1.0 Energy Use & Renewables

Introduction

The redevelopment of UWL St Mary's campus is to be a mixture of sustainable refurbishment and low energy new build. The following section of the report explores sustainable design strategies to help reduce the energy and carbon footprint of the redevelopment, as well as achieve the carbon emissions targets and planning requirements for the project.

At present the UWL St Mary's campus buildings are operating in an energy inefficient manner. Fuel and power is currently being wasted due to, but not limited to;

- A thermally inefficient facade
- Out of date, inefficient plant and distribution
- Uncontrolled ventilation
- Poor lighting control
- Lack of metering and control of services

The report appraises a range of sustainable strategies, energy efficiency improvements, and low/zero carbon technologies for the development to help conserve fuel and power and reduce its overall CO_2 emissions. The proposed strategies when calculated against a baseline benchmark will equate to an overall carbon emissions reduction of at least 25%.

The report has been prepared well in advance of the detailed architectural, structural and building services designs in order that information contained herein can be used to optimise the building configuration.

It is important to note that the energy strategy is only part of the overall sustainability strategy and needs to be considered in conjunction with all other sustainable objectives.

Legislation

The 2010 Building Regulations Part L governs the conservation of fuel and power in buildings and as such dictates the minimum energy efficiency targets for both new builds and refurbishments. Part L requires the following minimum energy efficiency targets are met for the project

- **New build (Part L2A)** – The actual building CO_2 emissions rate (BER) must be no greater (no worse) than the notional building CO_2 target emissions rate.
- **Refurbished Area (Part L2B) –** Consequential improvements to refurbished areas shall be made to censure that the building complies with Part L, to the extent that such improvements are technically, functionally, and economically feasible. A way of satisfying this requirement is to show that the improvements works are not less than 10% of the value of the principal works

The 2011 London Plan requires the development to demonstrate a 25% reduction in CO_2 emissions compared to a building that is compliant with Part L of the 2010 Building Regulations (TER).

Compliance with London Plan

It is realised that the 2011 London Plan is heavily geared towards new build developments. It does not currently take account of the CO_2 emissions associated with improving the energy efficiency of existing buildings from their current state to a Part L compliant CO_2 emissions emission rate (TER) in its scope. **It is proposed that the project will include the CO_2 emissions associated with improving the refurbished areas buildings as part of the calculation of the overall 25% CO_2 emissions reduction**. The main reason for this proposal is that the retained refurbished area accounts for 85% of the project gross internal floor area (GIFA) and therefore represents the biggest scope and opportunity for CO_2 emissions reduction.

It is proposed that the total CO_2 emissions reduction for the project will be calculated as

$$\frac{\textbf{Baseline } CO_2 \textbf{ emissions - Proposed Site } CO_2 \textbf{ emissions}}{\textbf{Baseline } CO_2 \textbf{ emissions}}$$

CO2 emissions baseline benchmark

The CO_2 emission baseline defines the project benchmark from which a 25% CO_2 emissions reduction must be made from. It is proposed that the baselines for benchmarking CO_2 emissions reductions for the project are

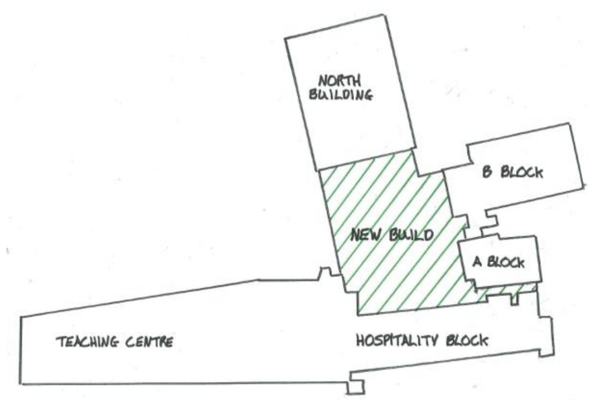
Element	Area	Baseline CO_2 emissions ($kGCO_2/yr$)	CO_2 emissions of proposed site ($kGCO_2/m^2/yr$)
Retained Areas to be Refurbished	Teaching Centre	Existing building	Proposed building
	Hospitality Block	Existing building	Proposed building
	A Block	Existing building	Proposed building
	B Block	Existing building	Proposed building
	North Building	Existing building	Proposed building
New Build	New Build	BR 2010 Part L TER	Proposed building
	TOTAL	**SUM Baseline**	**SUM Proposed**

For retained areas being refurbished it is proposed that the CO_2 emissions baseline is based on an estimate of the current building condition. Estimates regarding fabric U-values, lighting efficiencies, infiltration rates etc. will be based on information gathered from site surveys. Where information cannot be obtained from a survey then it will be approximated using a best estimate.

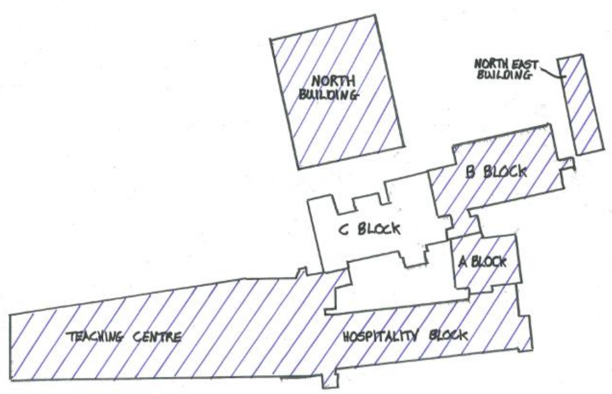
For new build areas it is proposed that the CO_2 emissions baseline is based on the National Calculation Method (NCM) defined set of parameters for calculating the notional building target emissions rate (TER) as required by 2010 Building Regulations Part L.

Therefore it is proposed that the total CO_2 emissions baseline will be a summation of the retained areas in their current condition and the new build area based on the NCM notional building BR 2010 Part L target emission rate (TER)

The areas representing new build and refurbishment are shown diagrammatically below



New Build Area



Refurbished Area to be Retained

The 25% CO_2 emissions reduction target will then be calculated as

Refurbished areas – % reduction in CO_2 emissions associated with proposed improvements to refurbished areas when compared from their existing state

+

New build areas – % reduction in CO_2 emissions compared to a building that is compliant with Part L of the 2010 Building Regulations

+

Any contributions from low/zero carbon technologies.

As the building design is still being progressed and servicing strategies yet to be finalised the CO_2 emissions provided in this report is only an estimate. The proposed building CO_2 emissions will need to be calculated in the future once the building design in finalised, and is calculated using an approved certified compliance tool.

Environmental Modelling

The CO_2 emissions associated with the existing and proposed site have been estimated using the Sefaira Concept software modelling tool. Sefaira uses dynamic energy/thermal modelling to predict energy and carbon use for buildings. . Sefaira was also used to test sustainable strategies and help develop the overall sustainable solution for the project

A detailed model of the entire UWL site was built in Sefaira based on the most current at the time architectural plans.

For refurbished areas being retained; information was gathered from site surveys, drawings, and site visits regarding existing fabric constructions, form and shading, glazing ratios, ceiling heights, lighting and internal loads. Where information could not be obtained from the survey appropriate assumptions and estimations were made using experience and all assumptions made are stated.

For new build areas; by applying the National Calculation Method (NCM) defined set of parameters for calculating the notional building target emissions rate into the Sefaira Concept Software modelling tool, we can provide an accurate estimate of the target emissions rate (TER) benchmark for the new build area.

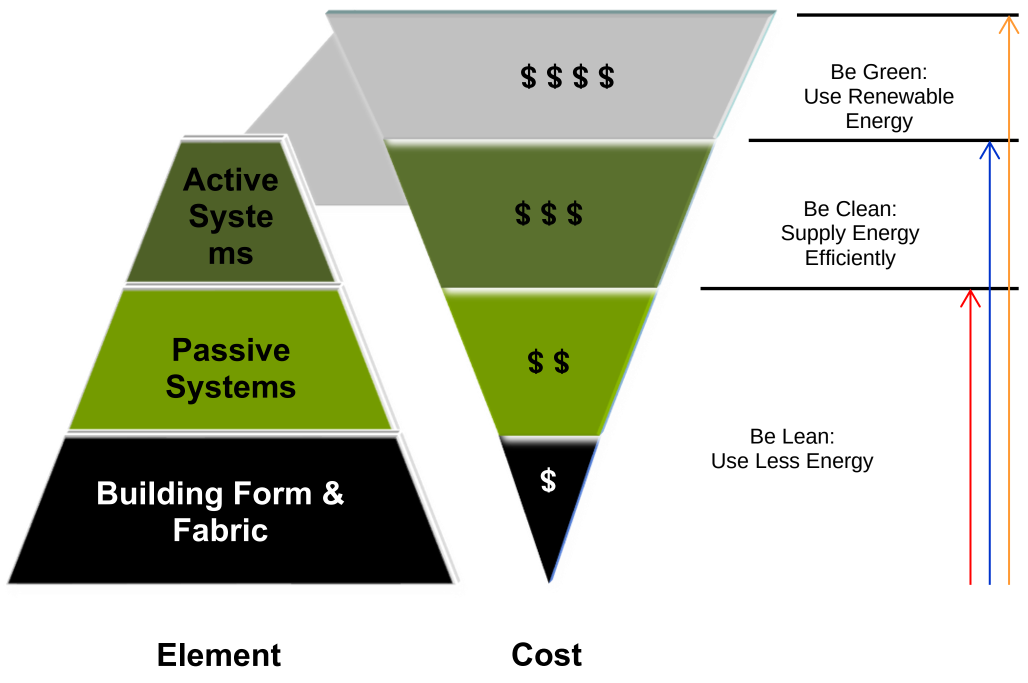
It is realised Sefaira not a certified compliance tool, and is only being used at this stage to provide an estimate of the target emissions benchmark and compare and analyse carbon reducing strategies.

Sustainable Methodology

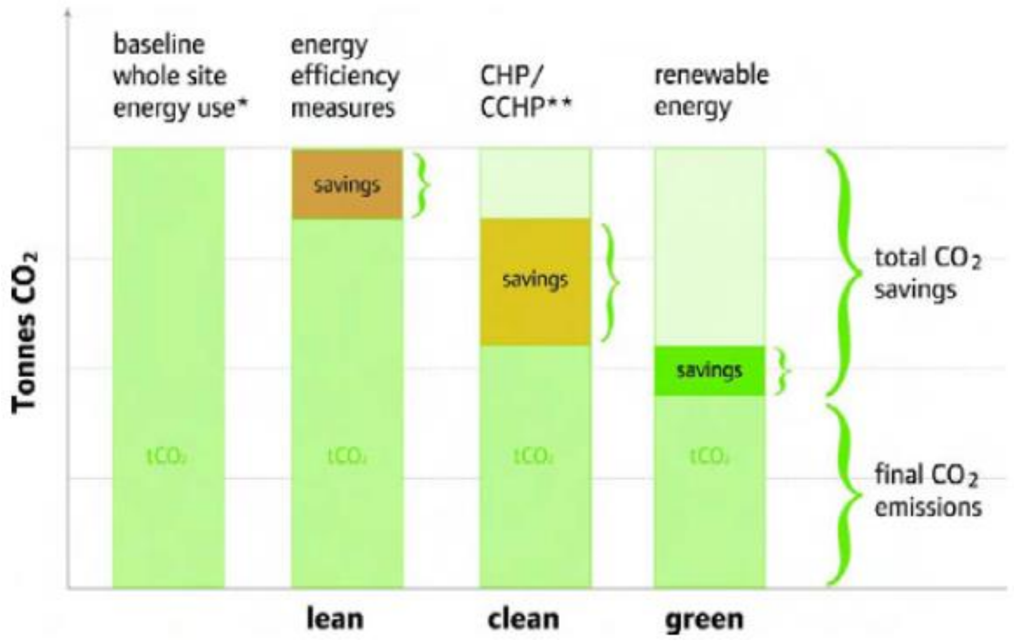
A strategic energy hierarchy, in line with the London 2012 shall be followed during the design process, whereby active system sizes and investment in on-site renewable energy will be reduced through exploring cost effective passive design features and optimising building façade and fabric.

