Rother Town Hall

Energy Strategy

July 2020

Contact
124-125 Princes St
Edinburgh, EH2 4AD
enquiries@harleyhaddow.com

Document Revision Control

Revisions	Date	Reason for Issue	By	Approved
00	06.07.2020	For Information	SJP	SJP
01	07.07.2020	Indicative Cost information Added	SJP	SJP

Contents

Executive Summary

This report has been prepared to review the potential energy and carbon savings that can be achieved for Rother Town Hall.

Consideration has been given to facilitate moving towards a Net Zero Carbon society and the move away from fossil fuels.

The aim of the study is to assess a range of solutions which can allow the Town Hall building to achieve reduced carbon and energy consumption, the solutions will focus on providing an element of future-proofing through considering appropriate future fuel sources and reduced ongoing maintenance and running costs.

Following a review of the options using an energy hierarchy approach the greatest carbon and energy savings can be achieved with the inclusion of the following measures:

Option	Measure	Hierarchy Stage	Energy Saving (%)	Carbon Saving (%)
Option1	Roof Improved to achieve a u-value of 0.25	**Lean**	**2.73%**	**1.69%**
Option 2	Glazing replaced to a achieve a u-value of 1.8	**Lean**	**13.57%**	**8.1%**
Option 3	Boiler replaced with high efficiency type, heating pipework, pumps, and emitter replacement.	**Mean**	**18.06%**	**11.55%**
Option 4	Replace hot water storage with point of use system	**Mean**	**3.77%**	**1.66%**
Option 5	Replace lighting with energy efficient fittings including controls	**Mean**	**3.11%**	**24.5%**
Option 6	Options 1 to 5 combined	**Lean & Mean**	**42.5%**	**48.35%**
Option 7	Option 6 plus Roof mounted PV Panels	**Lean, Mean & Green**	**49%**	**58.12%**
Option 8	Option 7 plus Air Source Heat pumps providing heating demand	**Lean, Mean & Green**	**77%**	**67.28%**

The inclusion of an Air Source Heat Pump solution to provide heating with PV to further offset the carbon demand for the site.

These technologies were selected as being the most feasible with the below key advantages highlighted as part of the study:

- Use of green electricity as fuel for heat pumps provides future-proof solution.
- High efficiency solution using currently available and tested technologies.
- Renewable source of heating available through air.
- Available roofscape for the installation of energy generating technology via PV

- Significant energy achieved compared to existing systems.

The carbon emissions have been calculated based on the current and future carbon emission factors (CEFs).

The options appraisal looks at each of the potential solutions individually so that each option can be appraised in isolation should they require to be split into separate work packages.

1.0 Introduction

1.1 General

Harley Haddow have carried out a high-level options appraisal for Rother Town Hall in Bexhill-on-Sea, to determine the potential energy and carbon savings achievable through implementation of a range of different energy efficiency measures and technologies including Low and Zero Carbon Generating Technologies (LZCGTs) in order to reduce energy and carbon emissions and future proof towards a move towards net zero carbon.

The Town Hall was built 1894 has had various extensions and additions over the last 100 years. Some energy efficiency measures have already been undertaken within the building, but these are understood to be limited and include:

- Double glazed UPVC windows in part
- New roof in part (2013)
- Lowered ceilings – suspended tiles
- LED lighting in part
- Voltage optimiser
- Central heating pipework lagged in part

However, the building and systems are relatively inefficient with an old inefficient gas heating system, energy intensive lighting systems and poor building fabric levels.

Figure 1: Rother Town Hall

1.2 Objective

The objective of the study is to review the potential energy efficiency improvement measures that can be applied to the building and provide comment on the potential energy carbon and running cost reductions.

The impact of future legislation moving towards net zero carbon shall also be reviewed and any applicable measures to futureproof the building investigated and included in this review.

1.3 The Energy Strategy Approach

Harley Haddow have adopted a comprehensive strategy to address the energy and renewable technologies used on the scheme and how they will be adopted on the proposed development.

The energy strategy will incorporate the following energy hierarchy:

- **"Lean"** Measures through Energy Efficiency & Passive measures including building fabric performance improvements
- **"Mean"** Measures through energy efficiency plant, low energy lighting and heat recovery systems. Viability of CHP and connection to district heating.
- **"Green"** Measures including the inclusion of renewable technology

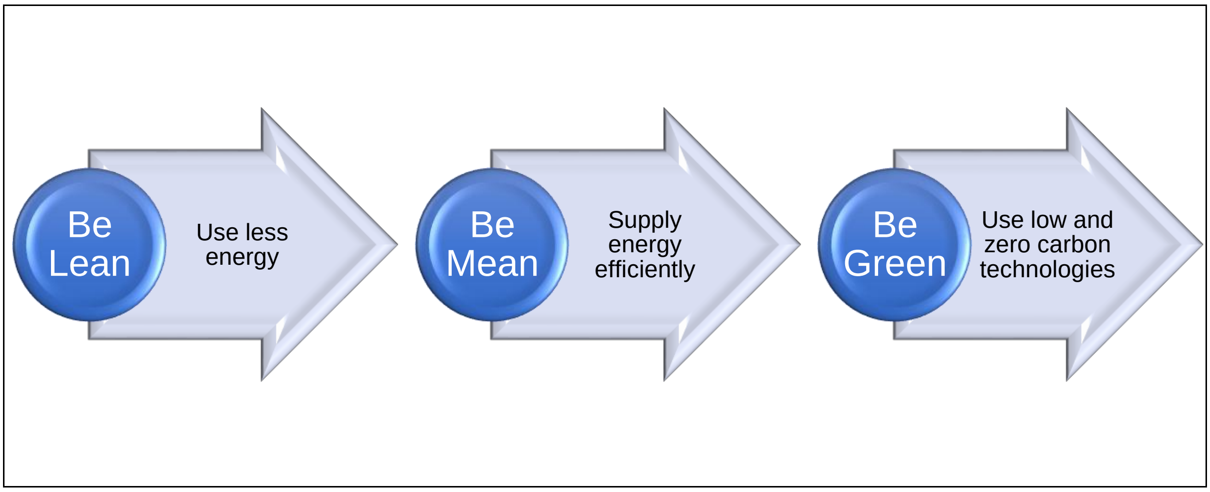


Figure 2: Energy Strategy compliance methodology

2.0 Zero Carbon

2.1 Net Zero Approach

The UK government has announced a climate emergency relating to climate change and requires urgent action to slow down unknown and unprecedented impact.

In 2019 the UK Government amended the Climate Change Act to adopt the recommendations of the Committee on Climate Change and adopted a target for achieving net zero emissions by 2050.

In the UK, 49% of annual carbon emissions are attributable to buildings, it is therefore vital the measures are taken to reduce the impact buildings have in the environment.

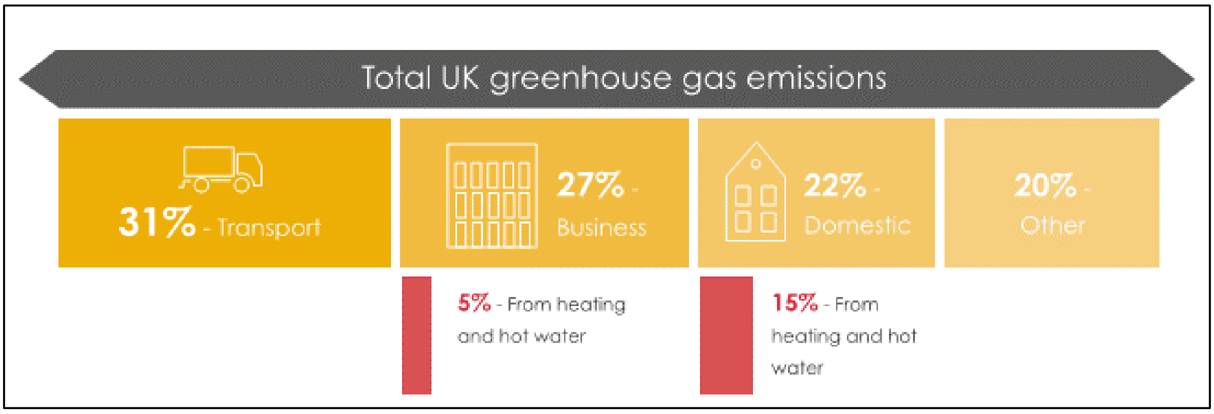


Figure 3: UK Carbon Impact

For new buildings building standards and planning policy are driving down the carbon impact via design. However, existing buildings will also require to be improved.

Currently there is the MEES scheme which drives energy improvement via EPC ratings for sale and lease of existing buildings as well as the ESOS scheme which requires large organisations to report on carbon emissions and options of how improvements can be made; with a view that the improvement measures will be required to be implemented as we move towards net zero.

The UK government will extend this ESOS scheme and are likely to implement carbon taxes and levies building owners and organisations to penalize against high carbon emissions in the next 10-15 years.

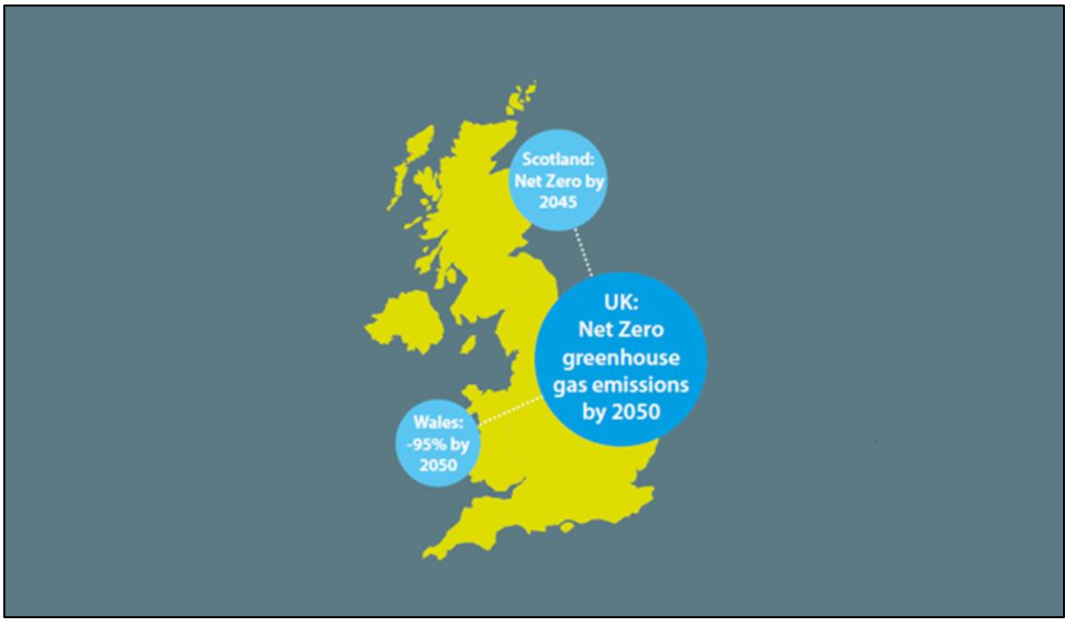


Figure 4: Net Zero Targets

2.2 Net Zero Definition

Net zero can encompass a variety of different elements:

Whole life carbon is formed of two key components:

Operational Carbon: a building with net zero operational carbon does not burn fossil fuels, is 100% powered by renewable energy, and achieves a level of energy performance in-use in line with our national climate change targets.

Embodied Carbon: Best Practice targets for embodied carbon are met, and the building is made from re-used materials and can be disassembled at its end of life in accordance with the circular economy principles.

