Hallmark Property Group

Mixed use Development of Warehousing and Student Accommodation

65-69 Holmes Road

London Borough of Camden

ENERGY STATEMENT

Final

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Document Control Record

Energy Statement in support of the Planning Application for the Proposed Mixed Use Development of Warehousing on Ground and Basement plus 6 upper Student Accommodation Floors at 65-69 Holmes Road by Hallmark Property Group

This report has been undertaken by Matthew Bailey of Richard Hodkinson Consultancy.

Report Status: Final

Schedule of Issue

Version	Date	Reason for Issue	Prepared By	Checked By
v.1	22.10.13	Final	M Bailey	Client

EXECUTIVE SUMMARY

An energy statement in support of the mixed use development of Warehousing on Ground and Basement plus upper Student Accommodation Floors at 65-69 Holmes Road has been prepared in response to regional planning policy in the London Plan 2011 and Local Planning Policy in the London Borough of Camden.

The statement considers energy strategy options in keeping with the London Plan (Policy 5.2) CO_2 reduction Hierarchy 'Be Lean, Be Clean, Be Green'. The energy statement will be structured in accordance with Energy Planning: GLA Guidance September 2011.

Planning Policy and Guidance	Energy strategy targets
National Planning Framework	- Presumption in favour of sustainable development
London Borough of Camden	- Implement the Energy Hierarchy of 'Be Lean, Be Clean, Be Green' in order to reduce overall CO_2 emissions (CS13) - Provision of 20% reduction in carbon dioxide emissions from on-site renewable energy generation where feasible (CS13) - BREEAM 'Very Good' rating to be achieved (DP22)
London Plan	- Compliance with Part L1A 2010 through energy efficiency measures - 25% reduction in 'regulated' CO_2 emissions - Decentralised energy generation and CHP where feasible - Limit the need for mechanical cooling and avoid overheating - Incorporate renewable energy where feasible

<u>Energy Strategy Summary</u>

The developer proposes to demonstrate a commitment to energy efficient design and construction by following the energy hierarchy. A 25% reduction in regulated CO_2 emissions will be achieved as follows:

- **BE LEAN STRATEGY:** Achieving current Building Regulations Part L 2010 targets through fabric and energy efficiency measures alone, prior to consideration of low carbon energy technologies.

- **BE CLEAN STRATEGY:** Consideration has been given to decentralised energy generation and combined heat and power (CHP). There are no existing or planned district heating networks in the vicinity of the site. It is therefore proposed to incorporate a CHP system and supplementary high efficiency gas boilers to provide space heating and hot water for the development.

- **BE GREEN STRATEGY:** Consideration has been given to renewable technologies. In line with the current consented scheme, the use of solar photovoltaics (PV) is not proposed due to the considerable CO_2 savings already achieved by BE LEAN and BE CLEAN measures.

The energy strategy for the development will include:

- Residential buildings to meet or exceed Part L2 2010 Building Regulation requirements through energy efficient measures and adoption of sustainable design and construction principles:

Demand Reduction Measures Summary	Part L2 2010: Average U – values	Strategy to meet Part L 2010
External Wall U-value	0.35 W/m^2K	0.22 W/m^2K
Roof U-value	0.25 W/m^2K	0.15 W/m^2K
Floor U-value	0.25 W/m^2K	0.15 W/m^2K
Window / Glazed Doors U-values	2.2 W/m^2K	1.6 W/m^2K
Air Leakage Rate	10 $m^3/m^2/hr$	5 $m^3/m^2/hr$
Ventilation Strategy	Part F 2010	Low-e MEV

- The strategy for the building will reduce regulated CO_2 emissions by at least 25% against Part L 2010 target emissions through the use of CHP.

Table 1 outlines the predicted regulated and total CO_2 emissions from the new development.

	Carbon dioxide emissions (Tonnes CO_2 per annum)	
	Regulated	Total with Unregulated
Part L 2010 Compliant Development	556	864
After BE LEAN measures	496	804
After BE CLEAN measures	410	719
After BE GREEN measures	410	719

Table 1: Predicted CO_2 emissions

Table 2 summarises the CO_2 savings resulting from the application of the London Plan energy hierarchy:

	Regulated carbon dioxide emission savings	
	Tonnes CO_2/yr	(%)
After BE LEAN measures	59	**11%**
After BE CLEAN measures	86	**17%**
After BE GREEN measures	**0**	**0%**
Total Cumulative Savings	**145**	**26%**

Table 2: Regulated CO_2 reductions

Figure 1 below summarises the predicted regulated CO_2 emissions at each stage of the energy hierarchy.

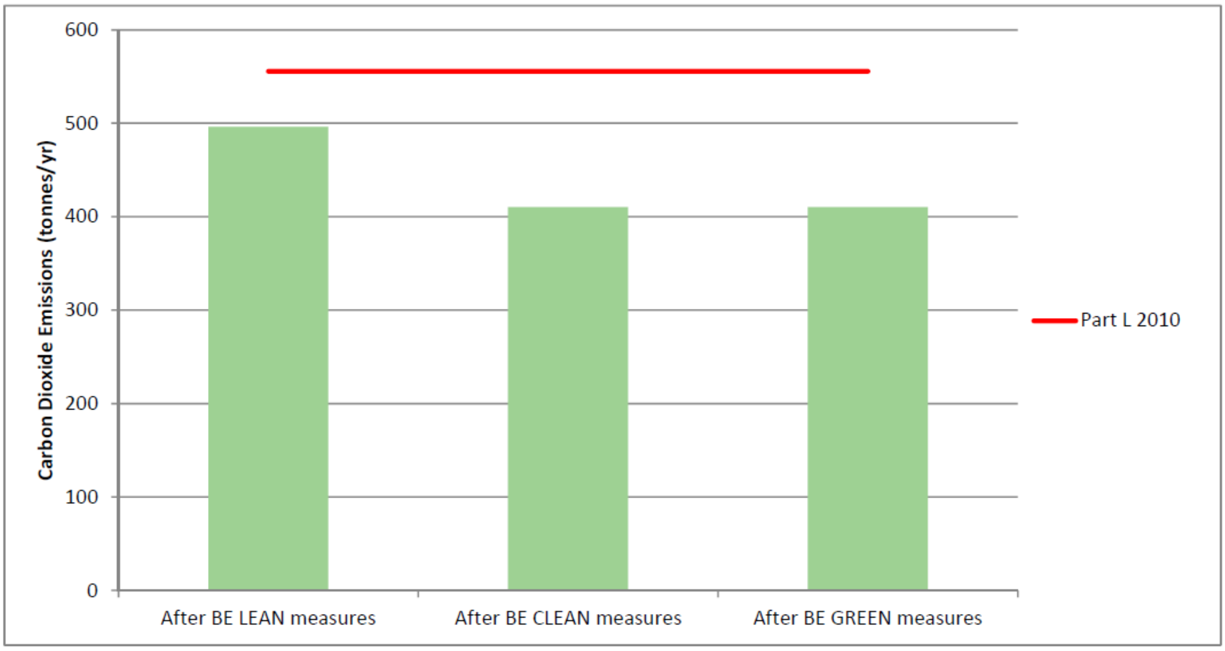

Figure 1: The Energy Hierarchy at 65-69 Holmes Road

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1. INTRODUCTION

1.1. This energy statement has been prepared by Richard Hodkinson Consultancy.

1.2. The energy statement establishes scheme CO_2 emissions and sets out the energy strategy for the mixed use development of Warehousing and Student Accommodation at 65-69 Holmes Road in the context of the local and regional planning policies.

1.3. The statement considers energy strategy options in keeping with the London Plan (Policy 5.2) CO_2 reduction Hierarchy 'Be Lean, Be Clean, Be Green', and is set out in line with *Energy Planning GLA Guidance September 2011.*

2. DEVELOPMENT OVERVIEW

2.1. The site is located at 65-69 Holmes Road in Camden and it is proposed that the site is developed into a mixed use building, housing student accommodation and B8 warehouse. The proposed development has 273 units totalling 301 student rooms as well as shared kitchen facilities, laundry, social/study areas and circulation space.

