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DESIGN REVIEW REPORT

FOR

Imperial College Union Building

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EXECUTIVE SUMMARY

This report presents the results of a Design Review at Imperial College Union. This assessment and report are provided by Price & Myers Sustainability and have been funded by the Carbon Trust [1] programme.

The agreed scope of work was to assess the current carbon footprint of the proposed refurbishment design and to suggest options for reducing the potential carbon impact. We were asked to provide recommendations for energy efficiency improvements and renewable energy.

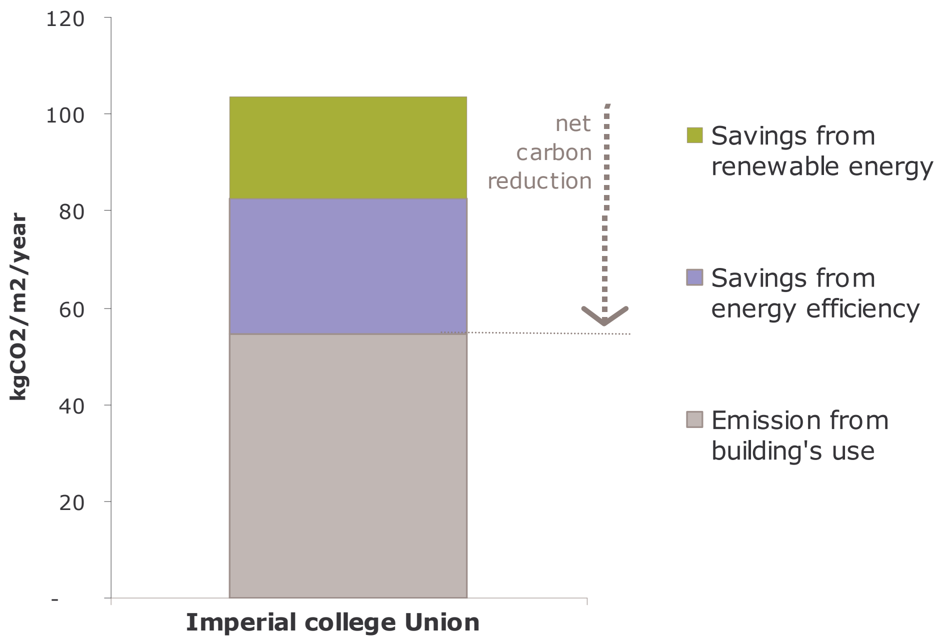
A summary of our key recommendations is as follows:

- Increase level of insulation and airtightness of the building fabric to reduce heat losses.
- Energy efficient and well-controlled building services for lighting, heating, ventilation, and other end uses.
- Renewable energy for heating and hotwater through biomass boilers and/or solar collectors.
- Renewable energy for electricity generation through the use of wind turbines on the roof.

Estimated Carbon Savings

The ICU building has a potential to cut carbon emissions from energy in use by more than 47% using energy efficient systems and renewable energy technologies discussed in previous section.

The estimated total cost of implementing the low carbon refurbishment strategies is £465,000.



[1] The Carbon Trust helps businesses and public sector organisations cut their energy costs through the provision of free, professional advice and assistance. Previously known as Action Energy, the programme has helped many organisations save up to 20% of their energy bills, which equates to total UK energy savings of around £800 million a year.

IMPORTANT NOTICE

All costs and savings stated in this report are based on the data available at the time of the report. For further liability information, see the Important Notice section.

1.0 INTRODUCTION & BACKGROUND

1.1 General

This consultation was carried out on 02/07/2006 by Prashant Kapoor of Price & Myers Sustainability. Our main site contact was Peter Haldane, Permanent Secretary, Imperial College Union.

This report presents the results of a Design Review consultation. This is a single intervention, typically at detailed design stage, whereby the client will receive a minimum of 2 days consultancy support from a Design Advice consultant

1.2 Project Background

Imperial College of Science, Technology and Medicine is an independent constituent part of the University of London.

Imperial College Union (ICU) is the students' union and focus of student life at the College.

The Union Building in Beit Quadrangle houses: Da Vinci's café-bar, the traditional Union bar, the ICU cinema, a concert hall and theatre and the newly refurbished entertainment venue, dBs.

Imperial College Union is a student led and student run organisation. In addition to the elected student Officers, ICU has a team of full-time professional staff who manage a wide-range of services and facilities, to support the representative functions of the Union.
ICU operates a range of commercial and non-commercial facilities and services. These facilities are available free of charge to student groups and to external organisations for extremely competitive rates.

