St Mary's University College Twickenham London

Estates Strategy and Projects

Carbon Management Plan

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Approval:
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Executive Summary

The spectre of global warming is forcing Governments around the world to take action to reduce the emission of greenhouse gases, and the UK Government has accepted a legally binding obligation to achieve a 34% reduction by the year 2020, compared with the situation in 1990. As 1990 emissions data is generally neither available for nor applicable to the existing higher education estate, the universities' funding body HEFCE has determined that tertiary education organisations should target a 43% reduction compared with their emissions in the year 2005/06, a year for which reliable data is generally available. A longer term target of 80% is proposed for 2050, together with "interim" targets for 2012 and 2017.

For St Mary's University College Twickenham (SMUC) the 2005 "manageable" emissions were calculated at 3,846 tonnes of which 47% was due to the use of electricity, and 52% natural gas with the balance being due to transport. The 43% reduction requires that these emissions are reduced to 2,192 tonnes, a reduction of 1,804 tonnes on current levels.

Since the base year, the University's emissions have increased by approximately 150 tonnes as a result of additional build and alterations, and are now nearly 700 tonnes higher than the target derived through a constant annual reduction based on 2005. In addition, the construction of the new sports centre will further exacerbate the situation with an anticipated additional 50 tonnes. The annual reduction required based on 2009/10 emissions is now 5.31%, compared with 3.68% in 2005. Without effective action, the annual reductions will increase exponentially, resulting in the requirement for massive savings in the final few years with corresponding capital and managerial implications.

This plan includes a number of potential energy saving measures that will not only assist SMUC in the achievement of the HEFCE emission targets, but which will also reduce the financial burden of utility costs and capital investment in the longer term. Significant among these measures are the "managerial" initiatives required along with other "enabling" proposals such as the installation of additional, sub and automated metering. Energy awareness and related subjects are particularly important in an educational establishment: St Mary's would like to see its students not only achieving good practice whilst at university, but also spreading that to the organisations in which they are subsequently involved. This plan also includes a number of technical measures such as the replacement of boiler plant; improved control of lighting and IT; elimination of the use of space heating plant for the production of domestic hot water; improvements in controls; voltage optimisation; fabric improvements etc. Effective maintenance is particularly important to the energy efficient operation of plant, and investigations have shown that there is considerable scope for improving maintenance standards within this estate. This will not only reduce the energy use of the plant throughout its life, but will also extend that life thus reducing capital costs.

A summary of these measures is included overleaf, and indicates a potential reduction in emissions of 1,670 tonnes, with an annual financial benefit of £264,000 and an estimated "payback" period of 3.3 years.

Successful implementation of the measures within this plan would therefore achieve 92% of the required savings, although it is likely that the furtherance of metering and "monitoring and targeting" will facilitate the identification of significant additional measures. The refinement of these together with an update on progress with the initial proposals will be included in the next revision of this plan, in 2015. In addition to this, the plan shall be monitored by the Estates Committee.

Proposed Carbon Emission Reduction Measures:

	Project	Estimated Annual Saving			Est. Cost £K	Payback yrs
		MWh	£K	tCO_2		
1	Increase engagement with Staff and Students	-	-	-	-	-
2	Enhance "monitoring and targeting"	-	-	-	-	-
3	Provide additional utility sub-metering	-	-	-	30	-
4	Isolate unnecessary boiler plant.	150	5	30	Nil	n/a
5	Improve space heating control	350	10	60	10	1
6	Implement and encourage "Good Housekeeping" Measures	700	25	200	2.5	0.1
7	Reduce energy use in Information Technology	400	40	200	10	0.25
8	Improve plant and equipment maintenance	1,250	30	280	Ongoing net savings	
9	Eliminate the use of space heating boiler plant for DHW production	1,500	45	280	180	4
10	Upgrade HVAC Controls	330	10	60	100	10
11	Upgrade building fabric	330	10	60	70	7
12	Improve lighting control and efficiency	350	35	190	140	4
13	Provide variable speed control to fans and circulating pumps	100	10	50	50	5
14	Boiler Replacement Programme	800	24	150	200	8
15	Voltage Optimisation	200	20	110	80	4
	TOTALS	**6,460**	**264**	**1,670**	**872.5**	**3.3**

2011/12	2012/13	2013/14	2014/15	2015/16	2016/17

Table 1: Carbon emission reduction measures

1. Introduction

1.1 Policy Statement

St Mary's University College Twickenham (SMUC) will implement policies and practices which reduce greenhouse gas emissions arising from its activities. We will do this by engaging staff, students and partners in ways that support and enhance teaching, learning and research.

Acting on published scientific literature and through our own scholarship, we will set targets, monitor progress regularly, and report publicly through the University Colleges Sustainability Group, Estates Committee and Planning & Resources Committee.

1.2 Context

Climate Change has long been acknowledged as the key environmental threat facing the world. Concerns over energy security and the rise in energy prices have also served to focus attention on the need for significant improvements in energy efficiency, and more generally, wide scale reduction in carbon emissions.

SMUC is a relatively small institution, based in an urban environment, with constraints imposed by the heritage of our site. To some extent these factors limit both the scale and types of transformational projects that can be undertaken when compared to other similar and or larger institutions. However, the same restrictions that are created may give an advantage when it comes to the speed with which other changes can be implemented.

Seen in this global context, the contribution of SMUC could be perceived as modest, indeed the same can be said for the entire Higher Education sector. The scale of the challenge is also daunting enough for many to see it as impossible. However to see the problem in this light is to make a fundamental error. The importance of strategies such as this one lies in a methodical change of behaviours that has already begun and the adoption of "carbon management" as a way of thinking about wider issues.

One of the aims of this document is to show that even if climate change and carbon emissions were unknown terms, and the world was unaware of their associated problems, every single action outlined within this CMP would still make sound financial and environmental sense with ethical and ecological benefits to the University College and environment. Tackling climate change by reducing carbon emissions requires us to adopt the highest standards of efficiency in everything we do, from printing to travelling. It leads us to reduce waste, to build better buildings, to reduce pollution, to reduce expenditure on energy, water and maintenance, to think more about our food and where it comes from. It is important to ensure that the reputation of the University College is protected and enhanced, and it can market a responsible approach to current and future students and staff. Where sustainability issues are, or can be, covered in the curriculum, we can ensure that excellence in teaching is matched by excellence in our approach to the whole estate. This supports teaching, as well as future research and capital funding bids. Most importantly, by setting an example and creating a resource of knowledge and practice in sustainability at St Marys, we influence and educate thousands of students every year, whose combined potential for acting to achieve our aims in this regard is far greater than any single institution.

1.3 Scope of Carbon Management Plan

The scope of this plan can be summarised under three broad headings:

- Data, quality of evidence and target setting
- Technical carbon reduction projects
- Cultural change: wider attitudes and actions

Data, quality of evidence and target setting

The plan identifies the nature of the problem and our current ability to quantify it, while setting out a rationale for action and outlining the scale of reduction in carbon emissions that the university aims to achieve.

Carbon reduction projects

A list of identified carbon reduction projects is presented, prioritised according to a number of factors including their potential for carbon savings, achievement within short timescales, and financial return.

Cultural Change; Wider attitudes and actions

Many aspects of university activities that have considerable environmental impacts are difficult, or practically impossible to quantify and monitor. Despite this, it is well known that many such activities can be both significant in terms of their impact and extremely cost effective. There is a danger in target based plans that these kinds of actions will not be prioritised because they do not deliver improvements with reference to any performance indicators. Clearly this would undermine the entire purpose of this plan. Consequently, the University College is devoted to laying out a framework for much wider future improvements to activities that we know deliver tangible savings but that may not show visible or immediate improvements.

The Sustainability Group will focus on this key area by seeking to embed the principles in this plan throughout the University.

1.4 Implementation plan

Detailed implementation plans will be developed each year as part of an annual progress report against the adopted target. The implementation plan for the 2009/10 academic year was to focus on a number of key estates based projects such as Chapel and campus general lighting, the R block sports hall re-development and refurbishment and preparation for an institution wide approach in future years.

2.0 Emissions Baseline and Targets

2.1 Data Collection

Until July 2009 SMUC did not actively record transport or general energy related emissions. Energy consumption has been systematically recorded from May 2009, although this is a collation of around 50 gas and electricity meters and is expected to rise to in excess of 110 meters with the introduction of sub-metering to all buildings as part of energy management in the future. The majority of all site meters are read only sporadically and this is by the energy suppliers for billing purposes, presenting difficulties when attempting to compile data centrally.

Estates Strategy & Projects is currently undertaking major improvements to the way energy is measured and recorded, which will enable better accounting of consumption, cost, and carbon emissions. A program to install automatic metering began in 2010 and will be extended over the next year to enable greater accuracy with regard to emissions, and energy consumption profiles. Given the nature of the SMUC estate and limited staff resource available, it is not currently feasible to incorporate the optional scope 3 emissions in any rigorous quantitative sense at this stage.

However, this does not mean that SMUC does not take these opportunities seriously; indeed they will form a major part of this ongoing plan and the University Colleges overall environmental strategy and it is intended to improve this situation throughout the first two years of the plan.
Actions of this sort will be undertaken as part of this and other related plans and will deliver real benefits. It is very likely that in the near future, the opportunity to quantify additional sources will become available, and at this point they will be incorporated into updated versions of the Carbon Management Plan.

Carbon emission baselines for all UK Universities are identified in the HEFCE Publication “Carbon baselines for Individual Higher Education Institutions in England”, produced for HEFCE by the Consultancy SQW in August 2010. For the majority of Institutions, this publication includes both a breakdown by fuel type, and figures for 1990 and 2005. For St Mary’s University College the quoted 1990 figure is 2,699 tonnes. The estate would have been very different in 1990, as a number of the current buildings would not have been built or completed. The 2005/06 baseline was assessed as 3,846 tonnes of CO_2. This included just 27 tonnes for “transport” with the balance being accounted for by building related emissions (gas and electricity). This includes Scope 1 and 2 emissions as determined in the following sections.

2.2 Scope

Accepted carbon foot printing methodology divides an organisation’s emissions into three scoping areas, as follows:

Scope 1: Direct emissions. This includes direct emissions from the use of fuels such as oil and gas, and emissions from vehicles that are entirely owned by the organisation. It also includes “process” emissions that would apply in some industries such as brewing, and “fugitive” emissions that result from the loss of such materials as refrigerant gases. As far as UoH is concerned, the relevant emissions here are deemed to be those resulting from the use of fuels: specifically natural gas, and fuel used in Unõ. In addition, the use of refrigerant gas must also be taken into account: use of this has to be recorded in accordance with the “F” gas regulations.

Scope 2: Imported energy. This includes “grid” electricity, and would also include emissions resulting from the import of steam, hot water or other energy sources. As far as the University is concerned, the only Scope 2 emissions that are currently applicable are those resulting from the use of grid electricity.

Scope 3: Other indirect emissions. This includes emissions that are an indirect result of the operations of the organisation. These are generally broken down into two categories: energy and nonenergy related. Energy related emissions include those from transport that is not owned by the organisation, and over which it has no direct control, including business travel by whatever means; commuting (staff and students) and including air-travel undertaken as a result of the operation of the University. Non-energy related emissions include the use of water and those resulting from arisings of waste.

Current carbon foot printing does not include emissions resulting from the use of materials and food; the construction of buildings; maintenance works and other emissions that result from the University’s operations and existence.

2.3 Baseline Emissions

The SQW figure for 2005 is quoted as 3,846 tonnes of CO_2 including Scope 1 “transport” emissions. The SQW publication also includes figures for emissions per “total student and staff numbers” and per “unit of income". It is currently at an institution's discretion as to whether they use an absolute target for emission reductions, or one related to employee/student numbers or income.

In common with the majority of institutions, the intention is that St Mary's University College will target an "absolute" reduction. Although relative targets might be superficially attractive in terms of achievability, it is considered that the possibility of falling numbers or income at some point in the future would result in significantly more demanding targets, possibly at quite short notice. With the absolute target, the University knows exactly where it stands on a year to year basis.

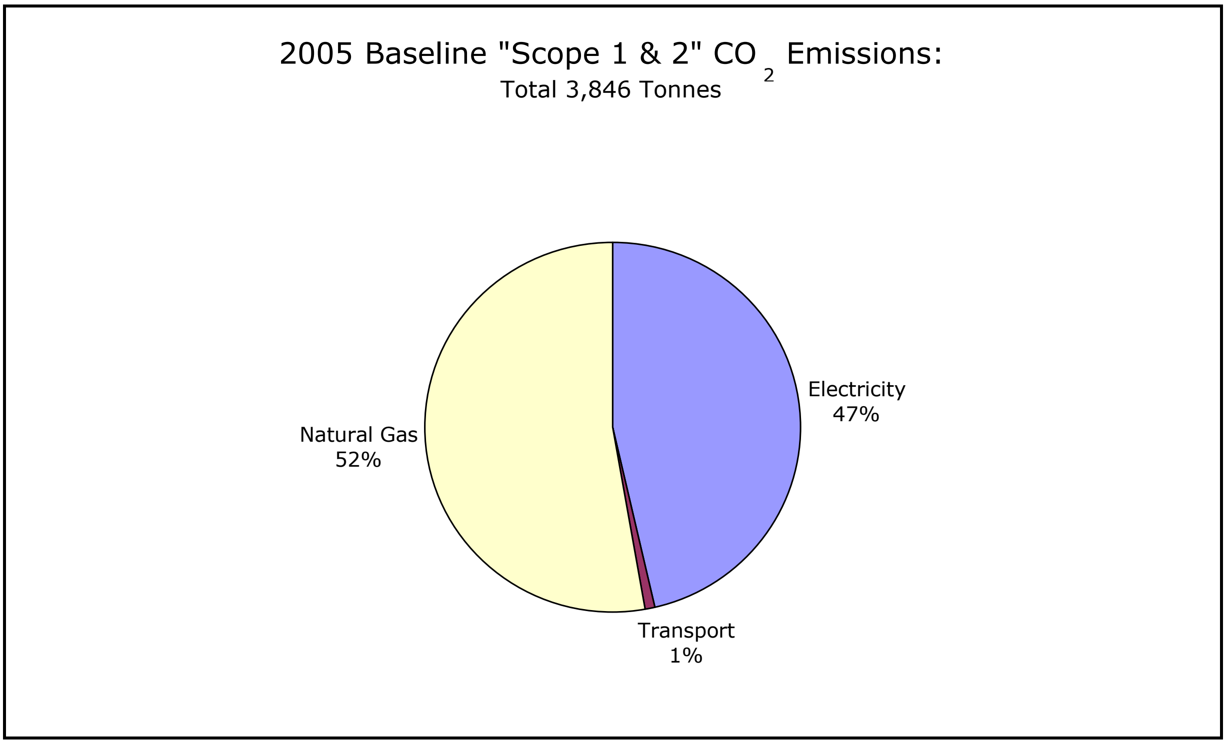

Chart 1: Carbon emissions for the base year 2005/06

2.4 Targets

HEFCE's 2009 grant letter from the Secretary of State is clear in its expectation that the Higher Education sector should reduce carbon emissions at least in line with UK government targets. After consultation with the HE sector HEFCE has proposed the following targets:

An 80% reduction in scope 1 and 2 emissions against 1990 levels by 2050, and at least 34% by 2020.