2.2. Further details of the development and an appraisal of the wider sustainability issues can be found in the Sustainability Statement.

3. PLANNING POLICY AND GUIDANCE

3.1. Local, regional and national planning policies, along with other guidance relevant to the preparation of energy strategies, are considered in the following section. A summary of targets applicable to the development is given in Table 3.

Planning Policy and Guidance	Energy strategy targets
National Planning Framework	- Presumption in favour of sustainable development
London Borough of Camden	- Implement the Energy Hierarchy of 'Be Lean, Be Clean, Be Green' in order to reduce overall CO_2 emissions (CS13) - Provision of 20% reduction in carbon dioxide emissions from on-site renewable energy generation where feasible (CS13) - BREEAM 'Very Good' rating to be achieved with at least 60% un-weighted credits in the Energy Section (CPG 3)
London Plan	- Compliance with Part L1A 2010 through energy efficiency measures - 25% reduction in 'regulated' CO_2 emissions - Decentralised energy generation and CHP where feasible - Limit the need for mechanical cooling and avoid overheating - Incorporate renewable energy where feasible

Table 3: Planning Policy Targets

<u>Local Planning Policy – London Borough of Camden Planning Guidance</u>

3.2. Camden Core Strategy Policy CS13 outlines that all new developments should implement the Energy Hierarchy of 'Be Lean, Be Clean, Be Green' in order to reduce overall CO_2 emissions :

…minimise carbon emissions from the redevelopment, construction and occupation of buildings by implementing, in order, all of the elements of the following energy hierarchy:

1. ensuring developments use less energy,

2. making use of energy from efficient sources, such as the King's Cross, Gower Street, Bloomsbury and proposed Euston Road decentralised energy networks;

3. generating renewable energy on-site;

3.3. As part of the informative text, it also states that:

the Council will expect developments to achieve a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation (which can include sources of site-related decentralised renewable energy) unless it can be demonstrated that such provision is not feasible.

3.4. Camden Development Policy 22 states that:

The Council will promote and measure sustainable design and construction by:

expecting non-domestic developments of 500sqm of floor space or above to achieve "very good" in BREEAM assessments and "excellent" from 2016 and encouraging zero carbon from 2019.

3.5. The London Borough of Camden's Planning Guidance 3: Sustainability (CPG 3) summarises the key sustainable energy requirements for new developments. This relates both to Camden's Core Strategy and the Camden Development Policies. In addition, Camden Planning Guidance 3 explains that at least 60% of the un-weighted credits from the Energy section of BREEAM must be achieved.

Regional Planning Policy – The London Plan 2011

3.6. Regional policy guidance is given in the London Plan 2011. Policy 5.1 recommends an overall target. Policies 5.2-5.9 are relevant to new development.

3.7. Policy 5.2 states that new residential developments should reduce regulated emissions by 25% beyond Part L1A 2010 standards.

3.8. Policy 5.3, Sustainable design and construction [BE LEAN], states:

> *"The highest standards of sustainable design and construction should be achieved in London to improve the environmental performance of new developments and to adapt to the effects of climate change over their lifetime."*

3.9. Policy 5.5, Decentralised Energy Network [BE CLEAN], states:

> *".. the Mayor prioritises the development of decentralized heating and cooling networks and the development and area wide levels, including larger scale heat transmission networks"*

3.10. Policy 5.6, Decentralised Energy in Development Proposals [BE CLEAN], states:

> *"Developments 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."*

3.11. Policy 5.7 Renewable Energy [BE GREEN], states:

> *"The Mayor seeks to increase the proportion of energy generated from renewable sources, and expects that the projections for installed renewable energy capacity outlined in the Climate Change Mitigation and Energy Strategy and in supplementary planning guidance will be achieved in London"*

3.12. Policy 5.8, Innovative Energy Technologies [BE GREEN], states:

"The Mayor supports and encourages the more widespread use of innovative energy technologies to reduce fossil fuels and carbon dioxide emissions. In particular the Mayor will seek to work with boroughs and other partners in this respect…"

3.13. Policy 5.9, Overheating And Cooling, states:

"Major development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and also meet cooling needs. New development in London should also be designed to avoid the need for energy intensive air conditioning systems as much as possible."

National Planning Policy

3.14. The National Planning Policy Framework (NPPF) was published on 27 March 2012. The document states that:

"At the heart of the NPPF is a presumption in favour of sustainable development, which should be seen as a golden thread running through both plan-making and decision-taking.

For decision-taking this means:

- *Approving development proposals that accord with the development plan without delay; and*
- *Where the development plan is absent, silent or relevant policies are out-of-date, granting permission unless:*
  - *Any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole; or*
  - *Specific policies in this Framework indicate development should be restricted.*

3.15. Paragraph 95 of the NPPF states that:

"To support the move to a low carbon future, local planning authorities should:

- *Plan for new development in locations and ways which reduce greenhouse gas emissions;*
- *Actively support energy efficiency improvements to existing buildings; and*
- *When setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards."*

3.16. The document also makes it clear that the delivery of a wide choice of well-designed high quality homes is central to delivering sustainable development.

BREEAM

3.17. BREEAM is a national sustainability standard for non-domestic buildings.

3.18. Under BREEAM Guidance (2011), Energy Credits relevant to the building's energy performance, external fabric, ventilation, heating and cooling are awarded under the following relevant credits:

- ENE 1 Improving the building Energy Performance Ratio (EPR); a triple metric based on energy demand, energy consumption and total CO_2 emissions
- ENE 2 Energy Monitoring
- ENE 3 External Lighting
- ENE 4 Low and zero carbon technologies
- ENE 6 Energy efficient transportation systems
- ENE 8 Energy efficient equipment

3.19. Guidance on achieving the standards for Ene 2 – 8 are included in the accompanying Sustainability Statement (within the BREEAM Pre-assessment Strategy).

3.20. Although the final SBEM calculations have yet to be completed for the development, the current strategy is anticipated to achieve between 6 and 11 Ene 1 credits. It should be noted however, that the Energy Performance Ratio (EPR) is highly sensitive, so detailed design will need to be carried out before the exact number of credits can be confirmed.

4. METHOD AND LIMITATIONS

4.1. Assessment of reductions in annual CO_2 emissions within this report is based on Part L 2010 Building Regulations. Annual CO_2 emissions are calculated from their association with a particular fuel source. Fuel factors have been taken from the Government's National Calculation Methodology (NCM) modelling guide 2010 and are outlined in Table 4.

Fuel Source	NCM 2010 CO_2 Conversion Factor (Kg/kWh)
Electricity (Grid)	0.517
Electricity (Displaced from Grid)	0.529
Gas	0.198

Table 4: Fuel Emission Factors

Energy Demands

4.2. CO_2 emissions for the building have been based on SBEM energy calculations for representative building areas and RHC benchmark data. Appendix A gives the results of a Part L2 Assessment for representative building areas.

Clarification of terminology:

4.3. Building Emission Rate (BER) is a term taken from Part L2 and is the measure for assessing a non-domestic building's annual carbon emissions. These are the emissions associated with 'regulated' energy uses, those that are controlled by Building regulations Part L2A: Conservation of Fuel and Power in New Buildings Other Than Dwellings.

5. BASELINE CO_2 EMISSIONS

5.1. Baseline CO_2 emissions for the development have been calculated and are summarised by building area in Appendix B.

5.2. Table 5 outlines the Part L2A 2010 baseline for the development.

	GIFA (m^2)	TER ($kgCO_2/m^2$)	Regulated CO_2 Emissions ($kgCO_2/yr$)	Unregulated CO_2 Emissions ($kgCO_2/yr$)	Total CO_2 Emissions ($kgCO_2/yr$)
Part L 2010 Compliant Development	13,575	40.92	555,537	308,190	863,727

Table 5: Baseline CO_2 emissions

5.3. A regulated CO_2 reduction of 138,884 $kgCO_2/yr$ must be achieved in order to comply with the 25% improvement target set by the London Plan 2011.

