University of Oxford Carbon Management Strategy

FINAL VERSION

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Revisions Table

Rev No	Comments	Checked by	Approved by	Date
1	Draft for initial feedback	Kevin Couling	Stephen Ward	2/8/10
2	Revisions following comments from Pro Vice Chancellor for Planning and Resources, Head of Environmental Sustainability and Energy Manager.	Kevin Couling	Stephen Ward	17/9/10
3	Revisions following further comments from client	Kevin Couling	Stephen Ward	13/10/10
4	Revisions following Sustainability Steering Group meeting of 22/10/10	Kevin Couling	Stephen Ward	27/10/10
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Executive Summary

Background and Approach

In August, 2009, AECOM was commissioned to assist the University of Oxford ('the University') in designing a strategy to address the management of its environmental impacts. The commissioning of this work resulted from a combination both of statutory drivers and the desire amongst the University population to take a more strategic approach to sustainability. The work consisted of three phases and associated outputs, namely:

- Phase 1: Sustainability Baseline Report, addressing environmental impacts and drivers for sustainability, as well as engaging with key stakeholders
- Phase 2: Carbon Management Strategy (this document)
- Phase 3: Sustainable Water Management Strategy and Sustainable Waste Management Strategy

Purpose and Scope

This Carbon Management Strategy defines the steps that the University has taken and will take in the future to achieve a reduction in its CO_2 emissions. [1] The Implementation Plan (chapter 5) outlines a strategy and a roadmap for the University's actions with regards to carbon management over the next ten years and beyond. Overall, the Carbon Management Strategy aims to bring all aspects related to energy and carbon management under a common focus and provide a formal and practical basis for communicating, seeking approval for and implementing a plan to reduce CO_2 emissions.

This document focuses on what are known as scope 1 and scope 2 emissions. Scope 1 emissions are defined as direct emissions that occur from sources owned or controlled by the University, for example emissions from combustion in University-owned boilers, furnaces and vehicles. Scope 2 emissions are defined as those arising from the generation of purchased electricity consumed by the University. The reason for focussing on these is that the Higher Education Funding Council for England (HEFCE) requires universities to set targets for reduction of scope 1 and 2 emissions, and scope 1 and 2 also represent the emissions the University has most control over.

The University is also taking steps to address scope 3 emissions, which are those that are a consequence of the activities of the organisation, but occur from sources not owned or controlled by the organisation. These sources include waste, water, procurement, and travel by staff both for commuting and for work. The University is developing strategies to increase the sustainability of the management of its waste generation and water use. This document should be considered in the context of these other strategies. This strategy also sets out some targets and actions for dealing with scope 3 emissions.

The scope of this strategy does not include the Colleges. This is because the key external drivers for the University to reduce its CO_2 emissions exclude the Colleges' emissions from the University's obligations. However, the University works closely with the Colleges to address many areas of common initiative, including sustainability.

Drivers and Risks

Aside from the moral imperative to reduce CO_2 emissions, the key drivers for the University to reduce its CO_2 emissions are as follows:

- HEFCE funding requirements
- Energy costs and energy security.
- The Carbon Reduction Commitment Energy Efficiency Scheme (CRC)
- Reputational risk

[1] CO_2 figures in this report are in terms of CO_2 "equivalent" emissions, that is they allow also for the emissions of other greenhouse gases stemming from the production and supply of electricity and fossil fuels.

Strategic Objectives

The five strategic objectives for this carbon management strategy, which *act to suppor*t the delivery of the University Strategic Plan and Estates Strategy, are as follows:

- To deliver a significant and commensurate reduction in its CO_2 emissions in line with its mission of sustaining excellence and its objective of making significant contributions to society.
- To follow an energy hierarchy in seeking to first implement cost effective measures to reduce energy use, then to use energy efficiently, but also to develop low carbon and renewable sources of energy where appropriate.
- To reduce energy use and carbon emissions from laboratory related activities, whilst safeguarding the primary requirement of the University to be able to carry out its academic research at the highest level.
- To engage and work in partnership across the University and Colleges, with staff and students, and with wider stakeholders to develop solutions for reducing the University's CO_2 emissions
- To take a whole life approach to assessing the carbon and cost benefits of carbon reduction measures, as well as considering future fuel supply security and sustainability

Targets

These are as follows:

- To reduce scope 1 and 2 CO_2 emissions to 11% below the 2005/6 baseline by the end of the academic year 2015/16 and to 33% below the 2005/6 baseline by the end of the academic year 2020/21.

The impact of this target is summarised in the graph below. The graph illustrates that the University's carbon emissions have risen sharply over the last five years.

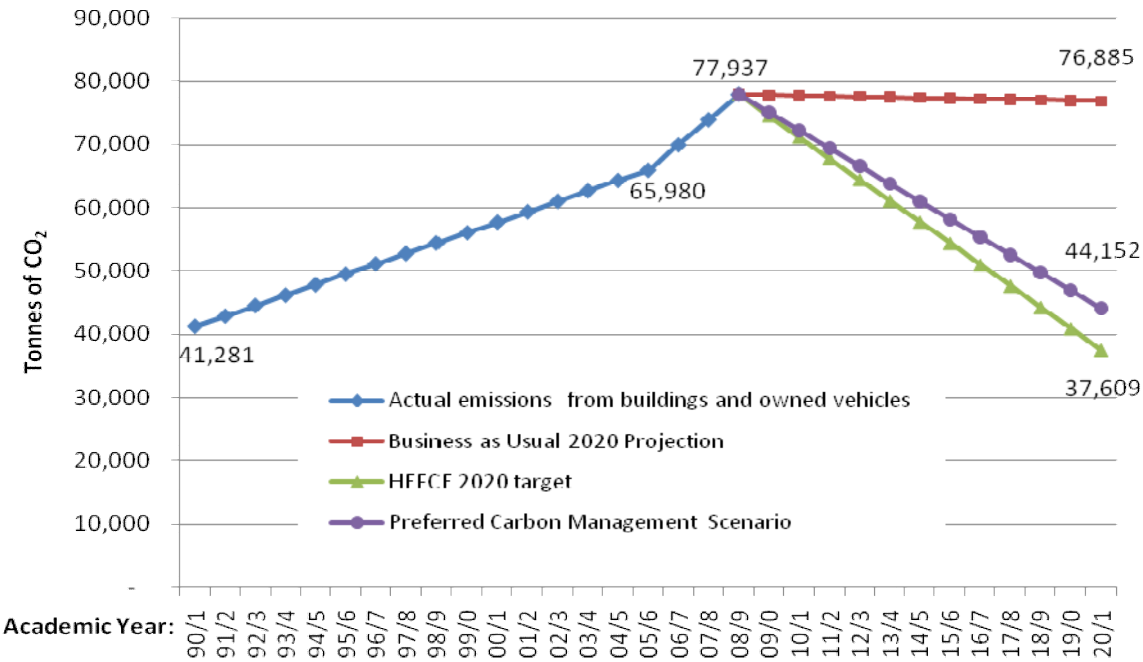

Figure 1: The trend in the University's scope one and two CO_2 emissions since 1990/1, using data from three years: 1990/1, 2005/6 and 2008/9. The figure also shows the Low Growth Business as Usual projection (76,885tCO_2 in 2020), the necessary trends to achieve the 2020/1 sectoral target from HEFCE (43% below 2005/6 by 2020, or 37,609tCO_2) and the University's chosen 2020 target of 33% below 2005/6 (44,152tCO_2), 'the 'Preferred Carbon Management Scenario'. The Business as Usual emissions are lower in 2020 than in 2008/9 due to the use of a lower emissions factor for electricity, which outweighs the fact that the projected electricity consumption in 2020 is 24% higher than for 2008/9.

In terms of scope 3 emissions, the targets (as set out in the University's Sustainable Travel Plan) are:

- To reduce the percentage of staff that usually travel to and from work by car from 23% to 18%, by 2012.
- To increase the percentage of staff that travel to and from work using alternative methods of travel (walking, cycling and public transport) by 5%, by 2012
- To monitor business air travel and develop an air travel reduction strategy.

Key Carbon Reduction Opportunities

The strategy sets out a number of options for reducing energy demand, covering both measures to reduce the energy demand from building services, as well as laboratory related energy use, which is responsible for a significant proportion of the University's carbon footprint. These measures include both technical as well as behaviour change interventions.

The strategy also identifies two potential opportunities for low carbon energy supply that could provide significant carbon reductions. These are gas engine Combined Heat and Power (CHP) for the Science Area, and medium to large scale wind power on more rural sites. Exploring the latter forms a key part of the Implementation Plan, although, due to the uncertainties involved in realising such an option, it has not been included in the carbon reduction target.

The potential carbon and energy cost savings of the plan are significant. If all of the opportunities identified in the plan were fully implemented, the annual CO_2 saving would be nearly 33,000 tonnes, potentially saving up to £3.5 million per year by 2020, compared to current energy costs. This would equate to saving around 23% on the University's £15M annual energy bill. This could potentially be further enhanced if the large wind project suggested in the strategy is also realised.

Strategic Enabling Actions

This strategy sets out nine strategic enabling actions that will facilitate the delivery of the carbon management plan. These actions are in the following areas:

- Financing of the implementation plan. A key recommendation is that **a budgetary envelope of £14.6 million** (in 2010 prices, excluding VAT) should be created to provide funding for carbon reduction measures up to 2020.

- Procurement of services and management of contractors
- Linking carbon reduction in new and existing buildings
- Incentivising energy and carbon reduction
- Communication, monitoring and feedback
- Devolving targets
- Leadership for behaviour change
- Student engagement
- Facilitating the Green Desktop Computing Initiative (GDCI)

Governance and Monitoring

Whilst ultimate responsibility for ensuring the delivery of the objectives in the Implementation Plan set out in this carbon management strategy lies with the Pro-Vice-Chancellor for Planning and Resources, the Plan will be delivered by the University's Sustainability Team.

Aside from the data provided to HEFCE through the Estates Management Statistics System, data on scope 1 and scope 2 emissions will be compiled annually by the Energy Manager and reported to the Head of Environmental Sustainability.

The energy use data and the evaluation of CO_2 reduction measures will be compiled into a monitoring report to be presented to the Sustainability Steering Group (SSG) for approval to fit in with budgetary cycles, before being made available on the Sustainability Team's website as part of a broader environmental sustainability report. This monitoring report will also report progress against targets in the Sustainable Travel Plan, as part of tackling scope 3 emissions.

Contents

1. Introduction

1.1. Purpose

This Carbon Management Strategy defines the steps that the University has taken and will take in the future to achieve a reduction in its CO_2 emissions. The Implementation Plan outlines 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 and provide a formal and practical basis for communicating, seeking approval for and implementing a plan to reduce CO_2 emissions.

This document focuses on what are known as scope 1 and scope 2 emissions.[2] Scope 1 emissions are defined as direct emissions that occur from sources owned or controlled by the University, for example emissions from combustion in University-owned boilers, furnaces and vehicles. Scope 2 emissions are defined as those arising from the generation of purchased electricity consumed by the University.[3] The reason for focussing on these is that the Higher Education Funding Council for England (HEFCE) requires Universities to set targets for reduction of scope 1 and 2 emissions, and scope 1 and 2 also represent the emissions the University has most control over.

The scope of work to date, in terms of the analysis of energy use and resulting CO_2 emissions, has not included the Colleges. This is because the key external drivers for the University to reduce its CO_2 emissions (CRC requirements and HEFCE targets – see section 2.1.1) exclude the Colleges' emissions from the University's obligations. However, the University works closely with the Colleges to address many areas of common initiative, including sustainability. The Colleges are represented on the University's Sustainability Steering Group (see section 7), amongst other forums for communication and cooperation.

This Carbon Management Strategy should be considered alongside the strategies that the University has in place to address sustainable waste management and sustainable water management. The focus in this scope of work on energy, water and waste should not be taken to suggest that the University does not consider it important to address other aspects of sustainability included in its Environmental Sustainability Policy, such as biodiversity and procurement. However, the University's current approach and performance in these areas do not present risks which require urgent action in this area, whilst such action is considered necessary in the areas of energy, carbon, waste and water.

Aspects of sustainability such as biodiversity and procurement are to a certain extent covered by other initiatives and work being carried out by the University, such as the University's target of achieving BREEAM 'Excellent' (see section 2.1.3) on new capital projects. This BREEAM target will mean that a high level of sustainability will be targeted in other areas aside from CO_2, such as ecology and community engagement.

1.2. Structure

Chapter 2 of this document presents the Carbon Management Strategy, including the drivers that have resulted in the compilation of the Strategy and the strategic objectives and targets. **Chapter 3** presents robust baseline data on the University's energy use and resulting CO_2 emissions and projects CO_2 emissions to 2020. **Chapter 4** presents the analysis of options for carbon reduction measures, the cost benefit analysis, the Marginal Abatement Cost Curves and the target carbon reduction scenarios. **Chapter 5** is the proposed implementation plan to meet the targets, including considerations of how the plan will be financed. **Chapter 6** considers some strategic enabling actions that the University will take in order to facilitate the realisation of the initiatives in the implementation plan. **Chapter 7** considers aspects of governance and monitoring in relation to carbon management and who will have responsibility for delivering the initiatives.

[2] This classification was developed by the World Resource Institute.
[3] Scope 3 emissions cover all other indirect emissions that are a consequence of the activities of the University, but occur from sources not owned or controlled by it, such as commuting and procurement.

Appendix I presents the full data that went into the Marginal Abatement Cost Curves. **Appendix II** presents detailed analysis of the District Combined Heat and Power System for the Science area. **Appendix III** presents detailed analysis of the energy supply options. **Appendix IV** provides a detailed implementation plan for achieving the target CO_2 reduction scenario. **Appendix V** provides a strategy for reducing laboratory user energy demand. **Appendix VI** outlines the emissions factors used in this document. **Appendix VII** provides a summary of the CRC Energy Efficiency Scheme. **Appendix VIII** outlines legislation related to fugitive emissions from refrigerants.

1.3. Background

In August, 2009, AECOM was commissioned to assist the University in designing a strategy to address the management of its environmental impacts. The commissioning of this work resulted from a combination both of statutory drivers and the desire amongst the University population to take an increasingly strategic approach to sustainability. The work so far has consisted of two phases, which are described below.

Phase 1: Sustainability baseline report

The output of Phase 1 of this process was a Sustainability Baseline Report focussing on the following:

- compilation of a robust data set of the University's energy use, CO_2 emissions, water use, and waste generation in 2008/9, to serve as a baseline;
- assessing key statutory and voluntary drivers for the University in relation to reducing energy use and CO_2 emissions; and
- engaging with key stakeholders across the University to understand their aspirations with regard to sustainability, as well as their views on key barriers and opportunities in relation to reducing CO_2 emissions from energy.

Phase 2: Carbon management strategy

Phase 2 of the work, of which this document is the result, involved developing a Carbon Management Strategy for the University that meets the requirements of HEFCE and sets out a strategy for meeting the University's own objectives in this area. This document was prepared in close consultation with the University's Sustainability Team, signed off by the Director of Estates and the Pro Vice Chancellor for Planning and Resources and approved by the Sustainability Steering Group, Buildings and Estates Sub Committee, Planning and Resources Allocation Committee and Council.

The main elements of Phase 2 were:

- Compilation and verification of the opportunities available to the University to reduce CO_2 emissions, covering:
  - technical/infrastructural interventions to reduce demand;
  - behavioural interventions to reduce demand;
  - technical/infrastructural interventions to reduce the CO_2 intensity of the energy that the University uses ('supply-side' interventions).
- Presentation of the three opportunity types alongside each other in a Marginal Abatement Cost Curve, allowing for the lowest cost combination of measures to achieve different levels of CO_2 reduction to be identified and thus for the University to make a decision on targets for reduction in CO_2 emissions.
- Designing a strategy to deliver the target CO_2 reduction chosen by the University in the most cost-effective manner.

Phase 3: Sustainable Water Management Strategy and Sustainable Waste Management Strategy

At the time of writing, these documents were still being compiled. They will outline measures to reduce the environmental impact of the University's waste stream and to reduce the amount of potable water the University uses.

The main elements of this stage are:

- Surveys of the University's top 10 waste generating buildings and of the top 10 water using buildings
- Email survey of all building managers
- Opportunity identification
- Target setting

1.4. Staff and student engagement during strategy preparation

Developing this Carbon Management Strategy involved an extensive process of staff and student engagement. Individual meetings were held with all Divisional Heads and a number of staff members in Estates Services.

In January 2010, an Environmental Strategy Workshop was held with around 25 stakeholders and interested parties from the University population to present and discuss the findings of the Sustainability Baseline report. Attendees demonstrated a high level of engagement in analysing the University's impacts. Suggestions and opinions on feasible means to reduce the University's CO_2 emissions were solicited and discussed. A key outcome of the facilitated discussions was that there appeared to be significant motivation amongst the research population to reduce laboratory-related energy use, and willingness to change working practices accordingly. This suggested that significant scope exists for a programme of technical and behavioural initiatives designed to reduce laboratory related energy use.

In June 2010, two focus groups were held with building users at the University's two highest CO_2-generating buildings. At the focus groups, 23 research staff and students took part in facilitated discussions and identified measures to reduce laboratory energy use (see section 5 for more on laboratories).

1.5. Introduction to the University of Oxford

Oxford has an international reputation for the excellent standard of its teaching and research. Today more than 20,000 students from a diverse range of backgrounds and nationalities benefit from Oxford's resources and unparalleled facilities.

The University estate (not including the Colleges) has grown in floor area by 36% over the last 10 years and now comprises over 542,000 square metres of space, and 240 buildings, including:

- specialist research buildings;
- teaching laboratories and lecture halls;
- sports facilities;
- libraries and museums of international standing;
- administrative and ceremonial buildings; and
- graduate accommodation.

2. Carbon management strategy

2.1. Introduction

This chapter outlines the Strategy that the University will employ to manage and reduce the CO_2 emissions for which it is responsible. Covered in this chapter are the drivers that have contributed to the creation of this Strategy and the strategic objectives and targets that the University has in place.

As with many areas of sustainability, drivers for carbon management and the resulting areas requiring action are wide ranging, disparate and variable. Thus, the manner in which the sustainability agenda influences activities in the higher education sector is rarely coherent, covering internal and external, academic and administrative, financial and moral, professional and personal aspects of University life.

The trend toward disclosure and incentive-based regulation means that the University will face increasing financial and reputational risk from poor performance on carbon management. The following sections present the University's conception of the drivers for carbon reduction, the cumulative effect of which presents a significant financial and reputational risk to the University.

This Strategy is an opportunity for the University to communicate with its population around a positive and forward facing goal, and to demonstrate leadership in sustainability in the higher education sector by robustly and clearly addressing this complex issue.

2.1.1. Legislative and fiscal drivers

The Higher Education Funding Council for England (HEFCE)

HEFCE has stated it is planning to link the amount of funding allocated to specific institutions to their performance on carbon management, through the Capital Investment Framework. Exactly how HEFCE will make this link has not yet been established, however, some means of assessing progress against carbon management targets is expected to be in place by 2011. HEFCE has suggested that data will be collected through the existing Estates Management Statistics collection system. [4]

In line with Government targets, [5] HEFCE has proposed that the Higher Education sector commits to reducing its CO_2 emissions from stationary energy and owned vehicles by 43% by 2020 against a 2005/6 baseline. [6]

The University's 2005/6 CO_2 emissions from stationary energy and owned vehicles were 65,980tCO_2, the 2020/1 target of 43% less than this is 37,609tCO_2; emissions in 2008/9 were 77,937tCO_2. Roughly speaking, over the last five years the University's CO_2 emissions grew by a quarter; to meet HEFCE targets, in the next ten years they would need to reduce by a half (see chapter 3 for more detailed data on the University's CO_2 emissions).

HEFCE has stated that they recognise the significant diversity of the HE sector with its range of missions, priorities, histories, subject mix, infrastructure and research; they ask that institutions set targets and develop plans that are appropriate to individual circumstances, but within the

[4] *Consultation on a carbon reduction target and strategy for higher education in England*, HEFCE, July 2009: p19.

[5] *The UK Low Carbon Transition Plan* July 2009. Government targets are actually a 34% reduction against a 1990/1 baseline. However, as many institutions do not have robust data for their 1990/1 CO_2 emissions, HEFCE have proposed that the baseline year for CO_2 reduction targets should be 2005/6. HEFCE have stated that, considering the growth in emissions of the sector as a whole since 1990/1, a reduction of 34% against a 1990/1 baseline is equivalent to a reduction of 43% against a 2005/6 baseline.

[6] *Consultation on a carbon reduction target and strategy for higher education in England*, HEFCE, July 2009: p19.

national target framework. These targets will be collated through the next Capital Investment Framework to determine whether collectively they are sufficient to meet the sector target. [7]

HEFCE has indicated that, rather than only using an absolute CO_2 reduction target, they may also employ a metric to take into consideration CO_2 emissions relative to income. [8] HEFCE requires all Universities to have a Carbon Management Strategy in place by the end of 2010, and guidance is provided on what the strategy should include. [9]

Energy costs

As the UK's reserves of North Sea oil and gas run out, the Government predicts that up to 60% of our gas could be imported by 2020. Therefore, the UK is going to become increasingly reliant on imported fossil fuels, which in turn will increase our exposure to global energy price increases and fluctuations. As many of our power stations are gas powered, this means that electricity will also be subject to these price fluctuations.

