mechanical & electrical services

SERVICES OPTIONS APPRAISAL REPORT

MIDDLE ASTON

DECEMBER 2019

contents.

1.00 aim of the report.

This Report and Energy Statement is a response to the requirement for a Renewables and Combined Heat and Power (CHP) Feasibility Appraisal as a part of the planning application for the Middle Aston Office Development.

The Report includes an assessment of a number of fuel and site infrastructure options:

- Decentralised (Local) Systems
- Centralised Plant
- Combined Heat and Power
- Heat Pumps
- Biofuels
- Solar
- Gas/Oil/LPG

Each of the options is considered in terms of

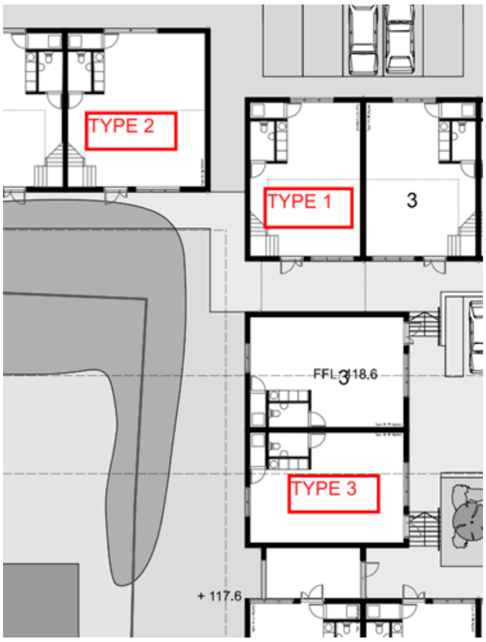
- Capital Cost
- Running Costs
- Carbon Emissions
- Management and Billing

To undertake the evaluation of the options, it is necessary to create a detailed thermal energy model of representative sample buildings. The model created is for building envelops which meet the requirements of Part L2 of the Building Regulations 2013. Compliance is evidenced through an SBEM calculation.

The SBEM (simplified building energy model) calculation is performed on non-domestic buildings to determine their building emission rating (BER) and compare it with a target emission rating (TER) of a notional building of the same type, size and shape. The figures are expressed in kg of CO_2 emitted per m^2 of building.

Provisional SBEM simulations have been carried for each separate office unit ‘type’ utilising the decentralised heating options that are considered in this Report.

The energy model uses 3 sample buildings as follows:



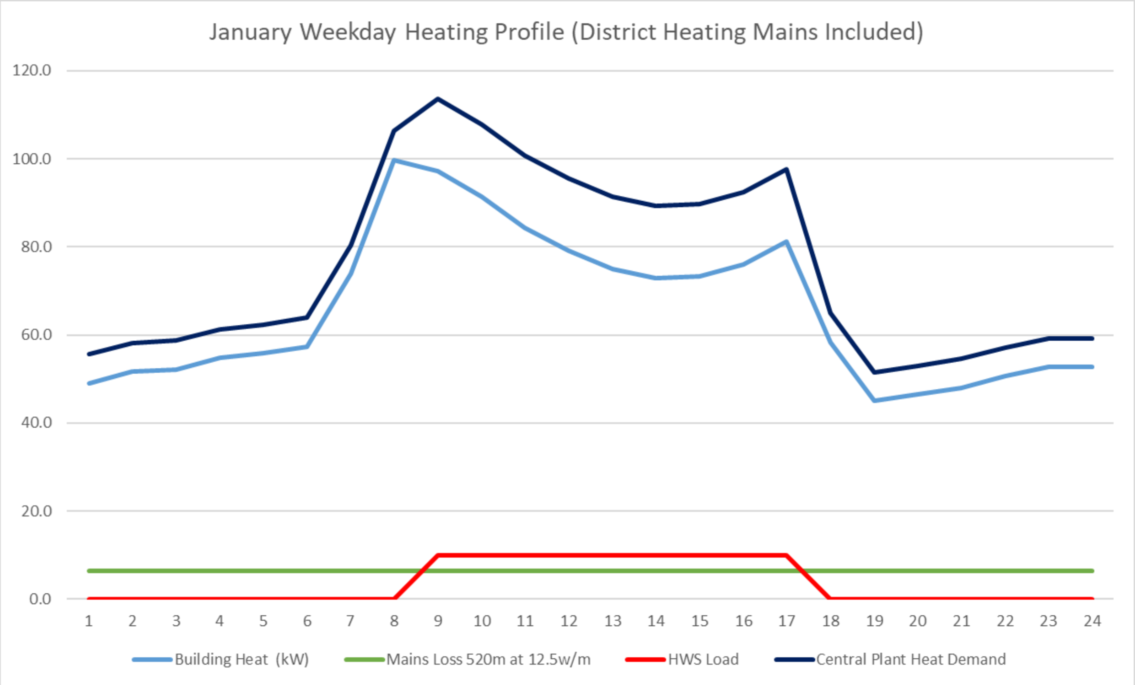
The following thermal properties have been established as sufficient to satisfy the requirements of the calculations:

