PRP

St Michael's Convent, Ham Common

Energy Statement

September 2016

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Architecture
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Project	St Michael's Convent, Ham Common
PRP Reference	AE6250
Location	Ham, London
Local Authority	London Borough of Richmond upon Thames
Client	Beechcroft Developments Ltd
Issue	Final for Planning
Author	Anthony Briden
Checked by	Filipa Fonte
Date	5 September 2016

Disclaimer: The performances of renewable systems, especially wind and solar, are difficult to predict with full certainty. This is due to the variability of environmental conditions from location to location and from year to year. As such all budget/cost and figures, which are based upon the best available information, are to be taken as an estimation only and should not be considered as a guarantee. Final specification must be provided by an M & E consultant after RIBA stage 3.

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Executive Summary

PRP has been appointed by Beechcroft Developments Ltd to produce an Energy Statement identifying how the proposed developments at St Michael's Convent, Ham, will address the policies set out by the London Plan, and the London Borough of Richmond upon Thames. In line with these policies, the developments must achieve a 35% reduction in CO_2 emissions over the Building Regulations Approved Document Part L (ADL) (2013) baseline and a 20% CO_2 emission reduction through the use of renewable energy.

The project is located in Ham, London Borough of Richmond upon Thames, and consists of the following new-build elements:

Application 1 – Ham Common

- 3 apartments in new extension to retained building;
- 15 new houses across the site;
  Total 18 new units.

Application 2 – Martingales Close

- 2 new houses, next to the orchard
  Total 2 new units

The strategy is based on the Mayor of London's Energy Hierarchy, as follows:

- Use less energy (be lean)
- Supply energy efficiently (be clean) and
- Use renewable energy (be green).

Proposed energy efficiency measures include a well-insulated building fabric, high levels of air tightness, and attention to thermal bridging details.

The communal parts of the development (circulation space) will have the same fabric specification as the rest of the building.

These measures are sufficient to provide improvements over Approved Document Part L (2013) Building Regulations emissions for dwellings in both Application 1 and 2.

The addition of a total of 30 kWp PV will further reduce CO_2 emissions to a total CO_2 emission reduction of 35% beyond Approved Document Part L (2013) requirements.

These proposals satisfy the CO_2 emission reduction and renewable energy requirements for the St Michael's Convent developments.

The proposal seeks two separate planning permissions for the following new units:

Application 1 – Ham Common

- 3 apartments in new extension to retained building;
- 15 new houses across the site;
  Total 18 new units.

The following chart and table summarise CO_2 emission reductions following this strategy:

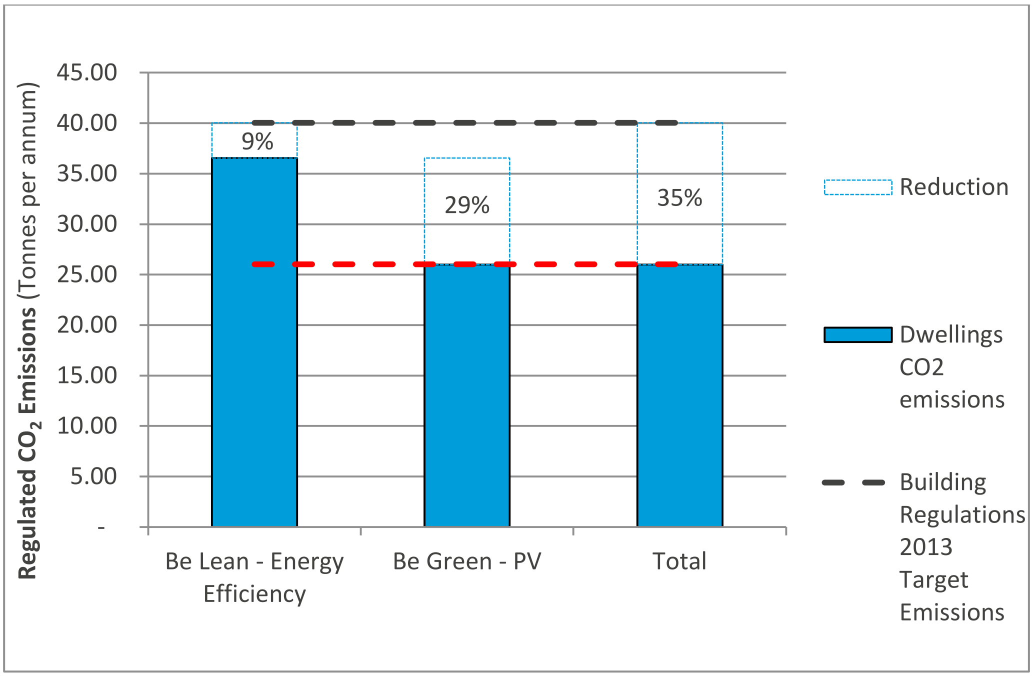

Figure 1 - *CO_2 Emissions*

Table 1 - *CO_2 Emissions and savings after each stage of the Energy Hierarchy*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		Dwelling Regulated Carbon Dioxide Savings (tonnes CO_2 per annum)	(%)
Building Regulations 2013 Part L Compliant Development	40.0	-	-	-
After Energy Demand Reduction	36.5	Savings from energy demand reduction	3.5	9%
After Renewable Energy (PV)	26.0	Savings from renewable energy	10.5	29%
		Total Cumulative Savings	**14.0**	**35%**

