THE ENERGY CONSORTIUM
(Education)
Your Partner in Energy Cost Management

Guidance Document

Project Manager's Guide to
Energy and Water Efficiency Measures
University Buildings

Foreword

The impact that buildings have on the environment is one of the most important issues of our time. We are in a decade where energy and water costs have dramatically increased, whilst the certainty of their supply has decreased. In years to come, when we look back at the way we are currently designing and refurbishing buildings, we will be judged by how we have dealt with these issue.

Universities set the standards in terms of knowledge and research, whilst many of the buildings they occupy exemplify mediocrity in sustainability. There is a gap between the typical energy and water efficiency solutions frequently seen in university buildings and potential best practice solutions. The challenge is bridging this gap which is both logical and achievable.

This is an excellent document. It has the potential to provide a vital contribution to the way that university buildings are designed and refurbished. It gets to the heart o the topic and points to solutions. History will judge its success.

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Contents

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Introduction to the Guide

Section 1 Introduction to the Guide	This section sets out the aims of this document and how to use it. It also provides an overview of the issues that the document addresses.
Section 2 Project Drivers	This section focuses on the key issues that affect the success of a project. It highlights exemplar solutions, client and design team issues, regulations, legislation, cost programme impacts and benchmarks.
Section 3 Project Guidance	This section focuses on different university buildings types and which primary efficiency measures should be focused on. The tables provide guidance on which sections of the guide should be looked at for further details.
Section 4 Passive Energy Measures	This section provides on passive energy solutions for buildings, and ways to avoid or limit the provision of building services. It highlights site layout and orientation, façade treatment and daylight, natural ventilation and thermal mass.
Section 5 Active Energy Measures	This section provides information on the use of energy in systems where passive measures are not possible. This effectively deals with building services and the ways to maximise the use of energy efficient designs and equipment.
Section 6 Renewable Energy	This section provides information on incorporating renewable energy into buildings. It highlights the effectiveness, cost issues and overall impact that renewables have on a building.
Section 7 Water Measures	This section provides information on water use in buildings. It highlights ways to optimise water use and limit unnecessary waste.
Section 8 Design Targets	This section provides information on strategic design targets that all university projects should use. These targets are intended to be simple and achievable but go beyond current minimum legislation.
Section 9 Help and Support	This section provides on references for this document and ways in which to find out further information on energy and water issues.

The UK's higher and further education fields are seen as promoters of academic excellence and leaders in a wide range of disciplines. The UK's university sector is respected around the world for its creativity and innovation.

The promotion of excellence is not however reflected in the buildings the sector occupies. Much of the building stock lags behind the best in building design, this is in spite of massive reinvestment in both refurbishment and new build projects over the last decade. The result is that the conservation and efficient use of energy and water at universities there exists significant opportunity for improvement. Such an improvement would align with the sustainability image that all institutions endeavour to portray.

Energy and water have financial as well as environmental implications for universities. Energy and water use is becoming a significant budgetary consideration in the overall running of university buildings. Over the last few years most universities have seen energy and water costs more than double.

The Energy Consortium is a "not for profit" organisation employing expert purchasing and technical staff to carry out the procurement of energy supplies. This is on behalf of its members within the higher and further education sectors. As a result of its involvement, a need has been identified to provide ways of delivering more efficient buildings.

This document has been produced to assist this aim. It has been made freely available on the Energy Consortium's website for the benefit of the whole sector.

The focus of the guide is to provide assistance to project managers who are responsible for delivering new and refurbished university buildings. It is not intended to be a design guide as project managers do not design buildings; they make sure they are delivered on budget, on time and to the correct level of quality.

Some of the key targets are highlighted here.

- **The client should confirm in writing that they are committed to low energy and water design and that excellence in this area should not be compromised unless it jeopardises the viability of the project.**

- **On all large scale projects, the client should be informed of the potential energy and water system solutions at each design stage. Whole life costing should be used. Systems with a payback of 15 years or renewable systems with 20 years should be considered. Ideally 60 years should be used for payback analysis. The exact timescale should be defined by the client.**

- **15% - The percentage that the Building Emission Rate (BER) should exceed the Target Emissions Rate (TER) for criterion 1 of Building Regulations Part L2A 2006.**
  (i.e. Carbon Dioxide Emissions 15% below current requirements)

- **25% - The percentage of energy that should be supplied via low or zero carbon systems.**

- **20% - The percentage that energy and water usage should be reduced existing buildings irrespective of the new use.**

- **Air leakage to be set at 5 m3/h/m2 for all new build and improvement of 50% on all refurbishments.**

- **Daylight linked dimming controls should be used on all spaces within 7m of a window.**

- **2 – Minimum number of credits to achieved on BREEAM Water Consumption calculator (Max score 3). To achieve this only best practice low water use fittings and equipment to be used.**

- **50% - The percentage of toilet flushing provided by recycled water subject to a financial viability study.**

- **90% of all energy shall be metered in accordance with CIBSE Guide TM 39 Building Energy Metering. Water to be sub-metered to separate at least 90% of water use by zones.**

- **The client should be committed in writing to use the Building Log Book.**

- **Updates on all of the above should be provided at each RIBA design stage and at appropriate stages in the project development.**

Introduction to the Guide

For the guide to be useful its intention is to be informative and easy to navigate. It will be successful if it assists university projects to deliver higher levels of energy and water efficiency.

Project managers have to take an active responsibility for this delivery. It should not be entrusted to just the design team to deliver.

An efficient design solution should embrace design innovation, provide effective solutions and consider budgetary limitations. It must have a clear brief, be well commissioned and avoid losing efficiency measures as budgetary pressures come to bear on a project.

Project manager's must understand primary energy and water issues. Only in this way will they be able to robustly challenge both the project team and the client's decisions.

It is important to realise the impact of decisions made at the start of a project. It is far better and cheaper for a client for efficiency measures to be provided during a project rather than trying to retrofit solutions once the building is occupied.

It is vital that the client has a full understanding of the impact of decisions at every stage of the development.

There is a wide range of buildings at most universities. Each type of building has its own particular requirements that affect efficiency. There are also a number of features that are common to all building types. In all cases the focus should always be to try and design out inefficient systems.

To allow university buildings to be seen as leaders in the field of building energy and water efficiency it is vital that designs go beyond current legislation and aspire to meet future targets.

Environmentally considerate buildings will be the leading buildings of the future.

Targets need to be simplistic but go beyond current legislative requirements for energy and water efficiency.

The targets highlighted on the previous page are in the direction that the construction industry is moving. These targets will allow buildings to meet the required legislation both now and in the coming years.

Legislation such as the Building Regulations Part L 2006 is moving in this direction. This requires buildings to be 25% more efficient than a notional carbon dioxide figure.

The figures can be used only for compliance rather than predict actual energy use. The regulations are also expected to be toughened by another 15-20% in 2010.

The extent of future legislation changes is difficult to predict but it is certain they will become tougher. Security of supply in the future will become an increasingly difficult challenge. Far-sighted clients will prepare for this risk and its impact on business continuity. If there is a crisis with energy in the future, will the university be able to cope with it?

The value of efficiency measures can be enhanced with the assistance of grants and funding bodies. Demonstrating the benefits of efficient systems through measures such as whole life costing is often the key to achieving this additional funding.

It is important to remember that the real winner of implementing energy and water efficiency measures is the client.

Sustainable buildings are healthy buildings to use. They are cheaper to run and easier to maintain.

Minimising the use of energy and water will be an integral aspect of promoting a positive sustainable image. Funding bodies, research groups and students are becoming more aware of these issues.

In the years to come this image will have a greater impact on institution selection by each of these three groups. The importance of this to the client cannot be identified.

Increasing levels of carbon dioxide generation from burning fossil fuels are contributing to global warming and its associated extremes in weather.

Building functions such as heating and lighting require energy to be derived from fossil fuels. Reducing energy use and incorporating renewable energy solutions reduce the impact that a building has on this global issue.

Reducing water use conserves a resource that is becoming stretched due to reduced rainfall levels and increased demand. Minimising use reduces the volume of water extracted from rivers and the pollution associated with processing this water.

Minimising water discharged to drains reduces erosion and flooding further downstream and minimises the chances of sewage being discharged directly into water courses due to overloading in the drainage system. Energy is also used in processing and pumping waste water.

The principles of providing energy and water efficient solutions are relatively easy. The challenge for project managers is to ensure that environmental issues retain an appropriate level of priority as design and aesthetic issues struggle for their proportion of the budget.

Energy and Water Options Table

Issue	Standard Practice Or Required By Law	Best Practice	Exemplar
Carbon Emissions	- Building Regs. Part L 2006	- 15% below Building Regs. Part L 2006 - 20% improve refurbishments	- Low or Zero Net Carbon emissions from site
Passive Design	-	- Natural ventilation / night time cooling - Use of thermal mass to dampen daily temperature fluctuations - Orientation / window optimisation and shading - Roof covered with vegetation (green roof)	- Air tubes to temper mechanical air supplies - Partially burying buildings in ground to reduce heating in winter and cooling in summer - Evaporative cooling using water
Ventilation	- Building Regs. Part F 2006 - Air permeability 10 $m^3/h/m^2$ @ 50Pa - Air pressure tested ductwork - Fan power 2.5 W/ls/1 (with heat recovery/heat/cool) - Fan power 2 W/ls/1 (heat/cool) - Fan power 1.8 w/ls/1 (other central systems)	- Air permeability 5 m3/h/m2 @ 50Pa - Inverter driven fans - DC fan coil units - Heat recovery, 50-70% efficient - Carbon dioxide sensors linked to volume supply - Mixed mode ventilation - Low energy ventilation systems such as displacement ventilation	- Air permeability 3 $m^3/h/m^2$ @ 50Pa - AHU Adiabatic cooling - Heat recovery, 70%+ efficient - Dependence on natural ventilation during summer months to provide all cooling to a space
Hot water, heating & cooling	- Building Regs. Part L 2006 - High efficiency boilers - Multiple boilers - Zone controls (e.g. thermostatic radiator controls) - Weather compensation - Optimised stop / start - Time controls - Full zoned time controls - Insulation of all pipework to within 1m of fitting - Scroll & screw chillers - Heat pumps - Hot water served by a separate heat source to heating system	- Euro Class A pumps - Condensing boilers - Boiler over-sizing less than 20% - Modulating boiler burner control - Inverter driven pumps to control speed, not just to commission system - Inverter air conditioning units - Natural Gas CHP - GSHP (Open/closed loop / thermal foundations) - Low energy cooling systems such as chilled beams - Occupation heat gains to heat space - Heat recovery from comms rooms. - Individual room temperature controls with local display set point adjustment	- Waste heat recovery - Absorption cooling linked to waste heat - Absorption cooling linked to solar collectors - Gasification of waste - Buildings that have no heating system except for morning air pre-heat, and have a fully natural summer cooling strategy

Energy and Water Options Table (cont.)

Issue	Standard Practice Or Required By Law	Best Practice	Exemplar
Electricity	- Building Regs. Part L 2006 - IEE Wiring regulations	- Small scale photovoltaics (solar collectors) - Small scale wind turbines - Voltage optimisation - Capacity diversity - Natural Gas CHP	- Large scale photovoltaics (solar collectors) - Large scale on-site wind turbines - Hydro electric turbines - Tidal generation
Lighting – passive & active measures	- Building Regs. Part L 2006 - Society of Light and Lighting Guidance Documents - 45 luminarie lumens / circuit watt - Occupancy, time switch and motion lighting controls	- Light efficient luminaries (high light output ratio) - Light tubes and light pipes - Energy efficient lamps - Daylight linked dimming - 4% daylight factor - Use task lighting only on working plane	- Full avoidance of artificial lighting during daylight hours - Advanced daylight systems such as semi-transparent insulation
Renewables	- 0 to 10% net import/export depending on area of country	- 25% net import/export	- 50% net import/export
Renewable Technologies		- Small PV installation - Solar LTHW - Ground coupled heating and cooling - Biofuels	- Gasification of waste - Biomass CHP - Large scale PV - Seasonal energy storage - Large wind turbines on-site
Water Use	- Water Act 2003 - Water metering - Low use fittings - Occupancy sensing controls	- Rainwater recycling - Grey water recycling - Low use lab equipment - Leak detection - Trickle hoses and drippers - Borehole extraction and treatment to potable standard - Dual flush toilets - Pressure regulating valves on taller buildings - Self closing taps - Waterless urinals such as flow restrictors on taps	- Composting toilets
Drainage	- Building Regs Part H 2001	- SUDS - Roof covered with vegetation (green roof)	- Full on-site sewage treatment - Reed beds

Abbreviations

AHU	- Air Handling Unit	GSHP	- Ground Source Heat Pump
CHP	- Combined Heat and Power	LTHW	- Low Temperature Hot Water
DC	- Direct Current	PV	- Photovoltaic
IEE	- Institute of Electrical Engineers	SUDS	- Sustainable Urban Drainage System

Client & Design Team

The most important contributor to the efficiency of a building is the client. The client set the brief, the budget and ultimately make the decisions on the solutions that are achieved.

Energy and water are an integral aspect of promoting a positive sustainable image. Funding bodies, research groups and students are becoming more aware of these issues. In the years to come, this image will have a greater impact on institution selection by each of these three groups. Exemplar facilities allow a responsible and considerate image to be promoted.

Most institutions have now set their own agenda with institution sustainability statements, environmental statements or energy statements. These should be reviewed in relation to the brief to confirm that the project brief is aligned with the stated objectives.

A member of the client team should be identified to be responsible for ensuring that the demands of the client do not clash with energy and water efficiency. This person should have real authority and backing at the highest level.

Decisions made at early stages and during construction will have implications throughout the life of the building. Facilities management needs to be considered early in the project; at concept design stage or perhaps even before the design begins.

Part of the project manager's role is to ensure that the appropriate design team is assembled. Only a good team with experience of delivering low energy designs should be considered. As part of the selection process, recorded evidence of energy efficiency design should be requested.

Design teams will only achieve tangible and quantifiable targets that they are set by the client. If a brief says "energy shall be taken into account when designing the lighting system" this has little meaning.

If the brief says "The lighting installation shall be a high frequency system, provided with automatic daylight and occupancy controls in all rooms and an installed lighting efficacy of at least 100lmns/W" then a low energy lighting system is guaranteed. This will allow the true intention of the brief to be understood.

Once the brief is set, communication is vital. Universities are cutting edge. If facilities are required to meet this expectation, the requirements need to be explained.

The design team must also communicate effectively. It is important for a client to be made aware of the impact that decisions made by the client will have on the project's energy efficiency.

Project Drivers

Client & Design Team

Feasibility / Early Design

- Ensure that a member of the client team with real authority will champion energy and water issues.
- Ensure client has identified key issues.
- Ensure client has provided all relevant policy documents to design team.
- The design team should be encouraged to challenge and look for clarification on the brief in relation to energy efficiency. The design team may be unclear on the importance of the energy aspects when making a decision, and brief clarification can assist in confirming that energy efficiency is a priority over most other constraints where practical improvements can be achieved.
- Ensure client has provided full details of use, occupation and equipment before the end of Stage C.
- Ensure design team has one or more dedicated meetings directly with client and client's maintenance team to discuss energy and water.
- Ensure that any existing energy and water use figures are available.

Design Development

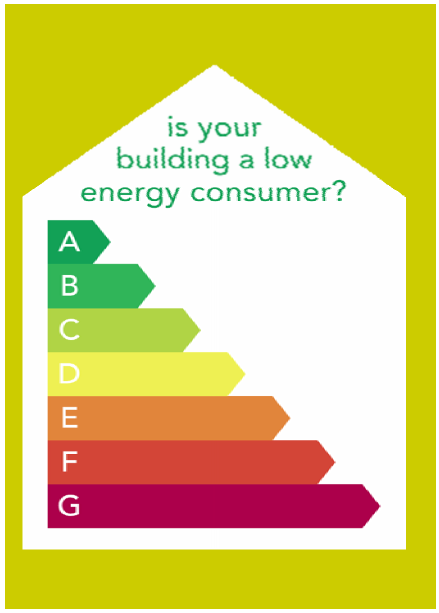
- Ensure that full energy estimates are to be produced (not just Part L calculations).
- Implications of energy and water targets due to brief changes need to be made clear to client.
- Ensure that the client commits to a post occupancy review of building.
- Ensure that client energy and water champion is informed of design changes.

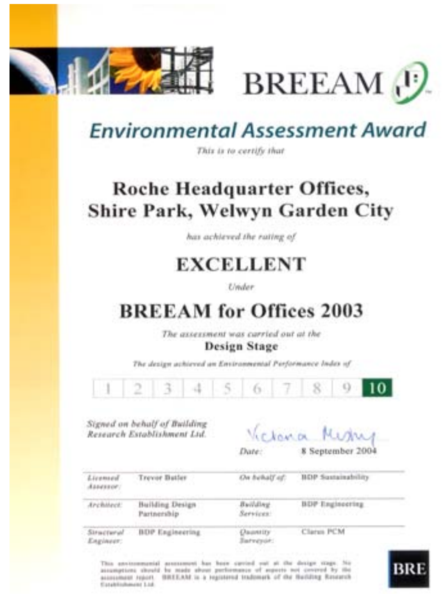
Construction

- Implications for energy and water targets due to brief changes need to be made clear to client.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the building.
- Ensure that client energy and water champion is informed of design changes.
- Ensure commissioning is carried out well in advance of practical completion, and energy saving systems such as lighting controls must be witnessed by the consulting engineer and demonstrated to the client.

Operation

- Ensure client is aware of maintenance issues.
- Ensure that client instigates post occupancy evaluation and seasonal commissioning throughout the first year of operation in accordance with CIBSE guidelines. A detailed report should be provided at the end of this period.
- Ensure that design teams are accountable to client for building's achievement of energy and water targets.
- Ensure that client adequately understands how systems can be run efficiently.
- Ensure that client has committed in writing to using the building as described in the brief and Building User Guide.





Regulations and Legislation

It is now clear that legislation and building regulations are steering the world of development towards more sustainable practices.

In practical terms this means that consideration must now be given to the 'triple bottom line' which incorporates social and environmental issues in parallel with economic factors.

Addressing energy and water usage assists the institution in addressing these three aspects of sustainability.

Kyoto Protocol:

This is an international agreement in which the UK Government has committed to a reducing greenhouse gas (GHG) emissions by 12.5% by 2012 (based on 1990 levels as a base year). This is the primary driver for all the other legislation listed below.

The Kyoto Protocol is by no means a full solution to global warming but it is a good initial start. It is likely that a second round of Kyoto targets will eventually be announced that are more stringent than the current targets. The UK are committed to improving on Kyoto targets.

EU Energy Performance of Buildings Directive:

This legislation is responsible for the European Energy Rating Scheme that requires buildings to have an energy rating certificate. Asset rating and Part L 2006 of the Building Regulations are the direct results of this.

Government CHP Strategy

This sets out a drive towards the use of Combined Heat and Power (CHP). This is a system that produces both electricity and heat and reduces losses by 10-15% compared to traditional heating and power supply systems.

Our Energy Future: Creating a Low Carbon Economy (Energy White Paper):

This sets out a target of providing 10% of UK energy by renewable technologies by 2010 and 15% by 2020. It also sets out an aspiration for CO_2 emissions to be reduced to 60% by 2050.

Local Planning Policy 22 (10% renewables)

Many local planning authorities are incorporating the themes of the Government's Planning Policy 22 into their policies.

This policy stipulates that 10% of a development's energy should be provided via renewable energy. The application of this policy to a particular building is dependent on its location.

Regulations and Legislation

Part L 2006 of the Building Regulations:

The recently revised regulations focus on carbon emissions and the conservation of fuel and power.

They are a tough set of targets that require a building's design to be 24-28% better than 2002 standards. It is also likely that these will increase by a further 15-20% in 2010.

