JSH

# Renewable Energy Report

**Proposed New Sports Hall**

**Queenswood School**

**Hatfield, Hertfordshire**

**for Ball Hall Limited**

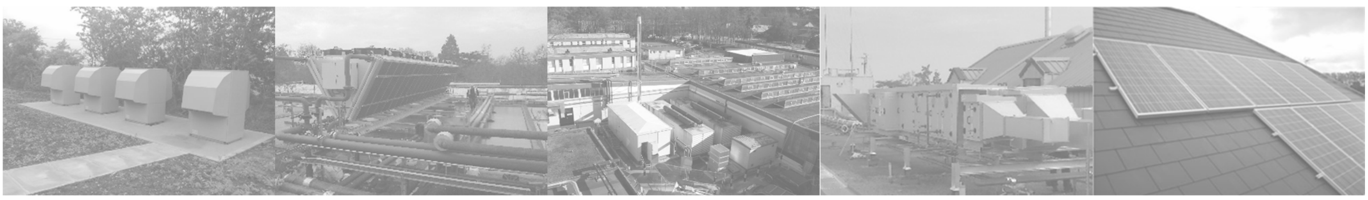
**AC/PB/5388/RENEW**

**December 2016**

**Revision 01**


**Johns Slater and Haward**
**Chartered Building Services Consultants**
**Clydesdale House**
**7 Sorrel Horse Mews**
**Grimwade Street**
**Ipswich, Suffolk. IP4 1LN**

**Tel:** (01473) 255965
**Email:** engineers@jshipswich.co.uk

**DOCUMENT CONTROL SHEET**

| Issue | Project Status | Author | Date | Checked By | Date |
|---|---|---|---|---|---|
| 01 | Preliminary | PB | December 2016 | AC | December 2016 |

## GENERAL INDEX

## 1.00 INTRODUCTION

Queenswood School is an independent school, situated in Hertfordshire.

Queenswood School is a girls-only independent school located near Hatfield, Hertfordshire, and twenty miles from London. It offers admission at ages 11, 13 or 16 (for sixth form).

The School is now proposing to construct a new purpose built sports hall, with associated changing facilities.

Essentially, this is to include:

Ground Floor

- Sports Hall
- 2 No. Sports Stores
- Mat Store
- Lobby
- Toilet Block
- Accessible Toilet
- Cleaners Cupboard
- Office
- Plant Room
- Cardio Room
- Aerobics Room
- 3 No. Stores
- Kitchen

First Floor

- Viewing Gallery
- Future Classrooms
- Accessible Toilet

Ball Hall Limited have been appointed as Project Managers for the Project and are progressing the Preliminary Design.

Clague Architects of Kent are appointed to take the scheme forward to Planning Application Stage.

Thereafter, it is anticipated that the scheme will be competitively tendered on a ‘Design and Build’ basis.

This preliminary Sustainability Statement reports on appropriate Renewable Energy Sources and as far as possible, ascertains how Hertfordshire County Council’s Sustainability Policy will be achieved.

## 2.00 BRIEF

The purpose of this report is to:

Analyse the energy requirements for the new development.

Explain the different renewable technologies that could be utilised.

Advise on which renewable technologies to consider further.

The recommendations of renewable technologies from this Report should be considered during the project design stage, and it would be during this design phase that specific details and costs could be calculated more accurately.

This Report is not intended as a detailed design analysis of the project, and should be considered only a guide as to which renewable technologies could effectively be pursued as viable options.

3.00 REVIEW OF PROPOSED WORKS

The proposed building is a purpose built sports hall for the School. The current status of the Project is at the submission for Planning Approval Stage.

It is understood that Hertfordshire County Council Sustainability policy as stated in their planning guidance documents is for 10% renewables to be provided by on site generation.

The works include the design and construction of the new building. The overall finished building will have a building area of 1,961 m².

