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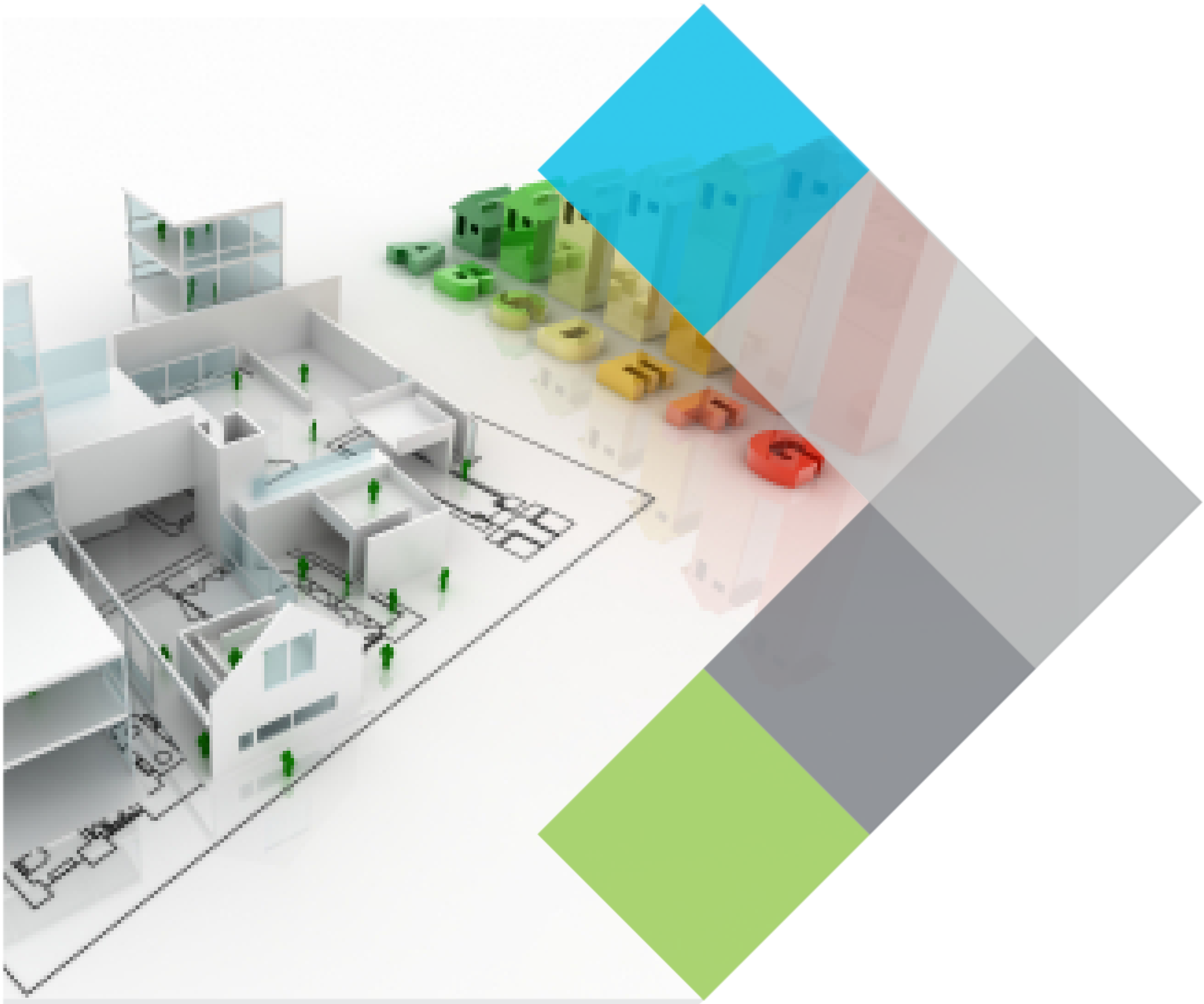

Energy Statement

Warmhaze Ltd

21A Ferdinand Street

SUBMISSION

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Our emphasis is to provide innovative and cost effective solutions that respond to increasing demands for quality and construction efficiency.

Executive Summary

The purpose of this Energy Statement is to demonstrate that the 4 storey house proposed by Warmhaze Ltd at 21A Ferdinand Street in the London Borough of Camden, will meet the requirements of the relevant local, regional and national planning policies.

The energy strategy for the dwelling 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.

A range of ***Be Lean*** energy efficiency measures are proposed which enable the dwelling to meet the requirements of Building Regulations 2013 Part L, the London Plan and Code for Sustainable Homes (CfSH) level 4 through energy efficiency measures alone. CfSH level 4 requires a 19% CO_2 reduction beyond Building Regulations Part L 2013. This report shows a strategy that will achieve a **21%** reduction in Regulated CO_2 emissions through specification of high performance building fabric and services.

In line with the London Plan, the feasibility of decentralised energy production as a ***Be Clean*** measure has been examined. It has been concluded that a communal heating strategy is inappropriate for this development.

The full spectrum of ***Be Green*** renewable energy generating technologies has also been considered, but due to the enclosed and overshaded location of the dwelling, none has been deemed appropriate.

This dwelling represents an excellent standard of sustainable design and construction, by meeting all relevant planning and policy requirements through exemplary ***Be Lean*** energy efficiency measures.

Table 1 below shows a summary of the CO_2 reductions.

Area (m2)	DER (kgCO2/m2/yr)	TER (kgCO2/m2/yr)	% Reduction
202.8	11.5	14.5	21%

Table 1: Summary of CO_2 Reductions

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1. INTRODUCTION

1.1 This Energy Statement has been prepared by Hodkinson Consultancy, a specialist energy and environmental consultancy, in support of the planning application by Warmhaze Ltd ('The Applicant') for an enclosed terraced house at 21A Ferdinand Street, Chalk Farm, Camden.

1.2 The proposed energy strategy will endeavour to:

> Achieve the required reduction in carbon dioxide (CO_2) emissions through the application of the London Plan Energy Hierarchy with a viable, affordable, deliverable and technically appropriate strategy;

> Create a high quality, low energy home that will be adaptable to future changes in climate;

> Meet the requirements of level 4 of the Code for Sustainable Homes.

1.3 This statement first establishes a baseline assessment of the energy demands and associated CO_2 emissions for the 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 at least a 19% reduction in Regulated CO_2 emissions over the baseline, in order to meet the requirements of the London Plan and Code for Sustainable Homes level 4.

2. DEVELOPMENT OVERVIEW

2.1 The Applicant proposes the construction of a 4-bed, enclosed terraced house arranged over 4 floors including a basement level. The address of the proposed dwelling will be 21A Ferdinand Street, Camden, NW1 8EU.

2.2 The development is situated to the rear of 10 and 10a Belmont Street and to the side of 21 Ferdinand Street. The site itself is almost entirely enclosed by the surrounding buildings, this will have an impact on the formation of the energy strategy.

2.3 The development site is in the corner of an existing yard located behind existing homes on Ferdinand Street. The site location is shown in Figure 1 below outlined in red.