6. 'BE LEAN' (ENERGY DEMAND REDUCTION)

6.1. Energy efficiency measures will be used to meet and exceed Part L1A minimum CO_2 standards. These have been summarised in Table 6.

Demand Reduction Measures Summary	Part L2 2010: Average U – values	Strategy to meet Part L 2010
External Wall U-value	0.35 W/m^2K	0.22 W/m^2K
Roof U-value	0.25 W/m^2K	0.15 W/m^2K
Floor U-value	0.25 W/m^2K	0.15 W/m^2K
Window / Glazed Doors U-values	2.2 W/m^2K	1.6 W/m^2K
Air Leakage Rate	10 $m^3/m^2/hr$	5 $m^3/m^2/hr$
Ventilation Strategy	Part F 2010	Low-e MEV

Table 6: Energy Efficiency Standards

Space Heating and Hot Water

6.2. The space heating requirement of the development will be reduced by the fabric measures detailed above or similar specifications as finalised during detailed design.

6.3. It is intended to take advantage of useful solar gains where practicable, to reduce the space heating demands of the units.

6.4. High efficiency gas boilers will be used to provide space heating and hot water, with highly insulated thermal stores and communal distribution system.

Limiting the Risk of Summer Overheating

6.5. It is not proposed to provide any mechanical cooling to the student bedrooms on the proposed development. It is proposed to reduce the need for active cooling as far as possible by following the Mayor's cooling hierarchy. This will be achieved through the specification of non-mechanical measures such as good thermal insulation and air tightness. Where appropriate, solar control glazing will be installed to reduce solar gains.

6.6. Open-able windows will be installed in all bedrooms to allow the natural ventilation. This will enable cross-ventilation, convective-ventilation and night purging.

Ventilation and Air Tightness

6.7. Low energy mechanical ventilation will be used to provide background ventilation to all relevant areas.

6.8. Air tightness standards will conform to, and exceed, Approved Document Part L requirements. By reducing air leakage loss and convective bypass of insulation, an improvement of design air permeability rate from $10m^3/hm^2$ to $5m^3/hm^2$ will further reduce space heating requirements.

Lighting and Appliances

6.9. Low energy lighting design will be included throughout the building, in line with CIBSE illumance levels.

6.10. External lighting will also be low energy lighting and controlled through PIR sensors, or daylight cut-off devices.

6.11. It is difficult to design and construct buildings to reduce the unregulated electricity demands, because this is almost entirely dependent on the occupant of a building and can vary substantially. However, the Applicant is committed to ensuring that all efforts are made to enable the building users to minimise their unregulated electricity consumption. Advice will be provided to occupants in the form of a Building User Guide on how to minimise electricity consumption.

CO_2 Emissions Following *Be Lean* Measures

6.12. Total regulated CO_2 emissions associated with the 'BE LEAN' scenario are outlined in

6.13. Table 7 below.

	GIFA (m^2)	BER ($kgCO_2/m^2$)	Regulated CO_2 Emissions ($kgCO_2/yr$)	Regulated CO_2 Reduction from 'BE LEAN' measures ($kgCO_2/m^2$)	Regulated CO_2 reduction (%)
'BE LEAN'	13,575	36.5	496,149	59,388	10.7%

Table 7: BE LEAN CO_2 emissions

7. 'BE CLEAN' DECENTRALISED ENERGY & CHP

7.1. There are no major heat networks in the vicinity of the site for the development to connect to. This is demonstrated in Figure 2, a copy of the London Heat Map for this area.

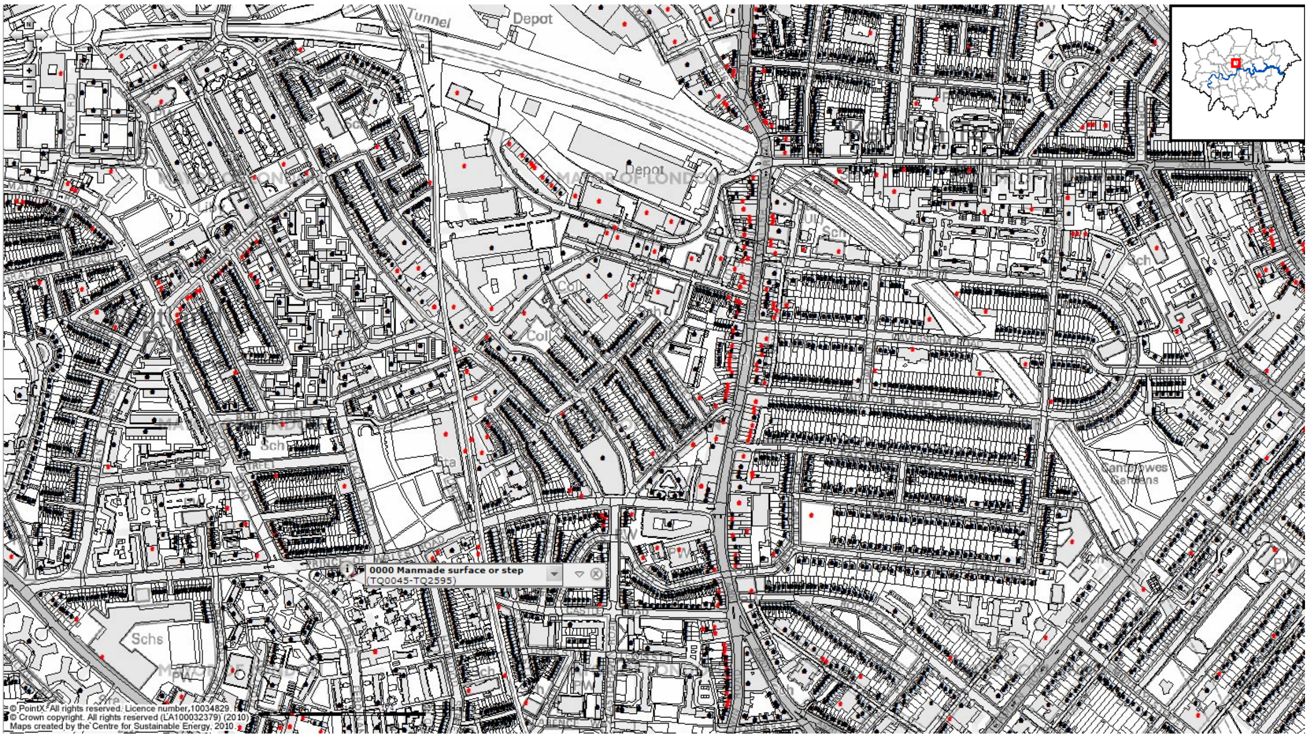

Figure 2: London Heat Map

7.2. In addition, in line with Camden Planning Guidance, reference to the existing or emerging heat network has been given, demonstrating that the development is not within 1km of an applicable heat network. This is evident from the map in Figure 3.