The standards are tough and will only be achieved by using a mixture of passive design, good thermal properties and efficient equipment. Renewable energy can also be used if traditional measures do not achieve the target.

The compliance tool iSBEM can calculate carbon dioxide emission and forms the main element of the new regulations.

Its principles are excellent but there are some limitations with the tool. This means that it should be treated as a compliance tool rather than an energy prediction tool.

The approach to the regulations is complicated by the fact that architects and engineers need to work in an integrated fashion. In theory this happens on all projects, but in reality this is difficult to achieve.

See the flow diagram on page 2.7 for further details on how to achieve compliance using iSBEM.

The regulations also require on site testing. Air pressure, leakage testing and commissioning are required. A metering strategy and a building log book are also required.

Water Act 2003

This does not set out specific water consumption targets. However it does set a duty to encourage water conservation. It encourages water use to be considered and minimised where reasonable.

EU Emissions Trading Scheme

All large energy users such as universities are subject to carbon dioxide emissions limits. It is based on your installed heating capacity. The threshold is 20MW. Institutions involved have targets that it must not exceed. All institutions face financial penalties if these are not met.

Asset Rating (Energy Labelling):

This will require a building's energy performance to be assessed and compared to national benchmarks. The performance will then need to be displayed in a prominent position such as the main lobby.

When it does come into practice it is likely to have the same effect as labelling on fridges. Clients will want to know why their new facilities are achieving an E of F rating rather than an A or B. It will soon affect the prestige of a building.

Don't wait for the legislation to be brought out. Completed buildings will also have to display energy labels and now is the time to take a look at all building stock and start taking measures to improve energy efficiency.

Water Act 2003

This does not set out specific water consumption targets. However it does set a duty to encourage water conservation. It encourages water use to be considered and minimised where reasonable.

BREEAM

In line with the Government's own policy on BREEAM (Office of Government Commerce Regulations) universities are adopting this tool.

This is an assessment that determines the environmental impact of a building. It incorporates a range of different topics, with energy and water being important aspects. Other topics such as health and well being or pollution are also affected by the energy and water design.

The targets that are set are dependent on issues that may be out of the control of the design team. It is important to remember that BREEAM assessments are not just concerned with energy and water. It is also important to understand how an "Excellent" or "Very Good" rating will actually affect a project.

Freedom of Information Act

There is an increasing pressure on universities to be transparent with their information. This includes energy and water use.

Universities will have to be able to provide information on request. Ideally this data should not be detrimental to the university's profile.

Feasibility Early Design

- Confirm specific planning and building control requirements.
- Undertake initial Part L review of design.
- Undertake initial renewable energy study and confirm extent of renewable energy required by local authority.

Design Development

- Undertake detailed Part L 2006 calculations by stage D.
- Undertake detailed renewable energy study.
- Consider design in relation to the EU Emissions Trading Scheme.
- Ensure that all required regulations and legislation are complied with.

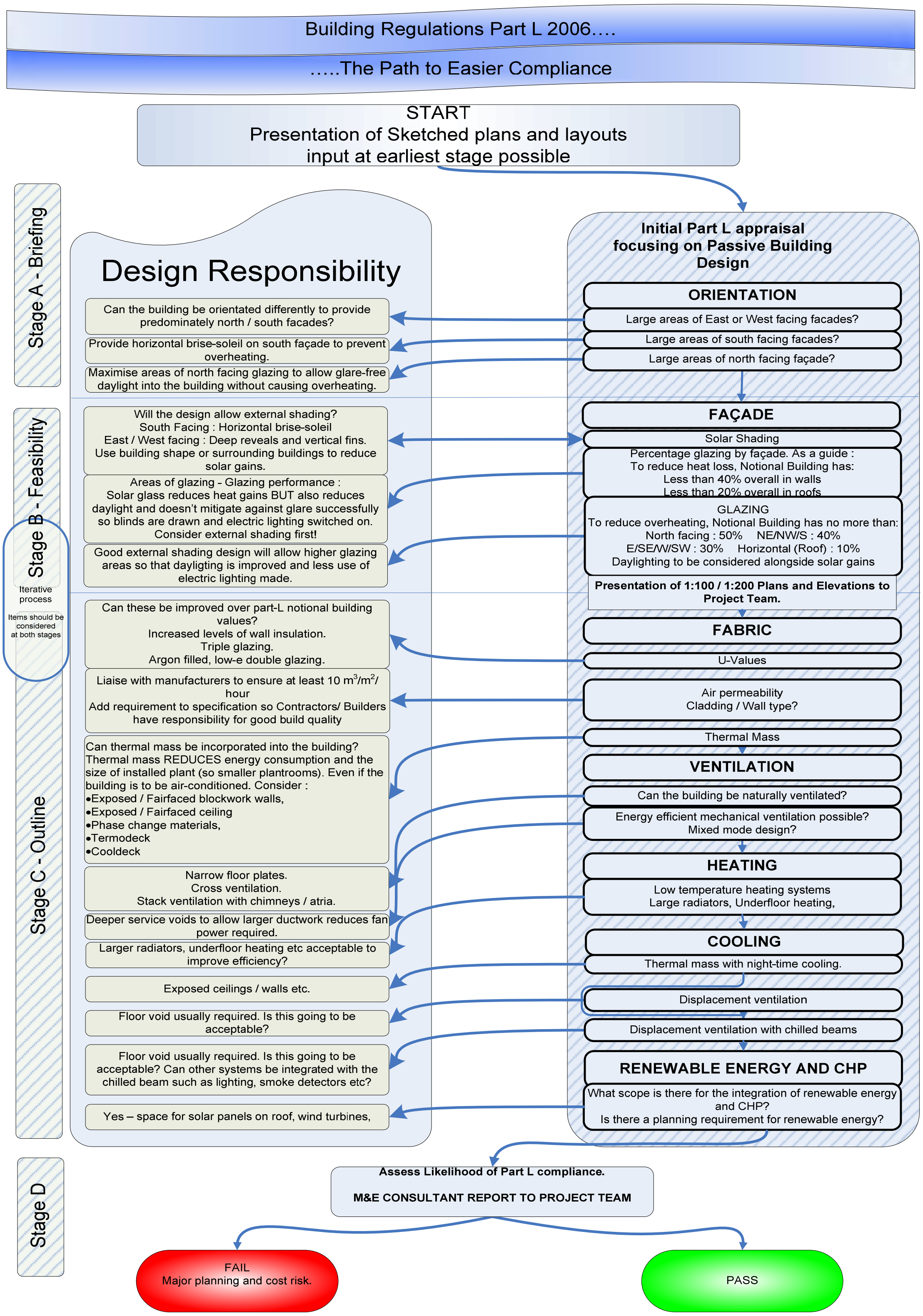
Construction

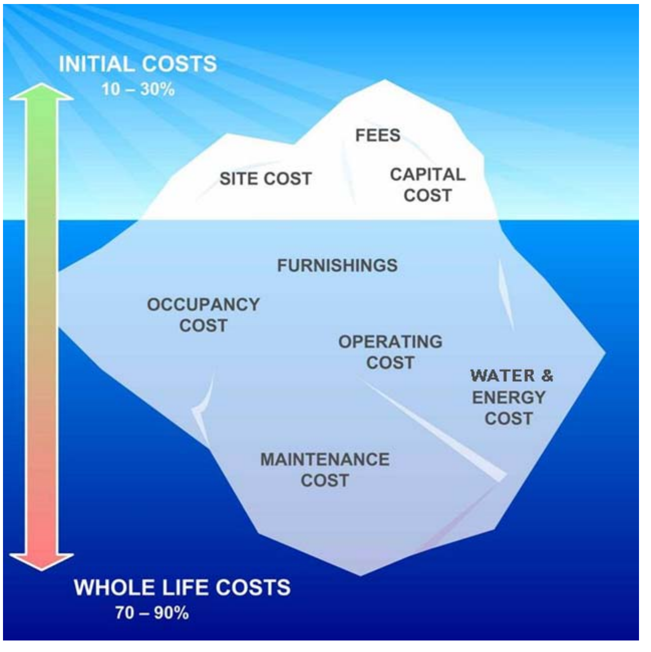
- Involve clerk of works or similar to ensure building built as designed to ensure Part L 2006 compliance.
- Ensure that all required regulations and legislation are complied with.

Operation

- Ensure that client displays Energy Certificate.

Regulations and Legislation (cont).





Costs and Programme

As soon as a client determines the need to initiate some form of construction, the risk process begins. Energy, and to a lesser extent water efficiency, are becoming a greater risk to the client.

The risks relate to programme, cost and money. Achieving an energy efficient design is even more important in terms of compliance with Building Regulations.

Many quantity surveyors as well as clients are not aware of the impact that recent changes in legislation have had. The design team needs to assist the education process at the start of the project.

The client needs to be made aware of the importance of energy and water efficiency. To ensure that a building is efficient, the client needs to understand the decisions that have an impact on energy and water usage.

There is a commonly held view that many professors using the buildings are not interested in the amount of energy or water that their building uses. Their budgets are not linked to utility costs and therefore there is a lack of understanding. These primarily need to focus on the balance between cost, programme and efficiency.

From a designer viewpoint, nothing can be done regarding the cost of energy. Therefore the focus has to be on kWh of energy actually used by the building.

CO_2 emissions are important, but they are ultimately the result of energy use. Therefore the team should be made to focus on this to provide a building that is cheaper to run.

Heat pumps are an exception. They have good power efficiencies but relatively poor CO_2 performance as they use electricity. Therefore they are cheap to run but have a poor emissions performance because they use electricity as their input and electricity has a large CO_2 content. Particular attention to CO_2 generation must therefore be taken into account alongside kWh figures when examining heat pump systems.

The CO_2 must be taken into account when looking at kWh figures.

Efficiency measures have to be to be viewed against long-term benefits. Their provision also has to be considered in relation to a project's programme.

Despite institutions having long-term commitments, funding is often driven by short-term goals. It can be difficult to secure additional funding for projects if the design is not agreed at a very early stage.

Advice from the design team is vital at the very earliest decisions.

Demonstrating the benefits of efficient systems through measures such as Whole Life Costing (WLC) is often the key to achieving additional funding.

Over the life time of a building it is reasonable to assume that fuel prices will increase at a larger rate than inflation. It is believed that remaining fuel reserves, or at least increased fuel demands associated with population growth, will result in increased fuel costs in the near future.

To see the true benefit of whole life costing, reasonable lengths of time need to be considered. Fifteen years for traditional systems and 20 years for renewables are reasonable. True WLC would consider in the order of 60 years.

These timescales need to be agreed with the client at the start of a project. Agreement is also required on who is to provide this information.

Costs and Programme (cont).

Higher Education Funding Council for England (HEFCE)
Along with private funding, this is a major source of funding. HEFCE has a commitment to providing funding which is currently focusing on refurbishment projects. Demonstrating the potential for improving the efficiency of existing stock will assist in securing greater levels of funding.

Regional Development Agencies
These agencies are committed to investing in sustainable solutions. Individual agencies have their own policies but in general renewable energy and water efficiency measures can assist in securing funding.

Low Carbon Buildings Programme (LCBP)
This is a central government initiative managed by the Energy Savings Trust. It makes grants available for installing micro generation technologies. It provides funding of up to 50% for renewable energy technologies. It is applicable to England and Wales.

Carbon Trust
The Carbon Trust is a possible source of grant if true carbon dioxide savings can be justified.

Renewable Obligations Certificates (ROCs)
Under the Obligation all licensed suppliers are obliged to supply a specified percentage of renewables, or at least hold ROCs equal to that percentage. ROCs can be traded independently of the electricity to which they relate. In simplistic terms, money can be claimed back by people supplying renewable energy back into the grid.

Scottish Community and Household Renewables Initiative
Similar in principle to the LCBP, it applies only to Scotland.

Northern Ireland
The scheme that covers Northern Ireland is currently being updated. On the date of this report's publication, details were not available.

RIBA Stages
A – Inception
B – Feasibility
C – Outline Proposals
D – Scheme Design
E – Detailed Design
F – Production Information
G – Bill of Quantities
H – Tender Action
J – Project Planning
K – Operations on Site
L – Completion

Feasibility / Early Design
- Ensure client is aware of risk associated with ignoring energy and water issues.
- Ensure client is aware of percentage impact of efficiency measures on programme and cost.
- Ensure client is aware of all funding opportunities
- Ensure client is committed to WLC.
- Confirm WLC period with client and funding bodies (recommended period 30 years)
- Select quantity surveyor capable of WLC

Design Development
- Ensure all relevant funding opportunities are optimised.
- Ensure efficiency measures are not lost due to value engineering.
- Ensure the client has the opportunity to decide whether to retain efficiency measures if building is over budget and ensure client has sufficient information to make an informed decision.
- Ensure WLC is updated at each design stage.
- Ensure design team provide information in adequate time to allow WLC.
- Ensure client is made aware of impact of strategic decisions on WLC.

Construction
- Ensure contractor has been made aware of efficiency measures.
- Ensure contractor's contract ties contractor into ensuring efficiency measures are provided.

Operation
- Ensure that there is a strategic plan for the long-term maintenance works in relation to efficiency and monitoring.

Accommodation

Typically residential accommodation in universities accounts for 25% of overall campus energy use. Domestic water use in university accommodation buildings can also account for a very significant proportion of the total campus water use.

Residential accommodation at universities has a relatively low density for sustained periods of the day compared to other space types on the campus. This means that there is a reasonably good potential for energy-efficient design through passive measures that may easily be controlled by the building occupants.

An automated heating control system is often used to optimise performance and efficiency, but with a manual override for individual residents.

Key issues:

1. Space heating and hot water energy loads tend to be significant in university accommodation buildings although, with good specification of thermal fabric and low air leakage standards, this should be minimised. Space heating energy loads can vary greatly according to how the buildings are used and particularly whether natural ventilation is 'mismanaged' by occupants causing excessive heat losses.
2. Electricity use mainly relates to lighting energy use and small power. Low energy task lighting should be provided for study areas.
3. Domestic water use is predominantly due to showers and baths with some use for drinking and catering in kitchen areas.

Key Design Solutions

1. The form, fabric and orientation of the building are critical to low energy consumption. Specification of high thermal performance fabric for good insulation and low air leakage is important.
2. The use of heavyweight thermal mass construction will be generally good for robustness and acoustic separation but will also help to moderate internal temperature swings, thus reducing energy use. Buildings should be designed with passive solar orientation to utilise winter solar gains and minimise summertime overheating.
3. 'Controlled' natural ventilation solution.
4. Automatic switching off of communal areas and equipment.
5. Good daylighting to study areas.
6. Low water use appliances.
7. Rainwater and grey water recycling should be considered to minimise water consumption. Recycled water should be used as WC flush supply.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)			
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

8. Hot water generation should be through direct gas fired condensing water heaters where gas is available rather than heating water from the boiler system.
9. Serious consideration should be given to the use of solar thermal water heating, particularly on larger accommodation blocks, but supplemental heat must be provided from an efficient source. (Never use electric water heating except for a single point that is far from a plant room)

Archive Facilities

Archive facilities are primarily concerned with providing the appropriate environment for the storage of documents and objects. People and occupancy patterns have less significance.

Since the conditions are required to be stable all year round, there is very good potential for minimising the demand passively through the use of thermal mass. If possible the design should be isolated from the external environment.

Key issues:

1. Space conditioning, i.e. heating and cooling to maintain steady storage conditions throughout the year.
2. Humidity control.

Key Design Solutions:

1. Establishing the design parameters for archive facilities during the project briefing stage can make a significant difference in terms of annual energy use. If the environmental control bands for archive areas are allowed to fluctuate seasonally, significant reductions can be made.
2. The most passive method for creating a low energy demand for storage and archive facilities would be to use heavyweight thermal mass construction and preferably locate the facilities in a basement or ground floor location away from external facades. This will maximise contact with the stable thermal mass of the earth and reduce heat gains or losses from the external conditions.
3. The use of ground source heat pumps that provide either heating or cooling by running pipework through the slab can provide an excellent solution.
4. For archives with year round dehumidification, desiccant systems should be considered. Waste heat sources can be utilised with this technology.
5. Heat recovery on air systems.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water			
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors			
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground	X	X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures			
Water Recycling			
Drainage Attenuation			
Other Water Issues			

Conference & Exhibition Spaces

Conference centres and exhibition centres tend to have a wide variety in density of occupation and patterns of usage. This means that these spaces require shorter and more frequent use of larger plant equipment and systems to provide environmental comfort. These spaces tend to be relatively high energy use spaces for their floor area.

There are fewer opportunities for saving energy through passive design measures, and ways of reducing the active plant load should be considered.

Key issues:

1. These spaces tend to be large volume spaces, often with a relatively high percentage of external façade and roof area. Therefore the heat gains and losses from the exterior may be significant. The ventilation loads during full occupancy conditions are also high. This also adds to the peak heating or cooling demand.
2. The electrical energy required for ventilation can be relatively high for this space type and care should be made to reduce duct lengths and air supply velocities where possible.
3. During peak summer conditions the cooling load can be high, particularly during periods of dense occupation during conferences or exhibition openings. The high ventilation requirement during peak occupancy conditions greatly adds to this energy load.
4. Conversely the heating load can be high during peak winter conditions particularly if the space has a high percentage of glazing.
5. The lighting load may also constitute a large percentage of the overall energy load for this particular type of space, particularly if specialist display or stage lighting are regularly used.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts		X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Key Design Solutions:

1. In large hall spaces the most efficient means of providing the required fresh air load is natural ventilation. Where this is not possible, a low-velocity displacement ventilation supply should be considered where air is supplied at low-level. This system requires less fan energy to operate and supply temperatures 2-3^{o}C below comfort conditions. This means that the heating and cooling loads are reduced.
2. Heat recovery should be considered for ventilation systems with a recirculation damper for fresh air supply control. This will reduce the fresh air heating load.
3. Underfloor heating is also an efficient way of heating large spaces providing a radiant heating surface located at low level, close to where occupants are situated in the space. It uses lower supply temperatures to operate making it very compatible with energy efficient condensing boilers and ground source heat pumps.
4. Low energy cooling techniques such as the use of adiabatic cooling air handling units or ground source cooling techniques should be considered.
5. Daylight linked and occupancy control solutions should be provided to limit artificial lighting. Automatic control should also be used to set-back mechanical ventilation or space conditioning solutions during low occupancy.
6. These spaces tend to be used infrequently and it is vital that the controls system is carefully designed to automatically shut down the system when not in use through the use of carbon dioxide sensors that control variable speed fans.

Catering Facilities

The energy and water demands of catering facilities are process focused rather than building environment focused.

Kitchens have large electrical and gas loads for cooking and hot water heating as well as ancillary electrical equipment such as dishwashers and extract fans. In heavily used kitchens significant energy savings can be made through the specification of energy and water efficient equipment.

Since the design of these elements tends to fall outside of the brief for the engineering consultant's brief, the requirement for energy and water use should be clearly communicated to the specialist catering consultant at an early stage for optimum outcome.

If considering conventional power sources, using gas as a cooking fuel is likely to result in lower CO_2 emissions and running costs. However, gas provision is not always possible. When electrical cooking methods are used, they must be the most efficient available in terms of cooking heat transfer.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels	X	X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Key issues:

1. Cooking on hobs is quite a wasteful process as much of the heat dissipates either side of the pot, or radiates from the pot, or unnecessarily boils the product when overheating it, or heats the room long after the cook is finished.
2. Heat can be lost from appliances such as ovens or dishwashers if they are poorly insulated.
3. Cooking processes and dishwashers can use excessive quantities of water
4. Ventilation systems can require significant energy use particularly if duct lengths to discharge points are long and high resistance filters are used.