The energy hierarchy is summarised below, in order of priority:-

a. Optimise the building fabric, glazing, structure to minimise energy consumption in the first instance by using low U-values and good air tightness – be lean
b. Include passive design measures to further reduce energy consumption, and ensure that active systems run as energy efficiently as possible – be clean
c. Only when the above design elements have been reasonably exhausted, consider Low or Zero Carbon (LZC) energy solutions – be green



The final CO_2 emissions will be a sum of the total CO_2 savings from energy efficiency measures, CHP, and other low/zero carbon technologies



Baseline CO_2 Emissions Parameters

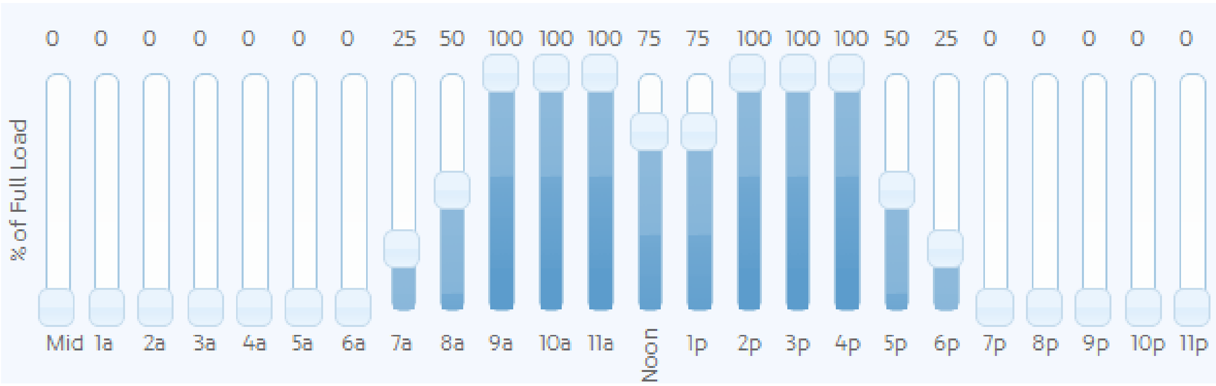
An overview of the key inputs used in Sefaira for calculating the baseline CO_2 emissions estimate of refurbished and new build areas is shown below.

Refurbished Buildings – Teaching and Hospitality Block, A Block, B Block, North Building

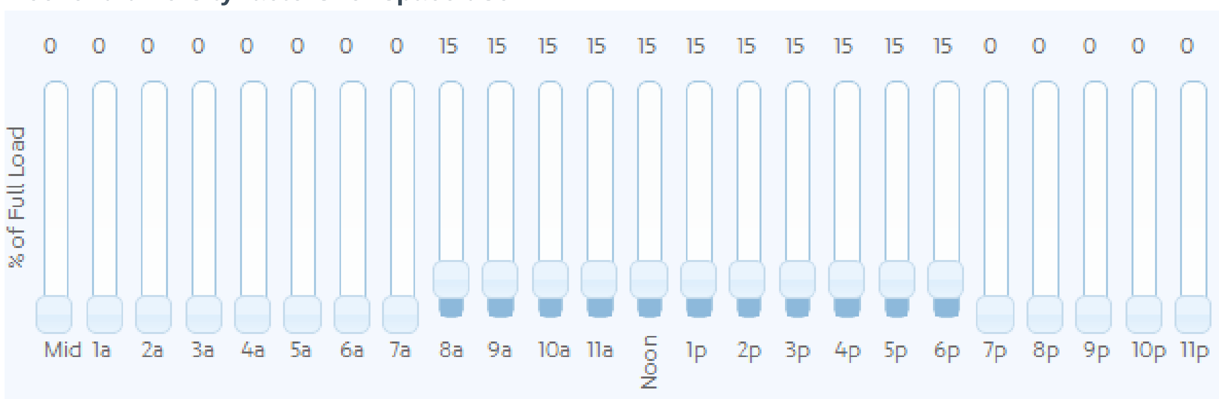
For refurbished areas being retained the inputs are largely assumptions made from site surveys. When information could not gathered then a best estimate has been used. All assumptions are stated.

Element	Value	Units	Source
External Wall U-Value	1.3	W/(m².°K)	Assumption base on site survey
Roof U-Value	1.0	W/(m².°K)	Assumption base on site survey
Floor U-Value	0.5	W/(m².°K)	Assumption base on site survey
Glazing U-Value	6.0	W/(m².°K)	Assumption base on site survey
Glazing SHGC-Value	0.4	n/a	Assumption base on site survey
Facade Permeability	20.0	m³/(h.m²$_{facade}$)@50pa	Assumption base on site survey
Ventilation Rate	1.0	L/(s.m²$_{floor\ area}$)	Assumption based on req'd vent rate
Design Fan Power	1.8	W/(l/s)	Assumption based on best estimate
Heating Efficiency or COP	0.75	n/a	Assumption base on site survey
Heating set-point	21	°C	Assumption based on best estimate
Lighting - classroom	12	W/ m²	Assumption based on best estimate
Lighting – common area	5	W/ m²	Assumption based on best estimate
No of people at full-time occ	4.92	m²/person	Based on NCM guidelines for a University

Weekday diversity factors for space use



Weekend diversity factors for space use

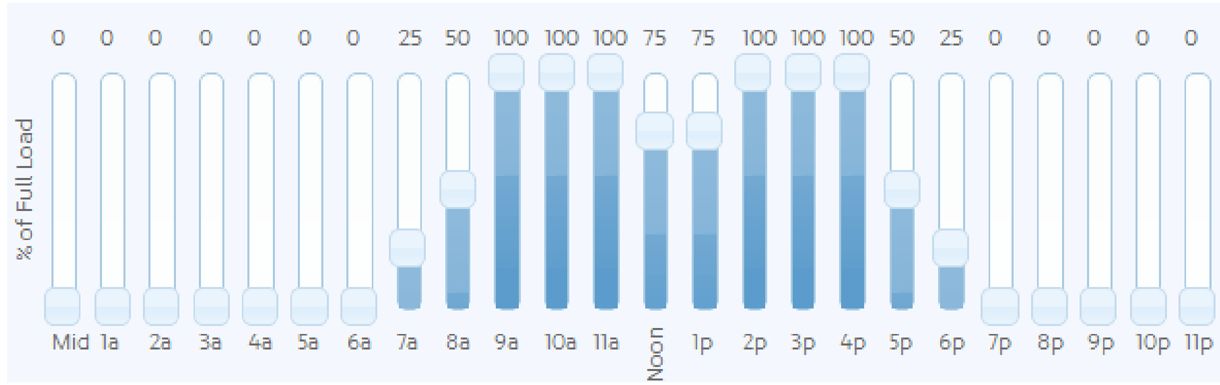


New Build

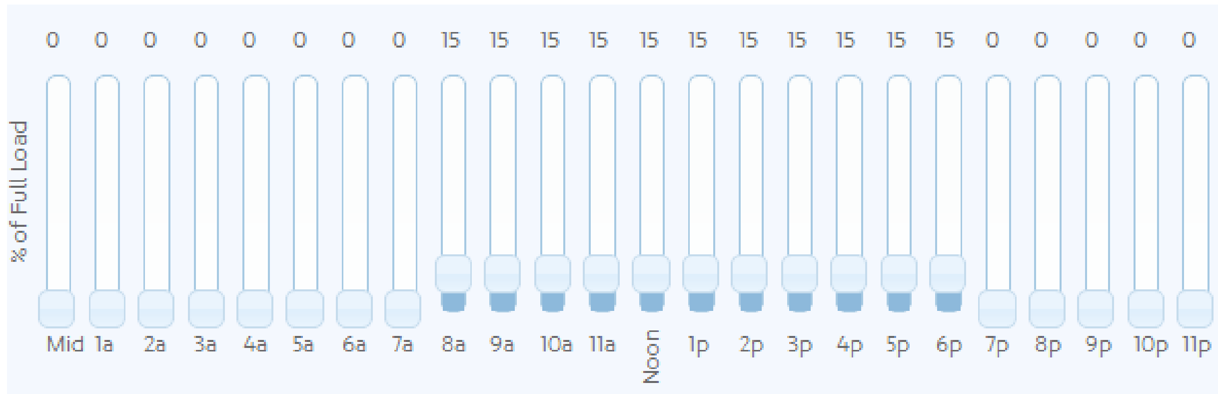
For the new build area inputs are based on the National Calculation Method (NCM) defined set of parameters for calculating the notional building target emissions rate (TER) as required by 2010 Building Regulations Part L

Element	Value	Units	Source
External Wall U-Value	0.26	W/(m².°K)	Assumption base on site survey
Roof U-Value	0.18	W/(m².°K)	Assumption base on site survey
Floor U-Value	0.22	W/(m².°K)	Assumption base on site survey
Glazing U-Value	1.8	W/(m².°K)	Assumption base on site survey
Glazing SHGC-Value	0.4	n/a	Assumption base on site survey
Facade Permeability	10.0	m³/(h.m²$_{facade}$)@50pa	Assumption base on site survey
Ventilation Rate	1.0	L/(s.m²$_{floor\ area}$)	Assumption based on req'd vent rate
Design Fan Power	1.8	W/(l/s)	Assumption based on best estimate
Heating Efficiency or COP	0.79	n/a	Assumption base on site survey
Heating set-point	21	°C	Assumption based on best estimate
Lighting - classroom	12	W/ m²	Assumption based on best estimate
Lighting – common area	5	W/ m²	Assumption based on best estimate
No of people at full-time occ	4.92	m²/person	Based on NCM guidelines for a University

Weekday diversity factors for space use



Weekend diversity factors for space use



Baseline CO_2 Emission Benchmark and 25% CO_2 Reduction Target Estimate

Below is a summary of the existing building CO_2 emissions baseline estimate calculated in Sefaira using the inputs provided above. Several iterations of the modelling were performed to provide accuracy. From the baseline emissions benchmark the 25% reduction target was then calculated. Both estimates are stated below

Strategy	Annual CO_2 Emissions (kgCO_2)*	Annual CO_2 Emissions per m² Gross Internal Floor Area (kgCO_2/m²)*
Baseline CO_2 emissions benchmark	**964623**	**37.1**

25% carbon emissions reduction target	**723467**	**27.8**

*Based on a carbon emissions intensity of (SAP-2009, Table 12)
- 0.517 kgCO2/kWh – electricity
- 0.198 kgCO2/kWh – gas (heating and hot water only)

Based on our estimates a reduction of 241156 $kGCO_2$/yr is required to achieve the 25% CO_2 emission reduction target. This equates to a reduction of 9.3 $kGCO_2/yr/m^2$.

