Energy Statement

McGregor Homes

159-161 Iverson Road

FINAL

Author: **Declan Price**
BA (Hons)
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We are able to advise at all stages of projects from planning applications to handover.

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Executive Summary

> The Energy Strategy for the Proposed Development has been formulated following the London Plan Energy Hierarchy: **Be Lean**, **Be Clean** and **Be Green**. The overriding objective in the formulation of the strategy is to maximise the reductions in CO_2 emissions through the application of this Hierarchy with a cost-effective, viable and technically appropriate approach and to minimise the emission of other pollutants.

> This Energy Statement assesses the scheme under Building Regulations (2013). London Plan (2011) policy stipulates a 35% reduction in Regulated CO_2 emissions is required.

> A range of **Be Lean** energy efficiency measures are proposed which enable the Proposed Development to exceed the Building Regulations (2013) baseline through energy efficiency measures alone. A 9% reduction in **Regulated CO_2** emissions is predicted. This represents a high level of sustainable design and construction.

> In line with the London Plan, the feasibility of decentralised energy production as a **Be Clean** measure has been carefully examined. It has been concluded that a communal heating strategy is inappropriate for a development of this size as it would substantially increase capital costs and operational costs (and resident energy bills).

> The full spectrum of **Be Green** renewable energy generating technologies has been considered. PV panels are considered the most appropriate and will be provided on the available roofspace.

> The Summary Table below shows the reductions in CO_2 that the Proposed Development has been designed to achieve by all proposed measures over Building Regulations (2013). The combination of **Be Lean** and **Be Green** measures will result in a **35%** reduction in Regulated CO_2 emissions. This exceeds the mandatory energy requirements of Level 4 of the Code for Sustainable Homes, and meets London Plan Policy 5.2 and Camden policy requirements

Summary Table		
	Regulated CO_2 (kg/yr)	**Total CO_2 (kg/yr)**
Building Regulations (2013) Baseline	28,250	37,800
Be Lean	25,590	38,640
Be Green	18,340	31,390
Reduction Achieved	**35%**	**24%**

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1. INTRODUCTION

1.1 This Energy Statement has been prepared by Richard Hodkinson Consultancy (RHC), a specialist innovation, sustainability and energy consultancy, in support of the planning application for the proposed mixed use development by McGregor Homes at 159-161 Iverson Road, West Hampstead.

1.2 The formulation of the energy strategy for the Proposed Development takes into account several important concerns and priorities. These include:

> To achieve the maximum viable reduction in carbon dioxide (CO_2) emissions through the application of the London Plan Energy Hierarchy with an affordable, deliverable and technically appropriate strategy.

> Provision of high quality low energy homes that are adapted to future changes in climate

> To achieve the highest viable levels of the Code for Sustainable Homes (Level 4 in this case).

1.3 This statement first establishes a baseline assessment of the energy demands and associated CO_2 emissions for the Proposed Development based on Building Regulations (2013). The report will then follow The London Plan Energy Hierarchy approach of Be Lean, Be Clean and Be Green to enable the maximum viable reductions in Regulated and Total CO_2 emissions over the baseline.

2. DEVELOPMENT OVERVIEW

2.1 The application proposes the development of a 7-storey mixed use building at 159-161 Iverson Road, West Hampstead. The location plan is shown below in Diagram 1.

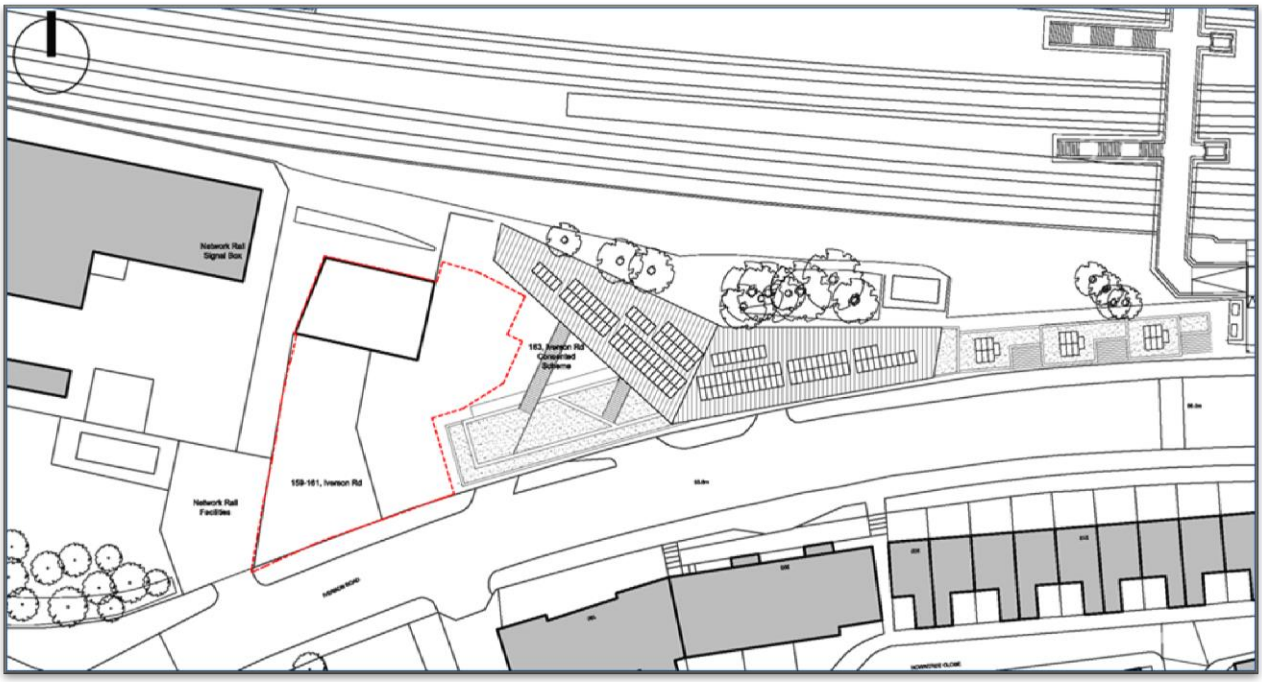

Diagram 1 - Location Plan

2.2 The development proposals provide 23 one, two & three bed homes of mixed tenure. Additionally, a 160m^2 ground floor B1 commercial space is proposed.