Application 2 – Martingales Close

- 2 new houses, next to the orchard
  Total 2 new units

The following chart and table summarise CO_2 emission reductions following this strategy:

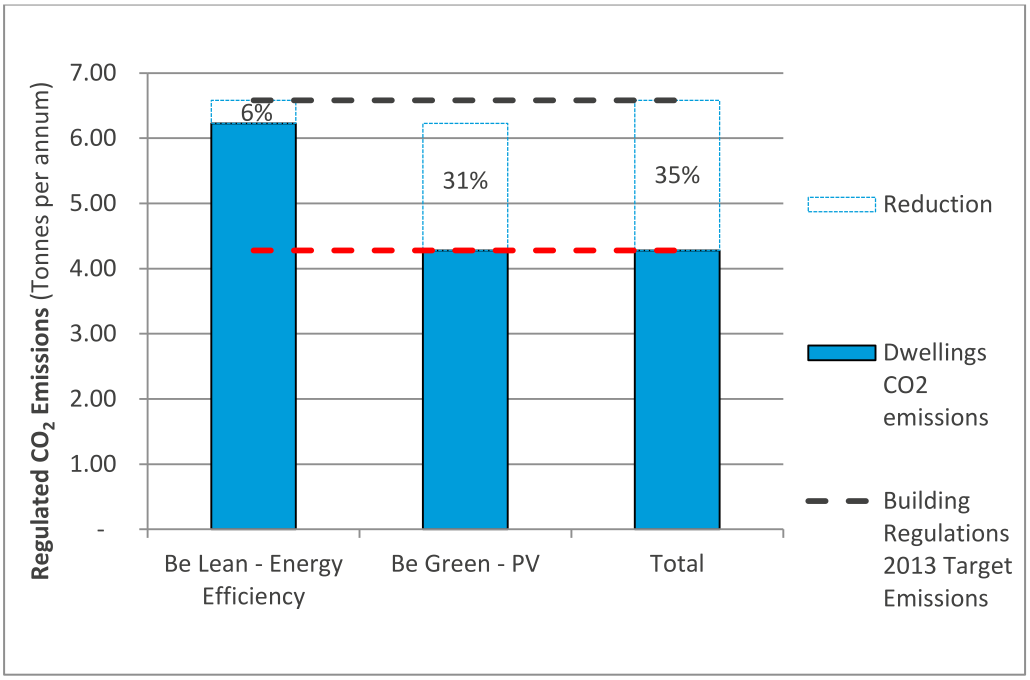

Figure 2 - *CO_2 Emissions*

Table 2 - *CO_2 Emissions and savings after each stage of the Energy Hierarchy*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)	Dwelling Regulated Carbon Dioxide Savings		
			(tonnes CO_2 per annum)	(%)
Building Regulations 2013 Part L Compliant Development	6.6	-	-	-
After Energy Demand Reduction	6.2	Savings from energy demand reduction	0.4	6%
After Renewable Energy (PV)	4.3	Savings from renewable energy	1.9	31%
		Total Cumulative Savings	**2.3**	**35%**

1. Introduction

1.1 PRP has been appointed by Beechcroft Developments Ltd to produce an Energy Statement identifying how the proposed development at St Michael's Convent, Ham, will address the policies set out by the London Plan, and the London Borough of Richmond. In line with these policies, the development must achieve a 35% reduction in CO_2 emissions over the Building Regulations Approved Document Part L (2013) baseline.

1.2 The proposal seeks two separate planning permissions for the following new units:

Application 1 – Ham Common

- 3 apartments in new extension to retained building;
- 15 new houses across the site;
  Total 18 new units.

Application 2 – Martingales Close

- 2 new houses next to the orchard
  Total 2 new units

1.3 The development also includes refurbishing and converting the Orford House listed building and coach house. This refurbishment falls under Building Regulations Approved Document Part L2B (2013) [ADL2B (2013)] - Conservation of fuel and power in existing buildings other than dwellings and therefore does not form part of this Energy Statement.

1.4 In support of this application, and in accordance with London Borough of Richmond upon Thames requirements, the energy strategy is based on the Energy Hierarchy, as follows:

- Use less energy (be lean)
- Supply energy efficiently (be clean) and
- Use renewable energy (be green).

1.5 Passive design and energy efficient features are considered paramount for reducing energy demand. The proposed energy efficiency measures include a well-insulated building fabric. These measures will go some way towards achieving compliance, however Low or Zero-Carbon (LZC) energy technologies will be required.

1.6 The strategy is based on information provided by the project design team.

1.7 The embodied energy of the development is beyond of the scope of this report. The focus will be on delivered energy demand.

Site Location and Development Proposal

1.8 The St Michael's Convent site is mainly occupied by Orford House (the original part of the main house), which was built between 1730 and 1734 and is now a Grade II listed building. It has been the home of the Community of the Sisters of the Church and is in their ownership since 1949. In addition to the main house, there is also a small Coach House and some outbuildings around the walled garden.