Energy Efficiency Strategies – Be Lean

Upon establishing the baseline emissions benchmark, Sefaira was then utilised to investigate the carbon emission reductions associated with improving the existing building envelope performance as well as introducing a heat recovery to the ventilation system. **The energy efficiency strategies apply only to the refurbished areas being retained**

Results from the 'Building Envelope Thermal Analysis' were used to provide the specification for the proposed building envelope upgrade. See the Building Envelope Thermal Analysis section of the Environmental Analysis report for details. Heat recovery was modelled as having 70% effectiveness

The energy efficiency improvement strategies are grouped into 2 categories as detailed below

Building Envelope Performance Upgrade
- Improving thermal performance of external wall, roof, walls and ground floor U-Value.
- Improving thermal performance of the glazing U-Value.
- Improving facade permeability (infiltration rate)

Element	Existing Building	Proposed Building	Units
External Wall U-Value	1.3	0.28	$W/(m^2.°K)$
Roof U-Value	1.0	0.18	$W/(m^2.°K)$
Floor U-Value	0.5	0.25	$W/(m^2.°K)$
Glazing U-Value	6.0	1.8	$W/(m^2.°K)$
Permeability	20.0	5.0	$m^3/(h.m^2)$ @ 50pa

Ventilation Heat Recovery
- Introducing mechanical ventilation with heat recovery to all refurbished areas. Heat recovery effectiveness of 70%

Element	Existing Building	Proposed Building	Units
Heat recovery - 70% effectiveness	none	70% effective heat recovery	n/a

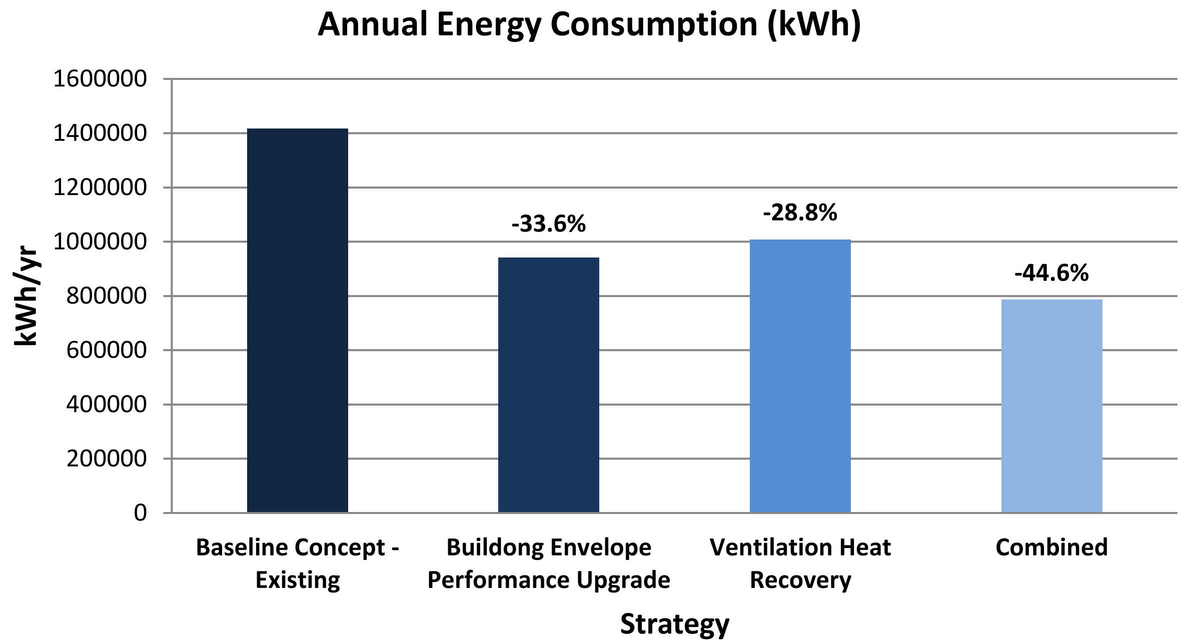
Results

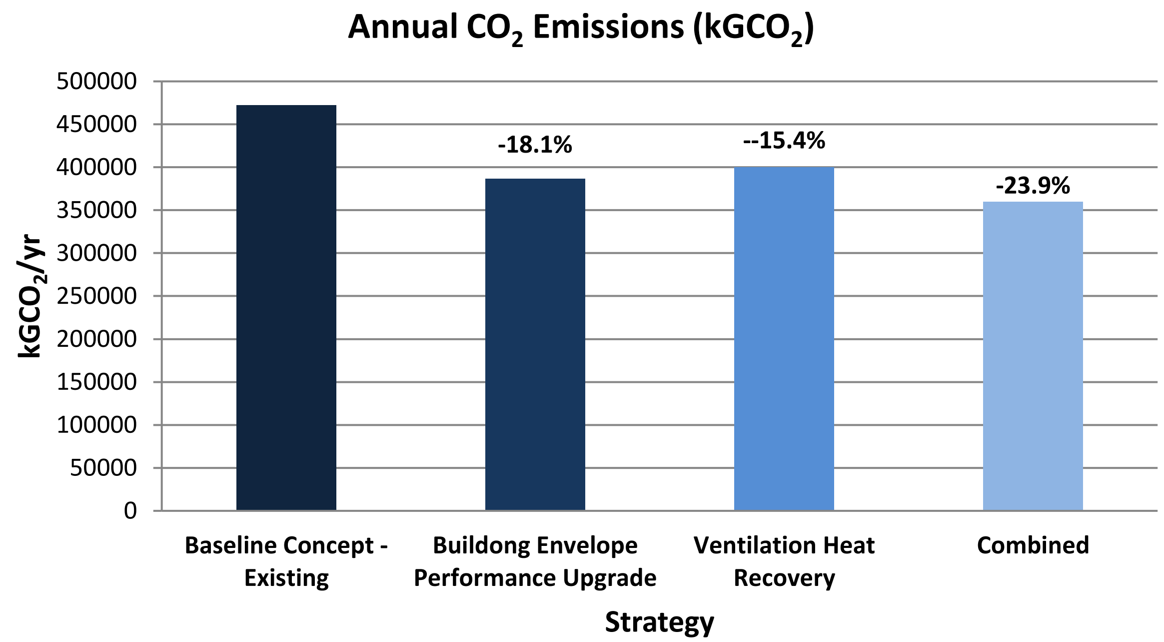
Below is a summary of the annual energy and annual CO_2 emissions reductions associated with the building envelope performance upgrade strategy and ventilation heat recovery strategy when compared against the CO_2 emissions baseline. The results have been divided into two building groups comprising of

1. Teaching and Hospitality Block
2. A Block, B Block, and North Building

The reason for dividing into two building groups is due to project phasing and the need to gain an appreciation of the estimated energy and CO_2 emissions reductions associated with each building group.

Teaching and Hospitality Block



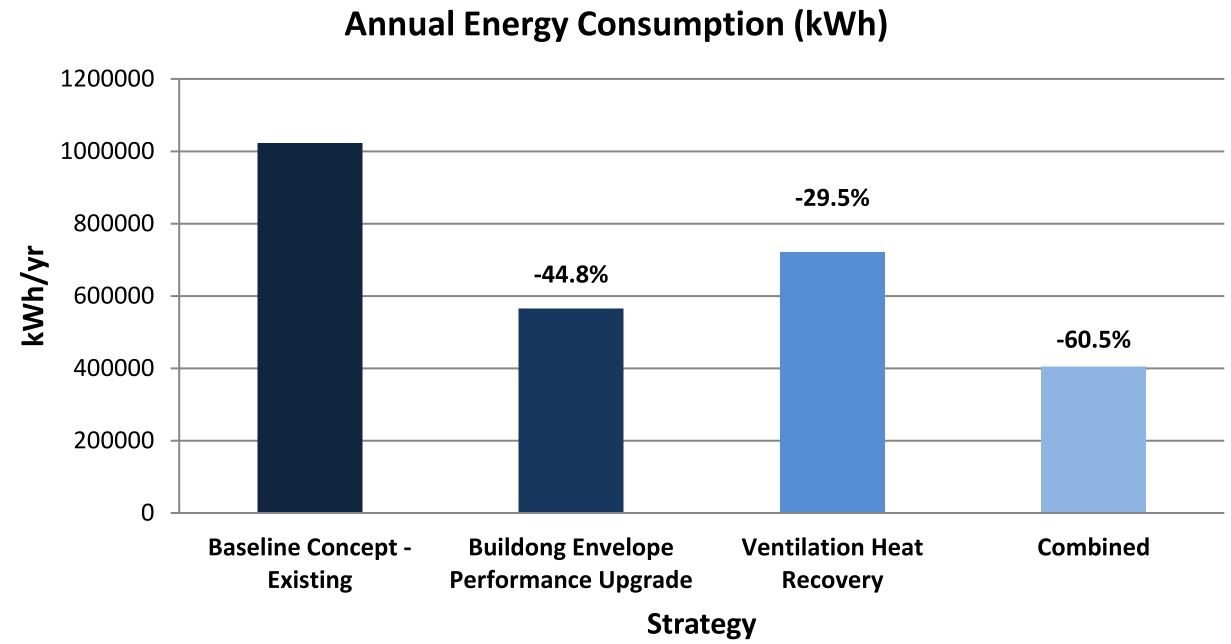


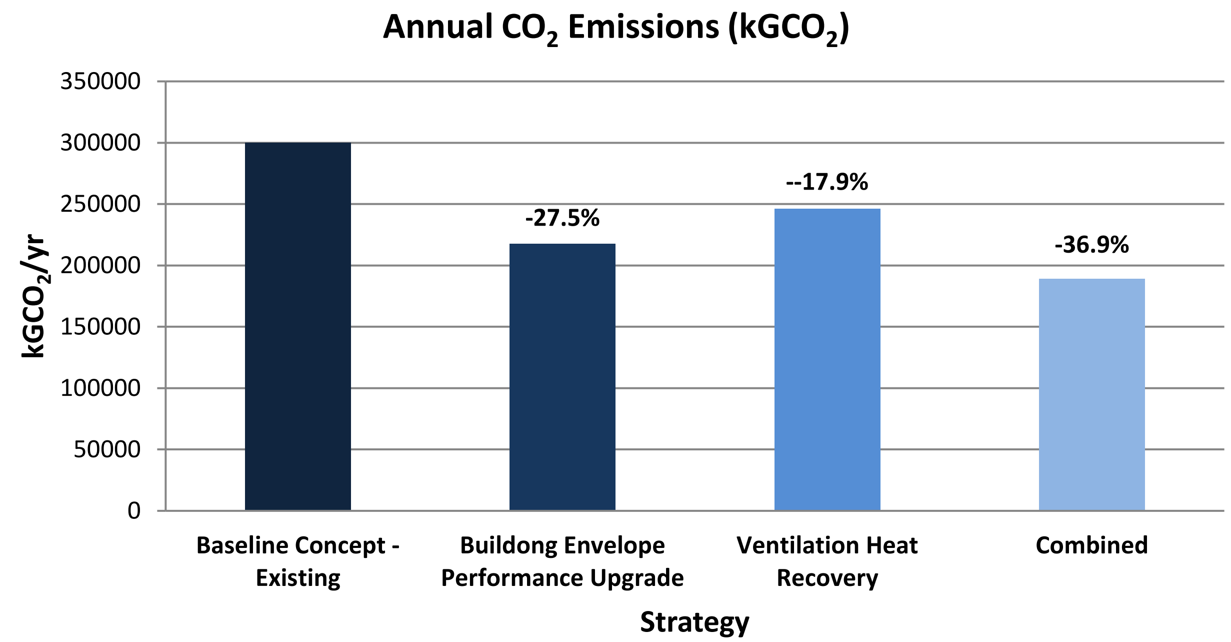
Teaching and Hospitality	Baseline Concept (Existing)	Building Envelope Performance Upgrade	Ventilation Heat Recovery	Combined (Envelope + Heat Recovery)
Annual Energy Consumption (kWh/yr)	1416384	940190	1008064	785170