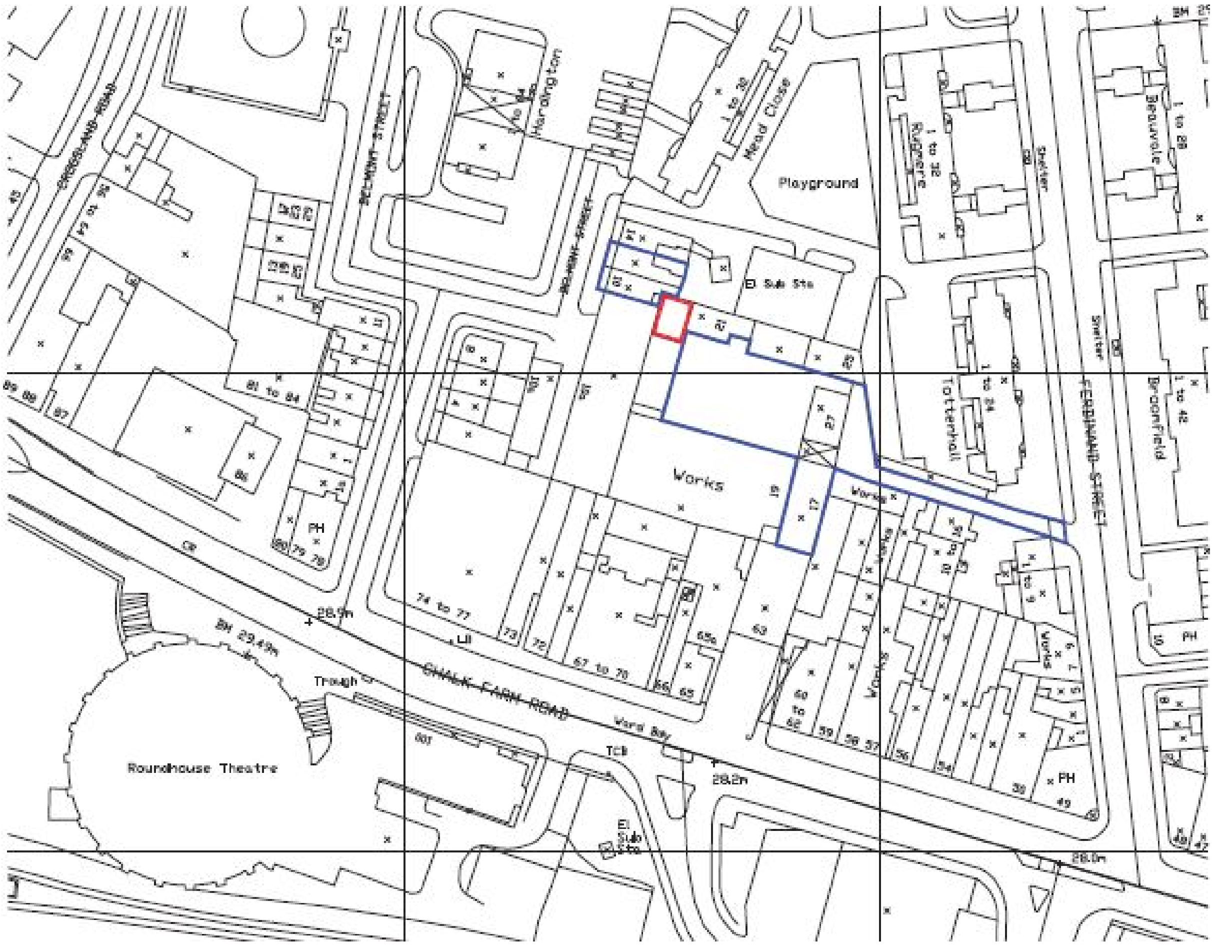

Figure 1: Site location

2.4 A close up of the site shows the enclosed nature of the development marked in grey, Figure 2.

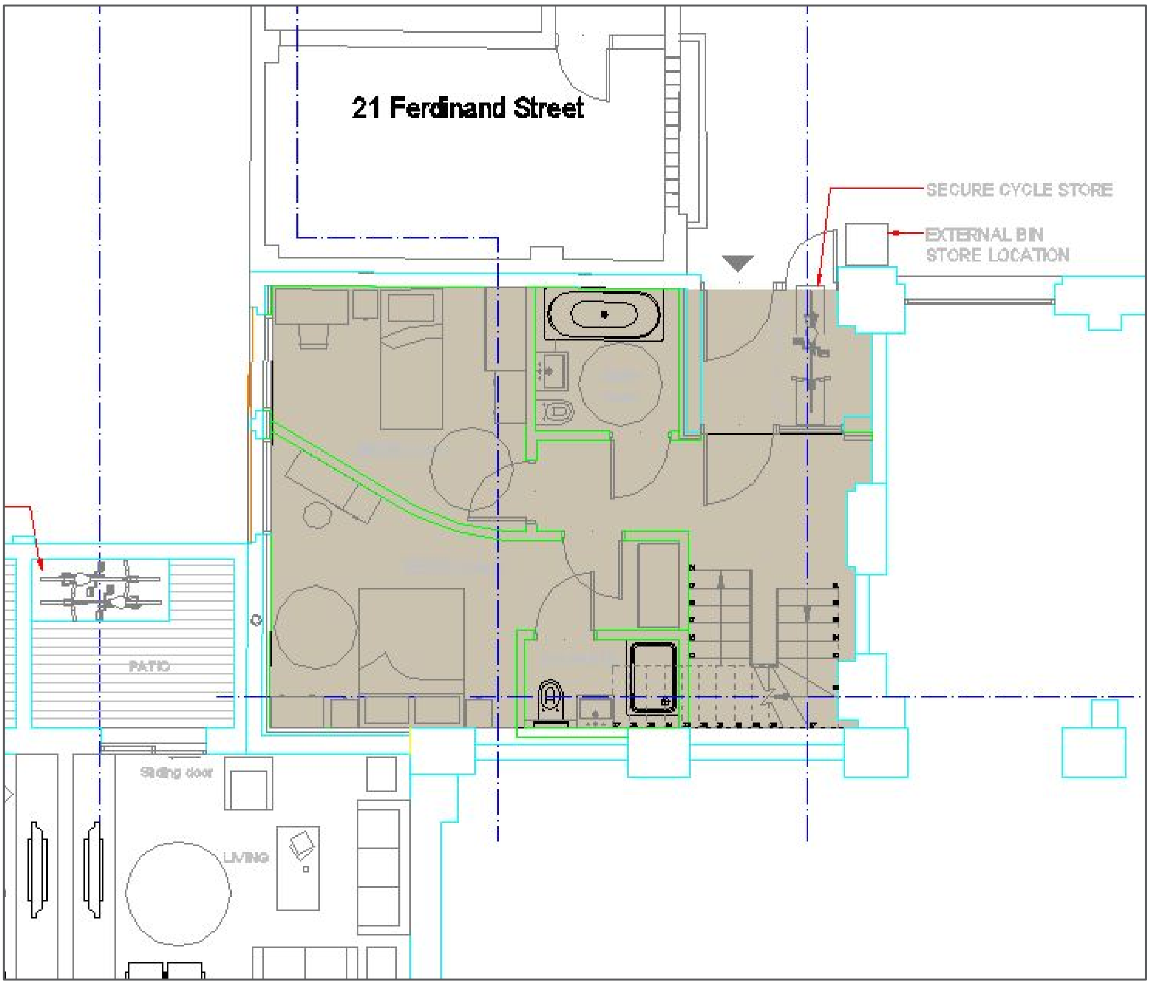

Figure 2: Site close-up

3. PLANNING POLICY AND 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 the 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 a building's sustainability, do so in a way consistent with the Government's zero carbon buildings 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:

3.7 *"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"*

3.8 The London Plan states that all major developments must achieve a 35% reduction in CO_2 emissions over the relevant Building Regulations baseline. As a major development is defined as 10 or more units this CO_2 reduction policy does not apply in this instance.