Figure 3- *Aerial Photograph of Site (red outline)*

1.9 The development proposals by Beechcroft Developments include the construction of new dwellings, as detailed below:

Application 1 – Ham Common

1.10 This planning application will cover the proposed 18No. new dwellings on the site.

1.11 Several new houses are proposed. These will be mainly located at the centre of the grounds and around the walled garden. Additional dwellings are proposed off the main building. Block F and E are two parallel rows, where 2No. 2bed dwellings will be created. These will be 1 storey high with a proportion of green roof. Off the walled garden (perpendicularly adjacent to it) 3 more rows of houses will be built (Blocks D and H). Block D will be a mews type of arrangement, 2 storeys high, with all houses being 2 double bed plus an office space and double pitch roofs. Block H will be similar to Block F and E with a full green roof. Blocks C and I are located along the East site boundary and are connected to the main building. These are similar to the houses in Block D.

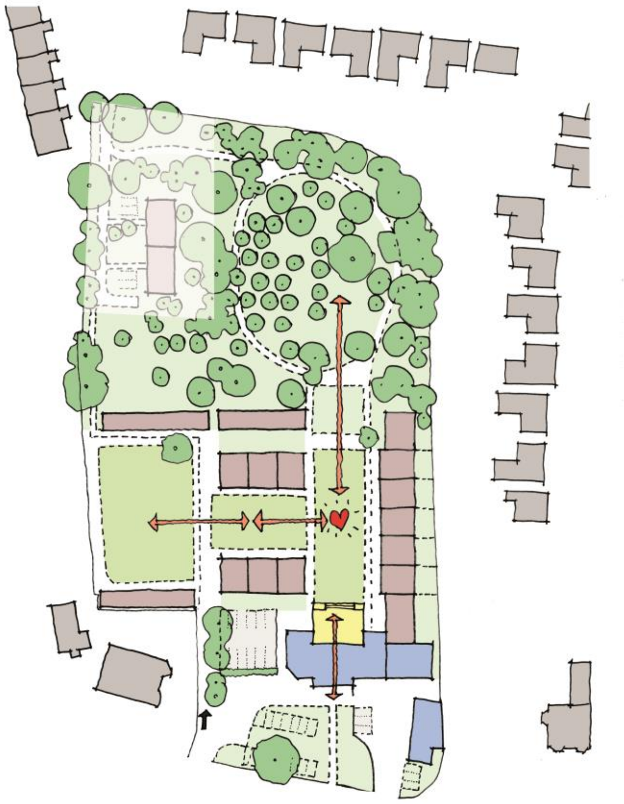

Figure 4 - *Application 1 – Ham Common*

Application 2 – Martingales Close

1.12 The second planning application proposes the construction of 2No.new houses (Stable Block) between the orchard and the site's West border.

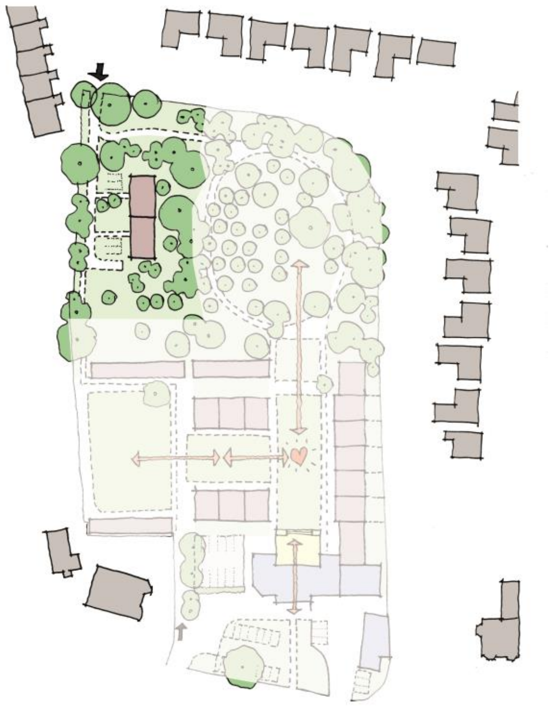

Figure 5 - *Application 2 – Martingales Close*

2. Planning Policy Guidance and Legislation

2.1 The following policies, and targets, will apply to the development;

National

- Building regulations Part L1 A and L2 A (2013)

London Plan

- Policy 5.2 - Minimising CO_2 emissions - 35% CO_2 emission reduction over Building Regulations Part L (2013)

London Borough of Richmond upon Thames

- Policy DM SD 1 - Sustainable Construction - Developments must achieve a minimum 40 per cent[1] improvement over Building Regulations (2010) from 2013 to 2016.

- Policy DM SD 2 - Renewable Energy and Decentralised Energy Networks - The Council encourages developers to achieve a 20 per cent reduction in total site CO_2 emissions from the use of on-site renewable energy

[1] This policy mirrors that of the London Plan policy 5.2 and will be applied as a 35% reduction over the newer Building Regulations Part L (2013)

3. Energy Modelling

Approach

3.1 Passive measures to improve the thermal performance of the building fabric focus on specifying higher levels of insulation for the roof, external walls and floor, and high performance windows and doors. Other important measures include targeting lower air permeability and minimising thermal bridges through best practice detailing. A recommended specification is provided in Section 4.12 of this report.