Author: David.simpson@kipo.co.uk

Annual CO_2 Emissions ($kGCO_2$ /yr)	472271	386556	399727	359606

A Block, B Block, North Building





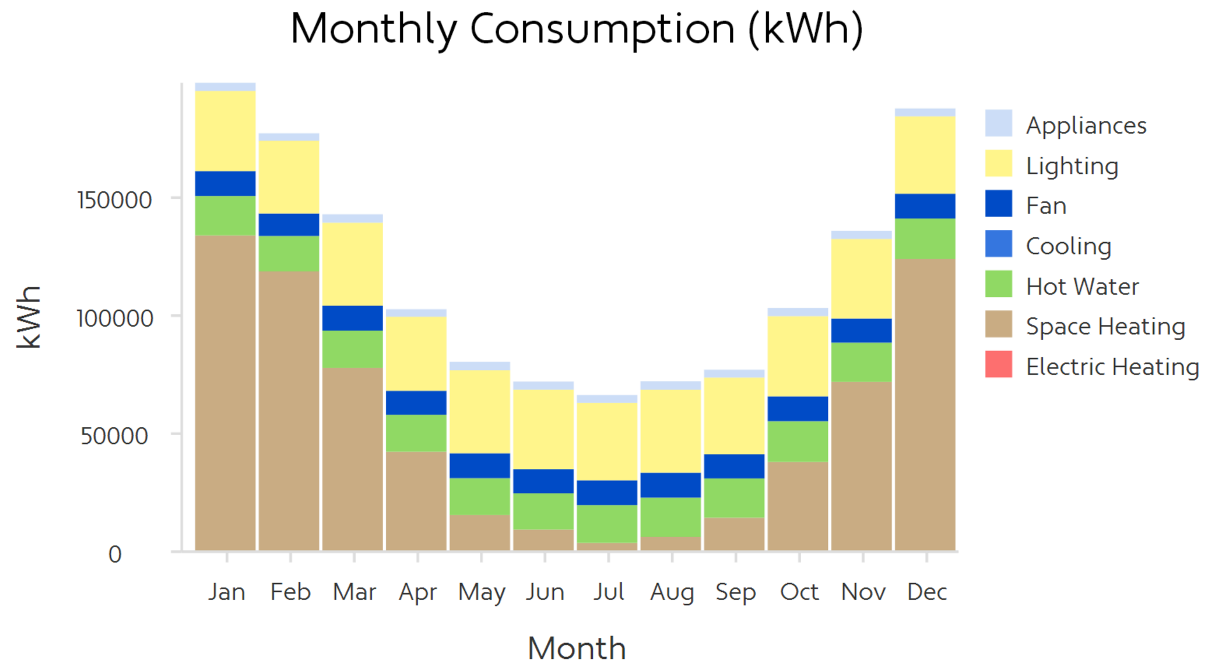
A, B, North Building	Baseline Concept (Existing)	Building Envelope Performance Upgrade	Ventilation Heat Recovery	Combined (Envelope + Heat Recovery)
Annual Energy Consumption (kWh/yr)	1022426	564543	720754	404242

Annual CO_2 Emissions ($kGCO_2$ /yr)	299868	217449	246079	189106

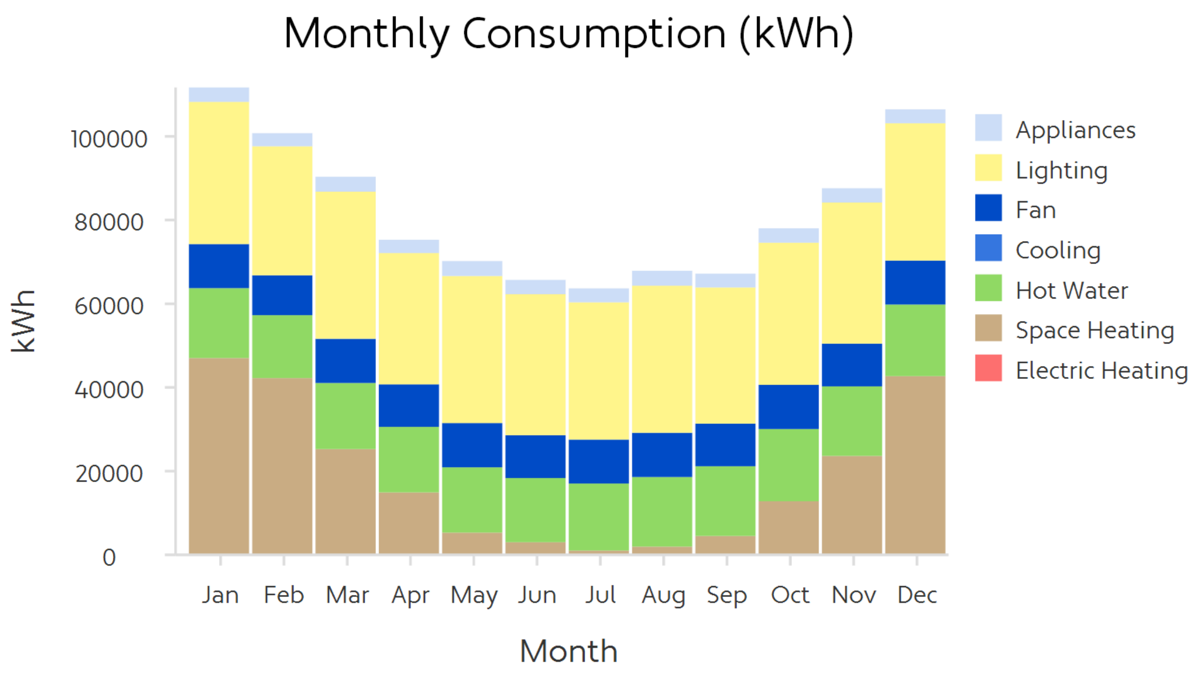
The results suggest that improving the refurbished buildings envelope to a 'modern' BR 2010 Part L compliant specification will result in a significant reduction of both annual energy consumption and annual CO_2 emissions.

The reductions are primarily a result of the reduced requirement for space heating due to the improved thermal performance of the building envelope. The space heating reductions between the baseline (existing) and building envelope performance upgrade strategies for each building group are shown below.