4.00 ANTICIPATED ENERGY USE

The anticipated energy consumption has been calculated using BRE accredited software produced by EDSL, TAS v9.3. Government figures have been used as a basis to calculate CO2 emissions from the energy figures.

All calculations have been based on entering the following information into the EDSL software programme:

Building definition - D1 Non-residential Institution: Education.

Heating of building - Air to Water Heat Pump via Underfloor Heating.

Heating of Sports Hall - Natural gas fired radiant heaters.

Heating and Cooling - Split type ASHP.

All Mechanically Ventilated areas have heat recovery of minimum 70% efficiency.

Lighting is controlled by a mixture of manual switching and PIR sensors.

Domestic hot water provided by point of use electric.

All estimations have been based on the following information supplied, or from logical assumptions:

Electrical and gas consumption figures in kWh/m² have been obtained from the output reports from the SBEM BRUKL document.

Lighting has generally been included as follows:

| **Location** | **Lighting Load (lm/w)** | **Illuminance (Lux)** | **Control** | **Parasitic Power (W/m²)** |
|---|---|---|---|---|
| Circulation | 80 lm/w | 100 Lux | Auto On / Off | - |
| Sports Hall | 60 lm/w | 300 Lux | Manual On / Auto Off | - |
| Aerobics | 80 lm/w | 300 Lux | Manual On / Auto Off, Photocell Control Dimming | 0.23 |
| Cardio | 80 lm/w | 300 Lux | Manual On / Auto Off, Photocell Control Dimming | 0.24 |
| Kitchen | 80 lm/w | 400 Lux | Manual On / Auto Off | - |
| Office | 80 lm/w | 400 Lux | Manual On / Auto Off | - |

| Location | Lighting Load (lm/w) | Illuminance (Lux) | Control | Parasitic Power (W/m²) |
|---|---|---|---|---|
| Plant Room | 80 lm/w | 200 Lux | Auto On / Off | - |
| Stores | 80 lm/w | 50 Lux | Auto On / Off | - |
| WC's | 80 lm/w | 200 Lux | Auto On / Off | - |
| Viewing Gallery | 80 lm/w | 100 Lux | Auto On / Off | - |

The heating season is assumed to be 35 weeks x 6 days per week, 10 hrs per day, and for this period, the heating will be running at an overall average of 50% of full load.

Heating from gas for the Sports Hall has been taken from the SBEM report to be 49,393.50 kWh/yr.

Heating from electricity has been taken from the SBEM report to be 5,332.35 kWh/yr (3,807.65 kWh/yr ASHP and 1,524.70 kWh/yr Split AC).

Energy consumption for DHW has been taken from the SBEM report to be 117.66 kWh/yr.

Lighting has been taken from the SBEM report to be 32,787.92 kWh/yr.

Cooling has been taken from the SBEM report to be 3.86 kWh/yr.

Auxiliary has been taken from the SBEM report to be 1,392.31 kWh/yr.

For the purpose of calculating energy savings and pay back periods, energy costs have been taken as 3.5p/kWh for gas and 9.5p/kWh for electricity.