Diagram 2 – Site Plan

2.3 Further details of the scheme are provided within the Sustainability Statement.

3. PLANNING POLICIES & DEVELOPMENT REQUIREMENTS

Climate Change Act (2008)

3.1 The Climate Change Act (2008) requires the UK Government to "ensure that the net UK carbon account for the year 2050 is at least 80% lower than 1990 baseline"

3.2 This Legal commitment sets the overriding objective for sustainability: the reduction of CO_2 emissions.

National Planning Policy Framework

3.3 The National Planning Policy Framework (NPPF) was published on 27th March 2012. This 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."*

3.4 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 building's sustainability, do so in a way consistent with the Government's zero carbon building policy and adopt nationally described standards."*

3.5 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.

Regional Policy: London Plan

3.6 The London Plan (2011) provides regional guidance. Policy 5.2 requires that:

"Development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the following energy hierarchy:

1. *Be lean: use less energy*
2. *Be clean: supply energy efficiently*
3. *Be green: use renewable energy"*

3.7 The recently published Sustainable Design and Construction Supplementary Planning Guidance (2014) and provides updated policies within the London Plan framework. The guidance requires that major developments achieve the following improvements over the Building Regulations (2013) Target Emission Rate (TER):-

> 2013-2016: 35%

> 2016-2031: Zero Carbon[1]

3.8 These targets refer only to the Regulated emissions associated with space heating, hot water and fixed electrical equipment.

3.9 **Policy 5.6: Decentralised Energy**, in Development Proposals states:

"Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also

[1] *Not yet defined by Government*

examine opportunities to extend the system beyond the site boundary to adjacent sites."

3.10 Furthermore:

"Major development proposals should select energy systems in accordance with the following hierarchy:

1. *Connection to existing heating or cooling networks*
2. *Site wide CHP network*
3. *Communal heating and cooling"*

3.11 Policy 5.7: Renewable Energy, States that:

"Within the framework of energy hierarchy, major developments proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible."

3.12 Policy 5.9: Overheating and Cooling, states:

"Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

1. *Minimise internal heat generation through energy efficient design*
2. *Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls*
3. *Manage heat within the building though exposed internal thermal mass and high ceilings*
4. *Passive ventilation*
5. *Mechanical ventilation*
6. *Active cooling systems"*

Local Policy: London Borough of Camden

3.13 Policy CS13, Tackling climate change through promoting higher environmental standards, of the adopted Core Strategy states:

> "The Council will require all developments to take measures to minimise the effects of, and adapt to, climate change and encourage all development to meet the highest feasible environmental standards that are financially viable during construction and occupation by:
>
> > *….minimising carbon emissions from the redevelopment, construction and occupation of buildings by implementing, in order, all of the elements of the following energy hierarchy:-*
>
> *4. Ensuring developments use less energy*
>
> *5. Making use of efficient sources, such as …decentralised energy networks*
>
> *6. Generating renewable energy on-site*
>
> > *Ensuring buildings and spaces are designed to cope with, and minimise the effects of climate change"*

3.14 Additionally, Policy DP22, Promoting sustainable design and construction, of the Camden Development Policies states:

> "The Council will promote and measure sustainable design and construction by:-
>
> > *Expecting new build housing to meet Code for Sustainable Homes level 4 by 2013"*

3.15 Camden Planning Guidance on Sustainability (CPG3) has also been consulted in the preparation of this Energy Statement. With regard to carbon offsetting, this states:

> *"Where the new London Plan carbon reduction target in policy 5.2 cannot be met onsite, we may accept the provision of measures elsewhere in the borough or a financial contribution which will be used to secure delivery of carbon reduction measures elsewhere."*

Summary of Targets

3.16 In Summary, the applicant is seeking to achieve the following:-

> London Plan: 35% reduction in Regulated CO_2 emissions over Building Regulations (2013) through application of the energy hierarchy.

> Code for Sustainable Homes Level 4 – requires a 19% reduction in Regulated CO_2 emissions over Building Regulations 2013.

4. BUILDING REGULATIONS (2013) BASELINE

Methodology

4.1 In line with London Plan policy, this statement first establishes a baseline assessment of the energy demands and associated CO_2 emissions for the Proposed Development based on Building Regulations (2013). The report will then follow The London Plan Energy Hierarchy approach of Be Lean, Be Clean and Be Green to enable the maximum viable reductions in Regulated and Total CO_2 emissions over the baseline.

4.2 The estimated annual energy demand for the residential portion of the Proposed Development has been calculated using Standard Assessment Procedure (SAP 2012) methodology. SAP calculates the Regulated energy demands associated with hot water, space heating and fixed electrical items. The unregulated energy demands for appliances and cooking are taken from RHC practice benchmarks drawn from NHER calculation outputs.

Building Regulations (2013) Baseline

4.3 The Building Regulations compliant baseline case provides that the homes and buildings just meet the Target Emission Rate (TER). Table 1 below shows the Building Regulations (2013) compliant Regulated & Total CO_2 emissions for whole site. These are shown in greater detail in Appendix B.

Table 1: Building Regulations (2013) Baseline

	Regulated CO_2 (kg/yr)	Total CO_2 (kg/yr)
Baseline Emissions	25,594	38,637

5. *BE LEAN*: ENERGY EFFICIENCY MEASURES

In line with the London Plan Energy Hierarchy, the following energy efficient, ***Be Lean*** measures are proposed to be applied to the Proposed Development. These measures will ensure that the Building Regulations (2013) baseline will be met through energy efficiency measures alone.

Insulation Standards

5.1 The new build elements will incorporate enhanced insulation in the building envelope (walls, roofs, floors and glazing) to achieve average U-values better than those required by Part L (2013) Building Regulations. These are likely to include:

> Glazing with a U-value of 1.2 $W/m_2.K$

> External walls with a U-value of 0.18 $W/m_2.K$

> Party walls will be fully insulated and sealed (achieving an effective U-value of 0.00$W/m_2.K$)

> Ground Floor U-value will be improved to 0.1 $W/m_2.K$

> Roof U-values will be improved to 0.1 $W/m_2.K$

Air Tightness and Ventilation

5.2 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 in the design air permeability rate from $10m_3/hr.m_2$ to $3m_3/hr.m_2$ or less will further reduce space heating requirements.

5.3 Additionally, all homes will have openable windows and therefore the ability to naturally ventilate should the occupant desire. Convective ventilation, cross ventilation and night purging of heat will therefore be facilitated.