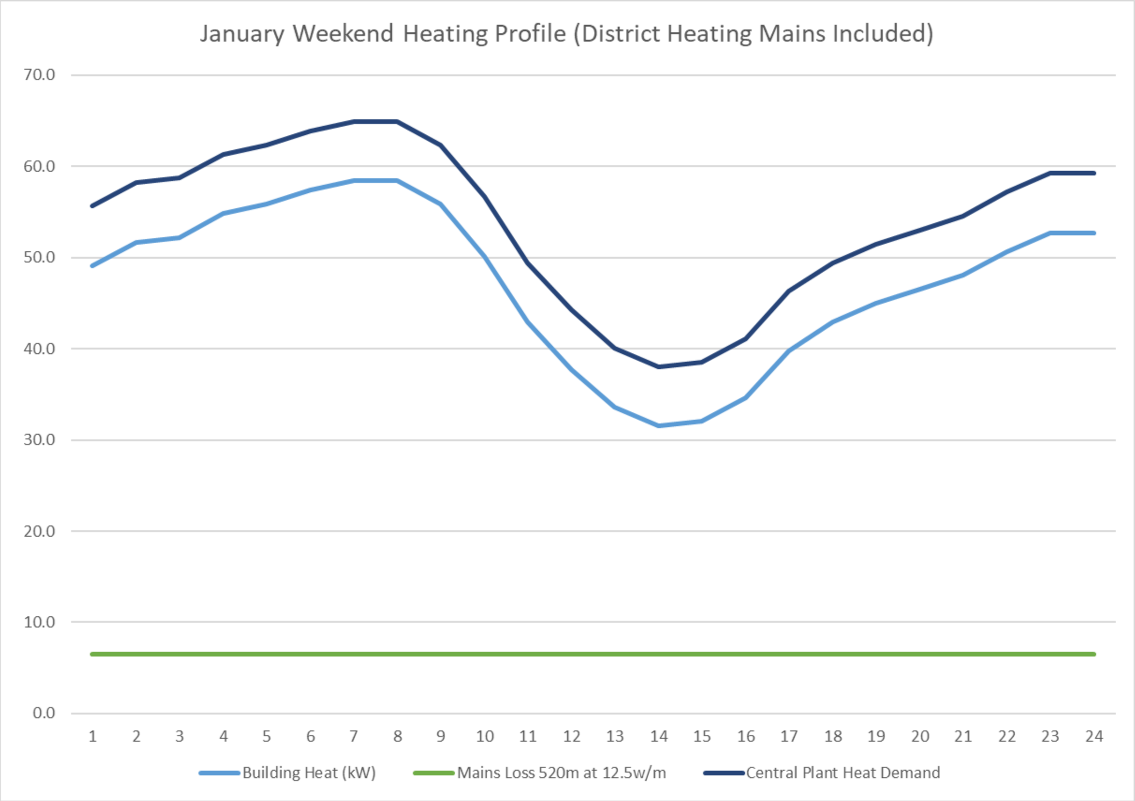
U Values

Walls	0.18 W/m2 °C
Roofs	0.18 W/m2 °C
Floors	0.2 W/m2 °C
Glazing	1.1 W/m2 °C

Air Permeability $3m^3/m^2$ @ 50Pa

From the 3 sample buildings, a site wide consumption profile has been constructed as follows:





For the purposes of the following comparisons the following assumptions are made:

Cost of Mains Gas	3.54p/kWh
Carbon factor for Mains Gas	0.208 $kgCO_2$/kWh
Cost of Mains Electricity	15p/kWh
Carbon factor for Mains Electricity (SAP10)	0.233 $kgCO_2$/kWh

2.00 centralised heating options.

Centralised heating system options would have a central heat producing plant or “energy centre” serving the entire site. From here, buried insulated “district heating” mains would be taken to each of the office units, to serve the local heating demand.