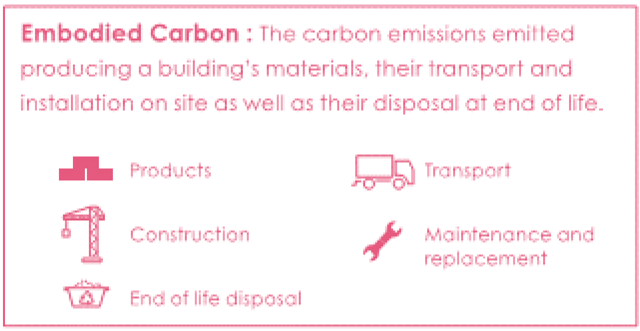


Figure 5: Embodied Carbon

This report and study shall focus on the operational carbon and energy impact of the building.

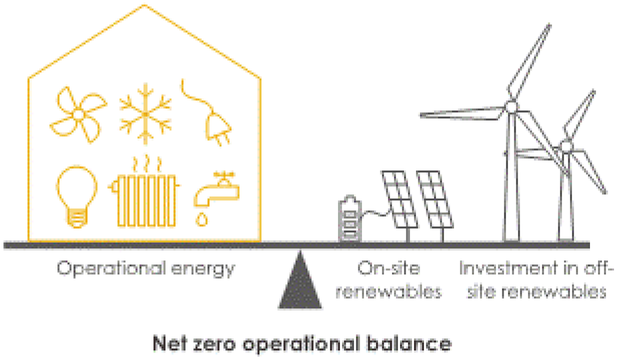


Figure 6: Operational Energy & Carbon

The development will emit carbon relating to the systems used to operate the building as well as the un-regulated (small power use) used day to day.

The UK Government aims to achieve net-zero carbon emissions by 2050 as part of this process, there will be policies and targets put in place which will push new developments and existing buildings to move away from fossil-fuel based heating systems such as gas or oil.

As part of this more and more developments will also aim to become net zero and self-sufficient from the electrical grid.

2.3 The Definition of a Net Zero Carbon building

Guidance on the definition of Net Zero Carbon buildings has been published in the last 12 months internationally and in the UK.

The Net Zero Carbon Buildings Framework developed by the UKGBC clarifies the key elements of any Net Zero Carbon strategy. The RIBA have also set target levels for operational energy uses (EUI) and embodied carbon.

As of May 2020, the most recent and detailed definition of Net Zero Operational Carbon new buildings has been developed by LETI, the UKGBC and the Better Building Partnership (BBP). It is supported by the RIBA, CIBSE and the Good Homes Alliance.

It is not only about regulated energy and offsetting - contrary to previous definitions of Zero Carbon, this definition includes all energy uses and does not exclude unregulated energy (e.g. energy used by appliances and white goods).

There is a growing body of guidance documents on how to achieve Net Zero Carbon. In particular LETI has developed a Climate Emergency Design Guide written by more than 100 industry experts from different organisations.

The target design methodology for a commercial office is detailed in in report appendix, this is based on the design standards for a new build, however some of the key elements relating to services strategy and energy consumption can be targeted for this development.

2.4 Grid Decarbonisation

As the electrical grid is now being produced more and more by renewable power sources rather than gas or coal fired power stations the grid is decarbonizing and as such the carbon emission factor for electricity as a fuel is due to be revised.

This will then be embedded in the compliance calculations as well as a number of other changes when the building changes are next revised.

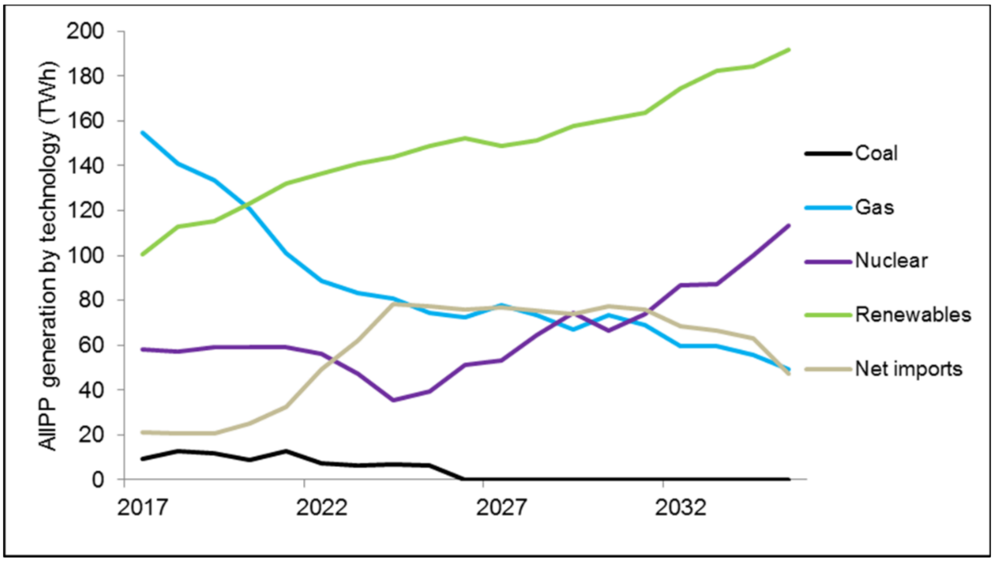


Figure 7: Grid generation breakdown

The change in carbon emission factors should therefore be taken consideration for in the assessment of the ongoing carbon impact of the development.

At the moment the carbon emission factor for electricity is 0.519kgCO_2/kWh this will be updated to 0.233 kgCO_2/kWh.

2.5 Fossil Fuel Reduction

As part of the process to move towards net zero, there will be policies put in place which will push new developments and existing buildings to move away from fossil-fuel based heating systems such as gas or oil.

Potential alternatives will include electric solutions which will be supplied by an electricity grid which will have been largely decarbonised due to the significant contribution from renewable technologies onto the network. As a result, the use of different replacement fuels including hydrogen and heat pump options are included in this analysis as potential heating solutions for the development to ensure an element of futureproofing in design.

In the past 10 years, the UK has achieved significant carbon savings through the decarbonisation of the electricity grid. Decarbonising heat is now acknowledged as one of the biggest challenges if the UK is to continue its trajectory and meet its carbon-reduction targets.

There is currently no clear, single contender to replace the wide coverage and convenience of gas heating, and a low carbon heating future is likely to require a mix of options.

These include electric heating (with a large role for heat pumps); hydrogen, whether used in fuel cells or for decarbonising the gas grid; and heat networks, particularly in dense and mixed-use areas, where they can take advantage of alternative fuel sources and heat rejection from cooling systems or other processes.

The carbon emission factors related to fuels are now beginning to be re-set to take cognisance of grid electricity now being generated from renewable sources such as off-shore wind farms, with the next planned change in fuel emission factors bringing the CEF for electricity down from 0.519 to 0.233, this will bring it in line with gas with a CEF of 0.216 being updated to 0.210.

This will have a massive impact on new buildings that will begin to see a pass with the carbon reduction requirements of the building standards with an electrically driven solution, however the change within existing building stock can only be driven by the planned replacement of plant and any new government policy removing the ability to install gas fired systems.

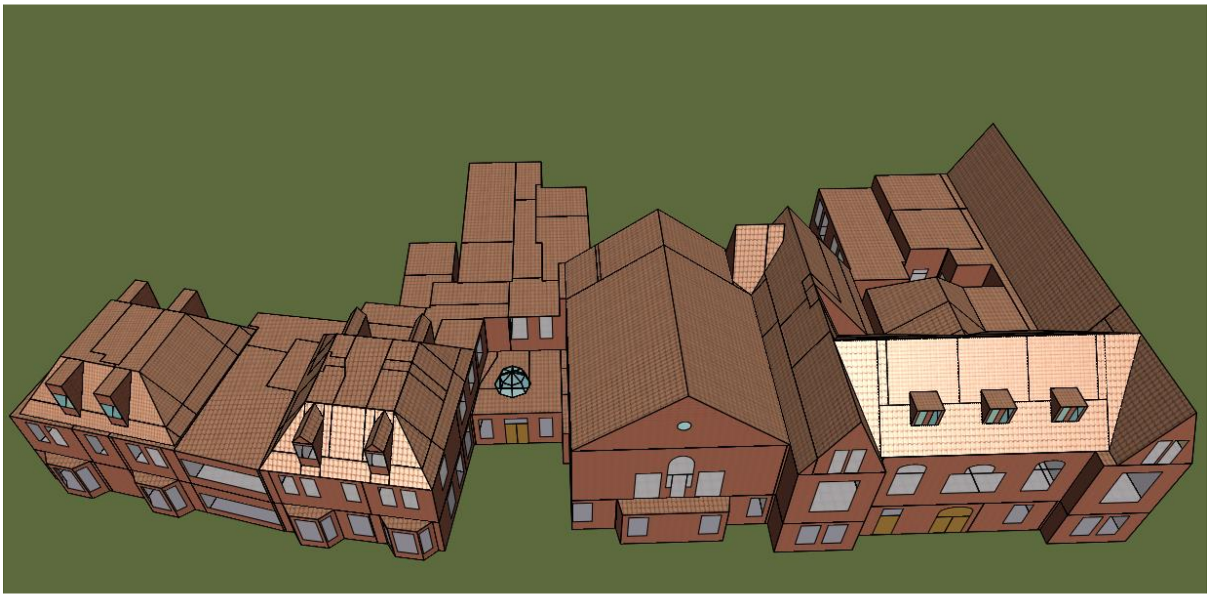
3.0 Methodology

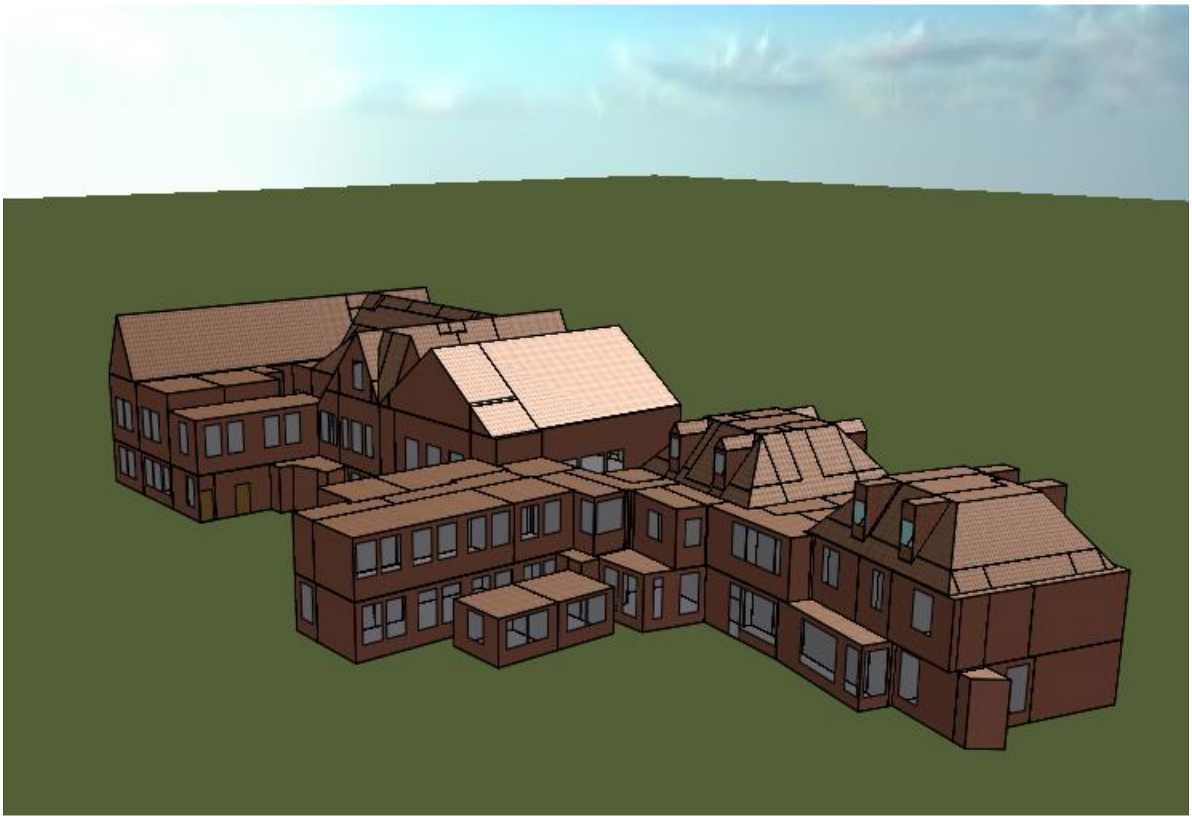
3.1 Dynamic Simulation Modelling

A dynamic thermal simulation was carried out for the building to predict the annual energy consumption and demand figures for the site. The model is based on architectural drawings where available and information gathered relating to the proposed building services systems for the current installations.