Key Design Solutions:

1. Appliances should be specified for the highest energy efficiency rating. Appliances such as cookers and dishwashers should be well insulated.
2. The use of induction hobs should be considered for the most efficient hob cooking process. They use an electromagnetic field to heat up the metal pan directly, producing very little waste heat. They are about 80% efficient compared to conventional hobs that are about 40% efficient.
3. Consideration of kitchen layout in order to maximise energy efficiency, particularly with regard to duct lengths.
4. Provision of equipment to an area is often in excess of the needs of the space. The brief should be queried if it is likely to cause the over-provision of energy intensive equipment (e.g. sandwich counters).
5. Avoid heating air being supplied to a space if cooling is also provided to the space.
6. Heat recovery from waste air (may not be appropriate due to grease and fat contained in air) or water should be considered. Fully circulating hoods effectively provide a local heat recovery in fully electric kitchens.
7. Simple controls should be provided for good housekeeping (i.e. ability to turn fans off when not required).

External Lighting

On large campus sites, external lighting represents a significant energy load, particularly the use of floodlighting for sports facilities. External lighting needs to be efficient, but it must not compromise safety.

Key issues:

1. Night time light pollution causes light to be sent into the sky that is not landing on the ground and is therefore wasteful.
2. Energy efficiency can compromise the visual interest of an external area.
3. The selection of the lamp and fitting can severely affect the efficiency of equipment.
4. A design is often considered in isolation and the benefit of surrounding lighting is not considered.
5. The control of the lighting.

Key Design Solutions:

1. Lighting master-planning should be used to ensure that individual buildings are designed to consider the beneficial surrounding light.
2. The layout can be used to optimise the distribution of light. For instance staggering street luminaries on alternate sides of the road can reduce the number of lamps needed and therefore the energy used to light the space.
3. Design the lighting to illuminate only specific areas. Good design should ensure that the appropriate lighting strategy is used and light is focused only on where it is required.
4. The use of lamps that ensure a long lifetime and high light output such as discharge lamps should be used.
5. Lighting should be controlled to ensure that it is used only when required. Photocells and time clocks should be used to minimise use.
6. Where lighting is remote from a major electrical supply, stand alone lampposts with an integral photovoltaic panel can be used.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			
Façade Treatment & Daylight			
Natural Ventilation & Thermal Mass			
Active Energy Measures			
Heating			
Centralisation vs. Decentralisation			
Hot Water			
Ventilation			
Cooling (non-ventilation systems)			
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors			
Wind Turbines			
Hydro Electric			
Energy from Ground			
Bio-fuels			
Water Measures			
Water Saving Measures			
Water Recycling			
Drainage Attenuation			
Other Water Issues			

Greenhouses & External Landscape

Greenhouses and external landscaping maintenance can consume a considerable amount of water. In addition there is energy use in the form of greenhouse heating where applicable.

Key issues:

1. Irrigation requirement for planting
2. Water evaporation
3. Capture and re-use of rainwater run-off
4. Heating to spaces in winter

Key Design Solutions:

1. Trees, shrubs and plants should be selected for low maintenance and irrigation requirement. Drought resistant indigenous species should be selected where possible.
2. Rainwater collection from greenhouse or adjacent building roofs should be considered for irrigation supply.
3. Surface water run-off should be collected via sustainable urban drainage systems, collected in settlement ponds or collection tanks and re-used for irrigation water supply
4. Greenhouses or plant nurseries should consider low-energy heating systems such as condensing boilers or ground source heat applications. Waste heat from other processes might also be considered.
5. Greenhouses tend to have a low energy use. Stand alone renewable energy with battery storage should be considered where the building is remote from major energy supplies such as gas and electricity.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water			
Ventilation			
Cooling (non-ventilation systems)			
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors			
Solar Thermal Collectors			
Wind Turbines		X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling	X	X	X
Drainage Attenuation	X	X	X
Other Water Issues	X	X	X

IT Suites

IT is becoming increasingly widespread across university buildings and less confined to specialist IT suites. Electrical power usage from computer terminals, server units and associated equipment not only consumes electrical power but also emits waste heat into the occupied zone.

This in turn creates an increased cooling requirement which may add further to the electrical load if a cooling system is employed. Passive design principles should be employed where possible to minimise solar gains and reduce overheating.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)			
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures			
Water Recycling			
Drainage Attenuation			
Other Water Issues			

Key issues:

1. IT equipment consumes a considerable proportion of the energy use in modern buildings. The heat gains that are associated with IT equipment also contribute to the mechanical ventilation or cooling load in the building.
2. The efficiency and effectiveness of an IT suite ventilation or conditioning system is heavily influenced by the path, temperature and quantity of cooling air delivered to the IT equipment and waste hot air removed from the equipment.

Key Design Solutions:

1. Server equipment should be specified for low power consumption with high efficiency power supply. Direct cooled equipment racks can be considered for improved efficiency.
2. Low-energy use equipment should be specified for user machines e.g. ‘thin-client’ solutions where an optimised hardware specification is provided.
3. Efficiency of cooling solutions can be improved by supplying cooled air directly to the loads, thus maximising the return air temperature and removal of waste heat.
4. Since IT loads are constant throughout the year, there is an opportunity for free cooling utilising the ambient air temperature for extended periods of the year.
5. Fan power requirements should be minimised through design of low pressure drop supply and extract system.
6. Good ‘glare-free’ lighting is essential. Natural daylighting solutions should be employed wherever possible to minimise lighting energy consumption. Artificial lighting should be provided at a background level and controlled to respond to daylight availability. Low energy task lights allow lighting levels to be increased locally.
7. Time clock or occupancy sensing control should be provided for control of lighting and mechanical systems to minimise unnecessary operation.
8. Use of energy saving computers.
9. Where there are high heat loads, instead of exhausting waste heat, the warm air could be supplied to other areas to reduce heating in winter.
10. Consideration should be given to the recovery of heat for use in other areas of the building.
11. Where air conditioning systems are fitted, they are often set to a far lower temperature than actually required and this can be very wasteful. Controls that block users from setting temperature set points below 22°C should be considered.

Laboratories

Energy consumption in research facilities is process related, but additional demands may arise from processes and requirements for maintaining special conditions in laboratories. Specific process energy and water loads may add considerably to the overall load. The use of laboratories tends to be for sustained periods of low-density occupation.

Key issues:

1. Process ventilation can contribute a considerable load if there is a high requirement for fume cupboards in laboratories.
2. High levels of thermal control and associated cooling.
3. Wasted water through inefficient processes.

Key Design Solutions

1. Low-energy fume cupboard solutions incorporating sensible control strategies. These include minimising the amount of supply air tempered and delivered, incorporating sensor controls and recovering heat where practical.
2. Making the best use of daylight and beneficial solar gains can help to minimise energy demand, while efficient lighting and heating will reduce fuel consumption.
3. Much of today's research involves personal computers, and good 'glare-free' lighting is essential. Natural daylighting solutions should be employed wherever possible to minimise lighting energy consumption. Artificial lighting should be provided at a background level and controlled to respond to daylight availability. Low energy task lights allow lighting levels to be increased locally.
4. Discuss the processes with the client at all stages to identify where equipment can be used to minimise water use.
5. Ensure location of heat emitting equipment such as freezers and fridges are considered. The equipment can be located in a single location where cooling can be provided. Alternatively, instead of the warm air being exhausted outside, this warm air could be supplied into other spaces to reduce heating loads in winter.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Lecture Theatres

Occupancy patterns can be dense but intermittent, or extended but sparse. Environmental control tends to be remote from the individual occupants.

Spaces require shorter and more frequent use of larger plant equipment and systems to provide environmental comfort. Thus these areas tend to be relatively high energy use spaces per floor area.

There are fewer opportunities for saving energy through passive design measures, and ways of reducing the active plant load should be considered. Providing robust low energy designs with appropriate control strategies can significantly reduce running costs.

Key issues:

1. These spaces usually require some form of mechanical ventilation. The electrical energy required for ventilation can be relatively high for this space type and care should be made to reduce duct lengths and air supply velocities where possible.
2. During peak summer conditions the cooling load can be high, particularly during periods of dense occupation during conferences or exhibition openings. The high ventilation requirement during peak occupancy conditions greatly adds to this energy load.
3. Conversely the heating load can be high during peak winter conditions particularly if the space has a high percentage of glazing.
4. The lighting load may also constitute a large percentage of the overall energy load for this particular type of space, particularly if specialist display or stage lighting are regularly used.

Key Design Solutions

1. A low-velocity displacement ventilation system may be considered where air is supplied at low-level beneath the seating. This system requires less fan energy to operate and supply temperatures that are 2-3ºC below comfort conditions. This means that the heating and cooling loads are reduced.
2. Night cooling of lecture theatres can provide considerable passive pre-cooling of the building structure prior to occupation the following day.
3. Heat recovery should be considered for ventilation systems with a recirculation damper for fresh air supply control. This will reduce the fresh air heating load.
4. Low energy cooling techniques such as the use of adiabatic cooling air handling units or ground source heating or cooling techniques should be considered.
5. Daylight linked and occupancy control solutions should be provided to limit artificial lighting. Automatic control should also be used to set back mechanical ventilation or space conditioning solutions during low occupancy. Such as CO_2 sensing.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

6. Thermal access should be considered to dampen thermal swings and assist natural ventilation.
7. Where low levels of light are needed during lectures the use of L.E.Ds should be considered on desks.
8. The careful design of automatic controls is vital for lecture theatres. Control systems must monitor room CO_2 levels and temperatures and automatically control variable speed fans to match flow rates to occupancy.

Libraries

Traditional library spaces tend to have a relatively constant, low density occupation and therefore are not intensive energy consuming spaces. Specialist IT sections of libraries have different requirements and the section on IT suites should be referred to.

Key issues:

1. The main energy uses in libraries are heating and lighting.
2. Deep plan library spaces will increase the energy use requirement for artificial lighting and ventilation

Key Design Solutions:

1. A natural daylighting solution should be provided where possible to minimise the amount of artificial light required. The design should incorporate measures to limit summer time solar gains and maximise winter passive solar gains where possible.
2. Artificial lighting should be provided at a background level and controlled to respond to daylight availability. Low energy task lights in study areas would allow lighting levels to be increased locally.
3. Proximity detection should be provided for artificial lighting in the library aisles.
4. High efficiency condensing boilers should be considered or heating should be linked with energy efficient or renewable energy fuelled centralised system.
5. Consider the thermal mass of the building structure and books in large libraries.
6. Use of CO_2 sensors to control ventilation in relation to occupancy.
7. Task lighting should be locally controlled, but where large areas will be unused, control should be provided to switching off large areas.
8. See 3.7 IT Suites for IT issues.
9. Consider task lights in study areas but these must be linked to automatic controls.
10. Use occupant detection techniques such as CO_2 sensors to control variable speed fans to adjust air flow rates to meet actual occupancy. This is vital as library occupancy varies considerably through the day.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Offices

Administrative offices tend to have a medium density, relatively steady occupation profile all year round. The layout of offices can have an impact upon the energy use; open plan offices tending to use more energy that cellular arrangements.

Whether or not the office is air-conditioned also greatly affects the amount of energy that is consumed. Offices can be passively designed for good natural ventilation and passive cooling if the external environment will allow (i.e. there are no sources of significant noise or pollution).

The high IT use in offices means that a well daylit, glare-free environment is important both for comfort and reduced lighting load.

Waste heat from increased usage of IT and electrical office equipment and the effects of climate change mean that although heating is still a significant energy load in offices it is likely that cooling could become the predominant energy consumer in offices in the coming decades. Therefore, passive and low-energy cooling solutions should be considered.

Key issues:

1. The internal gains tends to be one of the largest loads in offices, although this trend is changing.
2. There is a balance to be struck between reducing fabric losses and providing good levels of daylighting.
3. The ICT load can be very significant.
4. For deep plan offices (>15m) , ventilation, air-conditioning, and lighting energy use can be significant.
5. Water use is mainly for WC flush supply.

Key Design Solutions:

1. Good thermal fabric design with attention to limit the amount of glazed façade so fabric losses in winter are minimised. Careful consideration of glazing should also be given with regard to limiting solar gains in summer.
2. Use of thermal mass to moderate temperatures internally and reduce heating and/or cooling loads.
3. Some of the lowest energy buildings in the UK are university administration buildings using a mechanical ventilation solution utilising hollow-core concrete slabs to deliver the air supply to rooms. This thermal mass of the concrete soffit acts as a radiant heating and/or cooling surface.
4. Exposed concrete soffits allow for moderation of internal temperatures and therefore reduced plant loads.
5. Use passive ventilation and good natural daylighting where possible. As an approximate guide, this is best achieved by limiting work areas to within 6m of an external façade for single-sided and 12m for double-sided natural ventilation and daylighting. These proportions can vary depending on the floor to ceiling height of the space. The use of light shelves or refractive glazing can reflect light off the soffit deeper into the plan of a building for improved daylight distribution.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

6. Daylight linked and occupancy control solutions should be provided to limit artificial lighting. Automatic control should also be used to set back mechanical ventilation or space conditioning solutions during low occupancy.
7. Night purging of offices (especially if an exposed soffit is present) can provide considerable passive pre-cooling of the building structure prior to occupation the following day.
8. Low energy cooling techniques such as the use of adiabatic cooling air handling units or ground source cooling techniques should be considered.
9. Rainwater collection can be considered for WC flush supply.

Retail and Social Facilities

Retail and social areas can have a very wide range of occupancy profiles and uses. For the most part, university shops or student support areas will not be intensively occupied. High occupancy will be limited to short periods of unusual activity, such as at the beginning of term during registration.

In this context retail is considered to be 'light retail' e.g. student stationery without a strong commercial requirement for goods display.

Where facilities for private commercial retail are being provided, this is often carried out to shell and core stage with the retail organisation responsible for the fit-out which includes the energy and water systems.

Student social or common areas may have regular gatherings for meetings or party/club events and therefore require mechanical ventilation and specialist lighting use.

Key issues:

1. Non university commercial retail organisations generally tend to prefer climate-controlled, artificially lit spaces which can be relatively high energy consumers, particularly if there is a high use of specialist display lighting.
2. Student social spaces should, where possible, be designed adopting passive environmental control principles. Where high density use occurs, a mechanical ventilation solution may be required to ensure that requirement for fresh air is met.
3. Specialist lighting energy use for parties or events may be significant.

Key Design Solutions:

1. University shops and student support areas can generally be considered as spaces where a passive design solution should be considered for providing optimum natural daylight and ventilation. Exposed thermal mass should be provided for moderation of the swings in internal environmental conditions.
2. Where shell and core retail facilities are provided, a requirement to provide low-energy and water use installations should be written into the contract with the commercial retailer.
3. In large hall spaces the most efficient means of providing the required fresh air load can be through a low-velocity displacement ventilation system. This supplies air to the occupants at low level. This system requires less fan energy to operate and supply temperatures that are 2^{o}C below comfort conditions. This means that the heating and cooling loads are reduced.
4. Heat recovery should be considered for ventilation systems with a re-circulation damper for fresh air supply control. This will reduce the fresh air heating load.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			X
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

5. Underfloor heating is also an efficient way of heating large spaces providing a radiant heating surface located close to where occupants are situated in the space. It uses lower supply temperatures to operate making it very compatible with energy efficient condensing boilers.
6. Daylight linked and occupancy control solutions should be provided to limit lighting energy use. Automatic control should also be used to set-back mechanical ventilation or space conditioning solutions during low occupancy.

Sport & Swimming Facilities

Sports facilities tend to have variable occupation patterns and while most areas are fairly low energy use, there are some areas of relatively high energy intensity demand. Areas of high energy use include swimming pools and gyms.

Water use in changing areas with associated domestic hot water heating load, may also be considerable.

Key issues:

1. Space heating tends to be the predominant energy demand in sports centres and is typically around 50% of overall energy use.
2. In sports facilities with swimming pools, the energy required to heat the pool also accounts for a significant proportion of overall energy use, this can be up to 25% of the total demand at the sports facility.
3. Gym areas can demand a high level of ventilation and cooling to maintain comfortable conditions.
4. Water use in sports centres can be particularly high. Simple control solutions such as timed push-button operation for showers should be installed.

Key Design Solutions:

1. The detailing of the building envelope for good thermal performance and low air leakage can have a significant impact in reducing the heating loads. This is particularly important for swimming pools to reduce the likelihood of condensation on large glazed areas or the associated dehumidification load.
2. High efficiency condensing boilers or a Combined Heat and Power unit (CHP) should be considered for the supply of heat and energy to sports facilities. If the facility has a swimming pool then CHP is likely to be a very favourable option, reducing running costs and CO_2 emissions. Renewable bio-fuel or ground source heat pumps could also be considered for these facilities.
3. Heat recovery should be considered for spaces requiring high levels of mechanical ventilation such as changing rooms or pool halls. This will reduce the heating energy load.
4. Efficiency in areas of intensive energy use, such as swimming pools, can be improved by utilising proven techniques such as pool covers.
5. Control systems should be designed to allow appropriate programmable flexibility for building operation comfort parameters and time settings.
6. Variable speed fans should be used to supply air at appropriate flow rates and time settings.
7. Desiccant de-humidification systems should be considered, particularly in combination with CHP where waste heat can be utilised.
8. Pool covers also reduce evaporation and reduce the need for ventilation due to humidity control.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			X
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

9. Rain water recycling should be used due to the high water demand.
10. Consider the use of direct gas fired radiant tube heaters for halls as this system is an ideal low energy, quick response heating system for intermittently occupied spaces.
11. Solar thermal water heating should be given particular consideration for heating pools.
12. High ceilings and air movement can improve comfort conditions in high heat gain areas such as gyms.

Teaching / Seminar Rooms

In these spaces there is a variable occupancy pattern; with medium- to long-term use patterns which can be dense but intermittent, or extended but sparse.

Environmental control tends to be remote from the individual occupants. Providing robust low energy designs with appropriate control strategies can significantly reduce running costs. Creating healthy, comfortable conditions for learning is crucial to the success of teaching spaces.

Key issues:

1. Ventilation is a key issue in teaching spaces so that the room does not have poor air quality that inhibits learning. Teaching spaces designed to accommodate more than 100 people usually require some form of mechanical ventilation. Natural ventilation is preferred but this may be difficult to achieve where noise disturbance may become an issue.
2. A good level of natural lighting is preferable for teaching spaces. Control of light levels for projector / electronic board display may be required.

Key Design Solutions

1. Passive ventilation and good natural daylighting where possible. As an approximate guide, this is best achieved by limiting work areas to within 6m of an external façade for single-sided and 12m for double-sided natural ventilation and daylighting. These proportions can vary depending on the floor to ceiling height of the space. The use of light shelves or refractive glazing can reflect light off the soffit deeper into the plan of a building for improved daylight distribution.
2. Night cooling of teaching spaces can provide considerable passive pre-cooling of the building structure prior to occupation the following day, if thermal mass is utilised.
3. Daylight linked and occupancy control solutions should be provided to limit artificial lighting. Automatic control should also be used to set back mechanical ventilation or space conditioning solutions during low occupancy, such as CO_2 controls.
4. Good thermal fabric design with attention to limit the amount of glazed façade so fabric losses in winter are minimised. Careful consideration of glazing should also be given with regard to limiting solar gains in summer.
5. Use of thermal mass to moderate temperatures internally and reduce heating and/or cooling loads.
6. Some of the lowest energy buildings in the UK are university administration buildings using a mechanical ventilation solution utilising hollow-core concrete slabs to deliver the air supply to rooms. This thermal mass of the concrete soffit acts as a radiant heating and/or cooling surface. This solution could be potentially applied to teaching or seminar spaces.
7. Exposed concrete soffits allow for moderation of internal temperatures and therefore reduced plant loads.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight	X	X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation		X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts	X	X	X
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors	X	X	X
Solar Thermal Collectors	X	X	X
Wind Turbines	X	X	X
Hydro Electric			X
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling		X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Toilets, Washrooms and Bathrooms

Toilets, washrooms (i.e. changing facilities) and bathrooms tend to have a variety of occupancy patterns throughout the day. Due to the requirement for privacy and extraction of waste air during and after occupancy, there is very little opportunity for energy savings from passive solar design principles.