Local Policy: London Borough of Camden

3.9 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: -*

- *Ensuring developments use less energy*
- *Making use of efficient sources, such as…decentralised energy networks*
- *Generating renewable energy on-site*
- *Ensuring buildings and spaces are designed to cope with, and minimise the effects of, climate change"*

3.10 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"*

3.11 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

3.12 In summary, this energy statement is seeking to show a strategy that will achieve the following:

> Meet Building Regulations Part L 2013.

> Meet the energy requirement for Code for Sustainable Homes (CfSH) Level 4 – a 19% reduction in regulated CO_2 emissions beyond that required for Building Regulations Part L 2013.

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4. EMISSIONS 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 house 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 required reductions in Regulated CO_2 emissions over the baseline.

4.2 The estimated annual energy demand for the house 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.

Clarification of Terminology

4.3 Dwelling Emission Rate (DER) and Target Emission Rate (TER) are terms taken from SAP and apply to residential buildings. These are measured as kg of CO_2 per m^2 per annum and are defined below.

> DER is the 'actual' annual dwelling carbon emissions of the development as designed.

> TER is the minimum annual emission rate that the development must achieve in order to comply with Part L 2013 Building Regulations. Otherwise known as the baseline.

4.4 These are the emissions associated with 'regulated' energy use, those that are controlled by Building Regulations Approved Document Part L1A: Conservation of Fuel and Power in New Dwellings.

4.5 Dwelling Fabric Energy Efficiency (DFEE) and Target Fabric Energy Efficiency (TFEE) are also terms taken from SAP. They are measured as kWh per m^2 per annum and are defined below.

> DFEE is the actual Fabric Energy Efficiency of the dwelling as designed and/or built.

> TFEE is the minimum acceptable Fabric Energy Efficiency that must be achieved in order to comply with Part L 2013 Building Regulations. Otherwise known as the baseline.

Building regulations 2013 Baseline

4.6 The baseline of regulated CO_2 emissions (TER) and fabric efficiency (TFEE) for the development as determined by SAP, under Building Regulations 2013 are shown below in Table 2. In order to meet the CfSH level 4 energy target, the TER must be reduced by at least 19%.

Total Internal Floor Area (m^2)	TER ($kgCO_2/m^2/yr$)	Total regulated emissions ($kgCO_2/yr$)	TFEE ($kWh/m^2/year$)
202.8	14.5	2,940.6	55.1

Table 2: Building Regulations 2013 Baseline

5. BE LEAN: ENERGY EFFICIENCY MEASURES

5.1 In line with the London Plan Energy Hierarchy, the following ***Be Lean*** measures for improving the energy efficiency of the building fabric and services have been proposed.

5.2 Due to the enclosed nature and overshading of the site, typical renewable solutions such as Solar Thermal or PV are inappropriate (discussed further in chapter 7). Also with no district heating network with which to connect (chapter 6) it has been deemed that the development should meet the required targets through ***Be Lean*** measures alone.

5.3 These measures will ensure that the Building Regulations (2013) baseline requirements will be exceeded by at least 19%. A full summary of the specification can be found in Appendix B.

Insulation Standards

5.4 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.

Improved U-values:

> Triple glazing =1.0 W/m^2/K

> External walls = 0.17 W/m^2/K

> Party walls will be fully insulated and sealed (achieving an effective U-Value of 0.0 W/m^2/K)

> Ground floor = 0.13 W/m^2/K

> Main Green roof = 0.1 W/m^2/K

> Roof to balcony = 0.16 W/m^2/K

Air Tightness and Ventilation

5.5 It is proposed to install Parts L & F compliant (System 4) Mechanical Ventilation and Heat Recovery (MVHR). These systems will remove stale air and odours from kitchens and bathrooms, whilst retaining the heat within the home. In this way, substantial energy savings will be made. This system is illustrated in Figure 3.

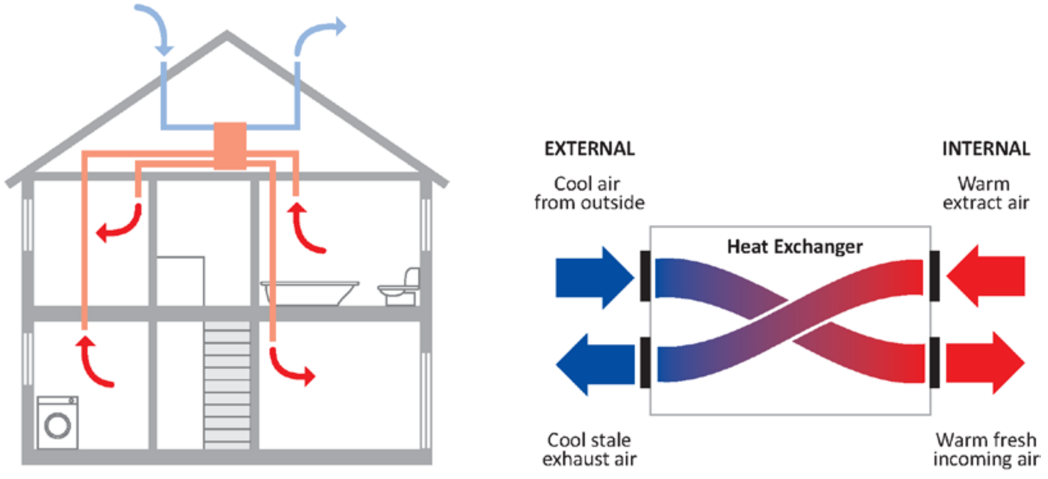

Figure 3: Example of MVHR

5.6 The selected MVHR unit will have a Specific Fan Power (SFP) of approximately 0.65 W/l/s and heat recovery efficiencies of ~93%.

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

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

Thermal Bridging

5.9 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. It is proposed that the house will meet, where possible, Accredited Construction Details for thermal bridges.

5.10 A preliminary thermal bridging detail calculation has established a Y – value of 0.055 $W/m^2/K$. Close attention should be paid to the thermal bridging detail at the design stage to ensure accuracy.

5.11 Figure 4 illustrates the concept of reducing thermal bridges.

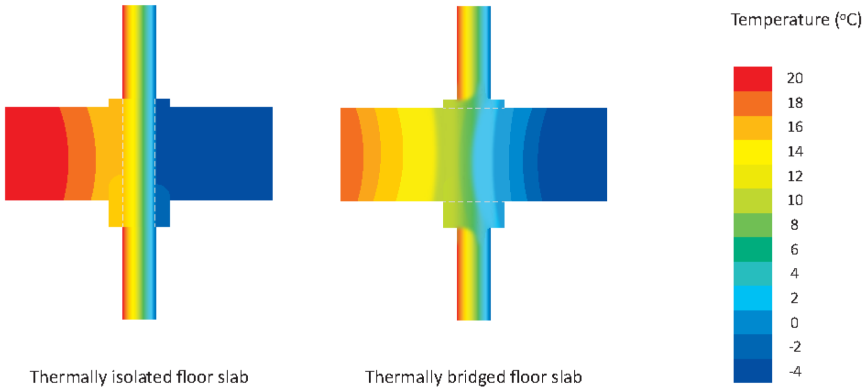

Figure 4: Illustration of Thermal Bridging

Space Heating and Hot Water

5.12 The space heating requirement of the house will be reduced by the fabric, air tightness and ventilation measures detailed above.