The chosen baseline year for measurements and targets is 2005, and against this baseline year the reduction required for the year 2020 is 43%. In accordance with this, and an ambition to eventually exceed these requirements, the University has adopted the following target:

In the longer term, St Mary's University College Twickenham aims to become a carbon neutral institution, although this will depend to a large extent on the "decarbonisation" of the grid electricity supply. We shall begin this task using a Carbon Baseline from 2005 and intend to achieve a total reduction of 43% in "Scope 1 and 2" emissions by 2020.

Since 2005, the University has expanded both student numbers and estate, with additional residential, teaching, catering and conferencing capacity, and a consequential increase in carbon emissions. The creation of a new sporting facility is currently underway, due for completion summer 2011. Although the new build shall achieve a BREEAM status of excellent, it will also result in an increase in carbon emissions for the site as a whole. With an internal area of about 1,875 m^2, this building is designed to achieve a figure of 50 kWh/m^2.yr, for a total of just under 95,000-kWh/year and equivalent to an additional 50 tonnes of CO_2. Furthermore, over the last two years there have been a number of additional projects undertaken to create new offices and lecture space and that the changes of use to these areas will also have resulted in a net increase in requirements for heating and electricity. Although these enhancements were designed with energy efficiency in mind the result will have been an overall increase in carbon emissions in some cases.

The result of this is that total emissions between 1990 and 2005 have increased by 3.9% from 3,846 to 3,996 tonnes. The revised breakdown of CO_2 emissions is shown in Chart 2 below:

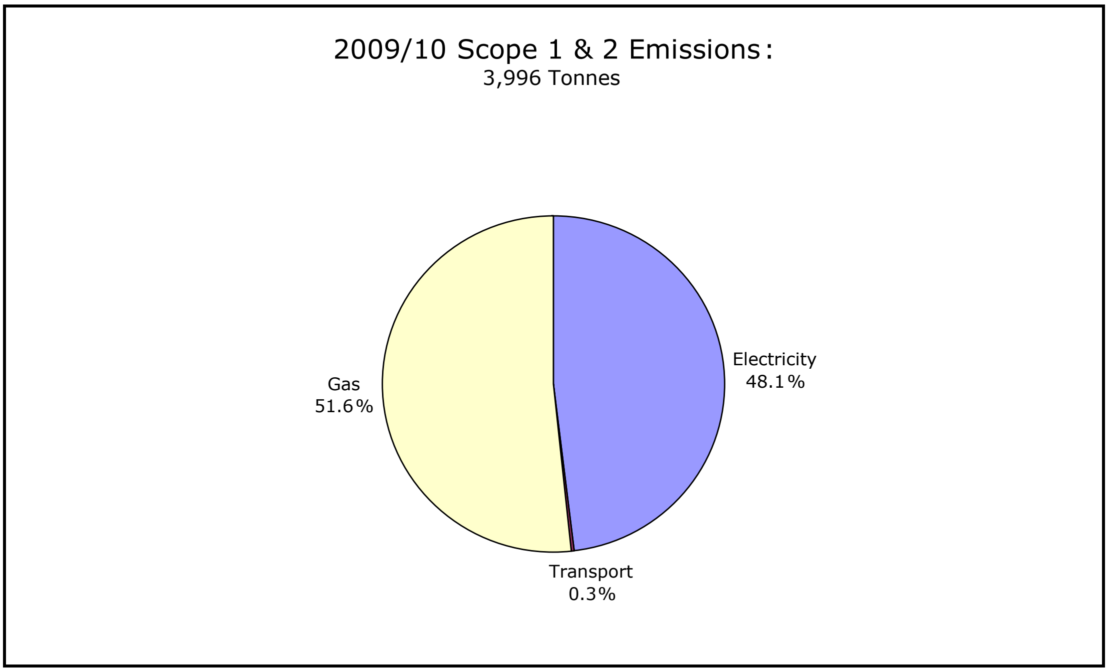

Chart 2: Carbon emissions for 2009/10

In addition to the overall reduction of 43% by 2020, HEFCE has also produced "interim" reduction targets of 12% by 2012/13, and 29% by 2017/18. These targets are shown in the chart below:

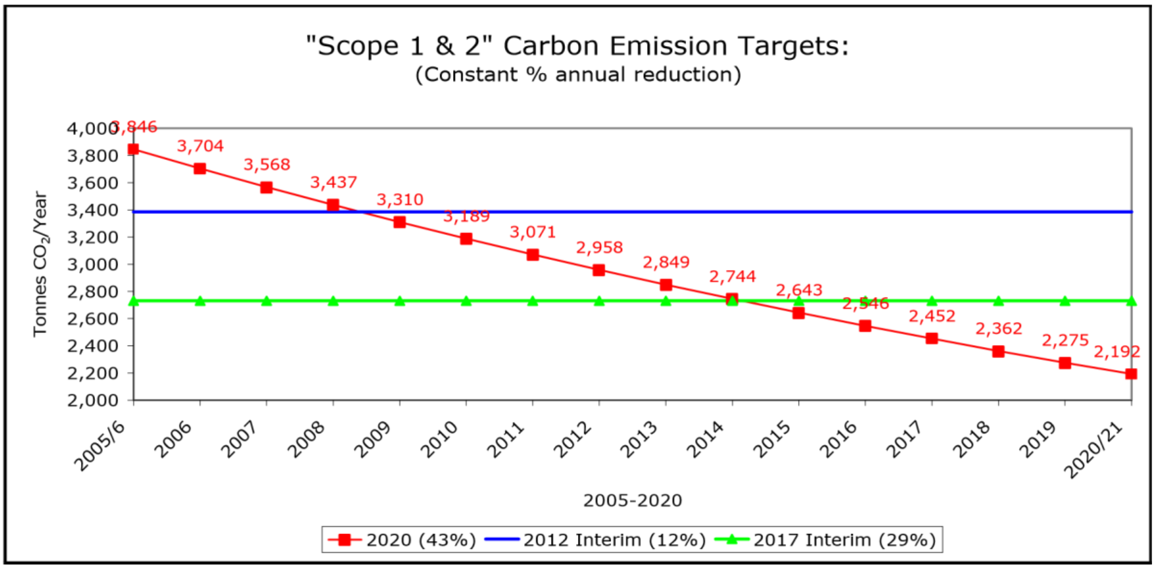

Chart 3: Carbon emission targets based on 2005/06 data – Scope 1&2 Emissions

The chart makes the assumption that the 43% saving could have been achieved using a constant percentage reduction of 3.68% each year on the previous year's target, over 15 years. It should be noted that the "interim" targets published by HEFCE are actually less demanding than this, and would therefore require much greater percentage savings in the later years.

2.5 Performance since 2005/06.

Chart 4 below shows that since the 2005/06 baseline year the University's performance has deteriorated slightly, with Scope 1 & 2 emissions now 686 tonnes greater than the target figure.

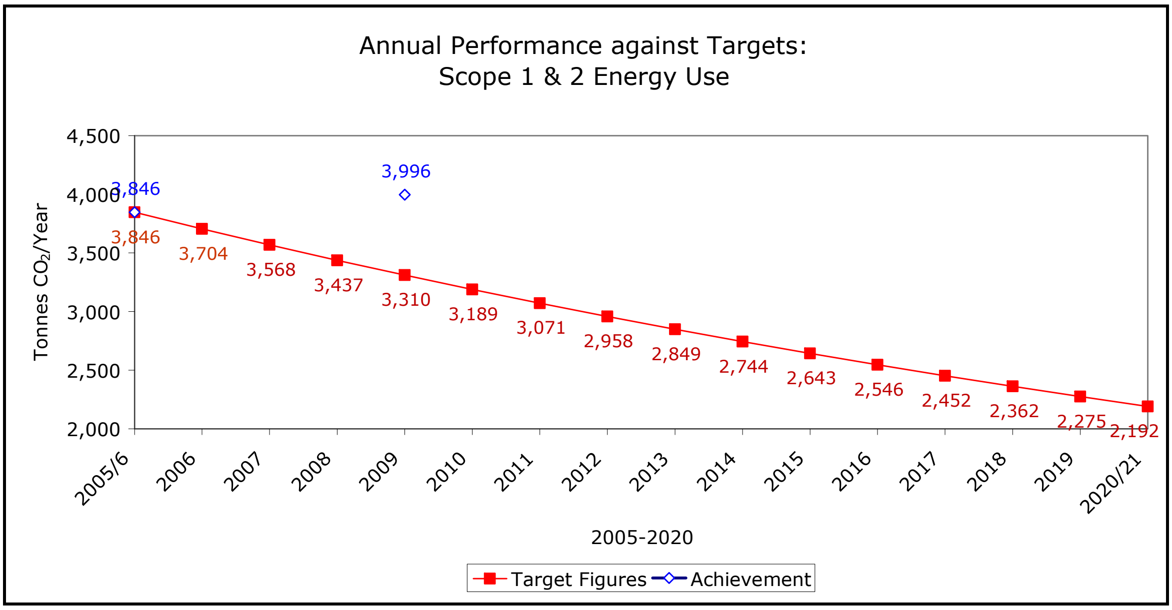

Chart 4: Scope 1 & 2 Emissions: Performance against targets to date

The result of this is that the University is now faced with a target reduction of just over 45% by 2020/21, requiring an average year-on-year reduction of 5.31%, and the application of this factor to current emissions results in the revised annual targets as shown in Chart %. The "interim" targets remain unchanged.

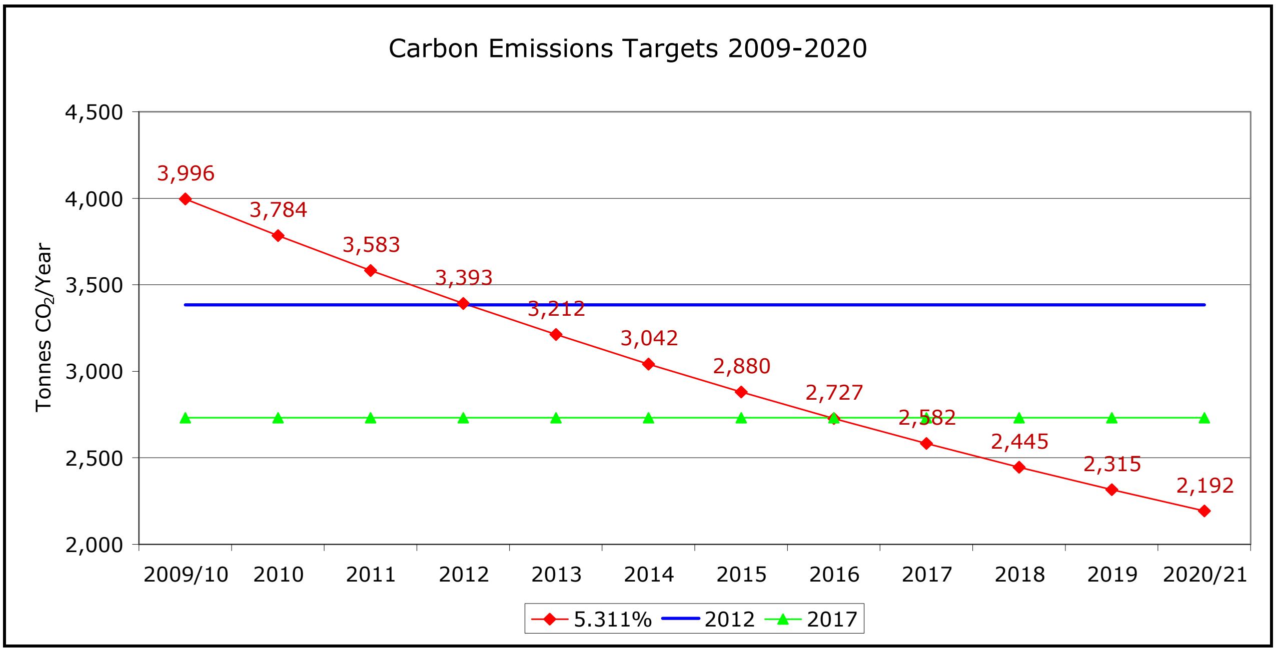

Chart 5: Revised carbon targets 2009 to 2020

It is anticipated that with minor additional savings the HEFCE interim target for 2012 (3,384 tonnes) can be achieved with the 2017 target will being achieved about a year early, in 2016.

In order to realise these figures, the University will have to achieve reductions in both electricity and gas use. The challenge is illustrated in the chart below. The estate currently uses about 11,000,000 kWh of gas, and 3,500,000 of electricity. In order to achieve the required reduction, gas use could be reduced by 10,000,00 kWh with electricity use unchanged, or electricity use could be reduced by about 3,500,000 kWh leaving gas unchanged. However, the most feasible option for achieving the reduction is likely to be by reducing electricity use by 2,000,000-kWh per annum, and gas use by about 4,000,000. Under achievement in either utility will require greater savings in the other.