Many of the measures outlined in this strategy will serve to reduce the University's susceptibility to this by reducing energy demand and increasing the University's ability to generate its own energy.

The potential carbon and energy cost savings of the plan are significant. If all of the opportunities identified in the target scenario set out in section 4.3.3 were to be fully implemented, the annual CO_2 saving could be nearly 33,000 tonnes, potentially saving up to £3.5 million per year by 2020, compared to current energy costs. This would equate to saving around 23% on the University's £15 million annual energy bill. This could potentially be further enhanced if the large wind project suggested in the strategy were also realised, which could provide an additional £900,000 annual revenue from reducing grid electricity purchase and benefiting from the Feed in Tariff for renewable electricity generation.

The Carbon Reduction Commitment Energy Efficiency Scheme (CRC EEC)

Annually from April 2012, the University will have to 'buy' carbon allowances at £12 for every tonne of CO_2 forecasted to be emitted as a result of its stationary energy use in the following 12 months. Based on the University's energy use from April 2008 to March 2009, which generated 68,718tCO_2, this amounts to £824,620.

Prior to October, 2011, the original scheme proposal was that each year the Government would 'recycle' all revenue generated by the sale of allowances back to the participating organisations. In 2012, each organisation involved would have received between 90% and 110% of the total they spent on allowances. [10] How much money each organisation receives in the recycling payment would have depended on its position in a publicly available league table containing all organisations in the CRC.

However, in the Comprehensive Spending Review statement of October, 2010, the Government stated (in para. 2.108) that:

"the CRC Energy Efficiency scheme will be simplified to reduce the burden on businesses, with the first allowance sales for 2011-12 emissions now taking place in 2012 rather than 2011. Revenues from allowance sales totalling £1 billion a year by 2014-15 will be used to support the public finances, including spending on the environment, rather than recycled to participants. Further decisions on allowance sales are a matter for the Budget process. "

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[7] Ibid

[8] *Consultation on a carbon reduction target and strategy for higher education in England*, HEFCE, July 2009: p21.

[9] *Carbon management strategies and plans - A guide to good practice* HEFCE January 2010

[10] As an example, if the University has emissions of 100 tonnes of CO_2 in 20011/12 and the total emissions from all participants in 2011/12 is 10,000 tonnes then the University's share is 1%. The basis for each future recycling payment to the University will therefore be 1% of the total revenue raised from the annual sale or auction of allowances each year. This is then adjusted by a bonus or penalty payment based on the University's position in the league table. The higher the University's position in the table, the bigger the bonus payment.

This suggests that the financial impact of the CRC EEC on Oxford University could be significantly greater than originally envisaged. However, at the time of writing, the precise details of the changes to the CRC EEC have yet to be announced or published.

The European Union Emissions Trading Scheme (EU ETS)

The EU ETS covers a large proportion of the natural gas use in the University's Science Area. The scheme is not considered to be a strong driver for the University CO_2 reduction, as the University is not currently using all of the allowances it is allocated under the scheme, and therefore is in a position to sell, rather than have to buy allowances. For example, in 2009, the University only used 61% of its allowances. The surplus will be sold and the proceeds invested in carbon reduction measures. The large allocation of allowances is primarily because, as insufficient historical consumption data was available, a proportion of the allowances allotted were calculated based on installed boiler capacity, which significantly exceeds heat demand in several buildings.

For the University, the main effect of the EU ETS is to reduce the liabilities that the University has under the CRC (see above), as emissions covered by the EU ETS are excluded from the CRC.

Government non-domestic buildings targets

The Government Budget 2008 announced the Government's ambition that all new non-domestic buildings should be zero carbon from 2019, with associated interim targets expected to be announced.

The exact definition of zero carbon is currently out for consultation, but meeting the requirement is likely to involve a combination of energy conservation, low carbon energy, and initiatives such as investment in offsite low carbon energy or similar [11] (referred to as 'allowable solutions').

Oxford City Council renewables requirement

Oxford City Council's Natural Resource Impact Analysis puts in place the relatively demanding target of requiring new building projects greater than 10 units (or 2000m²) to have 20% of their energy provided through on-site generation using renewable and low carbon technologies.

2.1.2. Reputational risk

The University press office receives many queries from student journalists and private individuals asking about the University's environmental performance, often requesting information under the Freedom of Information Act. This is an important issue for many students and academics carrying out research in this area. There is a reputational risk if the University does not take further steps to set targets, proactively manage its environmental impacts and communicate challenges and achievements to staff and students.

Green league

The Green League is an annual ranking of universities according to environmental performance by student environmental organisation People and Planet. Amongst the many criteria that contribute to an institution's ranking, the Green League awards points for annual reductions in CO_2 emissions per full-time equivalent staff member or student. Points are also awarded based on the percentage CO_2 reduction target that universities aim to achieve over a five-year period.

The Green League attracts publicity, and is covered in the national press and therefore represents a potential reputational risk and/or opportunity to the University.

[11] *Zero carbon for new non-domestic buildings: Consultation on policy options*. Department for Communities and Local Government, November 2009.

Table 1 below shows that the member institutions of the Russell Group of research intensive universities were spread throughout the rankings of the 2009 Green League.

Table 1: The rankings of the Russell Group Universities in *People and Planet's Green League 2010*

	Rank
University of Edinburgh	13
London School of Economics & Political Science	15
University of Bristol	32
University of Birmingham	34
University of Glasgow	43
University College London	48
University of Liverpool	61
University of Southampton	63
University of Warwick	65
University of Manchester	65
Cardiff University	77
University of Sheffield	86
University of Cambridge	89
University of Oxford	89
Imperial College London	101
Newcastle University	104
King's College London	113

2.1.3. Existing energy-related strategies and initiatives

This section considers documents and mechanisms already in place to achieve the energy-related targets set out in the University's *Environmental Sustainability Policy 2008.*

Energy management strategy and implementation plan

The University's *Energy Management Strategy and Implementation Plan* (October 2008) discusses financial and legislative drivers to reduce energy use and summarises past and present actions taken to achieve energy reductions. The University's commitment to reduce CO_2 emissions in line with government targets is stated, and strategies to be adopted to meet these targets are outlined under the following headings:

- Formation of a new Environmental Sustainability group
- Energy procurement
- Maintenance procedures and replacements
- Promotion and publicity
- Management and accountability

Energy conservation levy fund

The University's *Energy Management Strategy and Implementation Plan* (October 2008) set up the Energy Conservation Levy Fund that applies a levy of £0.01/kWh to most stationary energy consumption. This is raising approximately £180,000 a year to be spent on energy conservation projects, and applications for the funding are solicited from the University population.

Buildings energy surveys

Between June and September 2008, energy surveys were carried out for the University's 23 highest energy using buildings, which account for over 50% of the University's energy use. This process identified opportunities which if implemented could reduce the University's CO_2 emissions by approximately 3,993tCO_2 per year. This information is being used to inform decisions to use the funding secured from Salix (see below), and was also fed into the Marginal Abatement Cost Curve calculations (see section 4.3).

HEFCE & Salix finance revolving green fund

The University was awarded £400,000 from the HEFCE & Salix Finance Revolving Green Fund in January 2009, which it matched with a further £100,000, for the creation of a revolving investment fund for CO_2 reduction. This money will stay with the University for 15-20 years, and be invested in energy conservation projects with any resultant savings reinvested in further projects. The initial funding will then be repaid.

Most of the funding is being invested in one building, the Henry Wellcome Building of Genomic Medicine, so that the resultant energy savings can be readily tracked. The technology being installed is heat recovery on ventilation and chillers, and more efficient fans in the air-handling units.

New buildings

BREEAM

In their response to the HEFCE consultation on CO_2 reduction targets and strategies, the University stated that its target for all new capital projects is to achieve BREEAM 'Excellent'. The achievement of BREEAM Excellent will require new buildings to use significantly less energy [12] for 'regulated' uses, i.e. all use excluding 'processes' such as research activity, etc. As process energy use contributes significantly to total University energy use, the achievement of BREEAM Excellent will not in itself guarantee the achievement of the University's CO_2 reduction targets.

Achieving BREEAM excellent will help to ensure that a high level of sustainability is aspired to in other areas aside from CO_2, such as ecology and community engagement.

Buildings sustainability guidelines

Estates Services Sustainable Buildings Guide 2008 provides comprehensive checklists for design teams to manage the delivery of more sustainable buildings. These checklists are in the areas of energy, water, waste, materials, futureproofing, travel and biodiversity.

Energy metering

Effective energy management of an estate such as the University's requires a sophisticated energy metering strategy. Of the 390 data points compiled to calculate the University's (excluding OUP) gas and electricity use in July 2009 (the last month for which data was collected for this report), 59% were from meter readings (as opposed to bill data), accounting for 94% of all gas, water and electricity use.

Monitoring this data has allowed the Sustainability Team to identify energy wastage from human or technological error, and thus make considerable energy savings. Increasingly, departments are also installing electricity sub-meters to better understand their buildings' energy use, which

[12] More precisely, BREEAM Excellent, at the time of writing, requires new buildings to achieve an EPC rating of 40 or less.

may enable the recharging of energy use to research groups. This has the potential to provide a clearer incentive for research groups to rationalise their use of energy-intensive equipment.

Voluntary commitments

This section outlines the sustainability related commitments that the University has made voluntarily.

The University's CO_2 reduction targets

The University's publicly available *Environmental Sustainability Policy 2008* and the *Financial Statements 2008/9* state that the University has a policy of reducing its stationary CO_2 emissions in line with government targets. [13] The University's relevant CO_2 emissions have almost doubled since 1990/1; Government targets are to reduce emissions to 34% *below* the 1990/1 level by 2020/1, and 80% below by 2050/1, regardless of any growth in the size of the estate.

The University was, until recently, on track to meet these targets through purchasing low-carbon electricity (known as 'green tariffs') from its energy supplier. However, it has become clear that the government will not be taking into account the use of green tariffs when assessing the CO_2 performance of organisations, due in large part to uncertainty as to whether these tariffs actually achieve any CO_2 saving beyond that created by government regulation.

The 10:10 campaign

The University of Oxford signed up to the 10:10 Campaign in May 2010. The 10:10 Campaign is a voluntary pledge for organisations to reduce CO_2 emissions between 3% and 10% over a one-year period. The University's 10:10 target is to reduce CO_2 emissions by 3-10% between April 2010 and March 2011 (based on 2009 emission levels).

Measures that are being put in place to meet the 10:10 targets include:

- Improved energy efficiency of departmental buildings by providing £455,000 funding for 14 projects
- Revised boiler timings and replacing old boilers with efficient models
- Insulating pipework, lofts and flooring
- Installed energy efficient lamps, lighting controls and electricity sub-meters
- Rolling out energy reduction measures on IT

Staff and students have all played their part in reducing energy consumption and CO_2 emissions. By making use of the University's resources for saving energy they've been able to identify quick wins and longer term opportunities for reducing energy consumption in departmental buildings. Resources made available include:

- an Energy Toolkit;
- fact Sheets;
- Energy Toolkit monthly surgeries.

The International Alliance of Research Universities (IARU)

The University is a member of the IARU, made up of ten of the world's leading Universities. Member institutions to the IARU declare energy reduction targets, which are publicly available on the IARU website. The University has declared the targets in line with the HEFCE targets (see section 2.1.1).

[13] *The UK Low Carbon Transition Plan: National strategy for climate and energy*. July 2009

2.2. Strategic objectives and targets

2.2.1. Strategic objectives

The statement of strategic objectives frames the approach to be taken to implement measures and actions to reduce the University's CO_2 emissions and to ensure, in particular, that those actions support the delivery of the University's Strategic Plan and Estates Strategy. They are as follows:

1. **To deliver a significant and commensurate reduction in its CO_2 emissions in line with its mission of sustaining excellence and its objective of making significant contributions to society.**

   This objective recognises that as part of fulfilling its mission and key objectives the University needs to be a sustainable institution that plays its part, along with the rest of society, in taking urgent and extensive action to mitigate climate change.

   In particular, this objective will directly fulfil objective VII (g) in the University Strategic Plan, which states "*Take steps to further reduce the University's CO_2 emissions and reduce the environmental impact of all of the University's activities*". All of the remaining objectives below also work to deliver this objective in the Strategic Plan.

2. **To follow an energy hierarchy in seeking to first implement cost effective measures to reduce energy use, then to use energy efficiently, but also to develop low carbon and renewable sources of energy where appropriate.**

   This objective recognises the fact that the University is unlikely to be able to deliver the level of carbon reduction required to meet its responsibilities without considering the use and generation of low carbon and renewable energy.

   This objective also recognises that in line with the objective in the Strategic Plan to increase the financial sustainability of the University, any investment decisions should prioritise those carbon reduction measures that provide the best financial performance, as measured in whole life terms (see objective 5, below).

3. **To reduce energy use and carbon emissions from laboratory related activities, whilst safeguarding the primary requirement of the University to be able to carry out its academic research at the highest level.**

   This objective acknowledges that a significant proportion of the University's CO_2 emissions stems from energy used by laboratory research equipment, as well as from heating, cooling and lighting buildings. Feedback from stakeholders, and on-site investigations in some buildings, has suggested that there are opportunities to reduce the energy use from research activities without compromising the quality or ability to carry out research. There appears to be a willingness amongst research staff to explore these opportunities.

4. **To engage and work in partnership across the University and Colleges, with staff and students, and with wider stakeholders to develop solutions for reducing the University's CO_2 emissions.**

   This objective recognises that in order to implement many of the opportunities for reducing energy use it will require significant engagement and co-operation between departments. It also acknowledges the fact that within its academic staff and students, the University has a wealth of expertise and enthusiasm on which it can draw to implement solutions. Examples of this expertise include the Environmental Change Institute and the Smith School of Enterprise and the Environment.

   In terms of partnerships with the Colleges, there are particular opportunities in relation to identifying and developing low carbon and renewable energy sources, such as low carbon district heating or large scale wind turbines. There will also be value in the Colleges and University sharing lessons learnt and intelligence about the effectiveness of different approaches. Colleges will be able to evaluate individual University projects and decide whether they would like to co-develop them or participate.

In terms of engaging with wider stakeholders, this could involve the local authority, local industry and other bodies. An example of one area where such engagement could bear fruit is in relation to developing low carbon district heating networks across the city of Oxford.

This objective would support the delivery of a number of objectives in the Strategic Plan that relate to "Wider Engagement with Society".

5. **To take a whole life approach to assessing the carbon and cost benefits of carbon reduction measures, as well as considering future fuel supply security and sustainability.**

   This objective recognises the fact that some of the best carbon reduction measures may not be those that entail least upfront capital investment. Indeed, some of the solutions may involve significant capital investment, but may provide significant cost and carbon reduction benefits over their lifetime.

   This objective will also support the delivery of Objective VIII (d) of the Strategic Plan, which states "*Ensure that long-term financial planning incorporates full allowance for service and maintenance costs, and the sustainable replacement of assets*"

2.2.2. Targets

Defining the scope for carbon reduction targets

The accepted best practice approach to carbon management is the World Resource Institute's Greenhouse Gas Protocol (GHGP), recommended by DEFRA (2009) [14] and by HEFCE. [15] The GHGP outlines the approach that organisations should take to managing their CO_2 emissions. Central to this is the categorisation of the carbon emissions that result from an organisation's activities into three scopes; these scopes are numbered in order of the priority with which it is recommended an organisation address calculating and reducing their emissions, and are set out in **Table 2** below.

Table 2: Scopes of Carbon Emissions under the Greenhouse Gas Protocol

	Description	Examples
Scope 1 Direct Emissions	Direct emissions occur from sources that are owned or controlled by the organisation	• Direct fuel and energy use (e.g. gas or oil) • Transport fuel used in institutions' own fleet vehicles
Scope 2 Indirect Emissions	Emissions from the generation of purchased electricity consumed by the organisation	• Purchased electricity
Scope 3 Other Indirect Emissions	Emissions which are a consequence of the activities of the organisation but occur from sources not owned or controlled by the organisation	• Procurement • Commuting (both staff and students) • Water • Waste • Land based staff business travel • Staff business air travel

[14] *Guidance on how to measure and report your greenhouse gas emissions* DEFRA September 2009, accessed on 12/8/09 at http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-guidance.pdf
[15] *Carbon management strategies and plans: a guide to good practice*, HEFCE, January, 2010

The reason for the categorisation into scopes is that the majority of greenhouse gas emissions will be an organisation's scope 1 emissions. The emissions generated by the University's procurement are the scope 1 emissions of the companies that manufacture and distribute the goods or provide the services, and are therefore primarily the responsibility of those companies.

These scopes of emissions reflect how much control an organisation has over those particular emissions. For example, the University cannot affect how electricity is generated in the UK, but it can reduce how much electricity it purchases. HEFCE require institutions to set a carbon reduction target for scope 1 and 2 emissions. Similarly, the carbon emissions legislation to which the University is subject, namely the Carbon Reduction Commitment Energy Efficiency Scheme and the EU ETS only currently regulate scope 1 and 2 emissions. [16]

Targets for reduction of scope 1 and 2 emissions

HEFCE require that, by 2020/1, the Higher Education sector in England emit no more than 43% of the CO_2 it did in 2005/6. In 2005/6 the University emitted 65,980 tonnes of CO_2 (tCO_2).

HEFCE has stated that it recognises the significant diversity of the HE sector with its range of missions, priorities, histories, subject mix, infrastructure and research; it asks that institutions set targets and develop plans that are appropriate to individual circumstances, but within the national target framework. These targets will be collated through the next Capital Investment Framework to determine whether collectively they are sufficient to meet the sector target. [17]

Based on the options analysis set out in section 4 of this document, the University has set the following target:

To reduce scope 1 and 2 CO_2 emissions to 11% below the 2005/6 baseline by the end of the academic year 2015/16 and to 33% below the 2005/6 baseline by the end of the academic year 2020/21.

Based on the projections of Business as Usual emissions in 2020 (76,885tCO_2), this equates to an absolute reduction in CO_2 of 19,094tonnes of CO_2 (tCO_2) by the end of academic year 2015/16 and 32,733tCO_2 by the end of academic year 2020/21.

The following assumptions apply to this target:

- This target applies to scope 1 and 2 emissions only, i.e. from fossil fuel and electricity use directly controlled by the University, and vehicles owned by the University.
- The 2005/6 baseline is as per the one set out in this document. The choice of 2005/6 as the baseline year is in-line with HEFCE guidance. [18] The scope of the baseline is for the University only and excludes the Colleges and the Oxford University Press (OUP).
- This target is based on the assumed level of projected growth for the University set out in this document, based on the low growth scenario.
- The CO_2 saving is in terms of CO_2 "equivalent" emissions, that is it allows for the emissions of other greenhouse gases stemming from the production and supply of electricity and fossil fuels.
- In measuring progress against the target, in any reporting year the energy use and carbon emissions from space heating should *not* be degree day adjusted, but should be based on actual energy consumption for that year
- In measuring progress against the target, for any reporting year, the most recent Government guidance on the value of emissions factors for that year should be followed, [19] but the factors used for the baseline year should remain as set out in this document.
- If the University was able to implement a larger scale wind project[20] then it would seek to exceed its target of a 33% carbon reduction by 2020

[16] Note, neither the CRC nor the EU ETS currently cover emissions from transport, although it is reasonable to expect the remit of the CRC to be expanded in the near future to include emissions from vehicles owned by the organisation.
[17] *Carbon management strategies and plans - A guide to good practice* HEFCE January 2010: p19.
[18] As set out in *Carbon management strategies and plans: a guide to good practice*, HEFCE, January, 2010
[19] In the first instance, the source of these values should be HEFCE. If such guidance is not available, the source should be taken from prevailing Government guidance on company reporting of greenhouse gas emissions.

Reduction of scope 3 emissions

Staff travel

The University's publicly available Sustainable Travel Plan (contains the following targets, and these also form part of this strategy.

1. To reduce the percentage of staff that usually travel to and from work by car from 23% to 18%, by 2012.
2. To increase the percentage of staff that travel to and from work using alternative methods of travel (walking, cycling and public transport) by 5%, by 2012.
3. To monitor business air travel and develop an air travel reduction strategy.

The Sustainable Travel Plan will be updated in the near future to include information tracking progress towards these targets.

Waste and Water

Whilst it is unlikely that external requirements for targets for waste generation and water use will be in place in the near future, the University considers this an essential component of addressing its environmental impacts in line with its Environmental Sustainability Policy. The University's Sustainability Baseline Report 2008/9 includes baseline data for waste and water and at the time of writing a sustainable waste management strategy and a sustainable water management strategy are being developed and will sit alongside this document as part of the University's Sustainability programme.

Procurement

The University does not currently have sufficient information to set targets in this area, but will continue to monitor sector guidance relating to procurement emissions as it is published, with a view to setting appropriate targets in the future.