The current building has a gross floor area approximately 3600m^2 spread over 4 storeys. The building is due for a major refurbishment next year.

The ICU building currently has a very high electrical and heating demand. The fabric of the building is un-insulated with large single glazed windows. The building façade is draughty and has high air-infiltration rate.

The lighting system varies across the building i.e., T-12 florescent tubes with magnetic ballasts, tungsten/metal halide uplighters, halogen spotlights. During our visit to the site, we also noticed that the artificial lighting was poorly controlled with almost no zoning for switches.

1.3 Objectives

The agreed scope of work is as follow:

- Assess the current carbon footprint of the proposed design.
- Suggest options for reducing the potential carbon impact.
- Provide recommendations for energy efficiency improvements and renewable energy
- Provide indicative costs of implementing the carbon saving recommendations

2.0 – RECOMMENDATIONS

The recommended carbon reduction strategy for the ICU building is as follows:

2.1 Energy efficiency

A feasibility analysis was carried out to help inform the most optimum energy efficiency technology for this project.

The energy efficiency options considered include,

- Super insulation and draught proofing,
- Low energy lighting
- Lighting controls.

The main criteria for selection was carbon reduction, energy savings, operational cost and capital cost. Based on the feasibility study energy efficiency recommendations have been made for the refurbishment of the building.

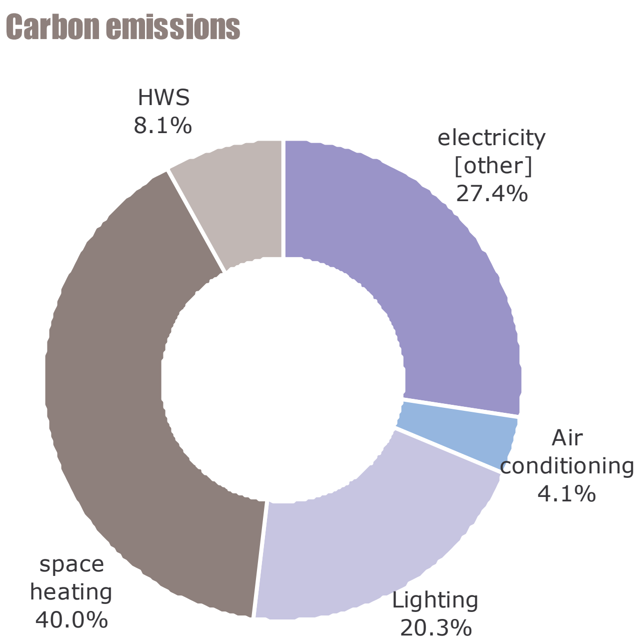


Figure 1: Default carbon emissions [based on data provided by ICU]

The key recommendations are as follows:

Increase insulation & air tightness:
The façade and roof for the ICU building scheme should be super insulated. It is recommended that thermal insulation of the fabric be improved by 35% above the current levels. This could be achieved through internal wall insulation, double glazing [or secondary glazing] and roof insulation.

Control of air infiltration is essential to ensure indoor thermal comfort and to minimise energy consumption in buildings. The quantity of air infiltration is determined by measuring the air leakage rate from the building envelope, which describes the relative tightness of a building.

Draught proofing of windows and doors is recommended, especially if the existing windows are not going to be replaced.

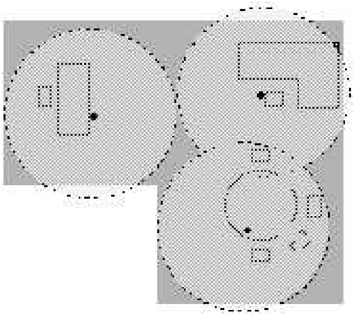
Low energy lighting:
Lighting in the ICU building contributes 20% of the total annual carbon emissions. Light design therefore needs to be energy efficient.

The lighting system should be specifically designed to accommodate only compact fluorescent lamps (CFL) luminaires or 16mm T5 high frequency florescent tubes with high frequency ballasts.

The internal light fittings specified should have an average efficacy of at least 65 lumens/watt.

Additionally, in order to reduce light pollution at night, external lighting must also be designed to minimise light lost to the sky by specifying fittings that reduce light emitted above the horizontal and directing it downwards [within an angle of 70^{o} from the downward vertical].