5.4 All dwellings will be fitted with efficient Part F compliant intermittent extract fans to remove stale air from wet rooms and kitchens as well as aid in the supply of background ventilation.

Thermal Bridging

5.5 In well insulated buildings, as much as 30% of heat loss can occur through thermal bridges, which occur when highly conductive elements (e.g. metal studs) in the wall construction enable a low resistance escape route for heat. An improvement over the SAP default y-value may be required for compliance with the required standards. This will be determined during the detailed design stage. Thermal Bridging illustrates the benefits of reducing thermal bridges.

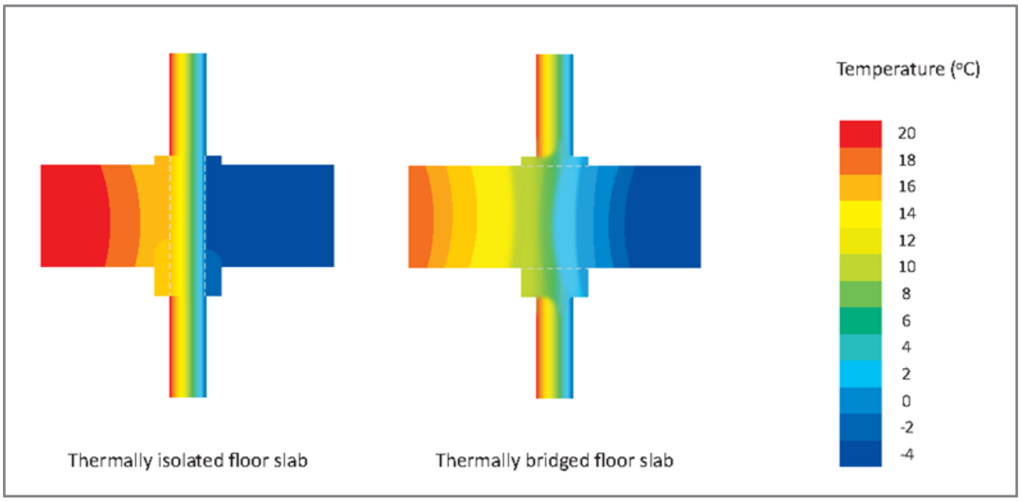

Figure 2 - Thermal Bridging

Space Heating & Hot Water

5.6 The space heating requirement of the Proposed Development will be reduced by the fabric and air tightness measures detailed above.

5.7 The combination of the above measures will create highly energy efficient homes.

5.8 All dwellings will have a High efficiency SEDBUK ‘A’ rated boiler installed. These systems have at least an 89% efficiency rating (SAP 2009) and are Energy Saving Trust recommended.

5.9 The space heating systems will include zoning controls. This will allow the occupants to have a flexible and efficient way of controlling heating throughout the dwelling.

Limiting the Risk of Summer Overheating

5.10 Minimising the risk of summer overheating is important so as to ensure that homes are adapted to climate change and remain comfortable to occupy in the future. An illustrative strategy is presented here that enables both dwellings to pass the overheating test. The Applicant commits to ensuring that all dwellings will not have a high risk of summer overheating and will adopt appropriate measures to ensure this is delivered.

5.11 In line with the Cooling Hierarchy within London Plan Policy 5.9, it is proposed to reduce the need for active cooling as far as possible and will not require the installation of mechanical cooling. All homes will therefore be subject to measures to minimise the risk of summer overheating to an acceptable level.

5.12 This will be done through the specification of non-mechanical measures such as good thermal insulation and air tightness.

5.13 Additionally, and where appropriate, solar control glazing (low g-value) will be installed to reduce solar heat gains.

5.14 Open-able windows will be used across the Proposed Development and will enable cross-ventilation (both the dwellings are at least dual aspect), convective-ventilation and night purging. These concepts are illustrated in **Error! Reference source not ound.** and will reduce the build-up of heat within homes.

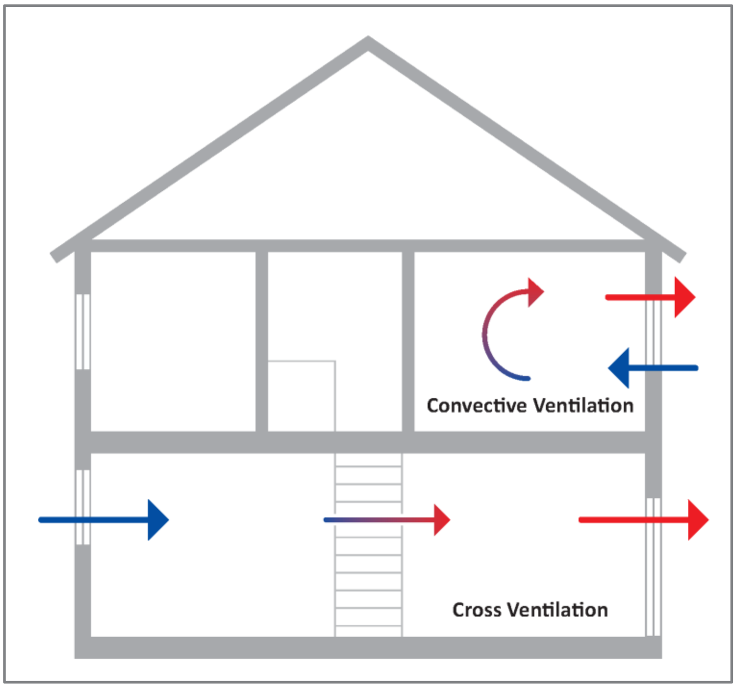

Figure 3 – Natural Ventilation

5.15 The SAP overheating assessments that have been undertaken on the sample home types show that there is not expected to be a high risk of summer overheating.

Lighting and Appliances

5.16 Energy efficient lighting will be installed in 100% of internal fittings in the dwellings.

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

5.18 Kitchen and other pre-installed appliances will be A or A+ rated for energy efficiency.

5.19 It is very difficult to design and construct homes to reduce the unregulated electricity demands, because this is almost entirely dependent on the occupant of a home and can vary substantially. However, the Applicant is committed to ensuring that all efforts are made to enable the residents to minimise their unregulated electricity consumption. Advice will be provided to all occupants in the form of a Home User Guide on how to minimise electricity consumption. This includes advice on purchasing low-energy devices as well as ensuring that they are used efficiently. It has been shown that the provision of such information can significantly reduce energy use.