[20] i.e. in the range of 4-5MW installed capacity

3. Emissions baseline and projections

3.1. Introduction and methodology

This chapter sets out a detailed analysis of the energy used by the University from August 2008 to July 2009, and the CO_2 emissions produced from that energy use. It also considers how energy use and emissions have grown since 1990/1.

The term 'stationary energy' is used throughout this Strategy to distinguish from energy used for transport. The analysis shows that stationary energy use accounts for over 90% of the University's CO_2 emissions. Therefore, section 3.2.2 focuses on stationary energy use and assesses how it breaks down between different Divisions and buildings.

For energy, the analysis has focussed on what are known as scope 1 and scope 2 emissions. [21] Scope 1 emissions are defined as direct emissions that occur from sources owned or controlled by the University, for example emissions from combustion in University-owned boilers, furnaces and vehicles. Scope 2 emissions are defined as those arising from the generation of purchased electricity consumed by the University. [22] The reason for focussing on these is that HEFCE requires Universities to set targets for reduction of scope 1 and 2 emissions and Scope 1 and 2 also represent the emissions the University has most control over.

The figures for energy use have been converted to CO_2 emissions using the latest Government guidelines for calculating Greenhouse Gas (GHG) emissions (see appendix V). The figures presented in this chapter are all in terms of CO_2 equivalent (CO_2-e). This means that they also take account of emissions of GHGs other than CO_2 (namely, methane and nitrous oxide) during the combustion of the fuel, in the case of natural gas and fuel oil, or during the generation of electricity at UK power stations.

A member of AECOM staff was based in the University for two days a week for four months to compile the baseline data, in collaboration with staff. During this time, interviews were held with 20 University staff, both academic and non-academic. The study team also held discussions with and gave a presentation of initial results to the University's Sustainability Steering Group.

[21] This classification was developed by the World Resource Institute.
[22] Scope 3 emissions cover all other indirect emissions that are a consequence of the activities of the University, but occur from sources not owned or controlled by it, such as commuting and procurement.

3.2. Energy and CO_2 emissions baseline

3.2.1. Oxford University's 2008/9 CO_2 emissions from energy use

Figure 1 shows the University's 2008/9 CO_2 emissions resulting from stationary energy use, owned-vehicles, work-related air travel and water consumption. Total emissions were 85,916tCO_2, of which 92% resulted from stationary energy use, consisting of 67% from electricity use, and 25% from gas use.

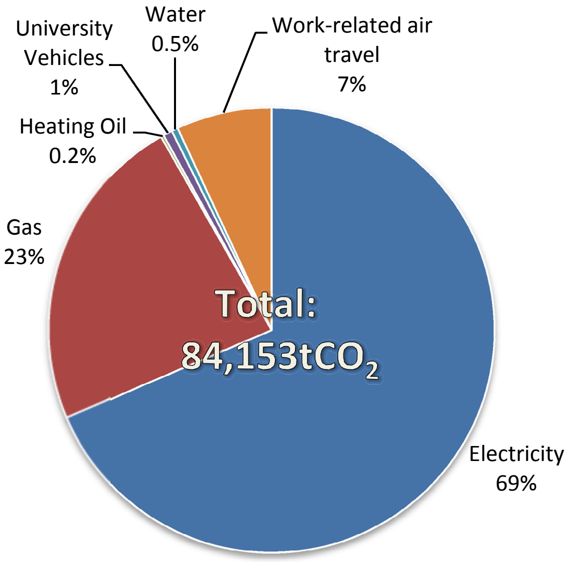

Figure 2: Oxford University CO_2 emissions resulting from consumption of electricity, natural gas, heating oil, fuel in owned-vehicles, fuel for work-related air travel [23] and water [24] in 2008/9.

3.2.2. CO_2 emissions from stationary energy use

This section explores how CO_2 emissions from stationary energy use have changed since 1990/1. There is a degree of uncertainty concerning the accuracy of the University's 1990/1 CO_2 emissions baseline. This uncertainty is due to a lack of clarity regarding which buildings were included in the baseline's scope. The baseline data included in this report is certainly the most accurate compiled to date, for example, this is the first year that energy and water use at transit and graduate accommodation sites has been included (accounting for 1.5% of total University stationary energy use).

As represented in Figure 3 below, in 2008/9, the University's scope one and two CO_2 emissions were 77,377tCO_2. For the academic year 2005/6, which is the year that is to be used as HEFCE's baseline for CO_2 reduction targets, the figure was 65,980tCO_2. Emissions from stationary energy increased 94% between 1990/1 and 2008/9; emissions in 2005/6 were 59% higher than in 1990/1 and in 2008/9 emissions were 17% higher than in 2005/6.

[23] There is some uncertainty around work-related air travel data. Data regarding departmental flights were obtained through the Sustainable Travel Officer in Estates Services.
The data was accessed from the database for the University block travel insurance policy. Each flight was entered into the *Climate Care Carbon Calculator* to estimate emissions. The estimate of the number of work-related flights can be considered to be a conservative number. Only flights registered through the University block travel insurance policy were counted, because no data is available for non-registered flights. A survey conducted by Edward indicates that up to 30% of University business flights are not registered, potentially leading to a significant underestimation of emissions. However, consensus does not exist on the correct factors for calculating CO_2 emissions from flights; other carbon calculators were compared, and figures of up to 25% lower CO_2 emissions than the *Climate Care Carbon Calculator* were found.
[24] This includes CO_2 emissions from potable water consumed and waste water treated.

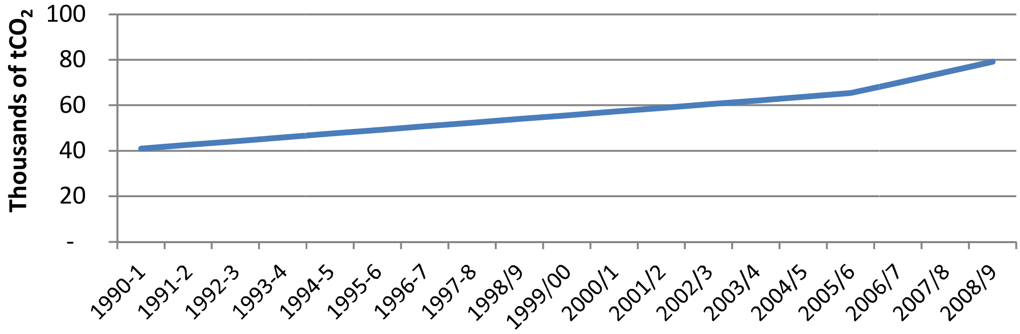

Figure 3: The University's CO_2 emissions from stationary energy use since 1990/1. Note that this graph is based on data from three academic years only: 1990/1, 2005/6 and 2008/9. [25]

In 2008/9, 106,248,059kWh of grid electricity was purchased, and approximately 19,000kWh was provided by photovoltaic cells on the new Biochemistry building. [26]

[25] Note that AECOM was provided with raw energy use data by Estates Services, with no verification of this data completed by AECOM.
[26] Figure for photovoltaic electricity provided by Jonathan Walford November 2009.

Energy use by division

This section considers how the different Divisions contribute to the University's energy use and CO_2 emissions. As can be seen in Figure 4, 45.6% of the University's stationary CO_2 emissions result from energy use in the Medical Sciences Division, with MPLS responsible for a further 31%. By contrast, Social Sciences, Humanities, Continuing Education and Administration are relatively low emitters.

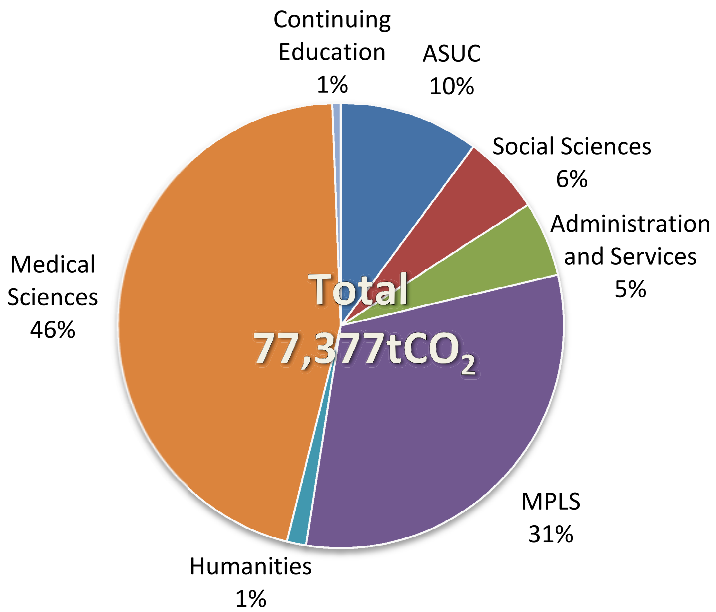

Figure 4: University CO_2 emissions by Division from electricity, gas and heating oil. [27]

Table 3: CO2 emitted, staff numbers and usable room area of the different Divisions by percentage of the University's total.

Division	% of University CO_2	Staff [28]	% Net Internal Area
Medical Sciences	45.6%	35.4%	25.2%
MPLS	31.0%	20.7%	26.9%
ASUC	10.1%	11.4%	27.1%
Social Sciences	5.7%	11.9%	7.6%
Administration	5.5%	11.5%	8.0%
Humanities	1.4%	7.8%	3.9%
Continuing Education	0.6%	1.3%	1.4%

Table 3 provides some indicators of the carbon intensity of the different Divisions' operations. Visual illustrations of these indicators of CO_2 intensity are given in the figures below.

[27] ASUC = Academic Services and University Collections (including libraries, computer services and museums), and MPLS = Mathematical, Physical and Life Sciences.
[28] Full Time Equivalent Staff

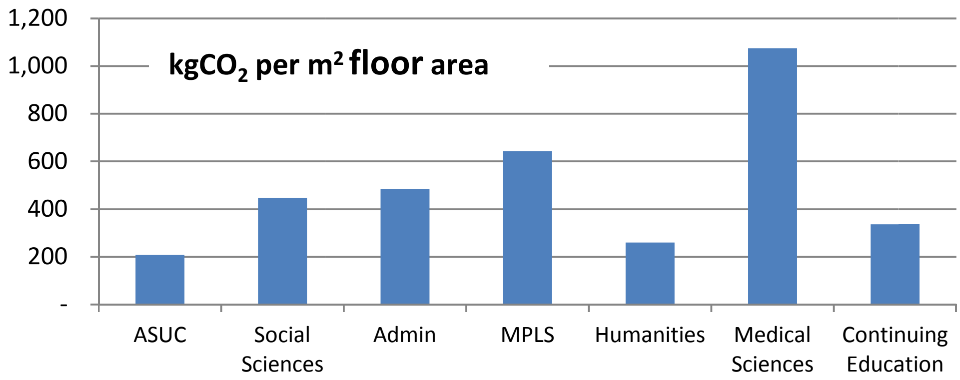

Figure 5: kgCO_2 per m^2 floor area [29] in 2008/9 broken down by Division.

Figure 5 above demonstrates that in terms of tCO_2 per m^2 of floor area, the Medical Sciences Division is significantly more carbon-intensive than any other Division. However, if the ratio of tCO_2 per full time staff member is considered (as in Figure 6), the Divisions perform quite differently, with MPLS being the most carbon-intensive Division.

The ASUC Division has a high floor area to staff ratio, as is to be expected from a Division that includes low occupation density buildings such as museums and libraries. The need to closely control the temperature and humidity in much of the museum and library areas may account for ASUC's relatively high CO_2 emissions.

Humanities, Continuing Education, Administration and Social Sciences appear to be the least carbon intensive Divisions, based on their contribution to total emissions being less than their proportion of total staff numbers and floor area. Activities in these Divisions tend to be office based, requiring relatively little process energy. The fact that Social Sciences and Continuing Education have higher carbon intensities than Humanities may be explained by the more extensive use of IT equipment in Social Sciences, and the longer hours of occupation, residential accommodation and catering facilities in the latter.

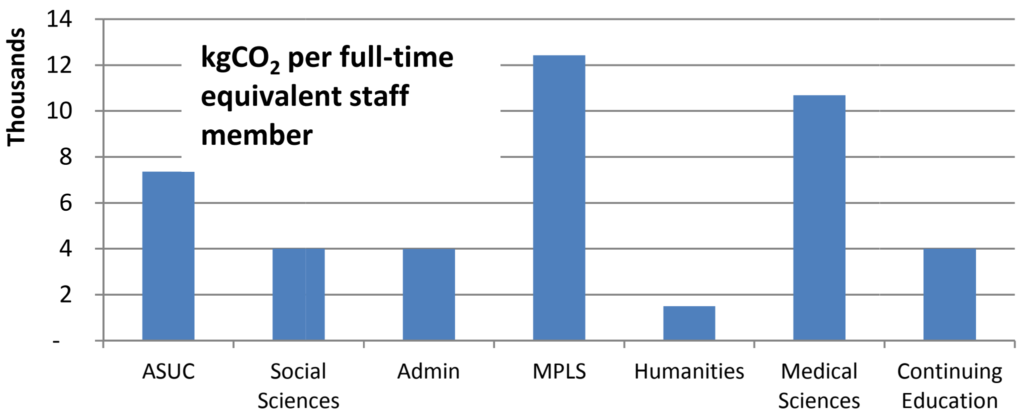

Figure 6: kg CO_2 emitted in 2008/9 per full-time equivalent staff member, broken down by Division.

3.3. Business as usual projection

A key question for this carbon management strategy is 'how many tonnes of CO_2 would the University be emitting annually by 2020 if we didn't take additional action to reduce emissions?': the Business as Usual (BaU) scenario. As stated in section 3.2, in 2008/9, the University's scope

[29] Net Internal Area

one and two CO_2 emissions were 77,937tCO_2. The HEFCE sectoral target (see page 4) suggests that the University should be emitting no more than 37,609tCO_2 per year by 2020.

For example, if the BaU 2020 figure employed is projected to be 100,000tCO_2 per year, then the University's target CO_2 reduction would be 65,690tCO_2 to reach the required HEFCE emissions level, whereas, if it were 50,000tCO_2, the target would be only 15,690tCO_2. Clearly therefore, the BaU 2020 figure is crucial for the scope of work in this carbon management strategy.

Over the last five years, the growth in energy use and CO_2 emissions for the University has been significant. Electricity use has risen by an average of 6.5% per year, and fossil fuel use (mainly natural gas for heating) by 2.8.

Projecting BaU 10 years into the future for an organisation of the complexity of the University with any degree of scientific rigour is a challenging process, and the opinions of expert stakeholders who know and understand the University are as important as hard data on factors such as historical energy use. Discussions with members of Estates Services and other expert stakeholders suggest that the growth patterns in scientific activity and expansion of the estate over the last five years are likely not to prove a precedent for the future, and that growth over the next 10 years is expected to be reduced in comparison. It was decided therefore that a low growth BaU scenario would be employed to project to 2020; the low growth scenario chosen assumes that fossil fuel energy use in 2020 will be at the same level as 2008/9, and electricity use will grow at 2% per year between now and 2020. This means that the working assumption is that the BaU 2020 figure would be 76,885tCO_2, and therefore that this Strategy would need to deliver a reduction of 39,276tCO_2 by 2020 (see section 4.3 below) to meet the HEFCE sectoral target.

The assumed Low Growth BaU 2020 figure is actually less than the emissions in 2008/9. This is because the latest Government guidance on projecting CO_2 emissions [30] states that it should be assumed that the carbon intensity of UK grid electricity in 2020 will be 21% less than in 2009 and natural gas will be 4% less.

An important consideration when projecting BaU scenarios for an organisation such as the University is how to take account of routine maintenance and replacements of equipment such as boilers and light bulbs. With equipment such as this, the replacements tend to be more energy efficient than the equipment they are replacing; however, this is the case for previous years as well as for future years; replacements have, in the majority of cases, been more efficient. Therefore, is was concluded that the most robust way to account for efficiencies through replacement is to leave these efficiencies as part of the BaU and only account for non-routine replacements as part of the measures in the Strategy. Opportunities which might be considered routine have also generally been filtered out of the schedule of opportunities provided as part of Hurley Palmer Flatt's previous work. For more on the distinction between routine and non replacements, see section 4.2.2.

This BaU 2020 figure will be reviewed and adjusted periodically. To this end, it is essential that robust data is collected that allows CO_2 reductions from carbon management and from BaU changes in energy demand to be separated out, so that progress towards the targets in place can be tracked accurately. Therefore, the more robust the data on the amount of CO_2 actually being saved from the measures in the implementation plan are, the smaller the risk of miscalculating the University's CO_2 trajectory, which could have significant financial implications.

[30] *Valuation of energy use and greenhouse gas emissions for appraisal and evaluation*, Department for Energy and Climate Change, June 2010.

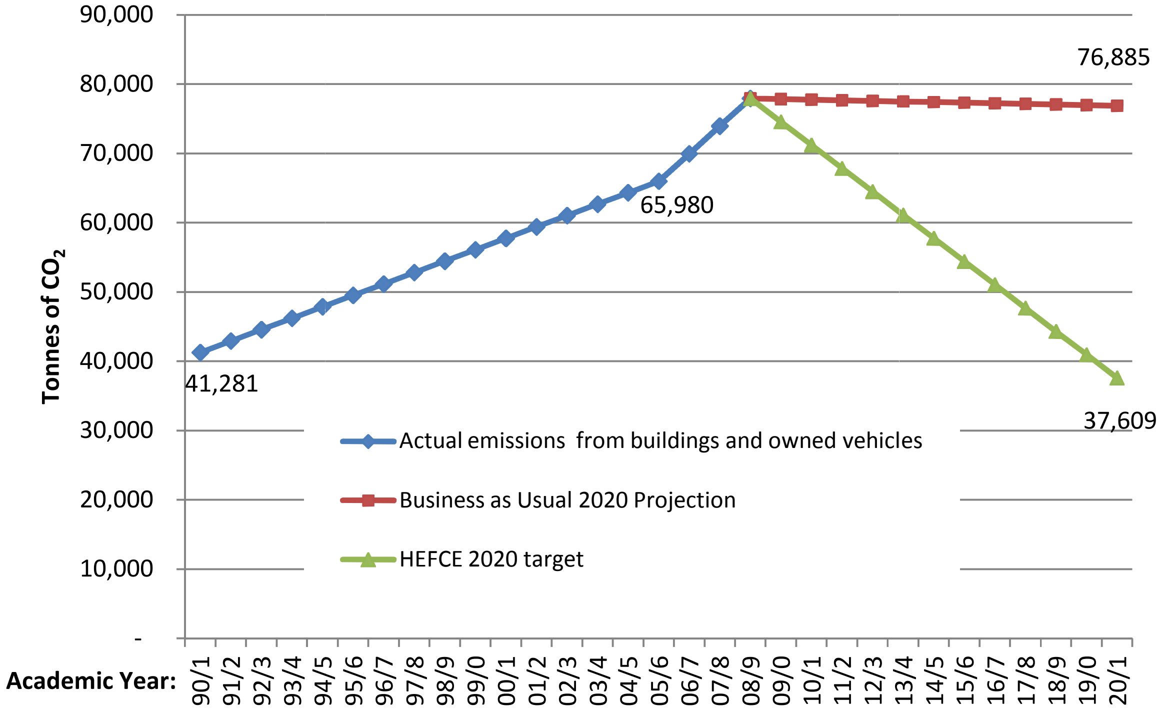

Figure 7: The trend in the University's scope one and two CO_2 emissions since 1990/1, using data from three years: 1990/1, 2005/6 and 2008/9. The figure also shows the Low Growth Business as Usual projection (76,885tCO_2 in 2020) and the necessary trends to achieve the 2020/1 sectoral target from HEFCE (43% below 2005/6 by 2020, or 37,609tCO_2).

4. Options analysis for carbon reduction measures

4.1. Introduction

This chapter presents the analysis of options available to the University for reducing CO_2 emissions from stationary energy use, split into demand side and supply side initiatives. Demand side initiatives reduce the demand for energy in the University's facilities, whereas supply side initiatives reduce the CO_2 intensity of the energy that is supplied to the University's facilities. The purpose of this chapter is to assess which options are available under these headings and to robustly estimate the potential that each option has for reducing the University's CO_2 emissions and the lifetime cost per tonne of CO_2 reduced that each option offers.

A large proportion of the University's energy use is associated with buildings containing laboratories; and within laboratories, a large proportion of the energy use is controlled by the occupants of the building, through the use of energy intensive research equipment. Therefore, a sub section of the demand side options analysis specifically considers measures focussed on laboratory occupant controlled energy use.

This chapter seeks to answer the question 'considering all the options available to the University, what is the most cost-effective combination of measures available to achieve a CO_2 reduction of X% by 2020?'. A key tool in answering this question is the Marginal Abatement Cost (MAC) curve, which is presented in the results section. The MAC curve has been used by the University's Sustainability Steering Group to identify a range of possible target scenarios for CO_2 reduction, from which a consensus was reached on a preferred scenario, which is presented in section 4.4.