Dynamic thermal simulation is a sophisticated form of building energy modelling. IES Version 2019 DSM software has been used. The software is able to base its performance calculations upon incremental time steps as low as 2 minutes. This allows realistic variations in fabric thermal storage (thermal mass effects), weather conditions, occupancy, internal and solar gains to be considered and their implications upon building/plant operation to be modelled effectively.

Dynamic thermal simulation uses zone specific operational profiles (occupancy, lighting, ventilation and DHW demand) and HVAC plant performance data to effectively model and predict the energy performance of a building. This comprehensive approach is considered best practice for assessing building energy consumption.





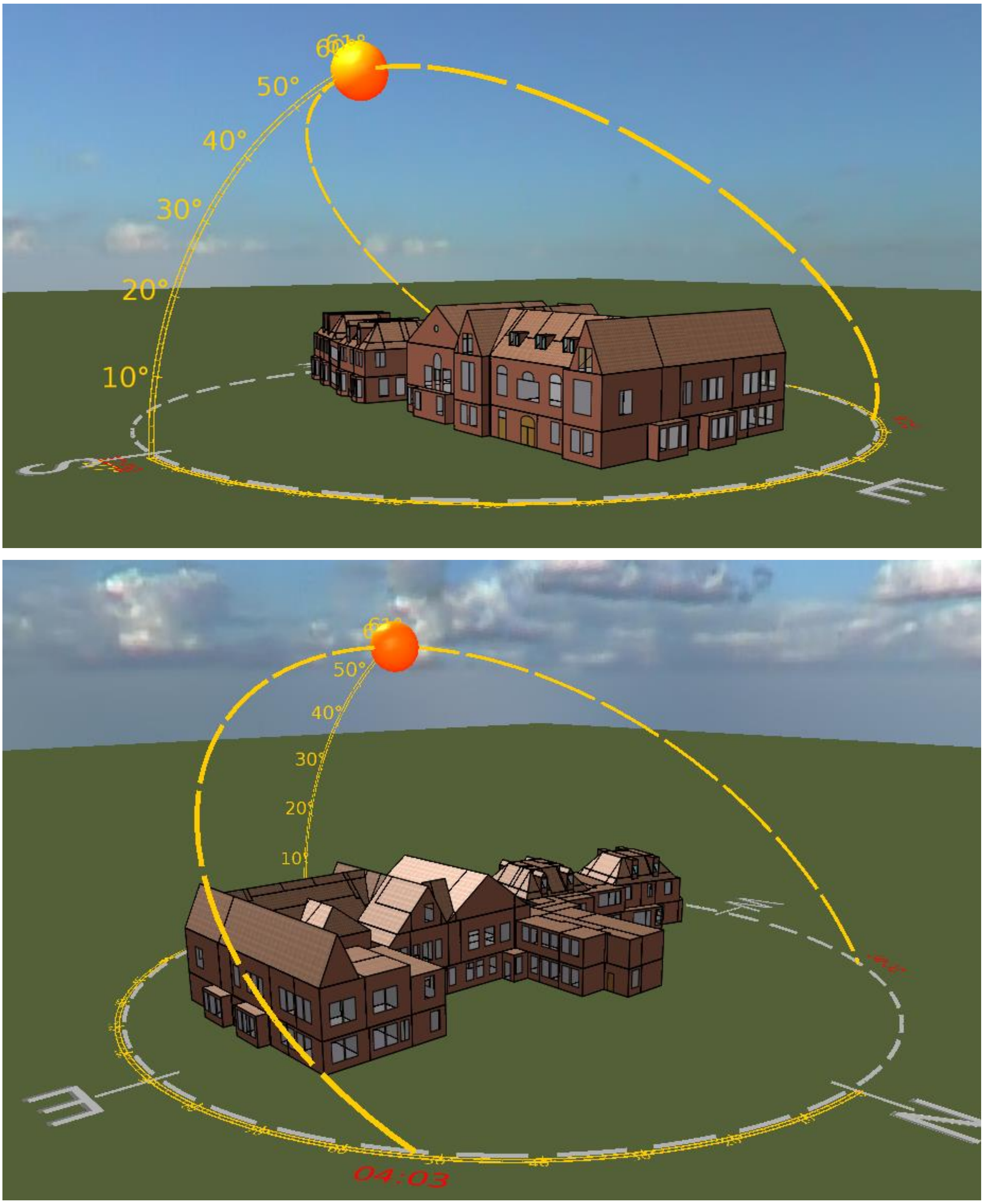


Figure 8: IES Model Images

3.2 Weather Data

To accurately model the dynamic nature of the building's thermal response, hourly recorded weather data is used in dynamic thermal simulations. Such weather data contains records of radiation, temperature, humidity, sunshine duration and additionally wind speed and direction.

Weather data for Brighton, Shoreham has been used in this case, taking cognisance of 10 years of historical weather data.

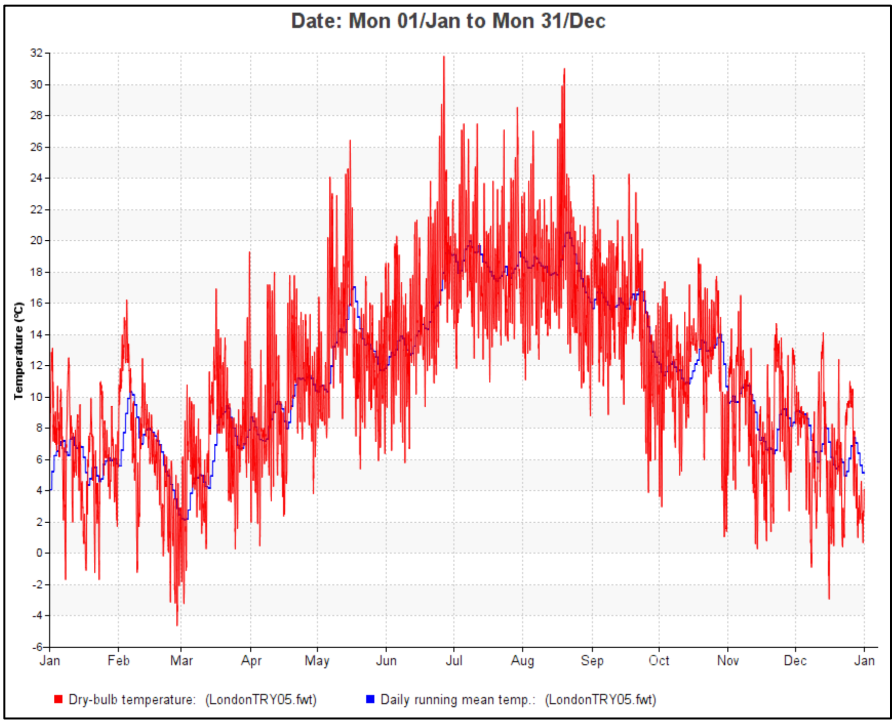


Figure 9: Annual Weather file data

3.3 Fuel Emission Factors

The following fuel emissions factors have been used in the calculations, which are the current approved UK values, a further assessment has also been undertaken to review the impact of the decarbonized emission factors.

Fuel	CO_2 Emission Factor ($kgCO_2/kWh$)
Natural Gas	0.216
Grid supplied electricity	0.519
Grid displaced electricity	0.519
LPG	0.241
Oil	0.319
Biomass	0.031
Waste Heat	0.058

Table 1: Carbon Dioxide Emissions Factors

3.4 Utility Costs

For the basis of the study the following utility costs have been utilised:

Fuel	**Utility Cost (p/kWh)**
Natural Gas	3.5 p/kWh
Grid supplied electricity	12.5 p/kWh

Table 2: Utility Costs

4.0 Baseline Results

4.1 Baseline Model

In order to measure the energy and carbon reduction attributed to each option assessed, a review has been undertaken to review and benchmark the current energy and carbon impact of the building.

Details of the current installation and an estimation of the current building fabric levels have been made and a dynamic review has been undertaken.

4.2 Baseline Design Parameters

The baseline model has included the below design parameters:

System	Performance Parameters
Glazing	Glazing: U-Value 5.6 W/m^{2}K VLT: 0.89 G-value: 0.8
Fabric	External Wall - Existing U-Value 0.9 W/m^{2}K Roof: U-Value 0.45 W/m^{2}K Doors: U-Value 2.5 W/m^{2}K Floor: U-Value 0.71 W/m^{2}K
Air Permeability	Equivalent to 15m^{3}hr/m^2 @ 50Pa
Artificial Lighting	Compact Fluorescent style lighting, LED to some areas. No lighting control– manual on/ off
Ventilation	Extract to toilets and kitchen facilities, specific fan power 0.6 to 1.0 W/l/s) Natural ventilation to all other areas.
Heating	Gas boiler serving radiators, seasonal efficiency 75% Central time control assumed, limited local control.
Cooling	None
Power Factor Correction	>0.95
Domestic Hot Water	DHW served from gas boiler to cylinder storage assumed 1,500 litres.
LZC Technology	None

Table 3: Baseline Design Parameters

4.3 Baseline Results

The baseline modelling results can be summarised as below:

Baseline Energy Consumption per annum	kWh	kWh/m^2
Heating	329,067	136.17
Electricity	276,099	114.25
Total	**605,166**	