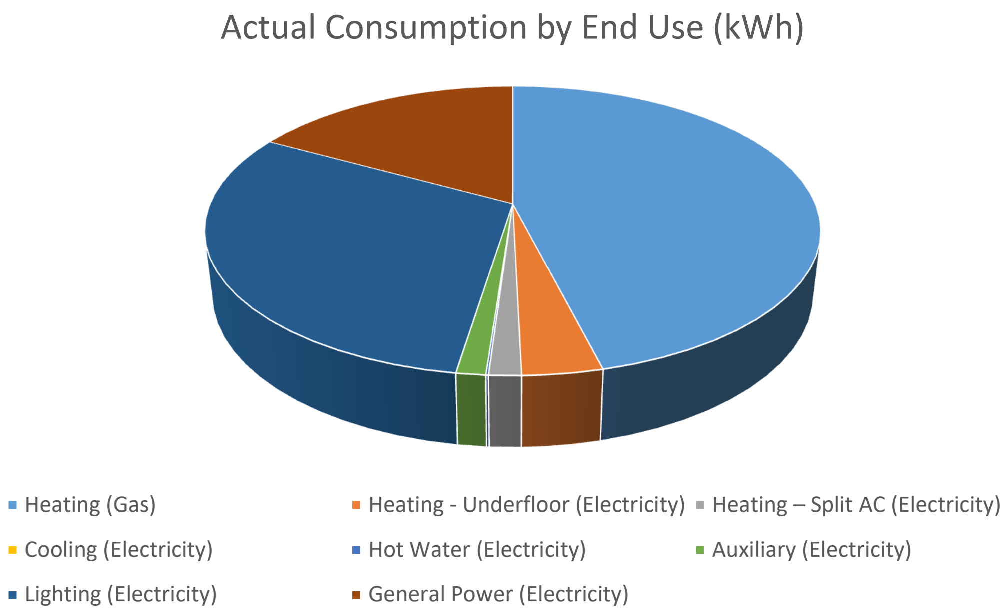
Carbon factors for each fuel have been taken as Gas at 0.216 kg/kWh and Electricity at 0.519 kg/kWh.

The calculated energy consumption and CO2 emissions can be seen below:

4.01 Heating and Power Requirements

| Load | kWh/annum | Cost of energy | $CO_2$ Emission tonnes per annum |
|---|---|---|---|
| Heating (Gas) | 49,393.50 | £1,728.77 | 10.67 |
| Heating - Underfloor (Electricity) | 3,807.65 | £361.73 | 1.98 |
| Heating – Split AC (Electricity) | 1,524.70 | £144.85 | 0.79 |
| Cooling (Electricity) | 3.86 | £0.37 | 0.00 |
| Hot Water (Electricity) | 117.66 | £11.13 | 0.06 |
| Auxiliary (Electricity) | 1,392.31 | £132.27 | 0.72 |

| Load | kWh/annum | Cost of energy | $CO_2$ Emission tonnes per annum |
|---|---|---|---|
| Lighting (Electricity) | 32,787.92 | £3,114.85 | 17.02 |
| General Power (Electricity) | 18,178.47 | £1,726.95 | 9.43 |
| TOTAL | 107,206.07 | £7,220.92 | 40.67 |




The $CO_2$ emissions calculated from the above for heating, cooling, lighting, hot water and power is 40.67 tonnes $CO_2$ per annum.

The Assessment of Renewable Technologies in Section 5.0 relies heavily on information provided in Section 4.1. Any major deviances from these loads could result in the payback periods changing from the anticipated figures. Once the development is finished, regular checks should be kept on energy use.

The energy consumption calculated from the SBEM generated kWh/m$^2$ for heating, air conditioning, lighting, hot water and power is **107,206.07 kWh per annum**.

As **10%** of the energy consumption is to be provided by renewable energy, the requirement would be **10,720.61 kWh per annum**.

5.00 <u>RENEWABLE ENERGY TECHNOLOGIES INCLUDED FOR PART L2A COMPLIANCE</u>

The technologies detailed below have been included within the design stage SBEM to provide the lowest cost solution in order to achieve compliance with Part L2A of the Building Regulations 2013.

This report incorporates the renewable energy sources as detailed within the Design Stage Building Regulations Part L2A report Ref: AC/PB/5388/PART L, dated December 2016.

5.01 <u>Photovoltaic (PV) Cells</u>

Solar photo-voltaics (PV) convert energy from sunlight into electricity using a semiconductor material. Solar PV delivers clean, silent electricity at the point of use and is only dependent upon a source of natural light.

The PV cells can be arranged on a building's roof or walls, and recent developments mean that PV can be integrated into the roof tiles and cladding. Photovoltaic cells should ideally face between south-east and south-west and at an elevation of about 30-40º.

