / Outputs	Energy (heat and power) requirement (or 'parasitic load') – 3,000MWh/annum Heat to the digester is provided by a nearby sewage sludge incineration facility The facility has a total biogas output of 1.8 million m^3/annum. The biogas has a total energy value of 10,000MWh, which is sufficient to power around 1400 cars/annum. Alternatively, if this biogas was used for electricity generation in a gas engine (at 35% efficiency), it would be sufficient to power the equivalent of around 830 households (based on average annual household consumption in London of 4200kWh). Depending on the market price of gas injected into the network versus that sold as vehicle fuel, the facility has the flexibility to alter ratio of outputs.
Site Footprint	22 hectares
Energy Sales Prices (£s/MWh)	Biogas sales price of CHF 0.07/kWh (around £0.04/kWh)
Electricity Mix (in host country)	Coal - 0% Oil – 0.4% Gas – 1.6% Nuclear - 42% Renewables - 56% (of which >90% is hydro-electricity)
Similar Operating Facilities	Kompogas anaerobic digestion technologies are operating commercially at 35 facilities across 4 EU Member States and Japan, with one further facility under construction in Qatar. Of these 35 commercial facilities, only 1 further plant is of a similar configuration to the facility at Pratteln, whereby it has been configured specifically to upgrade biogas for injection into the gas network and for vehicles.
Further Comments	It is understood that there have been some complications with the gas cleaning / upgrade system for injection of biogas into the natural gas network. Discussions with both Kompogas and Kuettner UK indicated that this was due to the technology selection by BioPower Nordwestschweiz AG, and that newer systems would not encounter any problems. Kompogas has licensed its AD technology to Kuettner Gmbh, which now has a UK arm (formerly known as Active Compost). The company has also recently formed a strategic alliance with Bioganix to market the technology in the UK alongside Bioganix own IVC technology. Kompogas itself is a subsidiary of AXPO (www.axpo.ch).
Postal Address / Website of Operator	BioPower Nordwestschweiz AG Mühlemattstrasse 6 CH-4410 Liestal Switzerland www.bio-power.ch (German only) Leureko AG Industrie Pratteln Nord Heissgländstrasse 12 CH-4133 Pratteln Switzerland www.leureko.ch (German only)

Figure 41 Biomethane Grid Injection Case Study

Appendix N Hydrogen Fuel Cell CHP

Due to the extended build programme and the size of the overall project, consideration has been given to future proofing the energy generation design to account for changes in generating technology and also fuel source. Though this will be considered in more detail during the detailed design stage, one of the key emerging energy generating technologies that is suitable for urban areas where there is tightening legislation on atmospheric emissions is gas fuel cell CHP. Though the capital cost of these schemes are still high compared to traditional gas internal combustion CHP (i.e. typically in the range of £7,000/kW compared to £400/kW for a 300kWe gas CHP), the associated emissions are considerably less as shown in Figure 30[26]