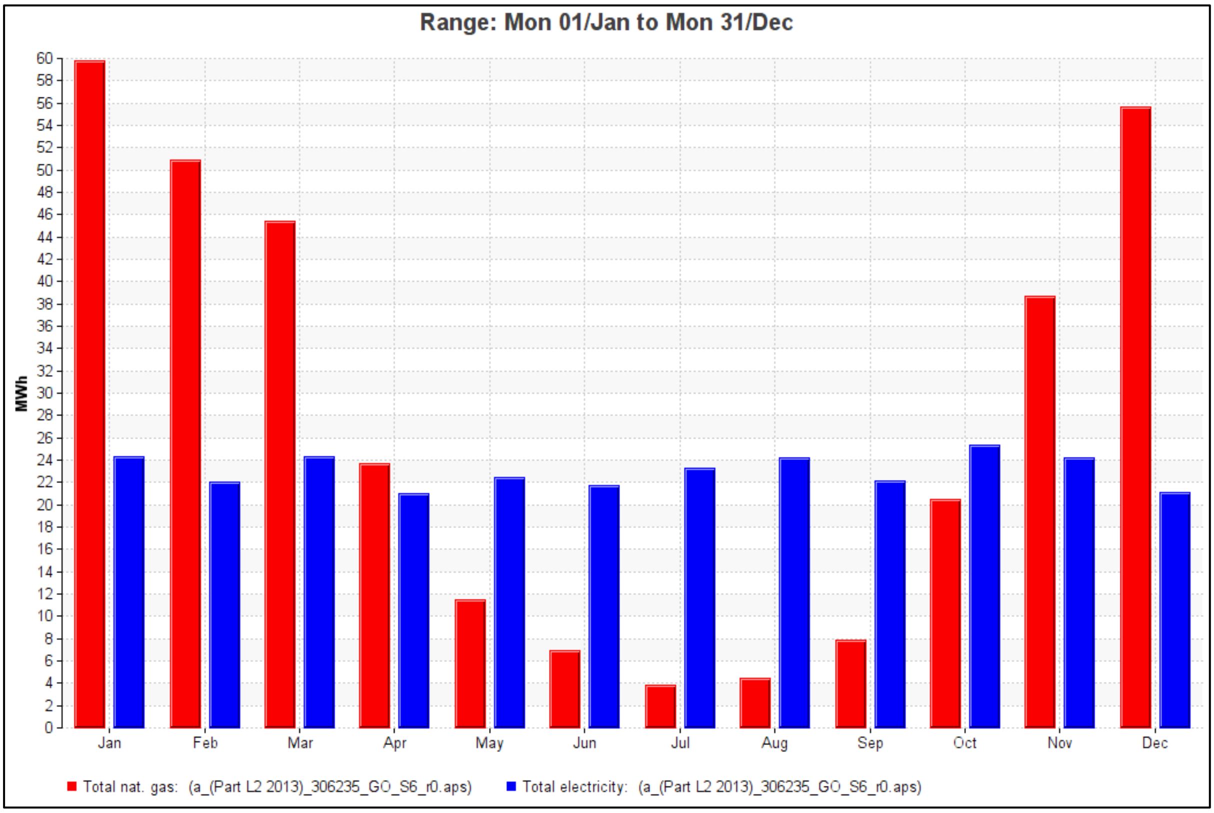


Table 4: Baseline Energy Demand

This has been compared to the energy use reported within the display energy certificate, which reports a heating energy consumption of 84 kWh/m^2 and electricity of 120 kWh/m^2. The modelled data shows a slight increase in the predicted heating energy consumption and a slight reduction in electricity consumption.

This difference can be attributed to variations in the dynamic modelling operation parameters for each space compared to actual operational use. To accommodate these minor variations all savings will also be reported ion a percentage saving from the baseline.

The modelling shows the following breakdown of energy use across the building:

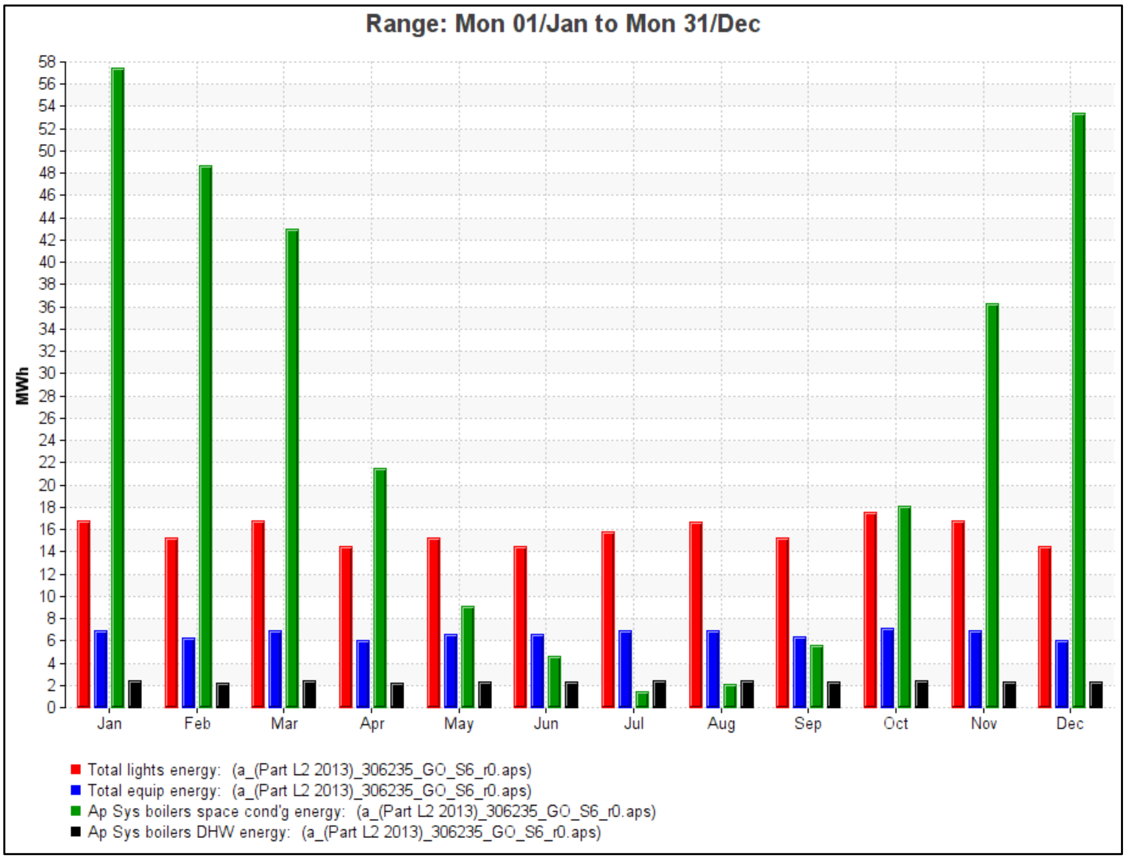


Figure 10: Baseline Energy Consumption breakdown

Heating is shown as the greatest energy consumer for the building followed by lighting then equipment and hot water.

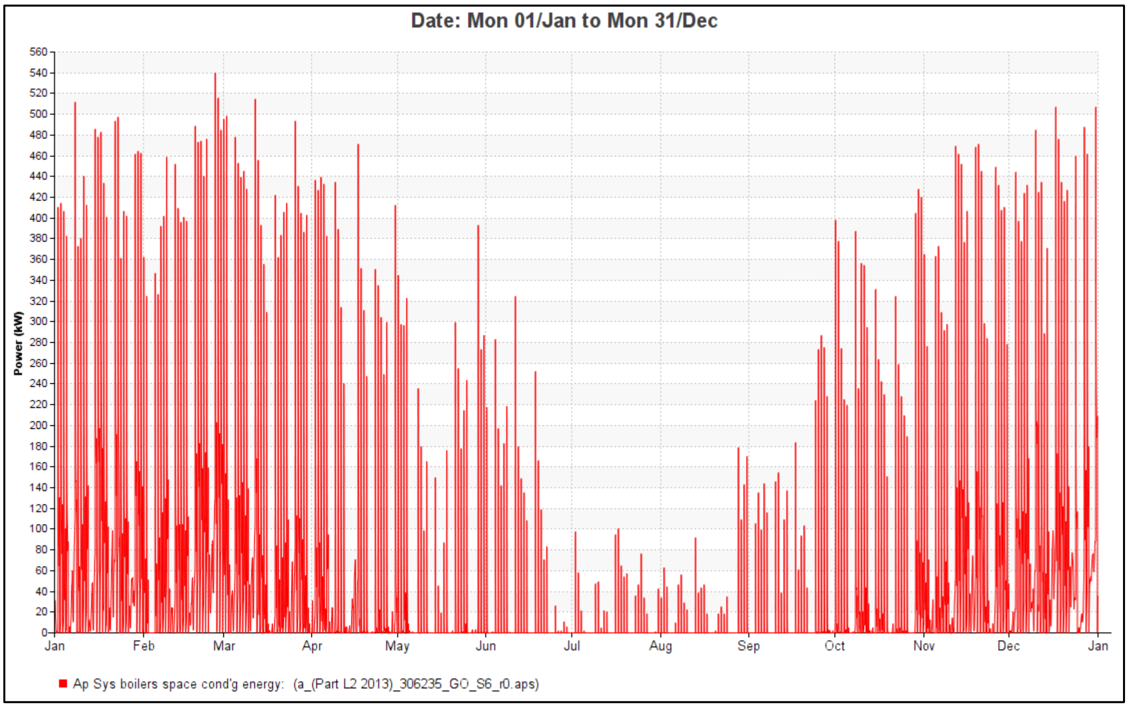


Figure 11: Hourly Heat Demand (MWh) as generated in IES VE

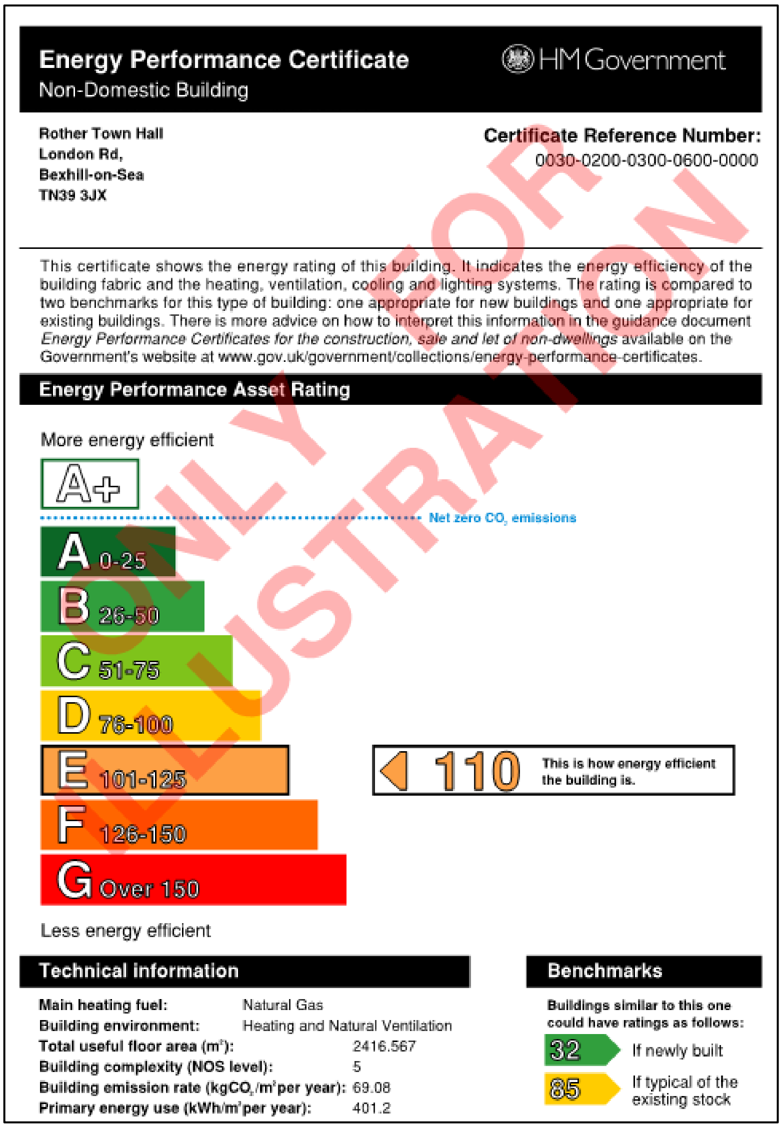
The total annual carbon emissions are estimated as follows based on the current and future fuel carbon emission factors

Carbon Impact	**CO_2/tonnes (Current CEF)**	**CO_2/tonnes (Decarbonised CEF)**
Total Carbon via Natural Gas	71	69
Total Carbon via Electricity	140	63
Total Annual Carbon Emissions	**211**	**132**

Table 5: Baseline Carbon Emission

4.3 Baseline EPC

The current installations would produce an EPC rating of “**E**”



Energy Performance Certificate
Non-Domestic Building

HM Government

Rother Town Hall
London Rd,
Bexhill-on-Sea
TN39 3JX

Certificate Reference Number:
0030-0200-0300-0600-0000

This certificate shows the energy rating of this building. It indicates the energy efficiency of the building fabric and the heating, ventilation, cooling and lighting systems. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings. There is more advice on how to interpret this information in the guidance document *Energy Performance Certificates for the construction, sale and let of non-dwellings* available on the Government's website at www.gov.uk/government/collections/energy-performance-certificates.