The local Planning Authority may not regard the inclusion of solar photovoltaic panels on the aesthetics of the development favourably, so early consultation is advised.

PV panels typically have a lifetime performance of 20-25 years, and can typically see paybacks of around 8 – 10 years.

Based upon the included installation of **4.66kW**, a PV system would produce **9,138.26kWh** electricity per year. The cost saving at 9.5p/kWh would be around **£868.13/yr**. A government lead incentive, a Feed-in Tariff, would be accrued for every kWh generated, which can be sold to electricity generating companies.

These are currently trading at around 3.57p/kWh based upon the current middle rate (*Source: Ofgem e-serve*). This would increase the annual cost saving to **£1,194.37/yr**.

The $CO_2$ emissions would be reduced by approx. **4.74 tonnes/yr**.

The proposed PV system demonstrates an **8.53%** contribution towards the **10%** renewable energy target.

Each 1kWp array requires approx. 6.5m$^2$ of space, equating to an overall area of 30.29m$^2$ for the PV cells.

The roof is large enough to accommodate such an array.

5.02 Heat Pumps (Ground/Air/Water)

A heat pump absorbs energy from one source, upgrades it in the compressor and then delivers this higher-grade energy to the desired location. It is this ability to absorb surrounding energy that makes a heat pump a renewable energy device. Heat pumps of the size required by this site generally have a reverse cycle, in which they reject heat into the ground, air or water, thus providing cooling.

Heat pump efficiency is measured by what is called the Coefficient of Performance (COP). The COP is a measure of the amount of energy delivered (in kW), divided by the amount of energy needed to run the compressor and pumps (also in kW). Typically, the minimum COP for a ground source heat pump will be 4, which means 4 kW of heat is obtained for every 1kW of electricity consumed.

A ground source heat pump as the name implies, extracts energy from the ground and has a COP of around 4. The high COP is due to the stable temperature found within the ground.

A water source heat pump is virtually identical to the ground source heat pump, but extracts energy from a water source located within the ground. Since the condition of the water is also stable, a COP of around 4 would be typical.

An air source heat pump extracts energy from the surrounding air and upgrades it to a useful temperature. As air temperature is not consistent, the COP or air heat pumps is not as high as that of the ground or water source heat pumps, and typically will be in the region of 3, although advancement of this technology has resulted in systems of up to 5 being available. Air source heat pumps will generally have a lower installation cost.

At the Sports Hall, Air Source Heat pumps could be used to provide heating via underfloor heating coils to circulation areas, toilets and changing rooms.

Using figures from a commercially available system with a COP of 3.00 the CO2 emissions savings would be as follows:

To achieve **7,615.30kWh** of renewable energy, as stated in Appendix 1, for heating a heat pump with an SCOP of 3.0 would be required when using the estimated electrical consumption of 3,807.65kWh.

Emissions from electricity input at 0.519 kgCO2/kWh x 3,807.65kW = **1.98kgCO2/yr**.

A ground source heating system would have a slightly higher COP, but would also have a higher capital cost due to the additional excavation works to install the ground loop.

The $CO_2$ emissions saving by utilising heat pumps is relatively low, due to the high carbon emission factor of grid electricity. However, this technology is being encouraged as it is hoped that the emission factor for grid electricity will be reduced over the coming years by the use of renewable generation of electricity.

The proposed ASHP system demonstrates a **7.10%** contribution towards the **10%** renewable energy target.

5.03 Air Source Heat Pumps (Refrigerant Based)

In additional to the Air to Water heat pumps mentioned in 5.2 above additional heat pumps that use refrigerant as the heating / cooling medium shall be utilised to condition the Fitness Suite area typically via ceiling mounted cassette type units.

With improvements in inverter controls as well as other aspects of these heat pumps, we can expect to achieve SCOP's in excess of 4.0 and SEER's in excess of 5.0.