Teaching and Hospitality Block

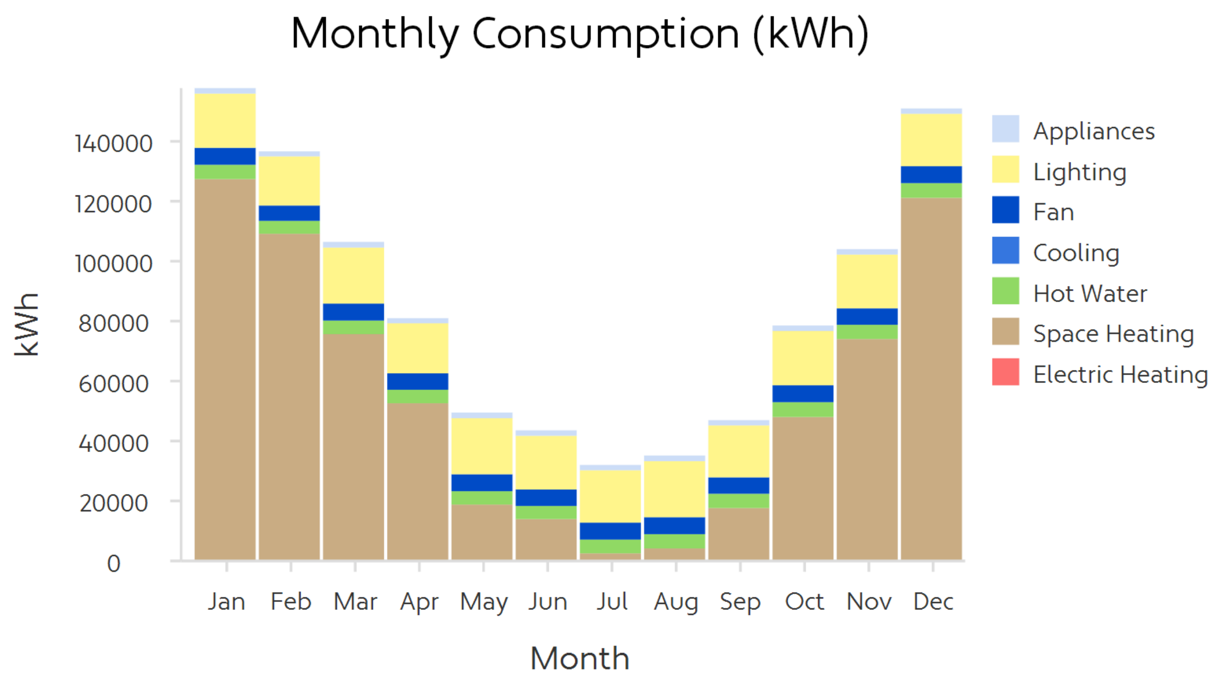


Baseline (existing) Energy Consumption Profile

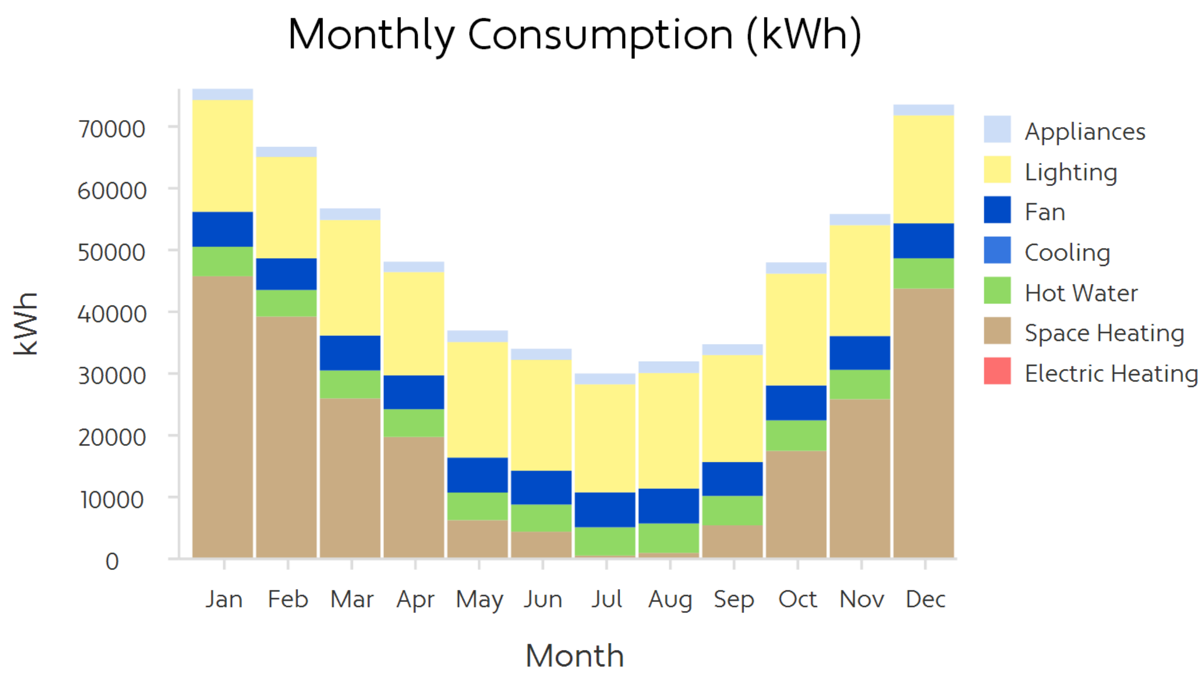


Building Envelope Performance Upgrade Energy Consumption Profile

A Block, B Block, North Building



Baseline (existing) Energy Consumption Profile

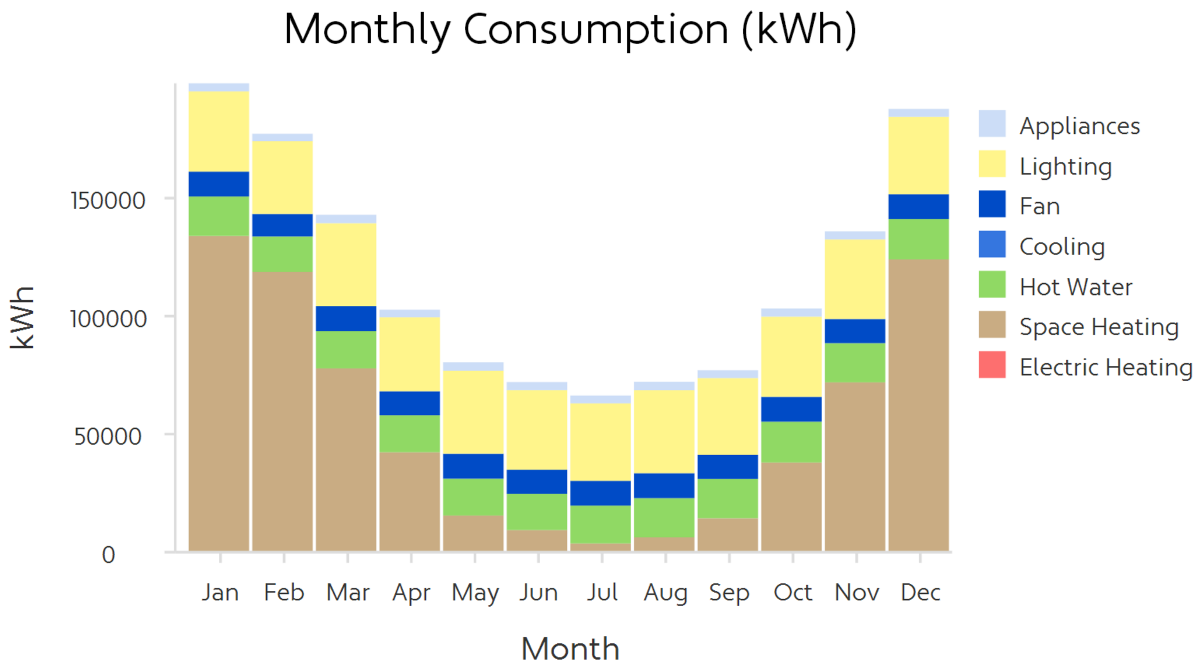


Building Envelope Performance Upgrade Energy Consumption Profile

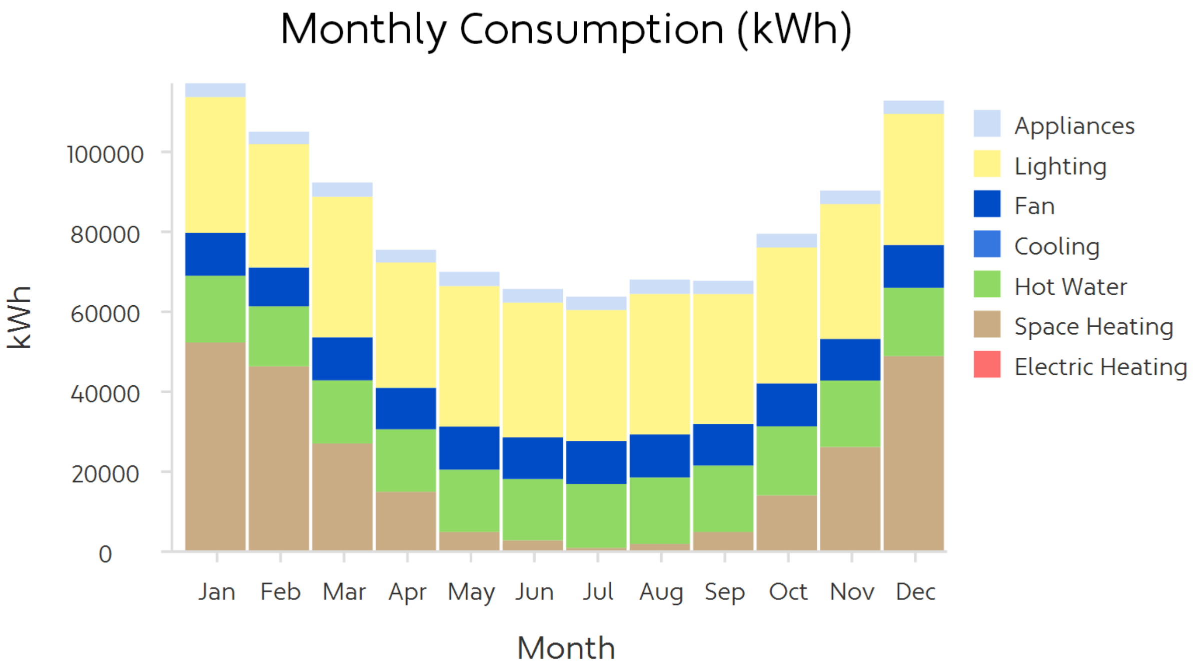
Both building groups display around a 65% reduction in space heating load as a result of the building envelope improvements.

The results also suggest that the use of mechanical ventilation with heat recovery will result in a significant reduction of both annual energy consumption and annual CO_2 emissions. The reductions are primarily a result of the reduced requirement for space heating. This is due to the temperature of fresh air for ventilation being closer to the room set point as a result of heat recovery. The space heating reductions between the baseline (existing) and ventilation heat recovery strategies for each building group are shown below.