4.2. Methodology

4.2.1. Costs benefit analysis and marginal abatement cost (MAC) curves

MAC curves indicate the level of emissions reduction which a range of measures could deliver at a given point in time. They show how much, in this case, CO_2 each measure could save (the level of abatement potential) and the associated cost per tonne.

Specifically, they show the:

- Cumulative annual CO_2 saving measures could achieve by 2020
- Cost Effectiveness Ratio of each measure, in terms of Net Present Cost/ lifetime CO_2 saving for each measure
- Cumulative cost of implementation

The opportunities shown in the MAC curves are divided into Demand Side (DS) and Supply Side (SS) measures and are generated from a number of sources, as follows

- Demand Side:
- examination of previous building energy surveys;
- site visits to three Oxford University buildings;
- Supply Side:
- AECOM's own observations and investigations;
- previous consultants' reports for the University
- site visit to the Science Area boiler houses.

Demand Side opportunities are those which seek to reduce the amount of energy consumed within the buildings portfolio and thus reduce the demand for energy from any source.

Supply Side opportunities are those which seek to reduce the carbon intensity of the heat and electricity being used by Oxford University by using alternative methods of generation through the use of Low & Zero Carbon energy technologies.

- Further details of these measures can be found in Section 4.3.

The key assumptions used in the development of the MAC curves were as follows.

- The capital expenditure illustrated on the various curves in the strategy are based on 2010 prices and are therefore not discounted. However, in the Net Present Value / Cost calculations (which consider expenditure in future years as well as future cashflows), discounted values are used. This is necessary in order to present the Cost Effectiveness Ratio which, as mentioned above, is calculated from the Net Present Cost. A discount factor of 4% has been used, based on the advice of the University.
- Emissions calculations associated with the opportunities presented have been based on those given in the joint Department of Energy & Climate Change (DECC) and HM Treasury report "Valuation of energy use and greenhouse gas emissions for appraisal and evaluation". This report presents a declining grid electricity emissions factor recommended for use in the appraisal of projects. The assessment of measures has assumed an electricity emissions factor of 0.43kgCO2e/ kWh for all electricity savings from 2010 up to 2030. The emissions factor then declines linearly to 0.04 CO2e/ kWh in 2040.
- Following discussions with Estates Services, no inflation has been included in the calculations supporting the MAC curves.
- Universal energy costs of 6.812p/kWh for electricity and 2.133p/kWh for gas have been used throughout (based on advice from Estates Services) including correcting previously identified opportunities shown in the Hurley Palmer Flatt Building Energy Audits, which used a variety of costs.

4.2.2. Stationary energy demand-side measures

'Stationary energy' refers to that consumed within the University through the operation of fixed building services and the activities within the various buildings. Measures to reduce carbon emissions from stationary energy use have been derived in three ways; the first two focusing on non-laboratory related opportunities (i.e. to do with the building services and fabric) and the third focusing on laboratory occupant controlled energy use.

Firstly, AECOM consultants carried out energy audits of three high energy use University buildings. The audits focused on infrastructural opportunities by observation of activities, equipment, plant and so on during a walk-through survey as well by developing an understanding of how the building and its features are used by discussion with building managers and other staff.

The second method of deriving carbon abatement opportunities relied on the review of a series of surveys undertaken by the consultancy Hurley Palmer Flatt in 2008. All of the survey reports were reviewed by AECOM and, where appropriate, the opportunities identified therein were transferred to the next stage of the process. As part of the process of reviewing the reports, opportunities which were considered to be covered by the routine activities of repairs and maintenance (such as changing light bulbs) were filtered out. The Business as Usual model accounts for these maintenance measures (refer to Section 3.3 for further information).

Finally, behavioural and technical opportunities relating to laboratory energy use were observed during the site audits and focus groups held with building users at two of the three sites.

Details of the methodology and processes for each of these are set out below.

Non-laboratory energy use

Each opportunity identified by either the AECOM energy audits or in the Hurley Palmer Flatt report was transferred to a spreadsheet which was used to model the various measures across the entire University building portfolio. The methodology for that extrapolation was as follows:

Each building in the University portfolio was allocated an age group based on its build date (1: Pre-1920, 2: 1920 - 1975, 3: 1976 - 2002, 4: Post 2002) as age is typically a good proxy for energy efficiency. The area of each building was allocated across 40 Area Types based on information provided by Estates Services.

Each opportunity was assigned a unique reference number and associated with the portfolio building in which it was originally observed and a number of key pieces of data provided for each as follows:

- Opportunity name;
- Opportunity type - Capital Project (Cap), or Behaviour Change (BC);
- Age group applicability - this is which one (or more) of the four Age Groups the measure could be applied to;
- Capital cost (£);
- Annual running cost (£);
- Gross annual saving (£);
- Annual carbon saving (tonnes CO_2);
- Start & End Year – indicating the lifetime of the measure; and
- Area where the opportunity is applicable based on the 40 Area Types.

The total capital costs, carbon savings and so on for each measure were then calculated on a per m^2 basis and multiplied by the total amount of area of relevant Area Types in the applicable Age Groups. This extrapolation provided the basis for the assessment of financial performance for each opportunity. A control was also provided which allowed for adjusting the level of extrapolation in each of the four Age Groups as well as an overall control to 'turn down' the level of implementation. These were used to reflect the fact there may be other factors affecting the ability to implement the opportunity (such as suitability, recent upgrades and so on) and also that opportunities which could cause more disruption are less likely to receive support from building users and thus are less likely to be implemented.

Clearly, similar opportunities might be seen in more than one building and in order to ensure as far as possible that overall savings were not overstated, the model allowed for similar measures to be marked as mutually exclusive. This ensured that only a limited number of similar measures (perhaps only one in some cases) were extrapolated across the portfolio.

Once opportunities had been extrapolated, a financial analysis of each was undertaken which examined capital expenditure, future cashflows (including maintenance costs, operating costs and so on) to derive the net present value (NPV) and cost (NPC) of the opportunity as well as understanding the level of CO_2 savings which could be achieved over the life of any measure

The model assumed that all measures would be 100% implemented by 2020 and that the rate of implementation would be flat over the ten year period (i.e. 10% per year for the next ten years). The model allowed for fixing the total percentage of a particular opportunity that would be implemented by 2020 and provided three different implementation scenarios: flat (which is currently assumed for all opportunities), front loaded and back loaded.

The output from the analysis is a summary showing each opportunity's reference, name, total capital cost, total carbon saving and Cost Effectiveness Ratio (calculated as NPC/Total carbon saved). This information is shown in appendix 1.

Laboratory user energy demand reduction

The scale of research activity at Oxford is substantial, involving more than 70 departments, the Colleges, over 1,600 academic staff, more than 3,500 contract researchers and around 3,600 graduate research students. Laboratories can consume up to four times more energy than the typical office. 14.3% of the University's floor area is classified as laboratory space, [31] and the University's highest energy using spaces are all laboratories.

Laboratories are highly 'serviced' environments; experimental conditions require close control of the temperature, humidity and air flow, which also reduces the scope for using 'natural ventilation'

[31] Laboratory space includes undergraduate teaching laboratories and ancillary areas that may be associated with laboratories.

(windows, vents or other means of bringing fresh air into the building without using energy). Therefore, the base building energy load of these buildings is relatively high.

Whilst the building services energy demand of laboratories is high, so also is the amount of energy use that is occupant controlled. Energy intensive equipment is spread throughout laboratories and this equipment is generally turned on and off by the building users themselves, the Facilities Management Teams having limited control over its use. Evidence suggests that approximately 40% of the electricity use of a chemical or biochemical laboratory is plugged in equipment, and therefore under the control of laboratory users. [32]

Target buildings

The focus initially was on all occupant controlled energy use. It was decided that three buildings would be investigated to serve as case studies, namely the:

- Henry Wellcome Building of Genomic Medicine (HWBGM)
- Chemistry Research Laboratory (CRL)
- Saïd Business School (SBS)

These buildings were chosen as they are the highest energy-using buildings in their respective divisions, as shown in the table below, and they were seen to be sufficiently representative of the University's building stock.

Table 4: Energy Use and CO_2 emission data of the three target buildings.

Name	Division	% of total University CO_2	Area (m^2) [33]	kWh % Electricity	kWh % Gas	$kgCO_2/m^2$ per year
Henry Welcome Building of Genomic Medicine	Medical Sciences	7.7%	10,019	38%	62%	615
Chemistry Research Laboratory	MPLS	5.9%	16,706	48%	52%	283
Saïd Business School	Social Sciences	1.5%	10,350	55%	45%	118

AECOM spent one day at each building, appraising how energy is used both in the plant rooms and throughout the buildings. Interviews were also undertaken with senior staff and facilities managers.

The Henry Wellcome Building of Genomic Medicine (HWBGM)

Opened in 1999, the HWBGM is the home of the Wellcome Trust Centre for Human Genetics (WTCHG), part of the Medical Sciences Division. The WTCHG undertakes research into the genetic basis of multifactorial diseases such as hypertension, diabetes, heart disease, infectious diseases, psychiatric disorders and multiple sclerosis.

The site has a very high electricity demand, due to the large amount of laboratory equipment (in particular a magnetic resonance imaging unit), freezers, and highly serviced laboratory space. A maximum of 450 staff can work in the building, with occupancy normally ranging from 300-350 throughout the year.

[32] Research from the University of California, available on the HEFCE-funded Higher Education Environmental Performance Improvement website (www.goodcampus.org), states that in an average chemistry laboratory, 'plug load' (equipment plugged into electrical sockets) accounts for 37% of electricity usage, the remainder consisting of lighting (18%) and heating, ventilation and air conditioning (45%). The assertion that plug load accounts for 30-40% of laboratory electricity use is supported by investigations undertaken by Estates Services, which found that in the University's Biochemistry Building, 'light & small power' accounted for 54% of electricity usage, servers 8% and plant (boilers, air handling, etc) 38%.
[33] Gross Internal Area.

The Chemistry Research Laboratory (CRL)

The CRL, part of the Mathematical Physical and Life Sciences (MPLS) Division, was opened in 2004. The facility can house up to 573 scientists working ‘at the bench’, with 332 fume cupboards, 11 nuclear magnetic resonance spectrometers, 11 mass spectrometers, and an x-ray crystallography facility.

The Saïd Business School (SBS)

Opened in 2001, the SBS is a very different facility to the other two target buildings. Part of the Social Sciences Division, there are no laboratories at the School, the space consisting instead of library space, lecture theatres, seminar rooms and extensive networked study areas with a considerable number of PCs, copiers and printers. Peak occupancy ranges between 450 and 550 people. The building users are a mixture of students doing a very intensive one-year Master’s of Business Administration Degree and Undergraduates from the Colleges who are doing part of their degree at the School. The state-of-the-art library facility stays open late and is therefore heavily frequented by Oxford students who are not studying at the School, but just come to use the facilities.

The focus on laboratories

One of the key conclusions of the site visits was that the scope for building user energy use reduction was relatively limited at SBS compared to the other two buildings. Generally, at SBS, building users do not turn on lights and do not use energy-intensive equipment. Lighting, heating, ventilation and comfort cooling are almost all either centrally controlled or automatically controlled with sensors. Computer use does represent a significant amount of energy use at SBS, but the computers are predominantly laptops that belong to the students and are taken home. However, significant opportunities for energy savings were identified at SBS through infrastructural measures.

At CRL and HWBGM, on the other hand, during the site visits AECOM staff observed a significant amount of user-controlled energy being used apparently unnecessarily. Due to the nature of the activities at these buildings, building users operate many different pieces of equipment, often at the same time, many of which are energy intensive.

Building user focus groups

Following the site visits, focus groups were held with building users from the CRL and HWBGM. Two focus groups were held, with a total of 23 attendees, covering representatives of the majority of the laboratory areas in the buildings.

At the focus groups, AECOM presented the points of occupant-controlled energy wastage that they had identified in the site visits and elicited from the attendees further ideas for points at which energy is wasted in their buildings. Target behaviours were then defined to address this energy wastage and the barriers to these behaviours were mapped and explored. To generate useful data for this process, in the invitation to the focus groups attendees had been asked to identify equipment that they think might be left on unnecessarily and to try turning it off to see if any comments were made, and to bring their findings along to the focus groups.

At this stage, AECOM presented to the groups some suggestions for interventions to remove the barriers identified and the groups’ opinions on the practicalities of these interventions were elicited.

4.2.3. Energy supply options

The energy supply options explored the potential for a reduction in carbon emissions by supplying heat and electricity to University buildings from low and zero carbon technologies. The technologies assessed included the following:

- Electricity only:
- Wind power
- Solar Photovoltaics (PV)
- Heat only:
- Solar thermal hot water (STHW)
- Biomass (wood fuelled) boilers
- Heat pumps (air source heat pumps, ground source heat pumps)
- Combined Heat and Power (CHP) and Combined Cooling Heat and Power (CCHP):
- Medium-scale CHP with District Heating
- Mini-scale CHP
- Fuel Cell CHP

To identify the opportunities for these technologies across the Oxford University estate, the following method was used:

1. Suitable buildings were identified based on their location, listed status and energy demand profile
2. Standard calculations were applied to estimate the potential carbon and cost savings:

- on a building by building basis, where sufficient information was available; and
- using one building as an example and applying these percentage savings to the similar buildings across the estate.

Carbon and cost calculation models included savings from government incentives such as Feed-in-tariff (FIT's) [34] and the proposed Renewable Heat Incentive (RHI), [35] operational and maintenance costs, and projected figures for a decarbonising grid and a reduction in the carbon emissions factor for electricity (as explained in section 4.2.1).

Section 4.3.2 provides a brief summary table of the opportunities identified including:

- Potential carbon savings
- Indicative capex
- Indicative annual savings, simple payback, £/tCO_2 and CER
- Wider pros and cons
- The detailed assumptions and approach used for each technology are set out below.

Wind

The potential for Wind to contribute to Oxford University's carbon reduction target was based on sites that had previously been identified in feasibility reports by PfR [36] and HPF.

A risk associated with the PfR reports is that they were carried out in 2007 and should be re-assessed because there may have been changes to the surrounding buildings or infrastructure which could affect the viability of wind power at those sites.

Wind power also is eligible for FIT if the total installed capacity on a site is less than 5MW, and it is assumed that for Oxford University sites these would be less than 5MW.

[34] http://www.fitariffs.co.uk/library/regulation/100201FinalDesign.pdf
[35] http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=Consultations\RHI\1_20100204094844_e_@@_ConsultationonRenewableHeatIncentive.pdf&filetype=4
[36] Partnership for Renewables (PfR) reports dated 19th August 2007 Site ref: C606 - C611

Solar

Solar panels, both photovoltaic (PV) and solar thermal hot water (STHW), can typically be installed on most types of roofs. Therefore the constraints that were applied to the available roof area on Oxford University buildings were to exclude:

- Listed buildings
- Shaded roof space
- North facing roof space
- Small isolated roof areas that are separate from larger arrays.
- In the case of STHW, only buildings with the hot water already supplied from central calorifiers were considered as this is easier to retrofit. This information was based on a condition survey database supplied by the University.

The roof availability was based on publically available aerial images (from www.google.com and www.bing.com) and roof plans from the Oxford University database.

Both PV and STHW are applicable for FIT and RHI and the associated tariffs were assumed in the financial model.

Biomass (wood fuelled heating)

The potential for biomass heating was restricted to those Oxford University buildings with the following:

- High heat demand
- Sites off the mains gas grid
- Buildings with wet central heating systems for ease of retrofit
- Large plant room and sufficient access space for fuel deliveries

Where available, previous studies were used to inform the appropriate boiler size. [37]

Based on the current consultation for RHI, biomass heating is eligible for RHI and the relevant tariff levels were included in the financial model.

Ground Source Heat Pumps (GSHP)

GSHP was assumed to be potentially viable for Oxford University sites with:

- large brownfield areas adjacent to the building (e.g. playing fields) which could be used for boreholes; and,
- buildings with low temperature or hot air heating systems for ease of retrofit, based on a condition survey database supplied by the University

Based on the current consultation for RHI, GSHP is eligible for RHI and the relevant tariff levels were included in the financial model.

Air Source Heat Pumps (ASHP)

Air Source Heat Pumps (ASHPs) are a versatile technology which can be installed in a range of applications and sizes. For this high level assessment of its contribution to Oxford University's carbon reduction target, the following buildings were considered most appropriate for retrofitting ASHP:

- Buildings with existing electrical heating systems (e.g. fan powered convection heaters); and
- Buildings with heating systems in need of replacement.

[37] Begbroke Biomass Heating Viability Report, Norland Managed Services (NMS), May 2009

This information was based on a condition survey database supplied by the University This represents buildings that could consider replacing and upgrading the building's heating system from electrical heating to an ASHP heating and cooling system. Based on the current consultation for RHI, ASHP is eligible for RHI and the relevant tariff levels were included in the financial model.

Combined heat and Power (CHP)

CHP is a viable technology for buildings, or clusters of buildings, with a high, and preferably year round, heat (and cooling[38]) demand. Therefore, gas engine CHP has been considered for clusters of Oxford University buildings within the same plot of land. Only buildings with an existing wet heating system have been considered for ease of retrofit.

CHP is currently not included in the RHI consultation, and only pilot scheme Micro CHP less than 2kW (domestic scale) is eligible under the current FIT documents. [39] For this Oxford University study, Mini-CHP between 5-15kWe was investigated which was therefore not eligible for FIT or RHI.

4.2.4. Key assumptions, uncertainties and risks

General approach to costings and assessment of feasibility

Where costs assessments are given, these are ballpark estimates only, with no allowance made for inflation, and should not be relied upon for detailed costing. Unless specifically stated, they also do not allow for any design or professional fees, contingencies or contractor overheads that may need to be applied. Costs estimates will need to be refined on the basis of future detailed surveys of each building.

The assessment of the potential for low and zero carbon energy technologies has been carried out at a high level only, predominantly from a desk top review of drawings, and data provided by Oxford University. Further detailed studies, design and costing, based on ground surveys, structural analysis, over shading and other studies (as relevant to each technology) would be necessary prior to implementation.

Demand side opportunities

The key uncertainty for these opportunities relate to the assumptions about how the various measures were extrapolated across the University portfolio of buildings. The extent to which the measures can actually be applied in practice, and the associated benefits and costs of each measure will only be determined in practice following more detailed surveys of each building. This has been allowed for in the Implementation Plan set out in section 5, and the assumptions underlying the MAC curve will need to be adjusted on a regular basis as the Plan is implemented.

Other areas of uncertainty that could affect the cost benefit analysis are as follows:

- Fuel prices may rise or fall in future to levels different to those assumed in the analysis
- The guidance on which carbon emission factors to use for grid electricity may change in the future

Supply side opportunities

A major area of uncertainty is around the Renewable Heat Incentive (RHI). This was due to be implemented in April 2011 by the previous Government. However, the new Government has yet

[38] As heat can be used to provide cooling via absorption chillers
[39] http://www.fitariffs.co.uk/library/regula tion/100201FinalDesign.pdf

to confirm whether this will still be the case, and if so, has yet to confirm the tariff levels that will be available.

The assessment of the potential for renewable and low carbon energy options has been carried out at a high level only (with the exception of gas CHP for the Science Area) and has relied on reports carried out by others. Therefore the results of this assessment should be taken as an indication only of the relative potential and cost-benefit of each option. Before implementing any of the options more detailed assessments of viability would be required at the level of individual buildings and sites.

For the option of one or more large scale wind turbines, there are many uncertainties at this stage around the viability of potential sites, not to mention the uncertainty over whether planning consent would be granted for such a scheme. The more detailed assessments that would be required to establish viability are set out in section 5.

4.3. Results

This section presents the results of the performance analysis for the various identified and quantified carbon abatement opportunities. The section discusses infrastructural, technical and behavioural opportunities for reducing energy demand as well as supply side opportunities (meaning those which seek to reduce the CO_2 intensity of the energy that the University uses).

Overleaf is presented a MAC curve which includes all of the available measures and accounts for the mutual exclusivity of similar opportunities observed in more than one building.

Following this are separate MAC curves for the demand side opportunities which are presented for clarity although it is important to use the overall curve for decision making and this overall MAC curve has been used to inform the target scenarios presented later in this section.