3.2 Efficient energy use and distribution is assured by specifying an efficient heating system and controls.

3.3 The development will generate a proportion of its energy needs through built-on-site-carbon technologies.

Methodology

3.4 Government approved software (NHER Plan Assessor 6.2.0) has been used to calculate energy consumption and CO_2 emissions based on current Standard Assessment Procedure (SAP) methodology (2012) for all self-contained dwellings within the proposed development.

3.5 CO_2 emissions are reported according to Part L (2013), which compares CO_2 emissions from regulated energy use (DER) with those of an equivalent building built to Part L 2013 (TER). This does not include cooking or appliances.

3.6 A representative sample (15 dwellings - 83% for Ham Common and 1 dwelling -50% for Martingales Close) were modelled and the results extrapolated to provide the proposed developments total CO_2 emissions as designed following the application of energy efficiency measures (including efficient heating and hot water systems).

3.7 Three stages of calculation are made by:

- The base case total CO_2 emissions and energy demand for the development modelled as complying with AD L1A (2013) using SAP (2012) methodology with an allowance for cooking and appliances - before the application of energy demand reduction measures.
- The proposed development total CO_2 emissions as designed following the application of the energy efficiency measures (including efficient heating and hot water systems).
- The proposed development total CO_2 emissions as designed following the application of energy efficiency measures, efficient heating and the LZC technologies considered (PV), up to levels required to meet the targets.

4. Energy Hierarchy Development

Baseline Energy Demand

4.1 Baseline energy demand assessment is based on a development with identical geometry built to meet Building Regulations, thus using standard building fabric parameters and notional heating systems.

Application 1 – Ham Common

4.2 Energy modelling using SAP (2012) shows that base CO_2 emissions from the development are approximately 40,000 kg CO_2/pa.

Application 2 – Martingales Close

4.3 Energy modelling using SAP (2012) shows that base CO_2 emissions from the development are approximately 6,600 kg CO_2/pa.

Energy Efficiency

4.4 Energy demand will be curbed by incorporating measures including high levels of thermal insulation, detailing to reduce air permeability and thermal bridging, and low-energy lighting. The following sections outline the energy efficiency measures adopted for planning applications 1 and 2 for St Michael's Convent.

Passive Measures

4.5 The most cost-effective method of improving energy efficiency and reducing the long-term CO_2 emissions of a new development is through passive, low-energy design. Every unit of energy saved is equivalent to a unit of LZC energy generated, however passive design measures will help reduce the building's carbon footprint throughout its entire life, and thus they should be applied before LZC energy technologies are considered. St Michael's Convent has been designed to accommodate these passive measures.

4.6 To minimise the requirement for space heating it is essential to minimise heat loss through the building envelope.

4.7 In addition to heat loss through conduction, it is important to reduce uncontrolled convective heat loss due to air leakage and it has been assumed that St Michael's Convent will have a Design Air Permeability of no more than 4.0 $m^3/m^2/hr$ @ 50 Pa.

Heating System

4.8 Once energy demand has been addressed, the next step is to supply energy efficiently. In the case of heat, this relates to heat source efficiency, distribution losses, control system and heat emitters.

4.9 At the demand reduction (be lean) stage of the energy hierarchy, in order to isolate energy efficiency measures from heating system efficiency gains a typical outline specification of high efficiency gas boilers, have been assumed.

Ventilation, Cooling and Overheating

4.10 Mechanical cooling is not specified.

4.11 Mechanical Ventilation Heat Recovery (MVHR) will be specified in all dwellings - See Table 3 for details.

Specification

4.12 The following specification has been assumed in modelling the energy efficiency case:

Table 3 - *Energy efficient specification for the dwellings*

Element	Energy Efficiency Specification
Heat loss ground floor U-value (W/m^2K)	0.12
Semi exposed heat loss floors U-value (W/m^2K)	0.15
Roof U-value (W/m^2K)	0.12
Terrace U-value (W/m^2K)	0.15
External Wall U-value (W/m^2K)	0.15
Internal Walls next to unheated areas U-value (W/m^2K)	0.18
Party Walls U-value (W/m^2K) - fully filled and sealed	0
Whole window U-value (W/m^2K)	1.4
Front door U-value (W/m^2K)	1.5
Ventilation	MVHR with SFP ≤0.5 and efficiency ≥90 %
Air Permeability@50 Pa ($m^3/m^2/hr.$)	4 (All dwellings to be tested in the As-Built Stage.)
Thermal bridging	Accredited Construction Details (ACD) in all possible junction types; Thermal breaks for balconies.
Low energy lighting	100%
Air conditioning	No
Circulation Space	Unheated

4.13 It should be noted that the above specification is a recommendation only and may be subject to change at a later stage. Any change in this specification will affect the size of any LZCs and may necessitate the addition of renewable technology to ensure the building continues to meet the target.

4.14 Other modelling assumptions:

- 'Medium' Thermal mass has been assumed in the dwellings.
- Terrain: Low Rise Urban/Suburban
- Exposure: average
- Overshading (glazing): average/unknown
- No flues, open fireplaces, or flueless gas fires
- Water use - less than 125 litres/person/day

Energy Efficiency Results

4.15 The goal of assessing energy demand is to quantify building performance, and to establish a basis for comparison of LZCs in view of the CO_2 emissions reduction targets.