Teaching and Hospitality Block

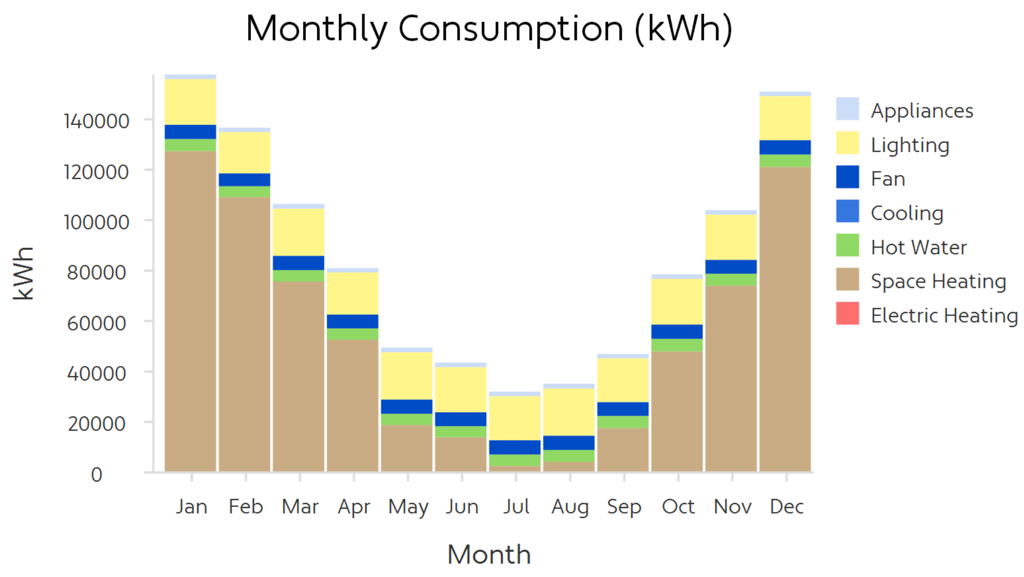


Baseline (existing) Energy Consumption Profile

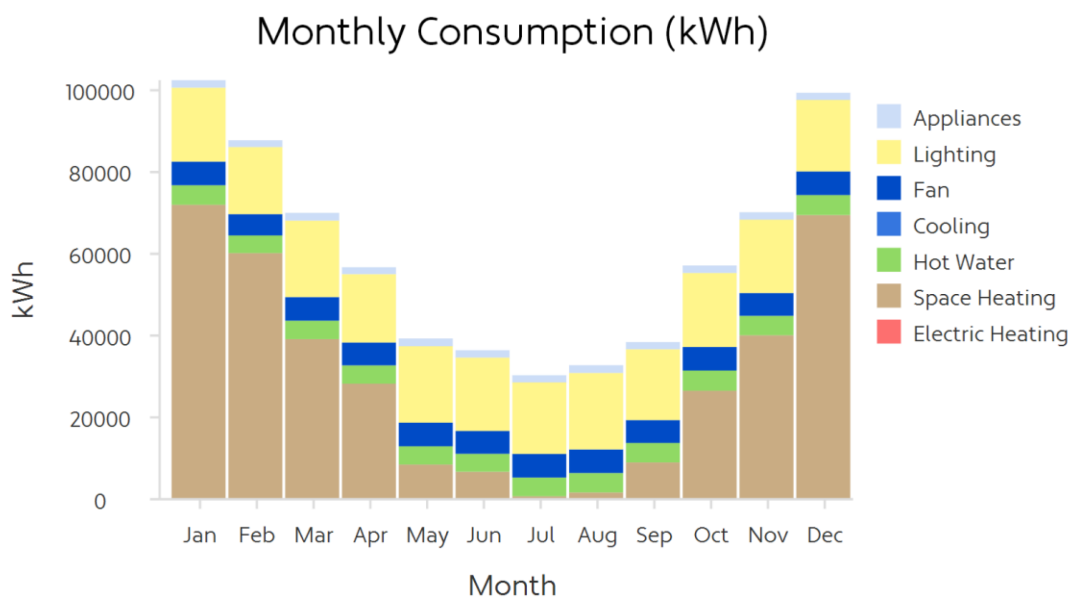


Ventilation Heat Recovery Energy Consumption Profile

A Block, B Block, North Building



Baseline (existing) Energy Consumption Profile



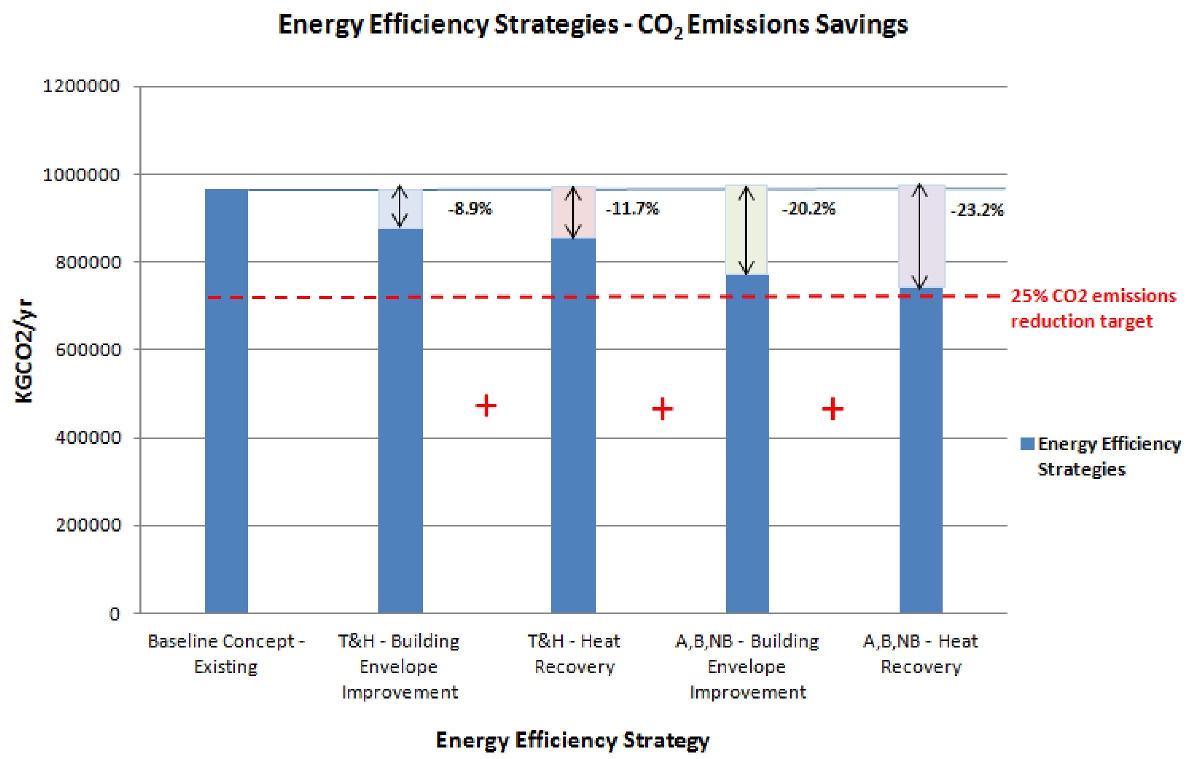
Ventilation Heat Recovery Energy Consumption Profile

Both building groups display around a significant reduction in space heating load as a result of the ventilation heat recovery;

- 65% reduction in space heating load for the Teaching Centre and Hospitality Block
- 45% reduction in space heating load for A Block, B Clock, and North buildin

The CO_2 emissions savings associated with each energy efficiency strategy is shown below. The total reduction of all 4 strategies when combined is also shown when measured against the baseline CO_2 emissions benchmark. Also shown is the ‘Be Lean’ CO_2 emissions benchmark. The ‘Be Lean’ benchmark is the total CO_2 emissions reduction associated with all 4 energy efficiency strategies combined.

Strategy	Annual CO_2 Emissions Reduction	Annual CO_2 Emissions Reduction per m²	Annual CO_2 Emissions Reduction
	($kgCO_2$)*	**($kgCO_2/m^2$)**	**%** (Measured from baseline)
Baseline CO_2 emissions benchmark	**964623**	**37.1**	**-**
Teach & Hospitality Building Envelope Improv	-85715	-3.29	-8.9%
Teach & Hospitality Heat Recovery	-26950	-1.03	-2.8%
A,B, North Building Building Envelope Improv	-82419	-3.17	-8.5%
A,B, North Building Heat Recovery	-28343	-1.08	-3.0%
TOTAL REDUCTION	**-223427**	**-8.57**	**-23.2%**
Be Lean Benchmark (Energy Efficiency)	**741196**	**28.53**	**23.2%**



Recommendations and Conclusions

The results demonstrate that the proposed energy efficiency strategies, which only apply to the refurbished areas being retained, result in a net CO_2 emissions reduction of 23.2% for the entire site. i.e. without any energy efficiency improvements applied to the new build area. This means that the project very nearly achieves compliance with the 2011 London Plan through energy efficiency improvements to the refurbished areas alone. It is possible that further energy efficiency improvements applied to both the refurbished and new build areas could result in an overall CO_2 emissions reduction of over 25%, and hence achieve compliance with the 2011 London Plan.

Based on the results of the energy efficiency strategies it is our recommendation that the project should progress forward with the following energy efficiency improvements.

1. **Improve the proposed building (refurbished and new build) envelope to the following specification.**

Element	Proposed Building	Units
External Wall U-Value	≤0.28	W/(m².°K)
Roof U-Value	≤0.18	W/(m².°K)
Floor U-Value	≤0.25	W/(m².°K)
Glazing U-Value	≤1.8	W/(m².°K)
Glazing G-Value	≤0.4	-
Permeability	≤5.0	m³/(h.m²) @ 50pa

The above specification is in line with the proposed building envelope specification detailed in the Environmental Modelling section of this report.

2. **Install mechanical ventilation with heat recovery to all spaces requiring ventilation**

In spaces with access to an openable window this should be used as part of a mixed-mode ventilation system. Users will have the choice to operate in either mode natural ventilation mode or mechanical ventilation with heat recovery mode.

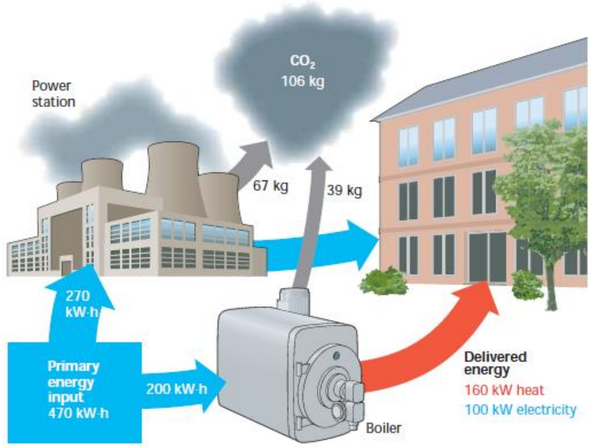
It is realised that heat recovery may not be a viable option for the project due to budget constraints. However due to its sizeable contribution towards the overall CO_2 emissions reduction it will be included as a viable recommendation in this report.

If either of the improved building envelope performance strategy or mechanical ventilation with heat recovery is not progressed further then it will significantly affect the projects ability to achieve the 25% CO_2 emissions reduction target.

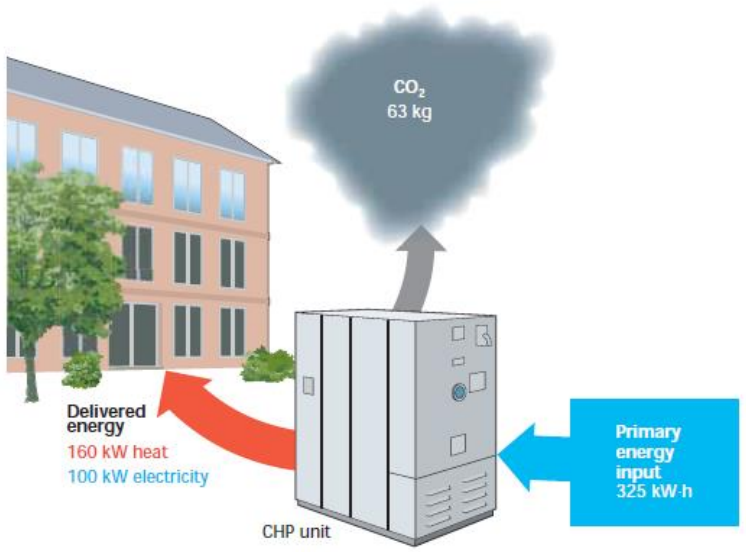
Combined Heat and Power – Be Clean

Introduction

Further CO_2 emissions reductions can be provided by installing a Combined Heat and Power (CHP) unit. CHP systems produce both heat and electricity from a single unit making it much more efficient than most power stations, which are not designed to make use of the surplus heat produced when generating electricity. Instead, this heat is exhausted into the environment and wasted. CHP systems use the 'waste' heat to provide hot water for heating and other purposes, as well as producing electricity for use on site. Power stations are generally about 35% efficient, while a CHP system is, on average, 85% efficient.

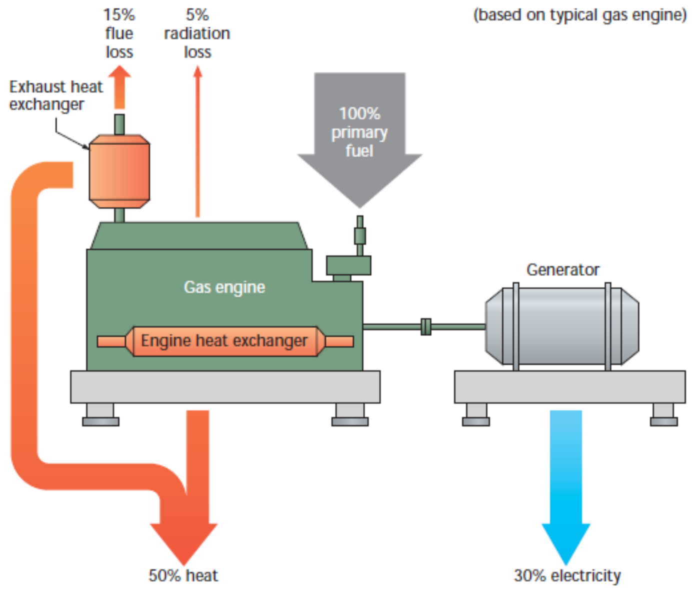


Conventional Energy Supply



CHP Energy Supply

Each kWh of electricity supplied from the average fossil fuel power station results in the emission of around half a kilogram of CO_2 into the atmosphere, with typical gas-fired boilers emitting around one fifth of a kilogram of CO_2 per unit of heat generated. CHP has a lower carbon intensity than these separate sources and this can result in around a 30% reduction in emissions of CO_2. The environmental impact can be seen in the figure above, which highlights that a CHP scheme produces far less CO_2 emissions with a reduced primary energy input than a conventional energy supply systems.
A typical CHP arrangement can be seen below, which highlights some of the typical losses from a unit and what they look like in reality.



Energy balance for a Typical Gas-fired CHP Plant

For this project the CHP units are to be powered by natural gas, however units can also be powered by renewable fuels in order to reduce carbon emissions further. These include biogas generated from anaerobic digestion or from waste oils from food processing, or even wood chip gasification, however this is still relatively new. Due to the reliability of fuel supply and the increased cost compared to natural gas, these alternatives have been discounted at this stage.

Considerations for successful CHP

Due to rising energy prices and, specifically, a widening gap between the cost of gas and electricity, CHP is becoming one of the principle technologies for providing a cost-effective solution for reducing Carbon emissions. In general, a CHP scheme can be considered economic if it runs for more than 5000 hours/year but will be dependent on a feasibility study based on reliable demand profiles to optimise the size of the plant. To be economic it needs to be used in buildings with a significant base heat demand and should be sized correctly or be of 'good quality' in relation to the demand. The CHP Quality Assurance scheme (CHPQA) sets out what is meant by 'good quality' CHP and for new installations the scheme must have a quality index over 105 and a electrical power efficiency of over 20%. This quality criteria is also required to meet Building Regulations requirements for all new and replacement CHP plants.