Energy use is not high for toilets, but for washrooms and bathrooms the energy load can be high for hot water demand throughout the day. Water use in toilets can be high for flushing and for basins. In washrooms and bathrooms water use will be high for washing.

Key issues:

1. Space heating will tend to be the highest energy demand for toilets, with lighting a close second. Energy demand (electrical) will also result from mechanical ventilation, but can be reduced if natural ventilation is available.
2. Water use for toilet flushing and urinal rinsing is very high and can account for over 50% of water demand. Also, water use for basins can be high. Simple solutions include specifying low flush toilets, waterless urinals, low flow taps and push button operation.
3. Water heating demand will be high but space heating demand will also be higher for washrooms and bathrooms since their design temperature is 3^{o}C higher than for most other rooms.
4. Electrical energy demand will result from mechanical ventilation, but can be reduced if natural ventilation is available.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight		X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation	X	X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)			
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors		X	X
Solar Thermal Collectors	X	X	X
Wind Turbines		X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling	X	X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Key design solutions

1. The detailing of the building envelope for good thermal performance and low air leakage can have a significant impact in reducing the heating loads. Exposed thermal mass should be provided for moderation of the swings in internal environmental conditions.
2. Specifying a rainwater harvesting system for toilet flushing will significantly cut water usage for toilet flushing and urinal rinsing (if waterless urinals are not used). In addition, specifying a grey water recycling system for the showers and basins will cut water use for irrigation.
3. Heat recovery should be considered for toilets, washrooms and bathrooms, which will reduce the space heating energy load. Automatic control should also be used to set back mechanical ventilation or space conditioning solutions during low occupancy.
4. High efficiency condensing boilers, biomass heating and roof mounted evacuated solar tubes should be considered for the supply of heat energy to toilets, washrooms and bathrooms.
5. Underfloor heating is an efficient way of heating and provides a radiant heating surface located at low level, close to occupants. This works well with highly efficient condensing boilers or ground source heat pumps.
6. Daylight linked and presence control solutions should be provided to limit lighting energy use. Automatic control should also be used to set back mechanical ventilation or space conditioning solutions during low occupancy. Maximum lighting levels in toilet areas should be 100 lux, to reduce energy consumption.
7. Presence detectors should be used to control urinals.

Workshops

Workshops tend to be spaces of variable low density occupation. The energy demand due to environmental control therefore tends not to be such a significant issue.

Additionally workshop spaces are often designed to contain a high level of thermal mass for robustness. This tends to stabilise the internal conditions and helps prevent peaks of overheating or cold, thus reducing the load on heating and ventilation plant.

Key issues:

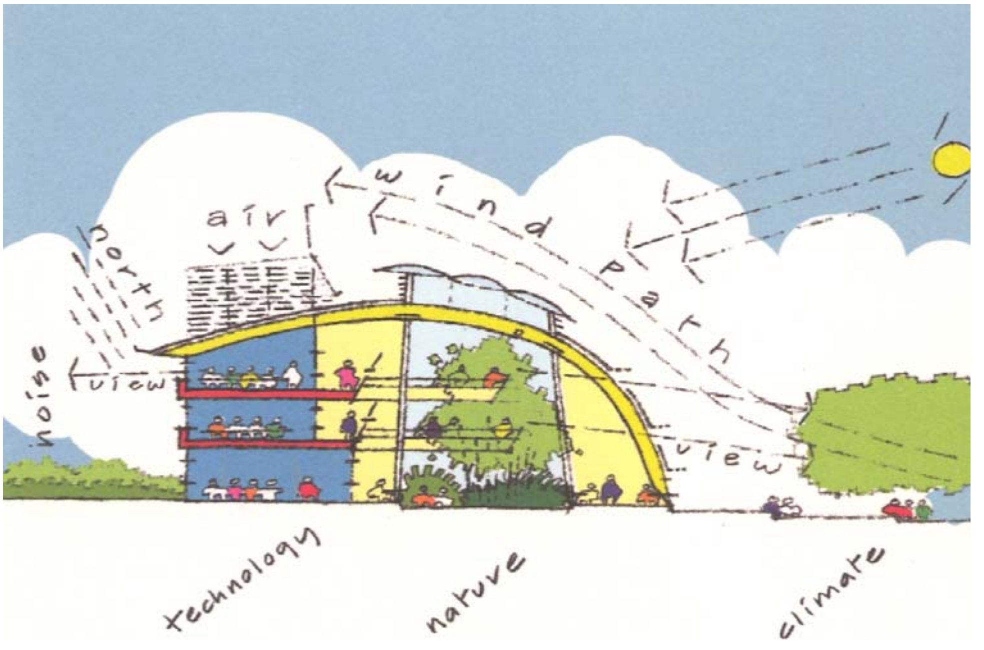
1. In workshops a significant proportion of the energy use arises from process equipment and small power usage.
2. Electrical lighting loads can be significant, particularly in deep plan, ground floor or lower ground floor spaces where workshops are often located for good delivery access.
3. Specialist ventilation equipment may also consume a considerable amount of energy.
4. Water usage may also be high in some workshop spaces e.g. art, textiles ceramics etc.

Key Design Solutions:

1. A natural daylighting solution incorporating north facing windows or roof lights should be considered to minimise the amount of artificial lighting. Direct sunlight should be avoided in workshop areas where glare may be a safety hazard.
2. Automatic daylight linked and occupancy control solutions should be provided to limit lighting energy use.
3. Where appropriate link use controls.
4. Radiant tube heating should be considered that can also be controlled to provide heat only where required.
5. Where large doors are provided, link heating controls to area to avoid "venting" heat to outside.
6. Use de-stratification fans or reduce the ceiling height to reduce heat stratification and the volume of air heated.
7. Consider the use of direct gas fired radiant tube heaters for large workshops as these systems provide efficient radiant heating, with a quick response time. Radiant heating reduces air temperatures and associated air heat losses.

	Small Scale Refurb.	Large Scale Refurb.	New Build
Passive Energy Measures			
Site Layout & Orientation			X
Façade Treatment & Daylight		X	X
Natural Ventilation & Thermal Mass	X	X	X
Active Energy Measures			
Heating	X	X	X
Centralisation vs. Decentralisation	X	X	X
Hot Water	X	X	X
Ventilation	X	X	X
Cooling (non-ventilation systems)	X	X	X
Electricity & Lighting	X	X	X
Lifts			
Commissioning	X	X	X
Metering	X	X	X
Building Log Books	X	X	X
Renewable Energy			
Photovoltaic Solar Collectors		X	X
Solar Thermal Collectors	X	X	X
Wind Turbines		X	X
Hydro Electric			
Energy from Ground		X	X
Bio-fuels		X	X
Water Measures			
Water Saving Measures	X	X	X
Water Recycling	X	X	X
Drainage Attenuation			X
Other Water Issues	X	X	X

Passive Energy Measures



Site Layout and Orientation

At the start of the first design meeting, the efficiency of a building and its systems can be compromised. If a design team does not take account of the effect of a building's surroundings on its energy usage, then potential energy savings of up to 25% may be missed.

The key issue to focus on is how the building relates to its environment. This has to be balanced against other issues such site boundaries and views, but it should be the driving force for the building's shape.

The landscape around the building needs to be considered. The use of natural features such as trees, slopes and open areas will affect the impact of the wind. Wind can be used positively to assist natural ventilation strategies. However if the site is too windy, the building may benefit from the use of a curved shape to avoid sharp edges that reduce air turbulence.

Main building entrances should face away from the prevailing wind direction or should be protected by planting or other wind breaks.

The orientation of the building should then be considered. It is better to have façades that face North and South rather than East and West. A northern façade works well for natural daylighting.

A southern façade can easily deal with a high sun in summer using external shading while allowing low winter sun to provide passive heating.

For buildings with high internal heat gains or for large double loaded buildings, N/S orientation is good but for smaller buildings that benefit from solar gain an east or south east main façade can be useful to maximise early morning solar gain that coincides with the heating period.

Windows facing towards the east and west are more difficult to deal with due to the low angle of the sun in summer combined with a high solar gain.

The use of passive solar gain can reduce heating requirements by up to 25% but creating a passive solar design becomes more difficult as a building's size increases. Steps can however still be taken by location of colder rooms (halls, plant, circulation) on the north and by increasing glazed areas (particularly feature glazing such as atria) on the south.

The layout is crucial to the ventilation and cooling strategy. The difficulty is finding the balance.

As insulation levels have improved, heat loss is becoming less of an issue. Therefore trying to minimise the external surface area to reduce energy loss is less effective that it used to be. More benefit can be had by increasing window areas to allow additional heating from solar gain.

The layout can restrict the form of ventilation strategy used. If the depth of a standard room is more than 2.5 times the floor to ceiling, it will not be possible to light the back of the room naturally or ventilate it from one side using a window. If the floor plate exceeds 15m (or ideally 12m) cross ventilation will not be possible.

The treatment of the external façade can have a major impact on the internal conditions. The building is integrated with the environment through consideration of its form and orientation.

The external environment has to be considered. Shading, window size, roof treatment, thermal performance and infiltration need to be considered.

External Envelope and Daylight

The treatment of the external façade can have a major impact on the internal conditions. The building is integrated with the environment through consideration of its form and orientation.

The external environment has to be considered. Shading, window size, roof treatment, thermal performance and infiltration need to be considered.

Shading

Shading is advisable if overheating due to solar gain or glare is an issue. Internal shades assist with glare. Venetian blinds are more effective than vertical blinds as they deflect more solar radiation.

Blinds are a significant help in reducing overheating. They reflect solar energy back out the window. This solar energy would otherwise hit the floor and radiate into the space. Their overall effect is approximate a 40% reduction in total solar transmittance. Solar film or fritting of windows can also provide levels of shading.

External shading assists both glare and overheating. Bries-soleil is typically used because it is relativity easy to install and price.

Main advantages of external shading are that it blocks solar gain before it reaches the window and is therefore more effective than an internal blind. It also lets in low angle sun in winter and keeps out high angle summer sun.

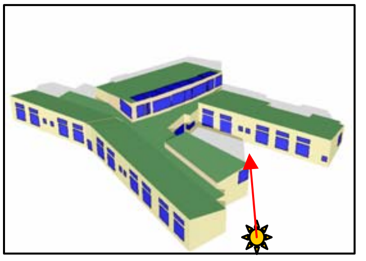
Balconies, deep window reveals and even plants can all be used to provide shading to a building.

These options are usually cheaper than high performance glazing. Glazing is often preferred by architects who favour “clean” façade lines.

Static or manually controlled devices should be selected in preference to mechanically operated devices. They will require maintenance, energy to drive the motors and eventually fail which will annoy the user sitting adjacent to the window.

An alternative is to use bio shading. This uses deciduous plants to grow over a façade to provide shading. In winter, the plant will die back to allow beneficial solar gain.

To assess the impact of shading hand calculations can be used to give a simple understanding of the likely performance of a building. A more detailed analysis that considers overheating can be undertaken using dynamic modelling package.



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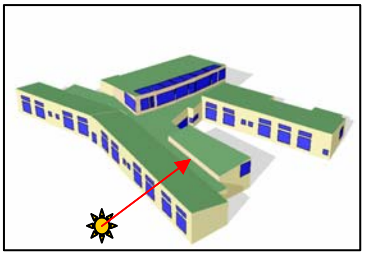

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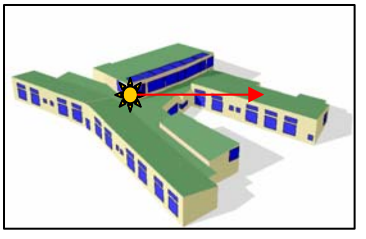

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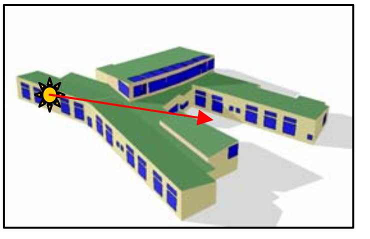

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External Envelope and Daylight

Window sizes

Windows work most effectively if they are optimised to balance letting light and solar gain in, but excluding overheating and large heat losses.

Windows sizes will be heavily influenced by the new Part L 2006 tool. To reduce heat loss, the Notional Building has:

- Less than 40% overall in walls
- Less than 20% overall in roofs

To reduce overheating, the Notional Building has no more than:

- North facing : 50%
- NE/NW/S : 40%
- E/SE/W/SW : 30%
- Horizontal (Roof) : 10%

The positive impact that glazing has is on the daylight in the space. Providing floor to ceiling glazing performs less favourably than 40% glazing that is located above the working plane.

The optimum design combines windows to provide views out, with high level windows to allow light to penetrate deep into the space. The optimum levels of daylight should be at least 4%.

Where soffits are exposed, they should always be painted white. This can improve the effectiveness of the natural daylighting by up to 25% as compared to exposed cast concrete.

Infiltration

As building insulation levels have been increased, the impact of energy loss due to unwanted air leakage increases. It can now form 15-50% of total thermal losses.

The current infiltration figure contained within the building regulations is set at a level of 10 $m^3/h/m^2$ at 50Pa. This is not particularly onerous.

Organisations such as supermarket chains have been stipulating a performance of 3 $m^3/h/m^2$ for many years. A figure of 5$m^3/h/m^2$ should be achieved on new builds. On refurbishments infiltration can be higher so a reduction of 50% should be achieved.

Good monitoring of on site processes and finishing is required. A site clerk of works is advisable. The programme should include time to allow pressure testing to occur and imperfections to be corrected.

On refurbishments, simple measures should be undertaken such as draught stripping old windows and sealing up holes around penetrations.

Particular consideration should be given to the specification of automatically opening sliding doors. These doors, particularly when unframed glass doors, can have a very large leakage level.

This is often not picked up in the air test as the main doorway is used to mount the test rig. In addition, internal lobby doors are often not draught sealed and care must be taken to specify quality seals on both inner and outer doors. (Unframed glass doors should be avoided).

External Envelope and Daylight

Thermal Fabric
The thermal fabric should meet current building regulations.

Increased levels of insulation are still advisable if heating is the priority. If cooling is the issue, a balance has to be struck between restricting the building's ability to lose heat and protecting it from external conditions.

The design needs to be considered carefully before the targets are set. Use of alternative insulation materials is recommended.

Insulation, especially blown insulation, can cause damage to the environment through pollution and greenhouse gases unless zero GWP blowing agents are used. The market for recycled insulation materials and natural alternatives is becoming more economic.

Roof treatment

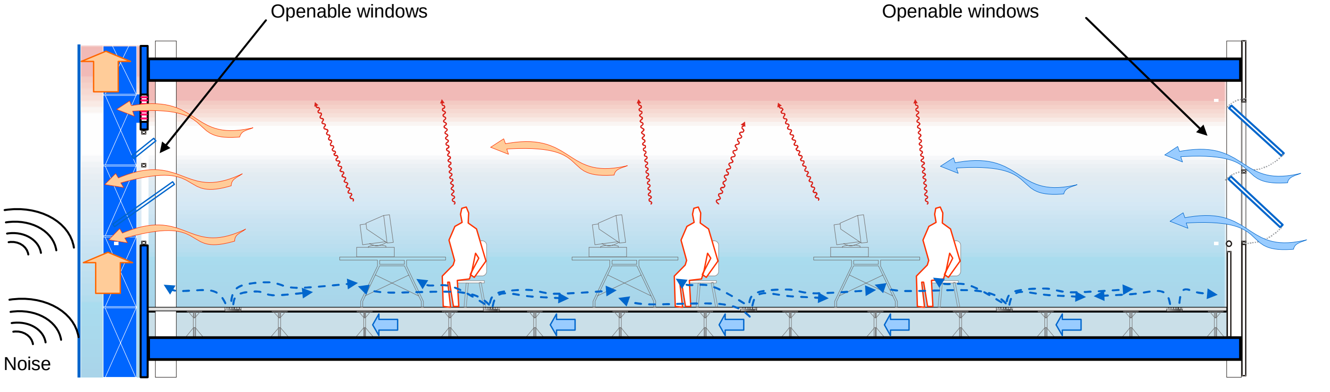
The roof's exposure to the sky means that it can absorb or emit a large amount of energy. This has a profound effect on the internal environment of the top floor of a building.

The use of a green roof can assist both heating and, to a lesser extent, cooling. It can act as an extra layer of insulation in winter and the natural evaporative effect of plant transpiration can reduce maximum internal temperatures.

Planted roofs come in a number of types. They vary between well managed intensively planted roofs through to sedum roofs which grow on matting or a wild flower roof which needs around 150mm of soil or gravel in which to grow.

In principle they can be very cheap and ideal for helping to prolong the lifespan of a roof. Existing flat roofs can be ideal. The expense comes when roofing manufacturers offer a green roof as a "bolt-on" to an existing range of roofing systems. This is why sedum roofs in particular are more expensive than a traditional roof.

An alternative cooling system is to use water on the roof. The natural evaporation will take heat away from the roof. However the health and safety risks associated with such a design need to be considered.



Natural Ventilation and Thermal Mass

Good natural ventilation is important in terms of sustainability as it reduces the need for buildings to be mechanically ventilated, thereby reducing energy use.

As with natural daylighting, natural ventilation generally requires a shallow floor plan. Deeper plan offices can also be suitable for natural ventilation if they have light wells or use the principles of stack effect to draw fresh air into a building.

Naturally ventilated spaces are more comfortable for the occupant. Naturally ventilated spaces usually have an element of user control. This assists comfort as the users have a feeling of control over their environment.

CIBSE defines comfort in a space as the temperature not exceeding 25^{o}C for more than 5% of the time and 28^{o}C for more than 1% of the time. These are much higher than the acceptable limits for mechanically ventilated spaces.

Natural ventilation should not be confused with having a leaky building. The ventilation needs to be controlled.

As previously stated a figure of 5m^3/hr/m^2 should be achieved on new builds. On refurbishments infiltration can be higher so a reduction of 50% should be achieved.

The limitation with natural ventilation is that the incoming air temperature will always be at the same temperature as outside. This means that mixing or tempering the air is important to provide comfortable conditions.

The most effective way to provide cooling is to absorb heat using thermal mass. Thermal mass can be provided by building a heavyweight structure. This is typically concrete, but could also be brick. The key is to expose the thermal mass.

The mass has to be visible as most transfer is radiant. The most effective solution is to absorb the heat during the day and then release the heat at night using passive ventilation. This is known as night time cooling. Not cooling the thermal mass at night means that the level of absorption the following day is reduced.

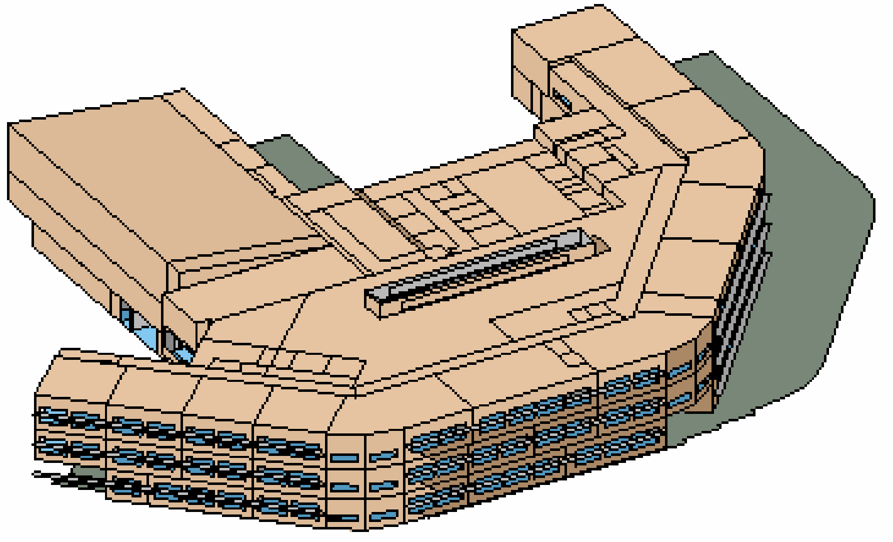
This principle allows internal temperatures to be reduced even when outside temperatures are high.