On entry into the individual unit, the district heating mains would be terminated into a heating interface unit, separating the site wide and local systems.

The heating interface unit would provide local heating control and incorporate heat metering, so that each unit could be contra charged for the energy used.

This centralised system architecture has a number of advantages and compared to a more traditional local system, such as a gas boilers. The key issues are as follows:

Advantages of Centralised District Heating	Disadvantages of Centralised District Heating
Can accommodate Combined Heat and Power (CHP) systems	High up-front site infrastructure capital investment
Can accommodate Biofuel Systems	Landlord responsibility for heat delivery
Can accommodate future technologies for heat generation, e.g. fuel cells	System heat losses from the district heating network – amounting to 10% of heat generated during the heating season.
More robust and resilient systems with stand by equipment	Management system required to sell the heat to the office units
Single point of maintenance	Heating system capacity has to be available irrespective of unit occupancy
No flues or other heating plant in the office units	Uneconomic to runs mains in summer months as losses greater than heat sales – local electric hot water heating required
	Landlord responsibility for all plant maintenance

The feasibility of three centralised systems have been considered:

2.01 gas fueled combined heat and power

Combined heat and power (CHP) is a highly efficient process that captures and utilises the heat that is a by-product of the electricity generation process. By generating heat and power simultaneously, CHP can reduce Carbon emissions compared to the separate means of conventional generation via a boiler and power station.

In this assessment, a gas fired CHP engine is considered. To make the most efficient use of the engine, it is selected to satisfy the “base” demand, such that it is operating at high output for as many hours as possible throughout the year. For the peak heat demand periods, supplementary boilers are used to up the heat requirement.

During the summer months, the heat lost from the heating distribution mains is greater than that used in providing domestic hot water. The calculations are therefore based on use during the heating season only.

From the daily heat demand profiles, it can be seen that a 60kW (thermal) CHP engine would be suitable, this unit produces 32kW of electricity.

The CHP engine unit would be connected to supplementary gas fired boilers, located within energy centre.

Advantages of Combined Heat and Power	**Disadvantages of Combined Heat and Power**
Combined heat and electrical production has lower CO_2 than imported power and gas heating	Development management responsible for heat and power supplies to the tenants
Plant resilience having stand by boilers in case of equipment failure	Landlord would have to have an expensive power supply agreement and availability charge for grid power
Possible use of CHP as site standby power generation	All of the other disadvantages associated with a centralised system.
	Only viable if all of the power generated in used on site
	Requires site private wire network

Option Data:

System Capital Cost	£696,226.00
Annual Cost	£13,960.00
Annual Carbon Emissions	91.6 Tonnes

Approximate plant space requirement:

CHP Unit	2m x 3m
Boilers & Ancillary Plant	4m x 3m

The following assumptions have been made in this analysis:

All power generated from CHP is used on site, the value (@ 15p/kWh) and Carbon (@ 0.233kgCO_2/kWh) has been used to offset the annual cost and Carbon emissions.

Southern Gas Networks budget incoming gas supply cost dated 20 November 2019 is representative

CHP operates during heating season only and hot water is generated locally using electricity in the summer

Heating systems in units utilise traditional radiators

Excluded from Costs:

Incoming power and private wire network costs

Building works associated

VAT

Design fees

2.02 biomass boiler

Biomass in the form of wood pellets or wood chips is now a common renewable heating fuel source. For this analysis, wood pellets will be considered as they have a lower volume to manage and store and are available to a consistent quality standard.

To make the most efficient use of a biomass boiler, it is selected to satisfy the “base” demand, such that it is operating at high output for as many hours as possible throughout the year. For the peak heat demand periods, supplementary boilers are used to up the requirement.

During the summer months, the heat lost from the heating distribution mains is greater than that used in providing domestic hot water. The calculations are based on use during the heating season only.

From the daily heat demand profiles, it can be seen that a 60kW biomass boiler would be suitable.

The biomass boiler would be connected to supplementary gas fired boilers, located within energy centre.