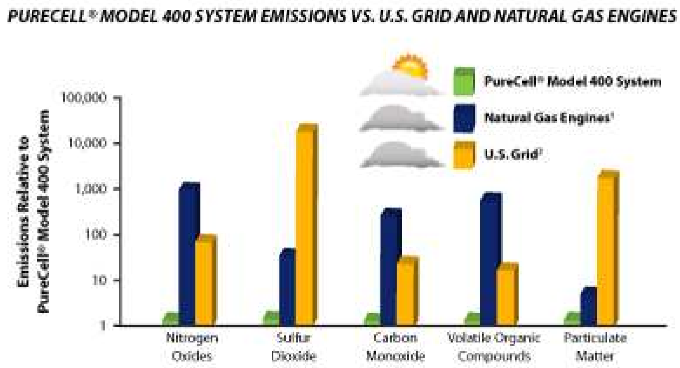


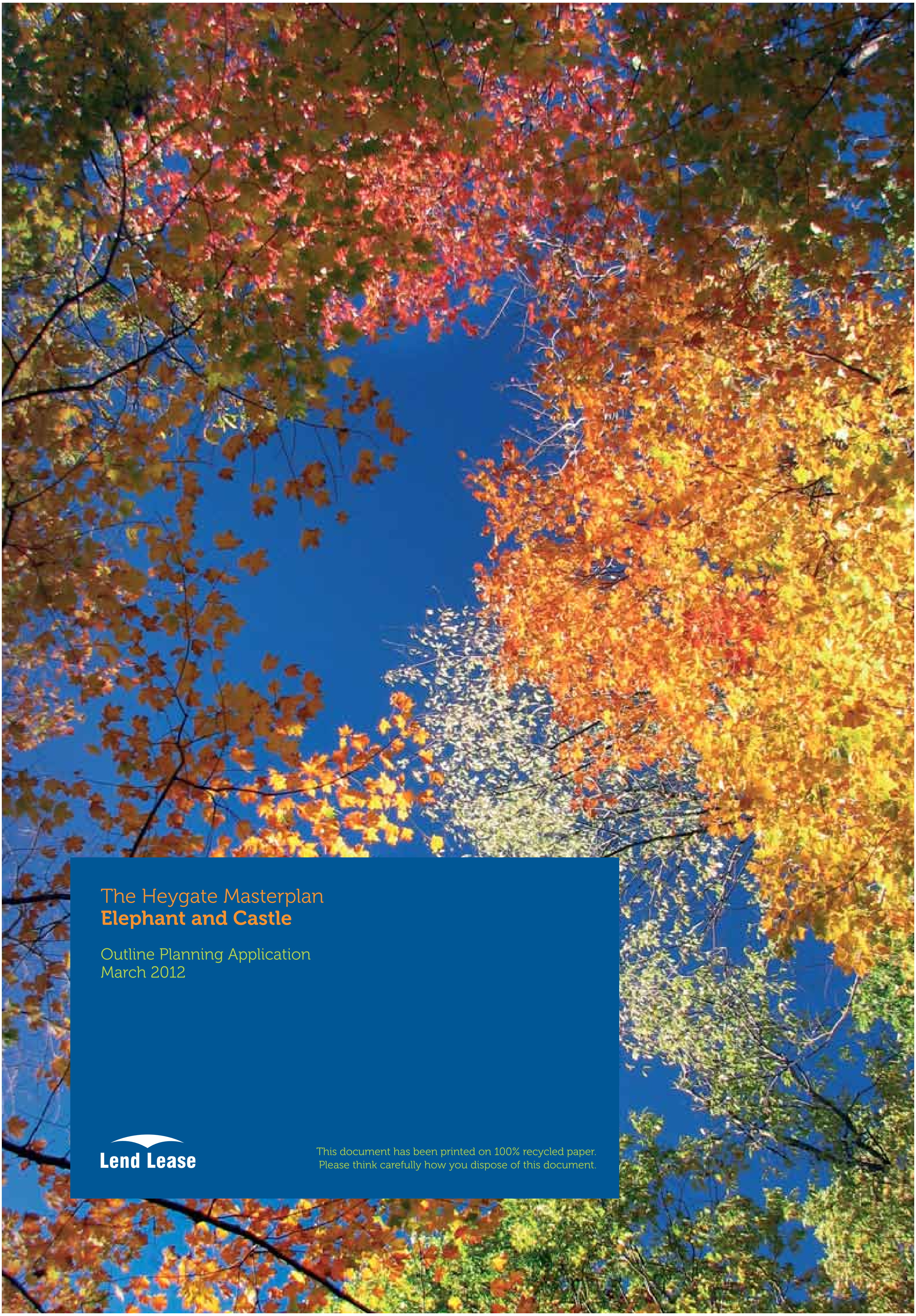
Figure 42 Fuel Cell CHP Emissions

It is anticipated that the European market for this technology will increase due to both a corresponding tightening of permitted atmospheric emissions and zero carbon targets and this will therefore be reflected in a more competitive capital cost. This technology also benefits any development as it enables the transition to a lower carbon emission fuel source as they become available. For instance, a phosphoric fuel cell CHP is suitable for the transition of the gaseous fuel source from natural gas through biomethane to hydrogen, and therefore offers the potential for low, and ultimately zero, CO_2 emissions and increased energy security.[27]

[26] Ref: http://www.utcfuelcells.com/fs/com/bin/fs_com_Page/0,11491,0252,00.html
[27] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/emerging_tech/h2_fuel_cells/h2_fuel_cells.aspx

Our vision is
to re-establish
Elephant and Castle
as one of London's
**most flourishing
urban quarters.**

Lend Lease



The Heygate Masterplan
Elephant and Castle

Outline Planning Application
March 2012

Lend Lease