Energy Performance Asset Rating

More energy efficient

A+

Net zero CO_2 emissions

A 0-25
B 26-50
C 51-75
D 76-100
E 101-125
F 126-150
G Over 150

110 This is how energy efficient the building is.

Less energy efficient

FOR ILLUSTRATION ONLY

Technical information

Main heating fuel: Natural Gas
Building environment: Heating and Natural Ventilation
Total useful floor area (m^2): 2416.567
Building complexity (NOS level): 5
Building emission rate ($kgCO_2/m^2$ per year): 69.08
Primary energy use (kWh/m^2 per year): 401.2

Benchmarks

Buildings similar to this one could have ratings as follows:

32 If newly built
85 If typical of the existing stock

Figure 12: Baseline EPC

5.0 Options Appraisal

Following a review of the current energy and carbon demands of the building potential improvement measures and technologies have been reviewed following the energy hierarchy approach:

5.1 "Be Lean" Energy Efficiency Measures

The "Be Lean" measures proposed will reduce the energy consumption and CO_2 emissions for the building so that a substantial energy and carbon reduction can be achieved without the sole reliance on "Be Green" measures.

Any identified improvements shall focus on 'lean' design measures first maximizing the opportunities available in energy efficient design.

The "Be Lean" measures can potentially include:

- Upgrades to fabric to reduce heat demand.
- Optimised glazing performance levels (both thermal and solar) which aim to maximize the benefits of passive solar gain where appropriate and limit unwanted solar gain where necessary.
- Reduced levels of air permeability to minimise uncontrolled heat gains or losses.

5.2 "Be Mean" Energy Efficiency Measures

Be "Mean" measures shall be incorporated throughout the scheme in order to reduce energy consumption and the associated carbon emissions, these include but are not limited to the following:

- Utilisation of high efficiency boilers/heating plant (where included in the final solution).
- The use of low energy variable speed drives and motors.
- The installation of automated controls to limit plant and lighting operation where practical.
- Installation of low energy lighting schemes throughout.

5.3 "Be Green" Energy Efficiency Measures

Various options shall be considered appropriate to the required energy and carbon demands, these may be options to provide the main heating demand or as a supplementary renewable technology.

5.4 Options for Review

The following options have therefore been deemed viable for review:

Option	Measure	Hierarchy Stage
Option1	Roof Improved to achieve a u-value of 0.25	**Lean**
Option 2	Glazing replaced to a achieve a u-value of 1.8	**Lean**
Option 3	Boiler replaced with high efficiency type, heating pipework, pumps, and emitter replacement.	**Mean**
Option 4	Replace hot water storage with point of use system	**Mean**
Option 5	Replace lighting with energy efficient fittings including controls	**Mean**
Option 6	Options 1 to 5 combined	**Lean & Mean**
Option 7	Option 6 plus Roof mounted PV Panels	**Lean, Mean & Green**
Option 8	Option 7 plus Air Source Heat pumps providing heating demand	**Lean, Mean & Green**

Table 6. Viable Options for Review

The following has been deemed unviable in this instance:

Option	Comment on viability
Floor u-value improvement	Disruptive to use of the building
Wall u-value improvement	Impact on historic fabric, reduction in floor area.
Biomass	Fuel Storage and supply Maintenance Flue and air quality
Ground Source	Lack of ground space Ground conditions unknown Expensive
Water Source Heat Pump	No local appropriate water source
CHP	Fossil Fuel Lack of a constant annual heat load
Solar Hot water	Limited hot water demand
Fuel Cells	Technology in its infancy, high capital cost.
Wind Turbine	Supplementary technology only, high capital cost and long payback. Site unsuitable due to proximity to adjacent buildings and likely planning restrictions.
Hydro Power	No suitable existing local water supply.
Energy from Waste	High capital cost, site likely unsuitable for waste incineration. Not suitable for size of project.
Waste Energy Recovery	Initial contact with Scottish Water indicates that appropriate sewer capacity is not available in close enough proximity to the site.
Water Source Heat Pumps	No suitable existing local water supply.
Biomass Boiler	Unlikely to be feasible due to air quality, fuel supply, storage, and maintenance issues.

Table 7: Unviable Technology

5.5 Option 1 - Roof improved to achieve a u-value of 0.25

As heating is the main energy consumption element for the building methods to reduce the heating demand shall be considered first to reduce the energy and carbon impact.

This first option is to improve the roof fabric to achieve an average u-value of 0.25.

All other inputs for the baseline building remain the same:

Option 1 Roof improved Energy Consumption per annum	kWh
Heating	312,575
Electricity	276,099
Total	**588,674**
% Saving from Baseline	**2.73%**

Option 1 Carbon Impact	CO_2/tonnes (Current CEF)	CO_2/tonnes (Decarbonised CEF)
Total Carbon via Natural Gas	67.5	65.6
Total Carbon via Electricity	140	63
Total Annual Carbon Emissions	**207.5**	**128.6**
% Saving from Baseline	**1.69%**	**2.63%**

5.6 Option 2 - Glazing replaced to a achieve a u-value of 1.8

As heating is the main energy consumption element for the building methods to reduce the heating demand shall be considered first to reduce the energy and carbon impact.

The second option is to improve the glazing to achieve an average u-value of 1.8.

All other inputs for the baseline building remain the same:

Option 2 Glazing improved Energy Consumption per annum	kWh
Heating	244,573
Electricity	278,444
Total	**523,017**
% Saving from Baseline	**13.57%**

Option 2 Carbon Impact	CO_2/tonnes (Current CEF)	CO_2/tonnes (Decarbonised CEF)
Total Carbon via Natural Gas	54	52
Total Carbon via Electricity	140	63
Total Annual Carbon Emissions	**194**	**115**
% Saving from Baseline	**8.1%**	**13%**

5.7 Option 3 - Boiler replaced

As heating is the main energy consumption element for the building methods to reduce the heating demand shall be considered first to reduce the energy and carbon impact.

The current boiler is inefficient and nearing end of life therefore an option has been provided to replace the boiler and replace with a high efficiency type, including replacement of heating pipework, pumps and emitter replacement.

All other inputs for the baseline building remain the same:

Option 3 Boiler Replaced Energy Consumption per annum	**kWh**
Heating	222,339
Electricity	273,543
Total	**495,882**
% Saving from Baseline	**18.06%**

Option 3 Carbon Impact	**CO_2/tonnes (Current CEF)**	**CO_2/tonnes (Decarbonised CEF)**
Total Carbon via Natural Gas	48	47
Total Carbon via Electricity	138	62
Total Annual Carbon Emissions	**186**	**109**
% Saving from Baseline	**11.55%**	**17.44%**

5.8 Option 4 - Replace hot water storage with point of use system

The domestic hot water demand for the building is low however the current system which is fed from the gas boiler with a storage cylinder is energy inefficient. An option has therefore been provided to replace the storage cylinder with electric point of use.

All other inputs for the baseline building remain the same:

Option 4 DHW Point of Use Energy Consumption per annum	kWh
Heating	301,272
Electricity	281,058
Total	**582,330**
% Saving from Baseline	**3.77%**

Option 4 Carbon Impact	CO_2/tonnes (Current CEF)	CO_2/tonnes (Decarbonised CEF)
Total Carbon via Natural Gas	65	63
Total Carbon via Electricity	142	64
Total Annual Carbon Emissions	**207**	**127**
% Saving from Baseline	**1.66%**	**3.57%**

5.9 Option 5 - Replace lighting with energy efficient fittings including controls

The lighting energy is the second highest energy consumer for the building, therefore, to replace the current lighting installation with energy efficient fittings to meet a target energy reduction of 2W/m^2 per 100 lux should be investigated.

This would typically be met via LED fittings. Lighting controls via PIR and daylight dimming have also been included where relevant to the specific space.

All other inputs for the baseline building remain the same:

Option 5 Lighting replacement Energy Consumption per annum	**kWh**
Heating	474,310
Electricity	112,040
Total	**586,350**
% Saving from Baseline	**3.11%**

Option 5 Carbon Impact	**CO_2/tonnes (Current CEF)**	**CO_2/tonnes (Decarbonised CEF)**
Total Carbon via Natural Gas	102	100
Total Carbon via Electricity	57	25
Total Annual Carbon Emissions	**159**	**125**
% Saving from Baseline	**24.5%**	**5.1%**

5.10 Option 6 - Options 1 to 5 combined

Options 1 to 5 concentrated on the main energy consuming elements for the building, measures to reduce heating demand to the building fabric have been included, following replacement of heating and hot water systems to reduced the main demand for the building.

Lighting as the second largest consuming also has a great opportunity to reduce energy and carbon with replacement of the current systems.

With each of these measures combined this gives the greatest opportunity for savings.

All other inputs for the baseline building remain the same:

Option 6 (Option 1 to 5 Combined) Energy Consumption per annum	**kWh**
Heating	231,735
Electricity	116,234
Total	**347,969**
% Saving from Baseline	**42.5%**

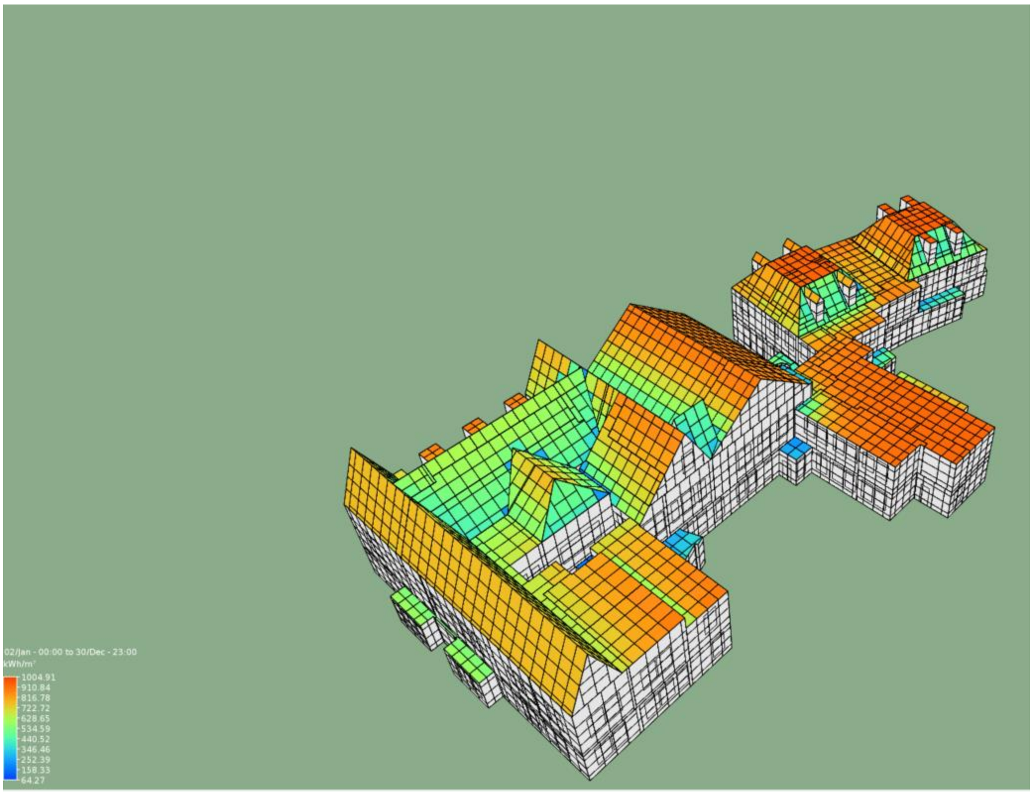
Option 6 Carbon Impact	**CO_2/tonnes (Current CEF)**	**CO_2/tonnes (Decarbonised CEF)**
Total Carbon via Natural Gas	50	49
Total Carbon via Electricity	59	26
Total Annual Carbon Emissions	**109**	**75**
% Saving from Baseline	**48.3%**	**43%**

5.11 Option 7 - Option 6 plus roof mounted PV Panels

Option 6 is the optimum improvement measures package, a further measure has therefore been included to incorporate a supplementary renewable technology to reduce the carbon impact further, in this instance PV has been selected as a viable solution to reduce the electrical demand for the building.