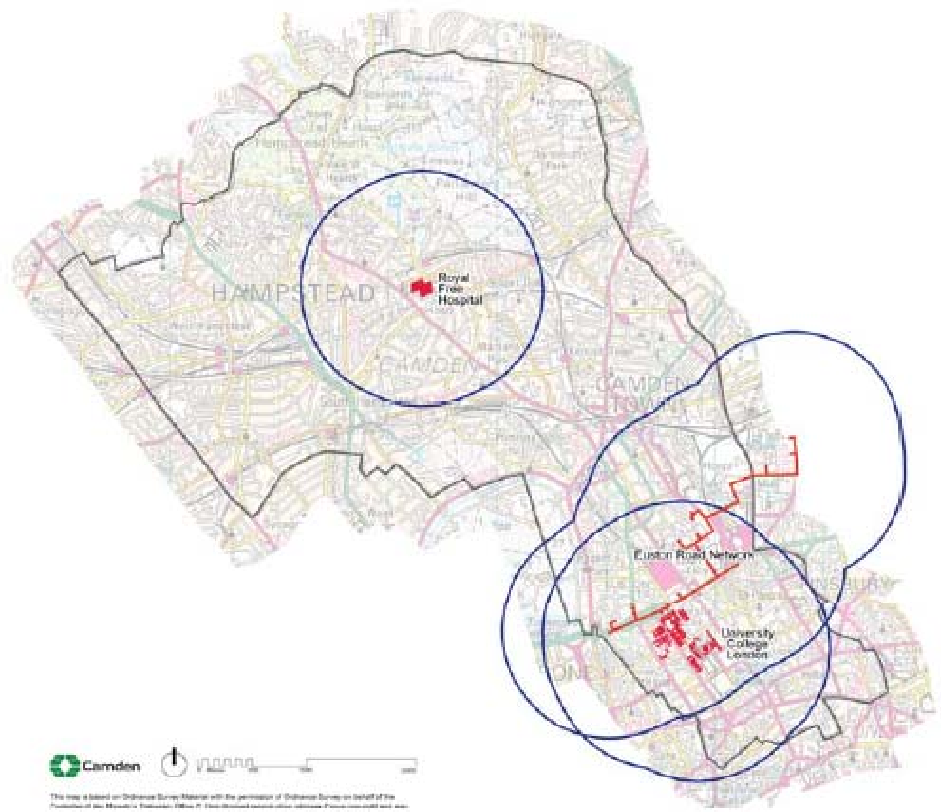

Figure 3: Developments within 1km radius of existing or emerging heat network

7.3. In line with the London Plan, the feasibility of installing a Combined Heat and Power (CHP) engine as a 'BE CLEAN' measure has been evaluated.

7.4. CHP is ideally suited to large, mixed use developments of a medium to high density. This allows the CHP to run for a significant proportion of the day, providing a high proportion of heat demand without losing efficiency due to distribution losses.

7.5. An assessment of the space heating and hot water demand for the proposed development has demonstrated that CHP is a technically feasible technology for the site. A breakdown of the calculations can be found in Appendix C.

7.6. Figure 4 is a heat demand profile for the site, clearly demonstrating that domestic hot water loads comprise the majority of overall heat demand. A CHP engine has been sized accordingly to meet the domestic hot water load, allowing year-round operation, with supplementary gas boilers to meet winter space heating demands.

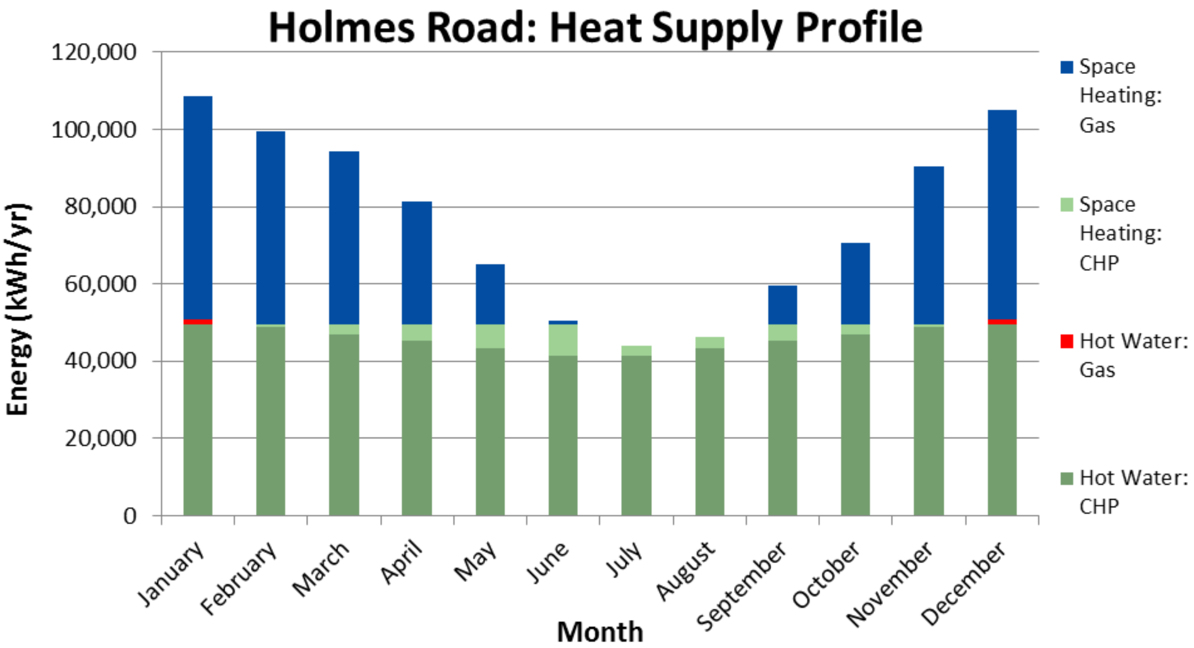

Figure 4: Heat Supply Profile

7.7. Table 8 outlines the predicted CO_2 savings from installing a $116kW_{th}$ CHP engine, sized to meet domestic hot water demand across the development. Confirmation of the exact engine size will require detailed calculation at technical design stage.

	Average DER ($kgCO_2/m^2$)	Regulated CO_2 Emissions ($kgCO_2/yr$)	Regulated CO_2 Reduction from 'BE CLEAN' Measures ($kgCO_2/m^2$)	Regulated CO_2 reduction from 'BE CLEAN' Measures (%)	Total regulated CO_2 reduction including 'BE LEAN' Measures (%)
'BE CLEAN'	30.2	410,467	6.3	17%	26%

Table 8: BE CLEAN CO_2 Emissions

8. 'BE GREEN' RENEWABLE ENERGY MEASURES

8.1. The feasibility of incorporating on-site renewable energy targets in order to achieve the Camden Planning Guidance target of a 20% reduction in CO_2 emissions through the use of on-site renewable technologies has been assessed.

Biomass Boiler

8.2. Biomass boilers generate heat on a renewable basis as they are run on biomass fuel which is carbon neutral.

8.3. Camden Development Policies Section 3 state that, due to air quality issues, Biomass is the least preferred renewable technology in the Borough.

8.4. A biomass boiler would also conflict with the CHP solution chosen as the 'Be Clean' solution for this site.

8.5. Whilst technically feasible, a biomass boiler is not appropriate for this development as it would conflict with the CHP for heat demand and could pose air quality problems.

Wind Turbines

8.6. Small scale roof-top wind turbines are unlikely to be a viable technology for this development due to its urban location where wind speeds are low and conditions are turbulent. These conditions reduce the generating potential of wind turbines to levels which are not viable. Detailed assessment of wind conditions at the development site over the course of a year would be required to determine the technical viability of wind turbines.

8.7. It has therefore been concluded that wind turbines are not a suitable technology for the proposed development.

Ground and Air Source Heat Pumps (ASHPs and GSHPs)

8.8. Heat Pumps upgrade energy from the ground or air and utilise it for space heating and hot water.

8.9. Heat Pumps are able to provide substantial reductions in energy. However, GSHPs require costly ground excavation works to bury the coils. Vertical boreholes would be the most likely solution for this site due to the high space requirements of horizontal ground coils.

8.10. Air Source Heat Pumps are a more economical alternative to GSHPs as they do not require ground works. However, the performance (COP) of ASHPs is substantially lower than for GSHPs are therefore the reductions in CO_2 are correspondingly low.

8.11. Whilst reducing energy significantly, heat pumps replace gas as the heating fuel with electricity, which is more carbon intensive. The result of this is that heat pumps do not generally enable sufficient reductions of CO_2 emissions for London Plan Policy compliance. Electricity is also a more expensive fuel than gas, so energy bills are not reduced by heat pumps as much as by other technologies.