4.16 The calculation methodology used is similar to that for baseline energy demand and was outlined in Section 3 of this report.

4.17 The greatest gains in energy efficiency will be achieved for space heating. Lighting requirements will be slightly higher in the efficient case since glazing units with a higher thermal resistance will have a lower light transmittance.

Application 1 – Ham Common

4.18 The proposed development total CO_2 emissions as designed following the application of energy efficiency measures (including nominal heating and hot water systems) are shown below:

Table 4 - *CO_2 emissions and savings after fabric measures*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		Dwelling Regulated Carbon Dioxide Savings (tonnes CO_2 per annum)	(%)
Building Regulations 2013 Part L Compliant Development	40.0	-	-	-
After Energy Demand Reduction	36.5	Savings from energy demand reduction	3.5	9%

4.19 The total CO_2 emission from the proposed development following energy efficiency is 36,500 kg CO_2/annum.

Application 2 – Martingales Close

4.20 The proposed development total CO_2 emissions as designed following the application of energy efficiency measures (including nominal heating and hot water systems) are shown below:

Table 5 - *CO_2 emissions and savings after fabric measures*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		Dwelling Regulated Carbon Dioxide Savings (tonnes CO_2 per annum)	(%)
Building Regulations 2013 Part L Compliant Development	6.6	-	-	-
After Energy Demand Reduction	6.2	Savings from energy demand reduction	0.4	6%

4.21 The total CO_2 emission from the proposed development following energy efficiency is 6,200 kg CO_2/annum.

4.22 Since demand reduction measures alone do not result in a sufficient reduction in dwelling CO_2 emissions to achieve the emissions target when measured against Part L 2013 Building Regulations, additional low/zero-carbon technologies are required.

5. Heating Infrastructure

Application 1 and 2 – Ham Common and Martingales Close

5.1 A heat demand density of at least 50 kWh/m^2 is recommended as 'viable' within 'Decentralised energy capacity study Phase 1: Technical assessment'[2].

5.2 Following a fabric first approach, heat demand significantly reduces (hot water load remains constant). For the development at St Michael's Convent, heat demand will be significantly less than the 50 kWh/m^2 required for decentralised energy system viability.

5.3 The St Michael's Convent site has been designed to achieve a suitable unit mix for the site. In seeking to meet local policy and sustainability requirements, a number of key factors have been considered in the design. These include:

- Access requirements
- Amenity space
- Waste Storage
- Vehicular access

5.4 In conclusion given the nature of the St Michael's Convent site, its area, constraints of location and the various requirements noted above, this site is unsuitable for district heating. Individual boilers are being specified with the highest efficiencies which will eliminate heat losses often experienced with a district network.

5.5 Further Low and Zero Carbon (LZC) measures will be considered in section 6 below and in Appendix A.

[2] http://www.london.gov.uk/sites/default/files/de_study_phase1.pdf

6. Renewable Energy

6.1 In addition to the possibility of installing a communal heat network as detailed in section 5 above, the feasibility of installing other technologies has been explored, please refer to Appendix A below. In accordance with the findings detailed in Appendix A, none of the other considered technologies, represented feasible, cost-effective and appropriate to the end user alternatives. Photovoltaics (PV) are considered the best option for Application 1 and 2 to meet the policy requirements.

Photovoltaics (PV)

6.2 Following SAP (2012) methodology, it is calculated that PV arrays totalling approximately 30 kWp will reduce CO_2 emissions by 12,400 kg CO_2/yr. - sufficient to achieve the 35% CO_2 emission reduction target beyond the TER of ADL (2013).

6.3 For this development, the roofs are predominantly double pitched (there are some single pitch and flat roofs), as such PVs should ideally be mounted on the South facing roofs (it is possible to mount them on East to West facing roofs, although efficiency will decrease).

6.4 It is proposed that the PVs are integrated on the roofs. Therefore in combination with the proposed dark roof slates, the PVs visual impact will be significantly reduced. The PV arrays will be mounted at the angle of the roof pitch (> 10^o angle PV) we estimate that approximately 230m^2 of un-shaded roof area will be required to fit in the 30 kWp PV panels.

6.5 The following table shows the SAP (2012) modelling results for St Michael's Convent following energy efficiency, and the addition of 30 kWp PV to the development.

Application 1 – Ham Common

Table 6 - *CO_2 Emissions and savings - PV Case,* Ham Common

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		**Dwelling Regulated Carbon Dioxide Savings** (tonnes CO_2 per annum)	(%)
Building Regulations 2013 Part L Compliant Development	40.0	-	-	-
After Energy Demand Reduction	36.5	Savings from energy demand reduction	3.5	9%
After Renewable Energy (PV)	26.0	Savings from renewable energy	10.5	29%

Application 2 – Martingales Close

Table 7 - *CO_2 Emissions and savings - PV Case, Martingales Close*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		Dwelling Regulated Carbon Dioxide Savings (tonnes CO_2 per annum)	(%)
Building Regulations 2013 Part L Compliant Development	6.6	-	-	-
After Energy Demand Reduction	6.2	Savings from energy demand reduction	0.4	6%
After Renewable Energy (PV)	4.3	Savings from renewable energy	1.9	31%

7. Carbon offsetting

7.1 The Greater London Authority guidance on preparing energy assessments (March 2016) provides specific guidance for the event that it is not feasible that a development meets the CO_2 emission targets.