A combined heat and power scheme, CHP should be developed to maximise the running hours in order to provide the most economically and environmentally viable solution. As a result CHP schemes are developed and sized based on individual project requirements and vary from project to project. One common feature however to all CHP schemes, is that the unit is very rarely sized for the peak heating or electrical demand, and supplementary heating and power systems are required to operate in parallel with the CHP unit.

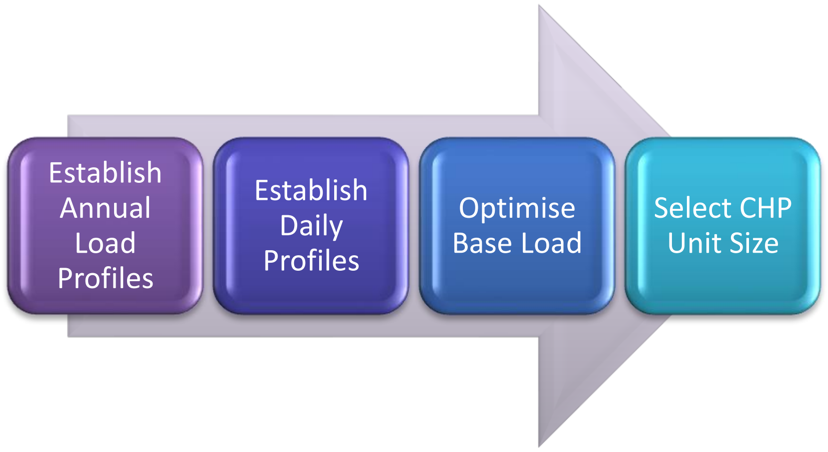
In the development of the CHP scheme for this project the following has been considered in order to arrive at the final arrangement.

- CHP will always be the lead heating source;
- Arrangement of the heating loads to have a year-round heat demand;
- The minimum running hours for the CHP will be over 5000 hours/year for economic viability.
- Preliminary heat and power demand profiles will be established for analysis of the CHP size;
- Use of the CHP unit to avoid the provision of standby generation;

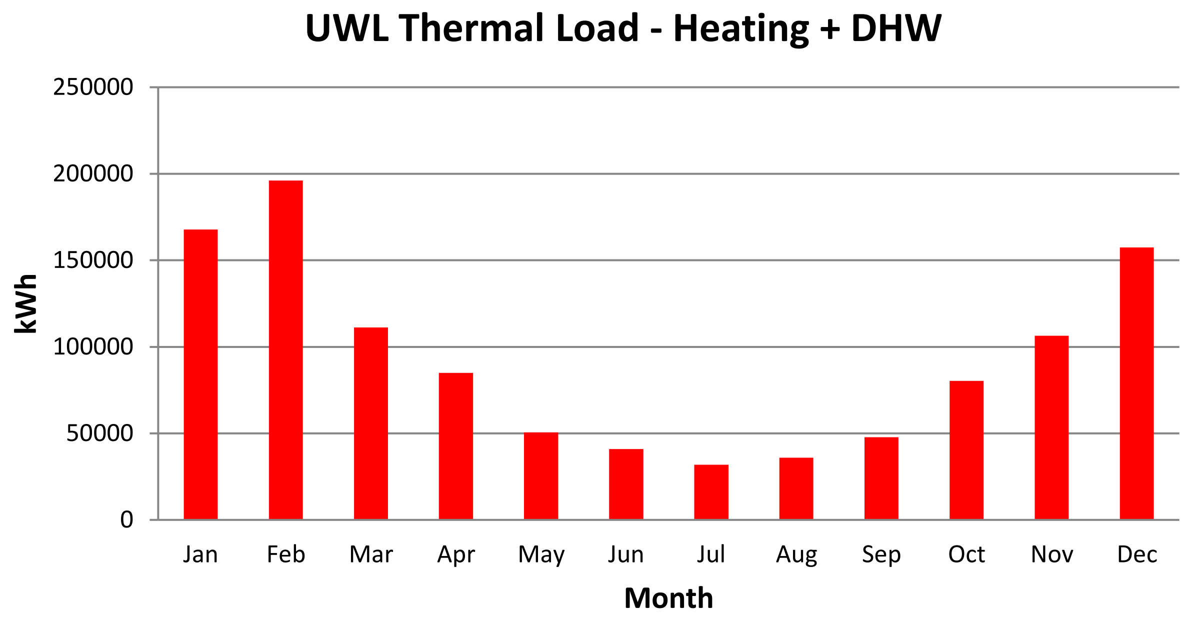
- CHP should be sized according to the base heat load, but the best economic case is often obtained by sizing the plant slightly bigger than this;
- Ensure heat is utilised in the building as savings are reduced if heat is rejected to atmosphere;
- Savings depend on the hours run, therefore the CHP will be arranged to run as much as possible to maximise savings.
- Correct energy prices from the client will be used for feasibility studies as savings are heavily dependent on fuel costs and electricity prices.

Building Loads & Annual Profiles

The following approach to developing the CHP scheme is to be adopted in order to determine the CHP size and arrangement.



In order to establish the annual thermal (heating + hot water)profile for the project, the massing of the development was simplistically modelled using Sefaira Concept thermal analysis software based on the proposed building envelope specification, as well as internal gains, and occupancy profiles. The estimated thermal load profile for the proposed development is shown below.



Results

Based on the above profile, initial discussions with CHP manufacturers have indicated that a suitable CHP for the size for the project is in the order of

- 152 kW $_{\text{electrical}}$
- 236kW $_{\text{thermal}}$
- 7884 run hours

Below is a summary of the annual CO_2 emissions reductions associated with installing a CHP unit as described above. Also shown is the 'Be Clean' benchmark. The Be Clean benchmark combines the CO_2 emissions reductions associated with the energy efficiency strategies and the CHP.

Strategy	**Annual CO_2 Emissions Reduction**	**Annual CO_2 Emissions Reduction per m²**	**Annual CO_2 Emissions Reduction**
	($kgCO_2$)*	**($kgCO_2/m^2$)**	**%** (Measured from baseline)
Suitable CHP	**279000**	**10.72**	**-28.9%**

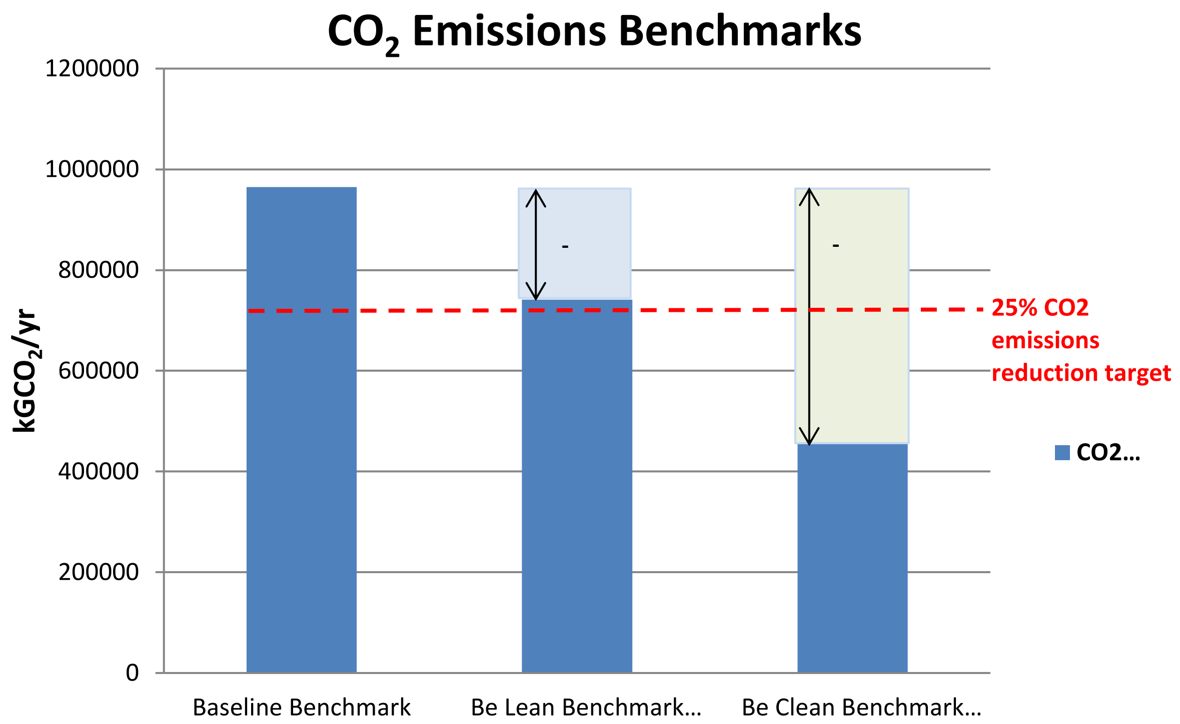
Strategy	**Annual CO_2 Emissions Reduction**	**Annual CO_2 Emissions Reduction per m²**	**Annual CO_2 Emissions Reduction**
	($kgCO_2$)*	**($kgCO_2/m^2$)**	**%** (Measured from baseline)
Baseline CO_2 emissions benchmark	**964623**	**37.1**	**-**
Energy Efficiency Strategy Reductions	-223427	-8.57	-23.2%
Suitable CHP Reductions	-279000	-10.72	-28.9%
TOTAL REDUCTION	**-502427**	**-19.29**	**-52.1%**

Be Clean Benchmark (Energy Efficiency + CHP)	**460196**	**17.81**	**52.1%**

The results demonstrate that the addition of a suitably sized CHP will reduce CO_2 emissions by a further 28.9%. Therefore based on our initial estimates it is likely that installation of the CHP unit would satisfy the requirements of the London Plan as a standalone solution.

However the CO_2 emissions reductions associated with the CHP is heavily reliant on the thermal profiles modelled in Sefaira which are at this stage only estimates. It is likely the thermal profile will change during the course of design and therefore the CO_2 emissions associated with the CHP will also change. Further to this it is preferred that the energy efficiency strategies be progressed in preference to installing a CHP – in line with the energy hierarchy of the project

The combined CO_2 emissions reductions of the energy efficiency strategies and the suitably sized CHP are shown below



The combined CO_2 emissions reductions of the energy efficiency strategies and the suitably sized CHP result in a net CO_2 emissions reduction of 52.1% when measured against the project baseline benchmark. The combination of both the energy efficiency strategies and the suitably sized CHP will likely achieve compliance with the 2011 London Plan.

The results illustrate that the Be Clean Benchmark provides a buffer of 25.2% CO_2 emissions reduction beyond the 25% reduction target. This provides a sufficient level of confidence that the combination of energy efficiency and CHP will achieve compliance with the 2011 London Plan. The extent of the buffer provides scope for reducing the performance of either the energy efficiency strategies and/or the CHP i.e. it is likely for example that a smaller sized CHP unit or taking away heat recovery will still achieve the 25% CO_2 emissions reduction target.

However the CHP unit will likely have a small simple payback period and therefore should be sized to generate the maximum ongoing savings for the life of its intended use.

Recommendations and Conclusions

Based on the results it is our recommendation that the project should progress forward with installing a suitably sized CHP unit. A suitably sized CHP can be defined as having the smallest payback period and greatest CO_2 emissions reductions. CHP generally has a smaller simple payback period than renewable technologies and is also a more robust and mature technology than most renewable energy technologies.