Advantages of Biomass Boiler Plant	Disadvantages of Biomass Boiler Plant
A demonstrable “Green” solution using renewable energy	Development management responsible for heat supplies to the tenants
Benefits from the Renewable Heat Incentive	Larger energy center building with regular vehicle access
Plant resilience having stand by boilers in case of equipment failure	All of the other disadvantages associated with a centralised system.
	Management of fuel supply
	Gas supply required as well as biomass fuel

Option Data:

System Capital Cost	£680,529.00
Annual Cost	£1,800.00
Annual Carbon Emissions	52.1 Tonnes

Approximate Plant Space Requirement:

Biomass Boiler & Thermal Store	4m x 5m
Gas Boilers & Ancillary Plant	4m x 3m
Wood Chip Store	4m x 4m

The following assumptions have been made in this analysis:

The Renewable Heat Incentive is available at current rates, at the time of the project completion. Note that the RHI expires after 20 years and the annual fuel cost would rise to £14,258.00 per annum.

The biomass boiler operates during heating season only and hot water is generated locally using electricity in the summer.

Southern Gas Networks budget incoming gas supply cost dated 20 November 2019 is representative

Heating systems in units utilise traditional radiators.

Excluded from Costs:

Building works associated

VAT

Design fees

3.00 decentralised heating options.

Decentralised or local heating system options would have a heat producing plant dedicated to each office unit.

A metered energy supply would be taken to the unit to serve its heating plant.

This decentralised system architecture has a number of advantages compared to centralised systems considered above. The key issues are as follows:

Advantages of Decentralised Heating	Disadvantages of Decentralised Heating
Lower up-front site infrastructure capital investment.	Limited to accommodate alternative fuel systems
No Landlord responsibility to deliver heat or power	Simpler, less robust and resilient systems without standby
Each tenant has its own fuel supply agreements with utility companies	Flues and other heating plant in the office units
No requirement for central energy centre building or external mains trenching	
Tenant responsible for maintenance	

3.01 local gas heating boilers

Each office unit would have its own small gas fired high efficiency combination boiler individually controlled and piped to a radiator circuit.

Advantages of Local Gas Heating Boilers	Disadvantages of Local Gas Heating Boilers
Lower capital cost	Requires flues and some space in the office unit
Familiar to potential users	Gas infrastructure required
Can be maintained by local Gas Safe engineer	
Can be a part of a fit out	

Option Data:

System Capital Cost	£535,750.00
Annual Cost	£13,569.00
Annual Carbon Emissions	72.5 Tonnes

Approximate Plant Space Requirement:

Boiler Cupboard in each office	600 x 600

The following assumptions have been made in this analysis:

Southern Gas Networks budget incoming gas supply cost dated 20 November 2019 is representative

Heating systems in units utilise traditional radiators.

Excluded from Costs:

Building Works associated

VAT

Design fees

3.02 air source heat pump

Air source heat pumps are a common low cost and low Carbon heating option.

Each office unit would have its own air source heat pump (ASHP) located to the rear of the property. This shall require an electrical supply to power to a compressor which absorbs heat from outside air and transfers this to a water circuit.

A heat pump of this type will reliably deliver 3.5 kW of heat for each kW of electricity supplied to the compressor, this is known as the Coefficient of Performance (COP). This is only achieved when delivering heating water at approximately 45°C, suitable for underfloor heating but not radiators.

Each heat pump will have its electrical consumption and heat metered.

Advantages of Local Air Source Heat Pump	**Disadvantages of Local Air Source Heat Pump**
Lowest capital cost for heating only options.	Requires internal and external space for plant
Low CO_2 emissions and demonstrably “green” option	Only suitable with underfloor heating
Qualifies for the renewable heat incentive	
Can be a part of a fit out	
Does not require gas supply to site	
No flues required	

Option Data:

System Capital Cost: £523,192.00

Annual Cost £7,314.00

Annual Carbon Emissions 25.2 Tonnes

Approximate Plant Space Requirement:

External plant per unit 1200(w) x 1500(h) x 400(d) in enclosure

The following assumptions have been made in this analysis:

Heating systems in units utilise underfloor heating.

The Renewable Heat Incentive is available at current rates, at the time of the project completion. Note that the RHI expires after 20 years and the annual fuel cost would rise to £16,259.00 per annum.

Excluded from Costs:

Building Works associated

VAT

Design fees

4.00 semi-decentralised heating option.

A hybrid solution might entail a local plant serving a series of units.

To offer an option which includes comfort cooling, a semi-decentralised option has been considered.

4.01 variable refrigerant volume (VRF) system

A VRF system uses heat pump technology to both heat and cool spaces. In this instance, each office block/wing would have its own VRF system.

Each system would comprise of a set of external compressors, requiring an electrical supply, to absorb or discharge heat to outside air. This heat is transferred via refrigerant to wall or ceiling mounted fan coils/cassettes within the offices.