8.12. In addition, heat pumps would compete with the CHP for heat demand, making the selected 'Be Clean' scenario less efficient.

8.13. It has therefore been concluded that heat pumps are not a suitable technology for the Proposed Development.

Solar Thermal Panels

8.14. Solar Thermal Heating Systems contribute to the hot water demand of a dwelling or building. Due to the seasonal availability of heat, solar thermal panels should be scaled to provide no more than 50% of the hot water load.

8.15. Solar thermal panels are not a preferred solution for this site as they would conflict with the CHP engine in satisfying domestic hot water demand, therefore reducing the efficiency of the chosen 'Be Clean' solution.

8.16. It has therefore been concluded that solar thermal hot water systems are not a suitable technology for the Proposed Development.

Photovoltaic (PV) Panels

8.17. Unlike solar thermal panels, PV panels are not constrained by the hot water demand of the building and do not conflict directly with CHP. PV panels enable substantial reductions in CO_2 emissions as a result.

8.18. There is approximately 1,200m^2 of roof space on this building. With a utilization factor of 60% (to allow for plant space, space between panels and shading from parapet walls, an estimated total of 724m^2 of PV panels could be located on the roof of the development. This equates to approximately 90kWp.

8.19. Whilst PV on this scale is technically feasible, the use of this technology would attract a high capital cost per kgCO_2 when compared with alternative renewable technologies.

8.20. As a substantial investment in 'Be Lean' energy efficiency measures and CHP will reduce regulated CO_2 emissions in excess of 25% beyond Part L 2010 levels, PV is not a preferred solution for the site.

9. SUMMARY

9.1. The proposed Energy Strategy for the mixed use development of Warehousing on Ground and Basement plus upper Student Accommodation Floors at 65-69 Holmes Road development in Camden has been formulated using the London Plan Energy Hierarchy.

9.2. The proposed ***Be Lean*** energy efficiency measures will enable the development to meet 2010 Building Regulations through energy efficiency measures alone. This represents a high level of sustainable design and construction.

9.3. The feasibility of a decentralised energy strategy, including Combined Heat and Power (CHP) as a ***Be Clean*** measure has been evaluated. It has been concluded that this is a suitable solution for the development, which will lead to overall CO_2 savings in excess of 25% beyond Part L 2010 targets.

9.4. Consideration has been given to renewable technologies. In line with the current proposed scheme, the use of solar photovoltaics (PV) is not proposed due to the considerable CO_2 savings already achieved by BE LEAN and BE CLEAN measures.

9.5. The combination of energy efficiency measures and CHP enables the regulated CO_2 emissions of the development to be reduced by **25%** over Building Regulations (2010). This proposed strategy meets all policy requirements and the mandatory energy requirements of Code Level 4.

9.6. The summary table, below, shows that the combination of ***Be Lean*** and ***Be Green*** measures will result in reductions in **regulated CO_2** emissions of more than **25%** over Building Regulations (2010).

	Regulated carbon dioxide emission savings	
	Tonnes CO_2/yr	(%)
After BE LEAN measures	59	**11%**
After BE CLEAN measures	86	**17%**
After BE GREEN measures	**0**	**0%**
Total Cumulative Savings	**145**	**26%**

Table 9: CO_2 reduction summary

Appendices

A) Energy Demands and CO_2 Emissions by Building Use

B) BASELINE AND 'BE LEAN' CO_2 EMISSIONS

C) 'BE CLEAN' CALCULATIONS

D) Low Carbon and Renewable Energy Technologies

E) Low and zero carbon energy technology feasibility

Appendix A: Energy Demands and CO_2 Emissions by Building Use

Use Type	Energy (kWh.m2/yr)						CO2 (kg/m2/yr)			
	Space Heating	Hot Water	Cooling	Auxiliary	Lighting	Unregulated Equipment	Regulated TER	Regulated BER	Total Base emissions	Total Emissions
Bedrooms	42.8	70.0	0.0	12.1	39.0	47.2	56.0	48.72	80.4	73.1
Kitchen	30.0	60.0	0.0	12.1	42.0	130.0	56.0	45.79	123.2	113.0
Social / Study Areas	31.8	7.7	0.0	3.2	36.8	50.5	22.7	28.45	48.8	54.6
Plant room & Services	0.0	0.0	0.0	0.0	19.0	427.1	6.3	9.81	227.1	230.6
Unheated Space	0.0	0.0	0.0	0.0	19.0	0.0	9.8	9.82	9.8	9.8
Corridor	4.0	0.0	0.0	2.4	8.6	12.8	7.2	6.47	13.8	13.1
Warehouse	2.0	1.0	0.0	3.0	27.0	15.0	16.2	16.10	24.0	23.9

Appendix B: BASELINE AND 'BE LEAN' CO_2 EMISSIONS

Unit Type	Total Floor Area (m2)	Energy (kWh/yr)						CO2 per Type (kg/m2/yr)			
		Space Heating	Hot Water	Cooling	Auxiliary	Lighting	Unregulated Equipment	Regulated TER	Regulated BER	Total Base Emissions	Total Emissions
Social/Study Areas	780	24,765	5,983	0	2,473	28,681	39,390	17,706	22,194	38,071	42,559
Bedrooms	8538	365,000	597,660	0	102,968	332,982	403,164	478,128	415,993	686,564	624,429
Unheated	584	0	0	0	0	11,096	0	5,737	5,737	5,737	5,737
Plant Room	204	0	0	0	0	3,872	87,118	1,285	2,002	46,325	47,042
Corridors	1032	4,118	0	0	2,446	8,886	13,210	7,430	6,674	14,260	13,503
Kitchen	145	4,350	8,700	0	1,755	6,090	18,850	8,120	6,640	17,865	16,385
Warehouse	2292	4,584	2,292	0	6,876	61,884	34,380	37,130	36,910	54,905	54,685
Total per Type		**402,816**	**614,635**	**0**	**116,517**	**453,490**	**596,112**	**555,537**	**496,149**	**863,727**	**804,339**
Total reduction over Building Regulations (2010)								**11%**			
London Plan 25% CO2 Reduction Target over 2010 Building Regulations (TER) (kgCO2/yr)								**138,884.16**			
Remaining CO2 reduction target after Be Lean Measures								**79,496.53**			

*TER = Target Emission Rate: The maximum allowable CO2 emissions per m2 (KgCO2/m2/year) arising from energy used in heating, cooling, hot water and lighting which would demonstrate compliance with Criterion 1 of AD L1A.

Appendix C: BE CLEAN CALCULATION

BASELINE - WITHOUT CHP

	Fuel Used	Efficiency	end	CO2 (kg/kWh)	kg CO2/yr
Gas Heating	**1,017,451**	90%	915,706	0.198	201,455
Electricity	**570,007**	100%	570,007	0.517	294,694
Total			1,485,713		496,149

CHP Contribution		**Conventional System**
65%		35%
CHP Efficiency		**Gas Boiler Efficiency**
Heat	48%	90%
Elec.	31%	
Heat:Power Ratio	1.6	

WITH CHP

		End Use Energy kWh	Efficiency (%)	Energy Demand kWh	CO2 kg/kWh	CO2 Associated with Heating	Electricity Efficiency	Electricity from CHP	CO2 Associated with Electricity
CHP	Heating	595,209	48%	1,234,873	0.198	244,505	31%	376,636	-199,241
Conventional	Heating	320,497	90%	356,108	0.198	70,509			
	Electricity	570,007	100%	570,007	0.517		100%		294,694
			TOTALS	**2,160,988**		**315,014**			**95,453**
					TOTAL CO2	**410,467**			

Size Of CHP (kWth)	116	5110	hours per year
Size Of CHP (kWe)	74	14	hours per day

Appendix D: Low Carbon and Renewable Energy Technologies

Introduction

- This Appendix is intended to provide the background information for the low carbon and renewable energy technologies that have been considered in the formulation of this Energy Statement.