This can be particularly effective in lecture theatres where the heat from short periods of high occupancy can be absorbed by thermal mass. It also works well in high heat gain areas such as offices.

A thickness of 100mm is needed. After that, increased thickness does not affect the performance. The key to a successful system is how quickly heat can be transferred into the mass, not how much mass is there. This is why profiled slabs are so good, as transfer of heat is directly proportional to area.

Problems often occur in the detailing. Architects want finishes to be “clean”. Casting of concrete can be tricky to detail well. Use of pre-cast slabs can be beneficial on occasions. However hiding the thermal mass and ventilating the ceiling to absorb the heat should not be considered as it functions poorly.

Exposure of thermal mass also needs to take acoustics and reverberation into consideration. If soft furnishing are not provided, as much as 50% of the ceiling may need to be acoustically treated.



Thermal Modelling

Passive design measures do not need to be modelled using computer software. Passive building strategies have been created by some designers for years using an understanding of basic physics principles, best practice guidance and experience. Of all these, experience is the most important element.

However changes in legislation, fear of failure and greater certainty are leading the industry towards the use of building modelling software. Building modelling software incorporates the physics and applies best practice guidance. However these models are only as good as the information that is put into them. Skilled people are required to use them effectively.

If a passive solution is considered, it is advisable to engage a suitably qualified consultant in building modelling. Early involvement can help to avoid time being wasted on poor design solutions before the model is even started.

A simulation consultant should ideally be provided in-house by the M&E consultant engineer rather than as a separate service, as it is vital that the engineer carrying out the simulation fully understands the building being simulated.

Building analysis software provides the designer with both the opportunity and tools to perform detailed analysis of a building's performance. This can provide information throughout a building's design process and operational life.

The software allows like-for-like comparisons to be made by feeding a full year of standard weather data into a software model of the building being analysed.

Every building is unique and energy usage is a product of many variables:

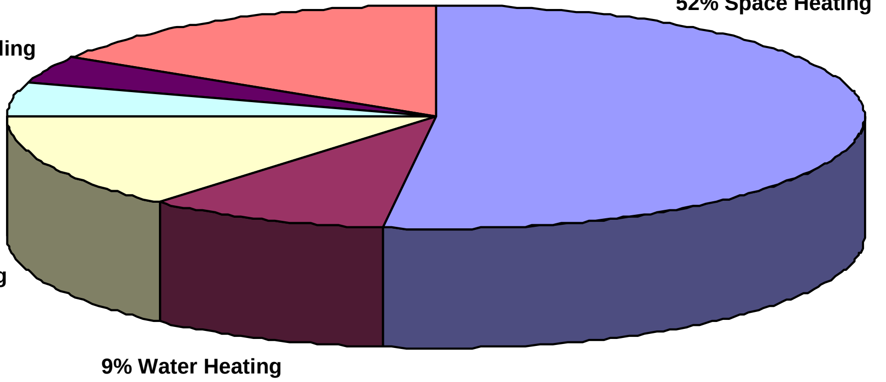
- Local weather, including solar gain, air temperature, wind speed and direction.
- The building envelope.
- Building loads, such as occupancy levels, power usage and waste heat.
- Space conditioning requirements.
- Daylighting and solar gain analysis.
- Performance of heating, cooling, lighting and ventilation and their controls
- Other effects such as thermal inertia, stack effects and local shading.

A holistic view of building energy can be taken using thermal modelling tools. They can bring active and passive energy measures together This enables the passive measures to be optimised.

The modelling can focus on particular aspects of the design. For instance, ventilation strategies can be interrogated or daylighting can be analysed to maximise daylight distribution in a space.

With respect to the building regulations and BREEAM assessments, thermal analysis software will be of assistance. The Building Regulations, Part L2A 2006, now require a carbon emission analysis to be performed for all new buildings. A number of software packages have the ability to produce compliant calculations.

Active Energy Measures



Breakdown of energy consumption in commercial and public buildings in the E.U., 1998, published by the European Commission 2000. Note: this is an overall figure. The percentages will vary greatly between different buildings, and in particular cooling can be a dominant energy user in some buildings.

All Systems

Active systems are systems that require significant amounts of energy input to operate. While active systems are required by buildings to operate, much can be done to select low energy systems or maximise the efficiency of the systems selected.

The approach of a project manager to building services will depend on whether the project is a refurbishment or new build. Whichever construction type is being constructed, it is vital to avoid over-design. While it is important to provide improved facilities, this should not result in energy intensive systems.

New builds need to focus on optimising the use of energy. This should be through selecting the most efficient systems, equipment and controls. Refurbishment needs to focus on the upgrading of systems by repairing, replacing and improving the existing systems, equipment and controls. Cost, programme and suitability of use will heavily influence the selected solution.

The future trend in design and client requirements is towards exemplar buildings being passively designed rather than heavily serviced. “Designing out building services” should be a key feature of the design.

This however clashes with traditional thinking. M&E Contractors make their profit on the cost of the equipment and time spent installing it.

Where systems are provided, it is often to the advantage of the contractor to offer an alterative system that is slightly cheaper, but has a higher profit margin for the contractor. This is often a false economy for the client as this equipment is generally less efficient and therefore the running costs are generally higher.

Without the knowledge of such changes, the client cannot make an informed decision on whether the additional capital cost should be met.

In all cases the specification of the most appropriate systems and equipment will have a major impact on the energy usage of the building.

Heating

The biggest energy saving on heating is achieved through good envelope design. Once this is optimised the focus should be on the efficiency of the heat generator and its delivery system (e.g. insulation, air tightness, passive solar design, use of thermal mass). A common phrase is "build right, ventilate right!"

The project manager needs to be fully briefed on the following issues:

- Type of fuel selected.
- The efficiency of the heat generation.
- The efficiency of heat distribution and controls to make sure that heat is used only when required.
- The selection of the heat emitters.
- The relationship between heating and cooling systems.

Heat Generation

Traditional boiler, 60-75% efficient

Old conventional gas fired boilers are generally inefficient because of design and deterioration due to age.

Modern high efficiency boiler, 85% efficient

In general they work on traditional water temperatures (e.g. 82oC flow, 71oC return from system) which work well with radiators, heater batteries and high level radiant panels. Several European countries seems to be changing to 80-60^{o}C systems in order to lower return temperatures and reduce pump and pipe sizes.

Condensing boiler, up to 95% efficient.

They work most effectively at lower water temperatures (e.g. 50oC flow, 30oC return from system).

They can achieve higher water temperatures but at a lower efficiency of 80-85%. They work well with underfloor heating but require larger pipework and emitters due to the lower temperatures. However the additional cost for the increased sizes is generally small.

Modulating burners

These should be used for all large systems. Heating systems supplied by boilers usually heat the water in a primary loop and mix down to the required temperature. Direct control of the burner by the BMS maximises efficiency by matching the supply to the demand and avoids heating up followed by mixing down the temperature.

Matching supply to demand

All heat generating equipment works more efficiently when working at or close to its full capacity.

Modern gas, fully modulating boilers work better at part load when all boilers run together, rather than sequencing them. This is not the case for older boilers or oil boilers which are better to be sequenced.

Using multiple boilers in sequence increases performance by improving the match between supply and demand.

Active Energy Measures

Heating

Over-design

Over-sizing of the generator reduces efficiency. Designers over-specify to reduce their risk of failures. Good design should be used to avoid failures. The maximum over capacity of the heat generators should be no more than 20% above the maximum load.

Thermal Inertia

In some large buildings high levels of thermal mass and inertia can affect the heating strategy. For some buildings less energy is used by continuous or "set back" heating rather than reheating the building from cold each day. This should be recommended to the client only if the M&E designer can prove the case using calculations.

Delivery

Pipework

All pipework jackets should be insulated to minimise losses including valve/flange.
. This ensures that heat is delivered only to where it is needed. Old pipework is often not insulated and should be surveyed to ensure that all pipework is covered.

Radiators and trench heating

Radiators and trench heaters are the most traditional forms of heat supply to a space. They are more efficient when provided with thermostatic radiator valves (TRVs) or other forms of individual room control.

Digital room sensors connected to two port valves, for example, provide much better control than TRVs. These should be used only to trim the output, not to turn the radiator on and off. Over sizing radiators can cause the heating to turn on and off too frequently and therefore cause inefficiency.

Old radiators are less efficient due to the build-up of dirt and scale which reduces the effectiveness of their output. Old radiators should be cleaned or replaced in refurbishments and TRVs installed.

Underfloor heating

Water is circulated at around 35-40°C through pipes that are embedded in floor screed or in a suspended floor construction. It has a radiant effect that heats objects in the space (including occupants) rather than the air.

In combination with condensing boilers, this is generally the most energy efficient (and comfortable) heating strategy using natural gas.

Under floor heating can be very inefficient if used in spaces that need to heat up or cool down quickly. Also the floor is at a high temp so the insulation of the floor must be increased more than it normally is to avoid increasing heat losses. Edge insulation is almost always done incorrectly leading to large edge thermal losses.

To use underfloor heating a number of practical issues must be addressed:

- Flexibility of space for future zoning changes.
- Heating pipes can be expensive and disruptive to repair.
- Not practical with floor voids.
- Careful selection and placement of insulation is required to "drive" heat in the right direction.
- Appropriate black bulb temperature sensors must be installed and located correctly.

Radiant panels

This is a wet system that delivers heat via radiation. If the heat can be delivered close to where it is needed, the system can be highly efficient.

It is effective where only the people rather than the space need to be heated. In this way it can provide heating very quickly which reduces heat-up times. It works well in large spaces or where internal gains can heat a space once the radiant panels have provided the initial heat up. .

Costs can be reduced if the space also needs cooling and the same panels can provide both heating and cooling.

Gas fired radiant heaters

These burn gas directly and heat the space by radiation. Both panel and tube systems are available. This radiation does not warm the surrounding air directly, but is absorbed by solid objects such as building occupants and surrounding fabric. This type of radiant heating is particularly suited to large volume buildings such as exhibition and sports halls. The efficiency comes from heating only the occupants rather than the air in the space.

Combined heat and power

A combined heat and power (CHP) system is a low carbon energy system. It takes fuel to create electricity and as a bi-product it generates waste heat. This waste heat can be used to provide heating.

CHP can be around 20% more efficient that using boilers and mains electricity.

CHP is most effective in large systems but can be as small as 5kW electrical / 10kW heat. For further details on larger systems, see Decentralisation vs. Centralisation section.

Heating

Air systems

Heater batteries mounted in incoming air supplies can be an effective way of delivering heat to a space. Heating can temper external air or provide all of the heating to a space.

The inefficiency occurs when air is not needed for occupancy but is needed for heating. Large amounts of air could be required which means fans running excessively.

The solution is to use heat recovery or recirculated air when fresh air is not required. Alternatively use the system in tandem with a heating source in the space. Direct gas fired heating should be used if long heating pipework needs to be avoided.

Electric heating

This is a poor choice for any sizeable degree of heat delivery. Electric heating should be avoided due to the high CO_2 emissions of electrical equipment. Storage heaters are better than instant heaters but still suffer from the same CO_2 emissions issue.

Trace heating

A form of electric heating generally employed for frost protection on vulnerable external services such as water pipes. Routing of pipework should be provided to avoid its use.

Controls

Controls allow a system to work efficiently. A lack of control means waste and cost. If a control measure is not used, it should be justified to the project manager in terms of both capital and whole life costs.

A Building Management System (BMS) should be used to both maintain and monitor the controls. It can significantly improve the overall performance of a building. To maximise this impact, the client must be fully involved in its development.

The following control elements would typically be used:

- Central control - Primary controls should be centralised. Local users should be able to adjust temperatures between set limits.
- Buildings should be zoned so that whole areas or floors can be controlled or turned off. Thermostats, time clocks (24 hour & 7 day settings) and occupancy sensors should be used.
- Where heating is required only on an occasional basis, push button timer controls should be used.
- Sequential control of multiple boilers.
- Weather compensation to reduce water temperatures. This should be directly applied to boiler set points for gas fired systems rather than the traditional approach of using blending valves.
- Optimised stop and start.
- Pumps should be turned off when heating is not required. Many are left running continuously.
- Pumps should have variable speed controls and drives. This will reduce the flow of water around a system when heat is not required. These should not just be used for commissioning as many designers are doing.
- The system should also consider the use of two port valves to further reduce the flow of water.

Feasibility Early Design

At early design stage the Project Manager should:

- Ensure client has provided full details of use, occupation and equipment before the end of Stage C.
- Ensure that the key design issues have been identified by the design team and communicated to the client.
- Ensure the design team has discussed possible solutions with the client maintenance team and a record of these discussions is made.
- Ensure that clear energy use targets are identified and set.
- If the project is a large scale refurbishment, ensure existing energy use figures are available to assist design team.
- Ensure client understands cost impact of solutions.

Design Development

- Ensure that full energy estimates of systems are to be produced (not just Part L calculations).
- As the design develops ensure that the accuracy of the energy predictions is increased.
- Ensure client understands impact of design changes on energy usage targets.
- Ensure that all control measures are incorporated unless justifications are provided which include calculated figures.
- Ensure client understands cost impact of solutions.

Construction

- Ensure that adequate commissioning has been programmed and undertaken.
- Ensure client understands impact of design changes on usage targets.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the building.

Operation

- Ensure client is aware of maintenance issues.
- Ensure that client has committed to using systems as described in the Building Log Book.

Centralisation vs. Decentralisation

There are benefits to both centralised and decentralised systems.
The project manager needs to be fully briefed on the following issues:

- Whether the university has an energy wide scheme or strategy.
- Understanding the possible contractual impacts of community heating.

Recent trends have been towards smaller, decentralised plant. The M&E consultant should advise on the advantages and disadvantages of maintenance issues for the particular project.

The main advantage of a decentralised system is the lower thermal transmission loss due to long pipe runs. This system also avoids a large amount of water being pumped around a system that it is not required. This can be partially offset for some systems by the use of 2 port valves rather than 3 port valves. 2 port valves reduce flow, while 3 port valves direct water flow through an alternate route.

Centralised systems offer the advantage of being able to run the plant more often at or close to its full capacity. They also offer the benefit of being able to balance the energy needs of a campus. Centralised systems also avoid the need to include local plant spaces but this benefit is normally not worth the additional energy and cost required.

Normally the only reason that a central system should be used is if a renewable technology is to be implemented such as biomass or CHP that it would benefit from, an economy of scale.

A normal gas or oil system should never be centralised.

Waste energy from certain processes can be utilised to obtain “free energy”. For example, it may be practical and cost effective to use heat rejected from cooling or refrigeration of a different area or from a building using heat pump technology.

Wherever cooling is required, the heat needs to be rejected. The designer should be challenged to reuse this heat either locally or as part of a wider system.

Combined Heat and Power

CHP (Combined Heat and Power) is a method of on-site energy generation. It is more efficient than obtaining thermal and electrical energy from utility supplies. It therefore saves energy and reduces CO_2 emissions in comparison with more conventional methods of energy supply.

In itself, CHP is not classified as a renewable energy source. However it can obtain funding as it is a “low carbon energy source”.

CHP is often viable for a campus wide development. A project manager should be certain whether a university has a campus wide scheme. If so, the first step is a feasibility study to determine if the new building can be incorporated.

If there is a constant heating demand, such as a swimming pool, it can assist the viability of the scheme. If a large cooling load can be identified and there is a consistent generation of waste heat, then absorption cooling should be considered. This uses heat rather than electricity to create cooling. Absorption cooling is expensive unless there is a significant waste heat load.

Centralisation vs. Decentralisation

Energy Services Companies (ESCOs)
ESCOs are private companies whose services can be used to deliver varying levels of input to Community Heat and Power schemes and other types of energy service contracts. Typically, these services include project design, capital finance, construction, management, fuel purchasing, billing, plant operation, maintenance, long-term replacement and risk management.

ESCOs typically provide capital finance to projects taking away cost and risk from the university. In return, the university will sign a long-term energy supply contract with the ESCO.

The benefit is that a cheaper low CO_2 solution can be delivered by the university without the costs and risks associated with large amounts of renewable energy. ESCOs absorb the risk as well as the cost in return for long-term financial rewards.

At present the uptake of ESCOs has been limited in the further education sector.

Feasibility Early Design
- Identify if there is an opportunity to integrate building with district system.
- Undertake site analysis to estimate loads and impact on district system.
- Investigate opportunities.
- Ensure client is aware of strategy opportunities.
- Agree on strategy to proceed.
- Ensure client understands cost impact of solutions.

Design Development
- If appropriate, ensure client is fully aware of contractual implications of district systems and ESCOs.
- If appropriate, ensure early involvement of ESCO organisation in project.
- Ensure client is fully aware of maintenance issues in relation to strategy.
- As the design develops, ensure that the accuracy of the energy predictions is increased.
- Ensure client understand cost impact of solutions.

Construction
- Ensure that adequate commissioning has been programmed and undertaken.
- Ensure client understands impact of design changes on usage targets.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the building.

Operation
- Ensure client is aware of maintenance issues.
- Ensure that client has committed to using systems as described in the Building User Guide.

Hot Water

The way to maximise the efficiency of a hot water system is to optimise the match between the volume of hot water created to the volume of hot water demand.

The most important thing to consider is how to reduce the demand by reducing water usage and using blending valves.

Next most important element is the generation efficiency.

Matching demand to storage would come third on the list of priorities.

The project manager needs to be fully briefed on the following issues:

- The relationship between hot water load and the delivery system.
- The efficiency of the equipment and standing losses.
- The zoning and controls of the system to minimise use.

To avoid issues with legionella, hot water systems must either be stored at high temperatures or used instantly once heated.

Heat Generation

Systems combined with heating generators

Hot water systems heated by the same plant as the heating plant are less efficient than a separate, dedicated system. In summer this is particularly apparent when no heating is required. This also reduces the efficiency if condensing boilers are used, as they will not work in condensing mode if heating the water.

Calorifers and plate heat exchangers can be highly efficient but the hot water tends to only be a small percentage of a building's total heating load. Therefore the plant is generally not well matched to the size of the load and inefficiencies occur. Refer to the Heating section for further details.

The exception is where there is a significant hot water demand such as a large catering facility or laboratory. Alternatively if biomass or CHP is used, the storage capacity of calorifiers is an effective way to incorporate a low or zero carbon dioxide system.

Separate hot water systems

These are the most efficient way to create hot water. If the demand is constant, the use of a direct fired storage heater would be effective. Condensing units are now available as well. They combine the effectiveness of direct heating with storage to cope with high levels of demand.

Local Units

Local gas fired and electric heaters should be used where there is intermittent demand in a small area. They are relatively cheap to install and avoid long pipe runs which result in losses. However they increase maintenance as there is more equipment that can go wrong.

The avoidance of electrical water heating should also be considered in relation to its carbon dioxide emissions due to the relatively high energy to emissions, ratio of grid electricity compared to natural gas.

Over-design

To avoid running out of hot water for centralised systems, they are often over-sized. This can result in a system that can produce excess quantities of hot water compared to demand. The solution is to provide more than one unit to allow units to be turned off when not required. Careful consideration of legionella is required.

Hot Water

Delivery

Pipework

All pipework jackets should be insulated including valve/flange. This ensures that heat energy is delivered only to where it is needed and minimises losses. Old pipework is often not insulated and should be surveyed to ensure that all pipework is covered.

