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Carbon Management Plan

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Table of Contents

Appendix 8-3 – Project Roof Maintenance Work 51
Appendix 8-4 – Travel Data 53
Appendix 8-5 – Water Data 53
Appendix 8-6 – Detailed Waste Data for Academic Year 2008/09 54

Table 1-1 Higher Education sector carbon emissions – scope 1, 2 and 3 4
Table 4-1 Carbon emission factors for energy 10
Table 4-2 Scope 3 carbon emissions factors from Water Use 10
Table 4-3 Scope 3 carbon emission factors from transport 10
Table 4-4 Scope 3 carbon emission factors from waste management 11
Table 5-1 LSE Carbon Emissions 2005 to 2010 17
Table 6-1: Summary results for Bankside House Halls of Residence 25
Table 6-2: Approximate costs of energy efficiency measures 26
Table 6-3: Indicative costs of external wall insulation and double glazing to academic buildings 26
Table 6-4: Indicative costs of insulation and double glazing to residential buildings 26
Table 6-5: Cost of heating improvements to academic buildings 27
Table 6-6 : - UK HE median space utilisation 27
Table 6-7 : UK HE total non-residential net internal area (NIA) per student FTE[3] 27
Table 7-1: Potential measures and capital costs for carbon reduction projects for the Residential Campus 34
Table 7-2: Potential measures and capital costs for carbon reduction projects for the Academic Campus 35
Table 7-3: Capital expenditure 36
Table 7-4: 10 Year cost analysis 36
Table 7-5: Table showing the proposed reduction in carbon emissions up until 2020 37

1 Introduction

The purpose of the LSE is to increase understanding of a complex and changing world through excellent teaching and research in the social sciences by promoting its work to policy makers and practitioners in the public, private and voluntary sectors.

Founded in 1895, LSE adopted the motto '*rerum cognoscere causas*' - to understand the causes of things. LSE staff or alumni include 16 Nobel Prize winners, in economics, peace and literature and 34 past or present world leaders have studied or taught at LSE.

LSE moved to its present site in 1902, occupying buildings in Clare Market and Houghton Street. The academic campus is situated in the London Boroughs of Camden and Westminster and currently comprises of 28 academic buildings, there are 8 LSE managed halls in the London Boroughs of Camden, Islington, Westminster and Southwark. In addition a sports ground in sited in the Royal Borough of Kingston Upon Thames and a pub with residential visiting academic flats. The total building portfolio is an area of ~115,700 m^2.

Figure 1-1 LSE academic campus

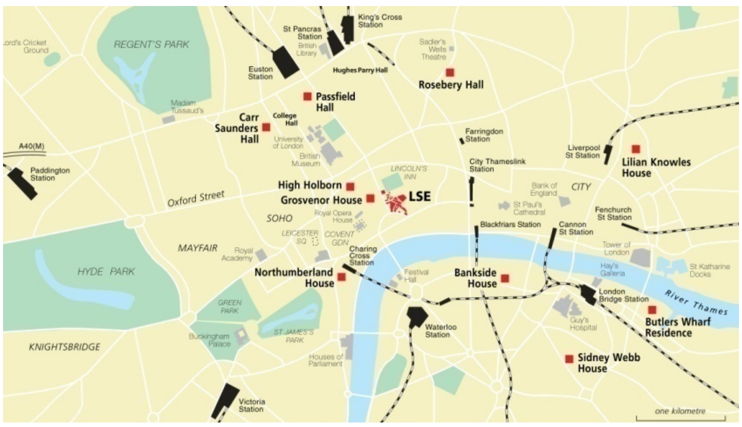


Figure 1-2 LSE residential campus

Figure 1-3 LSE sports ground, New Malden

The School has a global student body, with around 10,000 students from 140 countries and 45% of teaching staff from outside of the UK. Recognising that the activities, products and services of LSE have environmental, social and economic impacts, the School is committed to acting responsibly to minimise its environmental impact.

In December 2009, HEFCE issued their Capital Investment Framework no. 2 (CIF II) consultation document which set out the funding strategy from April 2011. The main focus areas for Higher Education Institutes (HEIs) to demonstrate that public funds are well spent include reducing carbon emissions and improving space usage. Guidance on how HEIs should demonstrate their commitment to reducing carbon emissions was provided in the HEFCE document 2010/02 Carbon Management Strategies and Plans. These documents give guidance on how HEI's might develop their own Carbon Management Plan (CMP) resulting in a reduction of carbon emissions by 48% from a suggested baseline academic year of 2005 (August 2005 to July 2006). This has been developed by HEFCE considering the Government's legally binding reduction targets over 1990 baseline emission levels.

HEFCE has suggested a baseline academic year of 2005/2006 as it was deemed that the majority of HEIs would have data available in order to be able to map out their baseline. To measure progress against the target 48% reduction, the following milestones have been set. An absolute reduction in CO_2 emissions of 20% by 2012 and 34% by 2017 against a 2005 baseline. The LSE will work towards this target of 48% reduction but has also set itself the target of 54% with an aspirational target of 57% reduction as well from the 2005/06 baseline year by 2020. In this first iteration of the CMP a target reduction of 55% has been identified for Scope 1 & 2 emissions has been set out. This is to be achieved through energy efficiency, capital investment programmes, improvements in space utilisation and behavioural change programmes.

In this first iteration of the CMPs, HEI's are required to develop a baseline that covers all Scope 1 and 2 emissions. Measurement of a baseline for Scope 3 emissions is encouraged but not yet mandatory. LSE has begun to identify ways to collect data and started to implement measures which will help reduce carbon emissions, including Scope 3 issues. These Scope 3 issues have not been included in the targeted carbon emission reduction at this stage; however suggestions on how these issues might be addressed have been included in the implementation section found later in this document.

Scope	Description	Examples
Scope 1 – Direct Emissions	Direct emissions occur from sources that are owned or controlled by the HEI	Direct fuel and energy use Transport fuel used in institutions' own fleet vehicle
Scope 2 - Indirect Emissions	Emissions from the generation of purchased electricity consumed by the HEI	Purchased electricity
Scope 3 – Other Indirect Emissions	Emissions which are a consequence of the activities of the HEI but occur from sources not owned or controlled by the HEI	Water Waste Land based travel Commuting (both staff and students) Air travel (international students, international student exchange, business)
		Procurement (this has not been assessed at the sector level as yet)

Table 1-1 Higher Education sector carbon emissions – scope 1, 2 and 3

During the baseline year 2005/06 the School had 8947 students[1] and 2869 average full time equivalent staff[2]. In 2008/09 year these figures had risen to 9914 students and 3182 staff. This increase in staff and student numbers and an increase in the LSE building stock led to an increase in the carbon emissions resulting from the operation of the School. However measures have been put in place over the last few years to compensate for these increases. This document sets out to clarify the baseline data

[1] http://www2.lse.ac.uk/aboutLSE/statisticsOnLSE/pdf/Table%20A.pdf - based on reported domiciled status
[2] http://www2.lse.ac.uk/intranet/LSEServices/divisionsAndDepartments/humanResources/informationAndSystems/staffNumbers.aspx - Head count figures taken on 31st July

information, set out a strategy for how absolute carbon emissions might be reduced to the HEFCE target level by 2020 and a methodology for how this programme will be managed.

1.1 Drivers for Change

Cost Reduction

Cost saving is not the main driver for this programme, however it is important to the LSE that the campus is operated and managed in a cost effective way, and that this programme presents positive opportunities for the school to reduce CO_2 emissions.

It has been estimated that the total cost of energy used by LSE properties is approximately £2.4M (Academic buildings at £1.1M and Residences at £1.3M per annum). This represents a major cost and has been subject to significant increase over recent periods, due to energy price rises, expansion in the school's portfolio and increases in student and staff numbers.

Leadership

Good environmental performance is complementary to the LSE Strategic Plan and embedded into the Environmental Policy. From an academic standpoint the LSE has an established research centre in the Grantham Research Institute on Climate Change and the Environment. Its mission is to generate world-class, policy-relevant research on climate change and the environment for academics, policy-makers, businesses, non-governmental organizations, the media and the public. To engage its students in sustainability irrespective of a student's degree selection, the LSE introduced the LSE100 Course: Understanding the causes of things' in January 2010, a compulsory course for all undergraduate students. The curriculum promotes an interdisciplinary approach to understanding sustainability issues. Also as part of its wider community engagement the LSE currently chairs the London Universities Environmental Group.

This CMP helps establish what the School can do to support sustainability issues from management, operation and investment angles.

Risk Minimisation

There are a number of carbon related risks such as energy price fluctuations, emerging Regulations, reputational risks associated with not acting, understanding and minimising these risks looking forward is important to the LSE. The LSE has a large portfolio of buildings, both academic and residential and is committed to reducing its energy demands.

As part of the funding assessment process required by HEFCE in the CIF II consultation document, HEIs have been charged with reducing carbon emissions and improving space usage.

Legislative and fiscal changes

Legislation associated with climate change e.g. the Energy Performance of Buildings Directive, the CRC Energy Efficiency Scheme and so on are being introduced and will impact upon the costs associated with new build, refurbishment, maintenance and operation of many buildings. In addition the Building Regulations Part L (fuel conservation and efficiency) 2010 update has just been brought into force and further revisions will be introduced in 2013. It is anticipated that these regulations will increase further the requirements to reduce emissions associated with buildings, particularly existing buildings. These types of activities will increasingly require efforts to improve CO_2 performance of the buildings that the LSE own and occupy and also the management of activities.

Given the School's energy use, it has registered for the CRC Energy Efficiency Scheme tackling and reducing energy demands will help reduce the burden of the CRC.

At a local level, planning requirements are also making increasing demands, in terms of the energy efficiency, environmental credentials and the incorporation of renewable energy technologies into new developments. It is anticipated that these requirements will become greater moving forwards.

The HEFCE requirements and CRC Energy Efficiency Scheme provide a good platform for LSE to demonstrate their leadership.

2 Overview of Strategy

Respect for the environment is one of the 9 values and commitments stated in the LSE Strategic Plan 2010-15. This value is rooted in the Environmental Policy, which core objectives include:

- Reduce consumption and increase efficiency of energy and water use in buildings and equipment
- Reduce emissions and discharges from buildings and equipment
- Create built environments that meet the highest environmental standards
- Minimise emissions arising from commuting, business travel choices and deliveries
- Ensure that LSE graduates have a full understanding of the environmental and social dimensions of leadership

The CMP defines the steps that the LSE has taken and will take in the future to support these core objectives and achieve the reduction target of 54% in its CO_2 emissions. It provides a formal and practical basis for communicating, seeking approval for and implementing a plan to reduce its emissions. It was produced with input from academic and administrative members of staff as well as students.

This implementation plan (Section 7) aims to outline a strategy and a roadmap for action over the next ten years and beyond. It aims to bring all aspects related to energy and carbon management under a common focus. Initial funding has been identified and cost planning advice has been submitted to the Finance Committee in December 2010 to give early warning of funding allocation. It is intended that the funding will commence in August 2011and funding applications will be made to Finance Committee in May or June 2011.

The document will be reviewed on an annual basis and updated as additional data becomes available in an iterative process. For example, many of the opportunities and objectives have already started to be implemented. It is intended that this first version of the plan be reviewed in terms of confirming practicalities, priorities, barriers and timescales. Once confirmed the plan should be regularly reviewed and updated as needed. It develops a range of key objective areas and the specific actions needed in order to deliver those objectives moving forward.

3 Approach to Carbon Reduction

3.1 New construction and renovation

While the School is not anticipating any significant growth in the student population in the next ten years, there is an on-going process of reviewing the School's building portfolio, both on the academic and residential campuses. This CMP will assist LSE in continuing to embrace low energy design approach to all future project works both on large and small scales from new construction through to long term maintenance programmes. This will be achieved through revised low energy / carbon specifications and review processes are being developed and will be incorporated into all planned works.

This has already begun through the 2008 renovation of the New Academic Building with energy efficient equipment, installed foundations for low and zero carbon technologies in the form of footings for building mounted wind turbines and boreholes for a ground source heat pump system. More flexible control intelligent lighting and thermal comfort controls were installed for more efficient occupant usage.

Further development is planned with designs progressing for a new student centre. This new building will be located on the St Philips site and replace the three buildings which are currently situated there. Although the new building will be larger than the current St Philips buildings it has been designed to use less energy per m^2 of floor area. With the recent acquisition of 32 Lincolns Inn Field, once the acquisition is complete in early 2011, this building will be included in the carbon reduction strategy and will guide the requirements of the refurbishment.

Other building upgrades and alterations which have been undertaken include the trial of a new lighting system in part of the Northumberland House.

3.2 Operations

Understanding that a building can be energy efficient when used effectively the LSE has undertaken a number of initiatives to engage with staff and students to encourage them to operate the space they use more effectively. One such initiative in the Halls has been to partake in the Student Switch Off campaign. This initiative monitors the energy use of the Halls periodically and encourages students to switch off lights and appliances that they have control of. This initiative has shown a reduction in the energy used in the Halls from the start of the campaign. To enable this type of initiative to work the LSE Environment and Sustainability Team has a Residences Environmental Champion who engages with the students to implement this type of initiative.

LSE introduced the Bin the Bin campaign eliminating individual rubbish bins and replacing these with communal recycling stations. This work has increased the amount of waste being recycled and improving the data collected on the amount of different waste types being generated.

In line with most Universities experience, the end of the second semester sees a significant amount of waste generated as students leave halls of residence. To combat this waste the LSE introduced the Reuse and Relove Campaign, offering facilities for promoting the reuse of unwanted books, clothes, stationery, furniture, and electronics from the campus and halls of residences. Relove events are planned throughout the year to encourage the reuse of unwanted items.

Green Tourism Business Scheme - during the summer periods LSE rents out the halls of residence to tourists. To help promote the environmental strategy LSE has joined the Green Tourism Business Scheme which promotes a recognisable best practice programme for accommodation in London. This scheme assesses both operations and buildings with regards to environmental best practice.

3.3 Engagement

In 2008 LSE appointed a Carbon Reduction Manager as part of the Estates Division. The role of the Carbon Reduction Manager is to monitor, record and report on emissions. Identify the opportunities for carbon savings and funding routes and work with other divisions to implement projects which result in a reduction in carbon emissions. The School has suffered from discontinuity from staffing and following the loss of the post in May 2010, a new Carbon Manager was appointed in January to take the implementation and monitoring of the Carbon Management Plan forward.

The Environmental and Sustainability Team form an important link between the school and its students and have provided data on waste and travel for this CMP. They have also implemented initiatives such as waste reduction campaigns and promoted the green credentials of the LSE through pursuing awards such as the Green Tourism Business Scheme.

4 Carbon Emissions Data

4.1 Data Sources

Energy consumption data and carbon emissions data has been gathered for all buildings for which the LSE pays the energy bills. There are a number of buildings which have not been included in this assessment currently as the utility data has not been made available by managing agents, or has been included as a standing charge for leased space. A table showing the buildings which have been included in the assessment of energy and water consumption can be found in Appendix 1.

Two systems have been utilised by the LSE to record energy data: Dynamat and Evolve Energy Online.

Dynamat is the historic energy management (meter reading) software package developed by Energy Metering Technology (EMT) for LSE. The monthly usage was entered manually into the software by the Carbon Reduction Manager until November 2009 for electricity and gas and through September 2009 for the water figures. Dynamat holds records back to 1995, but for the most part is no longer used for entering meter data now that Evolve Energy Online is operational.