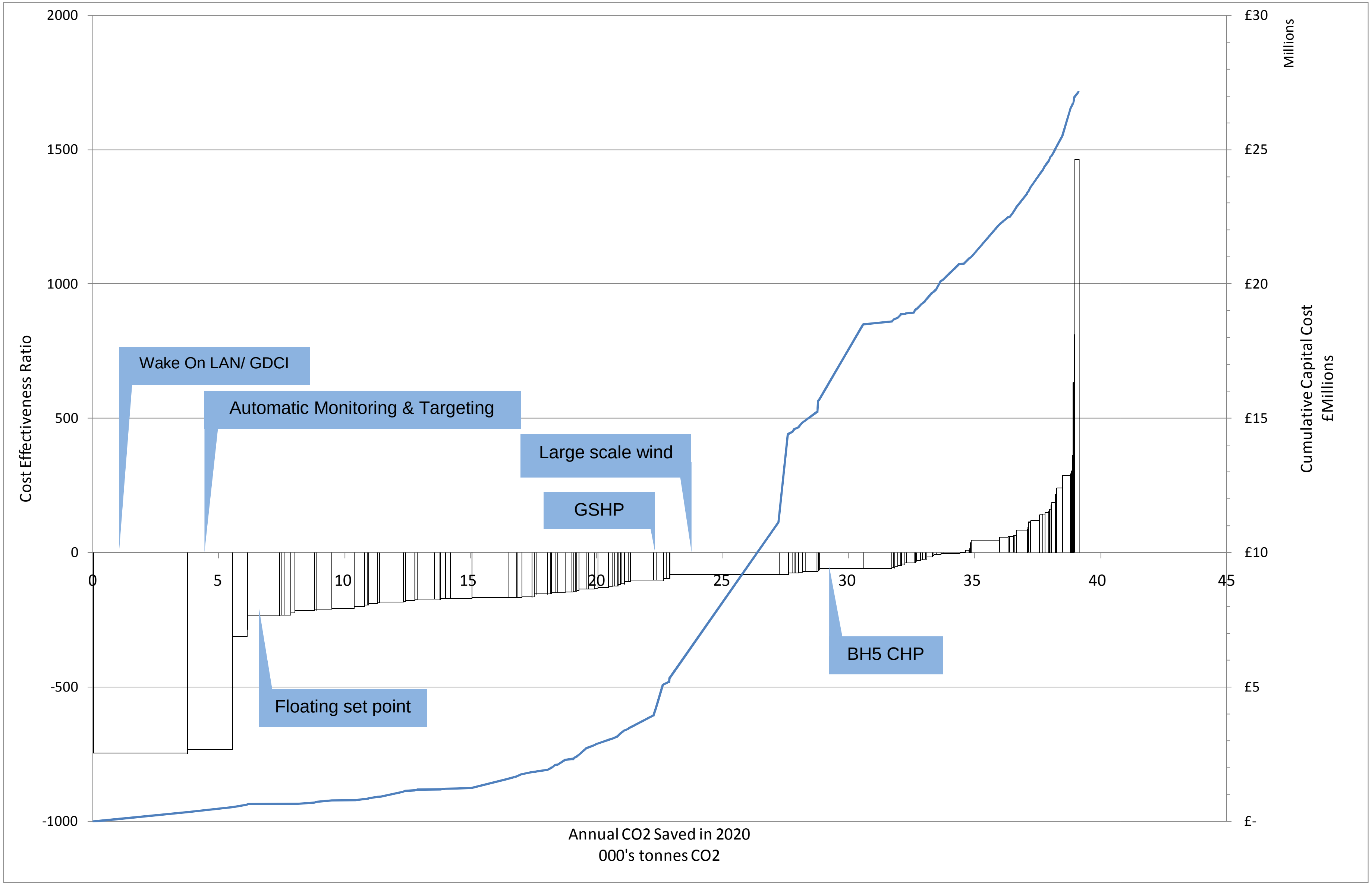

Figure 8: Marginal Abatement Cost Curve (accounting for mutual exclusivity) – the curve shows all of the demand side opportunities extrapolated across the portfolio as well as all of the supply side opportunities. The curve generally contains only one instance of any similar opportunities to ensure that the same costs and savings are not extrapolated across the portfolio many times thus presenting a misleading suggestion of potential CO_2 reduction

4.3.1. Stationary energy demand-side measures

The following MAC curve illustrates just the demand side opportunities which are included in the overall curve above and included in the scenarios below. The MAC curve presents opportunities from left to right in order of their Cost Effectiveness Ratio and this should inform the order in which they are investigated in detail and finally implemented (refer to the Implementation Plan in section 5 and Appendix IV for more detail).

This MAC curve is for illustrative purposes only. To understand the output of the performance analysis fully, readers should review the full MAC curve presented above and the detailed explanations given in Appendix I.

The stationary energy demand side measures MAC curve takes account of mutual exclusivity and therefore limits the extrapolation of like measures across the portfolio.

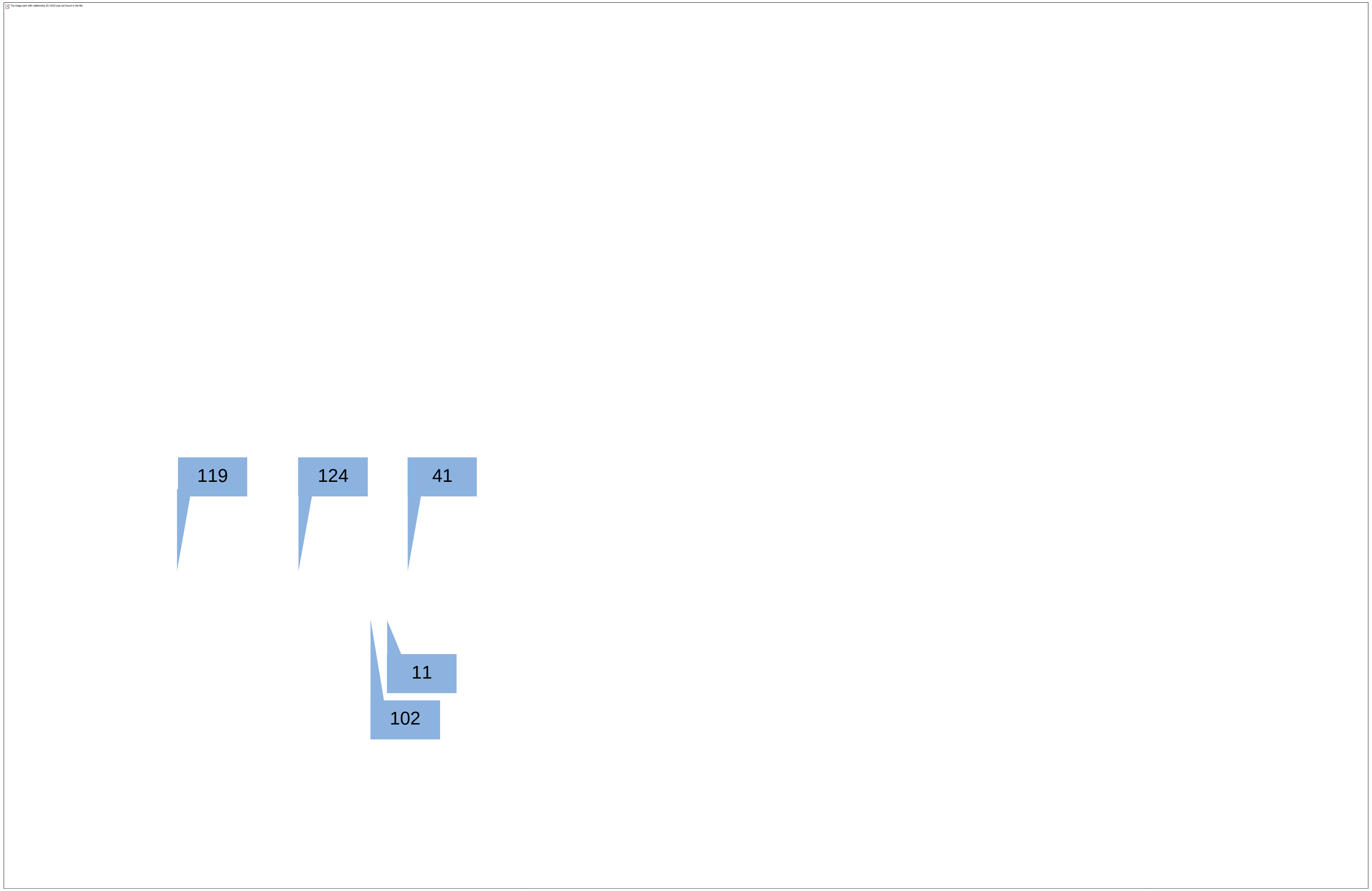

Figure 9: Demand side Marginal Abatement Cost Curve (accounting for mutual exclusivity) – the curve shows all of the demand side opportunities extrapolated across the portfolio. The curve generally contains only one instance of any similar opportunities to ensure that the same costs and savings are not extrapolated across the port folio many times thus presenting a misleading suggestion of potential CO_2 reduction.

The list shown below is the top ten demand side infrastructural carbon abatement opportunities emerging from the performance analysis. The top ten is generated from the Cost Effectiveness Ratio (CER) of each measure.

Table 5: The top ten opportunities by cost effectiveness

Ref	Opportunity	Cost Effectiveness Ratio	Cumulative CO_2 saved	Capital Cost (Undiscounted)
119	Green Desktop Computing Initiative *This includes power management monitoring and wake on LAN services. This measure would allow PCs to be switched on remotely to allow updates, ensuring that equipment is not left on overnight or over the weekend unnecessarily*	-744	3756	£331,295
124	Automatic Monitoring & Targeting *Provide metering and recording systems to allow energy use to be automatically monitored and to raise an alarm when use exceeds pre-determined thresholds.*	-732	2690	£294,484
102	Energy Management Measures *These opportunities are identified in the Hurley Palmer Flatt Building Energy Audit reports as raising awareness of energy issues and appointing an energy champion. However, they are more likely to be successful if they are supported by activities such as the Sustainable Laboratory Group and other behavioural change initiatives.*	-309	559	£88,782
11	Insulation of chilled water pipe work and valves *Any uninsulated pipework will lose energy to the surrounding atmosphere. Replacing insulation will reduce these losses.*	-282	50	£8,591
41	Floating set point *Control philosophy which allows the space heating system to float between an upper and lower set point temperature to reduce boiler modulation*	-234	1256	£10,763
68	Air Conditioning Control *Adding suitable controls to air conditioning systems or increasing their accuracy will reduce run-time as well as ensure they are operating more efficiently*	-231	76	£-
67	Store room conditioning *Examining and refining the control of conditioning to store rooms*	-231	92	£-
118	Switch off bench top laboratory equipment *This is a behavioural and technical issue which seeks to develop more efficient use of desktop equipment such as heating blocks, water baths etc*	-231	263	£-
177	Reduce light output *Reduce output levels of lighting in areas where original installation means there is more illumination than required*	-220	177	£13,410
162	Supply Air Handling Unit (AHU) efficiency *Improve the efficiency of air handling units*	-214	781	£51,571

The table above demonstrates that whilst each of the measures is cost effective with CERs less than zero (i.e. the measures will result in a net financial saving over their lifetime) the amount of CO_2 they are likely to save varies significantly. This illustrates the benefit of using a MAC curve approach for prioritising action on specific measures as implementing in order of cost effectiveness may not save as much CO_2 as quickly as implementing in order of possible CO_2 savings but it will ensure that investment is efficient and effective.

It may be that an element of overlap (as opposed to outright mutual exclusivity) occurs with some of these measures. For example opportunities 124 and 102 may target some of the same issues should they be implemented in the same building. Issues such as this will be resolved in the detailed surveying phase which will be carried out as illustrated in the Implementation Plan (refer to section 5 for further details).

Laboratory User Energy Efficiency

This section outlines opportunities identified as part of the Laboratory User Energy Efficiency Strategy through the site visits and building user focus groups. For full recommendations of how these opportunities should be realised, please refer to the full Strategy in Appendix V.

Whilst these measures do not represent the largest reductions in CO_2 identified, relatively speaking, they are often relatively low cost, and the processes involved in realising them will have benefits other than CO_2 reduction, such as student and staff engagement and raising the visibility of the University's commitment to sustainability.

Bench top equipment

Throughout the laboratory areas, a large number of bench top appliances were noted to be switched on, yet often not being used. These appliances include heated water baths, thermal cyclers, heat blocks and electrophoresis equipment. Discussions with building users during the site visits suggested that many pieces of equipment are left on permanently, despite only being sporadically in use. If the assumption is made that, at HWBGM, all of these pieces of equipment are on all the time, then the estimated saving that could be made by restricting this to 10 hours a day, 365 days a year is estimated to be $45tCO_2$ per year. This saving is considered to be representative of many of the University's biological laboratories, therefore these savings have been extrapolated by looking at the total floor area of other laboratory spaces across the portfolio and multiplying by a per m^2 rate for capital costs, financial savings and CO_2 savings derived from the HWBGM case.

Glass drying cabinets

Most laboratories in the CRL have at least two electrically heated cabinets, such as that pictured, for drying glass utensils. Building users indicated that all of the drying cabinets are left switched on at all times. With the exception of Inorganic Chemistry, who require glass to be completely free from moisture due to the nature of the reactants that they use, all other building users that were interviewed during the site survey confirmed that they could use the drying cabinets intermittently, using them to dry glass after washing but then switch them off. Using the same assumptions as outlined above for bench top equipment, this represents a saving of $40tCO_2$ per year at the CRL alone.

Fume cupboards

One significant way that occupants' behaviour affects energy use at the University is through the use of fume cupboards. Fume cupboards require air to be constantly drawn through them, which is expelled from the building. This uses energy in two ways: one being the large fan that draws the air through the fume cupboards, and the other, considerably larger, energy use is the energy needed to heat or cool the air that is replacing the expelled air.

Of the different types of laboratory, chemistry tends to have the most fume cupboards. The CRL has 332 fume cupboards, more than any other research building in Europe. Biological laboratories typically have far fewer fume cupboards, tending to have microbiological safety cabinets instead, which are less energy intensive than fume cupboards.

There is always a gap at the bottom of fume cupboard sashes to allow air to be constantly drawn through; however, the amount of air drawn through the gap increases significantly as the sash is raised. Sashes clearly often need to be opened to allow the user access to the equipment inside. However, AECOM observed many instances of fume cupboards being open unnecessarily, which was corroborated with evidence from discussions with building users. AECOM has estimated that approximately 65tCO_2 per year could be saved if fume cupboards at CRL were used correctly.

4.3.2. Energy supply measures

This section details the results from the examination of a variety of Supply Side (SS) options. The summary table below shows, for each technology:

- Indicative Capital Costs (£)
- Potential annual carbon savings in year 2020 (TCO_2/yr)
- Indicative Net Present Value (NPV) over the lifetime of the system (£)
- Indicative Carbon Effectiveness Ratio (CER = NPC / TCO_2/yr)
- Wider pros and cons

The analysis assumes that all of the technologies would be retrofitted to existing buildings, and the technical and economic viability assessment is on that basis. Although the technologies can, and are used on new buildings as well, the assumption is that the latter would not be contributing to reducing the existing carbon emissions of the University, but rather meeting the regulatory requirements for the new buildings. The carbon emissions from new buildings are built in to the energy and carbon baseline assumptions.

The Net Present Value (NPV) figures show whether the ongoing savings and revenues from an installation will pay for the capital outlay, with a minimum internal rate of return of 4%. Where the NPV figure is positive, then the option has a financial performance that exceeds a 4% rate of return. Where the NPV is negative, the option does not achieve this rate of return. This is reflected in the column for the Cost Effectiveness Ratio (CER). All of the options that have a negative value are cost effective (and are shown in red), because their net present cost is less than zero.

Table 6 Costs and carbon savings of the different energy supply options for Oxford University estate

Project description	Capital costs (£) (Undiscounted)	NPV of measure over system life (£)	Cost Effectiveness Ratio NPC / tCO_2	Annual CO_2 savings in 2020 (tCO_2)
Medium-scale Wind Turbines				
Wind power at Site B (275kW)	451,000	1,199,578	-292	208
Wind power at Site A (4.6MWe)	5,800,000	6,763,709	-79	4,332
Total	**6,251,000**	**n/a**	**n/a**	**4,540**
PV installed on all suitable roof area				
PV (Total)	5,482,119	1,235,833	-87	592
Solar water heating on maximum suitable [40] roof area. PV installed on remaining space.				
SHW (Total)	1,972,584	451,949	-108	234
PV (Total)	4,634,975	1,062,339	-87	503
Total	**8,323,057**	**n/a**	**n/a**	**677**
Biomass Heating				
Biomass (Begbroke)	258,000	375,461	-135	313
Biomass (All other sites)	436,200	-166,711	2	224
Total	**694,200**	**n/a**	**n/a**	**536**
Ground Source Heat Pumps (GSHP)				
GSHP Total	**1,145,122**	**787,735**	**-102**	**386**
Air Source Heat Pumps (ASHP)				
ASHP Banbury Rd	175,950	-154,350	532	14
ASHP roll out	3,513,764	-3,045,198	281	543
Total	**3,689,714**	**n/a**	**n/a**	**557**
Science Area Combined Heat and Power (CHP)				
1. BH5 current	192,500	63,114	-35	139
2. BH5 extended	1,950,725	1,606,304	-77	1,558
3. BH5 plus BH1 + BH2.2 current	880,000	-222,900	92	293
4. BH5 plus BH1 + BH2.2 extended	2,826,100	1,184,474	-59	1,745

[40] Suitable areas related to buildings with a suitable domestic hot water demand and existing calorifiers for ease of retrofit

Key Clusters CHP				
CHP - West End	378,836	-193,645	90	127
CHP - Begbroke	416,719	-130,822	82	153
CHP - St Giles and Beaumont Street block	378,836	-204,868	98	123
CHP - Bodleian library broad street junction	385,150	-210,844	135	116
CHP - Old Road Hospital	498,456	64,433	-24	258
CHP - John Radcliffe Hospital	252,557	-8,236	4	130
Key Clusters Combined Cooling Heat and Power (CCHP)				
CCHP - West End	385,150	-146,950	79	139
CCHP - Begbroke	621,827	15,698	-3	329
CCHP - Old Road Hospital	621,827	493,853	-61	507
Key Clusters Fuel Cell CHP				
Fuel Cell CHP – Old Road	1,530,650	-1,720,236	299	327
Mini-CHP				
Mini CHP - building specific	48,875	-29,392	112	16
Mini CHP - roll out	707,764	-288,279	82	209
Mini CHP - total	**756,640**	**-317,671**	**n/a**	**226**

This results table highlights the supply side projects which, on the basis of this high level analysis, may be cost-effective for retrofit or stand-alone (in the case of wind power) installation. These are:

- The wind power options
- PV
- Solar water heating (assuming Renewable Heat Incentive in place)
- Biomass at Begbroke (assuming Renewable Heat Incentive in place)
- Ground Source Heat Pumps (assuming Renewable Heat Incentive in place)
- Science area CHP
- CCHP at some sites

It should be noted that different technology options were investigated for certain buildings (such as Begbroke) and the associated savings shown in the table above are therefore mutually exclusive. Only one option for each area / building has been chosen for the MAC curve chart.

The details behind the different technologies and the buildings that were modelled are included in Appendix III. Further technical detail and assumptions for the Science Area CHP are included in Appendix II.

The table below provides an overview of the wider pros and cons of retrofitting the technologies at the University. For each of the aspects shown, the table indicates the following:

- Where there is a low level of potential impact or issues, the cell is shown in green

- Where there may be some issues or impacts that require some caution, the cell is shown in amber
- Where there may be significant issues or impacts, the cell is shown in red

Table 7: Pros and Cons of the different technologies with regards of retrofitting to Oxford University buildings.

Technology	Ease of retrofit installation	Maintenance	Fuel security and supply	Regulatory and planning issues
Medium-scale wind turbines (>100kW)	**Medium** Access required	**Medium** Annual checks	**Low** Risk of wind shadow from new developments	**High** Planning consent may not be granted, due to visual, landscape and other impacts
Solar photovoltaics (PV)	**Medium** Fittings available for different roof types.	**Low** Annual cleaning; Inverter replacement every 5-10 years	**Low** Risk of overshading from new developments	**Medium** Oxford City Council conservation policies
Solar thermal (SHW)	**Medium** Fittings available for different roof types. Existing calorifier required.	**Low** Annual cleaning; replacement of anti-freeze every 5-10 years	**Low** Risk of overshading from new developments	**Medium** Oxford City Council conservation policies
Biomass heating (wood fuelled)	**Medium** Access and fuel storage and wet heating system required.	**High** >250kW typically has automatic de-ashing	**High** Long-term fuel supply agreement recommended	**Medium** Air quality impact assessment and fuel supply.
Ground source heat pumps (GSHP)	**High** Significant groundworks and low temp heating system required	**Low** Only pumps and controls need regular maintenance.	**Low** Grid electricity required for compressor and circulation	**Low** May need to consult with Environment Agency
Air source heat pumps (ASHP)	**High** Outdoor plant room space and low temp heating system required	**Medium** Similar to standard chiller system.	**Low** Grid electricity required for compressor and fans	**Low**
Combined (Cooling) Heat and Power (CHP/ CCHP)	**Medium** Plant space, heat emitters and flue may require redesign	**High** Increased compared to standard gas boiler	**Medium** Mains gas required as fuel	**Medium** Air quality impact assessment, visual impact of flue

It is expected that for all new Oxford University developments, low and zero carbon technologies as discussed in this section, will be considered as to their suitability in meeting low carbon building targets. Therefore, new developments such as Radcliffe Observatory Quarter or the Swimming Pool rebuild have not been included in this part of the assessment as these carbon reductions have already been taken into account in the BAU emissions growth scenario.