This system generates renewable energy in both Heating and Cooling modes by upgrading energy taken from the ambient air via a compressor in the same way as described above.

Appendix 1 identifies this system as a small contributor to the **10%** renewable energy target of **2.84%** heating and **0.01%** cooling.

6.00 FURTHER RENEWABLE TECHNOLOGIES FOR CONSIDERATION

This section further considers the options of renewable energy technologies, which may be applicable to the scheme as well as or in lieu of the items already included in the Design Stage Building Regulations Part L assessment.

Energy systems that are currently considered renewable are:

- Wind Turbines
- Solar Thermal Hot Water Systems
- Biomass Heating
- Geothermal
- Anaerobic Digestion

In the descriptions for the renewable energy technologies below, the payback periods have been calculated using the current price of energy. As the fuel prices rise, the payback periods will reduce, and the periods will be shorter than shown.

Payback periods are calculated assuming, the capital costs would be provided solely by the Owner.

The level of grant funding available should also be considered at the detailed feasibility stage, for each individual technology.

The following gives a brief description of each technology considered and summarises how they may be appropriate for this development.

6.01 Wind Turbines

For the purpose of this Report, wind turbines have been included as they are a recognised method of achieving renewable energy. However, a full wind survey would need to be undertaken to establish the average local wind speed and the effects of turbulence from other buildings in the vicinity.

Wind turbines can be either connected to the grid electrical supply to enable the excess energy produced to be sold back to the electricity providers, or alternatively turbines can charge a bank of batteries. The output from the turbine is directly proportional to the average wind speed on the site.

Wind turbines come in certain sizes 1.2kW, 2.5kW, 6kW and 15kW. It is assumed for the purpose of this report that one 6kW turbine could be installed. The expected output of one 6kW turbine would be 1,509.97kWh per annum, which is 1.41% of the site energy use.

The costs saving at a rate of 9.5p/kWh would therefore be £143.45 per annum. In addition, the Feed-in Tariff would be accrued for every kWh generated, which can be sold to electricity generating companies. These are currently trading at around 8.13p/kWh. This would increase the annual cost saving to £266.21.

**The saving in CO2 emissions would be 1.63 tonnes CO2 per year compared with grid-supplied electricity.**

**The average annual energy saving would be 1,509.97kWh/yr compared with grid-supplied electricity.**

The over and above cost for a grid connected 6kW wind turbine, excluding civil work would be £20,000.00

Energy companies are now offering higher rates to consumers for purchasing energy back from renewable sources than ever before. This, in part, is driven by Feed-in Tariffs. Feed-in Tariffs are the electricity part of what some people call Clean Energy Cash back, which includes the Renewable Heat Incentive.

They have been introduced by the Government to increase the level of renewable energy in the UK towards the 15% of total energy from renewables by 2020.

The rate at which energy can be produced and sold back to the energy companies should be carefully considered when sizing electricity-producing renewable plant such as wind turbines. In particular, with wind turbines the general advice is (within budgetary constraints) “the bigger the better”.

Selling energy back to the electricity providers will greatly affect the payback period and therefore viability of installing a wind turbine. Again, a more detailed feasibility study will be required to ascertain these figures.

Based on the size of turbine detailed above the SBEM has been run to include this, the result is to reduce the required PV array by 5No. Panels to achieve a pass resulting in a capital cost saving of approximately £2,000.00, which would reduce the over and above cost to £18,000.00 for the wind turbine.

**Since the Sports Facility is to be located on the school grounds, it is unlikely that the erection of a wind turbine at the site due to the associated visual, noise and vibration implications would be preferred.**

6.02 <u>Biomass</u>

Biomass fuel for small-scale boilers and heating systems generally takes the form of wood chip or wood pellet. Wood pellet is a purpose manufactured fuel product that is clean and easily handled. Biomass systems require an area for fuel storage, as well as a feeder or hopper system for automatic fuel feeding.