As the information that was input into Dynamat may not have been entered on the same date every month, the programme uses interpolation to give monthly totals. Some of the information in Dynamat is not correct and has been subject to entry errors, as part of the process to develop the baseline some rationalisation of the data has been undertaken.

Dynamat has been used for gathering historical data and to generate the 2005 baseline emissions figure that will be used to measure all carbon reductions against (as specified by HEFCE [3]). This system has been used to track gas, electricity and water meter readings across the campus and student residences allowing energy consumption to be monitored. Annual energy consumption and carbon emissions for set periods of time can be determined from this system using interpolation of the actual readings.

LSE contracted Evolve to create an automated meter reading platform (Evolve Energy Online) to record half hourly data which can then be broken down into daily, weekly, monthly and annual energy (electricity and gas) and water usage for the academic campus and its offsite buildings. In March 2009, 26 electricity meters were upgraded to electronically read meters, enabling consumption to be monitored and interrogated using the Evolve Energy Online system. Other meters were added to the system with most gas and electricity usage being recorded from May 2009. Water readings being recorded from October 2009. Evolve Energy Online uses a Stark platform to process data from the meters and provide an online interface. Not all meters are linked to the Evolve Energy Online system and therefore the manual process of manually recording utility information still continues. Discrepancies in the data between the usage figures shown on the Dynamat and Evolve systems have been normalised as far as possible when developing the baseline. A comparison with billing information and documented usage would further resolve any discrepancies further and help calibrate the Evolve reporting. Following funding approval a study is currently underway to determine the best hardware are software systems to be implemented taking into account CRC compliance requirements, new electricity meters which are likely to be installed in July 2011 if a new supplier is appointment when the existing contract expire.

Water consumption figures have also been gathered from data shown on the Dynamat and Evolve Energy tools. There are instances during the changeover from using Dynamat to using Evolve where data entries are missing. Assumptions on usage have been made from the preceeding month's data.

LSE's Environment and Sustainability Group undertook a travel survey of staff and students for the academic year 08/09 and obtained some centrally held data on flight bookings undertaken by staff. The response rate to the questionnaire was 18% for Staff and 5% for Students. The response information was extrapolated using known student and staff figures. Data on arrival information for international and UK based students was developed from the LSE statistics of the domiciled status of students and cross referenced with the source of funding.

Data on waste has been provided by the LSE's Environmental and Sustainability Group. Over the past few years the amount of information being collected on waste, as well as the quantity that has been reclaimed, reused or recycled has increased. Given this and in order to develop an initial baseline for waste assumptions on quantities have been generated using an area weighting approach.

[3] HEFCE. (2010). *Carbon reduction target and strategy for higher education in England.*

4.2 Emission Factors

Guidance has been provided by HEFCE on how the LSE should calculate the CO_2 emissions for Scope 1 and 2 emissions and the assumptions that should be made when calculating Scope 3 emissions. The initial baseline of Scope 1 and 2 emissions of electricity, oil and gas usage have used the conversion factors found in the HEFCE guidance document dated 2010/02. This document refers to the following carbon emission factors.

Fuel Type	Units	Carbon emission factor		Reporting Year
Natural Gas	kWh	0.18523	kg CO_2e per unit (Gross Calorific Value basis, Total GHG)	
Electricity	kWh	0.53729	kg CO_2e per unit	2005
		0.54013	kg CO_2e per unit	2006
		0.54418	kg CO_2e per unit	2007
		0.54522	kg CO_2e per unit	2008
Gasoil (Fuel Oil)	kWh	0.26592	kg CO_2e per unit	

Table 4-1 Carbon emission factors for energy

In September 2010 HEFCE has issued an update to the 2010/02 document which provides new conversion factors. This report is based on the current CEF as detailed above.

Water : Carbon Emissions Factors (source Water UK 2008 (sustainability report)	kgCO_2e per m^3
Consumed water	0.276
Waste water (95% of total supplied)	0.693

Table 4-2 Scope 3 carbon emissions factors from Water Use

Mode of Transport (Source; Annex 6, 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting)	kg CO_2e per pkm
Bus	0.105
Boat	TBC
Coach	0.031
Car (Individual)	0.205
Car (with others)	0.205
Cycling	0.000
Taxi	0.172
Rail	0.061
Tube	0.079
DLR	0.084
Motorbike	0.119
Walking	0.000
Short Haul Flight	0.099
Long Haul Flight	0.113

Source; Annex 6, 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting
Table 4-3 Scope 3 carbon emission factors from transport

Waste fraction	Net kg CO_2eq emitted per tonne of waste treated / disposed of by:					
	Recycling		Energy from waste			
	Closed Loop	Open Loop	Power only moving grate	Anaerobic Digestion	Composting	Landfill
Paper and Card	-713		-500	-121	57	550
Kitchen/food waste			-89	-100	30	365
Garden/plant waste			-121	-100	57	210
Other organic	44		-271	-330	34	230
Wood	250		-700		250	930
Textiles	-3,800		600			300
Misc combustibles	58		242			305
Plastic (dense)	-1,500		1,800			40
Plastic (film)	-1,000		1,800			35
Ferrous metal	-1,300		-786			10
Non-ferrous metal	-9,000		23			10
Silt/soil	16		35			10
Aggregate materials	-4		35			10
Glass	-315	0	5			10
Estimated impact of other materials (municipal and C&I)	-259		97	-13	7	81

Source: 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting
Table 4-4 Scope 3 carbon emission factors from waste management

4.3 Data Reporting

In order to make a comparison between the 2005 baseline year and progress to date it is recommended in the GHG Reporting Protocol that the baseline emissions are revised using the most up to date carbon emission factors available when comparing with the current year. It should be noted however that the published conversion factors for a given year are made available 2 years after the reporting year, i.e. the 2007 conversion factors should be used in reporting 2009 data and then updated when the 2009 data is available in 2011. Updating the Carbon emission factor will normalise the reporting across years.

Unlike the current approach to Estate Management Statistics (EMS) reporting, all carbon emission conversion factors are reported in carbon dioxide equivalent (CO_2e). This takes into consideration all the greenhouse gases which are produced when a particular type of energy is used, but is then reported as an equivalent amount of CO_2 as CO_2e.

4.4 Data Quality

The Dynamat system was reliant on the data being manually entered. There is some overlap in the data records of the Evolve and Dynamat systems for energy (electricty and gas) but not for water. Some data has needed to be estimated in order to achieve a more complete baseline. Details of how the data has been gathered can be found in section 5.

The water data has been estimated in parts where consumption records are not available on either Dynamat or the Evolve system. Not all the buidings are connected with a pulsed output to the Evolve system which should be able to provide more accurate data; in addition some discrepancies in the units used on the Evolve Energy Online system have also been noted and estimations have been required.

4.5 Base Year Recalculation Method

A base year is a reference point in the past with which current emissions can be compared. In order to maintain the consistency between data sets, base year emissions need to be recalculated when change occurs that has a significant impact on the base year emissions. A significant impact is defined as a change in base year emissions of 10%. A base year recalculation shall only be undertaken if the following significance thresholds[4] are met.

- Structural Changes - When a structural change in the LSE occurs that has a 'significant impact' on the base year emissions. A structural change involves the transfer of emissions from one company to LSE (or vice versa) through the following:
  - Mergers, acquisitions, and divestments
  - Outsourcing and insourcing of emitting activities
- Methodology Changes - Where changes to the calculation methodology or improvements in the accuracy of activity data result in a 'significant impact' on the base year emissions data.
- Rectifying Errors - Where the discovery of significant errors, or a number of cumulative errors, that collectively have a 'significant impact'.

The base year is set at 2005/06 to meet HEFCE GHG reporting processes and performance targets. This base year can be redefined in response to new emissions reduction legislation or targets as required.

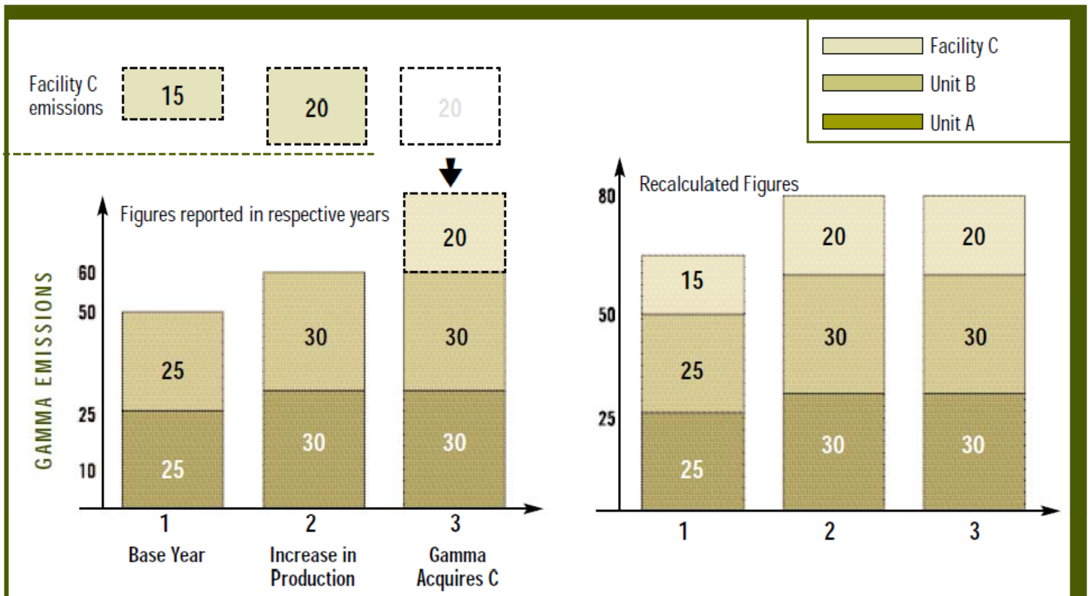
When structural changes occur during the middle of the year, the base year emissions should be recalculated for the entire year.

All base year recalculation should be recorded alongside subsequent GHG inventories.

Recalculation of the base year shall not be undertaken to account for changes in service provision, including the closing or opening of sites/facilities or organic growth. When there are specific changes in the Government's emission factors. Please refer to the Defra / DECC GHG conversion factors for further guidance.

[4] "Significance threshold" is a qualitative and/or quantitative criterion used to define any significant change to the data, inventory boundary, methods, or any other relevant factors. Greenhouse Gas Protocol A Corporate Accounting and Reporting Standard.

The following example is taken from the GHG Protocol Corporate Accounting and Reporting Standard Revised Edition.



Company Gamma consists of two business units (A and B). In its base year (year one), each business unit emits 25 tonnes CO_2. In year two, the company undergoes "organic growth," leading to an increase in emissions to 30 tonnes CO_2 per business unit, i.e., 60 tonnes CO_2 in total. The base year emissions are not recalculated in this case. At the beginning of year three, the company acquires production facility C from another company. The annual emissions of facility C in year one were 15 tonnes CO_2, and 20 tonnes CO_2 in years two and three. The total emission of company Gamma in year three, including facility C, are therefore 80 tonnes CO_2. To maintain consistency over time, the company recalculates its base year emissions to take into account the acquisition of facility C. The base year emissions increase by 15 tonnes CO_2—the quantity of emissions produced by facility C in Gamma's base year. The recalculated base year emissions are 65 tonnes CO_2. Gamma also (optionally) reports 80 tonnes CO_2 as the recalculated emissions for year two.

For more information on undertaking a Base Year recalculation see the documents outlined below.

- Guidance on how to measure and report your greenhouse gas emissions. Department for Environment, Food and Rural Affairs (DEFRA), 2009.
- GHG Protocol Corporate Accounting and Reporting Standard Revised Edition. World Business Council for sustainable Development and World Resource Institute
- Base year recalculation methodologies for structural changes; Appendix E to the GHG Protocol Corporate Accounting and Reporting Standard Revised Edition
- BS ISO 14064-1:2006; Greenhouse gases – Part 1: specification with guidance at the organisation level for quantification and reporting of greenhouse gas emissions and removals. BSI British standards.

4.6 Refrigerants

Leakage of refrigerant gases (also referred to as fugitive emissions) can significantly impact climate change. This is because 1 kg of refrigerant can have the equivalent global warming potential of several tonnes of CO_2.

There is limited guidance given by HEFCE as to whether emissions arising from refrigerant leakage should be reported as part of the Scope 1 emissions in this iteration of the CMP. Refrigerants are considered to be Scope 1 emissions in the Green House Gas protocol and standards such as the Carbon Trust Standard consider it good practice to report on these emissions although such reporting is not mandatory.

The fugitive emission data collected, is incomplete, therefore it is not yet possible to accurately benchmark all the fugitive emissions, therefore they have not been included in the development of the baseline. However, the following legislation will require more stringent testing and maintenance of systems in the future and provides an opportunity to be able to calculate emissions arising from refrigerants when relevant data becomes available.

The F Gas regulation – (EC Regulation 842/2006 and the GB Fluorinated Greenhouse Gases Regulations 2009)
This regulation affects HFC refrigerants and a summary of the requirements are:

Leak Checks	Regular checks for leakage; use of automatic leak detection on large systems.
Recovery	Refrigerant recovery during plant servicing and maintenance and at end of life.
Records	Good records kept for equipment containing 3 kg or more of F gases.
Training & Certification	Use of personnel with appropriate qualifications. Company certification required for all companies employing personnel to undertake work on equipment containing or designed to contain F gases (includes sole traders). Companies taking delivery of F gases need to employ personnel with appropriate qualifications if undertaking leak checking, gas recovery, plant installation, maintenance or servicing.
Other	Certain other actions including labelling of new equipment.

The Ozone Regulation – (EC Regulation 2037/2000, and GB Statutory Instruments 2002 No. 528, 2008 No. 91 and 2009 No.216)

This regulation affects HCFC refrigerants and a summary of the requirements are:

Phase-Out	Phase-out of HCFC usage between 2010 (virgin fluid) and 2015 (recycled fluid).
Leak Checks	Annual leakage checks for equipment containing 3 kg or more of refrigerant.
Recovery	Refrigerant recovery during plant servicing and maintenance and at end of life.
Training	Use of personnel with prescribed qualifications.

Air Conditioning Inspections – Energy Performance of Buildings Regulations Part 5 (England and Wales 2007)

This regulation is aimed at improving the performance of the system to lower the energy consumption of the air conditioning equipment and is not aimed exclusively at cutting fugitive emissions.

Inspections	Systems over 250kW must be inspected Systems over 12kW to be inspected by 4 January 2011
Frequency	Inspections should be carried out every 5 years
Content	The report will review the maintenance records and physical condition of the equipment and make recommendations to improve the system
Training	Inspector must be certified to perform Air conditioning Inspection

As LSE carries out work to comply with these regulations sufficient data should be obtained to accurately quantify the fugitive emissions and add this to the 2005/06 baseline. This should help LSE in achieving its carbon reduction targets because there are a number of air conditioning units currently using R22 refrigerant which will have to be replaced soon and a new refrigerant with a lower GWP will be required. As part of the implementation plan (Section 7) these requirements should be reviewed against LSE's Environmental Legislation Register.

5 Baseline Data

5.1 Carbon Footprint

One of the key outputs of the main Carbon Management programme is a detailed review of an organisation's carbon emissions, which involves defining an agreed carbon footprint. The footprint is an inventory of all of the emission sources that an organisation wants to focus upon in terms of measurement, review and action. This can include emissions from sources such as buildings, water, transport and waste.