- The information provided here forms the basis for the project specific technical selection of low carbon/renewable energy technologies contained in the main section of this Energy Statement.

Combined Heat and Power (CHP)

- CHP is a form of decentralised energy generation that generally uses gas to generate electricity for local consumption, reducing the need for grid electricity and its associated high CO_2 emissions. As the CHP system is close to the point of energy demand, it is possible to use the heat that is generated during the electricity generation process. As both the electricity and heat from the generator is used, the efficiency of the system is increased above that of a conventional power plant where the heat is not utilised. However, the overall efficiency of ~75% is still lower than the ~90% efficiency of a heat only gas boiler.
- Where there are high thermal loads, CHP can be used within district heating networks to supply the required heat.
- **Performance and Calculation Methodology: -** Most commonly sized on the heat load of a development, not the electrical load. This prevents an over-generation of heat.
  - Require a high and relatively constant heat demand to be viable.
  - CHP engines are best suited to providing the base heating load of a development (~year round hot water demand) with conventional gas boilers responding to the peak heating demand (~winter space heating). CHP engines are not able to effectively respond to peaks in demand.
  - In general, CHP engines have an electrical efficiency of ~30% and a thermal efficiency of ~45%.
  - Electricity produced by the CHP engine displaces grid electricity which is given a carbon intensity of 0.568 kg per kWh.
- **Capital Cost: -** High in comparison to biomass boilers.
  - Relative cost reduces as the size of engine increases.
- **Running Costs/Savings: -** CHP engines often struggle to provide cost-effective energy to dwellings on residential schemes.
  - Running costs and maintenance are higher than for domestic gas boilers.

- Needs Private Wire supply for economic case to be positive.

- **Land Use Issues and Space Required: -** CHP engines require a plant room, and possibly an energy centre for large residential developments.
  - CHP engines require a flue to effectively disperse pollutants. The height of the chimney required is dependent on the size of the engine installed.
  - Heat network issues.
- **Operational Impacts/Issues: -** Required to be run by Energy Services Company (ESCo) who are unenthusiastic about getting involved in small – medium scale schemes.
  - Issues with rights to dig up roads for district heating networks.
  - Emissions of nitrous oxides – ~1000mg/kWh – 20 times higher than for a gas boiler.
- **Embodied Energy: -** Comparable to that of a conventional gas boiler.
- **Funding Opportunities: -** Tax relief for businesses under the Enhanced Capital Allowances scheme.
- **Reductions in Energy Achievable: -** Can provide some reductions in effective primary energy, but when distribution losses and other local losses are included more fuel is required.
- **Reductions in CO_2 Achievable: -** Can provide greater reductions in CO_2 than energy, aided by the emissions factor of grid displaced electricity of 0.568 kg CO_2/kWh.
- **Advantages: -** Good reductions in overall primary energy and CO_2 emissions.
- **Disadvantages: -** More expensive and greater NO_x emissions than a biomass boiler.
  - Often do not supply energy cost-effectively in comparison to the market.
  - Requires Private Wire network to maximise cost effectiveness.

Combined Cooling Heat and Power (CCHP)

- CCHP is a CHP system which additionally has the facility to transform heat into energy for cooling. This is done with an absorption chiller which utilises a heat source to provide the energy needed to drive a cooling system. As absorption chillers are far less efficient than conventional coolers (CoP of 0.7 compared to >4) they are generally only used where there is a current excess generation of heat. New CHP systems are generally sized to provide the year round base heating load only.
- For this reason it is generally not suitable for new CHP systems to include cooling.
- Where there are high thermal loads, CCHP can be used within district heating and cooling networks to supply the required heat and cooling.
- **Performance and Calculation Methodology: -** Most commonly sized on the heat load of a development, not the electrical load. This prevents an over-generation of heat.
  - Require a high and relatively constant heat and cooling demand to be viable.

- CCHP systems are best suited to providing the base loads of a development with conventional gas boilers and chillers responding to the peak demands. CCHP systems are not able to effectively respond to peaks in demand.
- In general, CHP engines have an electrical efficiency of ~30% and a thermal efficiency of ~45%.
- Absorption chillers have a CoP of ~0.7.
- Electricity produced by the CHP engine displaces grid electricity which is given a carbon intensity of 0.568 kg per kWh.

- **Capital Cost: -** High in comparison to biomass boilers and increased further by inclusion of absorption chiller.
  - Relative cost reduces as the size of engine increases.
- **Running Costs/Savings: -** CHP engines often struggle to provide cost-effective energy to dwellings on residential schemes.
  - Running costs and maintenance are higher than for domestic gas boilers.
  - Needs Private Wire supply for economic case to be positive.
- **Land Use Issues and Space Required: -** CHP engines require a plant room, and possibly an energy centre for large residential developments.
  - CHP engines require a flue to effectively disperse pollutants. The height of the chimney required is dependent on the size of the engine installed. Additionally the absorption chiller requires either a cooling tower or dry cooler bed for heat rejection purposes.
  - Heat network issues.
- **Operational Impacts/Issues: -** Required to be run by an ESCo who are unenthusiastic about getting involved in small – medium scale schemes.
  - Issues with rights to dig up roads for heat networks.
  - Emissions of nitrous oxides – ~1000mg/kWh – 20 times higher than for gas boilers.
- **Embodied Energy: -** Comparable to conventional gas boilers.
- **Funding Opportunities: -** Tax relief for businesses under Enhanced Capital Allowance scheme.
- **Reductions in Energy Achievable: -** Can provide some reductions in effective primary energy, but when distribution and other local losses are included, more fuel is required.
- **Reductions in CO_2 Achievable: -** Can provide greater reductions in CO_2 than energy, aided by the emissions factor of grid displaced electricity of 0.568 kg CO_2/kWh.
- **Advantages: -** Good reductions in overall primary energy and CO_2 emissions.
- **Disadvantages: -** More expensive and greater emissions of NO_x than biomass.

- Often do not supply energy cost-effectively in comparison to the market.
- Requires Private Wire network to maximise cost effectiveness.

Biomass Boilers

- Biomass boilers generate heat on a renewable basis as they are run on biomass fuel which is carbon neutral. Fuel is generally wood chip or wood pellets. Wood pellets are slightly more expensive than wood chips but have a significantly higher calorific value and enable greater automation of the system.
- Can be used with district heating networks or as individual boilers on a house-by-house basis.
- **Performance and Calculation Methodology: -**
  - Biomass boilers are best suited to providing the base heating load of a development (~year round hot water demand) with conventional gas boilers responding to the peak heating demand (~winter space heating).
  - Operate with an efficiency of 87-91%.
  - Small models available.
  - Conflicts with CHP they are both best suited to providing the base heating load of a development. As such they should not be installed in tandem unless surplus hot water capacity is available. Special control measures would be required in this case.
- **Capital Cost: -** Low in comparison to CHP.
  - More suitable to smaller developments than CHP as installed cost is lower.
- **Running Costs/Savings: -** Biomass fuel is more expensive than gas and as such heat being provided to dwellings is generally more expensive than the market.
- **Land Use Issues and Space Required: -** Biomass boilers require a plant room and possibly separate energy centre for large residential developments.
  - Require a flue to effectively disperse pollutants. The height of the chimney required is dependent on the size of the boiler installed.
  - Fuel store will be required. This should be maximised to reduce fuel delivery frequency.
  - Space must be available for delivery vehicle to park close to plant room.
  - Heat network issues.
- **Operational Impacts/Issues: -** Normally run on biomass, but can also work with biogas.
  - Require some operational support and maintenance.
  - Fuel deliveries required.
  - Boiler and fuel store must be sited in proximity to space for delivery vehicle to park.

- Issues with rights to dig up roads, etc (for heat networks).
- Emissions of nitrous oxides – ~80-100mg/kWh.