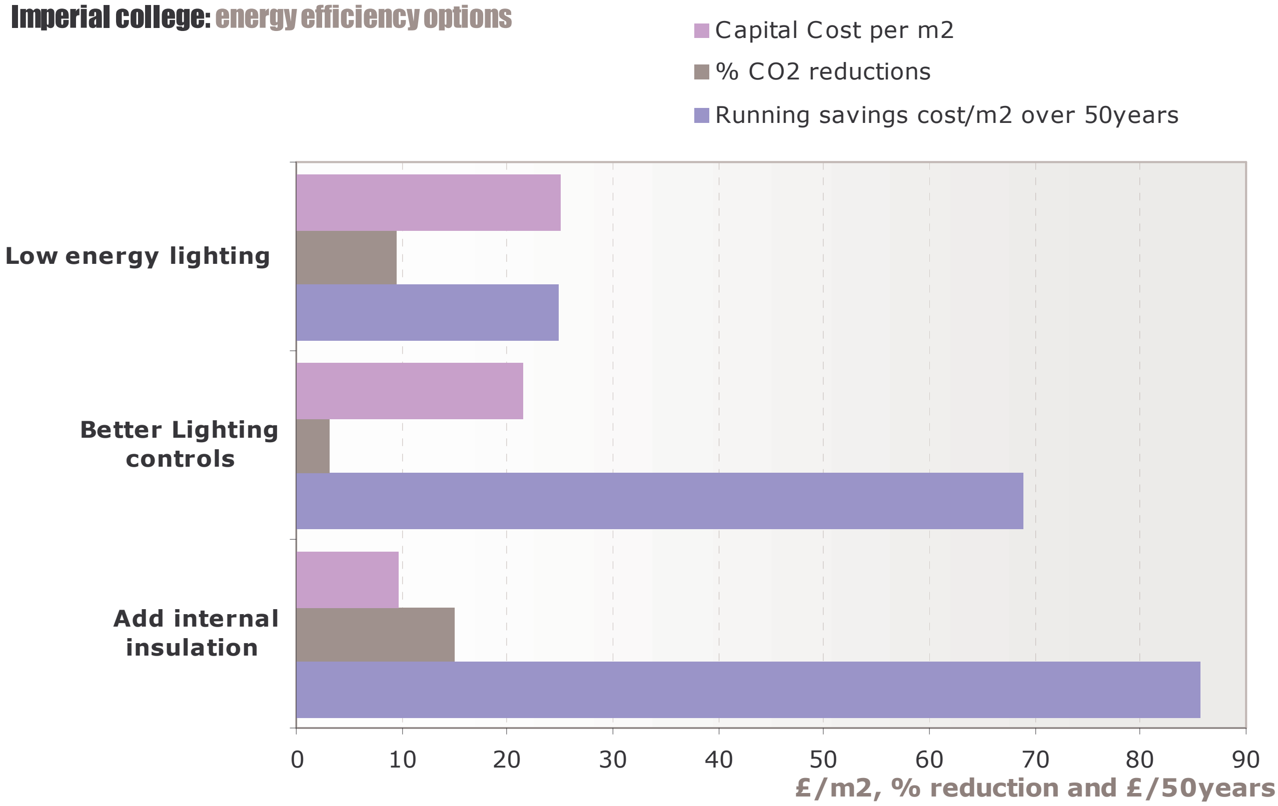
Lighting controls:
Good lighting controls can reduce 30% of the lighting demand in buildings. In cellular office spaces consider installing movement sensors with manual override switches.



Electronic photoelectric dimmers could be used in large rooms with adequate daylight such that artificial lighting is only used to compliment available natural light.

For more detailed information on the above energy efficiency options see Appendix 1

Imperial college: energy efficiency options



2.2 Sustainable energy

An analysis was carried out to check the preliminary feasibility of different onsite energy generation options, including solar water heating [collectors], solar electricity [PV], wind turbines and biomass heating [See Appendix 2 for the detailed analysis].