The emission sources making up the carbon footprint are quantified in terms of the tonnes of carbon dioxide emitted over the defined period. The aim of building the footprint is to provide a defined basis (or baseline) from which to measure performance moving forward through regular reporting and to also help prioritise activities.

In this first iteration of the LSE CMP the scope 1 and 2 emissions have been calculated and a baseline developed. Figure 5.1 below shows the total emissions of 14,484 tCO_2e for the baseline 2005/06 academic year and 15,324 tCO_2e for the most recent 2009-10 academic year. These have been broken down by energy uses across the academic and residential campuses.

		2005-2006 Total Carbon Emissions, TCO_2	% breakdown of total carbon emissions	2009-2010 Total Carbon Emissions, TCO_2
Academic	Heating	2157	15%	2,282
	Hot Water	35	0%	37
	Lighting	3280	23%	3,470
	Electricity	3709	26%	3,924
	Cooling	99	1%	105
Residential	Heating	1928	13%	2,040
	Hot Water	895	6%	947
	Lighting	896	6%	948
	Electricity	1424	10%	1,507
Sports Ground		60		64
Total Figure		14484		15,324

Figure 5-1: Total Scope 1 and 2 emissions by energy use for the residential and academic campuses

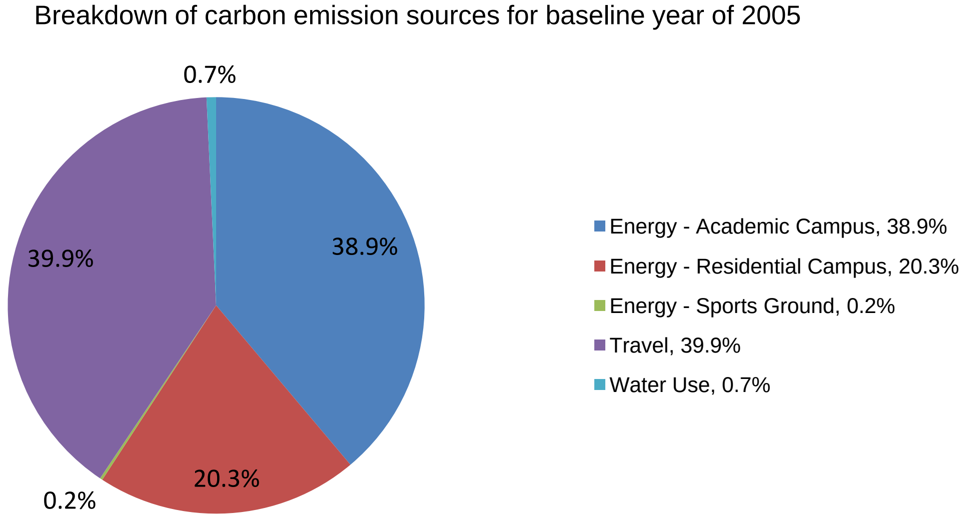


Figure 5-2: Total emissions for scope 1, 2 and 3[5]

In order to help develop the baseline for all emissions, using the data available an estimation of the emissions in the baseline year for transport, waste and water (Scope 3) have also been developed and included with the Scope 1 and 2 emissions to show the breakdown of emissions.

An explanation of how the baseline has been created is as follows:

5.2 Energy

The baseline emissions have been determined for all academic site, residences and leisure facilities operated by the LSE. The calculated baseline currently includes Scope 1 and 2 emissions associated with purchased electricity and combustion of fuel. Carbon emissions associated with combustion of fuel for operation of vehicles is not included as part of the baseline as the LSE do not operate a vehicle fleet. Given the limited data availability on fugitive emissions arising from refrigerant use and neither HEFCE nor the Carbon Trust make fugitive emissions reporting mandatory these emissions have not been included in the baseline.

The baseline year chosen is 2005 (August 2005 to July 2006) in line with HEFCE guidance. As such the baseline carbon emissions for this year is 14,484 tonnes CO_2 and 15,324 tonnes CO_2 for the 2009/10 year.

Data has also been gathered for all the academic years since 2005 as well as the past 12 months operation from April 2009 to March 2010 to determine the increase in emissions as well as the immediate impact of energy efficiency improvement works carried out over the past 12 months. The emissions data for all years can be seen in Table 5.1 below. The carbon emissions have been calculated using the carbon factors relevant to that year as well as the most recent carbon factors (2007), as discussed in the previous section, the calculations in this report will be using the 2008 carbon factors.

[5] These figures do not include waste figures which would be considered a scope 3 emission due to unavailability of data

Year[6]	Electricity, MWh	Fuel, MWh	Carbon Emissions, tCO_2 e
2005	20,145	19,381	14,484
2006	20,423	17,807	14,404
2007	20,367	19,714	14,810
2008	21,596	20,550	15,324
2009	20,648	22,561	15,323

Table 5-1 LSE Carbon Emissions 2005 to 2010

Additionally, Figure 5-3 below shows the increase in total carbon emissions from 2005 to 2009 with the subsequent decrease in emissions over the past 12 months. The increase in emissions can be attributed to an increase in student numbers and subsequent energy demand as well as various new buildings coming online such as the New Academic Building (2008) and Passfield Hall (2006). A reduction in carbon emissions has been achieved over the past 12 months due to a programme of energy reduction measures which has been undertaken across various university buildings. This programme includes installing shower restrictors in all residences, general lighting upgrades and boiler overhauls. Carbon emissions reduction has been around 0.6%.

Due to the overall rise in emissions since 2005, a reduction of 51% from 2009 levels will be required to reach the HEFCE target of a 48% cut in emissions against the 2005 baseline.

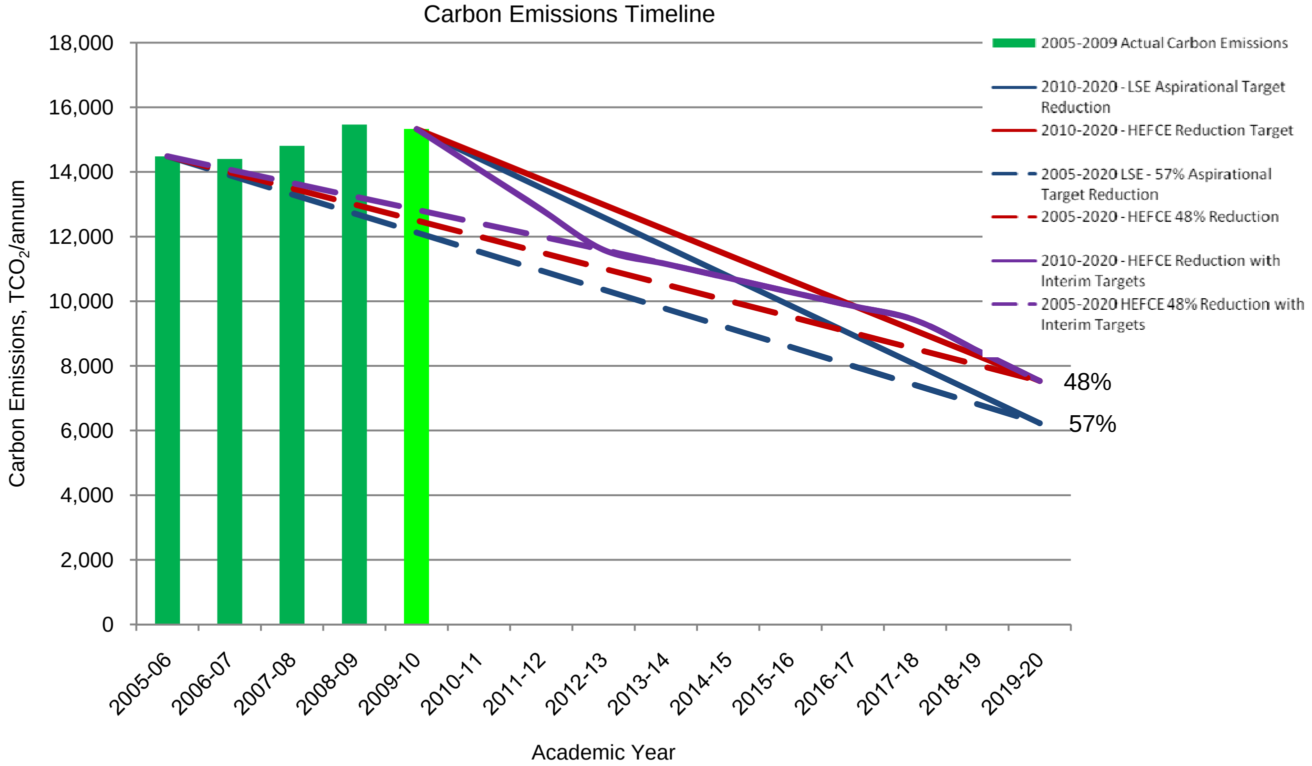


Figure 5-3: Chart showing increase in site wide carbon emissions 2005-2009 including 2020 target reductions

6 All years correspond to academic years, e.g. 2005 is August 2005 to July 2006

The following two graphs show how the consumption of electricity and gas is distributed across the different buildings. This highlights which buildings use the most energy and therefore need tackling if carbon emissions are to be reduced substantially, and which buildings use only a small amount of energy. Clearly the buildings that should be prioritised are Towers, Lionel Robbins and Old Building from the academic campus and Bankside House, High Holborn and Roseberry Avenue out of the residential buildings.

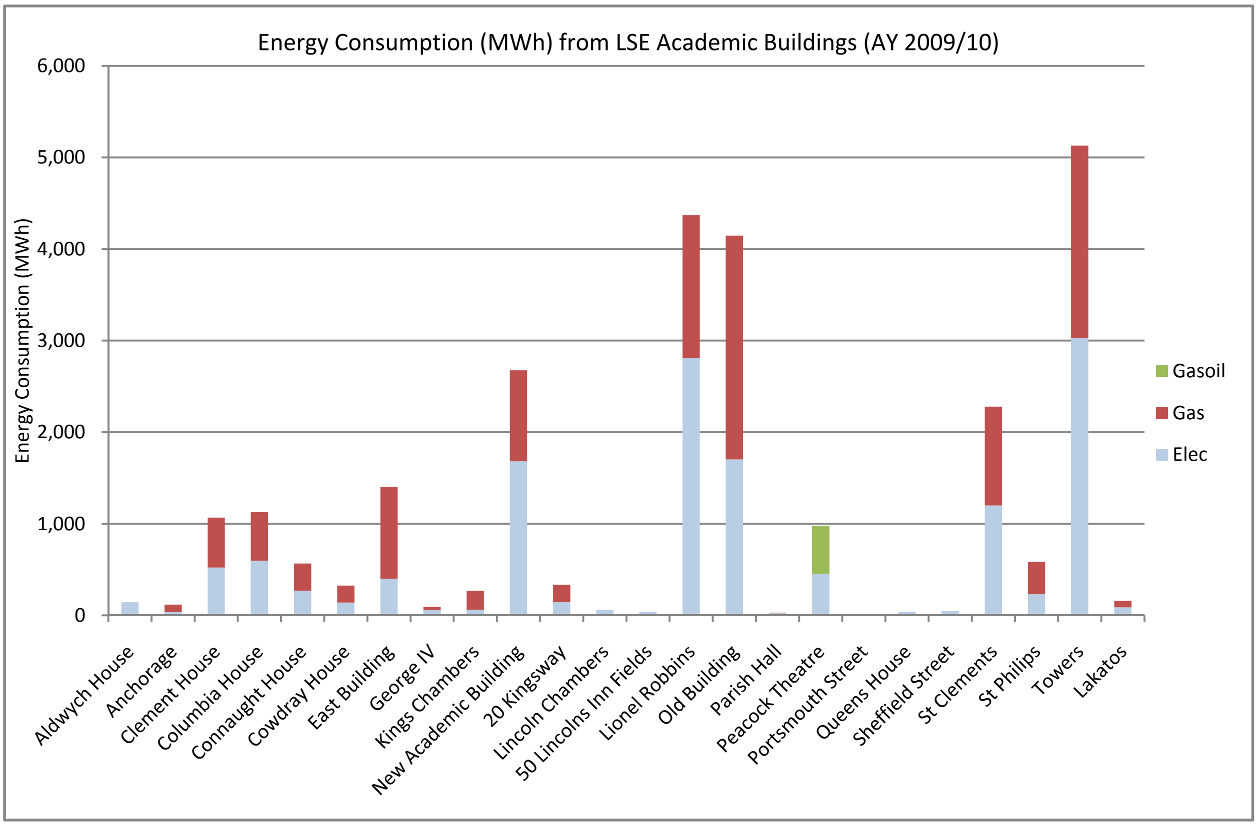


Figure 5-4: Energy consumption of academic buildings for academic year 2009/10

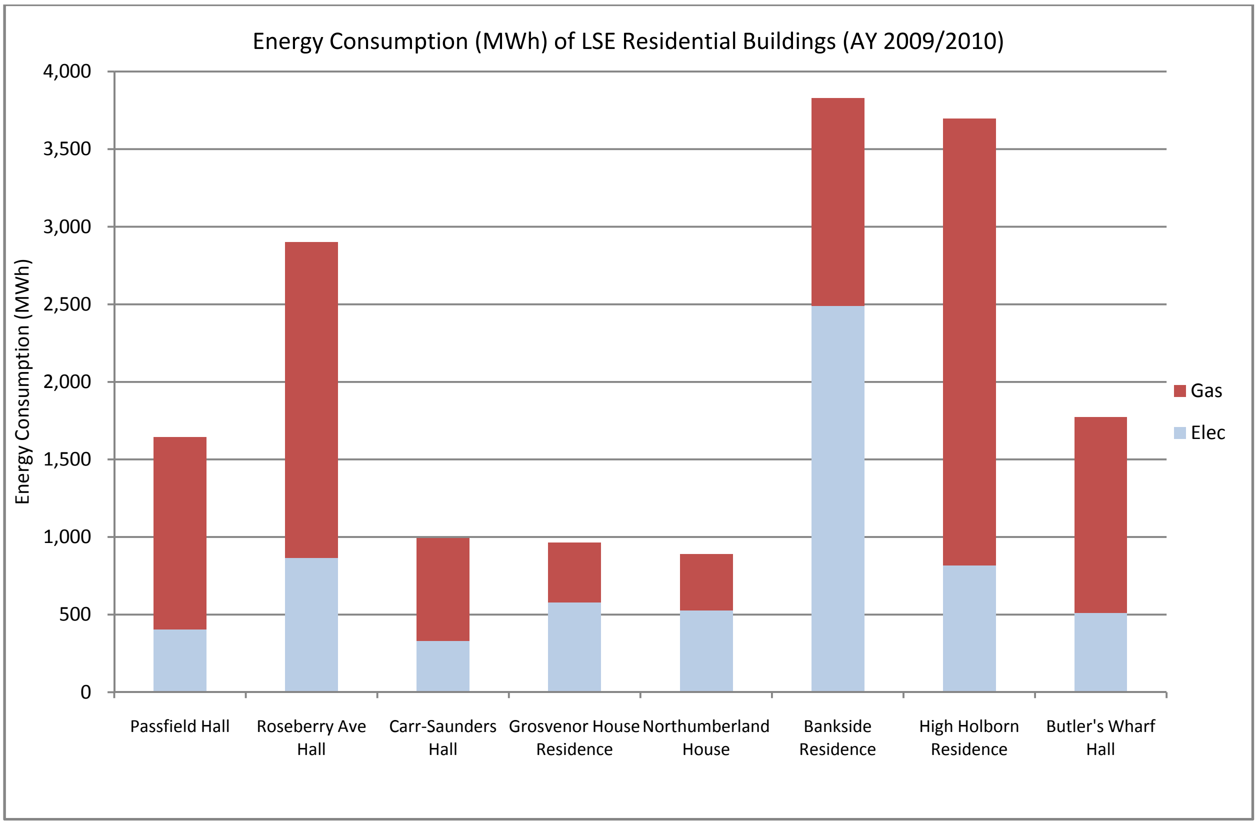


Figure 5-5: Energy consumption of residential buildings for academic year 2009/10

5.3 Energy Audits

In order to support and develop some of the assumptions made thus far, AECOM has undertaken 5 energy audits of buildings across the residential and academic campuses. The buildings selected were, the Lionel Robbins Library Building, Clement House, Old Building, Bankside House and Passfield Halls of Residence. These audits have highlighted opportunities in energy reduction as a result of lighting upgrades, equipment replacement and also adopting new strategies for the servicing of buildings. For example the boiler plant in the Lionel Robbins building runs all year to maintain temperatures in the rare books section. A smaller dedicated boiler would be able to serve the same purpose without the main buildings systems being required throughout the year.