The VRF system, unlike the air source heat pump, also has the capacity to reverse its operation and thereby provide cooling to the offices during the summer.

The VRF systems can have an integrated means of apportioning running costs between different users, however this system does not meet the metering standards and would have to be treated as approximate.

Operation shall be via a wall mounted programmable controller within each office.

Due to the VRFs capacity to provide cooling it is not eligible for RHI payment.

Advantages of Semi-decentralised VRF System	Disadvantages of Semi-decentralised VRF System
Lowest capital cost	Requires internal and external space for plant
Low CO_2 emissions and demonstrably "green" option.	Increased running costs
Provides cooling	Does not qualify for the renewable heat incentive
Does not require gas supply to site	Services for one unit passing through adjacent units
Can be a part of a fit out	
No flues required	

Option Data:

System Capital Cost	£496,800.00
Annual Cost (Heating)	£16,3258.00
Annual Cost (Cooling)	£7,054.00
Annual Carbon Emissions	36.2 Tonnes

Approximate Plant Space Requirement:

External plant per block	4m x 2m enclosure

The following assumptions have been made in this analysis:

Heating systems in units utilise wall mounted fan coil units.

Excluded from Costs:

Building Works associated

VAT

Design fees

5.00 overheating calculation.

The assessment of the options for heating systems includes that for a semi decentralised VRF system which offers comfort cooling.

The assessment shows that running costs rise considerably if cooling is used. Comparing the Air Source Heat Pump to the VRF system, the following contrast is evident:

	Air Source Heat Pump	VRF System with Cooling	Difference	Comment on Impact of Cooling
Capital Cost	£523,193	£496,800	5%	Lower Capital Cost
Annual Running Cost	£7,314	£23,313	-219%	Higher Running Cost
Carbon Emissions (T CO_2)	25.3	36.2	-43%	Higher Carbon Emissions

The very great penalty of having cooling in terms of cost and Carbon emissions means that a thorough investigation into ways of mitigating the need for cooling is necessary.

In order to quantify the risk of overheating within the office units a model was created using thermal simulation software. Building 7 was identified as having the highest chance of overheating and the following table indicates the temperatures that may be reached throughout a “design year” and when the Building is occupied (8am-6pm Monday-Friday).

For purpose of the simulation it was assumed that a 1 metre section of each window is side hung and fully openable during occupied times.

Internal temperatures reached with openable windows only:

Room Temperature (ºC)	% Of Occupied Year Above Temperature	Occupied Hours Above Temperature (Hours per Annum)
30	1.0%	28
29	3.2%	89
28	7.4%	206
27	11.2.%	311
26	15.4%	428
25	20.4%	568

One way of reducing the peak temperatures and the number of hours temperature over 25°C are experienced would be by adding roof ventilators. These would utilise wind speed and the natural stack effect of rising warm air to provide fresh air to the offices and utilise night-time cooing to lower temperatures experienced by the occupants.

The table below indicates predicted temperatures of ventilators capable of providing 3 air changes per hour to each unit during unoccupied hours (nighttime free cooling) and minimum 10 air changes per hour during occupied hours.

Internal temperatures reached with openable windows and roof mounted vents:

Room Temperature (ºC)	% Of Occupied Year Above Temperature	Occupied Hours Above Temperature (Hours per Annum)
30	0.0%	0
29	0.0%	0
28	0.2%	4
27	0.4%	12
26	1.5%	41
25	3.7%	102

With indoor temperatures over 25°C generally perceived as uncomfortable the above table indicates that the addition of roof ventilators could reduce the time the office units spend over this without the additional energy costs associated with a refrigerant based cooling system.


Various roof ventilators

6.00 electrical services strategy.

The assessment of the options for heating systems greatly informs the requirements for the electrical services infrastructure of the site.

The most intensive electrical demand infrastructure would be that needed to support the heat pump or VRF options.

An 11kV/400V Scottish and Southern Electricity Networks substation exists at the rear of the development site. Its size is unknown.

An 11kV below ground service feeds the substation from Fir Lane on the East side of the development. The existing below ground service passes between existing buildings and is thought to be outside of the footprint of all proposed developments.

It is thought that the substation serves existing units on the development site and the trading estate behind the development at 230/400V.

It is proposed the existing substation would provide a total of 28No low voltage, metered, single phase 100A rated supplies and 2No low voltage, metered, three phase 100A rated supplies to the proposed business units, including one supply for Landlord. The unit's occupier would be responsible for the associated energy billing.

The substation is extremely likely to require upgrading to accommodate the additional load demand.