Local Thermostatic Mixing Valves

In addition to providing protection from scalding, local thermostatic mixing valves will reduce the thermal energy consumed for water heating by blending the delivered water temperature to the required level.

Water use

Water reduction measures reduce the need for hot water in the same way as cold water. Refer to water section for more details.

Controls

Controls allow a system to work efficiently. A lack of control means waste and cost. If the following control measures are not used for central systems, it should be justified to the project manager in terms of both capital and whole life costs.

The controls that should be used on hot water systems:

- Central control should be provided and temperatures should be maintained between set limits.
- Buildings should be zoned so that whole areas or floors can be isolated when not required (but this should consider Legionella issues).
- Time clocks (24 hour & 7 day settings) should be used to ensure that water is always at a suitable temperature when required.
- Sequential control of multiple units.
- Pumps should be turned off when hot water is not required. Many are left running continuously.
- Pumps should be Europump A rated.

Feasibility Early Design

- Ensure client has provided full details of use, occupation and equipment before the end of Stage C
- Ensure that the key design issues have been identified by the design team and communicated to the client.
- Ensure design team has discussed possible solutions with client maintenance team and a record of these discussions is made.
- Ensure that clear energy use targets are identified and set.
- If a large scale refurbishment, ensure existing energy use figures are available to assist design team.
- Ensure client understands cost impact of solutions.

Design Development

- Ensure that full energy estimates of systems are to be produced (not just Part L2 calculations).
- As the design develops ensure that the accuracy of the energy predictions is increased.
- Ensure client understands impact of design changes on energy usage targets.
- Ensure that all control measures are incorporated unless justifications which include calculated figures are provided.
- Ensure client understands cost impact of solutions.

Construction

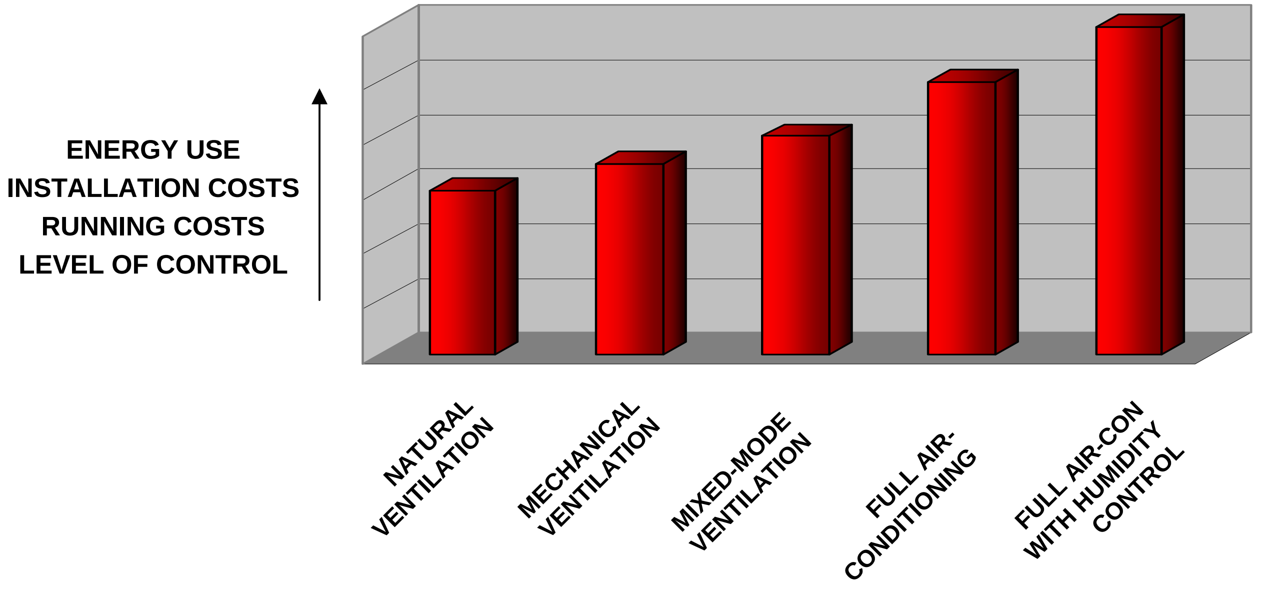
- Ensure that adequate commissioning has been programmed and undertaken.
- Ensure client understands impact of design changes on usage targets.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the building.

Operation

- Ensure client is aware of maintenance issues.
- Ensure that client has committed to using systems as described in the Building Log Book.

Active Energy Measures

VENTILATION HIERARCHY



Ventilation

If ventilation requirements of a space cannot be achieved through passive ventilation, mechanical ventilation will be required. Mechanical ventilation offers a highly controllable method of maintaining indoor air quality by the supply of fresh air and the removal of pollutants. It can range from a simple fan placed into an external wall to a fully ducted system. However this control comes at a price.

The project manager needs to be fully briefed on the following issues:

- The integration of the ventilation system with heating, cooling and humidity control.
- The efficiency of the equipment and the distribution system.
- The zoning and controls of the system to minimise use.
- The type of heat recovery system used and how it is bypassed during warm weather.

Systems

Mechanical Ventilation vs. Mixed Mode

Traditional mechanical ventilation blows air into a space at high level, mixes with the room air and then extracts the air at high level. Mixed mode uses both natural and mechanical systems depending on internal and external conditions.

Mechanical ventilation often has a lower capital cost than mixed mode ventilation as it is providing only one ventilation system. Mixed mode has to provide both and is often more expensive.

Displacement ventilation

A common ventilation strategy is to ventilate at low level and extract at high level. It is one of the most efficient ventilation systems as the velocities are low, excellent stratification occurs and the supply air is introduced at temperatures close to the room temperature.

In contrast to a traditional “mixing” system, a displacement system does not have to condition all the air in the space, just the occupied zone. It is particularly applicable to lecture theatres, teaching spaces and offices.

A displacement system can work even more effectively if combined with radiant panels or chilled beams.

Often the use of a displacement system can avoid the need for air conditioning in a room that would require it if a traditional high level supply ventilation system were used

Air conditioning

Air conditioning can use double the amount of energy natural ventilation does. However in some spaces effective control is required and therefore air conditioning must be used. Its use should be limited to specialised areas.

Humidity control should only be used where necessary. It uses excessive energy as it has to cool down and reheat air to extract the moisture from the air. Desiccant cooling is an alternative solution which should be considered to reduce energy use.

Ventilation (Cont'd).

VAV & CAV

In general, Variable Air Volume and Constant Air Volume systems should be avoided. They use large amounts of air and require air to be heated and cooled for most of the year. However they do provide localised control unlike the majority of other systems cannot.

In the case of refurbishments it may be inappropriate or too expensive to replace the existing system. Where this is the case, using VAV should be considered over CAV, combined with improved controls and variable speed drives.

Make up air

Where air does not need to be tempered for comfort, it should not be heated. Where there are high air change rates, air should be drawn in directly from outside. This is particularly applicable to laboratories but could also apply to some cooking and workshop applications.

Low occupancy

Large spaces with high occupancies require large volumes of air for ventilation and cooling. However when the same spaces have minimal occupancy, mechanical ventilation can be avoided. Infiltration (i.e. leaks in the façade) will provide background air that will suffice for breathing and odour removal. The level of background air change can be calculated. Mechanical systems should not be run in such cases.

Special Process Ventilation

Test rigs, machine rooms, chemistry and biological laboratories all have very specific and often critical conditioning requirements. Air volumes can be large and filtration requirements can mean very high air resistance.

The key focus should be on using the minimum air required and only when required. This requires modern equipment to replace old and the provision of adequate controls.

It also means using appropriate equipment in the right location. Researchers will use equipment differently than undergraduates, so different controls and equipment may be required.

Fume Cupboards

The following solutions should be considered.

- Re-circulatory filtration/ductless fume cupboards.
- Simple speed control where cupboards are connected to individual fans.
- Variable speed extract fan which vary flow rate in relation to the height of the sash.
- Use separate fans for each cupboard rather than a communal fan for a number of cupboards.
- Variable air volume (VAV) on multiple. systems and use of diversity in design.
- Heat recovery system where corrosion is not an issue.
- Fans connected to sash closing mechanism.

The exit velocity from fume cupboard stacks must be maintained at all times and when sashes are down, the traditional approach is to maintain velocities by drawing air from the room. However it makes more sense to draw it directly from outside.

Over-design

Designers often rely on standard figures for their design. Without a detailed knowledge of the process being ventilated, worst case scenarios are generally used. For instance, an air change rate of 40ac/h could be used when the final installation only requires 20ac/h.

Simply relying on such guidance can indicate a lack of information provided by the client or a lack of thought in design. The project manager must be responsible for ensuring that this does not occur.

Fan coil units

Fan coil units consist of a fan and heating/ cooling coils. Air can also be blown into the back of the unit which then tempers the air and distributes it to the space. They are inefficient due to the additional electrical loads of the fans. They can use up 40% more energy than a central Air Handling Unit system.

In some cases the fan can be avoided by using induction units that draw in fresh air by buoyancy alone if located on an external façade of the building.

Simple controls can be used to avoid the potential of both the cooling and heating being used at the same time. It is common for individual or groups of units fighting against each other to provide both heating and cooling to a single space.

Components

Fans

Fans have an optimum performance. Too often the fan is not performing at its optimum setting through poor design. Direct drive rather than belt drive increases efficiency. Typical figures should be:

- 2.5 W/l/s - Central mechanical ventilation including heating, cooling and heat recovery.
- 2.0 W/l/s - Central mechanical ventilation with heating and cooling.
- 1.8 W/l/s - All other central systems.
- 0.5 W/l/s - Local ventilation units within the local area, serving one room/area.
- 1.2 W/l/s - Local ventilation units remote from the area, serving one room/area.
- 0.8 W/l/s - Fan coil units (rating weighted average).

Fan motors

Variable Speed Drives (VSD), sometimes referred to as inverter drives, offer savings through being able to turn down and match demand. These should be used on all systems.

Where fan speeds will often be turned down during normal use, a permanent magnet, electronically commutated motor should be used as these motors use considerably less energy at part load than a traditional motor connected to an inverter drive.

Filters

Filters come in different grades and ratings: Coarse, Fine, HEPA, ULPA. The more critical the filtration requirement, the more fan power is required. Filters should not be finer than actually required as the energy usage of fans increases as filter efficiency rises. A strategy for regular cleaning and replacement needs to be put in place to prevent long-term performance loss.

Active Energy Measures

Ventilation

The face air velocity for panel filters should not exceed 1.75 m/s. Bag filter face air velocity should not exceed 2.5 m/s.

Heat recovery

Heat can be recovered from exhaust air. There are a number of ways.

Run around coils (45-55% efficient) pump a liquid (usually water) between the flow and return air streams and do not need the air streams to be near each other.

Plate Heat Exchangers (75% efficient) are made up of lots of thin layers of metal or polymetric material (plastic) that allow the flow and return air stream to pass across each other to transfer heat and if required, moisture, without coming into direct contact.

Thermal Wheels (60-90% efficient) rotate a wheel between the two air streams which transfers the heat. Energy is used by the motor to rotate the wheel. Thermal wheels should be fitted with variable speed drives that are adjusted to match the required load

Air to Air recovery units (85-95% efficient) use exhaust air to heat metal panels. The air flow is then altered to use the same panel to heat the supply air. With such high efficiencies, it is possible to offset the additional cost of the equipment by avoiding the provision of heater batteries and associated pipework.

Heat Pipes

Heat pipes can be used to transfer energy passively between air streams. A refrigerant is placed in a loop, and a simple refrigerant cycle occurs in the system. Heat pipes can be particularly suitable to dehumidification processes.

Heat recovery should be used on all new systems that supply and extract heat (except for commercial kitchens). Refurbishment should consider their use when practical.

Adiabatic cooling

Water can remove heat by evaporation much like sweat on a human body. The same process can be used to cool air in air handling units. The water cannot be sprayed directly into the air due to the risk of legionella, but can be used indirectly.

These systems are slightly more expensive than traditional air handling units. However they will reduce running costs as less energy will be used to modify the air temperature.

Ductwork

Ductwork should be designed to minimise air resistance. Careful attention should be applied to sizes, grilles, diffusers, plenum boxes and bends and other components. To reduce fan power requirements, there is a real possibility that ductwork sizes will have to increase. Architects will have to account for this with larger ceiling voids, risers and plantrooms.

Leakage

Ductwork that is leaky has to work harder to deliver the required air to a space. Pressure testing should be undertaken on new build and refurbishments alike to minimise losses.

Controls

Controls allow a system to work efficiently. A lack of control means waste and cost. For central systems, if the following control measures are not used, it should be justified to the project manager in terms of both capital and whole life costs.

The following controls should be used on ventilation systems:

- Central control should be provided to provide air and air temperatures at set limits.
- Buildings should be zoned so that whole areas or floors can be isolated and turned off when possible.
- Manual on / off controls with time control overrides should be used for local use.
- Manual on / off controls with humidity settings should be used in domestic cooking and bathroom situations.
- Speed controllers with time clock overrides should be used where occupants want to vary air speeds such as cooking lab and workshop areas.
- Occupancy sensors should be used in areas that are intermittently used, such as toilets.
- CO_2 sensing should be used to vary the flow of air to occupied spaces in tandem with room temperature sensors.

Feasibility Early Design

- Ensure client has provided full details of use, occupation and equipment before the end of Stage C.
- Ensure that the key design issues have been identified by the design team and communicated to the client.
- Ensure design team has discussed possible solutions with client maintenance team and a record of these discussions is made.
- Ensure that clear energy use targets are identified and set.
- If a large scale refurbishment, ensure existing energy use figures are available to assist design team.
- Ensure client understands cost impact of solutions.

Design Development

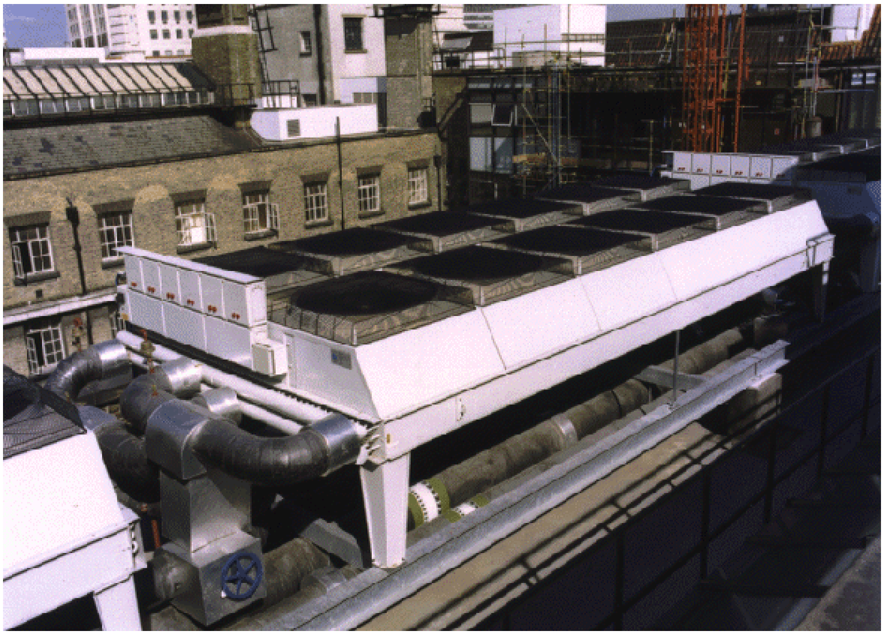
- Ensure that full energy estimates of systems are to be produced (not just Part L calculations).
- As the design develops, ensure that the accuracy of the energy predictions is increased.
- Ensure client understands impact of design changes on energy usage targets.
- Ensure that all control measures are incorporated unless justifications which include calculated figures are provided.
- Ensure client understands cost impact of solutions.

Construction

- Ensure that adequate commissioning has been programmed and undertaken and that ductwork is tested in accordance with DW142.
- Ensure client understands impact of design changes on usage targets.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the building.

Operation

- Ensure client is aware of maintenance issues.
- Ensure that client has committed to using systems as described in the Building Log Book.



Cooling (Non Ventilation Systems)

Comfort cooling is often provided on a "just in case" basis. There are financial as well as energy savings to be made by avoiding its use.

The project manager needs to be fully briefed on the following issues:

- The extent of cooling required.
- The efficiency of the equipment.
- The zoning and controls of the system to minimise use.

It is easy for M&E consultants to specify cooling as it reduces their risk of the design failing. Good design can avoid its use, but there is a fear of the blame culture and therefore a reliance on design guidance figures.

Simply relying on such guidance can indicate a lack of information provided by the client or a lack of thought in design. The project manager must be responsible for ensuring that this does not occur.

It is important that rooms are set to the highest temperature appropriate if energy use is to be minimised. For example, comms rooms are usually cooled to 19°C. In many cases they could only be cooled to 23°C without loss of performance of the equipment.

Supply temperatures

Chilled water systems typically work on 7°C flow and 12°C return temperatures. If the supply temperatures can be raised, higher evaporating temperatures occur and therefore efficiency is increased and losses decreased. Chilled water temperatures can be reduced through the use of high temperature cooling systems such as chilled beams or chilled ceilings.

Chiller plant

Chiller plant is complex and advice should be sort from specialists on its use. However to ensure that an efficient design is provided, the designer must be able to provide the following information:

- The average COP of the plant.
- The annual running costs.
- The utilisation factor of the plant over a year.

The use of buffer vessels should be considered to minimise starts at low load conditions.

Thermal storage

Efficiency can be improved by thermal storage to smooth out peaks and troughs in demand.

Ice storage is one example where it is created and stored at night. The heat that needs to be rejected from a space for cooling is absorbed by the ice as it melts. It is not a low carbon solution as it still uses electricity to create cooling. However it can make cooling systems cheaper to run as it takes advantage of lower night time electricity costs.

Passive design can be coordinated with chilled pipework or ducts run throughout the structure of the building. Systems such as Thermodeck use this principle to store coolth in the structure to be used at a different time in the day.

These are highly effective but are often not used as designers are unfamiliar with their use. This should not be an excuse for not considering or using them.

Cooling (Non Ventilation Systems)

Heat rejection

All cooling systems rely on rejecting heat from the building space to the atmosphere (or other appropriate reservoir) via a heat pump. Some areas such as IT hubs need cooling 24 hours a day. If mechanical cooling is required, the rejected heat should be used to heat other parts of the building.

Cooling Towers

Cooling towers provide a way of dissipating heat from a cooling system. In recent years they have been replaced in many cases due to reasons outside of efficiency.

Refrigerant

Systems can use refrigerant rather than water to transfer coolth around a building. It has some advantages over chilled water in terms of operating temperatures, but has some negative environmental impacts.

These impacts can be overcome using modern refrigerants that have a low or zero ozone depletion and global warming potential. Refrigerants such as ammonia are now more commercially available.

Refrigerants are used in DX (Direct Expansion) systems. These are typically the boxes you see on roofs and walls. They are often used in retrofit applications and are inefficient due to poor control and low electricity to cooling conversation factors (COPs).

VRF (Variable Refrigerant Flow) can achieve a high efficiency balance the variable heating and cooling demands of a building.

Pipework serving units located in the building or space. Depending on demand either heat is absorbed from, or rejected to the pipework. There fore if heating and cooling loads are balanced, no additional energy is required to heat or cool the building.

Compressors and Controls

Variable speed pumps, control, sequencing and other control measures applicable to heating are also applicable to cooling. However the refrigerant cycle associated with cooling add extra layers of complexity to the solution.

A number of “free” cooling scenarios and efficiency measures can be achieved through the detailed design. The selection of the evaporators, the condensers and compressors needs to be carefully considered. The key issue for project managers to understand is the impact that these efficiencies have on capital cost and whole life costs.