The opportunities to reduce energy use which were highlighted by undertaking the energy audits have been used to help refine the potential carbon reduction measures across the campus.

5.4 Scope 3 Emissions

At this stage reporting of a baseline for Scope 3 emissions is not required for the CMP. However institutions have been encouraged to develop this and certainly to put in place the procedures which will enable collection of data in the future. Data arising from transport, water and waste activities from LSE's operations have been included here. Further development of this section may be required as more detailed information or new calculation methods are developed.

5.4.1 Transport

Emissions resulting from transport for the baseline year have been calculated using data available on staff and student numbers from the baseline period. Information on overall student numbers[7] has been used for the baseline student figure. The results of the recent travel survey undertaken by the Environmental and Sustainability Team at LSE have been extrapolated to estimate the carbon emissions resulting from staff and student travel. The response rate to the travel survey was 5% of students and 18% of staff.

International arrival air travel for students

In order to estimate the breakdown of students from their home countries the proportions detailed in the overseas student data[8] for 2006/2007 have also been used for the 2005/06 baseline. This calculation estimates the following for student air travel for the period 2005 to 2009.

	Domiciled status of students	Tonnes CO_2e from travel				
	Academic Year	2005	2006	2007	2008	2009
Arrival/ Departure travel by International Domicile Students	European Union Members	869	898	923	927	900
	European Union	73	70	84	86	86
	North America	1720	1726	1903	1935	1949
	South America	328	416	414	435	466
	Africa	312	275	253	230	248
	Asia	4326	4767	5164	5016	5271
	Australasia	270	249	259	303	335
	(blank non UK)	49	38	52	20	33
	Total tCO_2e per year	7947	8439	9052	8952	9288

The travel survey that was undertaken by LSE reported that on average, those travelling within the EU member states undertook 3 return trips per year and that international students (non EU) undertook 2 return trips per year. This exceeds the estimates proposed within the HEFCE guidance documents. However, given the high proportion of students from overseas that study at LSE it is considered to be important to estimate as far as possible the CO_2 emissions arising from this form of travel. For the baseline year data was not available for actual home origins therefore the capital city of the home country has been used to calculate the distance travelled and subsequent CO_2 emissions.

[7] http://www2.lse.ac.uk/aboutLSE/statisticsOnLSE/pdf/Table%20A.pdf
[8] http://www2.lse.ac.uk/aboutLSE/statisticsOnLSE/pdf/Table%20I.pdf

Travel by Students in the UK

Arrival / Departure Student Travel	UK domicile students	tCO_2e from travel				
	Academic Year	2005	2006	2007	2008	2009
	Total tCO_2e per year	229	226	227	238	255

Business Travel

As part of the travel survey undertaken by the LSE Sustainability Team, students and staff were asked to respond to questions on how much business travel they undertake during the year. The survey respondents were asked to clarify whether their business was within London, national or international and this has been factored into developing the baseline. This data was then extrapolated based on student and staff numbers for the previous years. The baseline has been calculated using a number of assumptions which are detailed in Appendix 8-4.

Business Travel		tCO_2e from travel				
		2005	2006	2007	2008	2009
	Air	1778	1840	1877	1971	2021
	Land	88	91	90	97	99
	Total tCO_2e per year	1866	1930	1966	2068	2119

Commuting Travel

Questions on how students and staff travel to and from the LSE campus were included in the travel survey. Again the results were extrapolated to develop a 2005/06 baseline, using staff and student numbers. The survey asked for journey details in terms of time taken, however to more accurately estimate the CO_2e emissions arising from commuting these journey times have been converted to miles based on transport for London and National Rail information.

Commuting		tCO_2e from travel				
		2005	2006	2007	2008	2009
Staff and Students (various modes)	Total tCO_2e per year	15.9	16.4	16.7	17.6	18.0

Based on current carbon emission factors the CO_2e resulting from travel associated with the LSE has increased from the baseline year assuming that the travel patterns have remained the same.

Summary of LSE Travel Data	tCO_2e from travel				
	2005	2006	2007	2008	2009
Tonnes of CO_2e generated by LSE travel	10,069	10,624	11,275	11,289	11,693

The overall amount of CO_2e generated from student and staff travel has increased from the baseline year, based on the extrapolations using staff and student figures.

5.4.2 Water

Emissions resulting from water have been quantified from data gathered on the water usage arising from both the residences and academic campuses and the sports ground. This information was taken from Dynamat and Evolve. The downloaded data can be found in Appendix 8-5. Efforts in improving water efficiency will assist LSE not only directly in reducing carbon emissions accrued through water use and waste water treatment but also indirectly through less energy used for domestic hot water demands.

The carbon emissions have been calculated using the 2009 Guidelines to DEFRA / DECC's GHG Conversion Factors for Company Reporting. Both water consumption and wastewater is considered in the calculation of the carbon emissions. The following factors have been used

Supplied water emissions factor =0.276kg/CO_2e per cubic meter
Wastewater emissions factor = 0.693kg/CO_2e per cubic meter (assume 95% of supplied water as waste water[9]).

Water Use	Academic Year	2005	2006	2007	2008	2009
Academic	consumption m^3	66,808	57,958	58,832	60,572	59,058
Academic	tCO_2e	62	54	55	57	55
						-13.12%
Residential	consumption m^3	135,764	144,420	128,420	134,926	142,205
Residential	tCO_2e	127	135	120	126	133
						4.32%
Total	tCO_2e	189	189	175	183	188
		% change from 2005/06 to 2009/10				-0.80%

5.4.3 Waste

The Sustainability team have collated figures on waste and waste recycling efforts for the past few years. The table below shows the quantity of waste generated and that which has been diverted from landfill. Although the table shows a significant increase in the overall quantity of waste generated this is due to the fact that improved waste data collection and tracking is now in place for academic and residential campuses.

Academic Year	2006-2007		2007-2008		2008-2009	
Waste type	Tonnes of waste(1)	tCO_2e (2)	Tonnes of waste (1)	tCO_2e (2)	Tonnes of waste	tCO_2e
Waste mass: recycled	157	-84	254	-137	901	-571
Waste mass: reused					30	-46
Waste mass: composted					0	1
Waste mass: landfill	407	72	437	77	1,499	265
Waste mass: WEEE					4	8
Waste mass	**564**	**-12**	**691**	**-59**	**2,434**	**-351**
Waste diverted from landfill as a % of total waste generated	28%		37%		38%	
(1) Weight only includes the detail that was recorded at the time						
(2) Average Carbon Emission Factors used as composition of waste unknown.						

A detailed summary of the waste management statistics for the year 2009/10 can be found in Appendix 6

[9] Water UK 2008 (sustainability report)

6 Options Evaluation

6.1 Overview

The hourly heating, hot water, cooling and electrical consumption for each building was modelled by merging the metered data from Evolve with models for typical building types. For example a residential building has a higher hot water demand per m² than an academic building so these two types of building require a different model. Using these models the effects of improvements to each building could be quantified. Figure 6.1 summarises for the whole building stock of LSE the areas where carbon savings can be made in order to achieve a 54% reduction in carbon emissions. These are each discussed in more detail below.

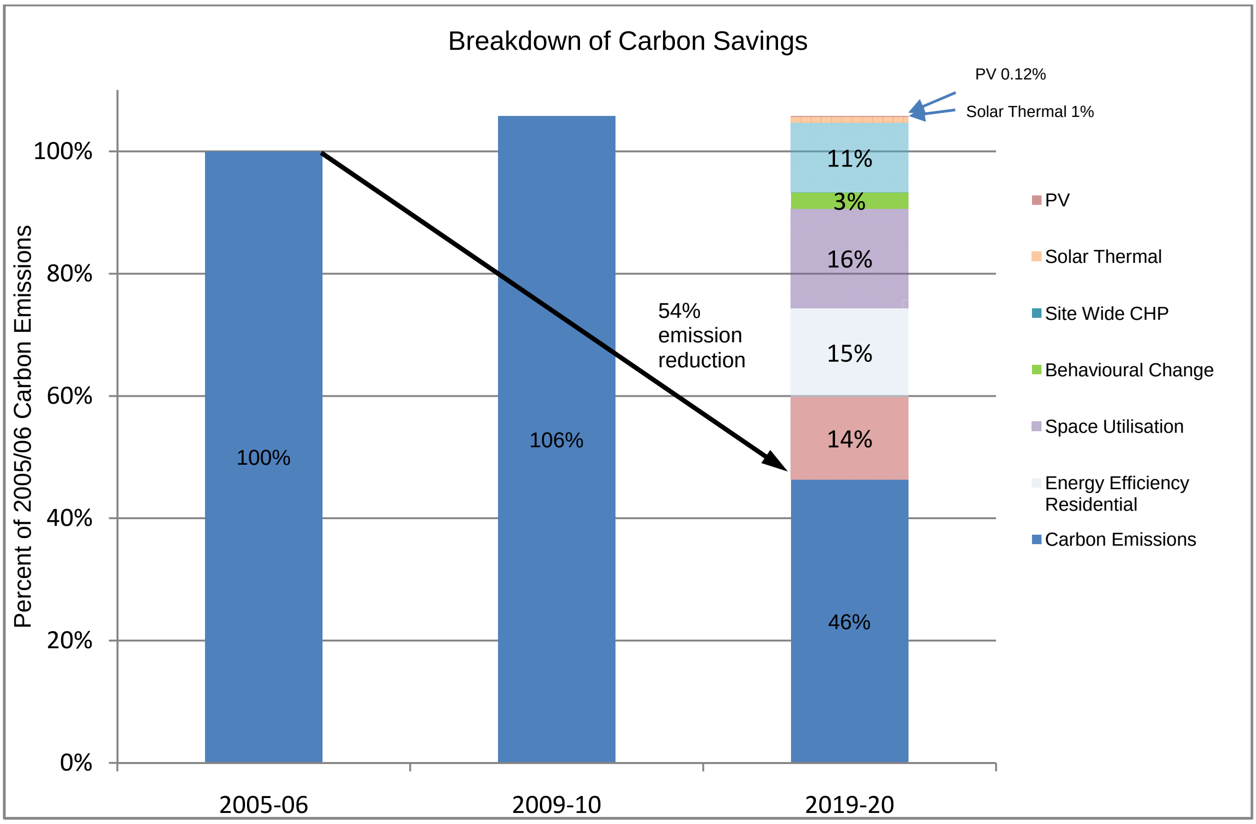


Figure 6-1: Breakdown of Carbon Savings

6.2 Energy Efficiency Improvements

Figure 6.1 shows that energy efficiency improvement measures could reduce the carbon emission by 29%: 15% from residential buildings and 14% from academic. Figure 6.2 identifies where these energy efficiency improvements can be made, i.e., heating, hot water, lighting, electricity or cooling. For the academic buildings;

- Improvements can be made to the carbon emissions from heating the buildings
- Domestic hot water demand in academic buildings is relatively low, so any improvement will have only a small affect on the overall reduction in emissions
- There is some opportunity to improve the efficiency of lighting

- No opportunity to improve the efficiency of equipment using electricity was identified as LSE already use modern computers and flat screen monitors (note that behavioural change is considered in section 6.4)
- Cooling actually increases slightly as a consequence of improving the buildings insulation, this is a worst case scenario as there are ways of mitigating this effect.

For the residential buildings:

- Improvements can be made to the carbon emissions from heating the buildings;
- Hot water demand is significant but only moderate improvements are estimated;
- There is some opportunity to improve the efficiency of lighting;
- No opportunity to improve the efficiency of equipment using electricity was identified as the efficiency of equipment used by students will be hard for LSE to influence (note behavioural change is considered in section 6.4) and
- It has been assumed that none of the residential buildings have cooling; some small DX units may be provided for cooling of an IT server room but this has not been modelled.

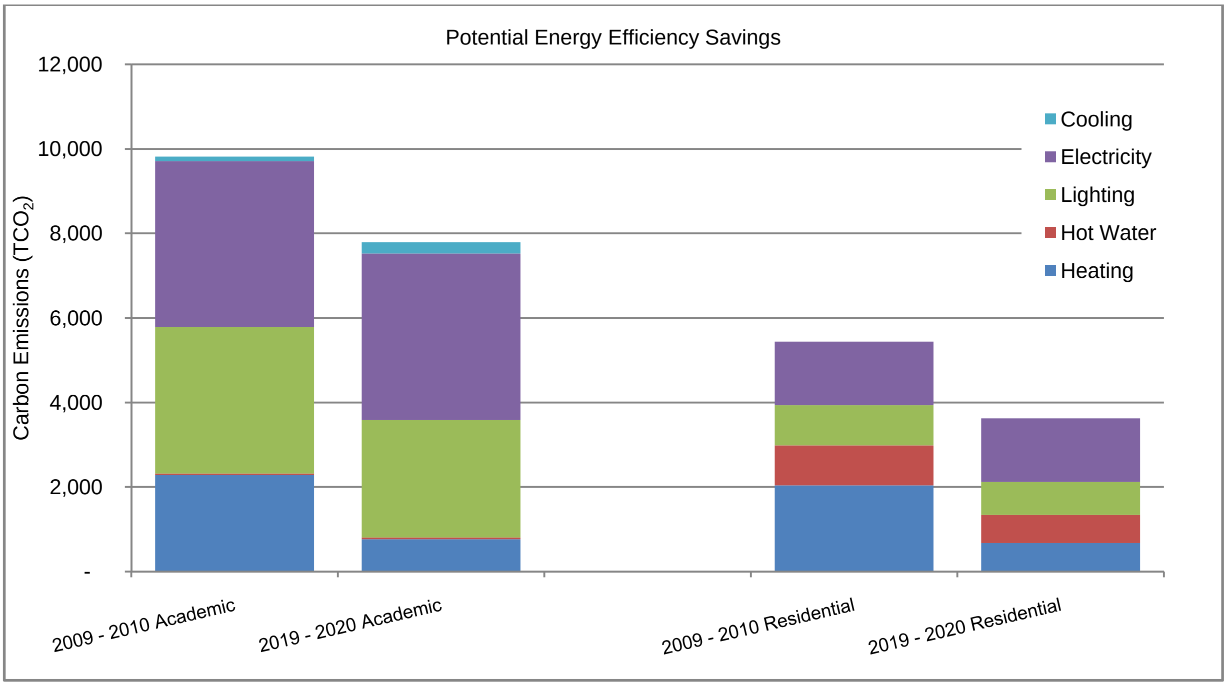


Figure 6-2: Energy efficiency savings

The measures required to achieve these savings include:

Lighting – replacing all T8 and T12 lamps with T5 lamps will reduce the electrical consumption of lighting by around 15%. Many residential buildings have manual lighting controls in communal areas and the provision of timers or proximity sensors could reduce operating hours.