- **Embodied Energy: -** Comparable to conventional gas boiler.
- **Funding Opportunities: -** The Bio-energy Capital Grants Scheme offers grants of up to 40% of the difference between the installed cost of biomass boiler and the cost of the fossil fuel alternative to the industrial, commercial and community sectors.
- **Reductions in Energy Achievable: -** No reduction in energy demand, but energy generated from a renewable fuel. Significant long term running costs (fuel).
- **Reductions in CO_2 Achievable: -** Can provide significant reductions in CO_2, but generally limited by the hot water load (base heating load).
- **Advantages: -** Reductions in CO_2 at low installed cost.
- **Disadvantages: -** High long-term running costs.
  - Often do not supply energy cost-effectively in comparison to gas boilers.

Solar Thermal Panels

- Solar Thermal Heating Systems contribute to the hot water demand of a dwelling or building. Water or glycol (heat transfer fluid) is circulated to roof level where it is heated using solar energy before being returned to a thermal store in the plant room where heat is exchanged with water from the conventional system. Due to the seasonal availability of heat, solar thermal panels should be scaled to provide no more than 1/2 of the hot water load.
- Can also be used to provide energy for space heating in highly insulated dwellings.
- There are two types of solar thermal panel: evacuated tube collectors and flat plate collectors.
- **Performance and Calculation Methodology: -**
  - Evacuated Tube Collectors: ~60% efficiency.
  - Flat Plate Collectors: ~50% efficiency.
  - SAP Table H2 used for solar irradiation at different angles.
  - Operate best on south facing roofs angled at 30-45^0 and free of shading, or on flat roofs on frames. East/West facing panels suffer a loss in performance of 15-20% depending on the angle of installation.
  - Flat plate collectors cannot be installed horizontally as this would prevent operation of the water pump. Must therefore be angled and separated to avoid overshadowing each other.
  - SAP limits benefit to a ~10-12% reduction in regulated CO_2 over baseline.

- **Capital Cost: -** Typically £2,500 per 4m^2 plus installation. Costs higher for evacuated tubes than flat plate collectors.
- **Running Costs/Savings: -** Reduce reliance on gas and therefore reduce costs.
  - Payback period of ~20 years per dwelling.
- **Land Use Issues and Space Required: -** Installed on roof so no impact on land use.
  - Due to amount of roof space required and distance from tank to panels, less suitable for dense developments of relatively high rise flats.
  - Within permitted development rights unless in a conservation area where they must not be visible from the public highways.
  - Dormer and Velux windows may conflict if energy/CO_2 reduction required is large.
- **Operational Impacts/Issues: -** Biggest reductions achieved by people who operate their hot water system with consideration of the panels.
- **Embodied Energy: -** Carbon payback is ~2 years.
- **Funding Opportunities: -** none
- **Reductions in Energy Achievable: -** Reduce primary energy demand by more per standard panel area than solar PV panels.
- **Reductions in CO_2 Achievable: -** Comparable to solar PV per m^2.
- **Advantages: -** Virtually free fuel, low maintenance and reductions in energy/CO_2.
- **Disadvantages: -** Benefits limited to maximum ~50% of hot water load.

Solar Photovoltaic (PV) Panels

- Solar PV panels generate electricity by harnessing the power of the sun. They convert solar radiation into electricity which can be used on site or exported to the grid in times of excess generation.
- **Performance and Calculation Methodology: -**
  - The best PV panels operate with an efficiency approaching 20%. ~7m^2 of these high performance panels will produce 1kWp of electricity.
  - Operate best on south facing roofs angled at 30-45^0 or on flat roofs on frames. Panels orientated east/west suffer from a loss in performance of 15-20% depending on the angle of installation.
  - Must be free of any potential shading.
  - Cannot be installed horizontally as would prevent self-cleaning. Must therefore be angled and separated to avoid overshadowing each other.

  - Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg CO_2 per kWh.
- **Capital Cost: -** ~£5,500 – £6,500 per kWp depending on performance of panels.
- **Running Costs/Savings: -** Reduce reliance on grid electricity and therefore reduce running costs.
  - At current electricity prices, payback period of ~60-70 years per dwelling.
  - Feed-in tariff and Renewables Obligation Certificates (ROCs) payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -** Installed on roof so no impact on land use.
  - Due to amount of roof space required are less suitable for dense developments of relatively high rise flats.
  - Within permitted development rights unless in a conservation area where they must not be visible from the public highways.
  - Dormer and Velux windows may conflict if energy/CO_2 reduction required is large.
- **Operational Impacts/Issues: -** Proportionately large arrays may need electrical infrastructure upgrade.
  - Virtually maintenance free and panels are self cleaning at angles in excess of 10 degrees.
- **Embodied Energy: -** Carbon payback of 2-5 years.
- **Funding Opportunities: -** Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable: -** Reduce energy demand by less per m^2 than solar thermal panels.
- **Reductions in CO_2 Achievable: -** Provide greater percentage reductions in CO_2 than energy. Comparable to solar thermal per square metre.
- **Advantages: -** Virtually free fuel, very low maintenance and good reductions in CO_2.
- **Disadvantages: -** More expensive than solar thermal.
  - Slightly greater loss in performance than solar thermal panels when orientated away from south.

Ground Source Heat Pumps (GSHPs)

- Ground Source Heat Pumps work in much the same way as a refrigerator, converting low grade heat from a large ‘reservoir’ into higher temperature heat for input in a smaller space. Electricity drives the pump which circulates a fluid (water/antifreeze mix or refrigerant) through a closed loop of underground pipe. This fluid absorbs the solar energy that is stored in the earth (which in the UK remains at a near constant temperature of 12^{o}C throughout the year) and carries it to a pump. A compressor in the heat pump upgrades the temperature of the fluid which can then be used for space heating and hot water.

- **Performance and Calculation Methodology: -** System requires electricity to drive the pump. Therefore displaces gas heating with electric, which has a higher carbon intensity (gas: 0.194; electricity: 0.422).
  - As they are upgrading heat energy from the earth, GSHPs operate at 'efficiencies' in excess of 350%. This is limited in SAP.
  - Due to the lower temperature of the output of GSHPs compared to traditional gas boilers, GSHPs work best in well insulated buildings and with underfloor heating. They can, however, also be installed with oversized radiators, albeit with a consequent reduction in performance
- **Capital Cost: -** ~£7,500 per house. Additional costs if underfloor heating is to be installed.
- **Running Costs/Savings: -** Electricity more expensive than gas, thus fuel costs not reduced as much as energy is reduced.
  - Payback period of ~20 years per dwelling.
- **Land Use Issues and Space Required: -** Require extensive ground works to bury the coils that extract the low grade heat from the earth. They therefore require a large area for horizontal burial (40-100m long trench) or a vertical bore (50-100m) which is considerably more expensive but can be used where space is limited.
  - Must be sized correctly to prevent freezing of the ground during winter and consequent shutdown of the system.
  - May require planning permission for engineering works. Once buried, there is no external evidence of the GSHPs.
- **Operational Impacts/Issues: -** Work best in well insulated houses.
  - Need immersion for hot water.
  - Highly reliable and require virtually no maintenance.
  - Problems if ground bore fails.
- **Embodied Energy: -** Low, but as gas is being replaced with the more carbon intensive electricity, carbon payback is slowed. Carbon payback depends on CoP.
- **Funding Opportunities: -** none.
- **Reductions in Energy Achievable: -** Reduce energy demand by less per m^2 than solar thermal panels.
- **Reductions in CO_2 Achievable: -** Provide greater %age reductions in CO_2 than energy. Comparable to solar thermal (esp. in SAP).

- **Advantages: -** Large reductions in Energy. Currently receives benefit from SAP of an electrical baseline rather than gas.
- **Disadvantages: -** Small reduction in CO_2. CoP limited in SAP. Only small cost savings.