Options	Advantages	Disadvantages
Photovoltaics*	• Potential to generate a large component of the total energy on site • Low maintenance	• Very high capital investment required
Solar thermal collectors	• Low capital cost • Low maintenance and easy to manage	• Limited potential CO_2 reductions
Wind turbines	• Medium capital cost • Education value	• High visual impact • Impact on structural cost due to vibration related issues • Maintenance required
Biomass heating	• Potential to reduce large component of the total CO2 emitted • Socio-economic benefit to the community • Cost of the system is relatively low for large schemes	• Requires space to store wood chips • Regular maintenance will be required • Reliable source of fuel required
Large CHP*	• Mature technology • High CO2 savings	• High capital cost • Regular maintenance will be required • More appropriate for mixed use developments

* PV and CHP system have not been analysed further due to high capital cost

Solar collectors

Solar collectors can provide heat for domestic hot water requirements [DHW] when used in conjunction with a conventional heating system. There are two common types of solar collectors applicable for water heating - flat plate and vacuum tube.

Solar collectors are recommended to supplement the DHW demand for the shower rooms in the recreational area.

30m^2 of flat plate collectors would be required to provide 30% of the hot water demand. These will need to be connected to a cylinder [buffer tank], which will feed the direct gas fired water heater.

Wind turbines

In the UK we have 40% of Europe's total wind energy. But it's still largely untapped and only 0.5% of our electricity requirements are currently generated by wind power. Wind power is proportional to the cube of the wind speed, so relatively minor increases in speed result in large changes in potential output. Individual turbines vary in size and power output, from a few hundred watts to two or three megawatts.

Our initial check [BWA] suggests that the site has an average wind speed of 4.4m/s, making it suitable for generating wind energy. We recommend that a detailed feasibility for installing wind turbines on the roof is carried out. Preliminary calculation suggests that 5 turbines [6kW each] would be able to provide 10% of the total electricity demand of the site [6% CO_2 savings].

Biomass Boilers

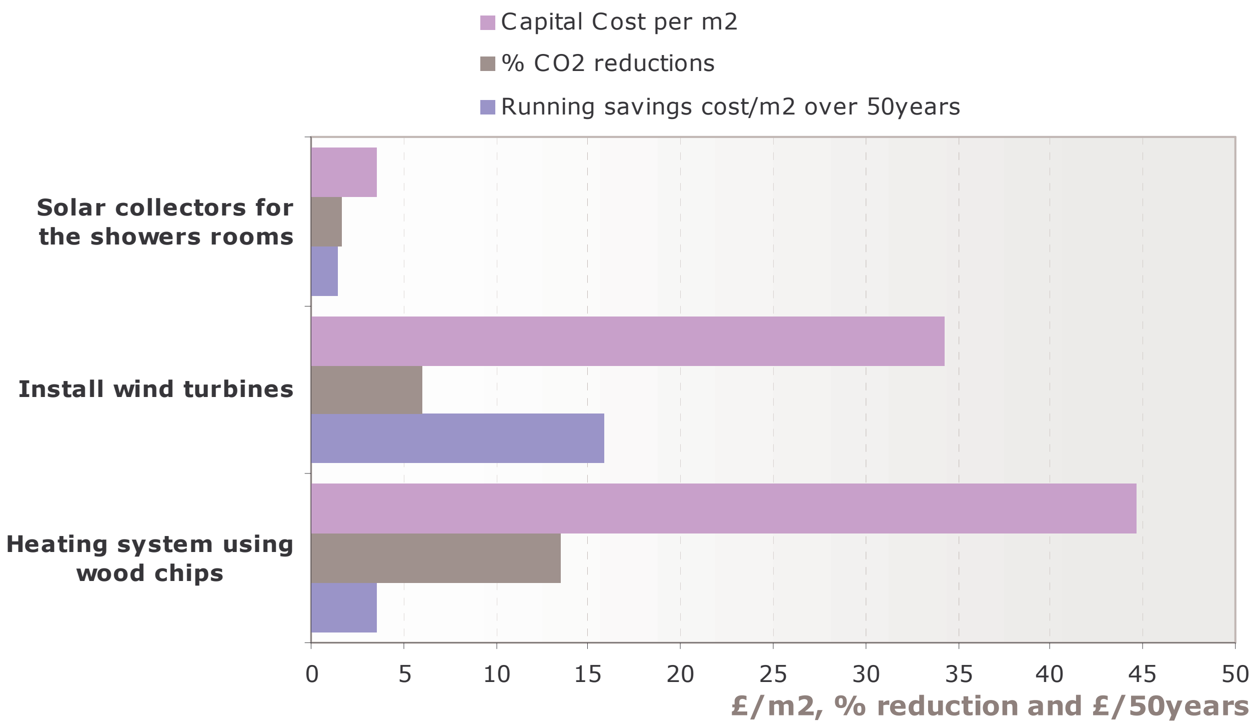
Wood chip and wood pellet boilers are now highly efficient (88-90%), reliable and sophisticated heating systems. They offer a convenience approaching that of fossil fuel enabling timers, thermostats and building energy management systems to be used in an identical way to conventional systems.