Fabric – only a few of LSE's buildings are recent constructions. Upgrading the external walls, roof and windows to achieve a thermal performance equivalent to a Part L 2010 compliant construction will lower the heating demands by up to 69% for the oldest buildings. However increasing the insulation of the building can trap heat in the summer which will raise the internal temperatures and potentially increase the cooling demand. Therefore an assessment of the overheating risk should be made for each building before the fabric is improved and an appropriate means of mitigation identified. This could be installing glass that reduces solar heat gains or making more windows open-able to provide extra ventilation in summer.

Flow restrictors will reduce the hot water consumption in residential buildings by around 10%.

Heating – boiler upgrades and improvements to the residential heating controls. Boiler upgrades to the academic buildings are not included in the graph because it is not compatible with a CHP system discussed later in this report. However if CHP is not viable these upgrades may be considered as an alternative strategy

The energy audits carried out on 5 of LSE's buildings provided detailed analysis of energy efficiency measures that could be applied. A summary of the measures proposed for Bankside House is shown below, see Appendix 8-2 for the complete list of assumed energy savings for each audited building.

Recommendations	**Estimated annual savings**			**Estimated cost (£)**	**Payback period (years)**
	(£)	**CO_2 (tonnes)**	**(kWh)**		
Improving on-site management, monitoring and targeting of energy use	**10,964**	**83**	**197,547**	**0**	**Immediate**
Replace remaining tungsten desk lamps with replacement CFLs	**4954**	**48.1**	**70765**	**1226**	**0.2**
Install time control on student kitchen extract and reduce operating time.	**1147**	**9**	**16380**	**400**	**0.3**
Insulate exposed boiler piping	**362.3**	**1.86**	**10108**	**200**	**0.6**
Install occupancy sensors to control lighting in a number of areas	**4279**	**33**	**61123**	**15,000**	**3.5**
Reduce domestic hot water temperature	**2,596**	**17**	**92165**	**10,000**	**3.9**
Replace existing light fittings in a number of areas with more energy efficient fittings and controls	**8558**	**67**	**122246**	**60,000**	**7**
Improve control of student room, electric panel heaters	**12166**	**95**	**173786**	**100000**	**8.2**
Replace gas boilers with modern units	**7,789**	**50.9**	**276,494**	**100,000**	**12.8**
Install solar water heating to provide hot water requirements	**6490**	**169**	**230412**	**234000**	**36**
Total	**£59,305**	**573.9**	**1,251,026**	**£520,826**	**8.8**

Table 6-1: Summary results for Bankside House Halls of Residence

The proposals in these audits were included when quantifying the energy efficiency measures for this report and extrapolated in general terms for the other buildings on academic and residential campuses. It should be noted that these are capital costs (excluding VAT) and do not include costs associated with LSE staff time organising and implementing the measures.

6.2.1 Energy Efficiency Improvement Costs

The following cost assumptions have be used when analysing the financial viability of the energy efficiency measures above. There are also detailed costs for the 5 buildings that were audited. All cost estimates exclude VAT.

Action	Cost Assumption
Lighting upgrade Including luminaires, wiring and emergency packs	£33-40/m² *From BSRIA Rule of Thumb guide, page 53-54* *Table 5 - Office fit-out costs*
Lighting controls upgrade Passive infrared lighting controls for general office areas	£9-12/m² *From BSRIA Rule of Thumb guide, page 53-54* Table 5 - Office fit-out costs
Lighting lamp replacement Switching a T8 for a T5 lamp	£180 Total rate for a 600x600 semi recessed 'architectural' linear fluorescent T5 lamp. From Spons
Roof insulation External panel insulation	£120/m^2 roof (Excluding prelims, fees and VAT) From Currie and Brown
Wall insulation	£80/m^2 wall (Excluding prelims, fees and VAT)

External panel insulation	From Currie and Brown
Wall insulation *Cavity Wall insulation*	Total £4.28/m² From Spons
Replacement gas boiler	£45/kW Capital Cost, £3/kW Maintenance cost per year

Table 6-2: Approximate costs of energy efficiency measures

6.2.1.1 Insulation

Using the cost of £80/m² of external wall insulation and measuring the perimeters of buildings on campus the cost of insulating the walls of all the academic and residential buildings was calculated at £3.7M and £5.3M respectively. This assumed that glazing accounted for 40% of the wall area. Note that external insulation is the most expensive option. Cavity wall injection or internal insulation would cost less to install where possible.

Re-glazing costs were also calculated and this was based on an indicative cost of £250/m² of glazing. This is considered an average cost. Due to the different façade types of each building the precise cost per building will vary.

<COST TABLE UNDER REVIEW>

Table 6-3: Indicative costs of external wall insulation and double glazing to academic buildings

<COST TABLE UNDER REVIEW>

Table 6-4: Indicative costs of insulation and double glazing to residential buildings

In addition the LSE maintenance programme provided a spreadsheet with a list of improvement works already planned under their ongoing maintenance programme. Among the improvement works were a number of roof upgrades that included the upgrading of roof insulation. The total cost of all the proposed roof upgrades was £0.5m. See Appendix 8-3 for details.

6.2.1.2 Lighting Upgrades

The two tables below show indicative costs of improving the lighting. The cost of installing a T5 lamp is provided in table 6.1 and the number of light fittings in each building was calculated based on a calculation that a 10x10m room requires 12 2x36W T5 lamps to achieve a typical lighting levels. For the academic buildings this provides a total of £2.4m.The BSRIA rule of thumb document estimates a cost of £40/m² which equates to £4.4m. This highlights the need for more detailed analysis of the buildings to understand whether the lighting upgrade is a simple lamp replacement or requires a more comprehensive upgrade of the lighting system.

<COST TABLE UNDER REVIEW>

Table 6.4: Cost of lighting improvements to academic buildings

<COST TABLE UNDER REVIEW>

Table 6.5: Cost of lighting improvements to residential buildings

6.2.1.3 Heating Upgrades

To estimate the cost of upgrading the heating system of each building the LSE asset register was reviewed. In many cases this had information regarding the boiler size and age. Where this information was not available the peak heating demand in the models described in section 6.1 was used. The costs are based on a price of £35/kW of boiler capacity and £130/radiator. Radiators would be needed where the existing heating system consists of electric panel heaters.

These costs have not been allowed for in the overall strategy to avoid double counting savings derived from the installation of a site wide CHP system.

<COST TABLE UNDER REVIEW>

Table 6-5: Cost of heating improvements to academic buildings

6.3 Space Utilisation

Space utilisation has been identified as a key area for making efficiency savings across the Higher Education (HE) sector. Various reports give guidance and best practice advice on the topic and the UK Higher Education Space Management Group has undertaken a HE space management project[10]. This project has included documentation such as 'Space utilisation: practice, performance and guidelines, September 2006'.

HEFCE has produced publications on Estate Management Statistics reporting space utilisation information across UK higher education institutions and figures show that improvements were made between 2001 and 2006 across the entire UK HE sector in overall space utilisation. However, more recent figures show a decrease in UK HE median space utilisation. Utilisation is measured as a function of frequency of use and level of occupancy. Figures for median space utilisation from 2001 to 2007 are shown in Table 6-6. In addition another measure of space management is the available area per student which has generally been declining between 2001 and 2007 as shown in Table 6-7.

	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Median utilisation	24.1%	25.2%	26.7%	26.5%	27.0%	25.4%

Table 6-6 : - UK HE median space utilisation[11]

	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Total non-residential NIA (m^2) per student FTE	8.9	8.4	7.9	8.0	7.9	7.6

Table 6-7 : UK HE total non-residential net internal area (NIA) per student FTE[3]

Table 6-6 shows that greater space utilisation on campus could reduce the carbon emissions by 17%. This could be achieved through not operating 75% of the academic buildings during weekends. This will involve some strategic collaboration between the LSE timetabling and the Estates Management team to rationalise usage while meeting the operational needs of staff and students. Buildings such as the library would remain open during the weekend but buildings with a large number of lecture theatres not used during weekends could be closed. The closed buildings will still consume some energy during the weekend to run building services at a reduced level, for example heating to a set point of 12°C rather than 20°C and only keeping emergency lighting on.

Cost

There is no equipment cost for this action but there will be staff costs to initiate the plan.

6.4 Behavioural Change

To obtain a sustainable building it is vital to have an engineered building with the ability to operate sustainably. However, if the users operate a sustainably engineered building in an unsustainable manner then all the good efforts made can be downgraded. One way to mitigate this is to effectively engage the users through behavioural change programmes.

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[10] http://www.smg.ac.uk/reports.html

[11] HEFCE (2008) *Performance in higher education estates – EMS annual reports*

Behavioural change strategies and programmes targeted at reducing energy use are an effective way of fostering sustainable behaviour and should be explored further by the university as part of their energy strategy. The HEFCE supported research into a carbon reduction target and strategy for Higher Education in England study (2009) suggested that "…between 5-10% carbon reductions are realistically possible through behaviour change alone".

Research indicates that attitudes are not strong indicators of behaviour and that there are four main groups of barriers to specific behaviours

- convenience
- cost
- social norms
- lack of knowledge

Simply providing staff and students with information is not enough. This action can only address the 'lack of knowledge' barrier but it's rarely the case that this is the only or dominant barrier to behaviour. Behavioural change is about encouraging or discouraging a specific behaviour. This is achieved by identifying the barriers to the desired behaviour and designing specific interventions to address each one.

An effective behavioural change programme should take into consideration the complexity of individual decision making, including factors such as:

- Organisational and systemic constraints;
- The power of other competing behaviours;
- Time pressures if scheduling is unrealistic;
- Whether people perceive that their peers consider the behaviour as important;
- Habit;
- Emotional reactions;
- Social, economic, historic and cultural context;
- Self and group identity; and
- Likelihood and consequence of not engaging in target behaviour.

This type of initiative must be developed with a firm understanding of the unique risks and opportunities present within HEIs. Behavioural change consultants can then provide structured programmes to identify and influence energy saving behaviours specific to life on campus. It is also possible to develop internal capabilities by identifying key staff and providing them with the skill and knowledge set required of effective change agents, enabling them to deliver potential carbon, energy and financial savings within an internal behavioural change program.

Of the carbon saving options, changing the behaviour of staff and students is the most difficult to quantify. Yet it is a low cost solution and critical to a successful carbon management plan because poor user behaviour can undermine the effect of installing energy efficient and low carbon technology. A detailed strategy for behavioural change can not only significantly impact energy related issues but the framework can be used to address other issues such as reducing waste, increasing recycling and reducing water use.

Due to the rotation of students, raising awareness of energy efficient behaviour will be an ongoing task. Students will have greatest control over the energy they consume in their residencies. One way of influencing behaviour might be through incentives. For example sub metering floors and having a prize for the floor with the lowest energy consumption.

In-line with the HEFCE report, a 5% cut in emissions due to behavioural change is proposed. With a 1% cut each year from 2010 to 2015. The 1% was applied after energy efficiency measures and space utilisation had been accounted for. Therefore the overall emission reduction due to behavioural change is about 3% as shown in figure 6.1.

Cost: There is no equipment cost for this action but there will be staff and consultancy costs to develop a suitable behavioural change programme and implement initiatives.

6.5

Figure 6-3 shows the LZC options considered and the carbon savings they could make. Due to the fact that cost per tonne of carbon saved is higher for most LZC's than it is for the energy efficiency measures it is assumed that the energy efficiency improvements outlined above are installed before any LZC technology. For example, rather than sizing a CHP engine to meet the current heating demand it is sized to meet the future, lower, heating demand brought about by improvements to building fabric. This approach also eliminates any double counting of carbon savings.

Indicative costs have been provided for the LZC options below, however Feed-In Tariffs (FITs) came into effect in April 2010 which give back to the owner a pence per kW of electricity generated onsite for most LZCs over a period of 20 -25 years depending on the technology, thereby reducing the payback time of LZCs. More information on FITs can be found in Section 7. As the FITs vary between the type of technology, when it is installed and the size of system detailed calculations have not been undertaken at this stage.

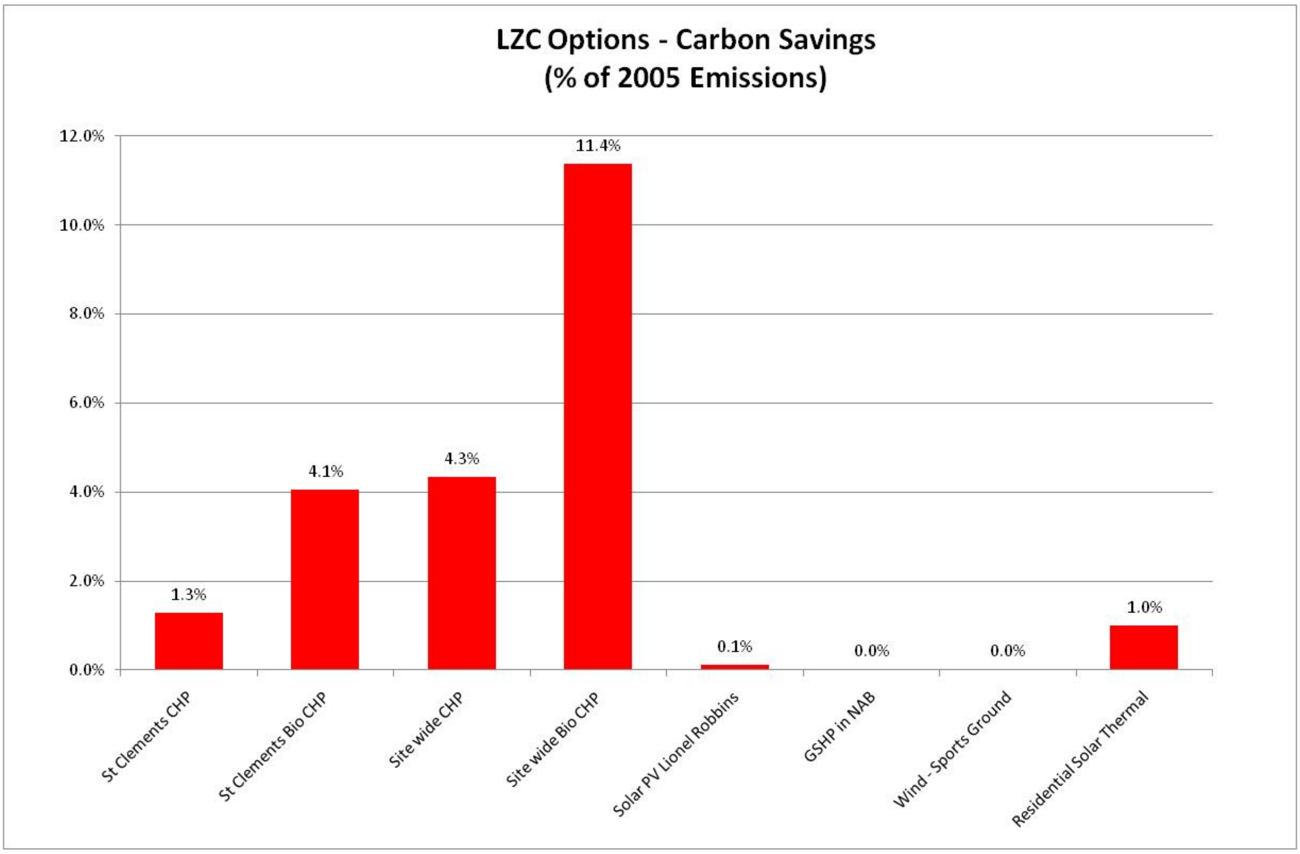


Figure 6-3: Carbon savings of LZC technologies

6.5.1 Combined Heat and Power (CHP)

The first CHP scheme considered was an 800kW thermal, 617kW electrical CHP engine that would provide heat and power to Clare Market, East Building, Towers and St Clements. This would meet 89% of the four buildings combined heating demand and 15% of their electrical demand. If bio-fuel were used the carbon savings more than triple (as shown in figure 6-3) although the type of bio fuel used would require careful consideration.