5.13 A high efficiency SEDBUK 'A' rated gas boiler will be installed in accordance with best practice. Time and temperature zone controls with weather compensation will be specified to ensure that the boiler is operated efficiently.

5.14 The development will have a fully insulated hot water cylinder.

Limiting the Risk of Summer Overheating

5.15 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. The Applicant commits to ensuring that the house will not have a high risk of summer overheating and will adopt appropriate measures to ensure this is delivered.

5.16 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 through non-mechanical measures such as good thermal insulation and air tightness. The house will benefit from shading from the surrounding buildings.

5.17 Open-able windows will enable convective-ventilation and night purging. Cross ventilation is not achievable due to the layout and location of the house. These concepts are illustrated in Figure 5 and will reduce the build-up of heat within the building.

5.18 The SAP overheating assessment shows that there is not expected to be a high risk of summer overheating.

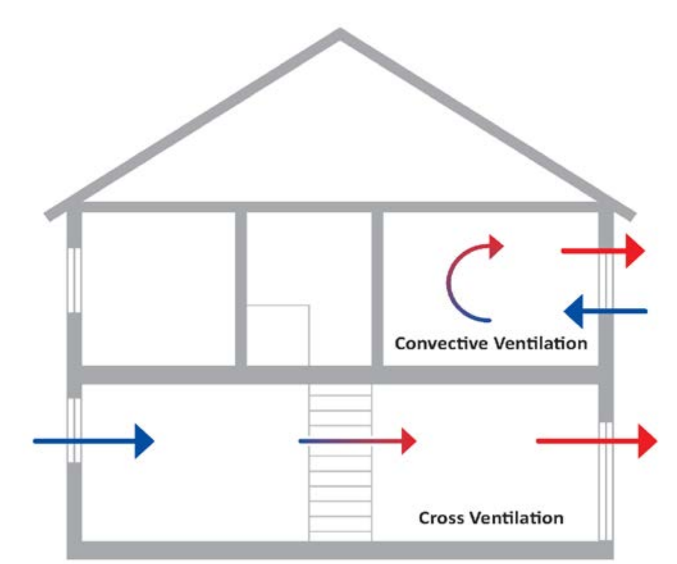

Figure 5: Natural Ventilation

Lighting and Appliances

5.19 Energy efficient lighting will be installed in all internal and external fittings. Any external lighting will be controlled through PIR sensors, or daylight cut-off devices. Kitchen and other pre-installed appliances will be highly energy efficient (A+ or A rated).

5.20 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.

5.21 It is proposed that the house will be fitted with an energy display device to enable the occupants to monitor their use of electricity and gas. A Home User Guide will also be provided which will include guidance on how to operate the house efficiently and minimise energy and water use.

Reductions Achieved by Be Lean Measures

5.22 Table 3 demonstrates that the development has a 21% reduction in regulated CO_2 emissions achieved by the ***Be Lean*** measures.

Area (m^2)	TER ($kgCO_2/m^2/yr$)	DER ($kgCO_2/m^2/yr$)	% Reduction	TFEE ($kWh/m^2/year$)	DFEE ($kWh/m^2/year$)	% Reduction
202.8	14.5	11.5	21.0%	55.1	43.9	20.3%

Table 3: Reductions from Be Lean Measures

5.23 Table 3 also shows that the development meets and exceeds the TFEE considerably, this is not a requirement of policy but a result of achieving the targets through exemplary Fabric Energy Efficiency alone.

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. 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 development and whether decentralised heating is the best technology to provide the greatest reductions in CO_2 emissions.

6.3 Communal heating and Combined Heat and Power (CHP) technologies are most suitable on larger developments, where advantage can be taken from economies of scale. This is true both in capital cost and operational cost. Further background information on the features of CHP systems can be found in Appendix A.

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

6.5 It would not be economically sustainable for CHP technology to be provided for this development due to its scale.

7. BE GREEN: RENEWABLE ENERGY TECHNOLOGIES

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 For this dwelling, the required reductions in Regulated CO_2 emissions have already been achieved through ***Be Lean*** measures, so use of ***Be Green*** technologies is not considered essential for meeting planning and policy requirements.

7.3 The section below justifies the argument that renewable energy technologies are not considered to be feasible for this development. Background information on the technologies that have been considered can be found in Appendix B.

Solar Thermal and Photovoltaic (PV) Panels

7.4 In theory, Solar PV or thermal panels would be the preferred ***Be Green*** option for this dwelling, due to the area of flat roof available. However, in practice, this enclosed property will be significantly overshaded by neighbouring buildings, ruling out the opportunity for effective use of solar renewable technologies.

Wind Turbines

7.5 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.

7.6 It has been concluded that wind turbines are not the most appropriate renewable energy technology for this dwelling due to the site being surrounded by other buildings.

Biomass Boiler

7.7 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.

7.8 However, like CHP engines, biomass boilers require large plant rooms. They also require significant areas of space for fuel storage and access for regular fuel delivery. Such a system has been discounted as inappropriate for a development of this size and location.

Air & Ground Source Heat Pumps (ASHPs & GSHPs)

7.9 ASHPs and GSHPs would generate heat for space heating and hot water. GSHPs are a very costly technology which would require boreholes due to the space restrictions on the application site. Although less expensive, ASHPs are also less efficient than GSHPs. The reduction in CO_2 emissions from heat pumps is not large unless directly powered by PV, due to the demand for carbon intensive electricity during their operation.

7.10 As all targets have been met through ***Be Lean*** ASHPs and GSHPs are not considered to be viable technologies for this dwelling.

8. SUMMARY

8.1 The energy strategy for the dwelling 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 meet the required 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 dwelling to meet the requirements of Building Regulations 2013 Part L, the London Plan and Code for Sustainable Homes level 4 through energy efficiency measures alone. A **21%** reduction in Regulated CO_2 emissions is predicted through specification of high performance building fabric and services.

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

8.4 The full spectrum of ***Be Green*** renewable energy generating technologies has also been considered, but due to the enclosed and overshaded location of the dwelling, none has been deemed appropriate.

8.5 This dwelling represents an excellent standard of sustainable design and construction, by meeting all relevant planning and policy requirements through exemplary ***Be Lean*** energy efficiency measures.

Appendices

Appendix A
Low Carbon and Renewable Energy Technologies

Appendix B
DER Worksheet

APPENDIX A: LOW CARBON AND RENEWABLE ENERGY TECHNOLOGIES

1. 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.

2. COMBINED HEAT AND POWER (CHP)

> CHP is a form of decentralised energy generation that generally uses gas to generate electricity for local consumption, reducing the need for grid electricity and its associated high CO_2 emissions. As the CHP system is close to the point of energy demand, it is possible to use the heat that is generated during the electricity generation process. As both the electricity and heat from the generator is used, the efficiency of the system is increased above that of a conventional power plant where the heat is not utilised.