CO_2 Emissions Following *Be Lean* Measures

5.20 The impact of the above measures on the site-wide Regulated & Total CO_2 emissions of the Proposed Development is shown in Table 2, below.

Table 2: Be Lean

	Regulated CO_2 (kg/yr)	Total CO_2 (kg/yr)
Baseline	28,250	41,300
Be Lean	25,590	38,640
Reduction Achieved	**9%**	**6%**

6. *BE CLEAN*: DECENTRALISED ENERGY

6.1 In line with Policy 5.6 of the London Plan, the feasibility of decentralised heating networks as a Be Clean measure has been evaluated. This is the next step in the Energy Hierarchy after Be Lean. The London Plan outlines the following order of preference: -

> Connection to existing heating or cooling networks

> Site wide CHP network

> Communal heating and cooling

6.2 The inclusion of decentralised heating has been investigated in terms of appropriateness to the Proposed Development, and, to be in line with the priorities for this energy strategy, whether decentralised heating is the best technology to provide the greatest reductions in CO_2 emissions.

6.3 There are no district heating systems in the area to which the development could connect.

6.4 Small Combined Heat and Power (CHP) engines are much less efficient than larger ones, having a worse heat to power ratio. This means that they do not enable as large a CO_2 reduction as for a larger development, which would be able to utilise a larger and more efficient CHP engine. Recent GLA guidance published in April 2014 states that it is not expected, for smaller sites (less than 300 dwellings) to carry out a full feasibility analysis for the use of CHP.

6.5 Communal heating is most suitable on larger developments, where advantage can be taken from economies of scale. This is true both in capital cost and operational cost. As an example the cost of gas boilers for a 100 home development would be less than double that for a 50 home scheme. This increases the cost per home for a small scheme such as this. With regard to operational costs, the same is true – the maintenance of a plant room for a 100 home scheme would be similar to that for a 50 home scheme. The cost per home is therefore double for a small scheme. This additional cost would be passed to residents in their heat bills.

6.6 Therefore, it would not be economically or socially sustainable for a communal heat network to be provided for this development due to its small nature.

7. *BE GREEN*: RENEWABLE ENERGY TECHNOLOGY

7.1 The final part of the London Plan Energy Hierarchy is Be Green which seeks for renewable energy technologies to be specified to provide, where feasible, a reduction in expected carbon dioxide emissions (Policy 5.7).

7.2 Further details on the renewable energy technologies discussed in this section can be found in Appendix A. Appendix D provides a feasibility study table of the technologies that have been considered

Solar Thermal Panels

7.3 Solar thermal panels generate heat for hot water. The benefits of solar thermal panels are constrained by the seasonal variation in solar radiation. This means that solar thermal panels can only deliver a maximum of 60% of the annual hot water demand.

7.4 Whilst technically viable, there are a number of reasons why solar thermal panels are not the favoured technology for this development: -

> Need for hot water cylinders in each home – it is likely that due to the size of the units most are best served with combination boilers. Cylinders would reduce internal space

> The fact that the CO_2 reduction possible is constrained by the hot water demand.

> Higher cost in comparison to solar PV panels

7.5 Therefore, solar thermal panels are not the preferred technology for the proposed development and are not specified.

Wind Turbines

7.6 Wind turbines would be roof mounted and intended to generate electricity. However, urban wind conditions are generally poor and turbulent, adversely affecting the performance of wind turbines. Before specifying or installing wind turbines extensive analysis of the wind resource at the specific site should be undertaken to ensure that wind conditions are suitable.

7.7 It has been concluded that wind turbines are not the most appropriate renewable energy technology for the Proposed Development. This is due to the expense of the technology itself and the uncertain CO_2 benefit that they would provide. As such they will not be installed.

Biomass Boiler

7.8 Biomass boilers with modern pollution abatement devices such as ceramic filter systems can almost eliminate particulate matter emissions and are also very low on emissions of NOx.

7.9 However, like CHP engines, biomass boilers require a central plant room and communal heat network. Such a system has been discounted as inappropriate for a development of this size and nature.

Air & Ground Source Heat Pumps (ASHPs & GSHPs)

7.10 ASHPs and GSHPs would generate heat for space heating and hot water. However, GSHPs are a very costly technology which would require boreholes due to the space restrictions on the Application Site. Although less expensive, ASHPs are less efficient than GSHPs. Furthermore, as heat pumps replace gas, which is more carbon intensive, as the main heating fuel, the reduction in CO_2 from heat pumps is not large.

7.11 Therefore, ASHPs and GSHPs are not the most viable technology for the Proposed Development and will not be installed.

Selected Technology: Photovoltaic (PV) Panels

7.12 PV panels generate electricity from solar radiation. The generating potential of PV panels is not dependent on development demand, but only on available roof-space for installation and ensuring that they are not over-shaded. For this reason and their current low cost, it has been concluded that PV panels are the most appropriate renewable energy technology for this development and will therefore be maximised on the available roofspace.

7.13 Based on the current designs for roof layouts it is proposed that a total power output 18kWp is installed across the site, covering $134m^2$.

7.14 The calculation for energy generation has been based on the PV panels being installed at a horizontal pitch. It is expected that the PV panels will be installed at a pitch nearer to 30° and orientated south. This would lead to a greater level of energy generation than currently estimated in this statement, further reducing CO_2 emissions.

7.15 Panels will be allocated to the various plots on site during the design stage energy assessment process. In order to achieve the Code level required for each plot, PV will need to feed into each apartment block as well as each home.

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Renewable Energy Generation

7.16 Table 3, below, shows that the specified PV panels reduce Regulated CO_2 emissions by 28% and Total CO_2 by 13% over the Be Lean case. The PV calculation is provided in Appendix C.

Table 3: Be Green

	Regulated CO_2 (kg/yr)	Total CO_2 (kg/yr)
Be Lean	25,590	38,640
Be Green	18,340	31,390
Reduction Achieved	**28%**	**19%**

8. SUMMARY

8.1 The Energy Strategy for the Proposed Development has been formulated following the London Plan Energy Hierarchy: ***Be Lean***, ***Be Clean*** and ***Be Green***. The overriding objective in the formulation of the strategy is to maximise the reductions in CO_2 emissions through the application of this Hierarchy with a cost-effective, viable and technically appropriate approach and to minimise the emission of other pollutants.