A larger CHP scheme was also analysed. This would serve the entire academic campus and would require a heating distribution network to be installed. A 2000kW thermal, 1544kW electrical CHP engine would meet 86% of the sites

heating demand and 22% of the electrical demand (see figure 6-4). As figure 6-3 illustrates, this CHP scheme would cut the sites carbon emissions by 3.9% and 11.7% if bio-fuel were used.

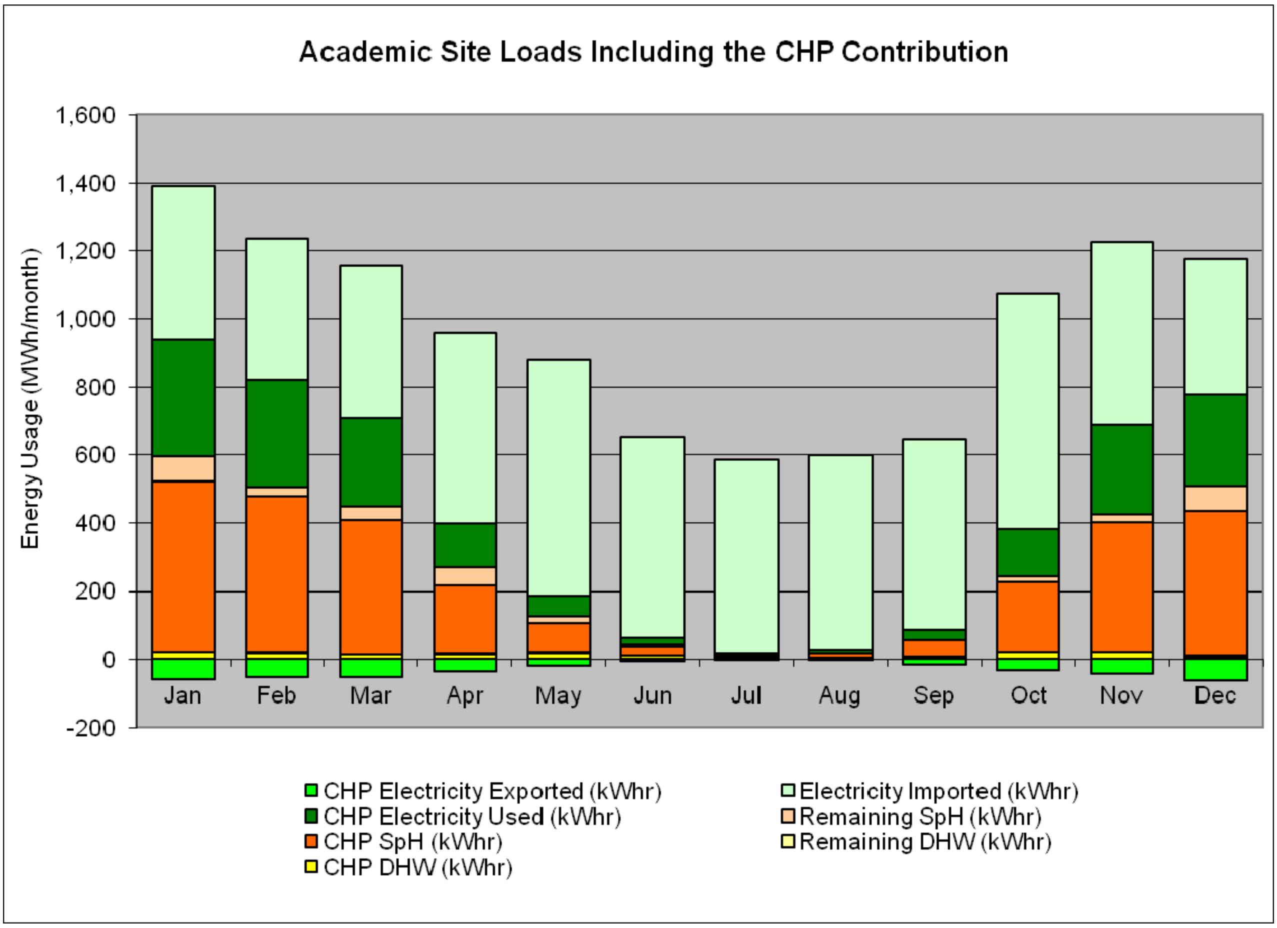


Figure 6.4: CHP contribution to academic site heating and electricity demands by month

Cost: Based on an indicative cost of £4000/kW of thermal capacity, installation of the CHP engine will be £8M. A quote should be obtained from a CHP installer to establish a more accurate cost as the cost of installing the heating network to each building is site specific. The maintenance costs based on a benchmark of 0.9p/kWh of electrical energy is £20,000 per year.

6.5.2 Solar Thermal

The residential buildings have a high hot water demand that can be partially met by solar thermal panels. The following table shows the potential for solar thermal for each building. The size of each system is based on aerial views of each building to ascertain available roof space, the system is also limited to provide no more than half the hot water demand, this is a rule of thumb used to prevent over-sizing a system which results in excess hot water in the summer. The calculations were based on evacuated tube panels. The optimum angle for a solar collector in London is 30° but evacuated tubes can be individually rotated so the frame can lie horizontally without hindering performance. This also eliminates the problem of panels shading each other, but may this increase may increase maintenance through cleaning to gain the most benefit from them.

Residential Site	Collector Area m^2	% of hot water demand met	Carbon Reduction, TCO_2
Bankside House	200	23%	33
High Holborn	100	10%	17

Roseberry	100	14%	17
Butler's Wharf	200	45%	33
Passfield Hall	100	6%	17
Carr Saunders	50	21%	8
Grosvenor	68	50%	11
Northumberland	64	50%	11
Total	**882m^2**		**148**

Table 6-8: Solar panels

As table 6-8 shows, if solar thermal panels were installed on all the residential buildings 148 tonnes of carbon can be saved, this equates to 1% of the 2005 emissions.

Cost

Based on a capital cost of £750/m², installation of these panels would be £662,000. Maintenance is expected to be about £4,000 per year. As FITs can be claimed for this type of technology it is intended to pursue this opportunity as appropriate.

6.5.3 Solar Photovoltaic (PV)

The academic buildings have a small hot water load, therefore photovoltaic panels are preferred to solar thermal panels. Based on an aerial view of the campus, there is space for 220m² of PV on the roof of the Lionel Robbins building. This would produce 32MWh of electricity per year (0.2% of the academic campus electricity demand) which would cut carbon emission by 0.1% (17 tonnes CO_2). This is a small amount, therefore if PV were to be installed before 2020 it should not be a priority. The energy efficiency measures highlighted earlier in this report will make far more significant savings if installed at lower cost per tonne of carbon saved.

Cost: Based on a capital cost of £5000/kW of capacity, installation of these panels would be approximately £157,000. Maintenance is expected to be about £2,000 per year.

6.5.4 Wind Power

Due to the urban location of the academic and residential sites opportunities for wind turbines are limited. Some of the taller buildings may have sufficient wind speeds for wind turbines to be installed but mounting wind turbines to an existing building may not be possible as the building structure needs to be designed to withstand the forces imposed by the turbine. The wind resource itself may not be suitable in an urban environment as even tall buildings create their own wind turbulence which can affect performance.

Whilst this is less of a problem for very small turbines, the carbon savings that would be achieved with very small turbines would be negligible. The New Academic Building has suitable footings at roof level to support vertical axis turbines which could be added retrospectively and offset a small amount of the energy demand of the buildings. However issues to do with acoustics and potential shadow flicker issues should be considered, especially near residential areas.

The onsite where wind power may be accommodated on a larger scale is the LSE sports ground in New Malden. See map of location below. The sports fields will provide reasonable exposure to the wind, however the residential setting may make planning permission challenging. If one 6kW turbine (9m hub height, 24m² swept area) were installed it would produce approximately 3MWh/year, this equates to a cut in carbon emissions of 0.01%. Given the cut in CO_2 that this would be able to contribute wind power is not considered a viable option at this stage.

Figure 6-4: Aerial Image of LSE Sports Ground

6.5.5 Ground Source Heat Pump (GSHP)

When the New Academic Building was renovated a 12kW ground source heat pump to ground loops was planned for and the boreholes are present. Should the heat pump be connected the design calculations for this were calculated to provide 35,000kWh per year and save 3.2 tonnes CO_2e.

7 Implementation Plan

7.1 Scope 1 & 2

As the previous section shows, in order to cut the carbon emissions of LSE to meet the HEFCE target a number of measures will have to be implemented. Table 7-1 summarises a list of potential projects which could be undertaken in order to reduce carbon emissions generated from the campus. The indicative cost estimates have been derived from the work undertaken in the previous options evaluation section. Much of this analysis has been based upon extrapolating the potential carbon reduction projects that were identified through the 5 energy audits undertaken. For most buildings general assumptions based on type, age, use and conditions of the buildings have been required. The potential carbon savings resulting from an upgrade of a lighting system, for example, will be greater in one building than another therefore the measures have been consolidated in the development of a marginal abatement cost curve for the residential and academic campuses in order to illustrate potential carbon savings. For each individual building related measure a full review which includes the project's viability, scope, financial and carbon savings potential will need to be undertaken prior to the commencement of works.

Table 7-1: Potential measures and capital costs for carbon reduction projects for the Residential Campus

<COST TABLE UNDER REVIEW>

Table 7-2: Potential measures and capital costs for carbon reduction projects for the Academic Campus

<COST TABLE UNDER REVIEW>

Note: in order to estimate target savings over the 10 year period the CMP has taken account of potential carbon savings which could be derived from other capital development projects that have not has estimated costs associated with them. For example potential carbon savings have been assumed in the calculations for the redevelopment of East Building however no cost implications have been shown here.

In the table below the measures and estimates for the rate at which they could be implemented before 2020 has been proposed taking account, where possible, of the Long Term Maintenance plan. For example, insulating all the buildings in one year is probably un-feasible so it is shown as a gradual process over 10 years whereas a large CHP engine cannot be gradually installed in the same way, instead it is proposed that it is switched on in year 2015 based on potential design and construction schedules. This is converted into capital expenditure in the table below.

<COST TABLE UNDER REVIEW>

Table 7-3: Capital expenditure

Using the capital and maintenance costs detailed in section 6 and the annual savings achieved by reducing the electricity and gas bills the Net Present Cost (NPC) of each action has been estimated. This was then plotted against the annual carbon saved in the marginal abatement cost curve shown below and the accompanying table that ranks the different actions in order of NPC.

<COST TABLE UNDER REVIEW>

Figure 7-1: Year 2020 Marginal Abatement Cost Curve

<COST CURVE UNDER REVIEW>

Table 7-4: 10 Year cost analysis

Commentary on the 10 year marginal abatement cost curve and table:

Clearly implementing activities to improve the space utilisation of the building stock, particularly arranging the buildings so that some can be closed at weekends is critical to reaching the carbon targets set as it saves more carbon than any other single activity. There will be some initial costs due to staff resources required to organise the changes necessary but because annual capital costs are zero and the savings from reduced energy bills is large the cost effectiveness ratio for this activity is very good.

Behavioural change has a good cost effectiveness ratio because, like space utilisation, the capital and maintenance costs are low. However, although the financial barrier of consultancy fees for behavioural change programmes may be very cost effective, changing behaviour is hard to achieve and sustain. It will require committed staff to implement. Due to the rotation of students, raising awareness of energy efficient behaviour will be an ongoing task. Students will have the greatest control over energy they consume in their residencies. A strategic and continuing behavioural change programme coupled with schemes engagement with the building users such as the Student Switch Off campaign, the Residences Environmental Champion, or the Flying Start Staff Inductions (including an Environmental Policy briefing),will all raise the profile of the CMP and can be delivered through the Sustainability Communications Plan..Hot water improvements to the residential buildings are estimated to require circa £145,000 of capital expenditure. This is shown to be cost effective over the 10 year life of the shower and tap restrictors and valves.

Of all the options, photovoltaics save the least carbon (the carbon saved is so small it is not visible on the chart) and after 10 years little of the capital investment has been paid back. The Government's Feed-in Tariff scheme has lowered the NPC from £110,000 to £86,000. For PV the FIT is a 25 year programme and would therefore potentially see a net income from the PVs over their 25 year life with the payback starting around years 12 – 1 4.

Part of the reason for the small savings for heating upgrades and solar thermal panels is that their implementation plans are slow between 2010-2020. Note that the academic heating upgrade measures will not be compatible with a site wide CHP system, if chosen.

Carbon savings from re-glazing are much smaller than savings from wall insulation. Due to the age of some of the buildings on campus changes to the glazing may be unfeasible or unacceptable. Also the cost of re-glazing may vary greatly between building types.

Academic lighting upgrades save significantly more CO_2 than residential; this is because the lights are on for more hours per day. Therefore lighting upgrades should be rolled out across the academic buildings first.

Upgrading the thermal performance of walls and roofs requires a significant capital cost and because a gradual implementation plan has been assumed, the NPC after the first 10 years is poor. However, after the capital outlay there are no additional annual costs and the life expectancy of upgrading the building fabric is over 30 years. Also, as a conservative estimate it was assumed that all wall insulation was fixed externally. There may be many buildings where additional insulation can be fixed to the internal side of the wall, which will be about half the cost.

Installing a bio-fuelled CHP engine to provide for the whole academic site would require the largest capital outlay. It's implementation date is assumed to be 2015, therefore on the 10 year assessment, the financial performance is poor. However the carbon savings are large.

To understand the financial performance of the different actions beyond 2020 the following chart and table show the NPC of each item during its life up to a maximum of 30 years. This Marginal abatement cost curve would alter again if the timescale was stretched to 2050, although maintenance issues would have more impact.

<COST CURVE UNDER REVIEW>

Figure 7-2: 30 Year Marginal Abatement Cost Curve

Compared with the 10 year chart, all of the NPC's improve when modelled over a 30 year period
The most significant improvements are for the activities targeting the academic buildings where lighting upgrades, wall and roof insulation, and bio-fuelled CHP have all jumped forward significantly in the priority list (which is a ranking of NPC) when compared with the 10 year chart.