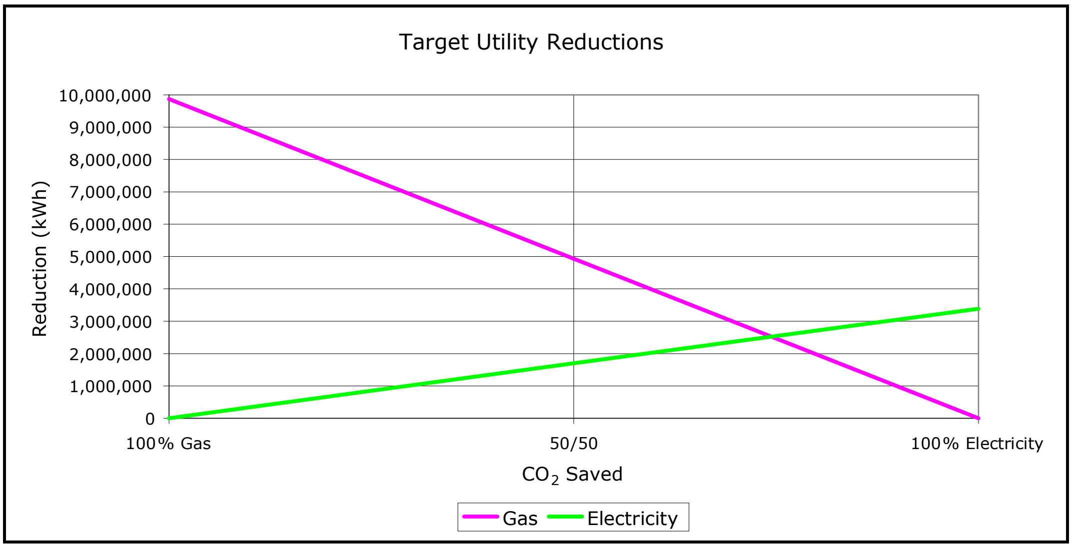

Chart 6: The Utility Reduction Balance

2.6 Historic Energy Costs

Energy costs since the base year are shown in the table below:

	2005-06	2006-07	2007-08	2008-09	2009/10
Electricity	£219,009	£269,001	£344,921	£494,848	£347,201
Natural Gas	£246,446	£244,586	£197,033	£307,056	£386,484
Total	£465,455	£513,587	£541,954	£801,904	£733,685

Table 2: Energy costs

Energy costs tend to be quite volatile, and this is illustrated in Chart 7 which plots the annual change in total cost compared with the "base" year. The figure for both gas and electricity is, in 2009/10, nearly 60% greater than in 2005/06, is equivalent to an average increase of about 12% per annum. This analysis may also understate the actual increase as the University has worked to improve the effectiveness of energy purchasing, and this will have had an effect that may not be replicable in the future.

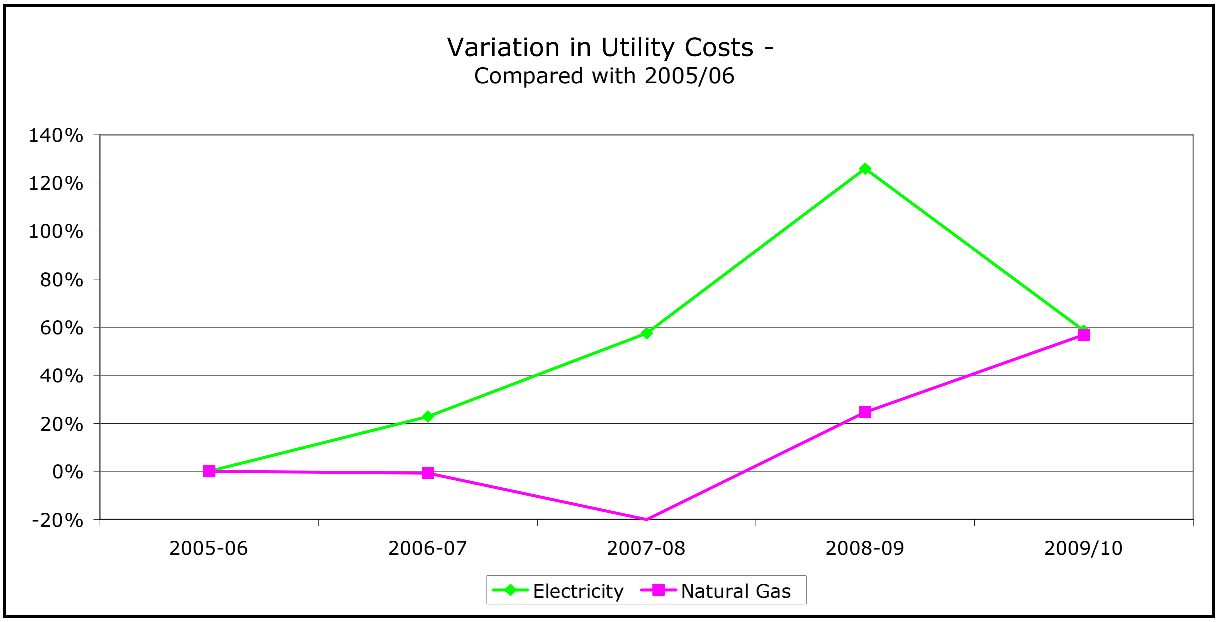

Chart 7: Variation in Utility Costs 2006-2010

2.7 Future Energy Costs

It is generally agreed that energy costs will increase in the future, as resources become scarcer; the costs of replacing the country's power generation and distribution infrastructure increase; and the effects of the increasing dependence on "renewable" energy sources become more apparent.

The chart below illustrates the effect of inflating the 2009/10 energy cost figure by 3% per year to represent inflation, and also 10% per year to represent a premium over the inflation figure of 7%. As shown in chart 7, this is actually a lower figure than has been experienced for the past five years, and may well understate the likely increases to be expected.

In the +7% scenario, the additional cost by the year 2020/21 would be over £1.3 million per year (at 7% compound interest prices double in 10 years), and the effect of reducing energy use by 45% in order to comply with the HEFCE target for 2020/21 would therefore save over £940,000 per year by 2020. Investment in energy efficiency should reflect the scope of the potential savings in the longer term.

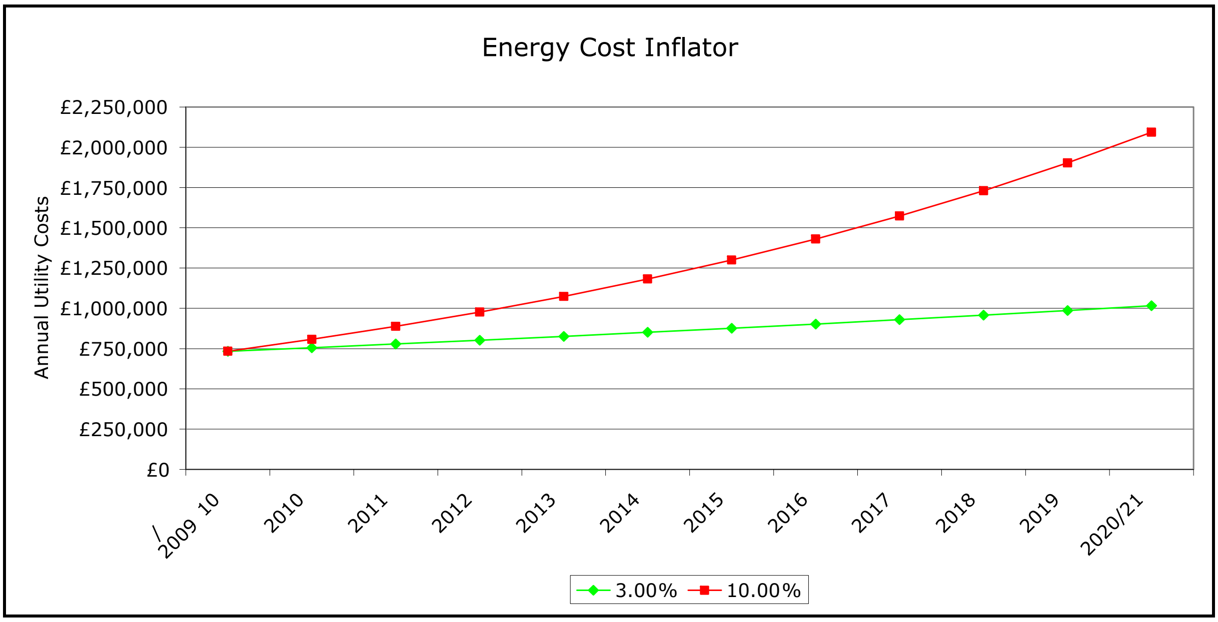

Chart 8: Projections of future energy costs – at constant consumption

Of course other factors must also be considered. Although the University is not currently liable for the purchase of carbon credits under the "Carbon Reduction Commitment" (as usage is below the threshold of 6,000,000 kWh per year) this could change in the future, and carbon taxes in general are likely to increase. Even the worst case scenario above could prove to be over-optimistic.

3.0 The "Built" Estate

The University's estate includes both residential and non-residential accommodation, and the current extent of the estate and detailed energy use figures are included at Appendix 2. Building related carbon emissions total nearly 4,000 tonnes per annum, and the breakdown of this is shown in Table 3 below.

Building Related Carbon Emissions 2009-2010	Gas kWh	Electricity kWh	CO_2 Tonnes
Residential	6,584,171	888,508	1,702
Non Residential	4,567,059	2,640,407	2,284
Totals	11,151,230	3,528,915	3,986

Table 3: Building related CO_2 emissions

This shows that the overwhelming majority of electricity is used within the academic and administrative estate, with only 25% used in the accommodation, although the figure for “Cashin and Conin” halls is suspiciously low at only 81,000 kWh. For gas, the usage is much more even, being split 60/40 in favour of the residential estate. However, the “R” Block boiler provides for the sports hall and Cashin and Cronin as well, and as there is no way of determining the actual breakdown of this usage, the figures may be rather more balanced than shown here.

3.1 Estate Emissions: Non-Residential 09/10

The use of gas and electricity in buildings depends on a number of factors, of which the building fabric and plant design and control are the major ones. Building energy use is used in “Display Energy Certificates” to make an assessment of the performance of buildings relative to their functional peers, and as an initial measure, it is useful to calculate the total carbon emissions and the carbon intensity for each building. The following table lists the major areas for which gas and/or electricity consumption data is available, and is used for initial analysis of the estate in order to identify the buildings that are likely to provide the greatest benefit from the application of energy efficiency measures.

Non Residential Energy Use	Area m^2	Gas Use kWh	Electricity kWh	CO_2 Emissions Tonnes
H,J,L & M Blocks	8,572	1,574,849	805,768	708
G Block	7,244	1,155,300	680,936	579
R Block	4,358	1,028,488	409,652	405
K & N Blocks	4,444	785,971	417,736	368
F & G Blocks	2,626	524,939	246,844	224
Totals	27,244	5,069,547	2,560,936	2,284

Table 4: Non-residential Estate Energy Use

Within this estate a number of assumptions on energy use have had to be made, and the determination of the “actuality” will have to take a high priority if effective abatement measures are to be successfully implemented. The first assumption is that all of the areas use the same amount of electricity, an average of 94 kWh/m^{2}/yr across this estate. In reality there is likely to be a huge variation from next to nothing in the chapel to very high figures, in extensively used areas with high concentrations of PCs for example. Ideally, each building/block should be fitted with its own electricity meter or meters. Preferably the meters should be automatically read and capable of generating a usage profile. This assists in the identification of unnecessary out-of-hours energy use.

As far as gas use is concerned, the gas supply to “R” Block provides heating and hot water not only to R Block itself but also the residential accommodation at Cashin and Cronin, and it has been assumed that usage is again pro-rata on area. This makes R Block the worst area within the estate by a considerable margin. As the pro-rata figure shows Cashin and Cronin in a relatively good light, it is likely that in fact R Block is doing somewhat better than the figures suggest, although this will increase the potential savings at the residential accommodation.

Finally, the “heated areas” may not be entirely accurate. Gas use performance indicators are shown in the chart below:

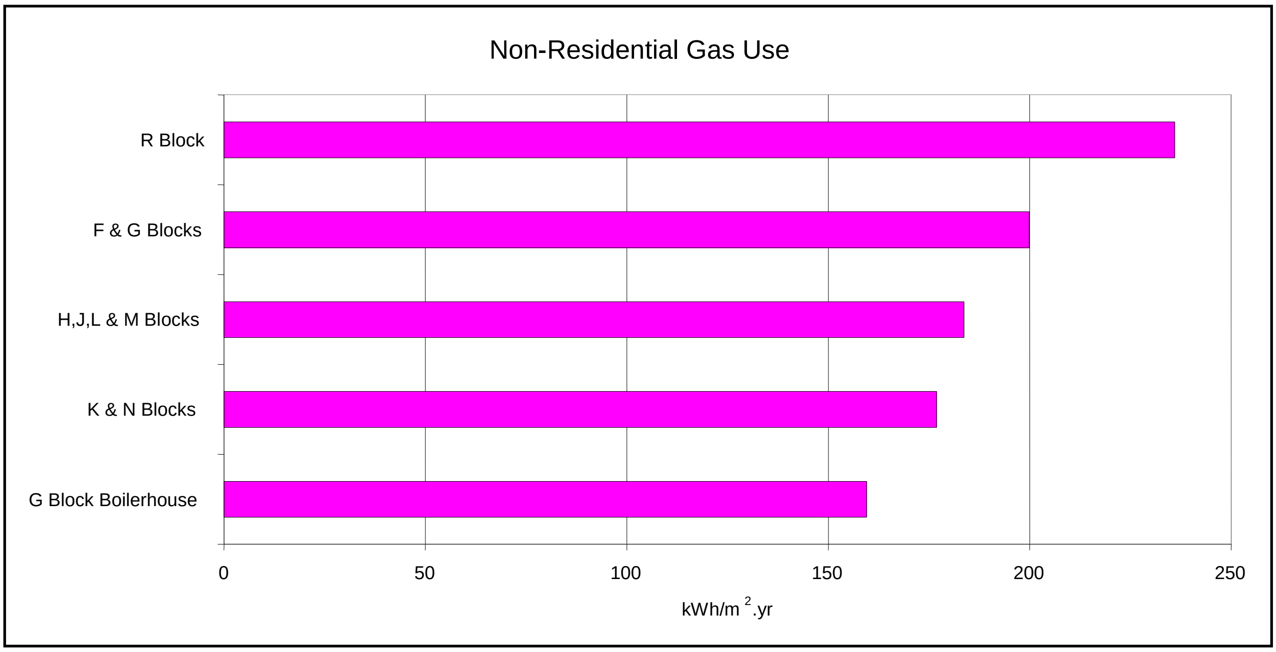

Chart 9: Non-residential gas use

Some universities are targeting 100-kWh/m^2.yr for gas use within their estates, and this has been shown to be an achievable target, along with figures of less than 70 for electricity. The achievement of these figures would result in emissions of 57 kg CO_2/m^2.yr, and realise a total reduction in CO_2 emissions of 780 tonnes or 33%. The estate will have to do even better than this if the 2020 target is to be achieved.