A wood chip burning boiler could be used on this site to meet space heating and hot water demand. This could be located at the back of the building [north east corner].

The suggested option is to provide two main boilers- one biomass wood chip boiler [200 kW] and the other a gas boiler [200 kW]. The feasibility of transporting the fuel [wood chip] and access to site will need to be considered. The biomass boilers will help provide up to 20% of the total energy requirement to run the building [13% reduction in CO_2 emissions].

For more detailed information on the above renewable energy options see Appendix 2

Imperial college: renewable energy options

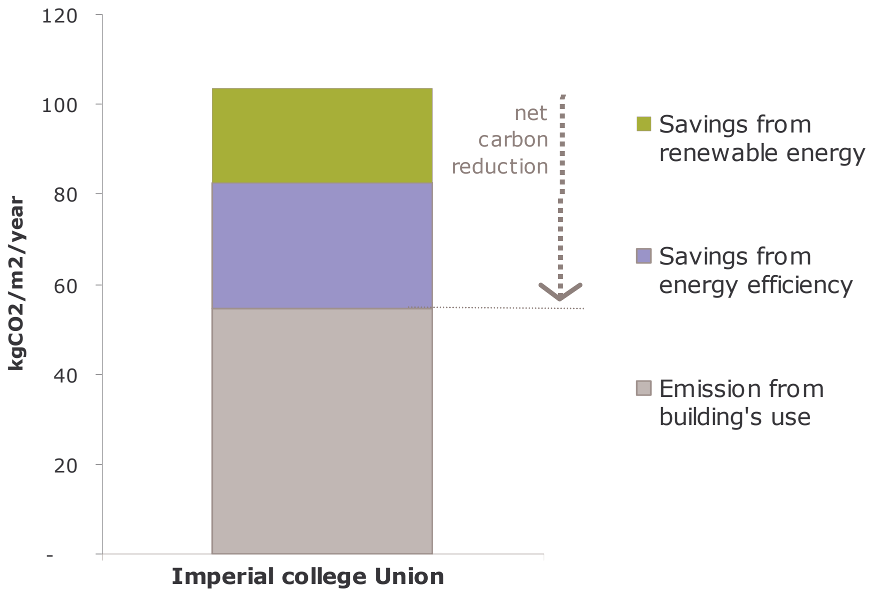


3.0 – POTENTIAL CARBON SAVINGS

The ICU building has a potential to cut carbon emissions from energy in use by more than 47% using energy efficient systems and renewable energy technologies discussed in previous section.

The estimated total cost of implementing the low carbon refurbishment strategies is £465,000.

However, government grants for renewable energy and energy efficiency such as, DTI's Low Carbon Buildings Programme (LCBP) and Enhanced Capital Allowance can help save up to 50% of the costs.



Funding opportunities: The low carbon buildings programme will provide grants for micro generation. The DTI's Low carbon buildings programme provides grants for microgeneration technologies for householders, community organisations, schools, the public sector and businesses.

Launched on 1 April 2006, the programme will run over three years and replaces DTI's Clear Skies and Solar PV programmes. The programme is UK-wide and will demonstrate how energy efficiency and microgeneration will work hand in hand to create low carbon buildings.
[See: www.lowcarbonbuildings.org.uk]

4.0 - FOLLOW THROUGH

4.1 Following the report

The purpose of this report is to help Imperial College Union reduce the carbon impact of the building. Following receipt of the report, the person responsible for commissioning it should discuss the results with relevant colleagues and designers to agree who will be responsible for overseeing the implementation of the recommendations. A timetable should be agreed to monitor progress and establish firm dates by which specific actions should be completed.

4.2 Providing Feedback

Following receipt of the final report, we will email you a Feedback Form to complete about your experiences of working with the Carbon Trust and our consultant. The Carbon Trust values all feedback we obtain. Part of this form provides you with an area in which you can request areas of further support if applicable. Please complete and return this web form using the link provided.

4.3 Follow up support

If you are interested in receiving follow up support to assist in implementing the recommendations in this report please contact the Carbon Trust Energy Helpline at anytime. [Before receiving follow-up advice the Carbon Trust do however expect the site to demonstrate good commitment to implementing the action(s) for which they will receive the support.