8.2 A range of ***Be Lean*** energy efficiency measures are proposed which enable the Proposed Development to substantially exceed the Building Regulations (2013) baseline through energy efficiency measures alone. A 9% reduction in **Regulated CO_2** emissions is predicted. This represents a high level of sustainable design and construction.

8.3 In line with the London Plan, the feasibility of decentralised energy production as a ***Be Clean*** measure has been carefully examined. It has been concluded that a communal heating strategy is inappropriate for a development of this size as it would substantially increase capital costs and operational costs (and residents' energy bills).

8.4 The full spectrum of ***Be Green*** renewable energy generating technologies has been considered. PV panels are considered the most appropriate and will be provided.

8.5 The Summary Table below shows the reductions in CO_2 that the Proposed Development has been designed to achieve by all proposed measures over Building Regulations (2013). The combination of ***Be Lean*** and ***Be Green*** measures will result in a **35%** reduction in Regulated CO_2 emissions. This exceeds the mandatory energy requirements of Level 4 of the Code for Sustainable Homes and achieves compliance with the London Plan emissions policy.

Summary Table		
	Regulated CO_2 (kg/yr)	**Total CO_2 (kg/yr)**
Building Regulations (2010) Baseline	28,250	41,300
Be Lean	25,590	38,640
Be Green	18,340	31,390
Reduction Achieved	**35%**	**24%**

APPENDICES

Appendix A
Low Carbon & Renewable Energy Technologies

Appendix B
Summary of SAP & SBEM Energy Calculations

Appendix C
Roof Plan

Appendix D
PV Calculation

Appendix E
Feasibility Table of Low Carbon & Renewable Energy Technologies

APPENDIX A: 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.

1. 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.

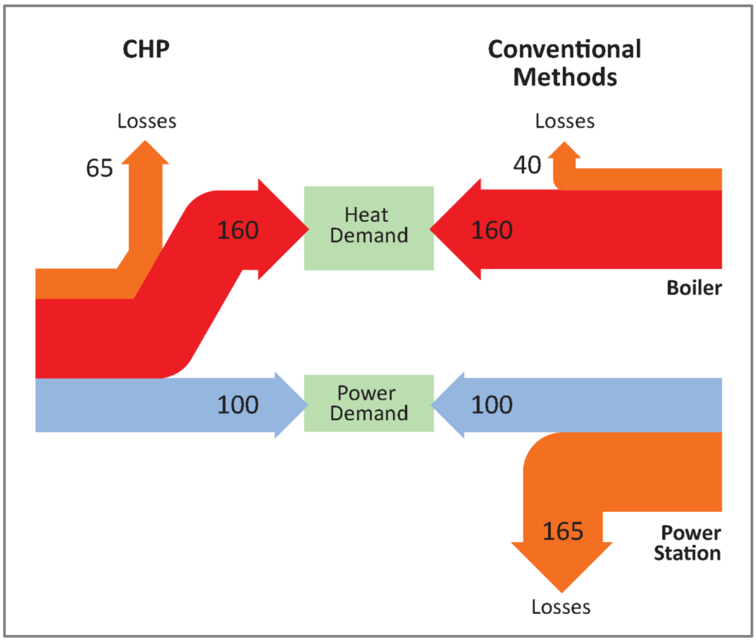

Diagram 1 – CHP Diagram

> 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 coolth.

> **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 0.519 kg per kWh.

> **Capital Cost: -**

> High in comparison to biomass boilers and increased further by inclusion of absorption chiller.

> **Running Costs/Savings: -**

> Coolth from absorption chillers is more expensive than from conventional systems unless heat used id genuine waste heat.

> **Land Use Issues and Space Required: -**

> CCHP systems require a plant room, and possibly an energy centre for large residential developments.

> CHP engines require a flue to effectively disperse pollutants. This is best to rise to a minimum of 2m above the roofline of the tallest building. Additionally the absorption chiller requires either a cooling tower or dry cooler bed for heat rejection purposes.

> Heating and cooling distribution pipework required around the site.

> **Operational Impacts/Issues: -**

> Often run by an ESCo who are unenthusiastic about getting involved in small – medium scale schemes.

> Can also be run in-house with specialist maintenance and customer services activities contracted out.

> Issues with rights to dig up roads for heat networks.

> Emissions of oxides of nitrogen– ~500mg/kWh – 10 times higher than for gas boilers. Specialist technologies exist (e.g. selective catalytic reduction) to reduce this ~20mg/kWh if air quality issues require.

> Rejection of heat is higher than for conventional cooling, thus enforcing the urban heat island effect.

> - Embodied Energy: - Comparable to conventional gas boilers.

- **Funding Opportunities: -**

  - Tax relief for businesses under Enhanced Capital Allowance scheme.
  - Reductions in Energy Achievable: - Absorption cooling generally requires more energy than conventional chillers.
  - Reductions in CO_2 Achievable: - Can provide greater reductions in CO_2 than energy, aided by the emissions factor of grid displaced electricity of 0.519 kg CO_2/kWh.

- **Advantages: -**

  - Reasonable reductions in overall primary energy and CO_2 emissions.
  - Disadvantages: - More expensive to install than conventional chillers.
  - Operational costs higher than for conventional chillers.
  - Application: Best suited where there is genuine waste heat available.

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2. BIOMASS BOILERS

- Biomass boilers generate heat on a renewable basis as they are run on biomass fuel which is almost 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.

- Various other suitable fuels are available including organic materials including straw, dedicated energy crops, sewage sludge and animal litter. Each fuel tends to have its own advantages dependant on site requirements.

- 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 around 90%.
- 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 alternatives.

> **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. This is best to rise to a minimum of 2m above the roofline of the tallest building. Additionally the absorption chiller requires either a cooling tower or dry cooler bed for heat rejection purposes.
- 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.
- Route for district heating pipe around the site must be safeguarded.

> **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 oxides of nitrogen – ~80-100mg/kWh.

    > Emissions of particulate matter. To minimise this ceramic filter systems are required.

    > Embodied Energy: - Comparable to conventional gas boiler.

> **Funding Opportunities: -**

    > Renewable Heat Incentive (RHI) provides incentive funds to developers of small or medium installations with a reasonable heat load that meet a minimum energy efficiency standard & meet the RHI eligibility criteria.