250m^2 of south facing PV panels have been modelled.

The dynamic simulation has modelled the optimum roof areas that would achieve the maximum annual yield as detailed below:



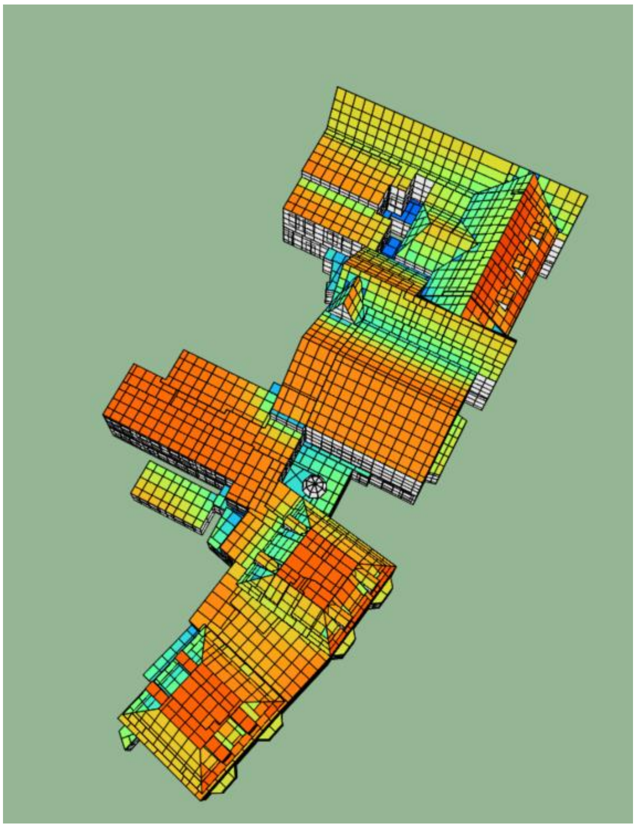


Figure 13: PV Dynamic Analysis

Option 7 (Option 6 plus PV) Energy Consumption per annum	**kWh**
Heating	231533
Electricity	76,658
Total	**308,191**
% Saving from Baseline	**49.07%**

Option 7 Carbon Impact	**CO_2/tonnes (Current CEF)**	**CO_2/tonnes (Decarbonised CEF)**
Total Carbon via Natural Gas	50	49
Total Carbon via Electricity	38	17
Total Annual Carbon Emissions	**88**	**66**
% Saving from Baseline	**58%**	**50%**

5.12 Option 8 - Option 7 plus Air Source Heat pumps providing heating demand

As a final option with the proposed energy saving measures to improve the fabric, lighting and hot water and with the PV an option to replace the gas heating system with an air source heat pump has been explored. This would assist in futureproofing the building with the move away from fossil fuels.

The existing heating systems consists of a gas-fired boiler serving radiators throughout the building. The boilers also provide domestic hot water to the buildings linked to hot water storage calorifiers.

The current systems operate at temperatures of approximately 80°C flow and 60°C return which is typical of a gas boiler installation and the distribution system and emitters currently installed onsite.

One of the available options to provide space heating and hot water through a renewable source is through the use of a high temperature ASHP, capable of a maximum flow temperature of 65°C. As the existing design flow temperatures are 80°C, the existing heating systems would require modification to accommodate the heat pump.

When considering heat pump option, it would be advised that the existing heating systems operating at 80°C are tested operating at 65°C in order to ensure suitability within the building. The system controls could be modified to ensure that spaces are adequately heated despite the lower flow temperature for example incorporating extended operating hours (pre-heat) and weather compensation.

In order to utilise a standard lower temperature heat pump solution (circa. 50°C flow temperature), the distribution system including emitters within the buildings would need to be replaced to facilitate their operation at the lower temperatures provided by these types of technologies.

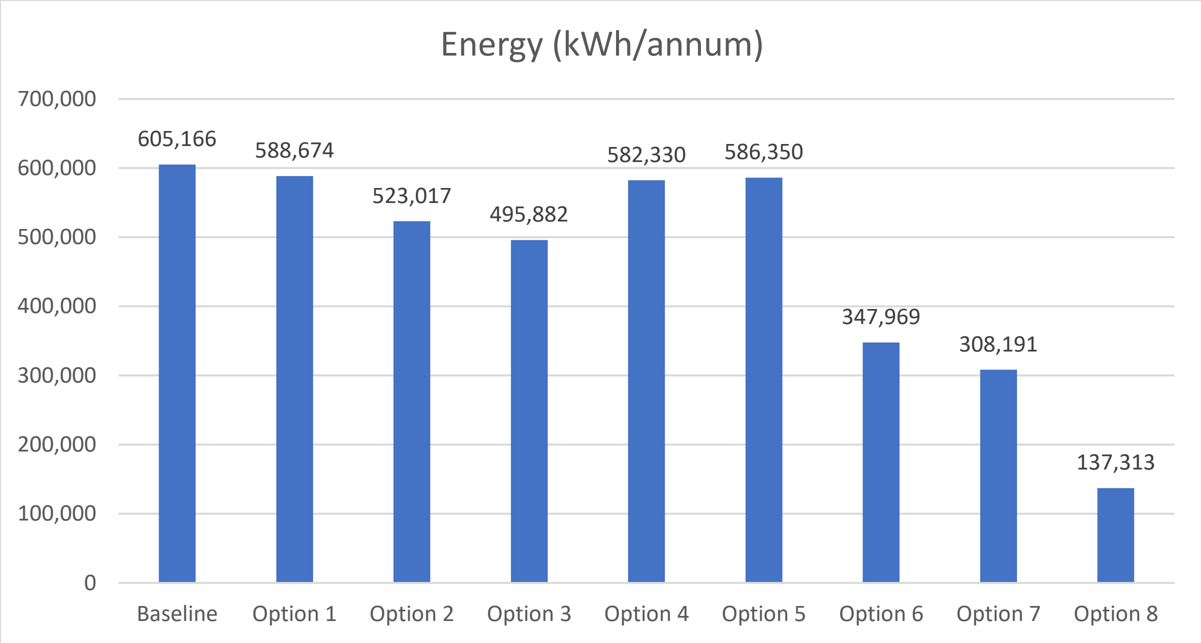
Option 8 (Option 7 Plus ASHP) Energy Consumption per annum	**kWh**
Electricity	137,313
Total	**137,313**
% Saving from Baseline	**77.3%**

Option 8 **Carbon Impact**	**CO_2/tonnes (Current CEF)**	**CO_2/tonnes (Decarbonised CEF)**
Total Carbon via Electricity	69	31
Total Annual Carbon Emissions	**69**	**31**
% Saving from Baseline	**67%**	**76.5%**

5.13 Results Summary

	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
Energy (kWh/annum)	605,166	588,674	523,017	495,882	582,330	586,350	347,969	308,191	137,313
Tonnes CO_2 /annum	211	207	194	186	207	159	109	88	69
TonnesCO_2 new CEF /annum	132	128	115	109	127	125	75	66	31
% Saving Energy		2.73%	13.57%	18.06%	3.77%	3.11%	42.50%	49.07%	77.31%
% Saving CO2		1.69%	8.10%	11.55%	1.66%	24.50%	48.35%	58.12%	67.28%
% Saving CO2		2.63%	13.06%	17.44%	3.57%	5.14%	43.05%	50.08%	76.51%
Running Cost (£)	£46,029.72	£45,452.50	£43,365.56	£41,974.74	£45,676.77	£30,605.85	£22,639.98	£17,685.91	£17,164.13
% Saving £		**1.25%**	**5.79%**	**8.81%**	**0.77%**	**33.51%**	**50.81%**	**61.58%**	**62.71%**

Table 8: Results Summary



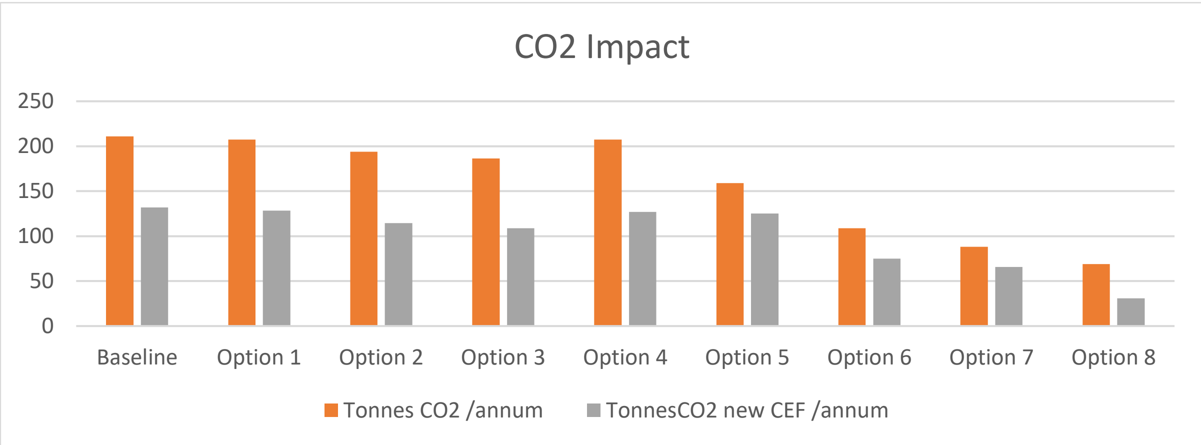


Figure 14: Results Analysis

5.14 Cost Review

As several the options are dependent on the integration with the existing building fabric and systems an accurate cost estimate for each of the options cannot be made at this stage.