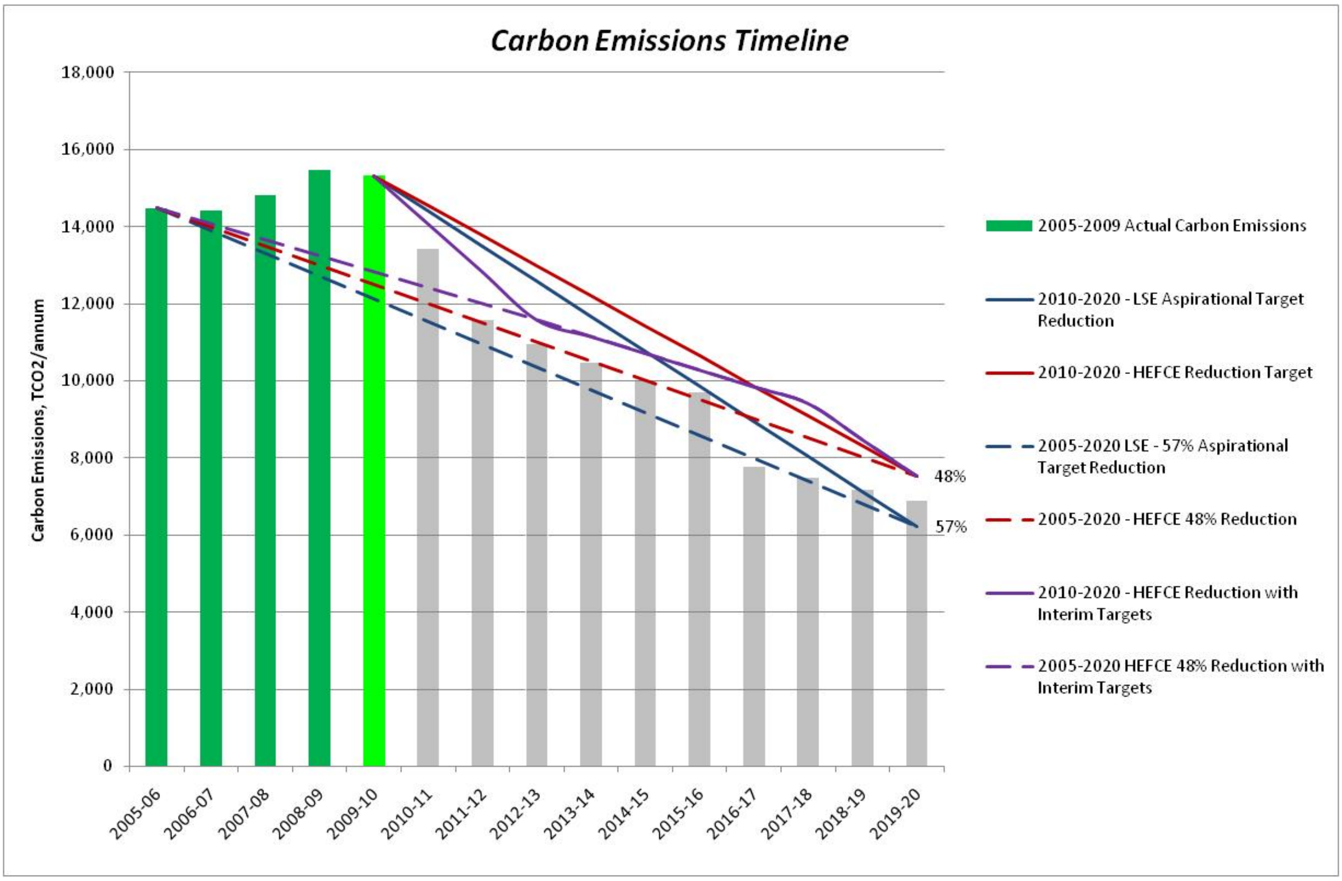
Decarbonisation of the grid has not been considered in this initial 10 year plan. Given that most of these measures have a lifetime of 25 to 30 years grid decarbonisation would need to be factored in to the calculations as the plan moves forward from 2020.

The table and graph below show the proposed reduction in carbon emissions from Scope 1 & 2 emissions based on the proposed activities highlighted above for the period from the 2005-06 baseline to 2019/20. The annual reduction in carbon emissions is based on the implementation plan detailed above as there will need to be a phased approach to carbon emission reduction.

Actual Emissions and Predicted Emissions		-1%	2%	7%	6%	-7%	-20%	-24%	-28%
	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Carbon Emissions, Tonnes	**14,484**	**14404**	**14810**	**15,468**	**15,324**	**13,417**	**11,581**	**10,965**	**10,480**
Annual Carbon Reduction - Academic Buildings - EE	N/A	N/A	N/A	N/A	N/A	313.8	236.3	255.5	255.5
Annual Carbon Reduction - Residences - EE	N/A	N/A	N/A	N/A	N/A	198.2	229.8	261.3	229.8
Annual Carbon Reduction - Academic - SU	N/A	N/A	N/A	N/A	N/A	1,199	1,177	99	-
Annual Carbon Reduction - Academic Buildings - LZC	N/A	N/A	N/A	N/A	N/A	3.2	-	-	-
Behavioural Change	N/A	N/A	N/A	N/A	N/A	193	193	-	-

Actual Emissions and Predicted Emissions	-34%	-37%	-50%	-51%	-53%	-55%
	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Carbon Emissions, Tonnes	**9,533**	**9,173**	**7,295**	**7,064**	**6,816**	**6,585**
Annual Carbon Reduction - Academic Buildings - EE	588.5	136.9	15.8	15.8	15.8	15.8
Annual Carbon Reduction - Residences - EE	227.1	223.0	214.8	214.8	214.8	214.8
Annual Carbon Reduction - Academic - SU	-	-	-	-	-	-
Annual Carbon Reduction - Academic Buildings - LZC	-	-	1,648	-	17.3	-
Behavioural Change	-	-	-	-	-	-

Table 7-5: Table showing the proposed reduction in carbon emissions up until 2020



7.2 Implementation Plan for Scope 3 Emissions

A detailed implementation plan estimating the potential carbon emission reduction from Scope 3 emissions has not yet been formally quantified however the following will be considered in more detail.

Technology and Procurement Issues

Recently LSE IT staff changed all computers to automatically hibernate during periods of inactivity. This will already be reducing the carbon emissions of the 2010-2011 totals. IT staff could also use timers to automatically turn off printers etc. during out of office hours.

LSE have already converted IT equipment such as computers, monitor screens, printers and photocopiers to more efficient versions and will continue to upgrade equipment up to and beyond 2020. Provided the amount of equipment does not continue to grow, these upgrades will reduce the scope 2 emissions.

The procurement of lifts and catering equipment also presents further opportunities for LSE to review the specification of this equipment and ensure there where and when procured energy efficiency becomes a key component of the selection process. This criteria can also be used in reviewing leased equipment such as washing machines and driers.

Travel

A significant proportion of emissions attributed to LSE's carbon emissions footprint are attributable to arrival and departure travel by overseas students. The travel survey showed that international students outside the EU member states complete 2 return journeys to their home country per year. It is assumed that this travel includes a return journey during the winter holidays. Students domiciled in EU member states complete at least 3 return journeys during the academic year. In order to help reduce this travel. It is proposed that LSE investigates the opportunities for encouraging students to remain in Halls during the winter holidays. This might be done by consolidating the international students into more central Halls and providing video/ Skype facilities for students here and perhaps partnering with other Universities abroad enabling families to keep in contact. Organised social events and student engagement might also encourage students to remain in Halls over the winter

holiday. For EU Member States and the UK, LSE will work with their travel provider in helping to secure the best price for students on train tickets to encourage travel by train rather than flights or private car.

Water

The benefit of reducing water consumption is twofold. The first is through the reduction in carbon emissions associated with supplying of potable water and conveyancing of waste water. Second, carbon emission reductions can be achieved through lower hot water demands and pumping of water in a building. A programme of fittings shower flow restrictors in the residences was undertaken in 2009/10 and the full benefit of these should be shown in the water consumption figures in subsequent years.

Waste

The LSE has already taken steps to reduce and reuse materials through a number of campaigns. Although the historic data is a sparse the LSE will set out a strategy for improved data collection as well as continuing to review options for recycling waste. Waste targets will be developed in order to set out a programme of waste reduction and diversion, this will be monitored through waste audits. As there is substantial redevelopment planned the LSE's waste targets will be passed on to all construction works.

7.3 Financing

In 2008 the LSE was accepted into the Salix Institutional Small Projects (ISP) fund. It is a revolving green fund that is sponsored by Salix and HEFCE. The school was awarded £500,000 to spend on energy efficiency projects. The money was put into a ring fenced fund that can only be spent on projects that have a payback of less than five years. For certain types of projects where a significant amount of CO_2 can be saved the payback may be extended to 7.5 year or if LSE contributes funds towards a project then a 10 year payback may be acceptable.

The LSE will also seek opportunities to fund the development of LZC energy systems or energy efficiency improvements through nationally operated grant schemes. The following section provides a summary of schemes that are relevant to the LSE, although the applicability and availability of each scheme would have to be judged on a case by case basis.

Partnership for Renewables (PfR)

The PfR scheme is run by the Carbon Trust to develop and manage onsite renewable energy projects in the public sector. The Carbon Trust will manage all aspects of the renewable project including detailed feasibility studies, construction and operation. Eligible technologies include:

- Wind energy generation
- Biomass
- Geothermal energy generation
- Hydroelectric
- Solar
- Wave and tidal power

Community Sustainable Energy Programme (CSEP)

CSEP allows qualifying organisations to apply for capital grants up to £50,000 or 50% of the project cost (whichever is lower) for the installation of micro-generation technologies (such as solar panels, wind turbines etc.) and energy efficiency measures (such as loft insulation, cavity wall insulation etc.). The programme will also provide a project development grant in order to ensure the technical and financial viability of the project. Studies must be carried out by a BRE-registered consultant.

EDF Energy Green Fund

This fund exists to help non-profit making organisations with a social purpose to install renewable energy technologies on their sites where they would not normally afford to do so. The fund can provide up to £30,000 towards the installation of renewable heat or electricity generating technology and its surrounding educational activity.
The Green Fund awards money twice a year with fund rounds closing in February and August each year.
Some works detailed in the Long Term Maintenance Plans and Capital Developments will contribute to the energy reductions as set out in the programme.

Feed-In Tariffs and Renewable Heat Incentive
FITs are the electricity portion of a Government led scheme to create a scheme that pays people for producing their own "green electricity". Heat is accounted for in the Renewable Heat Incentive which is a similar measure, which will be launched in June 2011. These tariffs have been introduced by the Government to help increase the level of renewable energy in the UK towards our legally binding target of 15% of total energy from renewables by 2020 (up from under 2% in 2009). The FITs can be claimed by most organisations including Universities and are obtainable on most renewable energy generation. The prime benefit of FiT is the generation tariff, which is paid for every kilowatt hour of electricity produced.

The amount paid per hour is determined by the type of technology and the size of the system for example a 10kW PV system installed in 2010 would benefit from 31.4p/kWh

8 Governance and Progress Reporting

The delivery of the Carbon Management Plan and the achievement of a significant reduction in carbon emissions resulting from the operation of the School is the responsibility of all, staff and students alike. The CMP will be led by the Carbon Management Team of the Estates Division who will be responsible for ensuring that the plan is managed and implemented. The reporting structure of the CMP is shown in the figure below.

The Carbon Management and Environmental & Sustainability teams will work with the academic, finance, maintenance, residential, procurement and the rest of the estates divisions to ensure that the CMP is considered, implemented and reported through the activities of all the service delivery areas of the School.

To ensure effective and ongoing ownership of this CMP progress reports will be made to the EMRG each term and an annual report to summarise progress will be presented. This will be made available to HEFCE as requested.

<ORGANOGRAM UNDER REVIEW>

Figure 8-1 LSE Carbon Management Organogram

8.1 Governance arrangements – ownership and accountability

Central to successful implementation of the carbon management plan is the need for clear ownership of the activities necessary to keep the plan operational.

It will be essential to put in place a cross organisational governance and responsibility (implementation) structure to help deliver sustained implementation of the Carbon Management programme. This structure will need to consist of the following elements.

- Senior Level Support
    - LSE Board
    - EMRG / EM Review Team
- Divisional Support
    - Estates Management
    - Finance
    - Sustainability
- Local Support
    - Building managers
    - Stakeholders
    - Staff Consultative Council
    - Student Liaisons
    - Carbon Reduction Manager

8.2 Communication Strategy

This CMP will be made publicly available via the LSE’s website. Supporting documentation and the calculations which have been generated in developing this CMP are available from the Carbon Management Team.

Progress against the CMP will be reported each term to the EMRG and annual updates will be made publicly available.

Reports on progress will also be available to HEFCE in order that they will able to track progress of the Higher Education sector overall and are able to consider the CMP and progress against it for future funding opportunities.

Student and staff engagement will be key in helping to reduce emissions through space utilisation and behavioural change, communication routes.

8.3 Ongoing Management

Updates to the CMP will be used as an opportunity to revisit the list of possible carbon reduction projects and track progress against the targets. To assist with that some revisions to the way in which data is collated will need to be implemented in order to provide more accurate data. As Scope 3 issues will need to be reported on and a strategy for reducing emissions arising from these issues implemented comments on the future strategy for this is commented on here as well.

The metering data collected by Evolve is a powerful tool for monitoring and subsequently reducing carbon emissions however it requires a significant allocation of staff time to do this. The Evolve system is currently used to verify energy bills but analysis of data to improve building performance has only been undertaken recently. The Evolve system was used to identify a building with an unusually high continuous load – the cause was discovered to be a chiller whose controls had been manually overridden and was continuously running at full load. Correcting this took a few seconds but the impact on the buildings electricity consumption is significant therefore more of this activity is an effective way of cutting emissions and requires minimal investment.

LSE should assign responsibility for monitoring Evolve data to appropriate staff and ensure they have sufficient time and skill to analyse, investigate and act to reduce high energy consumption. Either a staff member could be responsible for all the buildings, or staff could be assigned to individual buildings. Energy targets could be set based on historical usage to allow the performance of this staff to be measured.

Energy & Water - some issues to the Evolve Energy Online system have been noted throughout the baseline generation. A programme of ensuring that all meters associated with the LSE portfolio are properly calibrated and are giving the correct output figures. This should also be tallied with the billing arrangements to ensure accuracy. The estates division has been coordinating with the Evolve operators to add in historic Dynamat data enabling all data to be included in the online system.

Transport - the travel survey that was undertaken by the Environmental and Sustainability team collected data based on time taken for journeys rather than distance travelled. A consistent approach was taken in the development of the baseline calculations for the conversion of travel time to mileage, however in future iterations of the travel survey a mileage figure should be used. The procurement of business travel is currently being centralised this will enable a more complete picture of the business travel that occurs rather than through a sample travel survey.

Waste - the waste data collection that has been undertaken by the Environmental and Sustainability team has increased in terms of the data that they have collected. A detailed waste audit will help identify all sources of waste generated by both the academic and residential campuses, which can then be used to set targets and a monitoring strategy. These targets must include operational, demolition and construction waste.

Fugitive emissions – although fugitive emissions arising from refrigerants have not been included in the assessment of scope 1 and 2 emissions in this CMP, a programme to review all equipment using refrigerants needs to be undertaken.