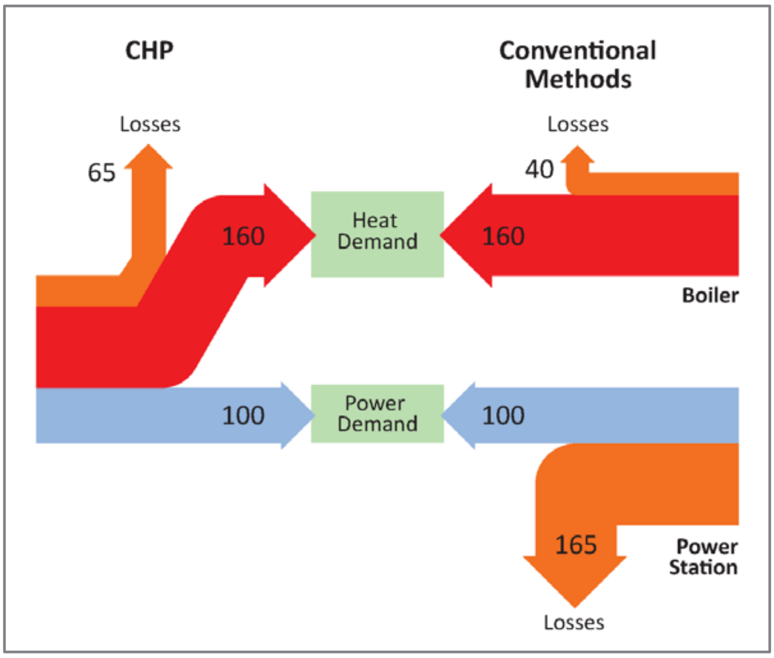

Diagram 1 – CHP Diagram

> However, the overall efficiency of ~80% is still lower than the ~90% efficiency of a heat only gas boiler.

> Where there are high thermal loads, CHP can be used within district heating networks to supply the required heat.

> **Performance and Calculation Methodology: -**

> > Most commonly sized on the heat load of a development, not the electrical load. This prevents an over-generation of heat.

> > Require a high and relatively constant heat demand to be viable.

> > CHP engines are best suited to providing the base heating load of a development (~year round hot water demand) with conventional gas boilers responding to the peak heating demand (~winter space heating). CHP engines are not able to effectively respond to peaks in demand.

  - In general, CHP engines have an electrical efficiency of ~30% and a thermal efficiency of ~45%. Larger engines have a better heat to power ratio and are therefore able to reduce CO_2 emissions by greater amount.
  - Electricity produced by the CHP engine displaces grid electricity which is given a carbon intensity of 0.519 kg per kWh.
- **Capital Cost: -**
  - Around £1,000 per kW of electrical output.
  - Relative cost reduces as the size of engine increases.
  - Generally best suited to larger sites, where there is a suitable economy of scale.
- **Running Costs/Savings: -**
  - CHP engines often struggle to provide cost-effective energy to dwellings on smaller residential schemes compared to conventional individual gas boilers.
  - Onsite use of CHP generated electricity; power Purchase Agreement with electricity Supply Company or Private Wire arrangement to local large non-domestic demand enhances economic case.
- **Land Use Issues and Space Required: -**
  - CHP engines require a plant room, and possibly an energy centre for large residential developments.
  - CHP engines require a flue to effectively disperse pollutants. This is best to rise to a minimum of 2m above the roofline of the tallest building.
  - Route for district heating pipe around the site must be safeguarded.
- **Operational Impacts/Issues: -**
  - Often run by Energy Services Company (ESCo) who maybe 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 district heating networks.
  - Emissions of oxides of nitrogen – ~500mg/kWh – 10 times higher than for a gas boiler. Specialist technologies exist (e.g. selective catalytic reduction) to reduce this to ~20mg/kWh if air quality issues require.
- **Embodied Energy:** - Comparable to that of a conventional gas boiler.
- **Funding Opportunities: -**
  - Tax relief for businesses under the Enhanced Capital Allowances scheme..
- **Reductions in Energy Achievable: -** Can provide some reductions in effective primary energy, but when distribution losses and other local losses are included more fuel is required.

- **Reductions in CO_2 Achievable: -** Can provide greater reductions in CO_2 than energy, aided by the emissions factor of grid displaced electricity of 0.519 kg CO_2/kWh. CO_2 reduction increase as size of engine increases.
- **Advantages: -**
  - Good reductions in overall primary energy and CO_2 emissions.
  - Most cost effective and appropriate strategy to achieve substantial CO_2 reductions on large schemes.
- **Disadvantages: -**
  - On smaller schemes often do not supply energy cost-effectively in comparison to conventional individual gas boilers.
  - Requires sale of generated electricity to maximise cost effectiveness.

Application: - Best suited to larger developments.

3. COMBINED COOLING HEAT AND POWER (CCHP)

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

4. 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 CO_2 Achievable: - Can provide significant reductions in CO_2, but generally limited by the hot water load (base heating load).
  - Advantages: - Reductions in CO_2 at low installed cost.

- **Disadvantages: -**
  - High long-term running costs, unless receiving RHI.
  - Often do not supply energy cost-effectively in comparison to gas boilers.

5. 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.

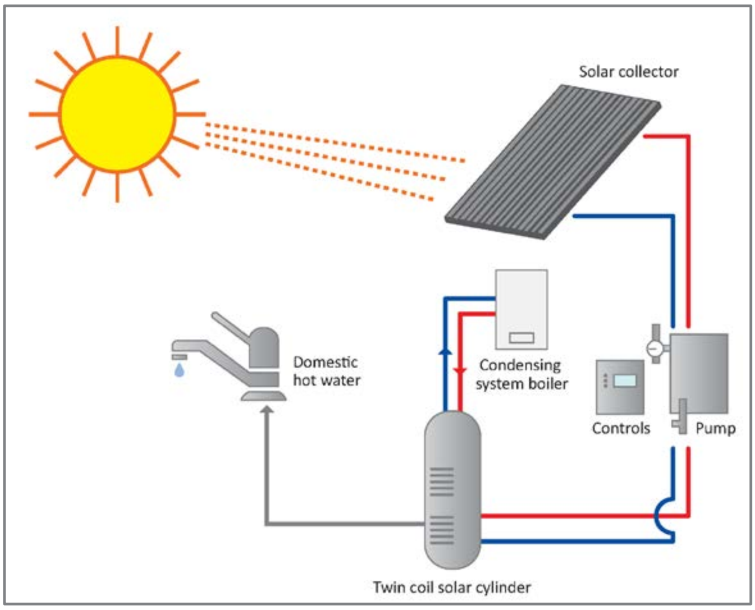

Diagram 2 – Solar Thermal System

- Can also be used to provide energy for space heating in highly insulated dwellings.
- There are two types of solar thermal panel: evacuated tube collectors and flat plate collectors.
- **Performance and Calculation Methodology: -**
  - Evacuated Tube Collectors: ~60% efficiency.
  - Flat Plate Collectors: ~50% efficiency.
  - SAP Table H2 used for solar irradiation at different angles.

  - Operate best on south facing roofs angled at 30-450 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 $4m^2$ plus installation. Costs higher for evacuated tubes than flat plate collectors.
- **Running Costs/Savings: -**
  - Reduce reliance on gas and therefore reduce costs.
  - Payback period of ~20 years per dwelling.
- **Land Use Issues and Space Required: -**
  - Installed on roof so no impact on land use.
  - 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/CO_2 reduction required is large.
- **Operational Impacts/Issues:** - Biggest reductions achieved by people who operate their hot water system with consideration of the panels.
  - Embodied Energy: - Carbon payback is ~2 years.
  - Funding Opportunities: - none
- **Reductions in Energy Achievable:** - Reduce primary energy demand by more per standard panel area than solar PV panels.
  - Reductions in CO_2 Achievable: - Comparable to solar PV per m^2.
- **Advantages: -** Virtually free fuel, low maintenance and reductions in energy/CO_2.
- **Disadvantages: -** Benefits limited to maximum ~50% of hot water load.
  - Higher Costs in comparison to PV
- **Application: -** Best suited for small to medium housing developments ~1-100

6. SOLAR PHOTOVOLTAIC (PV) PANELS

- Solar PV panels generate electricity by harnessing the power of the sun. They convert solar radiation into electricity which can be used on site or exported to the grid in times of excess generation.
- **Performance and Calculation Methodology: -**
  - The best PV panels operate with an efficiency approaching 20%. ~7m^2 of these high performance panels will produce 1kWp of electricity.
  - Operate best on south facing roofs angled at 30-450 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.