    > Reductions in Energy Achievable: - No reduction in energy demand, but energy generated from a renewable fuel. Significant long term running costs (fuel).

    > Reductions in CO2 Achievable: - Can provide significant reductions in CO2, but generally limited by the hot water load (base heating load).

    > Advantages: - Reductions in CO2 at low installed cost.

> **Disadvantages: -**

    > High long-term running costs, unless receiving RHI.

    > Often do not supply energy cost-effectively in comparison to gas boilers.

3. 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.

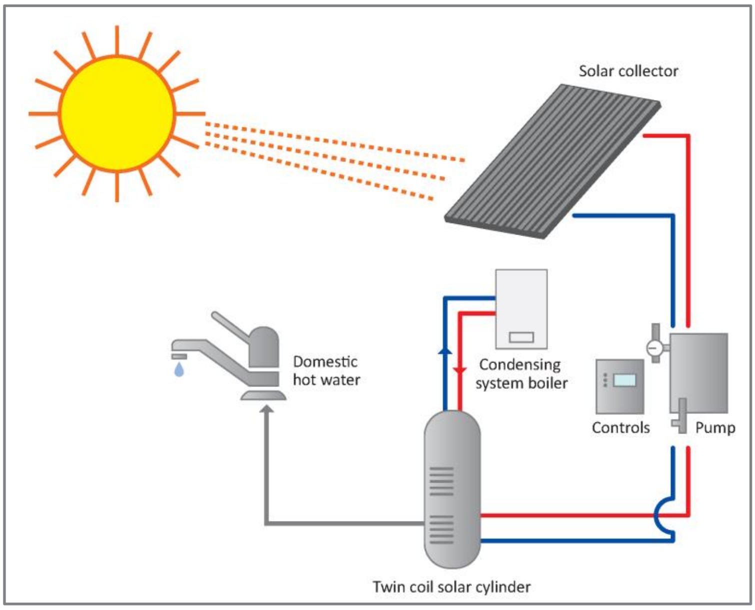

Diagram 2 – Solar Thermal System

> **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 30-450 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.

> **Capital Cost: -** Typically £2,500 per 4m2 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.

> Requires hot water cylinders in dwellings.

    - 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/CO2 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 CO2 Achievable: - Comparable to solar PV per m2.
    - Advantages: - Virtually free fuel, low maintenance and reductions in energy/CO2.
    - Disadvantages: - Benefits limited to maximum ~50% of hot water load.
    - Higher Costs in comparison to PV
    - Application: Best suited for small to medium housing developments ~1-100

4. 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%. ~7m2 of these high performance panels will produce 1kWp of electricity.

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- Operate best on south facing roofs angled at 30-450 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 0.519 kg CO_2 per kWh.

> **Capital Cost:** - ~£2,000 per kWp.

> **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.
- Provision for access to solar panels installed on flat roofs needs to be incorporated into the design of PV arrays layout as well as inclusion of spaces for inverters within the development.

> Quality of PV panels varies dramatically.

> **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 m2 than solar thermal panels.

> **Reductions in CO2 Achievable:** - Provide greater percentage reductions in CO2 than energy. Comparable to solar thermal per square metre.

> **Advantages: -** Virtually free fuel, very low maintenance and good reductions in CO2.

> Cheaper in comparison to solar thermal panels.

> **Disadvantages: -**

> Slightly greater loss in performance than solar thermal panels when orientated away from south.

> **Application:** Best suited for a variety of developments from single houses to multi apartment blocks and even whole estates.

5. 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

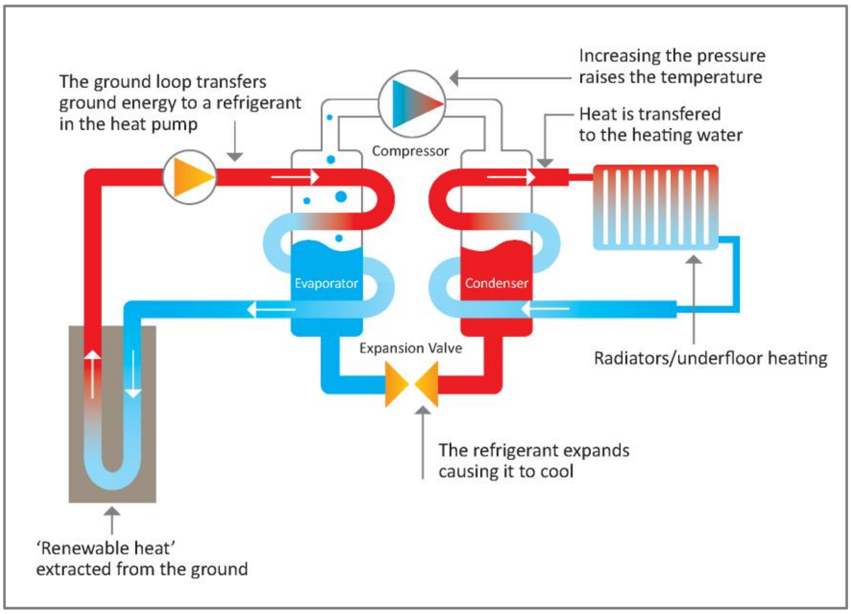

Diagram 3 – Ground Source Heat Pump

'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 12oC 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 higher carbon intensity (gas: 0.216; electricity: 0.519).

  > As they are upgrading heat energy from the earth, GSHPs operate at 'efficiencies' in excess of 350%. This is limited in SAP unless Appendix Q rated model used.

  > 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.

  > Best suited to new developments that have provision for large ground works already in place, to minimise ground work costs.

  > 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 backup 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:** - Renewable Heat Incentive (RHI) provides incentive funds to developers of small or medium installations with a reasonable heat load that meet a minimum energy efficiency standard & meet the RHI eligibility criteria.
- **Reductions in Energy Achievable:** - Reduce energy demand by less per m2 than solar thermal panels.
- **Reductions in CO2 Achievable: -** Provide greater %age reductions in CO2 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 CO2. CoP limited in SAP. Only small cost savings.
  - GSHPs are not entirely a ‘renewable’ technology as they require electricity to drive their pumps or compressors.
- **Application:** Best suited for small to medium developments ~1-100

6. 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.