The table of costs illustrates that the key opportunities for energy supply could be:

- Medium scale wind turbines: Site A
  - This is based on the PfR report for the site which recommended that the site should be taken forward for further investigation.
  - Although the PfR report suggested that several turbines could potentially be accommodated at the site, we have assumed, for the purpose of the analysis, that the site could accommodate two off 2.3MWe turbines, giving a total installed capacity of 4.6MWe.
- Science Area CHP scheme for Boiler House 5 (BH5)
  - The two options that appear most cost-effective, whilst also saving significant amounts of carbon, are the BH5 extended option, and the option of BH5 also serving the heat networks for BH1 and BH2.2

These two key opportunities have been recommended in the Implementation Plan to assist in delivering the new stages of the options. Note that due to the planning risk associated with the wind opportunity, it is suggested that it be treated as a 'special project' which would run in parallel with the main implementation.

4.3.3. Target scenarios

In order to make an informed decision about which and how many of the available opportunities to include in the Implementation Plan, a number of possible scenarios were modelled. Each scenario provided an illustration of the impact of a particular mix of opportunities in terms of the estimated capital cost to implement, CO_2 savings and percentage reduction against the Low Growth BAU scenario. High growth forecasts are also included for comparison. [41] These scenarios are summarised in the table below.

	Scenario	Total capex by 2020	Annual CO_2 saving by 2020	% CO_2 reduction by 2020 below 2005/6 baseline	
				Low growth	High growth
1	Cost effective DS Opps only, no energy supply options	£6,891,273	27,367	25%	-38%
2	1 plus all cost effective energy supply options	£17,527,942	34,237	35%	-28%
3	1 + large wind & BH5 CHP	£15,517,373	33,444	34%	-29%
4	All measures with CER below 200	£28,805,831	39,302	43%	-20%
5	All DS Opps with CER below 200 + large wind & BH5 CHP	£19,750,458	37,065	40%	-24%
6	All DS Opps with CER below 200 + BH5 CHP	£13,950,458	32,733	33%	-30%

Figure 10: CO_2 reduction scenarios based on the MAC curves presented above

4.4. Preferred scenario

Further to discussions with the University during the development of the strategy, and as supported by previous and updated calculations and modelling, achieving the full HEFCE sectoral target of a 43% reduction in CO_2 is unlikely to be cost effective based on current projections of costs and benefits.

Therefore, in line with previous discussions, it is recommended that Scenario 6 be taken forward as the preferred Target Scenario which is predicted to result in a 33% CO_2 reduction in 2020

[41] Low growth (as outlined in section 3.3) assumes that fossil fuel energy use in 2020 will be at the same level as 2008/9, and electricity use will grow at 2% per year between now and 2020. High growth assumes that both fossil fuel energy use and electricity use grow at the same rates as over the last 5 years, namely 2.8% and 6.5% per annum, respectively.

against the required baseline of 2005/06. The choice of this scenario was guided by discussion with the Sustainability Steering Group (SSG) at a meeting on 11th June, 2010.

At the SSG meeting, there was discussion around the contribution that Photovoltaic (PV) panels could make to the target. Although with the revenue available currently from Feed-in Tariffs this option could be cost-effective, and provide rates of return in the region of 6-8%, it requires a relatively large capital investment for a relatively small amount of carbon saving (see table 6). For this reason, the Group decided not to include PV as part of the target scenario at this stage. However, the University may still want to review the option of installing PV as a separate initiative outside of the strategy, particularly as there may be potential for the capital cost to be shared with external investors and companies.

It should be noted that if a large wind project is carried through successfully, then the saving would be significantly higher than that illustrated below. However, due to the risk associated with gaining planning permission for the turbines, it is felt that the prudent course of action is to adopt a stated aim which does not include this element of potential saving. Nonetheless, the exploration of the potential for large scale wind power forms a key part of the Implementation Plan set out in section 5, even though a contribution from wind is not included as part of the carbon reduction target figure. If the University was able to implement a larger scale wind project[42] then it could potentially exceed its target of a 33% carbon reduction by 2020.

The implications of the preferred carbon reduction target scenario are illustrated in the graph below.

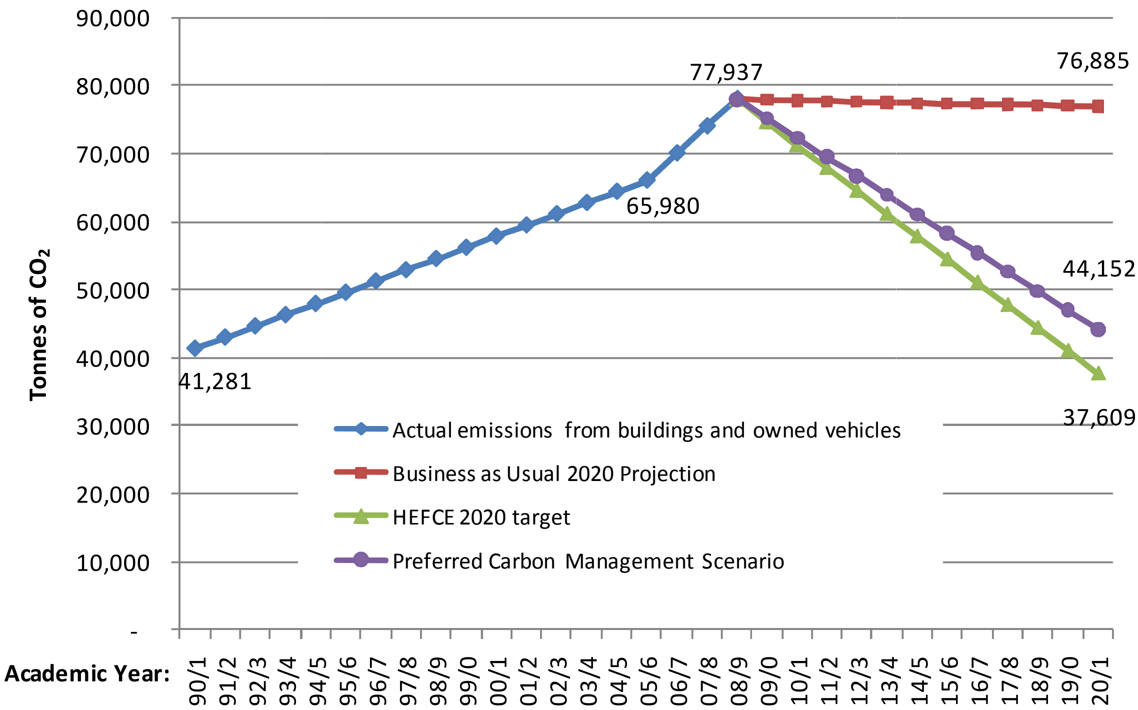

Figure 11: The trend in the University's scope one and two CO_2 emissions since 1990/1, using data from three years: 1990/1, 2005/6 and 2008/9. The figure also shows the Low Growth Business as Usual projection (76,885tCO_2 in 2020), the necessary trends to achieve the 2020/1 sectoral target from HEFCE (43% below 2005/6 by 2020, or 37,609tCO_2) and the University's chosen 2020 target of 33% below 2005/6 (44,152tCO_2), 'the 'Preferred Carbon Management Scenario'.

Note: the Business as Usual emissions are lower in 2020 than in 2008/9 due to the use of a lower emissions factor for electricity, which outweighs the fact that the projected electricity consumption in 2020 is 24% higher than for 2008/9.

[42] i.e. in the range of 4-5MW installed capacity

5. Implementation plan

5.1. Introduction

This chapter provides an implementation plan to deliver the target scenario of a reduction of around 34,000tCO_2 by 2020, as presented in section 4.4.

The plan consists of three distinct parts as indicated below:

1. The High Level Activity Plan. This incorporates a plan of high level actions for three years for the academic years 2010/11 through to 2012/13. It also recommends a series of ongoing actions through to 2020. This plan is in the form of a Gantt chart presented in this section.
2. The Detailed Activity Schedule. This schedule breaks down each of the high level actions into more detailed activities and their associated timeframes. This schedule is presented in Appendix IV along with a detailed description of all of the activities listed.
3. Implementation Plan Tool (spreadsheet file). This tool will allow the University to plan and monitor progress in the detailed surveying particularly of demand side opportunities as well as keeping track of projected capital costs and carbon savings.

The Implementation Plan as a whole should be seen as a live document, and will need regular updating as new information becomes available on the success of the initiatives and on the accuracy of the Business as Usual 2020 Projection.

This section specifically sets out the high level actions which will need to be undertaken along with the timescales for their execution and an estimation of the amount of University resource which is likely to be required. An assessment of the costs of external consultants is also included where specialist technical expertise may be necessary for the execution of a particular action.

There is a more detailed focus on the first three years as the activities which follow to 2020 will be heavily influenced by the results of early action such as surveying of opportunities and so on – this initial period is broken down in more detail in the accompanying Implementation Plan Tool.

Alongside the actions indicated here, the Strategic Enabling Actions as set out in Section 6 should also be considered as key steps towards the full implementation of the Carbon Management Strategy.

5.2. Summary

5.2.1. High level Activity Plan

Table 8: This table sets out the high level actions which will be required over the next three years to move forward with the implementation of the strategy. Where applicable, each action is further broken down in the Detailed Activity Schedule provided in Appendix IV. Beyond 2013, there are a number of regularly recurring actions which should continue throughout the life of the strategy as well as ongoing activities such as the installation of opportunities themselves.

					2010/11				2011/12				2012/13				13/14	14/15	15/16	16/17	17/18	18/19	19/20
Ref	**Activity**	**Ownership**	**Resource Estimate**	**Completion**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4							
1	Presentation of CMS to SSG	DE / HES	Internal process / existing resource	Oct 2010	■																		
2	Define and agree budgetary envelope	DE / HES	Internal process / existing resource	Nov 2010		■																	
3	Agree with HEFCE approach FiT & RHI	HES	Internal process / existing resource	Sep 2010	■																		
4	Survey of previously audited buildings for DS opps	EM	35 days ES	Jun 2011	■	■	■	■															
5	Implementation of Demand Side Opps	EM	up to 8 days / mth ES	Ongoing				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
6	Survey of all other relevant buildings for DS Opps	EM	up to 650 days ES	Aug 2013					■	■	■	■	■	■	■	■							
	BH5 CHP								■	■	■	■	■	■	■	■							
7	Detailed assessment of BH5 CHP options	HBS	£15K ext	Jan 2011		■																	
8	Performance design of science area CHP	HBS	£20K ext	Apr 2011			■																
9	Procurement and installation of BH5 CHP	HBS	£50K ext	Oct 2011				■	■														
	Wind power option							■	■														
10	Liaise with colleges and examine wind power resource	DE / HES	10 days ES + £12.5K ext.	Mar 2011		■	■																
11	Surveys and prepare planning application for wind power	DE / HES	up to £120K ext (wind)	Apr 2012				■	■	■	■												
12	Planning determination period for wind project	DE / HES	10K ext	Apr 2013								■	■	■	■								
13	Performance design for wind power project	DE / HES	£20K ext	Jul 2013		■	■									■							
14	Procurement and installation of wind power project	DE / HES	£150K ext														■						
15	Reviewing of budgetary envelope	DE / HES	Internal process / existing resource	Ongoing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
16	Progress review & reporting	HES	Internal process / existing resource	Ongoing				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
17	Progress updates to SSG	DE / HES	Internal process / existing resource	Ongoing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

DE = Director of Estates (DE), HES = Head of Environmental Sustainability, HBS = Head of Building Services (HBS), and EM = Energy Manager (EM)

Q1, Q2, etc. refer to the quarters of the academic year, i.e. Q1 = Aug-Oct, Q2 = Nov-Jan, etc.

The resource estimates give in the table are indicative only, at this stage, of the likely resource (i.e. Estates Services staff time) required to execute a particular activity or / and the likely level of fee necessary to engage an external consultant ('ext.') to carry out specialist activities. They exclude any capital costs.

5.2.2. Summary of activities

The activities listed in the high level plan above are presented in more detail below. For information on the sub-tasks required for each high level activity, refer to the Detailed Activity Schedule in Appendix IV of this document.

1 Presentation of CMS to SSG
Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Oct 2010**
A critical step in ensuring the success of the CMS is to have it presented and subsequently ratified by the SSG. This activity is assumed to happen at the next available SSG meeting in October 2010.

2 Define and agree budgetary envelope
Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Nov/Dec 2010**
An early agreement of the budgetary envelope for the implementation plan should be a priority. Securing the commitment to a budget dedicated to the plan will ensure that there is sufficient resource to act on opportunities, it will demonstrate central commitment to the various departments and will ensure that there are sufficient funds for the delivery of larger scale opportunities.

3 Agree with HEFCE approach to FiT & RHI
Owner: Director of Estates / Head of Environmental Sustainability **Timescale: asap**
To minimise risk with respect to supply side opportunities, a dialogue should be opened with HEFCE regarding their approach to Feed in Tariffs and any future Renewable Heat Incentive. The University should seek clear guidance, in writing, with respect to how energy supply must be arranged both physically and contractually to ensure any carbon savings can be claimed in their annual reporting.

4 Survey of previously audited buildings for Demand Side (DS) opportunities
Owner: Energy Manager **Timescale: Complete by June 2011**
This activity will have two key functions. Firstly it will examine each opportunity in the previously audited buildings in more detail than has been possible thus far, ascertain the exact requirements for implementation and refine the estimate of predicted cost / benefit. Secondly, it will determine the likelihood of the opportunity being replicated in other buildings across the portfolio. The Implementation Plan Tool has the functionality to allow these and future surveys to be programmed and progress monitored.

5 Implementation of Demand Side (DS) opportunities
Owner: Energy Manager **Timescale: Complete by 2020**
It has been assumed that in order to obtain best value from contractors, who are likely to be engaged for the implementation of at least some of the opportunities that a reasonable amount of work will have to be included in any tender package. Implementation therefore is not programmed to start until all of the previously audited buildings have been fully surveyed and therefore work packages of sufficient value can be tendered.
This raises the question of how large the economy of scale must be before works are tendered. The view has been taken for the purposes of this plan that the previously audited buildings present a sufficient scale for this purpose.
This implementation process will continue to run on as the buildings in the portfolio are surveyed.

6 Survey of all other relevant buildings for demand side (DS) opportunities
Owner: Energy Manager **Timescale: Complete by Aug 2013**
As each opportunity is surveyed at the original building where it was observed the Implementation Plan tool allows for the recording of the appropriateness of the measure to be replicated across other buildings in the portfolio. This period covers the surveying of all appropriate buildings for each opportunity.
An assumption has been made that all buildings will be surveyed within the first three years of the implementation plan. Depending on resource availability this may or may not be possible, but, as the plan is to be considered a live document, this can be updated as progress is monitored.

7 Detailed assessment of BH5 CHP options
Owner: Head of Building Services **Timescale: Complete by May 2011**
This activity would assess in more detail the potential for installing gas engine CHP into boiler house 5 as part of the planned boiler replacement. It would also assess the feasibility and cost benefit of alternative CHP scenarios on the science area site.

8 Performance design of science area CHP
Owner: Head of Building Services **Timescale: Complete by Dec 2011**
Once the preferred option had been selected (and assuming the University wish to proceed with the CHP option), this activity would prepare a performance specification to support a tendering exercise for a turnkey installer for CHP units, and potentially also associated M&E works and district heat network installation.

9 Procurement and installation of BH5 CHP
Owner: Head of Building Services **Timescale: Complete by Summer 2012**
This activity would involve selecting a contractor (s) and then supervising the installation works. The timing of this may be critical in order to fit in with the proposed boiler replacement "window" for BH5.

10 Liaise with colleges and examine wind power resource
Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Complete by Mar 2011**
This activity is aimed at ensuring opportunities to deliver supply wide opportunities in partnership with the colleges are not missed. This activity would involve carrying out a constraints mapping exercise to identify if any areas of land were suitable for larger scale wind power.

This would include assessing issues such as: wind speed; proximity to transport networks; proximity to existing dwellings; ecological, landscape or heritage constraints, slope, proximity to grid networks and viability of connection. It would also involve initial consultation with telecommunications operators, MoD and the Civil Aviation Authority. For the most promising sites, more detailed site visits would be carried out to assess issues such as access, and grid connection.

11 Surveys and prepare planning application for wind power
Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Complete by Apr 2012**
If a suitable site is identified that the University wish to develop for wind power, then the next stage would be to prepare a planning application, supported by an environmental statement (ES), as well as carrying out appropriate consultation. The local authority would be consulted with to establish whether a full Environmental Impact Assessment would be required, and if so, the scope of that. The University may also need to erect a wind monitoring mast for 6-12 months, and which would require planning permission (although a temporary structure). The monitoring can be carried out in parallel with preparing the EIA, and carrying out any relevant environmental

surveys.

Various surveys and studies would be required to support the ES, depending on the particular issues of sensitivity on the site, and that the local authority wanted to see assessed. This could cover surveys of ecology, ground conditions, as well as noise, visual impact and landscape impact assessments.

12 Planning determination period for wind project

Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Complete by April 2013**

This period covers the determination period for a planning application for a wind power project, should the University submit one. Although the official determination period is 12 weeks, generally wind power applications take longer than this to be determined.

13 Performance design for wind power project

Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Complete by July, 2013**

Assuming the wind power project receives planning consent, this work would involve preparing a performance specification to support a tendering exercise for a turnkey installer for wind turbines.

14 Procurement and installation of wind power project

Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Complete by end of 2014**

This activity would involve selecting a contractor (s) and then supervising the installation works. It would also involve discharging any planning conditions associated with the planning consent for the site.

15 Reviewing of budgetary envelope

Owner: Director of Estates / Head of Environmental Sustainability **Timescale: Ongoing**

To ensure that the plan remains live, the budgetary envelope should be reviewed regularly in light of the intelligence gathered during the surveying phase of implementation. Those responsible for day to day implementation should use the Implementation Plan tool to continuously update projected capital expenditure as firm quotations are provided by installers as well as updating energy and CO2 savings based on their findings.

16 Progress review & reporting

Owner: Head of Environmental Sustainability **Timescale: Annually**

This work includes reviewing progress against the plan particularly around the amount of opportunities implemented, their related carbon savings by analysing metered data wherever possible and comparison against the BAU scenario. It also encompasses the preparation and publication of public reporting as required by HEFCE.

17 Progress updates to SSG

Owner: Energy Manager **Timescale: Ongoing**

Progress against the Implementation Plan will undoubtedly need to be reported to the SSG. The Detailed Activity Schedule contains actions programmed to immediately precede SSG meetings ensuring that reporting can be prepared for presentation.

5.3. Implementation of stationary energy demand-side measures

5.3.1. Non-laboratory energy use

There are a significant number of opportunities available to reduce carbon emissions from making infrastructural changes in non-laboratory energy use. These opportunities have been observed by AECOM and Hurley Palmer Flatt in a number of buildings across the portfolio. However, the audits which have been carried out thus far have been necessarily brief and have not examined in detail the technical requirements of the activities required to realise the CO_2 savings.

An implementation plan has been developed which sets out a schedule for carrying out detailed surveys of each opportunity in the buildings where it was first observed. These surveys will have two objectives: firstly to ascertain the technical requirements of the opportunity and whether a quotation from a contractor is required in order to progress its implementation; secondly, to confirm whether the opportunity can be replicated across other buildings in the portfolio.

The plan presents the initial actions required over the next three years which focus mainly on surveying all of the opportunities in the original buildings where they were observed as well as any other buildings where the opportunity could be implemented. Assumptions have been made regarding the applicability of each measure in various buildings across the portfolio and the plan provides a method for surveyors to determine in which buildings opportunities might be implementable in order to plan their activities. However, the plan does not set out these 'other building' surveying activities in detail as this will be dependent on the results of the original building surveys.

The implementation plan is a spreadsheet based tool which allows the active tracking of progress in surveying and implementing opportunities across the entire portfolio. This section presents a number of extracts from the plan.

Note that in previous sections of this strategy, it has been necessary to ensure that similar opportunities are not extrapolated across the portfolio to prevent overstating available savings. However, for the purposes of the implementation plan, it is important that every instance of a particular opportunity is presented so that they can be surveyed in detail and their implementation planned.

Opportunity groups

Opportunities have been aggregated into a number of groups in order to allow a high level overview to be taken of where CO_2 abatement is likely to be found. The following table presents a summary of data at the group level.

Table 9: Summary of carbon abatement opportunity groups. All opportunities to be included in the implementation plan have been allocated to one of a number of groups and are presented below with the amount of opportunities, the estimated capital cost of implementation and the carbon savings for each group.

Opportunity Group	Number of measures	Capital Cost	Cumulative Annual CO_2 savings by 2020
Building Fabric	6	£534,485	817
DHW	3	£217,295	259
Lighting	21	£3,411,902	5652
Monitoring	5	£627,975	2472
Other	12	£1,099,486	4693
Plant Controls	24	£1,286,003	7391
Plant Efficiency	31	£2,683,693	5922
Plant Replacement	4	£85,957	116
Space Heating	7	£895,429	1023
Ventilation	8	£279,067	2224
Totals	**121**	**£11,121,292.**	**30,569**

The summary table presented above is based on all measures with a Cost Effectiveness Ratio of 200 or less as set out in the preferred scenario explored in Section 4.4.