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> 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 m^2 than solar thermal panels.

> **Reductions in CO_2 Achievable:** - Provide greater percentage reductions in CO_2 than energy. Comparable to solar thermal per square metre.

> **Advantages: -** Virtually free fuel, very low maintenance and good reductions in CO_2.

> 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.

7. GROUND SOURCE HEAT PUMPS (GSHPS)

> Ground Source Heat Pumps work in much the same way as a refrigerator, converting low grade heat from a large 'reservoir' into higher temperature heat for input in a smaller space. Electricity drives the pump which circulates a fluid (water/antifreeze mix or refrigerant) through a closed loop of underground pipe. This fluid absorbs the solar

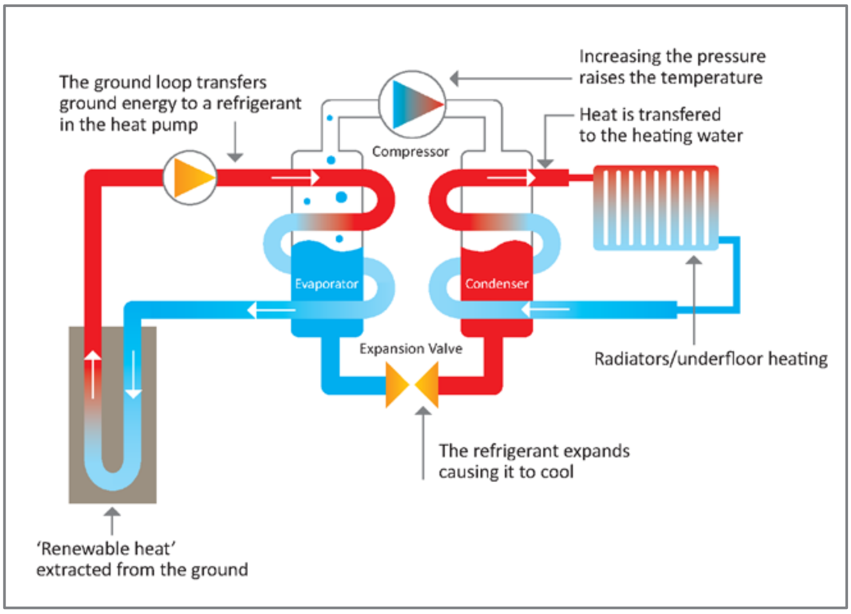

Diagram 3 – Ground Source Heat Pump

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 m^2 than solar thermal panels.
- **Reductions in CO_2 Achievable: -** Provide greater %age reductions in CO_2 than energy. Comparable to solar thermal (esp. in SAP).
- **Advantages:** - Large reductions in Energy. Currently receives benefit from SAP of an electrical baseline rather than gas.
- **Disadvantages: -**
  - Small reduction in CO_2. CoP limited in SAP. Only small cost savings.
  - 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

8. AIR SOURCE HEAT PUMPS (ASHPS)

- Air Source Heat Pumps work in much the same way as a refrigerator, converting low grade heat from a large ‘reservoir’ into higher temperature heat for input into a smaller space. Electricity drives the pump which extracts heat from the air as it flows over the coils in the heat pump unit. A compressor in the heat pump upgrades the temperature of the extracted energy which can then be used for space heating and hot water.

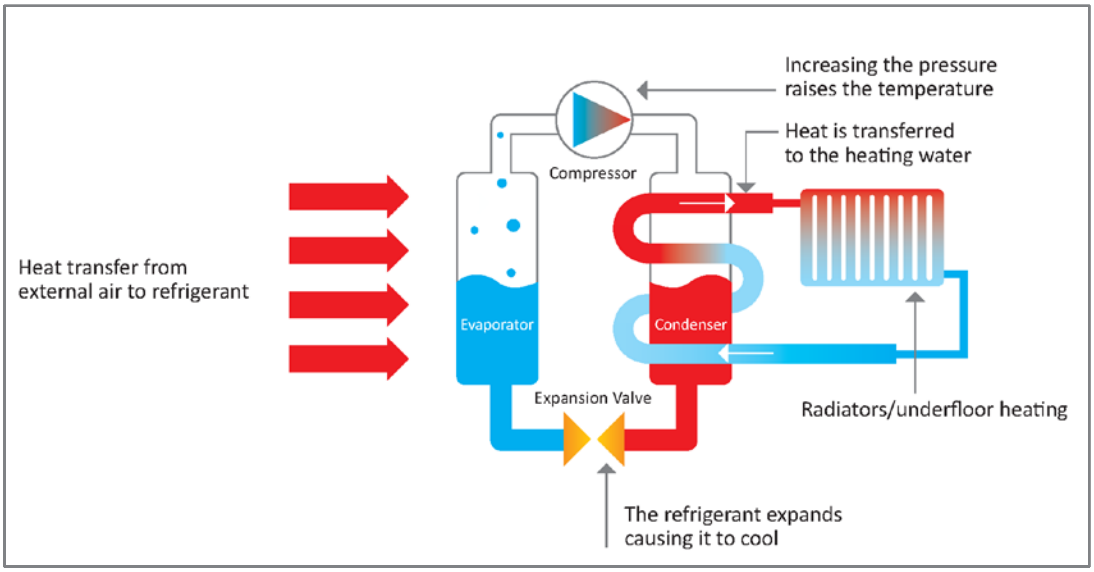

Diagram 4 – Air Source Heat Pump

- 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 CO_2 Achievable:** - Provide smaller percentage reductions in CO_2 than energy. Less than GSHPs.

> **Advantages:** - Large reductions in Energy. Currently receives benefit from SAP of an electrical fuel factor rather than a gas baseline.

> **Disadvantages: -**

> Small reduction in CO_2 CoP limited in SAP. Only small cost savings.

> 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

9. WIND POWER

> Wind energy installations can range from small domestic turbines (1kW) to large commercial turbines (140m tall, 2MW). There are also different designs and styles (horizontal or vertical axis; 1 blade to multiple blades) to suit the location. They generate clean electricity that can be provided for use on-site, or sold directly to the local electricity network

> **Performance and Calculation Methodology: -**

> Power generated is proportional to the cube of the wind speed. Therefore, wind speed is critical.

> Horizontal axis turbines require >~6m/s to operate effectively and vertical axis turbines require >~4.5m/s. The rated power of a turbine is often for wind speeds double these figures.

> Wind speeds for area from BERR's Wind Speed Database.

> Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg/kWh.