4.4 Impact Assessment

In the future a client manager will contact you to discuss how successful you have been in implementing the Action Plan and the estimated level of energy savings you have achieved overall in order that we can evaluate the effectiveness of our programme. We would be grateful if you could make time to take this call and provide the information we are seeking.

4.5 Envirowise

This report focuses upon energy efficiency, but making optimum use of other resources such as water and raw materials, together with waste minimisation, also offers cost savings for your organisation. The Envirowise programme (funded by the Department of Trade & Industry and the Department for Environment, Food and Rural Affairs) provides a helpline service on environmental issues and publications on waste minimisation, clean technology, water and effluent savings, and more. Further information can be obtained from the Envirowise website http://www.envirowise.gov.uk or from the Environment & Energy Helpline 0800 58 57 94 and selecting the Environment option

APPENDICES

1. Energy Efficiency options

Priority no:	**1**
Short Description of Recommendation	**Add internal insulation**
Type of action	Parameter Change
Main Technology	Building fabric
Sub Technology	Insulation
Date Identified	09/08/2006
Energy Savings per Year	
Running Costs savings (£):	**19,198**
Total Consumption (kWh):	**910,800**
Grid Electricity	**394,200**
Natural Gas	**516,600**
Diesel	
Petrol	
Heavy Fuel Oil	
LPG	
Heat Imported	
Wind	
PV	
Biomass	
Biogas	
Other - Renewable	
CO2 (tonne):	**268**
Simple Payback	
Capital Cost (£):	**£32,800**
Payback (Yr):	**1.7**
Detail:	Improve the thermal perforce of the building fabric by adding internal insulation to the walls, roof and specifying argon filled low-e coated glazing. Aim to achieve an overall U-value of at least <0.55W/m2K
Rationale:	Space heating in this building contributes to 40% of the total carbon emissions. Therefore, increasing the thermal resistivity of the building fabric will conserve considerable amount of energy, save on running costs and reduce CO2 emissions.
Risks:	-risk of interstitial condensation and thermal bridging -reduction in room size
Relevant publications:	Benefits of Best Practice: Heating and Insulation (CE11)

Priority no:	**2**
Short Description of Recommendation	**Better Lighting controls**
Type of action	New Technology
Main Technology	Lighting
Sub Technology	Controls
Date Identified	09/08/2006
Energy Savings per Year	
Running Costs savings (£):	**15,452**
Total Consumption (kWh):	**1,119,527**
Grid Electricity	**394,200**
Natural Gas	**725,328**
Diesel	
Petrol	
Heavy Fuel Oil	
LPG	
Heat Imported	
Wind	
PV	
Biomass	
Biogas	
Other - Renewable	
CO2 (tonne):	**307**
Simple Payback	
Capital Cost (£):	**£72,000.00**
Payback (Yr):	**4.7**
Detail:	Electronic photoelectric dimmers could be used in large rooms with adequate daylight such that the artificial lighting is only used to compliment natural light.
Rationale:	Artificial lighting can contribute more than 20% of the total annual carbon emissions in schools buildings. Good lighting controls can reduce 30% of the lighting demand in buildings.
Risks:	Ensure that CIBSE lighting levels are not compromised.
Relevant publications:	When the energy supply industries were deregulated the Government set up the Energy Saving Trust (EST). Of the money collected by electricity companies 1% is given to EST to be invested in energy efficiency projects. Lightswitch is one such project and provides a 50% grant for the installation of improved lighting controls up to a maximum sum of £3000. The grants covers the following items: time operated controls, presence or occupancy sensor operated controls, illuminance sensors (photocells) and daylight linking. Advice on making an application is available from the lightswitch website at: www.lightswitch.co.uk Or from the following Helpline number: 0990 133 538.