To ensure the carbon neutrality of a Biomass system, the fuel should be sourced from a manufacturer who actively replaces the plants used in making the fuel, and not a manufacturer who merely crops the fuel and does not re-plant. In essence, the carbon neutrality of an installation depends on the continuous replanting of a fuel source to absorb the CO2 produced by burning the fuel from the previous crop.

It should also be noted that if biomass fuel has to travel a long distance from where it is produced, the benefits are lessened due to emissions associated with transport. A carbon emission factor of 0.031 kgCO2/kWh has been used within this report.

Biomass is still a relatively new technology in the UK despite its wide use throughout Europe and America. As such, it is still a relatively expensive solution, with the average biomass boiler costing between 3-5 times more than the equivalent natural gas boiler. The wood pellet fuel itself is also currently at a similar price to natural gas.

A Biomass Fuel Store is not present at the site already and costs for it have been included.

A biomass boiler generating heating and hot water, would equate to 45,230.60kWh/yr consumption.
The estimated cost over for the biomass boiler, Fuel store and ancillary equipment (over and above ASHP heating) would be circa £65,000.

With energy costs estimated to 9.5p/kWh and 3.5p/kWh for Electricity and biomass respectively, only a small saving of £1,402.15 can be calculated based on and the feed-in tariff, offering 3.10 p/kWh.

In addition to this 12No photovoltaic panels would be required to achieve the same pass margin provided by the proposed compliant solution. This would add approximately £4,500.00 to the cost of this solution, but would generate 3,655.30kWhr/annum and provide additional feed in tariff these are currently trading at around 3.57p/kWh based upon the current middle rate (*Source: Ofgem e-serve*). This would increase the annual cost saving to **£477.74/yr**.

**Due to the extra over cost of £69,500.00 and the pay -back period for the scheme being excessively high, this option has not been proposed for the project.**

6.03 <u>Solar Thermal Hot Water Systems</u>

Solar thermal hot water systems use solar collectors, generally mounted on the roof of a building, to capture and store the sun's heat via water storage systems. The collectors either directly or indirectly heat water for domestic use by the building occupants. They are among the most cost-effective renewable energy system for dwellings, although most efficient when the hot water is used during the day. Requirements for mounting the panels are similar to photovoltaic cells.

The amount of solar thermal panels needed is calculated from the hot water cylinder capacity, at a rate usually of 1m² of panel for every 60 litres of hot water stored.

Unfortunately, due to the hot water being provided by point of use electric water heaters, there is no calorifier or HWS storage vessel to house the solar heating coil.

**This technology has not been considered for this project.**

Geothermal

Geothermal heating can only be considered when a source of hot water below the earth surface is available at an accessible depth via deep drilling and therefore is dependent on location.

**This technology has not been considered for this project.**

6.04 <u>Anaerobic Digestion</u>

Organic matter is broken down by bacteria in the absence of air, producing a gas (methane) and a solid (digestate). The methane (known as a biogas) used in a furnace to produce heat, or in a Combined Heat and Power plant (CHP) to produce electricity and heat.

The waste digestates can be re-used on farms as a fertiliser, making this a very efficient process.

The investment to create an anaerobic digestion power system is considerable, and must be local to a landfill or sewage site. This type of system works best when part of an actual waste centre.

For this building, no landfill or sewage site is presumed close enough to make this a worthwhile option, and the cost would also make it prohibitive.

**This technology has also not been considered for this project.**

6.05 <u>Exclusions</u>

The following technologies have been excluded from this section of the report for the reasons stated.

CHP – This is considered a low carbon technology rather than renewable.

7.00 CONCLUSIONS

1) The cost of installing renewable energies will be higher than conventional technology.

2) The 10% target of on-site energy generation is **10,720.61 kWh.** This is achieved by the inclusion of air source heat pumps and a Photovoltaic array of 30No panels.