- **Capital Cost: -**
  - ~£1,000 per kW. Smaller models are more expensive per kW.
  - Vertical axis turbines more expensive than horizontal.
- **Running Costs/Savings: -**
  - Reduce reliance on grid electricity and therefore reduce costs.
  - Payback period of ~15-20 years per dwelling.
  - Feed-in tariff and ROC payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -**
  - Smaller models (<6kW) can be roof mounted.
  - Must be higher than surrounding structures/trees.
  - Planning permission required.
- **Operational Impacts/Issues: -**
  - Urban environments generally have low wind speeds and high turbulence which reduce the effectiveness of turbines.
  - Vertical axis turbines have a lower performance than horizontal axis turbines but work better in urban environments.
  - Annual services required.
  - Turbines rated in excess of 5kW may require the network to be strengthened and arrangements to be made with the local Distribution Network Operator and electricity supplier.
  - Noise.
- **Embodied Energy: -** Carbon payback is ~1 year for most turbines.
- **Funding Opportunities:** - Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable:** - Significant reduction in reliance on grid electricity.
- **Reductions in CO_2 Achievable: -** Good. Greater reduction in CO_2 than PV for same investment.
- **Advantages: -** Virtually free fuel; reductions in CO_2.
- **Disadvantages: -**
  - Expensive, although cheaper than PV for same return.
  - Lack of suitable sites.

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> Maintenance costs.
> Often not building integrated.

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

10. HYDRO POWER

- Hydro power harnesses the energy of falling water, converting the potential or kinetic energy of water into electricity through use of a hydro turbine. Micro hydro schemes (<100kW) tend to be 'run-of-river' developments, taking the flow of the river that is available at any given time and not relying on a reservoir of stored water. They generate clean electricity that can be provided for use on-site, or sold directly to the local electricity network.
- **Performance and Calculation Methodology: -**
  - Flow rates at particular sites from National River Flow Archive held by Centre for Ecology and Hydrology.
  - Electricity produced displaces grid electricity which has a carbon intensity of 0.568 kg/kWh.
- **Capital Cost: -**
  - £3,000 - £5,000 per kW.
  - Particularly cost effective on sites of old water mills where much of the infrastructure is in place.
- **Running Costs/Savings: -**
  - Reduce reliance on grid electricity and therefore reduce costs.
  - Payback period of ~10-15 years per dwelling
  - Feed-in tariff and ROC payments required for maximum financial benefit.
- **Land Use Issues and Space Required: -**
  - Require suitable water resource.
  - Visual intrusion of scheme.
  - Special requirements where river populated by migrating species of fish.
  - Planning permission will require various consents and licences including an Environmental Statement and Abstraction Licence.
- **Operational Impacts/Issues: -**
  - Routine inspections and annual service required.
  - Automatic cleaners should be installed to prevent intake of rubbish.
- **Embodied Energy: -** Carbon payback for small schemes of ~1 year.

- **Funding Opportunities: -** Financier utilising Feed-in-Tariffs.
- **Reductions in Energy Achievable:** - significant reduction in reliance on grid electricity.
- **Reductions in CO_2 Achievable:** - High.
- **Advantages:** - Virtually free fuel, reductions in CO_2.
- **Disadvantages: -**
  - Expensive, but good payback period.
  - Lack of suitable sites.
  - Planning obstructions.
- **Application: -** Best suited to medium to larger developments in rural places ~ 100+ units

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Mr Matthew Bailey	Assessor number	6697
Client		Last modified	24/09/2014
Address	21a Ferdinand Street, Chalk Farm, Camden, NW1		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		50.00	(1a)	x	3.35	(2a)	=	167.50	(3a)
+1		52.90	(1b)	x	3.10	(2b)	=	163.99	(3b)
+2		52.20	(1c)	x	3.10	(2c)	=	161.82	(3c)
+3		47.70	(1d)	x	3.10	(2d)	=	147.87	(3d)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	202.80	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			641.18	(5)

2. Ventilation rate

			m³ per hour	
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	0	x 10 =	0	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of flueless gas fires	0	x 40 =	0	(7c)

				Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		3.00	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.15	(18)
Number of sides on which the dwelling is sheltered		3	(19)
Shelter factor	1 - [0.075 x (19)] =	0.78	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.12	(21)

Infiltration rate modified for monthly wind speed:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly average wind speed from Table U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.15	0.15	0.14	0.13	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.14	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	79.05	(23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (22b)m + (23b) x [1 - (23c) ÷ 100]

0.25	0.25	0.25	0.23	0.23	0.22	0.22	0.21	0.22	0.23	0.24	0.24	(24a)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in (25)

0.25	0.25	0.25	0.23	0.23	0.22	0.22	0.21	0.22	0.23	0.24	0.24	(25)

3. Heat losses and heat loss parameter

Element	Gross area, m²	Openings m²	Net area A, m²		U-value W/m²K		A x U W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Window			43.98	x	0.96	=	42.29			(27)
Ground floor			50.00	x	0.13	=	6.50			(28a)
External wall			47.56	x	0.17	=	8.09			(29a)
Party wall			190.64	x	0.00	=	0.00			(32)
Basement wall			96.14	x	0.17	=	16.34			(29)
Roof			47.70	x	0.10	=	4.77			(30)
Roof			5.60	x	0.16	=	0.90			(30)
Total area of external elements ∑A, m²			290.98							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	78.88	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		16.16	(36)
Total fabric heat loss	(33) + (36) =	95.05	(37)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	

Ventilation heat loss calculated monthly 0.33 x (25)m x (5)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
53.53	52.91	52.30	49.22	48.61	45.53	45.53	44.92	46.76	48.61	49.84	51.07	(38)

Heat transfer coefficient, W/K (37)m + (38)m

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
148.57	147.96	147.34	144.27	143.65	140.58	140.58	139.96	141.81	143.65	144.88	146.11	

Average = ∑(39)1...12/12 = 144.11 (39)

Heat loss parameter (HLP), W/m²K (39)m ÷ (4)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
0.73	0.73	0.73	0.71	0.71	0.69	0.69	0.69	0.70	0.71	0.71	0.72	

Average = ∑(40)1...12/12 = 0.71 (40)

Number of days in month (Table 1a)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	3.01	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	105.58	(43)

Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
116.14	111.92	107.69	103.47	99.25	95.02	95.02	99.25	103.47	107.69	111.92	116.14	

∑(44)1...12 = 1266.99 (44)

Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
172.23	150.64	155.44	135.52	130.03	112.21	103.98	119.32	120.74	140.71	153.60	166.80	

∑(45)1...12 = 1661.22 (45)

Distribution loss 0.15 x (45)m

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
25.83	22.60	23.32	20.33	19.51	16.83	15.60	17.90	18.11	21.11	23.04	25.02	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	310.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	2.20	(48)
Temperature factor from Table 2b	0.54	(49)
Energy lost from water storage (kWh/day) (48) x (49)	1.19	(50)