Air Source Heat Pumps (ASHPs)

- Air Source Heat Pumps work in much the same way as a refrigerator, converting low grade heat from a large 'reservoir' into higher temperature heat for input into a smaller space. Electricity drives the pump which extracts heat from the air as it flows over the coils in the heat pump unit. A compressor in the heat pump upgrades the temperature of the extracted energy which can then be used for space heating and hot water.
- Generally ASHPs are air-to-water devices but can also be air-to-air.
- **Performance and Calculation Methodology: -** System requires electricity to drive the pump. Therefore displaces gas heating with electric, which has a higher carbon intensity (gas: 0.194; electricity: 0.422).
  - Performance defined by the Coefficient of Performance (CoP) which is a measure of electricity input to heat output. However, the concept of a CoP must be treated with caution as it is an instantaneous measurement and does not take account of varying external conditions throughout the year.
  - As they are upgrading heat energy from the air, ASHPs operate at 'efficiencies' in excess of 250%. This is limited in SAP.
  - British winter conditions (low temperatures and high humidity) lead to freezing of external unit. Reverse cycling defrosts the ASHP, but can substantially reduce performance when it is most needed. Performance under these conditions varies considerably between models. Vital that ASHP that has been proven in British winter conditions is installed.
  - Due to the lower temperature of the output of ASHPs compared to traditional gas boilers, ASHPs work best in well insulated buildings and with underfloor heating. They can, however, also be installed with oversized radiators, albeit with a consequent reduction in performance.
- **Capital Cost: -** ~£2,000 per house.
- **Running Costs/Savings: -** Electricity more expensive than gas, thus fuel costs not reduced as much as energy is reduced.
  - Payback period of ~10 years per dwelling.

- **Land Use Issues and Space Required: -** No need for external ground works, only a heat pump unit for the air to pass through.
    - Minimal external visual evidence.
- **Operational Impacts/Issues: -** Work best in well insulated houses.
    - Unit must be sized correctly for each dwelling.
    - Vital that ASHP model selected has been proven to maintain performance at the low temperature and high humidity conditions of the British winter.
    - May need immersion for hot water.
    - Highly reliable and require virtually no maintenance.
- **Embodied Energy: -** Low. Carbon payback longer than for GSHPs as the CoP is lower.
- **Funding Opportunities: -** none
- **Reductions in Energy Achievable: -** Large reductions in energy demand. Less so than GSHPs.
- **Reductions in CO_2 Achievable: -** Provide smaller percentage reductions in CO_2 than energy. Less than GSHPs.
- **Advantages: -** Large reductions in Energy. Currently receives benefit from SAP of an electrical fuel factor rather than a gas baseline.
- **Disadvantages: -** Small reduction in CO_2. CoP limited in SAP. Only small cost savings.

Wind Power

- Wind energy installations can range from small domestic turbines (1kW) to large commercial turbines (140m tall, 2MW). There are also different designs and styles (horizontal or vertical axis; 1 blade to multiple blades) to suit the location. They generate clean electricity that can be provided for use on-site, or sold directly to the local electricity network
- **Performance and Calculation Methodology: -** Power generated is proportional to the cube of the wind speed. Therefore, wind speed is critical.
    - Horizontal axis turbines require >~6m/s to operate effectively and vertical axis turbines require >~4.5m/s. The rated power of a turbine is often for wind speeds double these figures.
    - Wind speeds for area from BERR's Wind Speed Database.
    - Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg/kWh.
- **Capital Cost: -** ~£1,000 per kW. Smaller models are more expensive per kW.
    - Vertical axis turbines more expensive than horizontal.

- **Running Costs/Savings: -** Reduce reliance on grid electricity and therefore reduce costs.
  - Payback period of ~15-20 years per dwelling.
  - Feed-in tariff and ROC payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -** Smaller models (<6kW) can be roof mounted.
  - Must be higher than surrounding structures/trees.
  - Planning permission required.
- **Operational Impacts/Issues: -** Urban environments generally have low wind speeds and high turbulence which reduce the effectiveness of turbines.
  - Vertical axis turbines have a lower performance than horizontal axis turbines but work better in urban environments.
  - Annual services required.
  - Turbines rated in excess of 5kW may require the network to be strengthened and arrangements to be made with the local Distribution Network Operator and electricity supplier.
  - Noise.
- **Embodied Energy: -** Carbon payback is ~1 year for most turbines.
- **Funding Opportunities: -** Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable: -** Significant reduction in reliance on grid electricity.
- **Reductions in CO_2 Achievable: -** Good. Greater reduction in CO_2 than PV for same investment.
- **Advantages: -** Virtually free fuel; reductions in CO_2.
- **Disadvantages: -** Expensive, although cheaper than PV for same return.
  - Lack of suitable sites.
  - Maintenance costs.
  - Often not building integrated.

Hydro Power

- Hydro power harnesses the energy of falling water, converting the potential or kinetic energy of water into electricity through use of a hydro turbine. Micro hydro schemes (<100kW) tend to be ‘run-of-river’ developments, taking the flow of the river that is available at any given time and not relying on a reservoir of stored water. They generate clean electricity that can be provided for use on-site, or sold directly to the local electricity network.
- **Performance and Calculation Methodology: -**

  - Flow rates at particular sites from National River Flow Archive held by Centre for Ecology and Hydrology.
  - Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg/kWh.
- **Capital Cost: -** £3,000 - £5,000 per kW.
  - Particularly cost effective on sites of old water mills where much of the infrastructure is in place.
- **Running Costs/Savings: -** Reduce reliance on grid electricity and therefore reduce costs.
  - Payback period of ~10-15 years per dwelling
  - Feed-in tariff and ROC payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -** Require suitable water resource.
  - Visual intrusion of scheme.
  - Special requirements where river populated by migrating species of fish.
  - Planning permission will require various consents and licences including an Environmental Statement and Abstraction Licence.
- **Operational Impacts/Issues: -** Routine inspections and annual service required.
  - Automatic cleaners should be installed to prevent intake of rubbish.
- **Embodied Energy: -** Carbon payback for small schemes of ~1 year.
- **Funding Opportunities: -** Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable: -** significant reduction in reliance on grid electricity.
- **Reductions in CO_2 Achievable: -** High.
- **Advantages: -** Virtually free fuel, reductions in CO_2.
- **Disadvantages: -** Expensive, but good payback period.
  - Lack of suitable sites.
  - Planning obstructions.

Appendix E: Low and Zero Carbon Energy Technologies Feasibility Table

Feasibility Study Table

Technology	Sufficient Energy Generated?	Payback	Land Use Issues	Local Planning Requirements	Noise	Carbon Payback	Available Grants	Feasible?	Reason not Feasible or Selected
Combined Heat & Power (CHP)	**Yes**	**Medium**	**Air quality in residential area**	**None**	**In Plant Room**	**Yes**	**Tax Relief - ECA**	**Yes**	**Selected**
Biomass	Yes	None	Air quality in residential area	Encouraged for large scale developments	In Plant Room	Yes	Bio-energy Capital Grants Scheme	Yes	Conflicts with CHP
Solar Thermal	Yes	High	Sufficient roof space required	Encouraged	None	~2 years	None	Yes	Conflicts with CHP
Solar Photovoltaic (PV)	Yes	High	Sufficient roof space required	Encouraged	None	2-5 years	None	Yes	Economically unviable compared to CHP engine
Ground Source Heat Pumps (GSHPs)	Yes	High	Requires large area for coils or borehole	Encouraged	None	Low	None	Yes	Conflicts with CHP
Air Source Heat Pumps (ASHPs)	Yes	Very High	Visual intrusion of external units	None	Low	Low	None	Yes	Conflicts with CHP
Wind Power	No	Low	Urban Area - low and turbulent wind; Visual impact	Encouraged for large scale developments	Yes	~1 year	None	No	Wind speeds in urban areas generally insufficient
Hydro Power	No	Medium	Requires suitable water resource; Visual impact	None	Low	~1 year	None	No	-