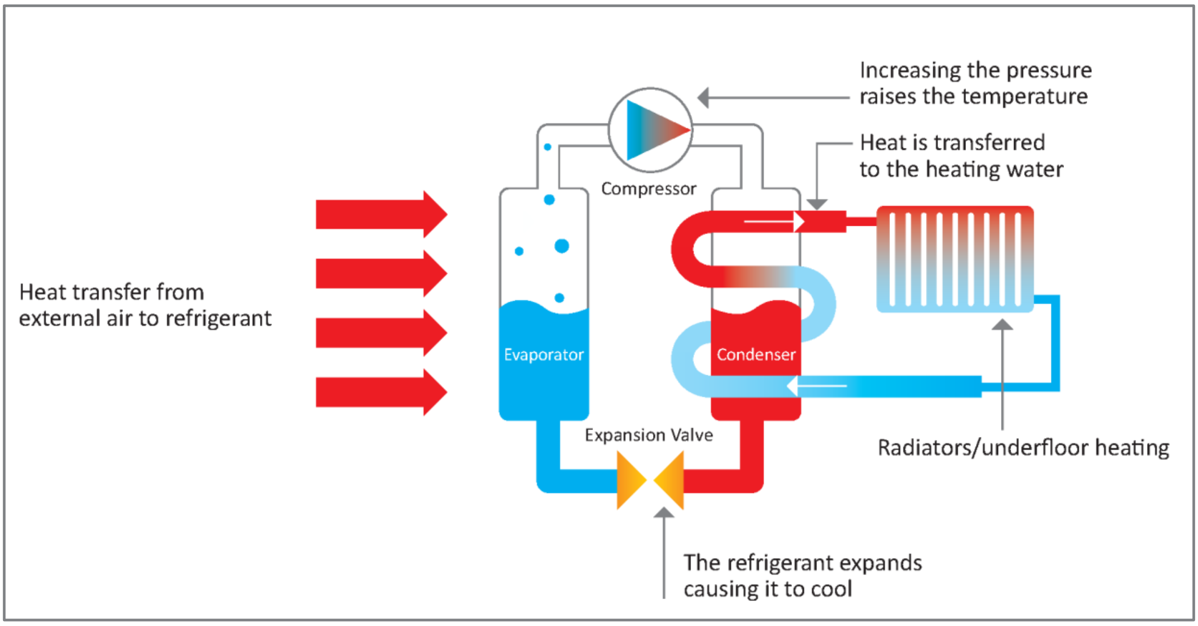

Diagram 4 – Air Source Heat Pump

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.

> Diagram 4: Air Source Heat Pump System

> 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 higher carbon intensity (gas: 0.216; electricity: 0.519).

> > 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 unless an Appendix Q rated model is used.

  - 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 backup for hot water.
  - Highly reliable and require virtually no maintenance.
  - Noise from ASHPs must be below 42 dB at a position one metre external to the centre point of any door or window in a habitable room. According to planning standards MCS020.

> **Embodied Energy:** - Low. Carbon payback longer than for GSHPs as the CoP is lower.

> **Funding Opportunities:** - Renewable Heat Incentive (RHI) provides incentive funds to developers of small or medium installations with a reasonable heat load that meet a minimum energy efficiency standard & meet the RHI eligibility criteria.

> **Reductions in Energy Achievable: -** Large reductions in energy demand. Less so than GSHPs.

> **Reductions in CO2 Achievable:** - Provide smaller percentage reductions in CO2 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 CO2. CoP limited in SAP. Only small cost savings.

> ASHPs are not entirely a 'renewable' technology as they require electricity to drive their pumps or compressors.

> **Application: -** Best suited for small to medium developments ~1-100

7. 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 CO2 Achievable: -** Good. Greater reduction in CO2 than PV for same investment.

> **Advantages: -** Virtually free fuel; reductions in CO2.

> **Disadvantages: -**

>> Expensive, although cheaper than PV for same return.

>> Lack of suitable sites.

>> Maintenance costs.

>> Often not building integrated.

> **Application:** Best suited for small to large developments in rural open areas

8. 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 CO2 Achievable:** - High.
- **Advantages:** - Virtually free fuel, reductions in CO2.

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- **Disadvantages: -**
  - Expensive, but good payback period.
  - Lack of suitable sites.
  - Planning obstructions.
- **Application: -** Best suited to medium to larger developments in rural places ~ 100+ units

Appendix B: Summary of SAP SBEM Energy Calculations

Building Regs 2013

Unit Type	No. Units	Representative Unit Area (m2)	Representative Unit Location	Energy Demands per Dwelling (kWh/yr)				Regulated CO2 (kg/m2/yr)		Total CO2 (kg/m2/yr)		FEE (kWh/m2/yr)	TFEE
				Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	DER / BER	TER	DER / BER		
1 Bed	0	62	Ground-floor; N/E elevations	1705	2529	585	860	19	18	26	25	48	50
2 Bed 3 Person	0	62	Mid-floor; N/S elevations	568	2546	559	864	16	14	23	21	31	34
2 Bed 4 Person	0	69	Mid-floor; S/E elevations	396	2641	594	942	14	12	21	20	25	29
3 Bed	0	107	Top-floor; N/S/E/W elevations	2738	3192	829	1288	15	14	22	21	45	46
Commercial: B1	1	160	-	4734	306	2026	2770	13	13	22	22		

Unit Type	No. Units	Representative Unit Area (m2)	Representative Unit Location	Energy Demands (kWh/yr)				Regulated CO2 (kg/yr)		Total CO2 (kg/yr)	
				Space Heating	Hot Water	Regulated Electrical	Unregulated Appliances & Cooking	TER	DER / BER	TER	DER / BER
1 Bed	1	62	Ground-floor; N/E elevations	1705	2529	585	860	1182	1115	1627	1560
2 Bed 3 Person	11	62	Mid-floor; N/S elevations	6248	28006	6144	9507	10917	9580	15832	14495
2 Bed 4 Person	6	69	Mid-floor; S/E elevations	2375	15848	3561	5652	5938	5164	8860	8086
3 Bed	5	107	Top-floor; N/S/E/W elevations	13688	15961	4144	6440	8155	7686	11484	11016
Commercial: B1	1	160	-	4734	306	2026	2770	2064	2048	3496	3480
Total				**28750**	**62650**	**16460**	**25228**	**28257**	**25594**	**41300**	**38637**
Area Weighted Average								**9.42%**		**6.45%**	