Enter (50) or (54) in (55)												1.19	(55)
Water storage loss calculated for each month (55) x (41)m													
	36.83	33.26	36.83	35.64	36.83	35.64	36.83	36.83	35.64	36.83	35.64	36.83	(56)
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)													
	36.83	33.26	36.83	35.64	36.83	35.64	36.83	36.83	35.64	36.83	35.64	36.83	(57)
Primary circuit loss for each month from Table 3													
	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)
Combi loss for each month from Table 3a, 3b or 3c													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)
Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m													
	232.32	204.91	215.53	193.67	190.12	170.36	164.07	179.41	178.89	200.80	211.75	226.89	(62)
Solar DHW input calculated using Appendix G or Appendix H													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)
Output from water heater for each month (kWh/month) (62)m + (63)m													
	232.32	204.91	215.53	193.67	190.12	170.36	164.07	179.41	178.89	200.80	211.75	226.89	
											∑(64)1...12 =	2368.73	(64)
Heat gains from water heating (kWh/month) 0.25 × [0.85 × (45)m + (61)m] + 0.8 × [(46)m + (57)m + (59)m]													
	105.34	93.51	99.76	91.58	91.31	83.83	82.65	87.75	86.67	94.86	97.59	103.53	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)													
	150.28	150.28	150.28	150.28	150.28	150.28	150.28	150.28	150.28	150.28	150.28	150.28	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	33.76	29.99	24.39	18.46	13.80	11.65	12.59	16.37	21.97	27.89	32.55	34.70	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	373.70	377.58	367.80	347.00	320.74	296.06	279.57	275.69	285.46	306.27	332.53	357.21	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	38.03	38.03	38.03	38.03	38.03	38.03	38.03	38.03	38.03	38.03	38.03	38.03	(69)
Pump and fan gains (Table 5a)													
	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	(70)
Losses e.g. evaporation (Table 5)													
	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	-120.22	(71)
Water heating gains (Table 5)													
	141.59	139.15	134.08	127.20	122.73	116.43	111.08	117.94	120.37	127.50	135.55	139.16	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m													
	620.13	617.79	597.36	563.74	528.35	495.23	474.33	481.08	498.89	532.74	571.71	602.15	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
NorthEast	0.77	x	29.28	x	11.28	x 0.9 x	0.57	x	0.70	=	91.35	(75)
SouthEast	0.77	x	14.70	x	36.79	x 0.9 x	0.57	x	0.70	=	149.55	(77)

Solar gains in watts ∑(74)m...(82)m													
	240.90	440.69	683.56	982.06	1223.29	1268.68	1200.57	1012.31	785.62	508.78	294.07	202.59	(83)
Total gains - internal and solar (73)m + (83)m													
	861.03	1058.48	1280.92	1545.80	1751.64	1763.90	1674.89	1493.39	1284.51	1041.52	865.78	804.74	(84)

7. Mean internal temperature (heating season)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Temperature during heating periods in the living area from Table 9, Th1(˚C)												21.00	(85)
Utilisation factor for gains for living area n1,m (see Table 9a)	1.00	1.00	0.99	0.93	0.74	0.51	0.37	0.43	0.74	0.98	1.00	1.00	(86)
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)	20.19	20.34	20.56	20.84	20.98	21.00	21.00	21.00	20.98	20.76	20.42	20.17	(87)
Temperature during heating periods in the rest of dwelling from Table 9, Th2(˚C)	20.31	20.31	20.32	20.33	20.33	20.35	20.35	20.35	20.34	20.33	20.33	20.32	(88)
Utilisation factor for gains for rest of dwelling n2,m	1.00	1.00	0.99	0.91	0.69	0.46	0.31	0.37	0.68	0.97	1.00	1.00	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)	19.20	19.42	19.75	20.15	20.31	20.35	20.35	20.35	20.33	20.05	19.55	19.18	(90)
Living area fraction — Living area ÷ (4) =												0.25	(91)
Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2	19.44	19.64	19.95	20.32	20.48	20.51	20.51	20.51	20.49	20.22	19.77	19.43	(92)
Apply adjustment to the mean internal temperature from Table 4e where appropriate	19.29	19.49	19.80	20.17	20.33	20.36	20.36	20.36	20.34	20.07	19.62	19.28	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	1.00	1.00	0.98	0.90	0.69	0.46	0.32	0.37	0.68	0.97	1.00	1.00	(94)
Useful gains, ηmGm, W (94)m x (84)m	860.53	1055.60	1261.06	1396.73	1211.02	808.20	528.22	554.05	868.18	1005.25	863.98	804.45	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	2227.35	2159.04	1959.87	1626.15	1239.20	809.30	528.27	554.22	884.95	1360.85	1813.54	2202.69	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	1016.92	741.51	519.92	165.18	20.97	0.00	0.00	0.00	0.00	264.57	683.68	1040.29	
∑(98)1...5, 10...12 =												4453.03	(98)
Space heating requirement kWh/m²/year — (98) ÷ (4)												21.96	(99)

9a. Energy requirements - individual heating systems including micro-CHP

Space heating

Fraction of space heat from secondary/supplementary system (table 11)		0.00	(201)
Fraction of space heat from main system(s)	1 - (201) =	1.00	(202)
Fraction of space heat from main system 2		0.00	(202)
Fraction of total space heat from main system 1	(202) x [1- (203)] =	1.00	(204)
Fraction of total space heat from main system 2	(202) x (203) =	0.00	(205)
Efficiency of main system 1 (%)		93.00	(206)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating fuel (main system 1), kWh/month	1093.46	797.32	559.05	177.62	22.54	0.00	0.00	0.00	0.00	284.48	735.14	1118.60	
∑(211)1...5, 10...12 =												4788.21	(211)

Water heating

Efficiency of water heater

87.80	87.45	86.58	83.89	80.25	79.30	79.30	79.30	79.30	85.05	87.22	87.88	(217)

Water heating fuel, kWh/month

264.61	234.33	248.95	230.86	236.92	214.83	206.90	226.24	225.59	236.10	242.79	258.19	

∑(219a)1...12 = 2826.31 (219)

Annual totals

Space heating fuel - main system 1		4788.21	
Water heating fuel		2826.31	
Electricity for pumps, fans and electric keep-hot (Table 4f)			
mechanical ventilation fans - balanced, extract or positive input from outside	635.57		(230a)
central heating pump or water pump within warm air heating unit	30.00		(230c)
boiler flue fan	45.00		(230e)
Total electricity for the above, kWh/year		710.57	(231)
Electricity for lighting (Appendix L)		596.26	(232)
Total delivered energy for all uses	(211)...(221) + (231) + (232)...(237b) =	8921.35	(238)

10a. Fuel costs - individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	4788.21	x	3.48	x 0.01 =	166.63	(240)
Water heating	2826.31	x	3.48	x 0.01 =	98.36	(247)
Pumps and fans	710.57	x	13.19	x 0.01 =	93.72	(249)
Electricity for lighting	596.26	x	13.19	x 0.01 =	78.65	(250)
Additional standing charges					120.00	(251)
Total energy cost				(240)...(242) + (245)...(254) =	557.36	(255)

11a. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	0.94	(257)
SAP value	86.82	
SAP rating (section 13)	87	(258)
SAP band	B	

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	4788.21	x	0.22	=	1034.25	(261)
Water heating	2826.31	x	0.22	=	610.48	(264)
Space and water heating				(261) + (262) + (263) + (264) =	1644.74	(265)
Pumps and fans	710.57	x	0.52	=	368.79	(267)
Electricity for lighting	596.26	x	0.52	=	309.46	(268)
Total CO_2, kg/year				(265)...(271) =	2322.98	(272)
Dwelling CO_2 emission rate				(272) ÷ (4) =	11.45	(273)
EI value					87.44	
EI rating (section 14)					87	(274)
EI band					B	

13a. Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	4788.21	x	1.22	=	5841.61	(261)

Water heating	2826.31	x	1.22	=	3448.10	(264)
Space and water heating				(261) + (262) + (263) + (264) =	9289.72	(265)
Pumps and fans	710.57	x	3.07	=	2181.45	(267)
Electricity for lighting	596.26	x	3.07	=	1830.52	(268)
Primary energy kWh/year					13301.68	(272)
Dwelling primary energy rate kWh/m2/year					65.59	(273)