5.3.2. Laboratory user energy efficiency

This section outlines the key learning points from the site visits and focus groups, and AECOM's recommendations for realising the opportunities for reducing laboratory energy use identified in the two target buildings. For full implementation plans, see Appendix IV, and for the full Laboratory User Energy Efficiency Strategy, see Appendix V. The interventions recommended are split into two categories: behavioural and technical. For some of the opportunities identified, there is more than one intervention recommended.

The initiatives in this section are not exhaustive. They are presented as a collection of measures for which data has been gathered that suggests that they are a likely to be the most beneficial measures to begin with.

Behavioural interventions

Proposed intervention: shutdown protocol stickers

During the site visits, AECOM staff observed many notes left on pieces of equipment by laboratory users indicating that they are using it, and that the equipment should be left on. This information, and that gathered in the barrier mapping exercise suggests that some energy savings could be made by clarifying the shutdown protocol for each piece of equipment in the laboratory. It is proposed that stickers to identify the shutdown procedure for each type of equipment put on to all relevant equipment would bring about energy savings by guiding people to turn off equipment. The suggested sticker types are:

- Always Shut Down
- Follow Shut Down Procedure
- Automatically Shuts Down
- Never Shut Down

The intention would be, for example, for anybody who sees the green ‘always shut down’ sticker on a piece of equipment, they would know that the particular piece of equipment could be turned off if no one is obviously using it. Those pieces of equipment with the yellow sticker on would have a shut down procedure on display nearby which would outline when and whether the equipment should be turned off.

Proposed intervention: fume cupboard use awareness strips

Significant changes in behaviour may be achieved by providing a constant reminder of the amount of energy wasted and CO_2 generated by leaving fume cupboard sashes up. Strips such as that shown in Figure 11 could be displayed down the sides of the fume cupboards, drawing attention to how far open the user has the sash. This would not only remind laboratory users of the need to close the sashes when not in use, but also would encourage them to keep the sashes as low as possible when they are working in the cupboard

The combination of measures recommended in the Laboratory User Energy Efficiency Strategy will serve to bring about an increased awareness of the importance of reducing unnecessary energy use. If the strategy were fully implemented, then as new researchers and students come to use the facilities, they would enter a facility where behaving in an energy-efficient manner is just ‘what people do’, the social norms of the facilities would have changed, and this would come to have an effect on all areas of energy using behaviour, including fume cupboards.

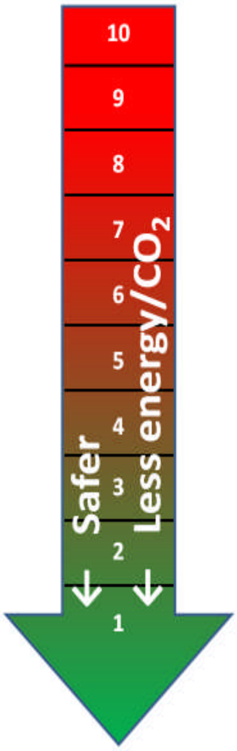

Figure 12: an example of a strip to be put down the side of the fume cupboards

Technical initiatives

This section considers initiatives that rely on simple technical interventions to reduce occupant-controlled energy use in the laboratories at the University. The technical initiatives outlined here have many of the same target energy uses as the initiatives outlined in the behaviour section.

Programmable timer switches

Programmable timer switches are simple inexpensive devices that can be programmed to turn equipment off and on at certain times. Many of these timer switches can now take into account what day of the week it is, allowing for different use patterns during weekends. Timer switches such as these could be attached to appropriate pieces of laboratory equipment that are not used outside of office hours to avoid them being left on. Programmable timer switches would be particularly effective in reducing the energy use of the glass drying cabinets.

Push-button timer switches

At the focus groups, attendees suggested that certain pieces of high power using equipment are only used sporadically and when they are used, they are only needed for a short time, and sometimes left on accidentally. Push button timer switches that turn on the equipment for a set amount of time and then turn it off could be connected to the plugs that these pieces of equipment are on. Alternatively, if the equipment in question is wired into a higher voltage circuit, a timer switch could be wired in.

Refrigerators and freezers

Laboratories (particularly biological laboratories) use a considerable amount of refrigerators and freezers. Many of the appliances observed in the laboratories appeared to be old and inefficient, and others seemed to have a lot of unused space. There may be scope for:

- replacing old refrigerators/freezers;
- consolidating the use of space in them (thereby reducing the number required);
- filling space in them (with anything – fuller fridges/freezers use less energy); or
- fitting refrigerator compressor motor controllers

Proposed delivery mechanism: the Sustainable Laboratory Group (SLG)

The measures outlined above will require a significant amount of person hours to pilot effectively. The most effective structure for the delivery of a laboratory user focused behavioural change programme would be through the use of a volunteer Sustainable Laboratory Group (SLG).

Wherever possible, this group should consist of laboratory users, and attempts should be made primarily in the laboratory user population to recruit members for the SLG. Although, crucially, this group must be led by an individual with work time allocated to the role of SLG Leader (this person would most likely be in the Sustainability Team). However sufficient input is unlikely to be available from current laboratory users to implement these measures effectively. Therefore, it is proposed that efforts be made to recruit members from the broader student population, possibly from the Oxford Environmental Change Institute; it is recommended that the group consist of a minimum of 10 students, but, considering that their input is likely to be irregular due to academic pressures, more would be preferable.

This should be seen as a significant opportunity; the student body is an often neglected group of stakeholders in the pursuit of environmental change at universities. However, effectively and positively engaging students reinforces and supports environmental impact reduction goals, whilst reducing potential barriers to action, injecting valuable enthusiasm and energy into the programme and providing students with invaluable experience in organisational change management for sustainability.

Many students are keen to embrace environmental behaviours and can be used as internal advocates to leverage action from the board and staff. Students can have a significant influence on operational environmental impacts, with a particular ability to influence academic staff (who often have more loyalty towards their students than their institution). Additionally, this represents an opportunity for collaboration between the academic departments and the Colleges, as the Colleges may be a key stakeholder in recruiting students.

The environment within which students attain their education will shape their approach to sustainability when they join the workforce. Therefore, influencing this approach has perhaps the greatest potential in terms of total carbon emissions reductions from higher education institutions.

However, the use of students from outside of the specific building in question should be considered on a case by case basis. Many laboratory users will not react favourably to someone from outside their laboratory space interfering with their equipment. In such cases people to roll out the SLG initiatives may need to be recruited within the building user population.

As mentioned above, whilst the initial focus of the SLG will be on energy use, it will also serve as the basis for building the University's capacity to deliver other sustainability objectives, such as increased recycling and reduced potable water use. A suggested structure would be for the SLG to be led by a member of the Sustainability Team, who would recruit laboratory users who are willing to give some of their time to the initiative and would also recruit members of the student population.

Laboratory users are generally very busy people, who may not react favourably to having students interfering in the operation of their laboratories, therefore the SLG members should be given some form of training in behaviour change for sustainability.

5.4. Implementation of energy supply options

An implementation plan for the supply side measures has been developed and integrated alongside the demand side measures. This sets out in more detail the key next steps over the next three years for taking forward the investigation for the key opportunities, namely:

- Medium scale wind
- Science Area CHP in boiler house 5 (BH5)

Medium Scale Wind

Medium-scale wind is a unique technology covered in this study because it is not building specific, and could be maximised on a site which is not in close proximity to an Oxford University building. In such a case, significant amounts of electricity generated by the wind turbine could be fed into the national grid network, rather than directly used in an Oxford University building. Oxford University would be eligible to receive Feed in Tariff incentives in this case; however this may have an effect on HEFCE eligibility. At the time of writing (September 2010) HEFCE have not clarified exactly what their approach will be to off-site electricity generation, although discussions with HEFCE have suggested that they may allow institutions to offset some of their emissions by supplying low carbon electricity to the National Grid.

Under the CRC, offsite generation is only recognised if the organisation itself is generating and using the electricity. [43] HEFCE's position on off-site generation should be clarified, and the overall benefits should be weighed up at an early stage before further assessments and studies are carried out.

The medium scale wind assessment is currently based on studies which were carried out two to three years ago and therefore there is a risk that this information is now out of date. Therefore, the key implementation action is to re-assess all available developable land that Oxford University own. In addition, this could be extended to College-owned land, and early stage discussions with the Colleges are advised.

If a suitable wind site can be identified, an Environmental Impact Assessment (EIA) may be required by the local authority in order to support a planning application. This and other associated consultations may make the implementation of medium-scale wind power a time consuming and costly exercise. The implementation plan in Appendix IV indicates the scale of cost and time that could be required, although this may vary greatly depending on the nature and complexity of the site.

Science Area CHP in BH5

The Science Area is a key opportunity for cost effective reductions in carbon emissions because there is an existing heating network and central boiler houses. This removes significant steps of a

[43] *Guidance on the CRC Energy Efficiency Scheme Electricity Generation* Environment Agency, March 2010

typical CHP implementation plan, but introduces key steps at the beginning in order to thoroughly assess the opportunities and constraints of this existing network. In particular, these steps are

- A replacement and refurbishment project has been planned for Boiler House 5 and any CHP study needs to be designed to fit in with this refurbishment.
- Further options analysis needs to be carried out on the central CHP unit housed in BH5 and which buildings should be connected to the network.
- The condition of the existing pipe network needs to be assessed to confirm it is suitable for use.
- The BH5 existing plant room and flues need to be surveyed for available space.

The implementation plan in Appendix IV includes these early stage option assessments and sets out the steps that would be required once a scheme has been identified.

5.5. Financing the plan

The financing of the implementation plan will require both capital investment and resource commitment. The analysis of required finance examines the capital investment required in the calculations supporting the MAC curves and, in the implementation plan, provides an indication of the level of resource likely to be required for surveying activities.

Detailed surveying activities discussed in the implementation plan will be required in order to understand with a greater level of certainty the applicability of demand side opportunities across the portfolio, as well as their likely performance over time. The levels of financing presented here and elsewhere in the strategy should be seen as defining a budgetary envelope rather than an exact financial plan.

This is also true of the various supply side measures presented in both the MAC curves and the implementation plan. These opportunities will need careful consideration during the initial three year period which will likely include liaison with specialist manufacturers and installers to establish with accuracy the costs associated with their implementation.

For these reasons, the budgetary envelope should be regularly reviewed during the implementation period as more information becomes available through supplier quotations, from examining opportunities in buildings not previously audited, liaison with manufacturers and so on.

The chart presented below illustrates the capital investment required each year which will be made up of existing capital funding and gap funding. It also provides an indication of the cumulative capital expenditure through to 2020. In this instance, the existing capital funding is deemed to consist of Salix funds (about £100,000 per year), the sale of EU ETS carbon allowances (about £50,000 per year) and the proceeds of the Energy Conservation Levy, (about £180,000 per year) giving a total of £330,000 per year. The revenue from the sales of surplus carbon allowances is assumed to come to an end in 2012, as phase 3 of the EU ETS starts in 2013, and the emissions caps are to be lowered, which means that the University may no longer have a surplus. The revenue from the Salix revolving fund is assumed to come to an end in 2015, as measures need to have 5 year payback to be eligible, and it is assumed that by then all of the measures with these payback times will have been implemented, leaving those measures that have longer payback times.

The indicated gap funding is an assessment of that which will need to be secured each year in order to implement the opportunities as illustrated.

The chart assumes a consistent distribution of the implementation of measures over the next ten years in order of their Cost Effectiveness Ratio. The figures used in the chart are based on the target scenario set out in Section 4.3.3. It may be that the actual order of implementation differs from that assumed here and this illustration should be taken as an indicator of one possible approach. Note that the capital expenditure in academic year 2012 / 13 is indicated as being significantly higher than other years due to the implementation of the BH5 CHP opportunity in that year to coincide with the refurbishment of Boiler House 5 which is understand to be likely to happen in 2012. Further note that the wind power project is not included in this chart but would require significant capital expenditure as a ‘special project’ as well as the resource requirement indicated in the implementation plan.

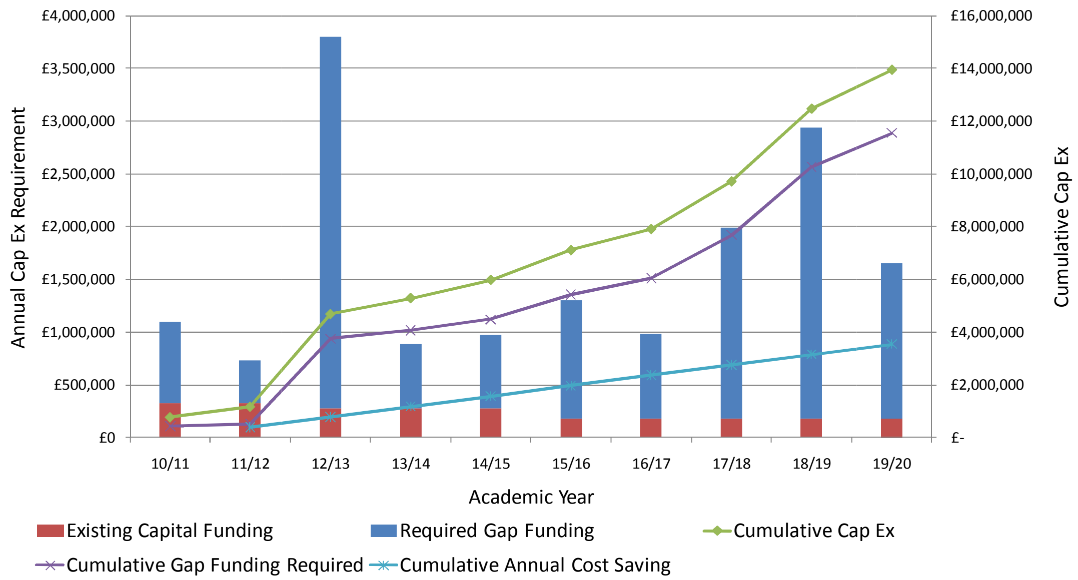

Figure 13: Chart indicating the estimated annual and cumulative funding position of the implementation plan to 2020. The chart is based on a flat rate of implementation between 2010 and 2020 with the most cost effective measures being implemented earlier. Academic year 2012 / 13 is high as this is assumed to be the point when the BH5 CHP opportunity will be implemented to coincide with the refurbishment of Boiler House 5.

Table 10: Table summarising the estimated annual funding position for the implementation plan between 2010 and 2020

Academic Year	Existing Capital Funding	Annual Capital Expenditure	Required Gap Funding	Cumulative Annual Cost Saving
2010/11	£330,000	£766,950	£436,950	-
2011/12	£330,000	£400,569	£70,569	£393,870
2012/13	£280,000	£3,515,938	£3,235,938	£787,740
2013/14	£280,000	£550,910	£270,910	£1,181,610
2014/15	£280,000	£697,968	£417,968	£1,575,480
2015/16	£180,000	£1,101,463	£921,463	£1,969,350
2016/17	£180,000	£856,156	£676,156	£2,363,220
2017/18	£180,000	£1,827,418	£1,647,418	£2,757,090
2018/19	£180,000	£2,759,020	£2,579,020	£3,150,960
2019/20	£180,000	£1,474,065	£1,294,065	£3,544,830
	Totals	**£13,950,457**	**£11,550,457**	**£17,724,150**

The figures presented in the chart and table above are based on 2010 costs and are therefore undiscounted. As costs are ‘current’ no account has been taken of inflation. Readers should note that this differs from the MAC curves presented elsewhere in the strategy which are necessarily based on discounted figures.

The cumulative annual cost savings assume that savings start in the second year of the implementation plan, and that, simplistically, the total potential savings that can be realised by 2020 grow incrementally and evenly in the preceding years. In practice, the annual savings in preceding years will depend on when, and how quickly, measures can be rolled out. It may be that the savings will be more “backloaded” than is shown in the table, i.e. savings could be lower in the initial years and higher in the later years.

The figures show that the total capital expenditure required by 2020 is estimated to be just under £14 million. Assuming that the current existing sources of capital for energy measures persist until 2020, then this would require an additional £11.6 million of capital from other sources, in 2010 prices. Allowing for an additional 10% to cover design and other professional fees, and a further 15% for contingency, **we recommend that a budgetary envelope of £14.6 million should be established to support implementation**. As mentioned in section 5.2, this figure should be kept under review as the implementation plan progresses.

This amount of capital would be over and above any funding that appears in the routine Repairs and Maintenance budget, such as for boiler and window replacements, as these measures are treated as being part of the Business as Usual growth scenario and not as part of the implementation plan set out in this strategy.

The figures for capital expenditure include £2.8 million for the CHP scheme for the Science Area, but do not include any figures for a wind energy project or any supply side options that may become viable in the future. The figures for the net annual savings from implementing the measures assume a lag time of one year between the date of incurring the capital costs of any particular measure and the time that financial benefits are seen.

6. Strategic enabling actions

6.1. Introduction

This section sets out a number of strategic actions that will be required in order to facilitate and enable the implementation of the various carbon reduction opportunities set out in section 5. These actions have been identified during the course of the project from discussions with key stakeholders and observations during site visits.

6.2. Financing

Currently, the extent to which energy/ carbon reduction can be implemented by the estates and sustainability team is constrained by the annual budget available for such measures. Currently, as detailed in section 5.5, about £330,000 per annum is available for carbon reduction measures, from the Energy Conservation Levy, the sales of EU ETS allowances and the Salix revolving fund. However, as the "low hanging fruit" are picked, this may mean that over time the Salix fund may be less available to fund measures as they may fall outside of the five year payback window.

It is recommended that the University, via the Planning Resource and Allocation Committee (PRAC) and its Capital Steering Group (CSG) should create a budgetary envelope for carbon reduction measures, similar in nature to a major capital project, into which bids for specific projects could be made. This budget allocation should be for £14.6 million (excluding VAT) to cover the demand reduction measures and Science Area CHP, allowing some headroom for contingencies and professional fees. Should the large wind option prove viable, then this should have a separate budget allocated for it. [44]

6.3. Procurement of equipment, services and management of contractors

In relation to maintenance contracts, there is a split of responsibility for maintenance between Estates Services, and individual departments, as set out in the Estates Regulations. Broadly speaking, Estates Services are responsible for all fixed items, whether the building fabric, or plant and equipment, and the Departments, or "occupying units" are responsible for routine internal maintenance and cleaning, and maintenance of movable equipment.

6.3.1. Maintenance contracts

The University has a number of contracts in place with maintenance contractors. The Building Services team manage a number of maintenance contractors for mechanical, electrical, Building Management Systems and cooling services and the Conservation and Buildings Team also manage a number of contractors who carry out works relating to building surveying and repairs.

It is recommended that all of these contracts should be systematically reviewed to ensure that part of their scope involves flagging up opportunities for additional energy efficiency improvements, both within and outside their core discipline, and ensuring that these are reported back to the Sustainability Team and other relevant estates teams. [45] **It is**

[44] The University may choose not to fully fund a large wind option, but may instead provide an equity stake only and look to secure debt finance.

[45] These opportunities may take the form of identifying areas of energy wastage that they happen to notice in passing whilst carrying out their core work. For example, some of the surveyors used by the Conservation and Buildings team also have expertise in carrying out energy efficiency audits. Another type of opportunity would be to flag up the potential use of a more energy efficient piece of building fabric or equipment rather

understood that progress has already been made in this area with respect to the M&E maintenance contract with Norland.

Whilst it may be difficult to introduce this requirement to existing contracts, it could be introduced as a key requirement at the point of contract renewal or retendering. It may also be worth considering holding a workshop or meeting with maintenance contractors working across the Estates team to identify the extent to which they feel they already identify these sorts of opportunities, but don't report them, or potential barriers to them being more pro-active in identifying such opportunities.

6.3.2. Repairs and maintenance activities

Estates Services has a programme of ongoing planned repair and replacement works, covering items such as window replacements and replacement of boilers that have reached the end of their working life. This strategy has assumed that these works will continue anyway, as part of "business as usual" and therefore they have not been included as specific opportunities in the implementation plan.

However, there is an opportunity for the Estates team to review these works on an ongoing basis to identify the following:

- Whether the proposed performance or specification of the replacement items could be enhanced. This is already regulated under Building Regulations, which ensures that the replacements will have a higher specification than the existing items. However, there may be scope for selecting performance levels that exceed the minimum required by Building Regulations. A cost-benefit assessment would need to be carried to assess whether this was worthwhile, for each case.
- Whether the planned works can be expanded to incorporate some of the measures identified in the implementation plan in this strategy
- Whether some of the planned works could be brought forward in time to ensure delivery of carbon savings by 2020, to assist in meeting the carbon reduction target

6.3.3. Occupying Unit maintenance and cleaning contracts

Data on the number of separate contractors that are being used by individual departments is not currently available. Although we know that there is some sharing of contractors with Estates Services, and that Estates Services has worked with the Purchasing Department to negotiate some facilities management contracts, as well developing some generic tendering documents. Many of the departmental maintenance responsibilities have strong links to energy use, such as replacement light fittings and lamps, compressed air, and all plant installed by the unit.