We would recommend a detailed survey and review is undertaken focusing on each of the options at the next feasibility stage. However, we have estimated the likely range of cost for each as below:

Option	Measure	Cost Range	Cost Notes
Option 1	Roof Improved to achieve a u-value of 0.25	£25,000 to £55,000	Detailed review of the roof would be required to ascertain how the improved u-value can be achieved, this may be with either adding in additional insulation where the structure allows or replacing the roof fabric completely. There may be a mix of both options, impact on existing structure unknown.
Option 2	Glazing replaced to a achieve a u-value of 1.8	£35,000 to £70,000	Glazing solution will be dependent on the individual space and ventilation requirements. Impact on aesthetics would require to be considered depending on the solution selected, for example slim frame sash and case replacement vs. new UPVC window units.
Option 3	Boiler replaced with high efficiency type, heating pipework, pumps, and emitter replacement.	Boiler Install £30,000 to £55,000 Heating upgrade £120,000 to £150,000	Cost will be dependent on the requirements of the existing installation. New boilers will be in the region of £50k, however consideration will also be needed to be given to radiator replacement (dependant on specification) pump replacement, pipework replacement, heating controls and builders work required to install dependant on the constraints of the existing building.
Option 4	Replace hot water storage with point of use system	£8,000 to £15,000	Cost per point of use DHW unit £350, the exact number of units required will dependant on the spaces that need to be served. Electrical supply to each will be required to be reviewed and provided along with any local pipework. Cost for strip out of existing system dependant on the constraints of the existing building plus any builder's work and making good required.
Option 5	Replace lighting with energy efficient fittings including controls	£80,000 to £105,000	Cost in the region of £45 per m2. Cost will dependant on the light fittings selected any electrical supply modifications required and any work required to existing ceilings. New ceilings and builders work may be required. Cost dependant on the constraints of the existing building.
Option 6	Options 1 to 5 combined	£298,000 to £450,000	See notes above.

Option 7	Option 6 plus Roof mounted PV Panels	£298,000 to £450,000 PV Panels only £50,000 to £65,000	Cost for PV panels circa £50k, review would be required into the roof structure to accommodate the panels and integration into the existing electrical infrastructure.
Option 8	Option 7 plus Air Source Heat pumps providing heating demand	£363,000 to £535,000	Heat Pump cost in the region of £45k to £75k, however consideration will also be needed to be given to radiator replacement (dependant on specification) pump replacement, pipework replacement, heating controls and builders work required to install dependant on the constraints of the existing building. Siting of the external heat pumps will be required to be considered and any builders work required to accommodate.

Table 9: Indicative Cost Range

6.0 Summary

Energy consumption has been reviewed for each of the potential options with Option 8 giving the greatest saving. This also future proofs the town hall with the move away from fossil fuels over the next 10-15 years.

However, with the implications of replacing a high grade gas boiler heating system with a low grade heat pump solution along with the siting of external heat pumps, this may not be a viable solution in the short term for the town hall.

A more realistic option may therefore be Option 6 encompassing the fabric improvement, boiler and DHW replacement and lighting upgrades. This is estimated to provide a **42.5%** annual energy saving compared to the baseline current consumption.

Further reductions can be made with the incorporation of roof mounted PV panels.

The carbon emissions have been calculated based on the current and future carbon emission factors (CEFs), Option 6 provides a **48%** carbon reduction compared to the current baseline building, this reduces to 43% once the carbon emission factors are reviewed for decarbonization.

With the incorporation of PV the carbon impact reduces further with a **58%** reduction from the current installation.

Battery storage can also be installed alongside the PV to maximise efficiency and reduce the demand from the grid connection throughout the year, this can be installed inconjuntion with electric vehicle charging points to maximise efficincny further.

Each of the measures reviewed can be installed as part of one large refurbishment project or taken as individual improvement packages phased to suit budget constraints.

Even with the greatest carbon reduction measure of Option 8 there is still a carbon impact of 31 tonnes per annum in respect of operational carbon. Therefore, in order to achieve net zero carbon further measures would be required.

As an alternative a whole site net zero carbon solution could potentially be achieved through the implementation of a Power Purchase Agreement where a long-term contract is set up to buy renewable energy in agreed volumes/prices which meet the needs of both the generator and consumer.

As this energy is generated from a renewable source this counts towards the consumers carbon reduction.

Carbon offset schemes could also be considered through solutions such as tree planting, however this would not give the added benefit of LZC produced energy which can supply the site or electricity grid with a renewable source.

In these instances, it would still be recommended to move to a heat pump electric heating solution to future proof away from fossil fuels and future carbon levy's that will be introduced in the future from their use.

The appraisal carried out has been based on the existing town hall in isolation. If there is a larger development encompassing new build accommodation (domestic, non-domestic or a mixed-use development) there may be alternative solutions that may be appropriate for the development.

As a larger campus wide development, the site can potentially make use of Energy as a service opportunities and operational contract arrangements with the installation of a site wide energy centre. Funded options are available without the need for upfront investment.

The energy centre and technologies included will be dependant on the end consuming users and energy demand profiles.

With this type of arrangement, an Energy Partnership Agreement would be set up with a specialist contractor installing a fit-for-purpose heat pump solution before maintaining the plant and energy centre and supplying heating and cooling at a discounted rate. The following key advantages associated with this type of arrangement:

- Reduced energy bills – fuel cost saving plus income from Renewable Heat Incentives (where available – current scheme due to be extended in March 2021 - TBC).
- Installation with no upfront costs – Funded options available and low ongoing maintenance.
- Reduced Carbon Footprint – Significant reductions in carbon emissions.

Appendix A – LETI Net Zero Carbon Design Guide

Commercial offices

Operational energy

Implement the following indicative design measures:

Fabric U-values (W/m².K)

Walls	0.12 - 0.15
Floor	0.10 - 0.12
Roof	0.10 - 0.12
Windows	1.0 (triple glazing) - 1.2 (double glazing)
Doors	1.2

Fabric efficiency measures

Air tightness	<1 (m³/h. m²@50Pa)
Thermal bridging	0.04 (y-value)
G-value of glass	0.4 - 0.3

Power efficiency measures

Lighting power density	4.5 (W/m² peak NIA)
Lighting out of hours	0.5 (W/m² peak NIA)
Tenant power density	8 (W/m² peak NIA)
ICT loads	0.5 (W/m² peak NIA)
Small power out of hours	2 (W/m² peak NIA)

System efficiency measures

MVHR	90% (efficiency)
Heat pump SCoP	≥ 2.8
Chiller SEER	≥ 5.5
Central AHU SFP	1.5 - 1.2 W/l.s
A/C set points	20-26°C

Window areas guide (% of wall area)

North	25-40%
East	25-40%
South	25-40%
West	25-40%

Balance daylight and overheating

Include external shading

Include openable windows and cross ventilation

Maximise renewables to generate the annual energy requirement for at least two floors of the development on-site

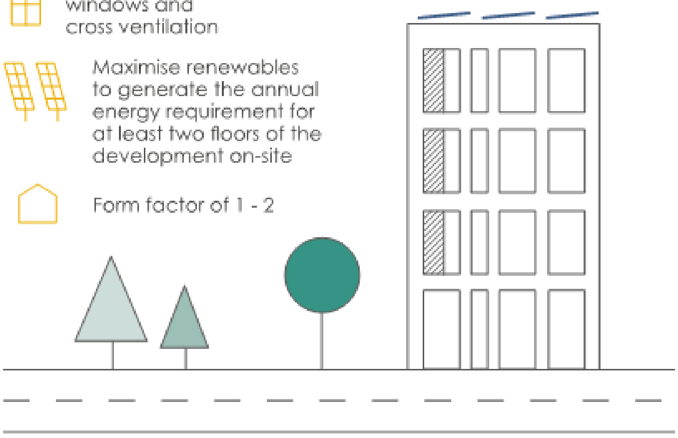
Form factor of 1 - 2

Reduce energy consumption to:

55 kWh/m².yr

Energy Use Intensity (EUI) in GIA, excluding renewable energy contribution

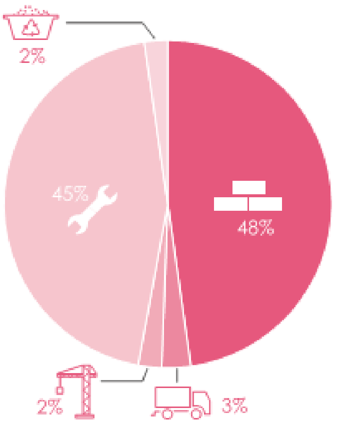
Reduce space heating demand to: **15** kWh/m².yr



Embodied carbon

Focus on reducing embodied carbon for the largest uses:

- Products/materials (A1-A3)
- Transport (A4)
- Construction (A5)
- Maintenance and replacements (B1-B5)
- End of life disposal (C1-C4)



Average split of embodied carbon per building element:

- **48%** - Superstructure
- **17%** - Substructure
- **16%** - Façade
- **15%** - MEP
- **4%** - Internal finishes

Reduce embodied carbon by 40% or to:

<600 $kgCO_2/m^2$

Area in GIA

Heating and hot water

Implement the following measures:

Fuel
Ensure heating and hot water generation is fossil fuel free

Heat
The average carbon content of heat supplied ($gCO_2/kWh.yr$) should be reported in-use

Heating
Maximum 10 W/m² peak heat loss (including ventilation)

Connect to community wide ambient loop heat-sharing network to allow excess heat from cooling to be made available to other buildings

Hot water
Maximum dead leg of 1 litre for hot water pipework

'Green' Euro Water Label should be used for hot water outlets (e.g.: certified 6 L/min shower head – not using flow restrictors).

Demand response

Implement the following measures to smooth energy demand and consumption:

Peak reduction
Reduce heating and hot water peak energy demand

Active demand response measures
Install heating and cooling set point control

Reduce lighting, ventilation and small power energy consumption

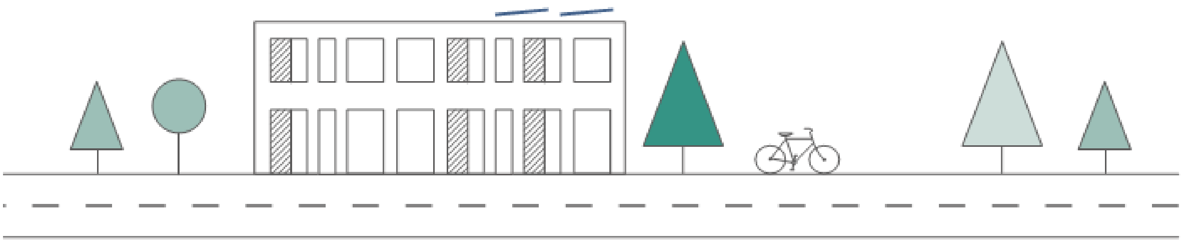
Electricity generation and storage
Consider battery storage

Electric vehicle (EV) charging
Electric vehicle turn down

Reverse charging EV technology

Behaviour change
Incentives to reduce power consumption and peak grid constraints

Encourage responsible occupancy.



Data disclosure

Meter and disclose energy consumption as follows:

Metering *(Metering strategy following BBP Better Metering Toolkit guidance)*

1. Record meter data at half hourly intervals
2. Separate landlord and tenant energy use meters and clearly label meters with serial number and end use
3. Submeter renewable energy generation
4. Use a central repository for data that has a minimum of 18 months data storage
5. Provide thorough set of meter schematics and information on maintenance and use of meters
6. Ensure metering commissioning includes validation of manual compared to half hourly readings.

123 **Disclosure**

1. Carry out an annual Display Energy Certificate (DEC) and include as part of annual reporting
2. Report energy consumption by fuel type and respective benchmarks from the DEC technical table
3. For multi-let commercial offices produce annual landlord energy (base building) rating and tenant ratings as well as or instead of a whole building DEC
4. Upload five years of data to a publicly accessible database such as GLA and/or CarbonBuzz.

Appendix B – Technology Information

Air Source Heat Pump

An Air Source Heat Pump (ASHP) could be installed to meet the building's space heating demands.