3.2 Estate Emissions: Residential

Analysis of the energy consumption data for the "Residential" properties shows a very wide variation in their energy use and the resulting CO_2 emissions. In the following charts all the electricity and gas use for a property, for both students and the warden, has been aggregated into single figures for each building, and converted to CO_2 emission figures using standard emission factors. This shows that there is a considerably high variation in the CO_2 intensity of the properties, as illustrated in the chart below:

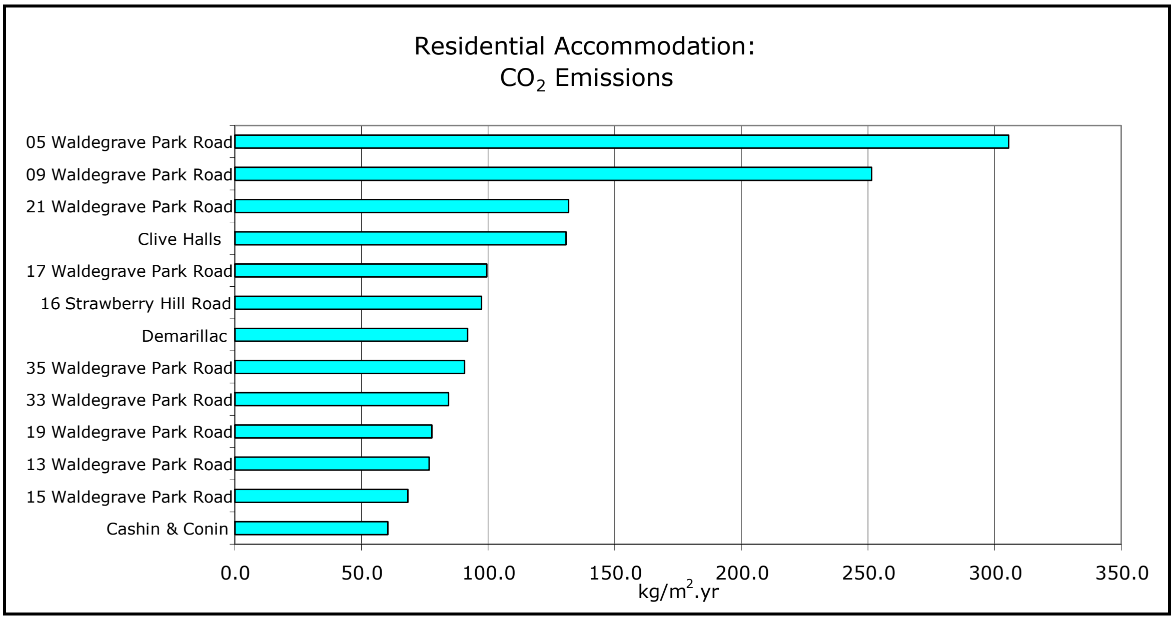

Chart 10: Residential CO_2 Emissions

One of the main reasons for the disparity is CO_2 emissions is the use of electricity, which varies enormously between the best site at 19 Waldegrave Park Road, and the worst at No 9, as shown in Chart 10 below:

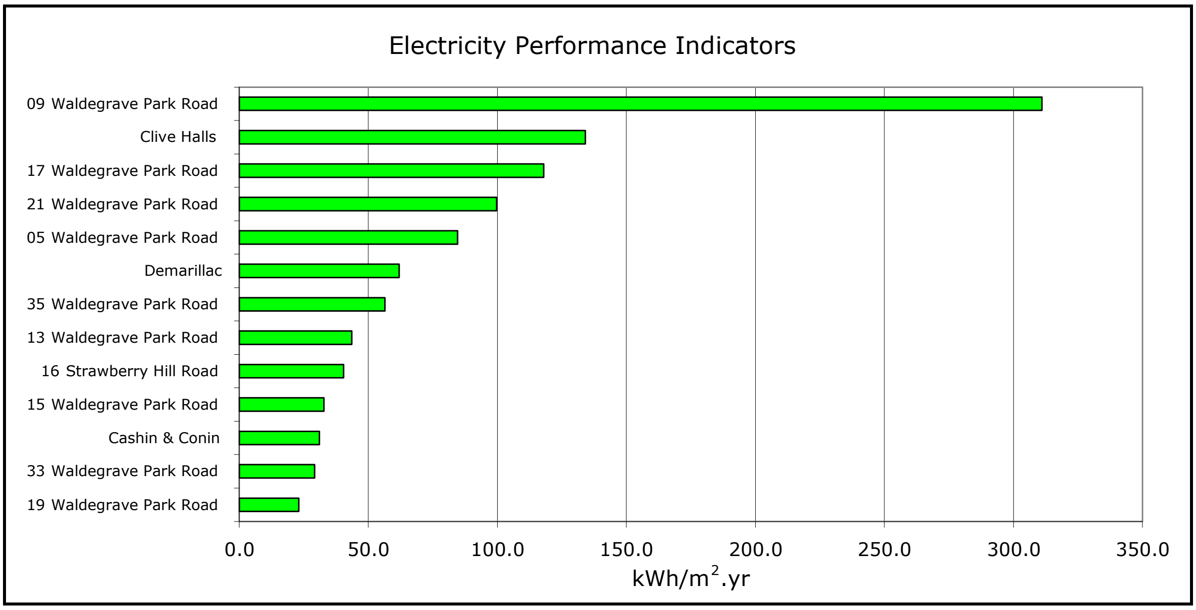

Chart 11: Residential electricity performance

In reality, it is likely that the reason for this is likely to be irregular or inaccurate meter readings. No 9 has allegedly used 98,000 kWh in a year, and this is the equivalent of a continuous load of 11-kW. This is very unlikely to be caused by the actual operation of equipment in a "domestic" situation.

Excessive gas use is the reason for the poor performance of No 5, for which the recorded usage is over 400,000 kWh compared with about 120,000 for the other buildings, and this results in a "performance indicator" of over 1,400 kWh/m^2.yr, more than three times worse than the next building at No 9.

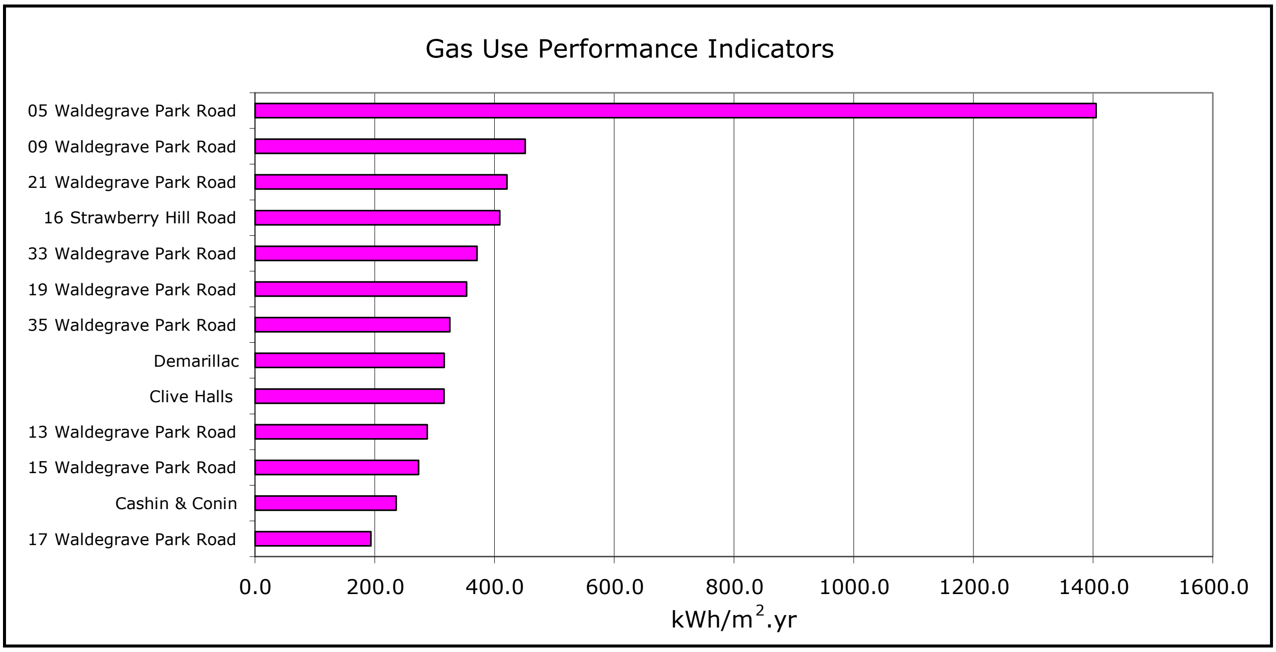

Chart 12: Residential gas performance

Again, this is likely to be due to erroneous meter readings or incorrect meter identification: it might be a metric meter that is being charged as an imperial one for instance. However, it is not impossible for this usage to have actually occurred, for example if there was a leak in the central heating system resulting in continuous discharge of heated water to drain or the ground. Furthermore, the figures for gas use for De Marillac and Clive are apportioned pro-rata, as the plant for both buildings runs from a single meter. In addition, the halls at Cashin and Cronin are heated from the plant in "R" Block, and again the usage has been apportioned pro-rata on building area.

This type of analysis illustrates the importance of running an effective "monitoring and targeting" system. Estates have therefore, as part of the energy contract consolidation carried out in previous years, had automated meters installed to each building. A programme of re-piping, installation of thermostatic radiator valves and automated timers with thermostatic control is planned for summer 2011 that will address the properties highlighted above.

4 Strategy

The purpose of this document is to outline the strategy required to achieve the 43% reduction in greenhouse gas emissions required by HEFCE. The scale of the challenge is very considerable, particularly so as the reduction is based on usage during the "base-year" of 2005/06. There are effectively only ten years to go. Analysis in this report indicates that building energy use has increased since the base year, and that a reduction of 45% is now required in order to comply with the HEFCE target.

Sustained reductions in energy use require two types of action: managerial and technical. Managerial measures are essentially "enabling" by nature, and although they will be critical to the success of the project they do not in themselves actually save any energy.

4.1 Managerial Measures.

Managerial measures include such items as:

- Policy and strategy
- Awareness
- The adoption of a robust system of "monitoring and targeting".
- Identification and provision of funding
- A concerted effort to reduce the use of energy "out-of-hours" in occupied and unoccupied buildings.

Awareness is likely to be of particular benefit, and Table** below includes a number of initiatives that will be addressed in the furtherance of this:

Emission Reduction Opportunity	Action
Engaging Staff and Students	Introduce energy/carbon element to staff and student inductions
	Energy/Sustainability training for relevant staff
	Consider ways of building avoidance of poor purchasing decisions into existing
	Develop section on website and intranet (and include a facility for users to forward

	Develop a range of University College specific publicity materials (posters, t d ti) stickers, strip thermometers, postcards etc.)
	Develop and promote a University College Sustainability Award
	Train student wardens and give specific responsibility for energy
	Run targeted events and publicise results t

Table 5: Opportunities for improving energy awareness

4.2 Technical Strategy.

Technical measures cover a wide range of opportunities including plant operation and optimisation, maintenance, controls, plant upgrades and building fabric improvements. SMUC's technical strategy will pursue a phased approach, aimed at maximising the long term savings and minimising the implementation costs. However, on many occasions the requirement for plant replacement or building refurbishment will take precedence in the scheduling of works. The ideal solution should be phased as follows:

Phase 1. Reduce energy use by existing buildings and plant through the "fine tuning" of plant operation; isolation of unnecessary equipment; improved maintenance; the refinement of controls and minimisation of time schedules and similar measures. The main thrust of this work will not require major capital investment, but some investment in the estate's control systems and in other areas may be required. These works will require refinement throughout the period, but the aim will be to have the majority completed within the calendar year 2011. As an example of the efficacy of these measures, other organisations have reduced their space heating demands by 30% without significant investment through relatively straightforward plant optimisation measures. For St Mary's this would equate to a saving of over 3 million kWh per annum, worth over £90,000, and equivalent to over 550 tonnes of CO_2 emissions. Similar savings may often be achieved in electricity use as well: investigations have shown that some plant/equipment within this estate runs continuously, and limiting it to 60 hours per week rather than 168 will produce a 64% saving. In most cases this could be achieved at no cost.

Phase 2. Reduce thermal demands by improvement of the buildings' fabric, through such measures as improving control of ventilation – particularly air-handling units, and by other capital measures such as the installation of additional controls and sensors. These measures will require considerable capital investment although the funding of them will be facilitated by the savings realised through the implementation of Phase 1. The cost effective achievement of this will require that each major building is modelled in order to determine its energy balance and to quantify the main causes of energy use. This phase would include measures such as the installation of "inverter" drives on pump and fan motors together with the necessary controls. The installation of a site-wide Building Energy Management System (BMS) in order to maximise energy efficiency opportunities and assist with maintenance is a longer term objective. Domestic hot water production is often very inefficient and the operation of extensive circulatory systems can also add to buildings' cooling loads in summer. Ideally, these should be replaced by "point-of-use" water heaters, but in areas of high water use directly fired gas water heaters may be more appropriate.