Priority no:	**3**
Short Description of Recommendation	**Low energy lighting**
Type of action	Parameter Change
Main Technology	Lighting
Sub Technology	Relamping
Date Identified	09/08/2006
Energy Savings per Year	
Running Costs savings (£):	**5,582**
Total Consumption (kWh):	**1,102,040**
Grid Electricity	**315,800**
Natural Gas	**786,240**
Diesel	
Petrol	
Heavy Fuel Oil	
LPG	
Heat Imported	
Wind	
PV	
Biomass	
Biogas	
Other - Renewable	
CO2 (tonne):	**285**
Simple Payback	
Capital Cost (£):	**£84,000**
Payback (Yr):	**15.0**
<u>Detail</u>:	Light design needs to ensure that all external and common area lighting is specifically designed to accommodate only compact fluorescent lamps (CFLS) luminaires or 16mm T5 high frequency fluorescent tubes. The internal and external light fittings specified must have an average efficacy of at least 65 lumens/watt.
<u>Rationale</u>:	Artificial lighting can contribute more than 20% of the total annual carbon emissions in schools buildings. Therefore by improving lighting design, providing effective controls and efficient fittings the school can reduce considerable energy and CO2.
<u>Risks</u>:	Ensure that CIBSE lighting levels are not compromised.
<u>Relevant publications</u>:	ISBN 0 11 271041 7, January 1999 The Stationery Office

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2. Renewable energy options

Priority no:	**4**
Short Description of Recommendation	**Heating system using wood chips**
Type of action	New Technology
Main Technology	Heating
Sub Technology	MTHW/LTHW Systems
Date Identified	09/08/2006
Energy Savings per Year	
Running Costs savings (£):	**£788**
Total Consumption (kWh):	**1,180,440**
Grid Electricity	**394,200**
Natural Gas	**196,560**
Diesel	
Petrol	
Heavy Fuel Oil	
LPG	
Heat Imported	
Wind	
PV	
Biomass	**589,680**
Biogas	
Other - Renewable	
CO2 (tonne):	**207**
Simple Payback	
Capital Cost (£):	**£150,000**
Payback (Yr):	**190.3**
Detail:	Wood chip fired boilers [75%] in combination with secondary gas boilers [25%] can provide for all thedomestic hotwater and space heating demand.
Rationale:	Biomass fuels such as wood chips , provide sustainable source of energy. Biomass is organic matter of recent origin. It doesn't include fossil fuels, which have taken millions of years to evolve. The CO2 released when energy is generated from biomass is balanced by that absorbed during the fuel's production. This is therefore considered a carbon neutral process.
Risks:	Three main issues need to be considered i,e., storage requirements to store the wood chips, access for the delivery lorry within the site to supply the fuel and reliability of supply.
Relevant publications:	www.lowcarbonbuildings.org.uk

Priority no:	**5**
Short Description of Recommendation	**Install wind turbines**
Type of action	New Technology
Main Technology	
Sub Technology	n/a
Date Identified	09/08/2006
Energy Savings per Year	
Running Costs Savings (£):	**£3,560**
Total Consumption (kWh):	**1,180,440**
Grid Electricity	**344,200**
Natural Gas	**786,240**
Diesel	
Petrol	
Heavy Fuel Oil	
LPG	
Heat Imported	
Wind	**50,000**
PV	
Biomass	
Biogas	
Other - Renewable	
CO2 (tonne):	**297**
Simple Payback	
Capital Cost (£):	**£115,000**
Payback (Yr):	**32.3**
Detail:	Install 5 wind turbines [6kW each] on the roof
Rationale:	UK has one of the highest potential to tap wind energy in Europe. A preliminary check indicates that the site could potentially have annual wind speeds of more than 4m/s which make wind energy feasible on site.
Risks:	Further planning permissions may be required. A more detailed feasibility will need to be undertaken.
Relevant publications:	www.lowcarbonbuildings.org.uk

Priority no:	6
Short Description of Recommendation	**Solar collectors for the showers rooms**
Type of action	New Technology
Main Technology	Heating
Sub Technology	Hot Water Services
Date Identified	09/08/2006
Energy Savings per Year	
Running Costs Savings (£):	**£329**
Total Consumption (kWh):	**1,200,600**
Grid Electricity	**394,200**
Natural Gas	**786,240**
Diesel	
Petrol	
Heavy Fuel Oil	
LPG	
Heat Imported	
Wind	
PV	
Biomass	
Biogas	
Solar Heat	**20,160**
CO2 (tonne):	**327**
Simple Payback	
Capital Cost (£):	**£11,903.75**
Payback (Yr):	**36.2**
Detail:	Install solar collectors to provide DHW for the showers in the sports facility
Rationale:	Solar collectors can provide 40% of the heat required for domestic hot water requirements [DHW] when used in conjunction with a conventional heating system.
Risks:	A more detailed feasibility will need to be undertaken to check the most appropriate location for the panels to avoid shadowing from surrounding buildings
Relevant publications:	www.lowcarbonbuildings.org.uk