It is recommended that all departmental administrators/ facilities managers should review their relevant maintenance contracts, as above, to ensure that part of their scope involves flagging up opportunities for additional energy efficiency improvements. The University could provide a template and best practice for the type of wording to use in such contracts. A potential barrier is that this could increase maintenance costs, although this could be offset by reduced energy costs in the medium term.

It is also recommended that, specifically in relation to cleaning contracts, Departments should review current procedures to identify whether:

- Cleaning staff could provide support in e.g. turning off lights and non-essential equipment (e.g. desktop fans) when leaving a building

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than just replacing with like-for-like or the Building Regulations minimum standard. A third type of opportunity would relate to identifying "good housekeeping" improvements.

- Whether current cleaning regimes and practices could be improved to reduce energy consumption e.g. the extent to which lights are turned on when cleaning is being carried out

6.3.4. Procurement of energy consuming equipment

A significant proportion of the University's CO_2 is generated by laboratory equipment procured by research departments. Information gathered in the Building User Focus Groups suggests that this procurement is often done directly by the researcher, often (but not always) with input from the local facilities management team.

Unilateral procurement of laboratory equipment in this manner is one of the effects of the University's commitment to the principle of subsidiarity (also mentioned in the section on 'devolving targets'). Were all procurement decisions channelled, vetted and approved by a central department, this would slow down the procurement process considerably, particularly as the researcher and the facilities management team are often the only people who understand the particularities of the requirements of the new piece of equipment and the restrictions of the space into which it is to be installed, such as dimensions and power availability. This decentralised flexibility is fundamental to the process that delivers the University's unparalleled research facilities.

However, it was suggested by building users at the focus groups that energy efficiency is often not considered in procurement of laboratory equipment, sometimes even despite the inclination of the researcher to the contrary. A better understanding is needed of the dynamics behind each of the many procurement decisions taken each day at the University in order to address this issue strategically. However, one of the key points raised by building users was that they do not know of a trusted source of information that they can access for relevant and succinct information on the specific types of equipment that they commonly procure (for example, freezers or pumps). Information does exist to support researchers on procuring energy efficient laboratory equipment; so the key questions are:

- When exactly should this information best be made available to facilitate the decision to procure equipment that is as efficient as possible?
- What would the most effective delivery mechanism be for this information?
- How could this delivery mechanism be brought to the attention of the procurer at the right moment?

It is recommended that a better understanding of procurement in the Departments should therefore be established to arrive at a considered course of action. An information-gathering exercise with laboratory users and procurement staff at the University would be beneficial, in order to:

- better understand how they procure
- collect case study data on previous instances of procurement
- collect data on upcoming procurement and associated information needs
- understand when and in what format information would be best provided to assist the incorporation of sustainability considerations into procurement decisions

This information could then be used to design and implement measures to increase the efficiency of the laboratory equipment that is procured. Once these measures are in place long enough to collect data to evaluate and improve them, a strategy to address laboratory procurement could be written up. At this stage, sufficient information should be available to expand the strategy to address University procurement of energy using equipment outside of the context of laboratories as part of a University-wide procurement strategy.

The costs of this work are not currently included in the envelope of funding being requested.

6.4. Linking carbon reduction in new and existing buildings

The construction of new buildings or major refurbishments can potentially provide opportunities for low carbon energy supply that can help to reduce the overall CO_2 emissions of the University. However, this will require the sponsoring department or division to take a more strategic approach to energy provision than is perhaps currently the case.

One key example of this is in relation to the use of low carbon district heating. If CHP is installed in the Science Area in the future, then from a carbon reduction perspective, strategically it would be better for any new buildings in that area to connect up to the network, rather than seeking to have their own stand alone solution. This would have the benefit of improving the economic viability of the central CHP plant, providing greater CO_2 savings, as well as allowing the new building to avoid the cost of having to implement its own low carbon solution to meet BREEAM standards, planning requirements, and the requirements of future Building Regulations. This would mean reversing the recent trend for the Science Area where new buildings have had their own stand-alone heating and cooling systems rather than connect to the district heating network. [46]

Another example is in relation to the use of wind power. A feasibility study for one new development site suggested that a medium scale wind turbine could be a cost-effective solution. The MAC curve suggests that this could be one of the most cost-effective energy supply opportunities. However, if the development were to just use the wind turbine to meet its own carbon reduction requirements for new build, there would be no overall reduction in the University CO_2 emissions. Therefore, the University may consider that if wind is feasible at the site, it could implement the wind solution as a wider carbon management measure, [47] and then implement an alternative solution to meet the carbon reduction requirement for the new build element, e.g. either through low carbon heating or the use of PV, or install as large a wind turbine as feasible so that it can contribute to meeting both the carbon reduction requirement for the new build as well as the wider University.

In order to facilitate this strategic approach, it is recommended that it should be made a mandatory requirement, as part of the revised Estates Management Strategy, that new capital projects should consider the potential for low carbon energy provision to meet the carbon reduction needs of the wider University as well as for new buildings. This should form part of the masterplanning and early concept design (RIBA stages A-C) for new developments and a funding mechanism would need to be developed to support this.

6.5. Incentivising energy and carbon reduction

6.5.1. Recharging energy costs

Experience of best practice in energy management suggests that a key critical success factor in encouraging energy reduction is to devolve the payment for energy use as close as possible to the groups that use the energy.

Currently, energy costs are recharged to each department on a building by building basis, rather than simply being an overhead for the whole University, which is commendable. However, best practice (in energy management terms) would be for the University to recharge energy costs at the level of research groups. This would be most straightforward where a single research group occupies an entire building or a whole floor of a building, in which case the energy use can be more readily sub-metered. [48] If multiple research groups use the same floor of the building, then a way of allocating energy costs would need to be devised, such as by floor area, making use of

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[46] Although a key reason for this trend may be that the current heating network is not low carbon
[47] Taking the benefit of the Feed In Tariff
[48] In the case of electricity use.

space management data. This would improve the accountability of energy use, and create a foundation for incentivising energy use reduction by research groups.

This would also assist in delivering Objective VIII (c) in the University Strategic Plan which seeks to improve knowledge of the costs of sustainable research and teaching.

A key issue here is the form by which much of the funding for scientific research is allocated. Often funding simply comes with an allocation for ‘overheads’ or similar; this overheads allocation is intended to cover all the costs of providing the facility for the research to take place in, covering everything from the gasses and other substances needed, to the salary of the Facilities Manager of the building, including energy costs. This dynamic means that researchers can be of the opinion, understandably, that the costs of the energy used in their research are already covered. In regards to whether energy could be recharged to the specific research groups, certain types of research are, by their nature, more energy intensive than others. As a result, groups that undertake such research may see it as unfair that they will be penalised for the nature of their research.

Therefore, although recharging energy costs may be controversial and time consuming, it is recommended that the potential to incentivise energy use reduction in this way should be explored.

6.5.2. Increasing incentives / disincentives

There are any number of incentive / disincentive based approaches which might be taken in order to deliver a reduction in energy consumption. The question of whether a ‘stick’ or a ‘carrot’ is most effective in any particular situation is ever present in any discussion about the use of such techniques, but this uncertainty should not rule out their careful consideration.

The most important thing to remember about both carrots and sticks is that they work whilst they are in place but rarely have lasting effect if they are subsequently removed. In particular this limits the appropriateness of a carrot approach if its implementation has an associated ongoing cost as unless there is surety that the incentive can be sustained indefinitely any benefit will only last as long as the funding.

A frequently used form of disincentive is to charge people for the excessive use of a particular commodity. In the case of the University, such a disincentive already exists to some extent in the form of the Energy Conservation Levy. However, at 0.1p per kWh, the Energy Conservation Levy is relatively insignificant when compared to the cost of electricity (7.5p per kWh) and gas (2.2p per kWh). Therefore, the issue with this particular disincentive is that any modest increase in cost is likely to be quickly lost in the noise of many other (often much larger) cashflows to and from the various University departments, even if there is initial reaction to its implementation. Indeed, discussions with stakeholders have indicated that energy costs are rarely a topic for discussion amongst the executive management of any of the University’s highest energy using facilities, suggesting that other financial drivers, such as securing research funding, are much more important.

However, it is recommended that an increase in the Energy Conservation Levy should be investigated as even if its effect on energy consumption is short lived, it will help to fund implementation and for some departments it may prove a lasting driver.

Incentives and disincentives also tend to have a stronger effect the more personally they are felt. In some organisations, the energy consumption of a particular department is set as a key performance indicator allocated to a single individual and forms part of their annual performance review. Whilst this may be too great a leap of faith for the University, finding a way to link incentives / disincentives to small groups of people or even individuals should be a consideration and is perhaps echoed in the Recharging Energy Costs section above.

Another technique to consider may be the use of league tables to make departments’ performance on energy management more visible. There are however, some issues which should be considered carefully in respect of such an approach, namely:

- the opportunity for the league tables to be seen as divisive may be a problem;
- the administrative burden for such an approach may be significant;
- the dynamics of financing research should be considered; energy costs are often covered by research funding and this may unfairly penalise research groups where activity which is unavoidably more energy intense than in other groups appearing in the same league;
- any league tables should demonstrate a sense of collective action, ideally resulting in a building manager feeling like they want to be part of a collective effort to reduce demand.

The University is considering implementing a form of league table to make the performance of each Department under the CRC (see section 2.1.1) more visible, although this may take the form of awards/rewards for top performers to avoid penalising the poorest performing Departments.

Further techniques exist and it is recommended that a review of a selection of potential incentive / disincentive techniques should be undertaken. Once preferred techniques have been established they should be tested with a group of stakeholders within departments to understand in more detail any barriers and benefits of such techniques ahead of implementation

6.6. Communication, monitoring and feedback

The MAC curve analysis identified that Automatic Monitoring and Targeting (AMT) could be one of the most cost-effective measures for energy demand reduction. However, AMT will only make savings if action is taken in response to exception reports, [49] and in response to progress reports identifying a deviation from targets.

The AMT equipment being installed is monitored by TEAM Sigma Monitoring & Targeting software package, which feeds information to the Energy Management Team. In this respect, the Energy Management Team has a critical role to play in alerting Departmental Administrators and Facilities Managers to exception reports, so that they can identify the reason for the exception and take action. Another key role for the Energy Management Team is to feed back regular reports on energy performance against targets and benchmarks to Departments, so that they can monitor their progress.

In order to support the delivery of the implementation plan, effective communication, monitoring and feedback on performance will be essential and it is recommended that the Energy Management Team/ Sustainability Team continue to be provided with sufficient resources such that:

- the profile and the services that the Sustainability Team can offer on energy and carbon management are kept at a high level, so that all departmental administrators and facilities managers are aware of the services on offer;
- all exception reports are notified to the relevant departmental staff if requested;
- all departments (and potentially research groups) continue to be provided with regular (ideally monthly and at least quarterly) reports on their energy use, [50] costs and carbon emissions with a comparison against historical trend and targets;
- the team can oversee the administration of incentives and disincentive schemes for reducing energy use and carbon emissions;
- additional metering can be effectively deployed and monitored to allow the reason for specific energy use to be interrogated.

The current 10:10 campaign provides an example of all of these services, and provides an excellent foundation for going forwards, as do the current Eco Reps scheme and the EcoFinance newsletter.

[49] These are automatic reports that identify when there is an unusual event in the hourly nature of energy use or the internal conditions in a building (such as temperature).
[50] Also showing the degree day adjusted figure for heating energy use

6.7. Devolving targets

Relating to action area 6.5 above, a further key principle is that the responsibility for delivery of carbon reduction targets should be devolved to the lowest practical level. This fits with the principle of subsidiarity which is enshrined in the culture and institutional structures of the University. Targets could also feed into the league table and/or award scheme mentioned in section 6.5.2.

Therefore, based on the overall carbon reduction targets for the University, as set out in section 3, it is recommended that targets should be established for each Division and each Department, potentially taking the form of annual targets. [51] These will provide a way of tracking progress towards the target; provide some accountability for progress at the level where energy is consumed, as well as supporting the use of AMT as set out above. It is suggested that these targets should be set via SSG, following consultation with the Departments and Divisions.

6.8. Leadership for behaviour change

The analysis of opportunities for energy demand reduction in the University has identified that there are significant opportunities to reduce energy use from research activities in laboratories through behaviour change. There is strong evidence that a critical success factor for any successful behaviour change intervention is that the example and message of good practice comes from a source that the target group trusts and respects, and is seen as one of their own, the so-called “trusted other”. In the case of researchers, for example, if the Primary or Chief Investigator (PI/ CI) shows concern about the need to manage energy use, and demonstrates leadership in this area, that is likely to have a far greater impact than if the message were to be conveyed by an external group.

This suggests that “awareness” campaigns by the Sustainability Team or other parties outside of the research group may only have limited impact. It is felt that the Heads of Department are best placed to raise the awareness of CIs and PIs about the importance of showing leadership in this area. [52] It is likely that this may already be the case in relation to Health and Safety procedures, and the issue of energy use could be seen as an extension of those Standard Operating Procedures (SOP), as it is a subset of good housekeeping. **Therefore, it is recommended that energy use should be introduced as part of the SOP for CIs and PIs**.

From prior experience it is clear that the messages that a PI gives about sustainability can have a very significant affect on the behaviour of the users of their laboratory space. However, it is important that the respected individual not only gives the message but that they demonstrate the behaviour personally for it to work, i.e. any inclusion in the SOPs should not make it possible for responsibility to be delegated for that issue. **It is recommended that the significance of this dynamic should be made clear to people in positions of authority at the research facilities, such as Heads of Department, Directors and Chairpersons, so they can take it into consideration in their interactions with their PI’s, and make it clear that they expect them to display clear leadership on this issue**.

6.9. Student engagement

The Sustainability Team currently provide University staff with the opportunity to become more engaged with improving the sustainability of the University through the Eco Reps scheme, which, amongst other things, provides interested staff with training, advice and support on how to design and drive sustainability initiatives in their workplace.

[51] This recommendation is set out in the University’s Energy Management Strategy and Implementation Plan, October, 2008
[52] Alternatively, the Sustainability team could engage with CIs and PIs directly via a workshop/ seminar.

However, there is not currently a programme that enables students to become more involved in this area. Engaging students on the issue of energy use and carbon reduction, particularly in areas of high research energy use, could be a significant channel in deploying the Implementation Plan. The Sustainable Laboratory Group, as discussed in Appendix V *Laboratory User Energy Efficiency Strategy*, would serve as a good foundation for such a group.

The potential benefits could include:

- raising the profile of the Sustainability Team and its activities with research staff via students;
- engaging and harnessing the considerable enthusiasm and energy of students to implement programmes to reduce laboratory energy use, as well as reductions in other resource use;
- students acting as internal advocates to leverage action from the board and staff;
- students having a significant influence on operational environmental impacts;
- positively influencing the approach of students to sustainability when they join the workforce. This has perhaps the greatest potential in terms of total carbon emissions reductions from higher education institutions;
- providing students with invaluable experience in organisational change management for sustainability would help to deliver objective III (d) of the Strategic Plan which aims to provide skilled graduates to meet the needs of an evolving economy.
- providing an opportunity to dissolve any barriers that may exist between the central University Administration and academic Departments

It is recommended that the University explore the feasibility of running such a programme, and how it could be funded, as it is likely to require considerable input from a co-ordinator in the Sustainability Team.

6.10. Facilitating the green desktop computing initiative (GDCI)

Clearly, the effect of the actions of departments within the University other than Estates Services will have a significant impact on energy consumption and subsequent carbon emissions. In examining the opportunities that have been highlighted by the MAC curve, the initiatives under the green desktop computing initiative (GDCI) are given as the most cost effective. [53] This is principally due to two key factors: firstly, the measure deals with grid electricity which is the most carbon intensive of the different types of energy consumed and, secondly, the measure is potentially replicable across virtually the entire portfolio of buildings.

To realise the full implementation of this opportunity, the Computing Services Department (OUCS) would certainly need to be involved and indeed Estates Services has already provided £15,000 of finance to an ongoing project led by OUCS to provide a GDCI service across the University. However, of all departments within the University only a minority have so far engaged with any significant success.

It is recommended that a key strategic action for the University is to examine the possibility of a joint project with OUCS, Estates Services and Heads of Departments to facilitate an increased rate of take-up of the service and achieve a much more significant penetration amongst all of the University's departments.

This is likely to involve the provision of resources to support direct engagement with departments on this issue as well as working with OUCS to understand and tackle the technical issues which have so far hindered widespread uptake of the service..It is suggested that the Sustainable Laboratory Group, (the voluntary sustainability action group discussed in the Lab User Energy Reduction Strategy [see also Appendix V]) could serve to support the rollout of the GDCI.

[53] GDCI includes power management monitoring and wake on LAN services.

7. Governance and monitoring

The University's *Strategic Plan for 2008-2009 to 2012-2013* was approved by Council on the 19th of May 2008, and by Congregation on the 10th of June 2008. Included in the Plan is the commitment to taking 'steps to further reduce the University's CO_2 emissions and reduce the environmental impact of all of the University's activities'.

Sustainability governance

Whilst ultimate responsibility for ensuring the delivery of the objectives in the Implementation Plan set out in this carbon management strategy lies with the Pro-Vice-Chancellor for Planning and Resources, the Plan will be delivered by the University's Sustainability Team. The Sustainability Team is based in Estates Services and reports to the Director of Estates, and it currently consists of the following staff positions:

- Head of Environmental Sustainability
- Energy Manager
- Assistant Energy Conservation Engineer
- Energy Assistant
- Sustainable Development & Waste Management Officer
- Sustainable Travel Officer

The Sustainability Team reports to the Sustainability Steering Group (SSG); the SSG reports on the University's progress towards sustainability objectives, and acts as an expert panel and high-level strategic group to advise on policy. SSG Reports to:

- the Buildings and Estates Sub-Committee;
- the Planning and Resource Allocation Committee of Council.

The SSG is also attended by the chair of BESC, the Director of Estates, and the Head of Environmental Sustainability, as well as representatives from Divisions, the Conference of Colleges and the student body.

The SSG is also advised by the Environment Panel, the purpose of which is to provide a practical forum for the exchange of information and discussion of matters relevant to the implementation and development of the University's Environmental Sustainability Policy. The Panel's membership has representation from each academic division, the Safety Office, the Conference of Colleges and the student body and liaises closely with the Sustainability Team.

The approval route for this Carbon Management Strategy has been:

- Sustainability Team
- Sustainability Steering Group
- Building and Estates Sub Committee
- Planning and Resource Allocation Committee
- University Council

The strategy put in place herein is intended to run until 2020, with a full review to be performed in 2015.

Carbon management monitoring and reporting

HEFCE require that progress against carbon management targets is reported annually and publicly. Aside from the data provided to HEFCE through the Estates Management Statistics System, data on scope 1 and scope 2 emissions will be compiled annually by the Energy Manager and reported to the Head of Environmental Sustainability.

It is essential that data is also collected quantifying the actual carbon reductions achieved by the measures in the Implementation Plan, so this data can be used to revise the BaU 2020 figure and the Marginal Abatement Cost Curve in consecutive iterations of this Carbon Management Strategy. Responsibility for collecting, compiling and interpreting this data lies with the Energy Manager, who will feed it on to the Head of Environmental Sustainability.

The energy use data and the evaluation of CO_2 reduction measures will be compiled into a monitoring report to be presented to SSG for approval to fit in with budgetary cycles, before being made available on the Sustainability Team's website as part of a broader environmental sustainability report. This monitoring report will also report progress against targets in the Sustainable Travel Plan, as part of tackling scope 3 emissions.

Scope three emissions

This focus of this Strategy is on scope 1 and scope 2 emissions (see section 1.1). However as set out in section 2.2.2, the University has had a Sustainable Travel Plan in place for many years, which will be updated in the near future; a process that will include a survey of staff and student travel practices.

Whilst little data is currently available on scope 3 procurement related emissions, the University is committed to managing these impacts under its environmental sustainability policy and will seek to monitor and develop targets in this area as sectoral guidance emerges.

With regards to waste and water management; whist it is unlikely that external requirements for targets for waste generation and water use will be in place in the near future, the University considers this to be an essential component of addressing its environmental impacts in line with its Environmental Sustainability Policy. A sustainable waste management strategy and a sustainable water management strategy have been developed and will sit alongside this document as part of the University's Sustainability programme.

Refrigerants

Leakage of refrigerant gases (also referred to as fugitive emissions) can significantly impact climate change. This is because 1kg of refrigerant can have a global warming potential equivalent to several tonnes of CO_2. HEFCE do not require emissions arising from refrigerant leakage to be reported as part of the Scope 1 emissions in this iteration of the Carbon Management Strategy. However, 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 but such reporting is not mandatory.

Whilst the University does not currently have sufficient data on the refrigeration systems across the Estate to estimate fugitive emissions from refrigerants, new EC legislation is coming into effect which will require more stringent testing and maintenance of refrigeration systems (see Appendix VIII for more detail on these regulations).

The University considers addressing fugitive emissions to be an important element of a comprehensive carbon management strategy, and will therefore use data arising from meeting the requirements of the regulations above to quantify and track these emissions, with the intention of incorporating this information into future iterations of the Strategy.