Phase 3. Most mechanical plant will eventually require replacement, and this phase includes the replacement of plant with modern high efficiency equipment The completion of Phases 1 and 2 will allow the minimisation of plant capacity, often freeing-up valuable space for other activities whilst reducing the capital investment required. Energy efficiency must always be addressed within the scope of refurbishment works whenever they occur, as these works usually provide a big opportunity for the implementation of energy efficiency measures. This Phase will usefully include detailed assessments of space utilisation in order to ensure that buildings are used efficiently, and not energised for occupation unnecessarily.

The achievement of the 45% target will probably require the efficiency of energy use to be raised to a figure approaching 100% of what is "achievable". For example, if a lecture theatre is only half occupied it will be important for the students to be concentrated in one area, with that area alone being illuminated, and this being completed to the lowest acceptable level using emitters of the highest possible efficiency. The ventilation will have to be controlled in order to provide sufficient fresh-air make up and no more; switch off when the space is unoccupied; and incorporate effective energy recovery for both heating and cooling. The luxury of being able to wear summer clothes all the year round will have to come to an end: in winter, it will be necessary to heat buildings to a maximum of only 18^{o}C, or possibly lower, whilst in summer cooling to less than 25^{o}C or even higher may be unacceptable due to the cost and emissions implications. Scheduling activity in order to avoid the hottest summer weather may become a necessity. That is the forecast for the year 2020.

In plant rooms, only the minimum amount of equipment necessary to achieve the aim will be connected, with the remainder isolated. The current practice of running a building on up to six boilers because "that is how many there are" will **h**ave to cease: aircraft regularly cross the Atlantic on two engines, and running excessive numbers of boilers because one might break down will no longer be acceptable.

4.3 Geographical Strategy

In addition to identifying the most beneficial technical measures, it is also useful to identify those buildings or sites that are likely to be the most productive in terms of potential for reducing energy use.
Self evidently, reducing energy use by 50% in a building that accounts for only 1% of the estate's use will have little impact on the overall situation, laudable though it may be. This section aims to identify those buildings for which remedial measures will be the most beneficial overall. In order to achieve this, it is necessary to establish two things:

- How much energy does a building use overall and
- How efficiently does it use it?

Within this estate the determination of a geographical strategy is complicated by the fact that there is no electricity sub-metering, and that gas meters supply more than one set of space heating plant without sub-metering. The installation of additional gas and electricity meters will therefore be given a high priority. In general, the use of heat meters is to be avoided as these tend to be inaccurate, particularly for space heating loads.

Academic Buildings.

The lack of electricity metering means that the "worst" buildings with the greatest scope for savings have to be determined by gas use and observation rather than measurement. As far as gas use is concerned, the achievement of a target of 100-kWh per square metre each year for the main academic areas would result in the reductions in CO_2 emissions shown in the chart below:

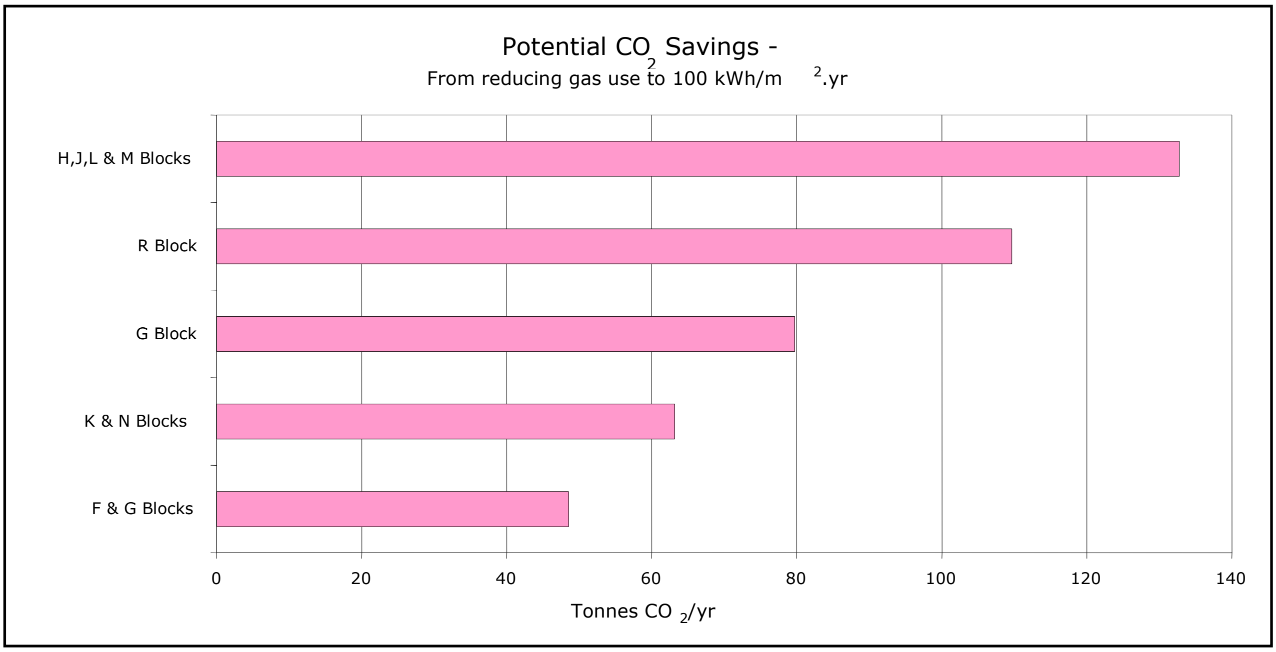

Chart 13: Potential CO_2 Savings – non-residential gas

The challenge here is that all of these areas are quite large, and in some cases cover a large number of quite different buildings. For example, the supply to "H, J, L and M" blocks covers four different building blocks as well as the Chapel. This building is a prime candidate for the implementation of energy saving measures as it is understood to be un-insulated, whilst being heated continuously, but only used intermittently. A heat loss calculation suggests that heating this building is costing between £6,000 and £12,000/year, depending on the assumptions made, and bringing this heating under firm control would realise useful savings.

Residential Estate.

The analysis in Section 4.2 facilitates the identification of the best opportunities for saving energy. If a building is doing very well compared to its peers it is unlikely that remedial works will be very beneficial there. If it is genuinely doing badly – in other words the energy use is actual as opposed to meter reading inconsistencies – then works are likely to be very much more beneficial. Buildings that are very similar in size and construction, such as the Waldegrave Park Road buildings, should have similar usage, and big variations will tend to indicate differences in how the buildings are operated or the malfunction of plant or controls.

Chart 13 below plots the actual emissions resulting from the operation of the residential buildings, and a notional target figure. This has been derived by combining good gas and electricity use figures into a target of 45-kg/m^2.yr. This compares with the current median figure of about 90-kg/m^2.yr, and although this may appear to be hopelessly optimistic, it should be borne in mind that even those buildings that appear to be doing quite well at the present have considerable scope for improvement. This would include, for example, the provision of improved boiler plant and water heating arrangements at the Waldegrave Park Road buildings, and improved heating controls throughout the estate. It should also be recognised that these are longer term targets.

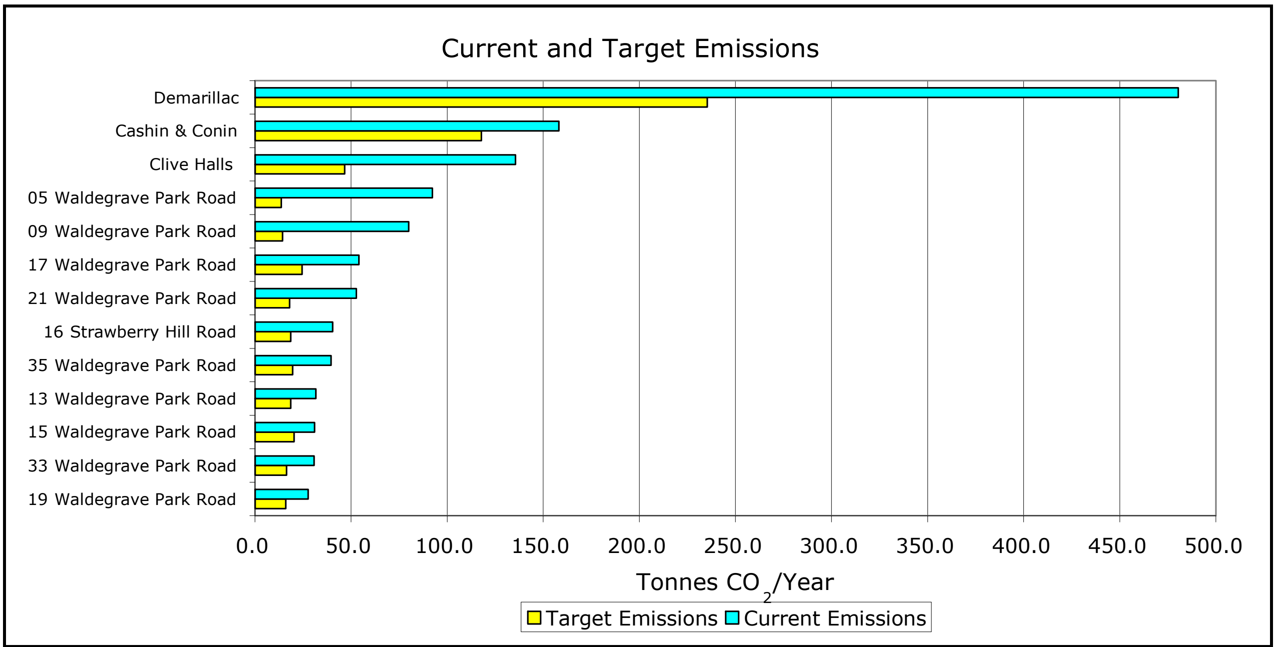

Chart 14: Current and target emissions

The aggregate savings from the achievement of the 45-kg target total about 500 tons, which equates to about 50% of the total emissions of the buildings.

4.4 Potential wider actions

The preliminary set of actions identified below deliver reductions in carbon emissions while dealing with wider issues that are often difficult to quantify compared with, for example, direct energy consumption.

As the plan develops it is anticipated that this list will identify additional new areas of attention and action. As technology, resource and funding allows, some aspects, such as waste, recycling and water use will be allocated quantitative targets to allow accurate monitoring of our progress.

The University College has the following aims.

Emission Reduction Opportunity	Action
Curriculum Development	Ensure that the Carbon Management Plan informs future curriculum development and academic activity reviews. Provide opportunities for students to link their academic work with the aims of the Carbon Management Plan.
Sustainable purchasing	Identify key procurement contracts / opportunities. Assess capacity to deliver a sustainable procurement strategy Link "Fairtrade" purchasing to wider environmental issues and expand scope of products covered. Encourage catering contractors to reduce carbon footprint of food products chosen Consider sustainability criteria in approved contractor assessment

Reduce Waste to landfill	Increase recycling rates Expand recycling trials across the campus Investigate potential for food waste recycling / composting Review opportunities for electric campus vehicles and onsite transport use
Reduce Water Consumption	Assess and fit low water/waterless sanitary ware in upgrade projects , Survey for percussion tap upgrades across the University College Check for / install water displacement device in toilet cisterns ' Improve system of metering, monitoring and targeting for water '

Table 6: Wider actions

5.0 Implementation Plan financing and responsibility

5.1 Funding

To meet the target emissions reduction and the associated benefit, a significant investment programme is required. Investment will include capital investment in technical measures (new plant, lighting / heating controls, insulation etc.), may include additional investment in or reorganisation of staff for data collection, and staff training to assist with staff and student engagement.

Funding for small scale estates-based projects has been identified within existing budgets, while some specific funding for wider environmental projects may become available from car parking income that the University College is likely to be prioritised towards ongoing sustainable transport and waste initiatives under being addressed by the Facilities Management teams. External funding and partnership opportunities will be sought where available for both capital projects and for relevant research across the institution.

5.2 Responsibility for delivery

If the University is to achieve the targets set out above, carbon management must become the clear responsibility of every individual member of staff.

Some staff, due to their roles or seniority, may have greater potential than others to make improvements, but without exception, all staff can make a contribution.

Responsibility for scrutiny and approval of this plan, revisions, and implementation plans lies with the Estates Committee. This committee reports and makes recommendations to the Board of Governors whose formal recognition and approval of the plan are a mandatory requirement by HEFCE in order to confirm its acceptance on behalf of the institution. Without such approval, future grand funding may be placed at risk.

Day to day responsibility for monitoring and revision of the plan and some specific project delivery lies within Estates Strategy & Projects department, specifically with the Director of Estates who will be supported with data collection, collation and entry by the Maintenance Administrator.

It is every manager's responsibility to ensure that their staff are aware of this and act accordingly, and that decisions within their authority are taken with due regard to any environmental consequences. Guidance and support will always be available where required.