Feasibility Early Design

- Ensure client has provided full details of use, occupation and equipment before the end of Stage C.
- Ensure that the key design issues have been identified by the design team and communicated to the client.
- Ensure the design team has discussed possible solutions with the client maintenance team and a record of these discussions is made.
- Ensure that clear energy use targets are identified and set.
- If a large scale refurbishment, ensure existing energy use figures are available to assist design team.
- Ensure client understands cost impact of solutions.

Design Development

- Ensure that full energy estimates of systems are to be produced (not just Part L calculations).
- As the design develops ensure that the accuracy of the energy predictions is increased.
- Ensure client understands impact of design changes on energy usage targets.
- Ensure that all control measures are incorporated unless justified with information that includes calculated figures are provided.
- Ensue client understands cost impact of solutions.

Construction

- Ensure that adequate commissioning has been programmed and undertaken.
- Ensure client understands impact of design changes on usage targets.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the building.

Operation

- Ensure client is aware of maintenance issues.
- Ensure that client has committed to using systems as described in the Building Log Book.

Electricity and Lighting

At one university, the maintenance team estimate that they have control over 85% of the gas use on the campus, but only 15% of the electrical use.

Electrical use is heavily dominated by user control and indirect use by mechanical equipment. However effective design can also make a vital contribution to reducing this waste.

The project manager needs to be fully briefed on the following issues:

- How the use of natural daylight is being optimised.
- Avoiding over-provision.
- The efficiency of the equipment.
- The control of the equipment, including its potential effect on health and safety.

Lighting

Lighting use

Lighting can account for up to 30% of a building's total carbon dioxide emission depending on its energy profile. Therefore minimising lighting is vital to a low energy solution.

An effective lighting solution is not simply a case of providing recommended lighting levels using the most efficient lamps. Lighting creates mood and character in a space and has to provide visual comfort for a healthy environment. These factors have to be balanced against minimising energy use.

Use of daylight.

Artificial light solutions should be coordinated with the daylight design to ensure that natural daylight is optimised.

The first step is to consider the relationship between the layout of the fittings, the circuitry and the windows. If lamps are grouped in lines parallel to the window, they can be dimmed or turned off more effectively when daylight levels are good.

Daylight linking

Manual operation is good if switches are within 6m of an occupant. However in many cases they are not and therefore lights are left on when not required. If light sensors are installed in a space, they can monitor the levels of light and dim or turn off the lighting automatically. This dimming can be slow enough so that it cannot be perceived by the occupants.

Controls

Time controls (24 hour & 7 day settings) should be used to turn lighting off when not required. These are particularly effective in areas that are rarely occupied. Alternatively, for small refurbishments, a management systems should be put in place to ensure switching off.

Occupant sensors can cause irritation in areas where occupants are likely to be sitting still to work for long periods. A more effective solution can be to use an out of hours time clock with a user override. This can be set to allow an additional "boost" of one hour each time a button is pressed.

Where only occasional lighting is required (e.g. corridors) use push button timer controls.

External lighting should be controlled by time clocks, movement sensors or photocells as appropriate.

Lighting Levels

Where specific lighting levels are required, it should be ensured that they are provided only where necessary. Simply relying on CIBSE guidance on light levels is not sufficient to ensure an energy efficient solution.

Electricity and Lighting

Task lighting works effectively at providing light only where it is required. Whether in an office or in a lecture theatre, light is needed only on the working plane and not on the circulation space. Desk lamps can be used in offices and LED can be used in lecture theatres. This can be 25% more efficient than traditional designs.

Where excessive lighting is provided in an existing system, reducing the number of lamps can be a cheap and effective way of reducing the lighting levels.

For further information on daylighting, refer to the External Envelope and Daylight section of this document.

Maintenance

Lighting is designed to include “fudge factors” to account for dirt and lamp deterioration. If the lighting is designed to avoid dirt build-up and a good maintenance programme is followed, the energy used by the system can be reduced.

Luminaries and Lamps

There are a range of different luminaries and lamp types available on the market. Each has its particular niche uses and advice needs to be given by the lighting designer. However the selection of lighting needs to be challenged on its efficiency as well as its cost. The architect should also be challenged if his or her design inhibits the efficiency of the lighting solution.

In general terms modern tubular fluorescent lamps with high frequency switchgear and soft start should be installed. These are more efficient than traditional tungsten filament lamps or old fluorescent lamps. Large external lighting 3 schemes should use high pressure lamps. Light fittings should be not cause light pollution.

However to ensure that an efficient design is provided, the designer must be able to provide the following information:

- Luminous efficacy (lumen output / watts input or luminarie-lumens/circuit watt) (this figure should not be less than 45).
- Rating (watts).
- Rated lamp life (hours).
- Lamp output ratio on surface (%).
- Lumen deterioration factor (%).

A figure of 45 luminarie lumens / circuit watts is required by the Building Regulations which is an appropriate figure to achieve. A figure of 100 luminarie lumens / circuit watts however is achievable.

LED’s (light emitting diodes) are commonly thought of as a low energy lighting source. However these fitting should be considered using the same criteria above before this judgement is made.

It is also important to ensure that the efficiency of the lamp is considered. This is the effectiveness of the fitting to distribute light onto the required surface. A bad example is an external fitting that throws light up into the night sky. The light is needed on the floor so light thrown into the air is wasted.

Non lighting issues

Power factor correction

Equipment such as motors and pumps require active power to produce motion and reactive power to energise their magnetic field. Inefficiencies occur due to the draw of power and the fluctuating current that is drawn.

Power factor correction equipment is effectively a large capacitor that can be used to reduce these fluctuations. Power factors of 0.95 can be achieved with correction equipment.

Voltage optimisation

Voltage Power Optimization (VPO)

VPO takes advantage of the fact that your building’s supply voltage is in 90% of cases substantially higher than is the optimum for all the equipment that is on site.

The statutory voltage band, within which the UK electricity distribution companies had to deliver three phase electricity, was changed in 1995 from 390–440 V (three phase) to 376–440 V. The Europeans increased their supply band from 360 – 400 V to 360–440 V. The next stage of European harmonisation in 2008 will see the UK paralleling Europe on a 360–440 V statutory range.

This whole harmonisation was purely theoretical as suppliers are not able to move supply levels. Instead manufacturers of electrical equipment had to broaden the voltage operating parameters of their product so they would run at 360–440 V.

The Grid was designed to deliver a 418 V supply level to consumers and, as physics dictates that as you move away from the power supply point (any high voltage 11,000 V to 415 V transformer), the voltage supply level reduces (this is called volt drop). This will not be changed in the foreseeable future.

Physics dictates that if you reduce voltage, and at the same time improve the balance of the phase supply to motors, as well as suppress some of the harmonics in circuit, you will produce substantial power savings and therefore reduce kWh consumption. This will also extend the operating life of equipment designed to run at lower voltages.

The technology is installed between the meter/breaker on the incoming supply and before the distribution board or bus bar and so optimises supply to the whole building and produces savings on the whole building.

Results have shown savings of between 10% and 20% at all sites where the technology is installed and perhaps most importantly it requires no maintenance and has a life expectancy of over 30 years.

To date it is installed in a number of university buildings such as Queen Mary University of London and The London.

Electricity and Lighting

Occupant Equipment

The project manager should ensure that occupants are provided only with low energy use equipment. Wherever possible Liquid Crystal Display (LCD) monitors should be used instead of Cathode Ray Tube (CRT) monitors. Computers, printers and photocopiers should have standby or switch-off controls.

Domestic equipment

The use of electrical tumble dryers should be avoided. Gas heated dryers should be used. They are cheaper to run and more energy efficient. All white goods should be A rated using the European Energy Labelling system.

Feasibility Early Design

- Ensure client has provided full details of use, occupation and equipment before the end of Stage C.
- Ensure that the lighting design is being coordinated with daylighting strategy and window design.
- Ensure that clear energy use targets are identified and set.
- If a large scale refurbishment, ensure existing energy use figures are available to assist design team.
- Ensure client understands cost impact of solutions.

Design Development

- Ensure that full energy estimates of systems are to be produced (not just Part L calculations).
- As the design develops, ensure that the accuracy of the energy predictions is increased.
- Ensure client understands impact of design changes on energy usage targets.
- Ensure that controls strategy is agreed and signed off by client.
- Ensure client understands cost impact of solutions.

Construction

- Ensure that adequate commissioning has been programmed and undertaken. This is especially relevant to dimming installations.
- Ensure client understands impact of design changes on energy usage targets.
- Ensure that design team and contractor provide detailed briefing to client on how to operate the lighting.

Operation

- Ensure that client is aware of maintenance issues.
- Ensure that client has committed to a robust occupant energy use policy.
- Ensure that client has committed to using systems as described in the Building Log Book.

Lifts

Vertical transportation is usually confined to ramps, stairs and lifts in university buildings. Lifts are usually provided to provide access for disabled users or transport people up a large number of floors.

The project manager needs to be fully briefed on the following issues:

- The need for the lift.
- The efficiency of the equipment.

The easiest way to avoid energy use with lifts is to not provide them at all. Ramps and variable levels can be used instead. Architects should see this as a design opportunity rather than an issue to be overcome, while at the same time considering disabled access and the Disability Discrimination Act.

If lifts cannot be avoided, then a number of solutions can be investigated. However these are not usually considered as normal practice is to select a manufacturer on cost and then use their standard range.

If more than one lift is provided to a lobby, the use for more than one lift is rare except for peak periods. Lift sequencing can be set up, at no extra cost, so that for periods of low use only one lift is used.

Where more than one lift is required, "intelligent" lift sequencing can also be used. If lifts are called on a number of floors, the system will ensure that the minimum amount of car travel is instigated. This, however, is more expensive to provide.

All lifts require auxiliary energy such as lighting. However when no-one is in the car, this is not required. Therefore as long as health and safety issues are addressed, there is no reason why this power cannot be turned off using simple controls.

Traction lifts are more efficient than hydraulic lifts. Hydraulic lifts use energy to force the piston to raise the car but then lose this potential energy when the car is lowered. Traction lifts do not suffer the same energy loss, as they are partially counterbalanced.

The counterbalancing can affect the energy used to move the lift. It is usually sized to balance a 50% full car. Most lifts generally operate at around 33% full. Therefore it is more efficient to use this lower figure.

The drive motor is sized to match the number of people in a lift car. As they are rarely occupied to their theoretical limit, this is oversized and therefore less efficient. The motor should be re-sized accordingly.

Feasibility Early Design

- Ensure a true assessment of the potential usage is undertaken.
- Ensure that the key design issues have been identified by the design team and communicated to the Client.
- Ensure client understands cost impact of solutions.

Design Development

- Ensure that energy use estimates are provided by the manufacturers.
- Ensure that control measures and sequencing options are investigated.

Construction

- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure client is aware of maintenance issues.
- Ensure that client has committed to using systems as described in the Building Log Book.

Commissioning

An efficient building design can only work efficiently if it is set up correctly. Effective commissioning can improve performance significantly. This can have a major impact on a university's carbon dioxide commitment.

The project manager should also be aware of:

- The principles of best practice pre-commissioning, commissioning and post- commissioning.
- Who is commissioning the systems.
- Programme implications of commissioning.

Many buildings are being handed over that do not work as they were designed. The consequence is that they waste large amounts of energy and water.

Effective commissioning is not helped by control measures being omitted during value engineering, incomplete or in some cases forgotten altogether. Installed systems are often poorly commissioned and do not function effectively. In some instances completed commissioning records bear little resemblance to how the building actually performs.

If effective commissioning is not undertaken, problems are often noticed only over a period of time. If this is the case, defects liability periods could have run out and the cost of fixing the problem is with the client.

A lack of quality monitoring during construction often leads to problems. Having independent monitoring of the installation and commissioning, or a clerk of works, should be considered.

Pre-commissioning, commissioning and post-commissioning should be undertaken. Post occupancy seasonal commissioning should be undertaken throughout the first 12 months of occupation. Work should be carried out in accordance with best practice industry guidance such as BSRIA or CIBSE.

Feasibility Early Design

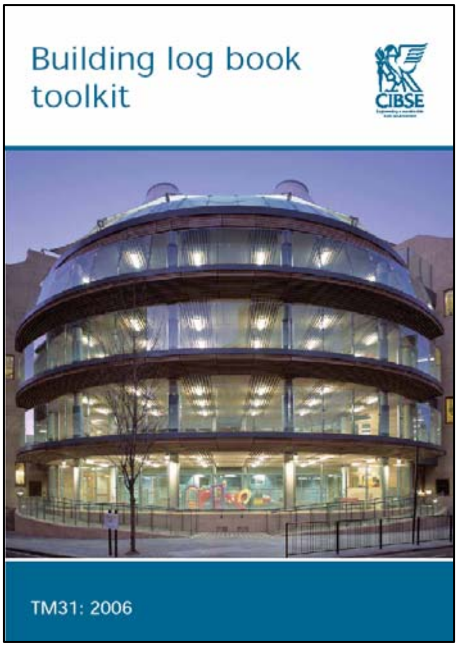
- For major energy and water consuming systems it is recommended that an independent specialist commissioning agent is appointed who is not involved with the installation. Although independent of the main contractor, there needs to be a good working relationship between parties.

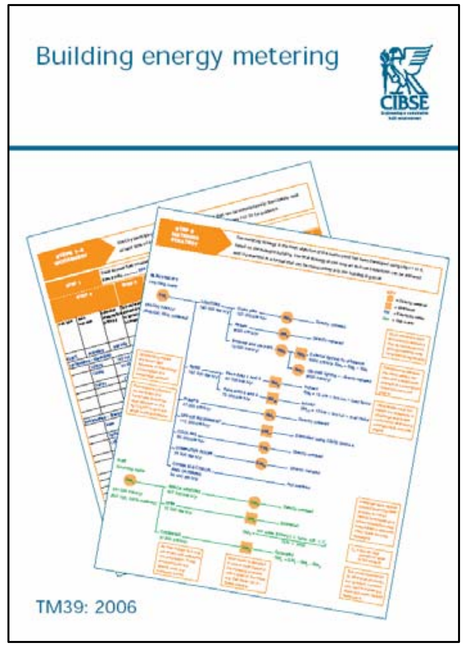
Construction

- For large projects it is recommended that a clerk of works should be responsible for overseeing work on site. For small projects, a member of the design team or client maintenance team should be responsible.

Operation

- It is also recommended that provision is made within the project programme and budget for seasonal commissioning of systems in the first 12 months of operation. Systems should be tested at full load and part load seasonal conditions.
- In use, figures should be compared with design figures. Therefore there is a responsibility on the design team to produce realistic figures and on the client and occupants to use the building correctly and as designed.





Metering, Log Books and Asset Rating

The provision of metering and Building Log Books is intended to assist the user to run a building more efficiently. Knowledge is power. Efficient use is impossible without a good understanding of how a building should be run and how well it is performing.

The project manager should also be aware of:

- The overall metering strategy.
- What will be included in the Building User Guide and how it will be used.

Metering

A structured metering strategy should be provided in accordance with CIBSE Guide TM 39 Building Energy Metering. This is not just advice; it is a requirement of the building regulations.

A metering strategy is needed on all new buildings to be able to monitor 90% of all energy use. This needs to include primary supplies, major pieces of equipment and sub-metering of zones or floors.

Metering requirements for refurbishments is not as simple, but fundamentally any systems that are altered will need to be metered.

Methods

Building Regulations are flexible to allow for various metering strategies. Direct metering is best but can be impractical or uneconomic in certain situations. The acceptable metering methods are:

- Direct metering.
- Estimation from hours run.
- Indirect metering.
- Estimation by difference using two meters.
- Estimation of small power loads using specific guidance outlined in Good Practice Guide GPG 118.

Meters are only useful if the information is easily available and used. Manually read meters can provide basic information. Meters with pulsed outputs can be connected to a Building Management System (BMS). These allow information to be automatically downloaded and acted upon.

Consultant energy predictions, benchmarks and “out of boundary” warning alarms can be used to identify energy waste.

There is no point in having the information unless it is acted upon. Meters are only useful if they are used to monitor use. “Out of boundary” alarms can be used to save 5% of a building’s energy use.

Building Log Books

A Building Log Book should be provided in accordance with CIBSE Guide TM 31 Building Log Book Toolkit. This is not just advice; it is a requirement of the Building Regulations. There is a legal requirement to have a log book, there is no requirement to use it.

A Building Log Book should describe how the building is designed and how it is to be serviced. It also provides a means to log the energy use and maintenance of the services within the building.

It should be a non-technical guide like an owner’s manual for a car. It can be contained in the Operation & Maintenance (O&M) manuals, but must be an extractable or ‘stand alone’ section. It can be paper based or electronic.

For new buildings the Log Book should be provided for all the systems. For refurbishments, only systems that are altered need a Log Book.

Metering, Log Books and Asset Rating

Asset Rating

A consequence of the EU's Energy Performance of Buildings Directive is that buildings will need to be rated in terms of energy. Target figures have not been agreed but buildings performing below 2006 standards are likely to be rated poorly.

The Log Book will play a pivotal role in the management and control of energy and water consumption. It will assist in the predicted carbon emission rates and assist in identifying ways to achieve a better score. In time these ratings will have a high impact on people's perceptions of the building.

Feasibility Early Design

- Ensure that the metering strategy is outlined and agreed with the facility manager.
- Ensure that the client has committed to using the Building Log Book.

Design Development

- Ensure that the metering strategy is updated as the design develops.
- Ensure that the metering is not lost as part of value engineering procedure.

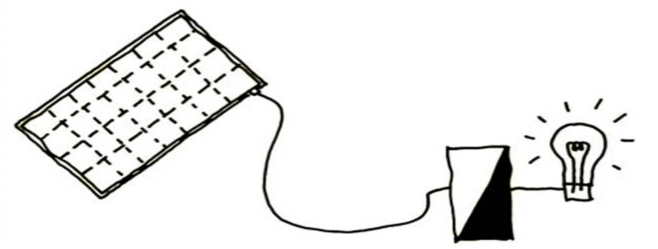
Construction

- Ensure that a Building Log Book is completed before handover and that it contains metering strategy.

Operation

- Ensure that the client is aware of how the Building Log Book and metering strategy is to be used and how it will affect maintenance issues.
- When legislation demands an asset rating to be produced, confirm that it is produced and displayed in the building.

Renewable Energy



Photovoltaic Panels

Solar photovoltaic (PV) materials generate electricity directly from daylight at around 15% efficiency. This electricity can be integrated into the main electrical distribution or set up as a stand alone system.

Systems generally supply around 100W/m², and 100-150kWh/year/m². This means a large area is required to supply a small amount of electricity.

Photovoltaics can be integrated in inclined or vertical south-facing roofs and elevations to make best use of natural daylight. The best angle is 30° above horizontal.

Their cost per square metre reduces as the size of the installation increases. Large installations can cost +£750/m². This means that they are extremely expensive. Payback periods are usually 25+ years.

They become more viable when their cost is partially offset by doubling up their use (e.g. being used as an external roof or wall element. They are also economic when it is expensive to provide wiring to remote units (e.g. pay and display machines).

Grid connected 230V systems can supply energy back into the grid if more electricity is generated than required. An interface unit is required so that the electricity generated by the panels matches the cyclical phase of the mains electricity.

Feasibility Early Design

- Confirm specific planning and building control requirements.
- Ensure design team review technology as part of an initial renewable energy study.
- Ensure that the opportunity to integrate PVs into the design has been considered.
- If on the external façade, ensure they have been included in the planning application.

Design Development

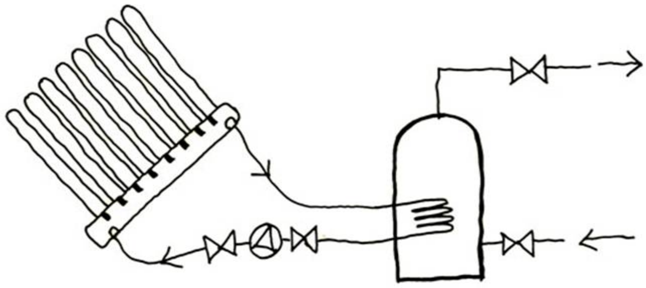
- If appropriate, ensure design team review technology as part of a detailed renewable energy study.
- Ensure that design and installations have been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated and secured where available.