Appendices

Appendix 8-1 – List of Buildings

Building Ref	Building Name	Area of building m^2	Year of Construction	Tonnes of CO_2e	Kg/ CO_2e per m^2	Kg / CO_2e per building per student	Notes
AH	Aldwych House	989		78	79	8	
N	Anchorage	324	c.1890	34	105	3	
C	Clare Market	2,514	1966-1969		0	0	Energy fed from Clement House
D	Clement House	6,230	1909-1911	386	44	37	
B	Columbia House	3,392	1928-1929	424	125	41	
H	Connaught House	3,951	1924-1925	201	51	20	
J	Cowdry House	2,006	1903	110	55	11	
E	East Building	4,566	1931	404	88	39	
	George IV	435		37	85	4	
K	Kings Chambers	780	1905	72	92	7	
NAB	New Academic Building	12,707	1912-1915	1,101	87	107	Major refurb, completed and occupied 2008
G	20 Kingsway	2,182		113	52	11	
L	Lincoln Chambers	811	1905	33	41	3	
M	50 Lincolns Inn Fields	304		22	72	2	
R	Lionel Robbins	21,641	1913	1,821	84	177	Major refurbishment c.2005
A	Old Building	15,786	1920-23	1,381	87	134	
PH	Parish Hall	403	1897-1898	14	35	1	
PE	Peacock Theatre	5,255	1960	388	74	38	
PS	1 Portsmouth Street	152	c.1870	6	39	1	
QH	Queens House	244		176	721	17	
Q	Sheffield Street	413	c.1904	26	63	3	
S	St Clements	9,364	c.1881, extension 1970	854	91	83	

X, Y Z	St Philips	3,194	1903	191	60	19	To be replaced by new student centre
U, V, W	Towers	14,866	1: 1971; 2:1971; 3:1971	2,041	137	198	
T	Lakatos	983	1903	61	62	6	
Halls of Residence	Passfield Hall	4,363		450	103	1982	Kg CO_2e per student is based upon bed spaces
	Roseberry Ave Hall	7,404		849	115	2687	Kg CO_2e per student is based upon bed spaces
	Carr-Saunders Hall	5,600		303	54	1942	Kg CO_2e per student is based upon bed spaces
	Grosvenor House	4,754	1896 (extension 1907)	388	82	1764	Kg CO_2e per student is based upon bed spaces
	Northumberland House	17,017	1883-1887	355	21	959	Details not included in the base year 2005-06. Linked to Whitehall DHS. Kg CO_2e per student is based upon bed spaces
	Bankside House	18,540		1,605	87	2601	Kg CO_2e per student is based upon bed spaces
	High Holborn Residence	12,110		980	81	2188	Kg CO_2e per student is based upon bed spaces
	Butler's Wharf Hall	7560		512	68	1992	Kg CO_2e per student is based upon bed spaces
	Sports Ground – Malden			51		5	
	York Buildings No 7			13		1	
Buildings not included in the CMP	Sardinia House						New purchase, details have not been included in this iteration of the CMP
	Ye Old White Horse						Leased to tenants/ managing agent, not included in CMP
	Lillian Knowles						Residence not managed by LSE who do not pay utility bills
	Anson and Carleton						Residence not managed by LSE who do not pay utility bills
	New Court						Leased space by LSE, utility bills are in the base build

Appendix 8-2 - Energy Efficiency by Building

Analysis has been carried out using compiled energy consumption data to determine the baseline carbon emissions for the site (2005) as well as the carbon emissions up to the past 12 months (April 2009 to April 2010). Further calculations have then been carried out to determine potential energy reductions over the next 10 years through implementation of Energy Efficiency measures (fabric upgrade, lighting upgrade, heating plant improvements etc).

Energy efficiency measures have been applied to the current usage hourly figures (2010) calculated for each academic and residential building. The assumptions of the reductions available for these buildings are shown below:

Anchorage:
Lighting efficiency = 15% (T8 to T5)
Fabric upgrade = (ext walls, roof, windows all to Part L 2010)

Clare Market:
New build to Part L 2010 standard

Clement House:
Lighting efficiency = 9% (Coordinated with Energy Audit)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Energy Audit recommendations

1. Improve energy management procedures on site
2. Change heating set point from 22°C to 21°C
3. Adopt free cooling overnight for Thai Theatre
4. Install optimiser control on the space heating operation
5. Install additional heating zone control, to enable discrete areas to be heated
6. Replace existing light fittings (T8 to T5)
7. Replace existing boilers

Columbia House:
Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Connaught House:
Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Cowdray House:
Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

East Building:
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

George IV:
Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Kings Chambers:
Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

NAB:
No efficiency improvements due to recent refurbishment.

20 Kingsway:
Lighting efficiency = (T8 to T5)
Fabric upgrade = (ext walls, roof all to Part L 2010)

Lincoln Chambers:

Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Lionel Robbins:
Lighting efficiency = 43% (Coordinated with Energy Audit)
Fabric upgrade = (ext walls, roof, windows all to Part L 2010)

Energy Audit recommendations
1. Reduce run hours of the Lionel Robbins
2. Improve energy management procedures on site
3. Change heating set point from 22°C to 21°C
4. Reduce run hours of extract fans
5. Lux detectors for perimiter lighting
6. Replace existing light fittings (T8 to T5)
7. Install PIR in the 5th floor conference room
8. Add a dedicated summer boiler for rare books area

Old Building:
Lighting efficiency = (Coordinated with Energy Audit)
Heating system = (Coordinated with Energy Audit)
Fabric upgrade = (ext walls, roof, windows all to Part L 2010)

Energy Audit recommendations
1. Improve energy management procedures on site
2. Review BMS and change heating set points to 21°C
3. Reduce run hours of kitchen AHU
4. Insulate pipes
5. Add VSD to boiler room pumps
6. Install Lux detectors for lobby and senior dining
7. Add VSD and CO2 sensor to Café AHU
8. Replace existing light fittings (T8 to T5)
9. Install PIR for Selegan Library and A386
10. Replace boilers

Parish Hall:
Lighting efficiency = (T8 to T5)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Peacock Theatre:
Lighting efficiency = (T8 to T5)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Portsmouth Street:
Lighting efficiency = 15% (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Sheffield St:
Lighting efficiency = (T8 to T5)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

St Clements:
Lighting efficiency = (T8 to T5)
Fabric upgrade = (ext walls, roof, no window improvements (already double glazed or secondary glazing) - all to Part L 2010)

St Philips:
New build to Part L 2010. Area increases from 3,190 to 5,960m^2

Towers
Lighting efficiency = (T8 to T5)

Fabric/glazing upgrade = (ext walls, roof, no window improvements (already double glazed or secondary glazing) - all to Part L 2010)

Lakatos:
Lighting efficiency = (T8 to T5)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Passfield Hall:
Lighting efficiency = (Coordinated with Energy Audit)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (Coordinated with Energy Audit)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Energy Audit recommendations

1. Improving on-site management, monitoring and targeting of energy use
2. Recommission boiler
3. Insulation on pipes
4. Install vending machine optimisor
5. Occupancy detection in the kitchen and computer room
6. Lux detectors in stairwells
7. Solar hot water

Roseberry Ave Hall:
Lighting efficiency = (T8 to T5)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (boiler upgrade, heating controls)
Fabric = (ext walls, roof all to Part L 2010)

Carr Saunders Hall:
Lighting efficiency = (T8 to T5)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Grosvenor House:
Lighting efficiency = (T8 to T5)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Northumberland House:
Lighting efficiency = (T8 to T5)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Bankside House:
Lighting efficiency = (Coordinated with Energy Audit)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (Coordinated with Energy Audit)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Energy Audit recommendations

1. Improving on-site management, monitoring and targeting of energy use
2. Replace remaining tungsten desk lamps with replacement CFLs
3. Install time control on student kitchen extract and reduce operating time.
4. Insulate exposed boiler piping
5. Install occupancy sensors to control lighting in a number of areas
6. Reduce domestic hot water temperature
7. Replace existing light fittings in a number of areas with more energy efficient fittings and controls
8. Improve control of student room, electric panel heaters
9. Replace gas boilers with modern units
10. Install solar water heating to provide hot water requirements

High Holborn Hall:
Lighting efficiency = (T8 to T5)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Butler's Wharf:
Lighting efficiency = (T8 to T5)
Domestic Hot Water = (restrictors to reduce flow)
Heating system = (boiler upgrade, heating controls)
Fabric/glazing upgrade = (ext walls, roof, windows all to Part L 2010)

Appendix 8-3 – Project Roof Maintenance Work

20 Kingsway
The asphalt deck to the roof to the first floor is cracked and crazed and the solar reflectant paint is worn. It is also unlikely that the roof has any insulation. Allow to recover the roof in due course and upgrade to current building regulations standards.
£1,500

Clement House
The main asphalt roof has a worn solar reflective covering. There is some minor rucking and splitting in isolated areas. To the section of roof over the access stairs there more significant splits. Allow in due course to repaint the roof with a solar reflective covering and carry out isolated repairs. Regular inspections should be carried out. When the roof is next recovered allow to provide insulation.
£6,000

Connaught House
Main Roof. To the main roof there is no insulation below the asphalt covering. The solar reflectant paint is in a reasonable condition. However, there is cracking to the upstands. We understand that there have been a number of previous leaks to the roof. Allow to carry out a thermographic scan. Costs allowed to replace the roof covering and consideration should also be given to providing insulation to improve its thermal efficiency.
£52,000

Connaught House
The asphalt covered dormers have a number of significant cracks which can allow moisture to enter the building. Allow to re-cover/ repair the dormers and consider upgrading the insulation to improve the thermal efficiency of the building. The cost is high due to the scaffolding required.
£30,000

Cowdray House
The asphalt from over J404 is blistered and in areas has slumped, allow to recover in improve the insulation to current standards in due course.
£1,500

Peacock Theatre
The asphalt roofs could not be directly inspected, although from the very distant inspection from the Old Building, there would not appear to be solar reflectant coverings. It is also unlikely that there is any insulation. There is no evidence of any significant leaks internally.
£15,000

St Clements
To the front of the building is a asphalt gutter with solar reflective paint. The gutter is cracked and crazed and will require relaying in due course. At this time insulation should be provide to current standards.
£10,000

The Old Building
The asphalt deck to the roof outside A618 has some minor slumping to upstands and in the long term some repairs will be required to the upstands. The roof also does not appear to be insulated and when recovered insulation should be provided and the falls increased to prevent the ponding currently seen.
£6,000

Tower 1
The asphalt covered roofs and stairs have solar reflective film covering. There is minor cracking and crazing to the finishes. There does not appear to be any insulation under the asphalt. In due course allow to carry out some patching. In the very long term consider relaying the roofing and providing insulation to current standards.
£37,500

Tower 2
The asphalt covered roofs and stairs have solar reflective film covering. There is more significant blistering in areas than to tower 1. There does not appear to be any insulation under the asphalt. In due course allow to carry out some patching. In the very long term consider relaying the roofing and providing insulation to current standards.
£15,000

Tower 3
The asphalt covered roofs and stairs have solar reflective film covering. There are some areas of blistering to the roof coverings.. There does not appear to be any insulation under the asphalt. In due course allow to carry out some patching. In the very long term consider relaying the roofing and providing insulation to current standards.
£20,000

Clare Market
The asphalt roofs are cracked and crazed and is starting to reach the end it economic life. The flashing to The Anchorage is poor. It is also unlikely that there will be any insulation to these roofs.
£156,000

East Building
There are a number of small flat roofs to parapets and balconies. There is evidence of moisture ingress to a number of rooms below these areas and significant repairs will be required. These should include improving the insulation within the roof.
£40,000

East Building
To the other asphalt roofs, there are at present, small isolated areas of damage which can be patched repaired. This is likely to be an ongoing maintenance issue. It is also noted that there is a lack of solar reflective materials to the finishes and these should be provided in improve the life expectancy of the roof coverings. There is no insulation at present and when they require recovering then this should be provided.
£50,000

George IV Pub
The lead roofs, gutters and dormers are starting to reach the end of their economic life and some repairs and replacement are required. (We understand that there have been a number of previous leaks). There is also no insulation to this roof at present. Consider when the roof require replacing to upgrading the insulation.
£50,000

Kings Chambers
The lower asphalt roof does not have a solar reflective coating but generally appears satisfactory. However as part of the M&E works a condensing unit will be placed on the roof. At this time, given the age of the building, consideration should be given to replacing the roof covering and providing insulation. Handrails will also be required.
£5,000

Lincoln Chamber
The asphalt roof does not have a solar reflectant coating. There are a number of cracks and some rucking. Allow to replace in due course and provide insulation to meet building regulations requirements.
£3,000

Sports Ground
Carry out renewal of all waterproof coverings to the front elevation balcony flat roof area, including all upstands and flashings and upgrade insulation to current standards. Provide patio/paving slab surface as this area is used as a public viewing area.
£6,000

Sports Ground
Carry out insulation works to the pitched areas
£800

Sports Ground
Carry out renewal of all waterproof coverings to the Workshop building flat roof area, also the flat roof to the 1st floor flat, including all upstands and flashings and upgrade insulation to current standards.
£9,000

Total: £514,300

Appendix 8-4 – Travel Data

Appendix 8-5 – Water Data

Appendix 8-6 – Detailed Waste Data for Academic Year 2008/09

These figures have been used in the calculations of tCO2

Type of Waste for Academic Year 08/09	Disposal Method	Tonnes	%	Calculating the breakdown of mixed recycling (1)		Mixed Recycling	Type of Waste	% of waste type	Tonnes CO_2
non segregated waste and non recyclables	Landfill	1,471	60.0%				1,471	60%	260.2
mixed recycling (plastics, glass, coated paper, tins, glass)(1)	N/A	443	18.0%					0.0%	
cardboard and paper	Recycled	207	8.4%				207	8.4%	-147.3
construction recycled (one project)	Recycled	82	3.3%				82	3.3%	-21.3
glass	Recycled	51	2.1%	51	51%	224.1	275	11.2%	-86.6
furniture	Recycled	36	1.5%				36	1.5%	-9.2
paper	Recycled	24	1.0%	24	24%	107.1	131	5.4%	-93.7
plastic bottles and cans	Recycled	24	1.0%	24	24%	106.5	131	5.3%	-196.0
confidential waste	Recycled	21	0.8%				21	0.8%	-5.4
construction landfill (one project)	Landfill	21	0.8%				21	0.8%	3.6
food	Composting	20	0.8%				20	0.8%	0.6
clothes	Reuse	11	0.4%				11	0.4%	-41.3
mixed reuse	Reuse	10	0.4%				10	0.4%	-2.7
IT equipment	Reuse	8	0.3%				8	0.3%	-2.1
sanitary waste (2)	Landfill	7	0.3%				7	0.3%	1.3
scrap metal (3)	Recycled	5	0.2%				5	0.2%	-6.4
WEEE	WEEE	4	0.1%				4	0.1%	7.7
hazardous waste - construction	Recycled	3	0.1%				3	0.1%	-0.8
wood	Recycled	2	0.1%				2	0.1%	0.5
oil	Recycled	1	0.0%				1	0.0%	0.1
cardboard	Recycled	1	0.0%	1	1.11%	4.9	6	0.2%	-4.3
fluorescent lamps	Recycled	1	0.0%				1	0.0%	-0.3
wood pallets	Reuse	1	0.0%				1	0.0%	0.2
cartridges	Recycled	1	0.0%				1	0.0%	-0.2
TOTAL		2,453	100.0%				**2,453**	**100%**	**-343.5**

(1) in order to more accurately assign carbon emission factors to the (mixed recycling group the proportions of these groups have been used to divide the total amount by waste type
(2) Assume landfill
(3) Assumed ferrous metal.