The technology works by extracting available heat from the air and boosting this to a higher temperature which can be used in the building for heating and hot water using compressor technology. ASHPs are more cost effective to install than ground source systems as they do not involve the expensive ground works required for GSHPs. An example ASHP is shown below.

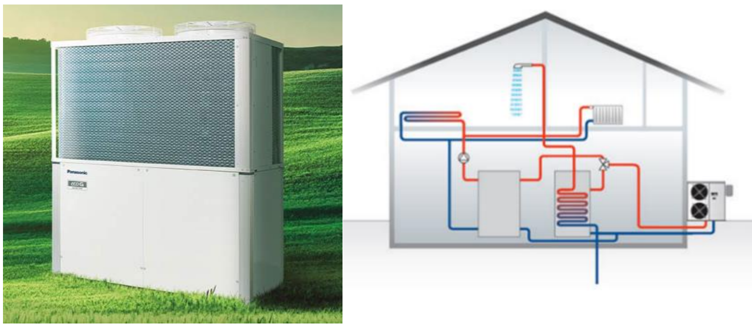


Figure 3. Example ASHP System

ASHPs require evaporator units to be exposed to ambient air. This is most effectively achieved by mounting the units external to the building(s). Any planning implications would have to be assessed prior to installing external units.

For calculation purposes the ASHP Coefficient of Performance (CoP) is 3 therefore assuming that each 1 kW of electricity used to drive the ASHP, generates 3 kW of heat energy from the outside air to heat the building(s).

An ASHP installation would be appropriately sized and designed to meet the heating requirements of the development.

Colder climates will result in a reduction in efficiency and the achievable seasonal coefficient of performance (SCoP) of Air Source Heat Pump technology. However, ASHP technology has advanced in recent years and through consideration of the specification of a system with key design features, such as those listed below, the negative impact on their performance when the outside air is cold can be reduced:

- Refrigerant specification: refrigerants that operate at a lower pressure will work more efficiently in cold climates.
- Surface Area and Fin Width; damp air in the UK means that the formation of ice on the evaporator can be an issue resulting in energy intensive defrost cycles for the equipment. Therefore, it is important to specify a heat pump with a large surface area with wide fins allowing good airflow across the evaporator.

The seasonal efficiency of the heat pump is greatly affected by the building/heating system it serves, thus efficient levels of fabric insulation and the specification of a heating system which can operate effectively at lower temperatures will improve the performance of the unit throughout the year. Good quality heat pumps are capable of providing hot water above 52°C when the outside air is as cold as -16°C.

The latest energy price forecasting by the UK Government suggests that a reduction in the cost of electricity is expected in the future, however this is only a projected pattern. As a rough guideline, electricity is predicted to become around 20% cheaper within the next 5-10 years as it becomes decarbonised. In this case, the ASHP solution would become more economical in the long-term using electricity as the primary fuel source.

This type of system has been included in Option 8, however this type of heating system would only be deemed viable if installed in conjunction with improvements to the building fabric and replacement of the heating pipework and heating emitters due to the temperatures achievable with this type of system and the existing distribution system which operates at a flow temperate of 80°C.

This type of system would be eligible for RHI payments. The current non-domestic tariff rate for an ASHP system is:

- 2.79 p/kWh

However, the current scheme is only available to systems installed and approved by March 2021.

A replacement funding stream will likely be available however it is not expected to be as lucrative.

Pros

- Low carbon solution (potentially not carbon net zero).
- Low capital installation cost.
- Familiar technology, simple maintenance for a heating & refrigeration engineer.

Cons

- Will require the existing internal heating infrastructure to be replaced to suit an ASHP system.
- Increase in electrical consumption to the building, consider the installation of PV to reduce the running costs.

Ground Source Heat Pump

Aa an alternative to the Air source heat pump, Ground Source Heat Pump (GSHP) could be utilised to serve the buildings' heating system as well as providing hot water. GSHPs typically need to run at low operating temperatures in order to work efficiently therefore they are best suited to underfloor heating systems which require lower temperatures to operate. When utilising radiators with GSHP's they are required to be "over-sized" to compensate for the lower circulating water temperatures. The GSHP collector is not visible from outside the building, with the only visible portion being the heat pump itself located within a plantroom.

The Coefficient of Performance (CoP) for these systems is typically 3 to 4 (i.e. for every 1kW of electricity consumed to drive the heat pump system, 3 to 4 kW of energy would be transferred from the ground to heat the building).

Ground source heat pump systems can take various forms. The most common are borehole installations where the energy is transferred from the ground to a pipe loop down to a depth of approximately 100-150 meters. This type of system collects both solar energy and geothermal energy for use within the building through the heat pump. Alternatively, a horizontal 'slinky' system can be installed which is designed to cover a large area of ground and collect solar energy absorbed by the ground near the surface. The 'slinky' system is less efficient than the borehole system however the cost of excavation for 'Slinkys' can be less than drilling boreholes. It is expected that a borehole installation should achieve an efficiency of approximately 4.0 to 4.5 i.e. 4.0 kW of heat for 1.0 kW of electricity consumed over the annual heating season while a horizontal 'slinky' would tend to deliver a CoP in the range of 3.0 to 3.5 hence careful consideration should be given before deciding the optimum solution.

Vertical GSHP System **Horizontal GSHP System**

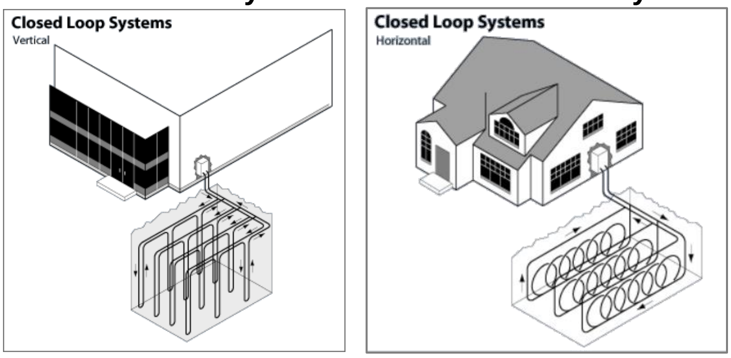


Figure 4. Typical GSHP Configurations

The GSHP installation would be designed to meet the space heating requirements of the buildings. The domestic hot water load of the building(s) may be met by the GSHP but the CoP of the system may reduce due to the higher temperatures required for domestic hot water. In this case, the heat pump could be used to pre-heat the hot water with an electric immersion heater used to bring the water up to the required temperature. A GSHP system is heavily dependent on ground conditions which will determine whether there will be adequate load to serve the buildings.

This type of system would be eligible for RHI payments. The current non-domestic tariff rate for a GSHP system is:

- 8.72 p/kWh for Tier 1 payments.
- 2.60 p/kWh for Tier 2 payments.

However, the current scheme is only available to systems installed and approved by March 2021. A replacement funding stream will likely be available however it is not expected to be as lucrative.

Pros

- Low carbon solution.
- Simple plant replacement strategy should a component fail.
- Resilience can be built into technical design by including a spare dormant GSHP, removing downtime in the event of a failure.
- Central plant strategy, easy for maintenance and access.
- Existing boiler infrastructure may be retained, for use as a back-up heat source.

Cons

- High capital installation cost.
- Extensive GPR & borehole test surveys required to ascertain number of boreholes, thermal response from the ground conditions and in turn actual expected system efficiencies.
- Space is required for a buffer vessel, to allow the vessel to take the peak loads from the GSHP. This shall be quantified upon receipt of the metering data.
- Increase in electrical consumption to the building(s), consider the installation of PV to reduce the running costs.
- Most likely to be viable alongside a central plant solution as part of a masterplan development.

High Temperature Air and Ground Source Heat Pumps

The existing building currently operate at heating system temperatures of 80°C flow and 60°C return.

Measures can be undertaken in order to help reduce the required flow temperature of the system such as adding enhanced controls including weather compensation and optimum start/stop to improve the efficiency of system operation. The lowering of temperatures within the system is essential for the efficient operation of a heat pump system which operates much more efficiently at lower temperatures, typically with flow temperatures around 50-60°C. The system relies on a higher temperature difference between the flow and return temperatures. Achieving this enables the use of lower flow rates in the system to provide the same kW of heat demand into the spaces.

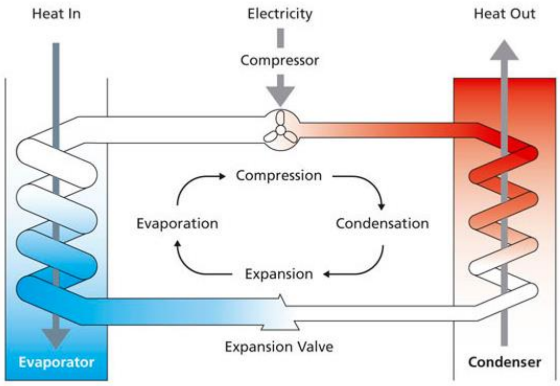
There are high temperature heat pumps available which can provide a higher grade of heat.

This will have a negative impact on the efficiency of the system with a typical Coefficient of Performance (CoP) of around 2.0-3.0 compared to 4 or higher for a lower temperature system. However, this efficiency level can still provide significant energy and carbon savings when compared to a fossil fuel solution such as the existing boiler installation.

To achieve a sufficient efficiency to qualify for the receipt of Renewable Heat incentive Payments (RHI) a flow temperature of 65°C would be required. However, due to the existing distribution systems 70°C would likely be the minimum requirement.

A high temperature ASHP or GSHP system works very similarly to a standard installation as summarised below:

1. Liquid refrigerant passes through the heat exchanger to ground loop coils at a low temperature.
2. Liquid from the ground loop enters the unit and heat is transferred from this liquid to the refrigerant. As a result, the refrigerant boils and becomes vapour.
3. The vapour is drawn into the compressor, where the pressure and therefore the temperature of the gas is increased.
4. The vapour then enters the condenser or load side heat exchanger and heat from the vapour is transferred to the water used to heat the building. As the vapour cools it condenses back to a liquid, which releases considerable latent heat to water passing through the heat exchanger.
5. The refrigerant, which is now a cold liquid at high pressure, passes through an expansion valve, which reduces the pressure so that the cold liquid can re-enter the evaporator and begin the cycle again.



Heat Pump Operation Diagram

A high temperature solution uses HFO refrigerants or ammonia which have a low Global Warming Potential (GWP) and Ozone Depletion Potential (ODP) while providing improved characteristics to promote heat transfer and facilitate higher system operating temperatures.

Energy Storage & PV

PV is reviewed in isolation and in conjunction with a heat pump options to demonstrate the potential energy and carbon savings associated with the inclusion of PV in conjunction with the main heating system.

PV would provide an effective solution to offset some of the electrical demand for the building and for the heat pump units themselves.

However, electricity is only generated during daylight hours when the heat demand and electrical demand for lighting etc. may be lower therefore the buildings are unable to take advantage of the electricity being generated. Battery storage would provide a solution to help increase the proportion of PV generated electricity which can be used to benefit the building.

Battery storage is still relatively expensive; however, the technology will likely become more affordable in the future. This would help to encourage the use of locally generating PV technology as electricity generated during the day could be stored and used at peak times such as in the evening and early morning when generation is lower.

A heat pump option could take advantage of the inclusion of PV through using some of the generated electricity to power the heat pump itself.

HARLEY HADDOW

The Multi-disciplinary Engineering Consultancy

—

Edinburgh | London | Glasgow

Contact
124-125 Princes St
Edinburgh, EH2 4AD
enquiries@harleyhaddow.com