7.2 As St Michael's Convent has been designed to meet all of the relevant planning and Building Regulations carbon reduction targets using on site measures alone, offsetting arrangements should not be necessary to comply with planning requirements.

7.3 Available roof area, utilising the least visible accessible roof areas should be sufficient to accommodate the required PV arrays, however it may be that additional factors relating to the conservation area status of the site may reduce available roofspace for PV. In this case it may be necessary to offset any CO_2 emission shortfall.

8. Conclusion

Application 1 – Ham Common

8.1 Following the energy hierarchy, the proposed energy demand reduction measures will provide a 9% improvement over ADL (2013) Building Regulations emissions, which is equivalent to 3,500 kg CO_2/yr. This is achieved with thermal envelope improvements as detailed in Section 4, as well as energy efficient heating and hot water systems and controls.

8.2 The installation of roof mounted PV arrays totalling 25 kWp will be sufficient to reduce CO_2 emissions by 10,500 kg CO_2/yr, which in addition to the CO_2 emission reductions resulting from the energy demand reduction measures is sufficient to achieve the 35% CO_2 emission reduction target beyond the Target Emission Rate (TER) of ADL (2013). The following chart and table summarise the CO_2 emission reductions following this strategy.

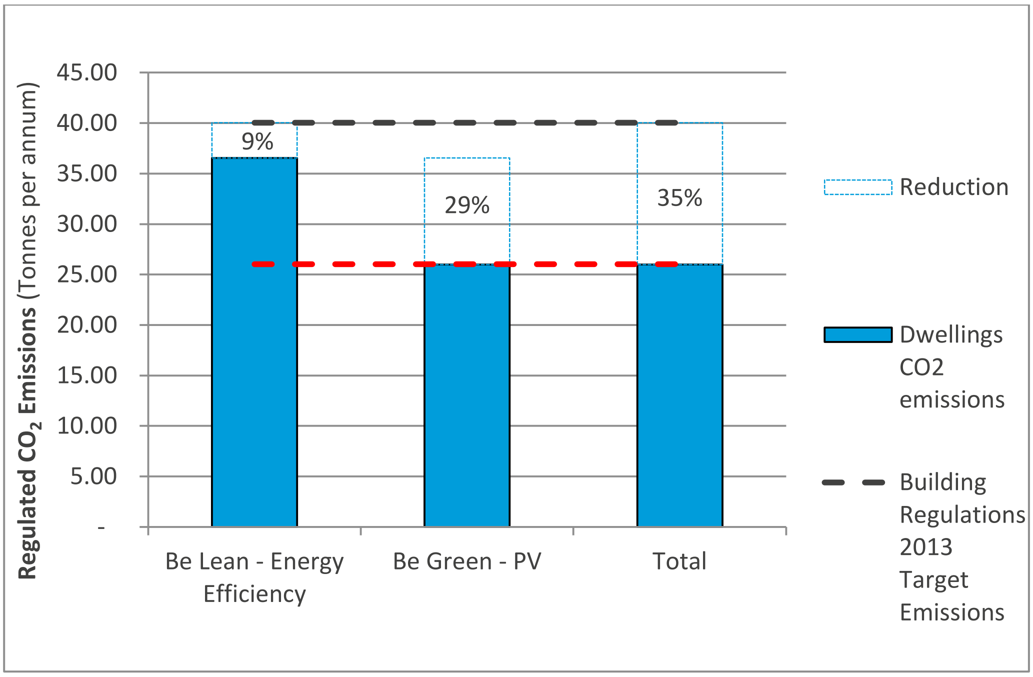

Figure 6 - *CO_2 Emissions*

Table 8 - *CO_2 Emissions and savings after each stage of the Energy Hierarchy*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		Dwelling Regulated Carbon Dioxide Savings (tonnes CO_2 per annum)	(%)
Building Regulations 2010 Part L Compliant Development	40.0	-	-	-
After Energy Demand Reduction	36.5	Savings from energy demand reduction	3.5	9%
After Renewable Energy (PV)	26.0	Savings from renewable energy	10.5	29%
		Total Cumulative Savings	**14.0**	**35%**

Application 2 – Martingales Close

8.3 Following the energy hierarchy, the proposed energy demand reduction measures will provide a 6% improvement over ADL (2013) Building Regulations emissions, which is equivalent to 400 kg CO_2/yr. This is achieved with thermal envelope improvements as detailed in Section 4, as well as energy efficient systems and controls.

8.4 The installation of roof mounted PV arrays totalling 5 kWp will be sufficient to reduce CO_2 emissions by 1,900 kg CO_2/yr, which in addition to the CO_2 emission reductions resulting from the energy demand reduction measures is sufficient to achieve the 35% CO_2 emission reduction target beyond the TER of ADL (2013). The following chart and table summarise the CO_2 emission reductions following this strategy.