5.3 Implementation Plan Finance

Total Estimated Capital Expenditure						
	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Annual capital requirement (£)	42,500	10,000	280,000	210,000	250,000	80,000
Cost Savings						
Annual (£K)	40,000	70,000	55,000	45,000	34,000	20,000
Cumulative Annual (£K)	40,000	110,000	165,000	210,000	244,000	264,000
Carbon Emission reduction (tonnes CO_2)						
Annual Reduction	290	480	340	250	200	110
Cumulative	290	770	1,110	1,360	1,560	1,670

Table 7: Cost savings and Carbon Reduction Summary

The implementation plan above shows anticipated capital requirements between 2011 and 2017 (likely to be re-geared to suit available funds). The program represents a forecasted capital funding availability of £872,500 spread over the first six years of this program. The investment has an anticipated cumulative energy saving value of £264,000. It is projected that this saving will then be realised annually beyond 2017 representing a payback on capital of three years. The aforementioned representing an anticipated 1,670 tonne reduction in CO2 emissions. 6 Carbon Reduction Projects

6.1 Major opportunities at St Mary's University College

As a small, urban institution, opportunities for major transformational projects are limited. It is therefore vital that when capital investment is made in buildings (new and refurbished), vehicles, or equipment, an appraisal is made of the carbon impact that different options will have. These decisions can have a very long legacy, and if the carbon emissions are not taken into account, they have the potential to derail this plan by locking the University into a high emission trajectory from which any alteration will be both very difficult and very expensive. Introducing a system to avoid this is an important point within the implementation plan. Key opportunities include:

- New building Development
- Refurbishments / redecoration

- New heating strategy
- Major maintenance / equipment replacement
- Major IT infrastructure Improvements and standardisation of Communications
- Procurement of any significant electrical equipment / appliances
- Student and staff participation

Table 8 overleaf summarises the initial carbon reduction measures currently identified, with additional detail included in Appendix 1.

Carbon Reduction Projects

	Project	Estimated Annual Saving			Est. Cost £K	Payback yrs
		MWh	£K	tCO_2		
1	Increase engagement with Staff and Students	-	-	-	-	-
2	Enhance "monitoring and targeting"	-	-	-	-	-
3	Provide additional utility sub-metering	-	-	-	30	-
4	Isolate unnecessary boiler plant	150	5	30	Nil	n/a
5	Improve space heating control	350	10	60	10	1
6	Implement and encourage "Good Housekeeping" Measures	700	25	200	2.5	0.1
7	Reduce energy use in Information Technology	400	40	200	10	0.25
8	Improve plant and equipment maintenance	1,250	30	280	Ongoing net savings	
9	Eliminate the use of space heating boiler plant for DHW production	1,500	45	280	180	4
10	Upgrade HVAC Controls	330	10	60	100	10
11	Upgrade building fabric	330	10	60	70	7
12	Improve lighting control and efficiency	350	35	190	140	4
13	Provide variable speed control to fans and circulating pumps	100	10	50	50	5
14	Boiler Replacement Programme	800	24	150	200	8
15	Voltage Optimisation	200	20	110	80	4
	TOTALS	**6,460**	**264**	**1,670**	**872.5**	**3.3**

2011/12	2012/13	2013/14	2014/15	2015/16	2016/17

Table 8: Carbon Reduction Recommendations

Appendix 1: Project Implementation Sheets

Project 1: Increase engagement with Staff and Students	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Introduce energy/carbon element to staff and student inductions Provide energy/sustainability training for relevant staff Consider ways of building avoidance of poor purchasing decisions into existing processes Develop section on website and intranet (and include a facility for users to forward comments and suggestions) Develop a range of University College specific publicity materials (posters, stickers, strip thermometers, postcards etc.) Develop and promote a University College Sustainability Award Train student wardens and give specific responsibility for energy management Run targeted events and publicise results
Benefits:	This is an important "enabling" measure that will assist in ensuring the success of other technical and managerial initiatives.
Funding:	Limited funding required to be achieved through exiting budgets.
Measures necessary to ensure success:	"Buy in" by senior management.
Duration and programming issues:	2011/12 - Ongoing

NOTE

<u>This item applies to each of the 15 programmed project areas.</u>

At the time of writing this carbon management plan, the post of Energy/Space Manager as detailed in the header as the Responsible Person does not exist. All tasks are currently being carried out by the Director of Estates Strategy & Projects and Administrator. Whilst this is producing favourable results, it is un-sustainable and it recommended that if SMUC are to achieve the targeted reductions and savings, additional access to resources is made available beyond those already within the small estates team. One such proposal might be the creation of a new surveying/technical post with specific responsibilities in the areas of energy and space management. This would enable dedicated and focussed support whilst also providing a project manager and surveyor role to progress any energy related projects. It is likely that the requirement would be on a fixed three/five year period.

Project 2: Enhance "monitoring and targeting".	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)

Description:	Effective “monitoring and targeting” is the key to the achievement of sustained reductions in energy use. Consumption through each meter should be compared with expected figures, these being derived from historical usage (how much was used in the same period last month or last year, what is the annual trend doing?), by comparison with “drivers” such as occupancy or degree-days, or simply by comparison with other similar buildings such as in Waldegrave. Effectively applied, these measures can quickly identify where things are going wrong, and enable the cost of changes in usage patterns to be established, assisting in the prioritisation of remedial works. In the longer term, the effectiveness of this will be enhanced through the installation of additional metering to boiler plant and building electricity supplies.
Benefits:	This is an “enabling” measure that will not produce savings directly, but will facilitate the implementation of useful remedial and energy savings measures.
Funding:	Existing budgets and personnel
Measures necessary to ensure success:	This function must be appropriately resourced in order that it may be completed regularly and comprehensively.
Duration and programming issues:	2011/12 - The process has already been started but needs to be further developed and continued.

Project 3: Provide additional utility sub-metering	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	It is not currently possible to identify the energy use of most of the main buildings within the estate from the current metering infrastructure. This needs to be improved to the point where there is, as a minimum, a gas meter for each set of boiler plant, and an electricity meter for each main building. This should include: • The installation of new electrical sub metering throughout the University College Campus • A switch to smart electricity metering in smaller buildings where possible • The identification of load shape and application of saving opportunities to individual buildings • Improve 'visibility' of metering to building users
Benefits:	This is an “enabling” measure that will enhance the effectiveness of monitoring and targeting, allow a comprehensive “league table” of building performance to be established, and to begin to make departments more aware of the environmental impact of their operations.
Funding:	An estimated £30,000 required for the provision of gas meters to allow the usage of each set of boiler plant to be determined, as well as additional electricity metering to each main “Block”.

Measures necessary to ensure success:	It is essential that the correct operation of each meter is confirmed, that all conversions from metered data to kWh are completed correctly, and that automatic meter reading provides comprehensive and useful data.
Duration and programming issues:	2011/12 - Early progress is essential if specific energy reduction target5s are to be achieved.

Project 4: Isolate unnecessary boiler plant	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Much of the estate is over-supplied with boiler plant. As the load on plant falls so does the efficiency and as a result over-sizing is extremely detrimental. Furthermore, the continuous connection of excessive plant results in control problems due to dilution and the associated difficulty in achieving set-points. The estate has many sets of boiler plant, and much of this is continuously in circuit when it is not required. Investigations have shown that poor boiler control is endemic within this estate, with all boilers continuously in circuit and suffering from excessive short-cycling. Boiler sequencing is non-existent, and this exacerbates the control issues and flue losses from purging etc. In most boiler rooms it should be possible to isolate 50-75% of the boilers, with no more than one being connected during spring/summer/autumn.
Benefits:	Financial: £5,000/yr Energy savings: Gas 150,000 kWh/yr CO_2 emissions reduction: 30 tonnes/yr Estimated payback: N/A Additional Benefits: Improved plant reliability
Funding:	This should be achievable within existing maintenance budgets as it is usually possible to utilise existing isolation valves, and most plant already has controls for weather compensation etc.
Measures necessary to ensure success:	Staff involved in the operation of boiler plant will have to be comprehensively briefed and educated on the required operational procedures.
Duration and programming issues:	2011/12 - This should be implemented immediately

Project 5: Improve control of heating circuits	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)

Description:	Most areas within the estate are over-heated. There was clear evidence for this in the number of open windows on cold days, and temperatures measured within the buildings ranged up to 28ºC. The unoccupied Chapel was at 21ºC, but is likely to be at a much higher temperature on warmer days. Many of the older buildings have large bore single pipe heating systems and these provide a significant thermal input even if the associated radiators are valved off. This challenge may be mainly addressed through the improvement of the "compensating control". Many of the circuits are fitted with compensators, and these should be re-set to reduce flow temperatures by at least 10 degrees. In addition, other control points should also be re-set including ting "eco-off" controls and temperature set-points. In many cases time schedules may be reduced. In the case of some discrete buildings such as the chapel, the incorporation of separate "zone" controls would be very beneficial. Most buildings do not require heating throughout the working day, except in the coldest weather.
Benefits:	Financial: £10,000/yr Energy savings: Gas 350,000 kWh/yr CO_2 emissions reduction: 60 tonnes/yr Estimated payback: 1 year Additional Benefits: Improved plant reliability
Funding:	This should be achievable within existing maintenance budgets as it is usually possible to utilise existing isolation valves, and most plant does have controls for weather compensation etc. Some additional funding may be required for the installation of zone controls for buildings such as the chapel.
Measures necessary to ensure success:	Staff involved in the operation of boiler plant will have to be comprehensively briefed and educated on the required operational procedures.
Duration and programming issues:	2011/12 - This needs to be implemented starting in Summer 2011.
Project 6: Implement and encourage "Good Housekeeping" Measures	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Energy use in a university is to a large extent a situation of "death by a thousand cuts", with many opportunities for waste through the unnecessary operation of lighting, IT systems, cooling etc, leaving doors/windows open and taps running. In addition, there are many small "technical" opportunities such as the maintenance of insulation and the fine detail of plant control and operation that must be attended to if energy use is to be minimised. An effective "Good Housekeeping" programme will raise awareness of these issues and encourage the measures necessary for the implementation of remedial works. A GHK measure that is particularly applicable here is the provision of pipeinsulation to the extensive single pipe heating systems that are fitted in most of the older buildings, and which will provide significant thermal input even when the radiators are switched off. The figures assume overall 5% savings.

Benefits:	Financial: £25,000/yr Energy savings: Electricity 175,000 kWh/yr Gas 525,000 kWh/yr CO_2 emissions reduction: 200 tonnes/yr Estimated payback: n/a Additional Benefits: Many measures will improve working conditions as well as reducing energy use.
Funding:	This measure should not require significant funding.
Measures necessary to ensure success:	The support of senior management is essential if this type of measure is to be successful.
Duration and programming issues:	2011/12 - Ongoing.

Project 7: Reduce energy use in Information Technology	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Information technology is a major cause of electricity use within University estates, not only in PCs directly, but also in printers, projectors and other auxiliary devices. These are frequently left on for long periods unnecessarily. The university will therefore introduce a programme that will: • Investigate centralised shutdown of unused PC's • Implement standard cooling / free cooling policy for server rooms • Ensure best practice compliance for new purchasing • Introduce training across the university to ensure best practice in printing/ email • Undertake review of video / teleconferencing possibilities • Undertake review of scope and feasibility of IT assisted behavioural change The costs include an estimated £10,000 for appropriate software for shutting down idle PCs, as well as additional controls etc.

Benefits:	Financial: £40,000/year. Energy savings: Electricity: 400,000 kWh/year Gas: N/A CO_2 emissions reduction: 200 Tonnes Estimated payback: 0.25 Years Additional Benefits: In some case equipment life will be increased. For example, data projector lampas have a limited life and are extremely expensive at £200 or more each. Reducing their operation significantly increases their lifespan. As with all electrical equipment, its operation for long periods unattended does represent a health and safety issue – fires can occur in computers etc, with the potential for serious damage and even loss of life.
Funding:	TBD
Measures necessary to ensure success:	It might be useful to include an energy saving message on the screen of each computer on start-up, reminding the user that idle PCs are automatically shut down after a certain period, and possibly carrying a more general energy saving message as well.
Duration and programming issues:	2012/13 - To be completed during 2012

Project 8: Improve plant and equipment maintenance	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)

Description:	Investigations have indicated that there is considerable scope for improving the standard of maintenance throughout the estate. There are many obvious maintenance issues ranging from dangerously untidy plant rooms and missing/loose guards, to jury-rigged lighting and poorly maintained boiler plant. It is apparent that maintenance is limited to statutory checks and there is a world of a difference between a well maintained and managed system and a legally compliant system. Examples of this can be seen across the site with numerous boiler plant running at maximum temperature (in some cases with pumps on manual so therefore running permanently) and only statutory boiler checks and tests being carried out. There is no evidence to support daily or weekly management of boiler and heating plant anywhere beyond failure and repair. Hot and cold spots are evident throughout the system where annual drain downs, flushing and treatment is not carried out and significant decay to valves and pipe work is occurring un-checked. Whilst restrictions on funds are often cited as the main reason for this approach, experience suggests that the likely outcome is a catastrophic system failure that is more often than not, more costly than maintaining the system over time. What are also never factored into the equation are the increased running costs to a poorly maintained system. Further details on this can be seen in annex a-case study-boiler plant control. If plant is to operate at optimum efficiency it needs to be well maintained, and this will not be completed to a high standard if the technician faces an assault course every time a plant room is entered. Good lighting and access are a pre-requisite for a high standard of workmanship in plant rooms, and are covered under the CDM regulations. The person in charge of maintenance needs be pro-active in maintaining standards, and it may be desirable to introduce a system of individual responsibility for plant rooms.
Benefits:	Financial: £30,000/year. Energy savings: Electricity: 150,000 kWh/year Gas: 1,100,000 kWh/year CO_2 emissions reduction: 280 Tonnes Estimated payback: Years Additional Benefits: Enhanced health and safety.
Funding:	This measure assumes that in the longer term the savings would equate to £45,000/year, at an annual cost of £15,000.
Measures necessary to ensure success:	A positive managerial lead is essential if success is to be achieved.
Duration and programming issues:	2012/13 - Ongoing.

Project 9: Eliminate the use of space heating plant for DHW production	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)

Description:	Space heating boiler plant is used for the generation of domestic hot water (DHW) in a number of buildings within the estate, as shown in Appendix 2. This is generally an inappropriate use of plant, resulting in sustained operation at very low load-factors. The problems are exacerbated by the requirement to maintain the water at sufficiently high temperatures to Combat Legionella. A programme of DHW de-centralisation will eliminate much summer plant operation and facilitate Legionella avoidance. In many cases the preferred option will be to install "point-of-use" water heaters in washrooms etc, although in some cases the use of directly fired gas water heaters may be appropriate. This measure should generally be completed prior to the replacement of boiler plant, although in some cases it may be necessary to do it in parallel.
Benefits:	Financial: £45,000/yr Energy savings: Electricity Nil Gas 1,500,000 kWh/yr CO_2 emissions reduction: 280 tonnes/yr Estimated payback: 4 years Additional benefits: Legionella avoidance improved
Funding:	Salix may provide funding for this measure.
Measures necessary to ensure success:	In the case of some of the larger installations such as that at De Marillac, it would be useful to install meters in the cold-water make up to the calorifiers in order to assess actual DHW usage. This will facilitate the optimisation of replacement plant.
Duration and programming issues:	2013/14 - This should be progressed as early as possible due to the significant savings that are likely to be achievable.