It is preferred that the energy efficiency strategies be progressed as a CO_2 emissions reducing solution in preference to installing a CHP.

If during the course of design it is discovered that energy efficiency strategies can achieve the 25% reduction target as a standalone solution then CHP may be removed from the CO_2 emissions reduction solution.

It is shown, with a sufficient level of confidence, that the 25% CO_2 emissions reduction target can likely be achieved without the need for renewable technologies. Renewable technologies will however be appraised for their suitability.

It is preferred that CHP be progressed as a CO_2 emissions reducing solution in preference to installing renewable technologies

Renewable Technologies – Be Green

Introduction

From initial calculations it appears that the 25% CO_2 emissions reduction target will be achievable through improvements to building fabric, building services systems and CHP. Therefore no renewable technologies will be considered for the project at this stage.

However renewable technologies could be incorporated into the scheme if deemed necessary. The following section describes the various renewable energy options and includes an appraisal of each.

Photovoltaics

A Photovoltaic system could be installed to convert the energy from the sun into electricity to supply the building. A typical PV system can produce around 100 kWh per m² per year dependent on the type of system used.

In order to meet the 25% CO_2 emissions reduction requirement as a standalone solution a PV system with a total area of 4700m² would need to be installed. The likely installed cost for providing 4700 m² of PV is circa £1mil

In order to meet the 25% CO_2 emissions reduction requirement as a combined solution with the energy efficiency strategies a PV system with a total area of 340m² would need to be installed. The likely installed cost for providing 340m² of PV is circa £100k

The most suitable location for mounting photovoltaic panels is on roofs as they usually have the greatest exposure to the sun. The proposed UWL site has a potential useable roof area of around 6500m², consisting of 3000m² for the Teaching and Hospitality Block, 900m² for the new build, 1200 m² for A and B Block, and 1400m² for the North Building. Given it's favourable East-West axis and building height, the Teaching and Hospitality Block would provide the ideal location for mounting photovoltaics

Figure 1. Solar PV Array

The installation of a PV system would prove suitable to meet the CO_2 emissions reduction target. The size of the PV necessary to meet the CO_2 emissions reduction target will heavily depend on the level of contribution from energy efficiency strategies and CHP.

Solar Water Heating

A Solar Water Heating System could be installed on the roof of the building to provide hot water. Solar panels are cheaper than PV systems so this system would involve a lower capital cost.

It is estimated that the heating and hot water demand of the site is too small to meet the 25% CO_2 emissions reduction if it were produced by solar hot water as a standalone system. Therefore a solar hot water system would need to be combined with energy efficiency strategies or CHP to achieve the 25% CO_2 emissions reduction target

In order to meet the 25% CO_2 emissions reduction requirement as a combined solution with the energy efficiency strategies a solar hot water system with a total area of between 20-50m^2 would need to be installed. The likely installed cost for providing 20-50m^2 of PV is circa £20-50k

Like photovoltaic panels the most suitable location for mounting solar hot water panels is on roofs as they usually have the greatest exposure to the sun. Given it's favourable East-West axis and building height, the Teaching and Hospitality Block would provide the ideal location for mounting solar hot water panels

Figure **Error! No text of specified style in document.**.1 – Solar Heat Collector

The installation of a solar hot water system would prove suitable to meet the CO_2 emissions reduction target. The size of the solar hot water system necessary to meet the CO_2 emissions reduction target will heavily depend on the level of contribution from energy efficiency strategies and CHP.

Wind Turbines

Wind technology applied to buildings is a relatively new, innovative field in renewable technologies. Potential exists for its development, but care is needed to check the viability thoroughly, given the likely opposition from planners and local residents to their installation.
Large scale wind turbines can either be stand alone units or be building-mounted. This is normally subject to the available space. The UWL site has space available to install a building mounted wind turbine, however, it is unlikely that a turbine, with a large blade diameter, mounted on a high mast, would present the most sensible approach for the purposes of this analysis nor would it yield the energy required to meet the necessary carbon emissions reduction. This option is also likely to attract much resistance from local community.

Smaller building mounted turbines are currently being developed and marketed throughout the UK. These are small enough to be roof mounted thus negating the need for open space. The elevated position also gives access to a more beneficial wind regime. They are also less visually invasive and therefore less likely to receive the negative reactions provoked by stand-alone turbines.

Figure 2. Integrated & Rooftop Wind Turbine

For the purposes of this project, a number of smaller turbines have been investigated up to a 6kW unit with blade diameter of 5.5m; however, the electrical contribution from the small wind turbines is relatively small.

Typically a 1.5 kW turbine can provide 4,000 kWh of electrical power annually therefore around 117 turbines would be required to meet the 25% CO_2 emissions reduction as a standalone solution. Based on an average cost of smaller roof mounted turbines at £2,000/kW the cost of providing 60 1.5kW turbines would be circa £180k

As a combined solution with the energy efficiency strategies around 9 1.5kW turbines would need to be installed to meet the 25% CO_2 emissions reduction target. Based on an average cost of smaller roof mounted turbines at £2,000/kW the cost of providing 60 1.5kW turbines would be circa £27k

An initial review of the available space would indicate that there would be sufficient space to roof mount the turbines in order to gain the benefit of higher wind speeds and avoid vandalism. However it is likely that planning restrictions and resistance from the local community make wind turbines an unviable option for the project

Biomass Boilers

Biomass boilers are those which burn sustainable organic fuel, where the most common biomass fuels in the UK are wood chip and wood pellets. Both these fuels are purpose grown and sustainable for utilisation in biomass heating systems.

The use of biomass is generally classed as a ‘low carbon intensity’ fuel because the carbon dioxide released during the generation of energy is balanced by that absorbed by plants during their growth. However, it is not entirely neutral as account must be made for any other energy inputs that occur in the production and transportation of the fuel.

Figure 3. Typical Biomass Boiler

Biomass heating is one of the few renewable technologies that require the regular delivery of fuel for input in to the system. In order to sustain a biomass boiler, regular deliveries of wood chips or pellets need to be received, transported to boiler and stored on site, requiring the site to be accessible. Biomass technology is considered to be “environmentally friendly” and can yield high savings in both carbon emissions and energy bills, but requires a very broad feasibility assessment, and because of the practicalities of such a system, it needs thorough further assessment.

A biomass boiler could be installed on site to meet the part of the supplementary LTHW heating, however one of the major factors influencing the suitability of a biomass boiler is the availability of the biomass fuel. There needs to be a local and reliable fuel source in order for the biomass boiler to be an efficient replacement for a conventional boiler system.

It is estimated that the heating and hot water demand of the site is too small to meet the 25% CO_2 emissions reduction if it were produced by a biomass boiler as a standalone system. Therefore a biomass boiler would need to be combined with energy efficiency strategies or CHP to achieve the 25% CO_2 emissions reduction target

In order to meet the 25% CO_2 emissions reduction requirement as a combined solution with the energy efficiency strategies a 125kW biomass boiler would need to be installed. The likely installed cost for providing a 125kW biomass boiler is circa £50k. Additional cost of providing and storing the biofuel also needs to be factored in.

Assuming there is availability of a suitable bio-fuel and there is sufficient plant space for fuel storage and delivery, biomass boiler heating is considered viable for the scheme at this stage.

Ground Source Heating

Ground Source Heat Pumps can be a very efficient way of heating a building, using the ground as a heat source. An efficient system can produce 3 to 4 units of heat for every unit of electricity used, however due to electricity being the fuel source carbon emissions savings are much less.

There are three main methods of installing a ground source heat pump system. A closed loop horizontal system relies on installing vast lengths of ‘slinky’ pipework at a shallow depth. A closed loop vertical system uses a series of boreholes to obtain greater heat exchange benefit with shorter pipework lengths. Finally, an open loop vertical system could abstract water from the aquifer beneath the site to yield an even greater heat exchange. Only the later two would be feasible for this site due to the space available.

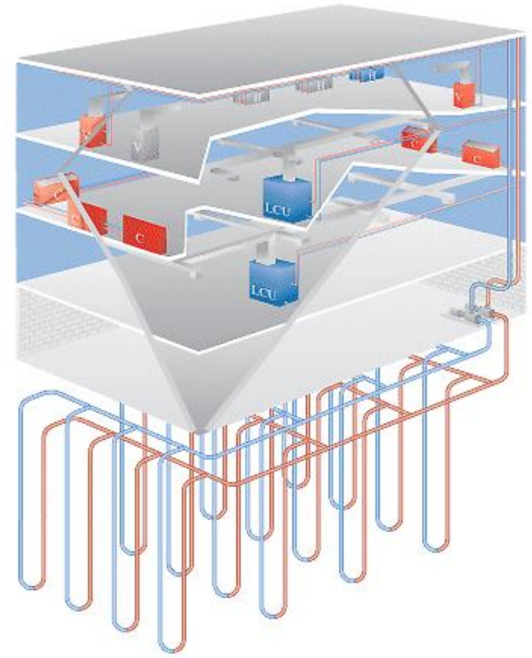


Figure 4. Vertical Ground Source Heat Loop

The capital cost of installing a ground source heat pump system is quite high, especially if a vertical borehole system is used, but the maintenance costs are low and the life of the system can be over 20 years.

It is estimated that the heating and hot water demand of the site is too small to meet the 25% CO_2 emissions reduction if it were produced by a ground source heat pump as a standalone system. Therefore a ground source heat pump would need to be combined with energy efficiency strategies or CHP to achieve the 25% CO_2 emissions reduction target

In order to meet the 25% CO_2 emissions reduction requirement as a combined solution with the energy efficiency strategies a 200kW ground source heat pump would need be installed. The likely installed cost for providing 200kW of ground source heating is circa £230k, based on a typical installed cost of £1,150 /kW.

Savings in annual energy usage would be in the order of 4% although carbon dioxide emissions would only be reduced by around 2% due to the need to use electricity as the fuel source. In addition, due to the difference in cost between electricity and gas the annual cost saving would be marginal, meaning a simple payback period of 230 years which is well beyond the life of the building and the plant within it.

Due to cost and the relatively low carbon emissions reduction realised by this option we deem ground source heat pumps as unsuitable for the development.

Air Source Heating

These systems work on the same principle as a ground source heat pump but use the outside air as the heat source instead of the ground. They are a lot cheaper to install than ground source heat pumps but are only available on a relatively small scale. If applied across the site a number of plant zones would be required for generation of heat, leading to increased plant space requirements. The coefficients of performance given by air source heat pump systems are inferior to that of ground source systems due to varying air temperatures. For this reason we can conclude that carbon dioxide emissions savings will be less than that of the ground source heat pump and hence are not suitable for the UWL site as a carbon reducing solution. Air source heat pumps may however be suitable as an HVAC solution.

Due to cost and the relatively low carbon emissions reduction realised by this option we deem air source heat pumps as unsuitable for the development in any form.

Renewable Technology Summary

Technology	System Size	CO2 Emissions Reduction	Estimated Installed Cost
Photovoltaics (stand alone)	700kWelec	25%	£1000k
Photovoltaics (combined)	51kWelec	1.8%	£100k
Solar Water Heating (combined)	88MWh heat	1.8%	£20-50k
Micro Wind Turbines (Stand alone)	175kWelec	25%	£180k
Micro Wind Turbines (combined)	13.5kWelec	1.8	£27k
Biomass Boilers (combined)	125kW heat	19.6%	£50k
Ground Source Heating	200kW heat	19.6%	£230k
Air Source Heating	n/a	n/a	n/a