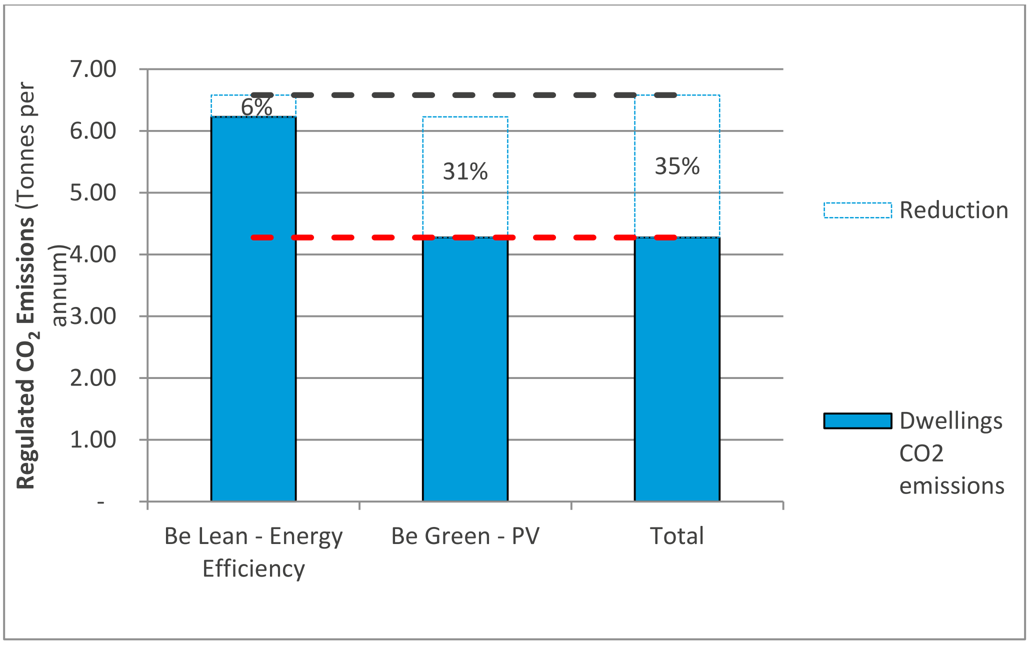

Figure 7 - *CO_2 Emissions*

Table 9 - *CO_2 Emissions and savings after each stage of the Energy Hierarchy*

	Dwellings Carbon Dioxide Emissions (tonnes CO_2 per annum)		Dwelling Regulated Carbon Dioxide Savings (tonnes CO_2 per annum)	(%)
Building Regulations 2010 Part L Compliant Development	6.6	-	-	-
After Energy Demand Reduction	6.2	Savings from energy demand reduction	0.4	6%
After Renewable Energy (PV)	4.3	Savings from renewable energy	1.9	31%
		Total Cumulative Savings	**2.3**	**35%**

8.5 These proposals satisfy the CO_2 emission reduction and renewable energy requirements for the St Michael's Convent developments.

Appendix A - Low or Zero Carbon Technologies

Solar Thermal

Application 1 and 2 - Ham Common and Martingales Close

Solar thermal collectors are the most efficient way to convert solar irradiation to usable energy. Panels heated by the sun supply hot water into a storage cylinder. During the summer the panels will typically meet all of the hot water demand, but at other times a secondary heating system (e.g. gas boiler) will top up the stored water.

A correctly sized system is designed to supply 40% - 50% of the hot water demands of a dwelling, and this therefore limits the maximum CO2 offset that can be achieved as a whole.

Expected panel lifetime is up to 30 years, with some component parts needing replacement more frequently. The antifreeze which is needed in the UK to prevent systems freezing, will need checking every 2 years, but should need replacement no more frequently than every 7-8 years.

The optimum pitch and orientation for solar panels in the UK is due south, at a tilt angle of 30-35 degrees. However, anywhere between SE and SW, and at an angle of between 20-60 degrees will not result in significant efficiency losses.

Shading the panels will cause efficiency to decrease in proportion to the shaded area.

Solar thermal collectors can be used in a communal heating arrangement for small blocks of flats or terraces, either by connecting the thermal array to a central thermal store (if centralised boiler plant) or by linking individual thermal stores in each flat into a network. The latter is the case if individual boilers are preferred; this would entail conventional system boilers rather than combi' units.

One of the considerations for the most appropriate technologies to be installed in either Application 1 site or Application 2 site, or both, was the visual impact that any proposed technology would have. This is due to both sites being located within a conservation area, the existence on site of a listed building and also the need to protect the existing habitats. Although solar thermal panels have changed significantly throughout the years, they are still less able to blend in against a roof than the PV panels are able to. The technology is a bit bulkier and thicker than the panels used in PVs. As such the visual impact of a solar thermal panel would be higher than the one that a PV panel is likely to have.

In addition, recent cost reductions in PV technology have produced the situation where PV is more cost effective for production of hot water than dedicated solar thermal, where immersion controllers are used. Relative maintenance costs also favour PV when used for this purpose.

Given the reasoning above solar thermal is not the recommended technology for either Application 1 or Application 2.

Biomass

Application 1 and 2 - Ham Common and Martingales Close

Biomass systems emit CO_2 during combustion, however the amount released will be re-absorbed through photosynthesis when the wood source is renewed, and so the fuel is sometimes referred to as “carbon-neutral”. Modern enclosed biomass-fuelled boilers can achieve an efficiency of 80-90%. Hence a biomass system can provide a cost-effective and CO_2-efficient method of producing space and water heating.