3) The renewable technologies included within the Design Stage Part L compliance report (AC/PB/5388/PART L, December 2016) would produce energy savings, which equate **18.48% of the total energy consumption** of the proposed building and would comply with the planning obligations.

4) The renewable technologies investigated could provide the following kWh savings:

| **Renewables** | **Energy Generation (kWh/yr)** | **Running Cost Saving (£/yr)** | **Extra Over Capital Cost (£)** | **Payback Period (Yrs)** |
|---|---|---|---|---|
| ASHP's and Photovoltaics | 19,810.38 | - | - | - |
| Biomass and Photovoltaics | 45,230.60 | £1,879.89 | £ 69,500.00 | 36.97 |
| ASHP, PV and Wind Turbine | 1,509.97 | £266.21 | £ 18,000.00 | 67.61 |
| Solar Thermal Hot Water | N/A | N/A | N/A | N/A |
| Geothermal | N/A | N/A | N/A | N/A |
| Anaerobic Digestion | N/A | N/A | N/A | N/A |

8.00 RECOMMENDATIONS

1) The heating of the Sports Halls can remain as gas fired radiant units.

2) It is recommended that Air Source Heat Pumps and 30No Photovoltaic Panel be incorporated to achieve Part L2A compliance and satisfy the planning policy requirements of 10% on-site renewable energy generation.

3) Where appropriate the client should pursue Feed-in Tariff and/or Renewable Heat Incentive registration to optimise the saving achieved from renewable energy technologies.

**APPENDIX 1: RENEWABLE ENERGY GENERATION CALCULATION**

10% On-Site Renewable Energy Generation and Part L2 Compliance to be achieved with: Gas fired Radiant heating, ASHP for general heating, Air Conditioning to Studio and Office and a PV Array.

**Information**

| | | |
|---|---|---|
| **Building Area:** | 1961.00 | m² |
| **Gas Heated Area:** | 1326.00 | m² |
| **ASHP Heated Area:** | 301.00 | m² |
| **Split AC Area:** | 193.00 | m² |
| **PV Array (kWh/m²):** | 4.66 | (kWh/m²) |

Calculation is based upon the energy consumption figures produced from the TAS SBEM modelling Software

| End Use | Energy (kWh/m²) | Area (m²) | Actual Consumed (kWh) | Energy Consumed by End Use (%) | Heat Pump Seasonal COP's | Renewable Energy Outputs (kWh) | Renewable Energy Production (%) |
|---|---|---|---|---|---|---|---|
| **Heating (Gas)** | 37.25 | 1326.00 | 49393.50 | **46.07%** | | | |
| **Heating (ASHP)** | 12.65 | 301.00 | 3807.65 | **3.55%** | 3.00 | 7615.30 | **7.10%** |
| **Heating (Split AC)** | 7.90 | 193.00 | 1524.70 | **1.42%** | 3.00 | 3049.40 | **2.84%** |
| **Cooling (Split AC)** | 0.02 | 193.00 | 3.86 | **0.00%** | 3.00 | 7.72 | **0.01%** |
| **Auxillary** | 0.71 | 1961.00 | 1392.31 | **1.30%** | | | |
| **Lighting** | 16.72 | 1961.00 | 32787.92 | **30.58%** | | | |
| **Hot Water** | 0.06 | 1961.00 | 117.66 | **0.11%** | | | |
| **General Power*** | 9.27 | 1961.00 | 18178.47 | **16.96%** | | | |
| **Photovoltaics **** | | | | | | 9138.26 | **8.52%** |
| | | | | | | | |
| **Total** | 84.58 | 1961.00 | 107206.07 | **100.00%** | | 19810.68 | **18.48%** |

* General Power not included in SBEM Calculation but given as a guide only from Software.

** Photovoltaic systems consists of 30No PV Panels, South-East facing on the Roof, Panel Efficiency of 20%.