Project 10: Improve HVAC Controls through the installation of a BMS	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)

Description:	The plant within the estate is currently controlled throughout by "stand-alone" controllers of various types including Satchwell and Honeywell. Investigations have shown that there is very considerable scope for improving the operation of these controls. In particular, boiler sequencing was shown to be inadequate, and many buildings are overheated. Evidence for this is the number of open windows in both residential and academic/administrative blocks Specific measures that must be addressed include: • Replacement and upgrade of obsolete and ineffective controls • Upgrade BMS system, controllers, to fully networked system that assists with maintenance • Review and adjust temperature settings / compensators etc • Identify and eliminate heating / cooling conflicts • Survey building use and requirements • Install additional controls to facilitate consistent control settings and comprehensive area coverage • Formulate the scope of possible future space management policies
Benefits:	Financial: £10,000/yr Energy savings: Electricity n/a Gas 330,000 kWh/yr CO_2 emissions reduction: 60 tonnes/yr Estimated payback: 10 years Additional benefits: Improved working conditions
Funding:	TBD
Measures necessary to ensure success:	BMS require active management by informed and experienced operators. It may not be cost-effective to provide full BMS control to the smaller sets of boiler plant such as those at the "Waldegrave" buildings.
Duration and programming issues:	2013/14 - Much of this work could be combined with boiler replacement or DHW decentralisation works

Project 11: Upgrade building fabric.	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Many buildings, particularly older ones, are poorly insulated and suffer from considerable uncontrolled ventilation. This causes considerable unnecessary energy use: effective insulation can reduce heat loss from a building by 90%. Fabric details for all buildings should therefore be ascertained and a programme of remedial works implemented in order to improve air-tightness and insulation values. The figures below are illustrative, and assume that cavity wall insulation is applied to about 2,000 m^2 of external wall, and 1,000 m^2 of ceiling/lofts.

Benefits:	Financial: £10,000/yr Energy savings: Gas 330,000 kWh/yr CO_2 emissions reduction: 60 tonnes/yr Estimated payback: 7 years Additional Benefits: Good insulation allows space temperatures to be reduced, improving working conditions.
Funding:	Salix funding may be appropriate, and this should be included as part of all refurbishment projects.
Measures necessary to ensure success:	It is vital that heating controls are effective in well insulated buildings, or over-heating will result in poor working conditions and reduced savings.
Duration and programming issues:	2014/15 - This measure will often have to be completed during major refurbishment, although in some buildings other opportunities may present themselves.

Project 12: Improve lighting control and efficiency throughout the estate	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Lighting is probably responsible for the use of 40-60% of the estate's electricity use, potentially costing about £150,000 per year. Lighting is frequently left on unnecessarily, and in some cases uses inefficient fittings. There is currently little in the way of automatic controls. The following remedial measures are proposed: • Complete building lighting surveys of the entire University College and identify the main opportunities. • Improve control of lighting by making use of presence detection, daylight dimming, timers and other controls as appropriate. • Replace tungsten lamps with compact fluorescent lamps, "2D" lamps or LED fittings as appropriate. • Upgrade fluorescent lighting to high frequency with appropriate controls • Investigate the suitability of LED lighting for floodlighting / security applications. • Replace luminaries incorporating T12 and T8 fluorescent tubes and mains frequency ballasts with T5 fitting incorporating high frequency ballasts.

Benefits:	Financial: £35,000/yr Energy savings: Electricity 350,000 kWh/yr Gas n/a CO_2 emissions reduction: 190 tonnes/yr Estimated payback: 4 years Additional benefits: Improved working conditions
Funding:	TBD
Measures necessary to ensure success:	Lighting controls can be problematic, mainly when users are unaware of their mode of operation. In addition, manual switches will need to be retained in many areas such as lecture rooms, in this case being used as an "enabling" device rather than a by-pass.
Duration and programming issues:	2014/15 - This will need to be completed as a "rolling" programme to tie in with other refurbishment works etc. The overall aim is to complete 20% of the estate each year.

Project 13: Provide variable speed control to fans and circulating pumps	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Many of these operate at a fixed speed corresponding to the maximum required load on a system. Systems are often over-sized, and the result in that plant runs at high speed and high power for long periods unnecessarily. "Inverter" drives may be used to reduce the speed according to the load, and as there is a cubic relationship between the speed of a circulating pump and the power demand, the savings are considerable. On cooling circuits there are additional savings as less energy is dissipated in the cooling water. Savings assume that plant running at 40-kW for 3,000 hours/year is brought under inverter control in the first instance, with speeds being reduced by 40% to produce an 80% reduction in motive power.
Benefits:	Financial: £10,000/yr Energy savings: Electricity 100,000 kWh/yr CO_2 emissions reduction: 50 tonnes/yr Estimated payback: 5 years Additional Benefits: There are frequently maintenance benefits (reduced wear and tear on bearings and drive belts etc).
Funding:	Salix funding may be appropriate.
Measures necessary to ensure success:	Good control is a critical issue if savings are to be maximised. This is best achieved through the BMS.
Duration and programming issues:	2015/16 - Ongoing

Project 14: Boiler Replacement Programme

Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)
Description:	Much of the boiler plant within this estate is approaching obsolescence, and combustion tests (See Appendix 3) indicate that it is no longer operating at anywhere near peak efficiency. Similarly, much is also oversized. Replacement of existing plant with smaller capacity boilers will therefore improve efficiency by improving combustion and ensuring that the plant is appropriately sized for the load. Some of the plant is also elderly and approaching obsolescence. Bringing forward replacement will reduce maintenance costs overall. Appendix 2 lists boiler plant that should be replaced, and this measure addresses that plant dated 1998 or earlier. The current capacity is approximately 2,700 kW and replacement plant would require a capacity of about 1,000 kW (subject to detailed survey). Assuming standing losses of 3%, this would reduce gas demands by 50 kW, and greatly reduce the losses from purging etc. As in some cases (R block plant room for example) the number of boilers could be reduced, control would also be simplified.
Benefits:	Financial: £24,000/yr Energy savings: Gas 800,000 kWh/yr CO_2 emissions reduction: 150 tonnes/yr Estimated payback: 8 years. Additional Benefits: Reduced long term maintenance costs.
Funding:	SALIX may be an option.
Measures necessary to ensure success:	The minimum boiler capacity for each building must be carefully assessed, and any feasible fabric improvements be completed prior to implementation of this project.
Duration and programming issues:	2015/16 - This measure would ideally be completed in a "rolling" programme, starting with the oldest boilers that need to be replaced for maintenance reasons anyway.

Project 15: Voltage Optimisation	
Responsible Person/Department:	Estates Strategy and Projects (energy manager/space manager)

Description:	The vast majority of electrical equipment including lighting, motors, refrigeration and air-conditioning etc is designed to operate at 220 volts. Operation at higher voltages increases losses and thus results in the use of more electricity than necessary, with reductions in voltage achieving useful savings. Measurements taken on site indicate that the supply is at around 235-240 volts in most areas, suggesting a 6% reduction in voltage should be acceptable. Voltage reductions can be achieved through the adjustment of the tap settings on existing supply transformers, or through the installation of "secondary" transformers, although there is a significant cost. Secondary transformers come in two types with either fixed or variable voltage outputs, and are installed on the "low" voltage side of the existing transformer. In some cases it may be preferable to install secondary transformers at subdistribution points rather than, main incomers. The figures assume a 6% reduction in electricity use across the estate, although savings on much equipment will be greater than "pro-rata".
Benefits:	Financial: £20,000/yr Energy savings: Electricity 200,000 kWh/yr CO_2 emissions reduction: 110 tonnes/yr Estimated payback: 4 years Additional Benefits: In some cases, reducing the voltage of the supply can be beneficial in terms of equipment life and reduced maintenance.
Funding:	"Salix" funding may be available for this measure.
Measures necessary to ensure success:	The success of this will require a detailed independent survey of the estate and its electricity distribution infrastructure. For "variable" output transformers it will be advisable to establish a system for checking the output voltage, either continuously or periodically. This could be achieved through the BMS.
Duration and programming issues:	2016/17 - Systems will have to be shut down in order to enable the connections to be made, although this will generally be completed within a working day provided that preparatory works are comprehensively completed.

Appendix 2 – Estate Details

Residential Properties

Building or site	Gross Internal Area (m^2)	Annual Electricity Use (kWh)	Performance Indicator ($kWh/m^2.yr$)
5 Waldegrave Park Road	302	25,548	85
9 Waldegrave Park Road	318	98,918	311
13 Waldegrave Park Road	300	17,980	60
15 Waldegrave Park Road	300	14,850	50
17 Waldegrave Park Road	544	64,169	118
19 Waldegrave Park Road	356	8,195	23
21 Waldegrave Park Road	400	29,975	75

33 Waldegrave Park Road	365	10,644	29
35 Waldegrave Park Road	436	24,597	56
Cashin & Cronin	2,618	81,193	31
Clive Halls Blocks ST&U	1,036	138,861	134
St Marys Halls, Grosvenor Road	1,600	4,964	3
16 Strawberry Hill Road	314	8,422	27
De Marillac	5,229	323,690	62
13 Waldegrave Park Road (Warden)	117	4,964	42
15 Waldegrave Park Road (Warden)	153	3,390	22
21 Waldegrave Park Road	179	9,927	55
34 Clive Road	250	9,929	40
16a Strawberry Hill Road	100	8,290	83
Totals:	**14,917**	**888,508**	**60**
		Gas Use (kWh)	
5 Waldegrave Park Road	302	424,285	1,405
9 Waldegrave Park Road	318	143,504	451
15 Waldegrave Park Road	353	123,895	351
17 Waldegrave Park Road	544	105,286	194
19 Waldegrave Park Road	356	125,811	353
21 Waldegrave Park Road	579	168,371	291
33 Waldegrave Park Road	365	135,370	371
35 Waldegrave Park Road	436	141,930	326
34 Clive Road	250	71,227	285
Cashin, Cronin, R, R1 Sports Halls	7,184	1,695,066	236
Clive Halls Blocks S & T + De Marillac	6,265	1,977,928	316
Clive Halls Blocks U	457	32,441	71
St Marys Halls, Grosvenor Road	1,600	918,750	574
16 Strawberry Hill Road	314	169,251	539
13 Waldegrave Park Road (Warden)	417	118,806	285
16a Strawberry Hill Road	100	169,251	1,693
E Block - Priests Flat	127	63,001	496
Totals:	**19,967**	**6,584,171**	**330**

Non Residential Properties

Building or site	**Gross Internal Area (m^2)**	**Annual Electricity Use (kWh)**	**Performance Indicator ($kWh/m^2.yr$)**

Teddington Lock Change & Grnds Store	866	43,631	50
Teddington Lock Pavilion	126	21,263	169
DOLCHE VITA	224	21,094	94*
B Block	1,149	108,200	94*
C Block	674	63,470	94*
D Block	1,496	140,876	94*
E Block	1,299	122,325	94*
F Block	1,287	121,195	94*
G Block	2,678	252,184	94*
H Block - Chapel	1,022	96,240	94*
J Block	2,660	250,489	94*
K Block	2,130	200,579	94*
L Block	2,002	188,526	94*
M Block	780	73,452	94*
N Block - REF AND KITCHEN	2,609	245,686	94*
P Block - SMALL CHAPEL	8	753	94*
Q Block - CHAPLAINCY	80	7,533	94*
R Block - Sports Hall	2,503	235,704	94*
R1 Block - Tennis Hall	1,855	174,683	94*
NEW LRC AND LIBRARY	2,894	272,524	94*
N Block New Sports Hall	2,000	0	0
Totals:	**30,342**	**2,640,407**	**87**
		Gas Use (kWh)	
Clive Groundsmans Hut & Areas	38	2,993	79
Teddington Lock Change & Grnds Store	866	519,332	600
D Block Serving SCR	410	3,675	9
G Block Boilerhouse	7,244	1,155,300	159
F & G Blocks	2,626	524,939	200
K & N Blocks Incl New Ref & Kit	4,444	785,971	177
H,J,L & M Blocks	8,572	1,574,849	184
Totals:	**24,200**	**4,567,059**	**189**

NOTE
*Due to metering restrictions the annual kWh use has been calculated across total floor area served to arrive at a flat rate of 94.17 kWh/m2/yr.
(B Block = 94.17kWh/m2 x 1,149m2 = 108,200kWh energy used)

Appendix 3 – Boiler Plant Details

The estate accommodates a total of over forty gas fired space heating boilers, and the details of the majority of the most significant plant are included in the table below.

Boiler Plant	Total Capacity	Heated Area	Specific Boiler Power

Location:	**Boilers:**	kW	m^2	watts/m^2	Date	Provide DHW*?
G Boiler Room	2 x Ideal Viceroy	446	5,264	85	1978	Yes
L Block	1 x Vaillant	126	2,002	63	1978	
T Block	2 x Broag	268			1978	Yes
Cashin Hall	2 x Regency	108	1,300	83	1988	
R Block	6 x Regency	600	3,800	158	1988	Yes
Lensbury	2 x Wessex	400			1993	
Clive Hall	2 x Worcester	47	1,036	45	1998	
Waldegrave Park	9 x Regency 2	720	3,587	201	1998	Yes
J Boiler Room	3 x Remeha	1,601	6,570	244	1999	Yes
D Boiler House	3 x Remeha	993	3,319	299	2000	Yes
De Marillac	2 x Remeha	874	5,229	167	2003	Yes
K Block	3 x MHS Strata	181	2,130	85	2003	No
	Totals:	6,364	34,237			

* DHW = Domestic Hot Water

The first priority with this plant must be to make separate provision for the generation of DHW. For the older plant, such as that at “G” Boiler room and “T” Block this should probably be done in parallel with boiler replacement. In other areas it should be completed in advance. It is worth remembering that the phasing of boiler replacement becomes much easier when it no longer has to provide for DHW.