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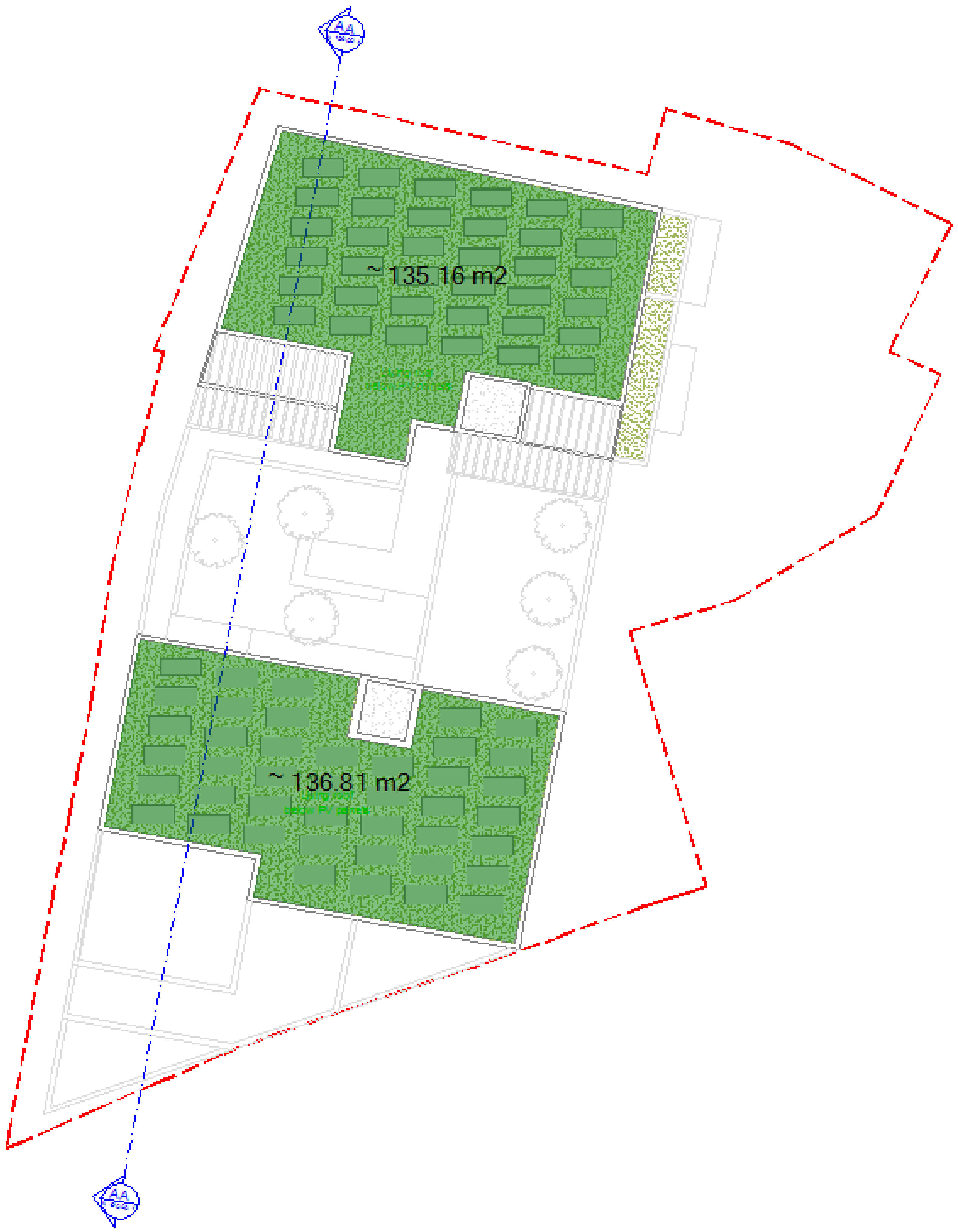
Appendix C: Roof Plan



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Appendix D: PV Calculation

Renewable Energy Generation	
CO2 Reduction Required	7249
Aspect	South
Angle	Horizontal
PV Required (kWp)	17.8
Panel Area Required (m2)	134
CO2 Reduction (kg/yr)	7249

1kWp (m2)	8

SAP Table H2					
	Horizontal	30	45	60	Vertical
North	961	730	640	500	371
Northwest	961	785	686	597	440
West	961	913	854	776	582
Southwest	961	1027	997	927	705
South	961	1073	1054	989	746
Southeast	961	1027	997	927	705
East	961	913	854	776	582
Northeast	961	785	686	597	440

PV Output (kWh/yr) for 1kWp				
Horizontal	30	45	60	Vertical
769	584	512	400	297
769	628	549	478	352
769	730	683	621	466
769	822	798	742	564
769	858	843	791	597
769	822	798	742	564
769	730	683	621	466
769	628	549	478	352

Overshading Factor		None/V. Little	1
	% Sky Blocked	Overshading Factor	
Heavy	>80%	0.5	
Significant	>60%-80%	0.7	
Modest	20%-60%	0.8	
None/V. Little	<20%	1.0	

	CO2 for 1kWp				
	Horizontal	30	45	60	Vertical
North	407	309	271	212	157
Northwest	407	332	290	253	186
West	407	386	361	328	246
Southwest	407	435	422	392	298
South	407	454	446	419	316
Southeast	407	435	422	392	298
East	407	386	361	328	246
Northeast	407	332	290	253	186

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Appendix E: Low Carbon and Renewable 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	No	Development too small
Biomass	Yes	None	Air quality in residential area	Encouraged for large scale developments	In Plant Room	Yes	Bio-energy Capital Grants Scheme	No	Development too small
Solar Thermal	Yes	High	Sufficient roof space required	Encouraged	None	~2 years	None	No	PV more appropriate
Solar Photovoltaic (PV)	No	Very High	Sufficient roof space required	Encouraged	None	2-5 years	None	Yes	Selected
Ground Source Heat Pumps (GSHPs)	Yes	High	Requires large area for coils or borehole	Encouraged	None	Low	None	No	PV more appropriate
Air Source Heat Pumps (ASHPs)	Yes	Very High	Visual intrusion of external units	None	Low	Low	None	No	PV more appropriate
Wind Power	No	Low	Urban Area - low and turbulent wind; Visual impact	Encouraged for large scale developments	Yes	~1 year	None	No	Monitoring needed to assess wind speeds. Expensive
Hydro Power	No	Medium	Requires suitable water resource; Visual impact	None	Low	~1 year	None	No	-

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