Many types of biomass can be used as fuel, including wood chips, wood pellets, switchgrass, rapeseed oil and others. Wood pellets are the most refined form of wood fuel, and are manufactured from a variety of sources including wood waste and sawdust. They have the highest and most consistent energy content and modern automated pellet boilers provide a viable alternative to fossil-fuelled systems.

All wood fuel requires dry storage. Wood chips must be aerated to prevent decomposition, and pellets require a fireproof, dry storage room or silo. In all cases, the storage area must be easily accessible by road to allow deliveries to be made. Pellet and chip boilers are usually fed automatically by an auger system. All systems generate ash which must be periodically removed. An additional consideration is the location of a flue, which must be at least as high as adjacent buildings.

Maintenance costs are greater than for a gas-fuelled boiler, due to the increased frequency of servicing. Fuel costs presently are competitive with natural gas.

Noise implications for biomass boilers stem more from fuel delivery than from the boilers themselves. If wood pellets are blown from a delivery lorry, the noise is comparable to a street sweeper. Depending on biomass fuel store capacity and delivery schedule, this could present a nuisance.

The combustion of solid biomass fuels has an impact on air quality due to relatively high emissions of fine particulate matter (PM2.5) and oxides of nitrogen (NOx). Emissions increase with the moisture content of the fuel.

The existence of a local, sustainable supplier of fuel is paramount for realising true CO2 reductions. It should also be considered where wood fuel comes from. On a small scale, biomass can be produced from local sources, however to ensure a secure fuel supply a larger supplier is preferred. There are few large scale wood pellet producers in the UK, and suppliers occasionally rely on imports.

A biomass system would be impractical for either Application 1 or 2.

Ground Source Heat Pumps (GSHP)

Application 1 and 2 - Ham Common and Martingales Close

GSHPs make use of the fact that at a given depth, soil temperature remains fairly constant year round (between 7-13°C at a depth of 1.5m and around 10°C at a depth of 20m). Heat is exchanged by means of a buried pipe network. It is then upgraded to useful heat for space heating (and hot water in some cases) by a compressor similar in size to a large floor mounted gas boiler.

Heat exchange pipework is installed either horizontally in trenches or vertically into boreholes, up to 100m deep. Vertical boreholes require a special auger, and are typically reserved for large commercial developments due to their high fixed costs. For Application 1 and Application 2 this solution would not be cost effective.

With a horizontal system, the collector pipework is laid ~1.8 m below the ground. A geotechnical survey is required to be undertaken as part of a feasibility assessment, since some soil types may be unsuitable.

A horizontal collector system typically requires use of a similar amount of land to the floor area of the building. Considering that the site is located on a conservation area, with several trees, an orchard and walled garden that are to be protected, the installation of a horizontal system would significantly put those areas at risk as the installation of the system would require many trees to be felled. It is also likely that there would be insufficient area available for the required collector system.

Individual GSHPs are relatively large compared to gas combi' boilers, and would not be considered suitable for use in the type of dwellings proposed for Application 1 site and even less for Application 2 site 2.

Air Source Heat Pumps (ASHP)

Application 1 and 2 - Ham Common and Martingales Close

Air source heat pumps (ASHP) work in a similar way to ground source heat pumps, but instead of taking heat from the ground, heat is absorbed from the air for space heating and hot water. Heat is passed through a heat exchanger in the heat pump, which operates in a similar way to a 'reverse' refrigerator. The heat pump raises the temperature of the fluid. This fluid, with an 'upgraded' temperature, can then be used for low temperature heating systems.

Even wintertime external air temperatures can provide enough heat for a pump to give flow temperatures of up to 65^{o}C although between 35^{o}C and 45^{o}C is more common. Due to low winter air temperatures in the UK, the CoP of most air source systems is lower than that of ground source heat pumps.

Installation of an air source heat pump would require an external unit. Careful consideration should be given to the location of these units and the noise being produced from them. Noise abatement measures would be required.

Ground mounted systems should be located on solid surfaces, and the impacts of condensation from the pump should be considered. When mounted on the sides of buildings, it is essential that the wall on which it is mounted is structurally capable of supporting the weight of the pump. In addition, a duct will be required to connect the pump and the interior of the dwelling. Space within the dwelling should be allocated for the hot water cylinder.

ASHP therefore cannot be considered as a feasible option.

Large Scale Wind and Micro Wind

Application 1 and 2 - Ham Common and Martingales Close

The site is within a predominantly residential urban area and large-scale wind turbines are not appropriate in this location. The site is located within a conservation area and close to a Grade II listed building. It would not be possible to make the technology blend with its surroundings and therefore it is not considered appropriate to either Application site.

Small-scale wind-power has been discounted for the same reasons as large-scale wind (see above) and also because evidence of their performance (particularly where turbines are mounted on building structures), are not encouraging with very low generation from micro-wind turbines in built up areas.

Small-scale Hydro-generation

Application 1 and 2 - Ham Common and Martingales Close

Neither site (Application 1 or Application 2) is adjacent to any running water and therefore hydro-power has been discounted.