In academic buildings with little demand for DHW the preferred option will be to install “point of use” water heaters. In residential buildings it will probably be necessary to retain the centralised DHW supply, but provide it using directly gas fired water heaters.

Boiler Combustion Efficiency

Independent combustion efficiency checks have been completed on ten of the estate’s gas-fired space heating boilers, or about 25% of the total. Details are included in the chart below, for the boilers tested, all of which were at “low” fire (where they have a variable output):

Boiler Combustion Efficiency Checks					
	"J" Block Boiler Room			"R" Block Boiler Room	
	No 1	No 2	No 3	No 1	No 6
Flue Temperature °C	171	158	184	290	271
Efficiency on GCV %	82.2	83.8	83.8	75.3	76.3

CO	ppm	178	3	3	5	109
O_2	%	8.6	7.0	3.1	8.2	8.2
CO_2	%	7.0	7.9	10.2	7.3	7.3
Excess Air	%	69.8	50.1	17.2	64.0	64.0
		Clive Hall	"G" Block	De Marillac	"D" Block Bo ler Room No 1	No 2
Flue Temperature	^{o}C	147	241	182	198	151
Efficiency on GCV	%	82.7	80.1	82.4	81.5	84.3
CO	ppm	27	6	0	6	16
O_2	%	10.4	5.9	6.3	6.8	6.5
CO_2	%	6.0	8.6	8.3	8	8.2
Excess Air	%	98.0	38.7	43.3	48.4	44.5

The points to note from this are as follows:

Flue temperatures: in most cases these are very high, and for the “R” block plant they are particularly so. In a modern “condensing” boiler they would be at or around 100°C, and a 20°C increase in flue temperature reduces boiler efficiency by about 1%. This is the main reason for the very poor efficiency of the “R” Block boilers. High flue temperatures are indicative of a “scaled” boiler where the heat exchanger surfaces have been covered in deposits from the products of combustion (on the “fire” side) or scaled with calcium and other scale on the water side. However, some boilers are “over-fired”, and this also results in excessively high flue temperatures.

Efficiency: This ranges from 75 to 84%, and the best standard efficiency plant will achieve about 87%. If plant is using 1,000,000 kWh per annum, such as at “R” Block, an increase in efficiency from 75 to 88% would save nearly 150,000 kWh per annum, worth about £4,500. Improvements to over 90% would be achievable with modern high efficiency boilers. This analysis only measures combustion efficiency: the overall efficiency will be 5-10% lower than this, and will vary according to the season and the load on the plant. The savings are therefore likely to be considerably greater.

CO (Carbon Monoxide): Good boiler plant does not produce CO, and the presence of significant levels is another indicator for poor combustion efficiency.

O_2/CO_2/Excess Air. In order to achieve optimum efficiency, the fuel/air mixture must include sufficient air (at 20% O_2) to completely combust the fuel. If there is too little air incomplete combustion will result and this may result in the generation of smoke, whilst if there is too much air this has the effect of removing additional heat from the boiler. Ideal combustion requires about 20% “excess air” as measured by the ratio of O_2 to CO_2, and the “J” Block number 3 boiler is doing extremely well in this respect. J1 and the Clive hall boiler were particularly bad, suggesting poor maintenance/adjustment of the burners. The “R” block plant has “atmospheric” burners and limited scope for adjustment, although de-scaling is likely to be very effective at improving the efficiency of these boilers.

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In association with The Green Consultancy

Annex A: Case Study – Boiler Plant Control

This estate has a number of sets of boiler plant and investigations have shown that poor boiler control is endemic. This case study looks at the plant in the "J" Block plant room in order to illustrate the challenges that must be overcome if the plant is to operate at peak efficiency.

The boiler plant includes three units and these are illustrated below:

J Block Plant Room. This is fitted two "Remeha" P500 boilers with rated outputs of 635 kW, and one Remeha P300 with an output of 331 kW.

The different burners on the two P500 boilers (nearer) are notable.

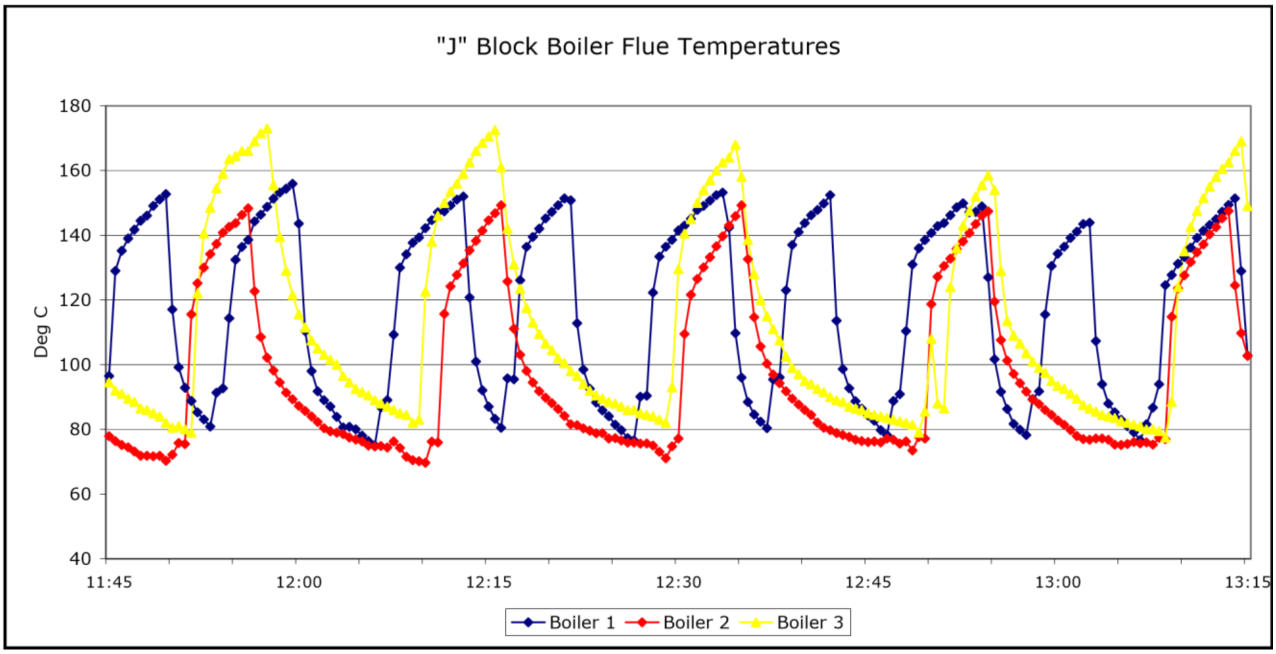
A large amount of extraneous equipment makes this plant room something of an assault course.

The first point to note is that No 1 and 2 boilers are fitted with different burners, which is unusual as the boilers were understood to be installed at the same time. It is possible that some capital savings were made by fitting a burner from an old boiler. However, the burner on No 1 is rated at 430-1,090 kW, whilst that on No 2 is rated at 248-738 kW. As the input rating of the boilers is 784 kW, the burner on number 2 is appropriately rated. However, that on No 1 is over sized, and this is less than ideal as although the burner may be set up not to exceed the rated input of the boiler, the minimum rating of 430-kW is not likely to be adjustable.

As the ambient temperature changes, the heat loss from buildings and thus the load on the boiler plant varies also. At temperatures above about 17^{o}C the space heating load on the plant will be almost zero, and this will increase to a maximum at the lowest temperature experienced – usually about minus 5^{o}C.   Ideally, the boiler plant should be able to respond to this range of demand operating one or more boilers as required by the demand, and also adjusting the output of the burners.

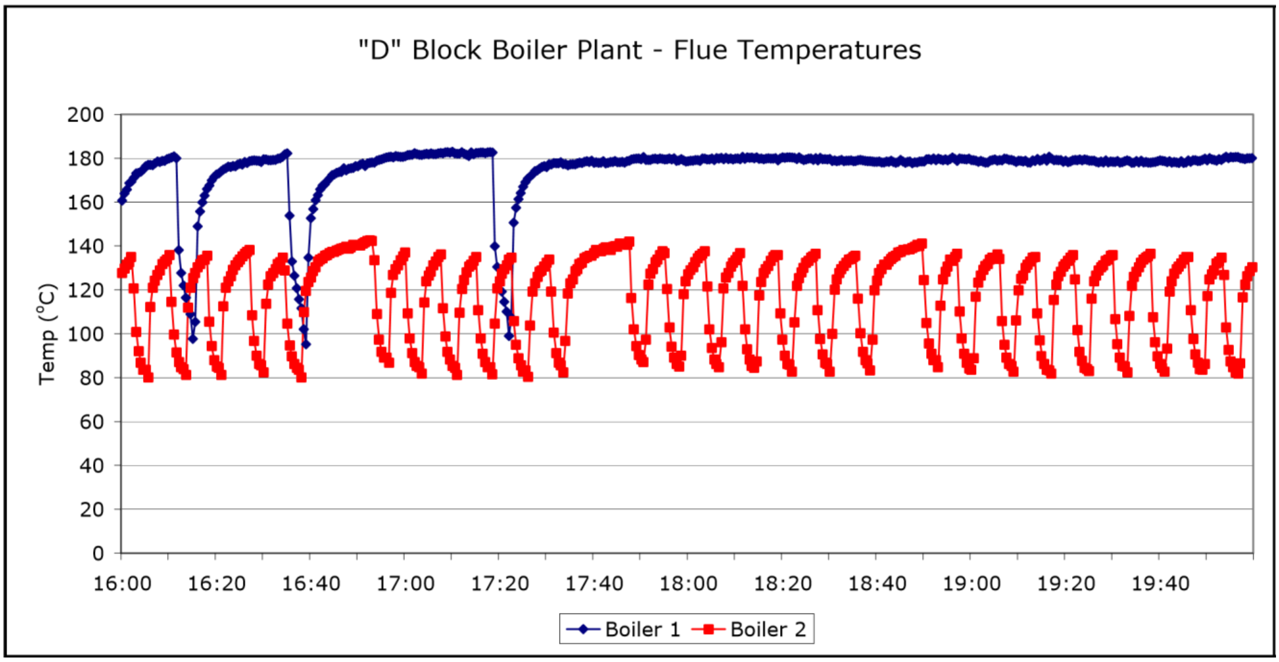
The Chart overleaf illustrates what is actually happening with this boiler plant. It was derived by placing temperature sensors in each boiler's flue which gives a clear indication of whether the boilers are firing or not. Inspection shows that during the 90 minutes of the test, No 1 boiler started no less than nine times, whilst numbers 2 and 3 started five times each. Assuming that the plant operates for 14 hours per day (0600-2000), and it may be longer this would equate to a total of nearly 900 starts per week, assuming only 5 days of operation. It is likely to be even worse than this.

Each start involves a boiler carrying out a "purge" prior to lighting, and this typically continues for one minute whilst the forced draught fan blows cold air through the boiler. This removes heat from the heat exchanger surfaces within (as that is what they are designed to do), and it also takes some time for the flame to stabilise in the furnace. This all results in considerable wasted energy that is in addition to the 3% or so that boilers lose from radiation whilst they are operating. This plant is likely to be "purging" for at least 15-hours per week.



During this 90 minute period No 1 was firing for 50% of the time, whilst Nos 2 & 3 fired for about 34% each. This is actually insufficient load to sustain 1 boiler for 100% of the time. The priority here is therefore to improve control of the boilers/burners in order to achieve the operation of just one boiler for the majority of the time, supplemented by a second if necessary.

This is illustrated in the chart below which plots the flue temperatures for the "D" Block plant between 1600 and 2000 on 14 February 2011. Until about 1740 both boilers are operating intermittently, with either both on or both off for some periods. After 1740, Boiler 1 is firing continuously, with the flue temperature a steady 180°C. Ideally, ALL boilers should operate like this: the intermittent operation of boiler 2 is again expensive in terms of both maintenance and energy use.



The “J” block plant itself provides DHW, and heating for a number of areas through a number of separate circuits. These are all controlled from the panel shown below:

The control panel in “J” Block Plant room. This incorporates a single time switch that possibly controls all the plant and heating circuits, although there is also a “Honeywell XL 50 MMI” controller that should be able to provide time control for a number of separate circuits.

Although the controller has four 0-10V outputs and there appear to be four VT circuits, it is unclear whether it is able to provide effective “weather compensation”.

The Circuits are labelled:

- Students Union and Library
- CT to Library and Theatre
- Kitchen + Student’s Union HWS Primary M N K Cowsheds, Bookshop
- Refectory Under-floor.

The circuits are fitted with “3-port” valves and weather compensation may be possible or even occurring, although the temperature settings need adjustment.

The scheduling and other circuit control parameters are unknown for these circuits.
One of the buildings supplied from this plant is the Chapel, probably through the library/IT suite.

The Chapel is a large building and being largely uninsulated it suffers from considerable heat loss. Calculations suggest that heating costs will be somewhere between £6,000 and £12,000/year. The building is apparently heated all the time the boiler plant is enabled, probably through the “Library/LRC” building adjacent on the far side, and the ability to effect time-scheduling for the heating of the chapel would therefore generate very useful savings.

The building is apparently utilised for only a few hours per week, although it is available throughout the day for prayer and meditation.

Heating in the Chapel includes lengths of bare radiating pipe work at the ground floor level and radiators at the balcony level. Under the main building there is a small “Crypt” chapel that is used for smaller gatherings and is in use more frequently than the main Chapel. Given the potential costs of heating this largely uninsulated building, considerable environmental and financial benefit would accrue if the heating were controlled to prevent operation outside scheduled times for Mass and other gatherings. It would obviously be necessary to maintain heating for the Crypt chapel for longer periods as this is more heavily utilised.