The overall demand for the development has been assessed at 280kVA based on heat pump systems.

The Landlord's supply would serve any lighting required in car park areas and would be capable of powering a limited number of fast charge electric vehicle charging stations.

Each business unit would be self-contained and not reliant upon any other unit for power requirements.

Each unit would be provided with a single-phase distribution board adjacent the incoming supply meter.

7.00 renewable energy.

The Report had considered renewable and low Carbon technologies in the evaluation of the heating options.

A further consideration would be the integration of solar collection.

7.01 solar thermal

A Solar Thermal System uses roof mounted flat panels or evacuated tube collectors to capture the Sun's energy to produce hot water for the Building. This hot water is stored in a tank, ready to be used as and when needed.

It is anticipated that the offices will use minimal hot water so this option is discounted.

7.02 solar pv

Over recent years Solar PV has become common across the UK.

As well as the panels, often seen on roofs, the installation includes inverters which convert the generated power into a suitable form that can be used in the offices or exported to the Grid.

Following the very strong take up of the Government incentive (Feed in Tariff) the funding has now been exhausted. The FIT has now been replaced with a new scheme, the “Smart Export Guarantee”. At the time of the Report, the Scheme is not finalised and so the economic case needs to be revisited before any installation proceeds.

If there is a requirement for photovoltaic panels then this could be configured in two ways:

Building Mounted	Each unit having dedicated roof mounted panels feeding into the unit’s own power supply. This arrangement allows the tenant to benefit from the generated power and can be applied to the SBEM and unit EPC.
Site Wide	A remote solar array feeding into the Landlord supply. This would predominately be an export system.

For the purposes of this report, only building mounted PV’s are considered, as a site wide installation would be simply an investment decision and would not impact the energy status of the buildings on the site.

Any proposed arrangement would be subject to approval by Scottish and Southern Electricity Networks.

An initial assessment of the feasibility of an array on each office is as follows:

Capital Cost	£360,000.00
Cost Saving	£27,147.00
Simple payback period	13 Years
Carbon Saving	1.17 Tonnes (5%)

The assessment assumes that the offices are used 5 days per week.

8.00 energy statement.

A thorough site wide assessment of the energy low Carbon and renewable energy technologies have been assessed and are ranked in the following table in order of overall Carbon emissions:

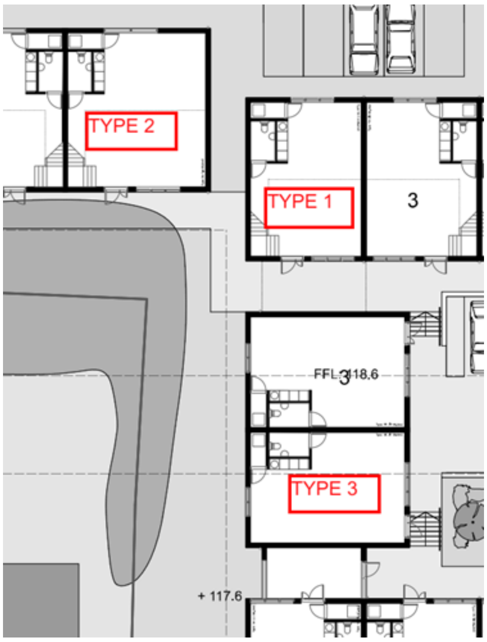
Heating System	Primary Fuel	Carbon Emissions (Tonnes CO2)
Site Wide Combined Heat and Power	Gas	91.6
Local Boilers	Gas	75.2
Site Wide Biomass Heating	Biomass	52.1
Local VRF with Cooling	Electricity	36.2
Local Air Source Heat Pumps	Electricity	25.2

The lowest CO_2 option is only feasible if the need for cooling can be mitigated.

An assessment of overheating finds that with the use of openable windows and roof mounted vents there is an expectation that internal temperatures will exceed 25°C for a little over 100 working hours per annum.

An assessment of renewable technology has been assessed and found that the addition of Solar PV makes only a 5% reduction in Carbon emissions and is therefore discounted.

A sample SBEM calculation has been undertaken for 3 unit types as follows:



Office Type	Target Emission Rate (TER)	Target Emission Rate (BER)	Percentage Improvement
Type 1 Unit	17.5	11.3	35.40%
Type 2 Unit	16.5	12.5	24.20%
Type 3 Unit	18.8	11.2	40.40%

These results demonstrate compliance to Part L2 of the Building Regulations.