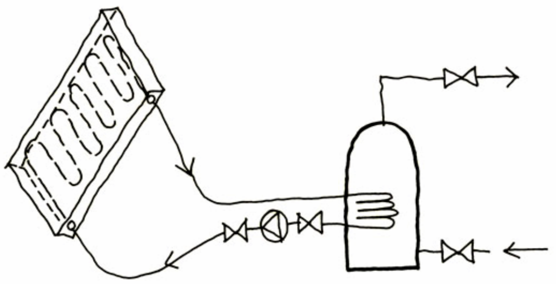
Construction

- Ensure that interfaces between contractors are agreed before delivery.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure client is aware of maintenance issues.





Solar Thermal Collectors

Solar thermal collectors can provide heat for the domestic hot water needs of the building. They produce most of their heat in summer so are not well matched to providing heating.

There are two types of solar collectors:

- Flat plate – work in all conditions, but work most effectively in direct sunlight. They are more robust that evacuated tubes and are generally cheaper.
- Evacuated tubes – work in all conditions, most notably in diffuse radiation that makes them ideal for climates such as the UK. This is the more efficient for the area of collector.

Whichever type is used, the collectors should be located on inclined or vertical south-facing roofs and elevations to make best use of natural daylight. They can supply around 400kWh/year/m^2.

The integration of the collectors with the hot water design is required to ensure their success. They are most efficient when combined with a traditional hot water storage system.

The optimum design is for the collectors to provide around 75% of the hot water load in summer and 20% in winter.

Leaks are the main problem with this type of system, especially the transfer medium in the tubes. A way of dumping excess heat in summer needs to be provided to avoid overheating.

The risks of legionella has to be considered at all times when designing solar hot water systems.

Feasibility Early Design

- Confirm specific planning and building control requirements.
- Ensure design team review technology as part of an initial renewable energy study.
- Ensure that the opportunity to integrate panels into the design has been considered.
- If on the external façade, ensure they have been included in the planning application.

Design Development

- If appropriate, ensure design team review technology as part of a detailed renewable energy study.
- Ensure that design and installation have been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated and secured where available.

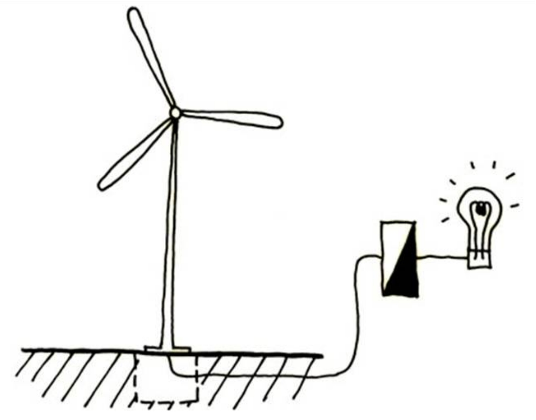
Construction

- Ensure that interfaces between contractors are agreed before delivery.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure client is aware of maintenance issues.

Renewable Energy



Wind Turbines

Wind turbines produce electricity by harnessing the energy of the wind using aerodynamic blades. This electricity can be integrated into the main electrical distribution or set up as a stand alone system.

They offer a good potential source of energy but are dependent on having a windy site. Less wind is required than might be expected.

Typically for a small 6kW installation, the costs are in the order of £25,000 which could provide around 10,000kWh/year. Larger installations can benefit from economies of scale. Second-hand wind-turbines are also available due to the upgrading of turbines in prime sites across the E.U.

A wind turbine's potential for generating energy is directly related to its size. Doubling the blade diameter can increase this potential by a factor of four.

In Dundalk, Ireland, an 850kW turbine was installed that provided excess electricity to the site. Its payback period was 8 years.

Grid connected 230V systems can supply energy back into the grid if more electricity is generated than required.

An interface unit is required so that the electricity generated by the turbine matches the cyclical phase of the mains electricity.

Feasibility Early Design

- Confirm specific planning and building control requirements.
- Ensure design team review technology as part of an initial renewable energy study.
- Ensure that integration issues have been considered.
- Ensure that proposed turbines are included in the planning application.

Design Development

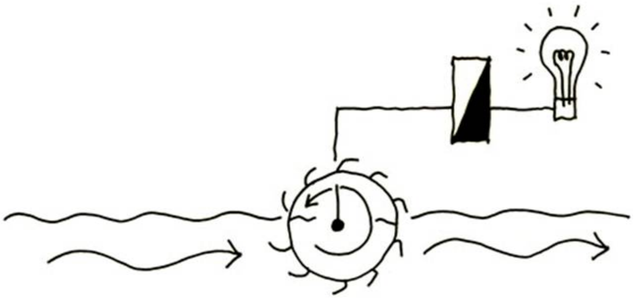
- If appropriate, ensure the design team review technology as part of a detailed renewable energy study.
- Ensure that design and installations have been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated and secured where available.

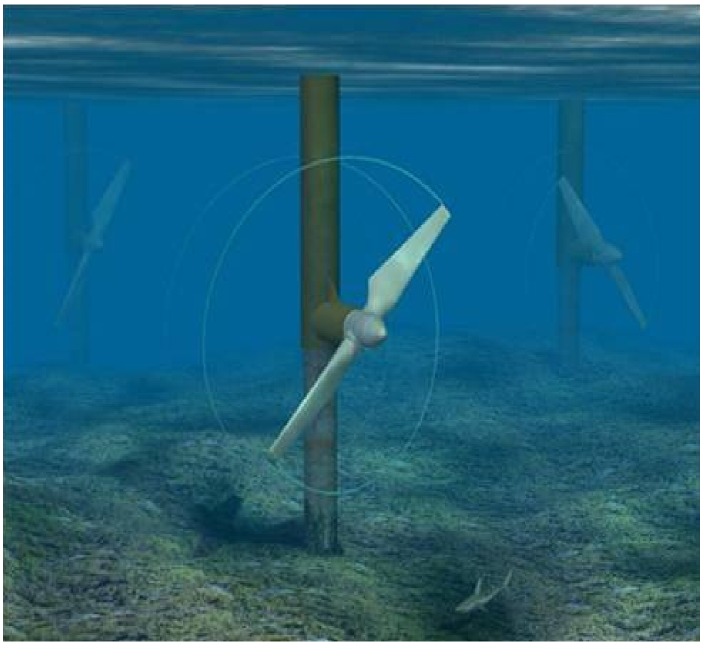
Construction

- Ensure that interfaces between contractors are agreed before delivery.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure client is aware of maintenance issues.





Hydro Electric

Hydro electric turbines produce electricity by harnessing the energy using aerodynamic blades in the water. This electricity can be integrated into the main electrical distribution or set up as a stand alone system.

They offer limited potential due to their need for a large source of either fast flowing water, tidal flow or water falling from a great height. The electrical energy they can produce is directly related to this.

Grid connected 230V systems can supply energy back into the grid if more electricity is generated than required. An interface unit is required so that the electricity generated by the panels matches the cyclical phase of the mains electricity. The loads that they generate are limited.

Tidal generation is currently being developed and on a large scale and could be considered for projects by the coast.

Feasibility Early Design

- Confirm specific planning and building control requirements
- Ensure design team review technology as part of an initial renewable energy study.
- Ensure that integration issues have been considered.
- Ensure that proposed turbines are included in the planning application.
- Ensure that discussions have been undertaken with the Environment Agency.

Design Development

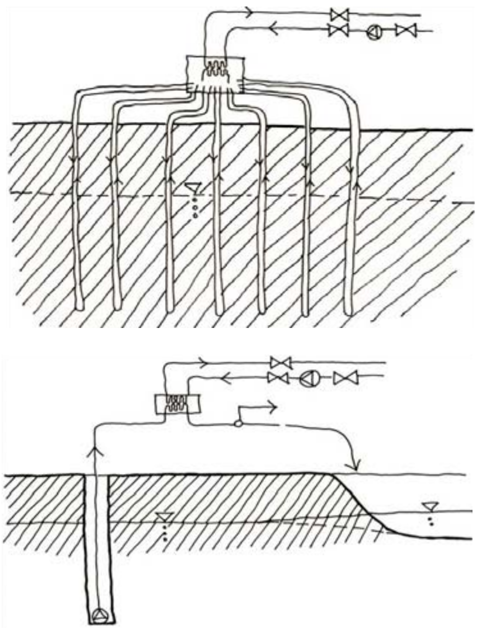
- If appropriate, ensure the design team reviews the technology as part of a detailed renewable energy study.
- Ensure that design and installations has been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated and secured where available.

Construction

- Ensure that interfaces between contractors are agreed before delivery.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure client is aware of maintenance issues.



Energy from Ground

Groundwater temperatures remain stable throughout the year, with typical temperatures for the UK around 12°C.

Ground source heat pumps (GSHP)
GSHP are a mechanical system that can harness the earth to provide both heating and cooling. It is more economic if both are provided.

This solution is not a true renewable energy source because it requires electricity to drive pumps and compressors. However the efficiencies are such that far more energy is provided than used.

The potential solutions are:

- Open loop - the ground can be used to provide energy either by drawing water out of the ground or lake, and passing it through a heat exchanger.
- Closed loop - pumping a heat exchange medium into the ground via plastic pipework system buried in the ground.
- Thermo active foundations – a closed loop system where the pipes are run in the piled foundations of a building. GSHP are extremely expensive but the systems have a relatively low maintenance cost.

Once installed, no maintenance is required to the pipework only the associated pumps and equipment.

The initial capital costs are expensive. For instance, a 200kW installation could cost around £200,000. Costs can be reduced if the water is needed for external uses or if landscaping allows pipes to be installed in the ground cheaply.

If equipment is placed in the ground, or affects a water course, it must be approved by the Environment Agency. When water is extracted from a borehole, a British Geological Survey should be carried out. This will allow the potential for extraction flow rates to be discussed with a drilling contractor.

The temperatures that can be achieved (40-45^{o}C) are lower than a conventional heating system (75-80^{o}C).

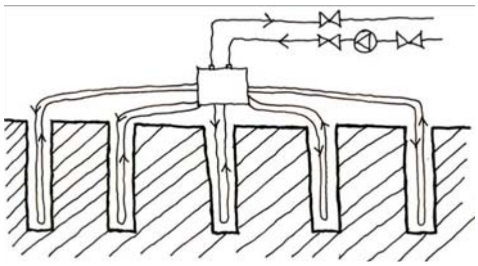
This means that if used for heating it is more suitable for underfloor heating or in an enlarged heating coil in an air handling unit.

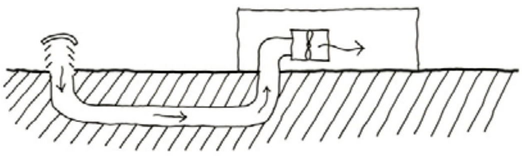
For cooling it works well with chilled beams and panels.

If a heating and cooling system can be designed so that only one or other is required, a GSHP can be used to provide energy from both systems.

GSHP systems can become economically viable for buildings that have simultaneous heating and cooling loads. Alternatively if two buildings in close proximity have mixed loads, such as an IT block and a creche, this principle can also be applied.

Additional savings can be achieved if the pipework that is installed can be incorporated into the piles. This way two elements of the construction can be absorbed into a single cost.





Energy from Ground (cont.)

Earth Tubes
A more passive solution to harnessing the earth's energy is to use earth tubes or labyrinths.

They reduce the energy consumed in mechanical ventilation systems by preheating air in winter and cooling it in summer. Fresh air is drawn through tubes in the ground which expose the air to the earth's stable temperature.

The degree to which the air is tempered is dependent on the external temperature and the surface temperature of the pipe.

The cost is dependant on the cost of the earthworks involved, but could be in the order of £100-200/m run of pipe. A typical length of pipe would be around 30-40m.

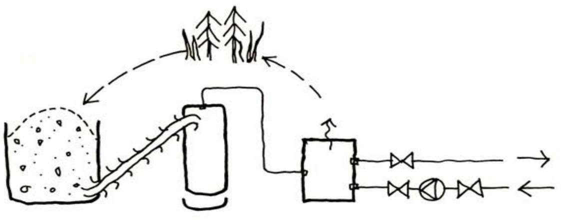
Earth tubes can be highly effective if designed and installed correctly. Temperatures drop in the order of 5^{o}C have been recorded in summer and similar increases have been recorded in winter.

Feasibility Early Design
- Confirm specific planning and building control requirements.
- Ensure design team reviews technology as part of an initial renewable energy study.
- Ensure that integration issues have been considered.
- Ensure the possible provision of both heating and cooling has been considered.
- Ensure that proposed turbines are included in the planning application.

Design Development
- If appropriate, ensure design team reviews technology as part of a detailed renewable energy study.
- Ensure that design and installation have been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated and secured where available.
- Ensure that discussions with the Environment Agency and the British Geological Survey have been carried out and that that all required notices have been issued.

Construction
- Ensure that interfaces between contractors are agreed before delivery.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation
- Ensure client is aware of maintenance issues.



Bio-Fuels

All bio-fuels work on the same principle. A renewable source is grown directly (or as a by-product of another process) and combusted to provide energy.

The fuels are in theory carbon neutral as they only release energy that has been absorbed by the growing medium.

In reality, they are a low carbon source because of the energy involved in supplying the fuel to the site.

Biomass is the most common form of bio-energy used in buildings. This is typically a material, such as sawdust, wood chip or wood pellets which is burned in a boiler to provide heat.

These boilers are less sophisticated that modern gas fired boilers and their control needs to be considered carefully. Capital costs are more expensive than normal boilers but are relatively cheap compared to other forms of renewable energy. The challenge is the supply chain and the physical size of the installation.

Some parts of the country are not well located to receive deliveries of biomass. Security of supply is vital if this fuel source is to be used.

Providing space to store the fuel is also difficult. For a 150kW installation, a 3m x 3m x 3m storage space would provide enough fuel for 2-3 weeks. This does not take into account the additional space required for the delivery space, and the additional building structures required.

A biomass boiler potentially provides the most economic solution to meet the renewable energy target. The cost of a 150kW boiler would be around £40,000. However this does not take into account the costs for the hopper, the additional structure required to house an installation and the associated loading equipment.

Maintenance is also an issue. They need regular maintenance and cleaning which require the unit to be shut down. Biogas and biodiesel are alternative fuel sources. Both require equipment to produce the fuel. This generally means that they are more expensive than biomass. This might change with the increase in interest in alternative fuels by the motor industry.

The combustion of waste is not discussed here as it is more suitable for a large scale infrastructure development.

Feasibility Early Design

- Confirm specific planning and building control requirements
- Ensure the design team review technology as part of an initial renewable energy study.
- Ensure that integration with other traditional systems has been considered.
- Ensure that chimney and system are included in the planning application.

Design Development

- Ensure design team review technology as part of a detailed renewable energy study.
- Ensure that design and installation have been considered and solutions agreed.
- Ensure that the delivery issues have been discussed with the client and that storage space has been provided.
- Ensure funding opportunities have been fully investigated and funding secured where available.
- The combination of biomass and CHP technology would prove to be extremely efficient. The limitation is the amount of manufacturers currently providing this equipment.

Construction

- Ensure that interfaces between contractors are agreed before delivery.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure client is aware of maintenance issues.

Water Efficiency

Rainfall has decreased significantly in the UK over the last 25 years. However, the demand for water is increasing. This is especially the case in Universities.

There are a range of reasons for this increase. These include greater provision of catering facilities in buildings, increased facilities for individual students and a greater demand for water used in research.

The primary benefits of saving water are environmental and economic. However they can reduce supplier fees and infrastructure charges which most universities are keen to achieve.

Environmentally water efficiency reduces the volume of water extracted from rivers and its associated pollution due to processing mains water. Pollution issues associated with discharging water to drains is also produced.

The cost of most efficient installations is minimal. They may be more expensive than some alternative installations but the cost relative to the overall cost of the project is likely to be small.

Systems that should be used include:
- Use low flush WCs.
- Repair faulty float operating valves on WCs and tanks.
- Use percussion and low volume spray taps.
- Replace the washers on dripping taps
- Use manual urinal flushing.
- Use infra red controls to ensure water is supplied only when demanded.
- Use mechanical solenoid valves to isolate supplies to reduce leaks.
- Use water efficient washing machines and dishwashers.
- Recycle water that has been used for cooling purposes in experiments.
- Use leak detection so that system leaks can be identified and losses restricted.
- Use water meter connected to a BMS to allow accurate management and targeting.
- Pressure test water pipework to identify concealed leaks.
- Avoid excessive boiler blow-down (steam plant).
- Avoid uncontrolled humidification plant and systems that may cause leigonella.

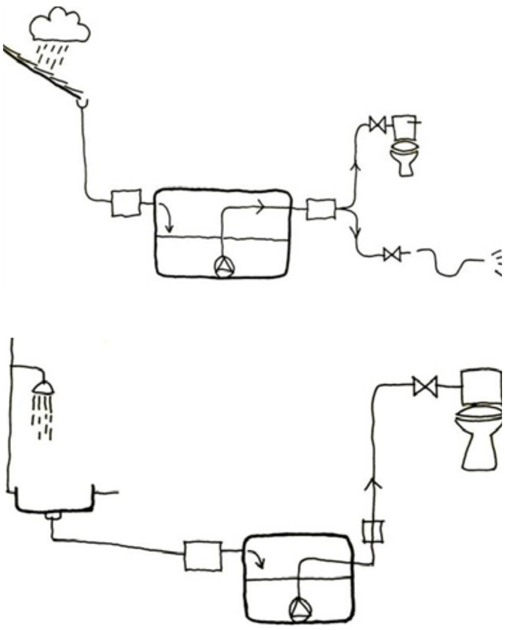
Feasibility / Early Design
- Ensure that water efficiency and client expectations are identified in the brief.
- Ensure that design targets are clearly identified.
- Ensure that integration issues have been considered.

Design Development
- Ensure that simple rather than complex systems are used.
- Ensure that design and installation have been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated and funding secured where available.

Construction
- Ensure that contractors are aware of water efficiency issues in the design.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation
- Ensure client is aware of maintenance issues and adequate training is provided.
- Ensure a water saving programme will be put in place.

Water Measures



Water Recycling

The aim of recycling water is to reduce the use of mains water that has been treated to drinkable standards. For processes such as toilet flushing, this level of quality is not required. Recycled water is more than suitable for such purposes.

The two main solutions are rainwater harvesting and grey water harvesting.

Rainwater Harvesting

Rainwater harvesting, at its simplest, is storing water that has fallen on a roof and collected in a water butt for use.

Water is generally collected from roofs as this is unlikely to be polluted. Water that has landed on the ground is more likely to be contaminated.

More complicated systems require tanks to store the water and filters to remove contaminants. For large projects, the storage tank should be located at low level or below ground. A submersible pump moves the water to the point of demand. An overflow is also required.

It is possible to provide drinking quality water, but special consideration is required. These systems are more expensive to install.

The economics come down to storage size and use. The correct balance has to be made so that excess capacity is not provided. Recycled water can offset water supply charges but also has to include additional equipment, pipework and maintenance costs.

A rainwater system is unlikely to pay for itself, but should be selected on all large jobs as long as the costs are not prohibitive.

Grey Water

This is recycling of waste water from baths, showers and wash to flush toilets. The water is collected and filtered before being stored ready for use.

There is a "personal use" issue with grey water. People generally do not like to use somebody else's dirty water so they have traditionally been used on a domestic basis where you only use your own water.

Due to the filtering of the water, the quality of the water is generally good. It suffers from the same economic issues as rainwater recycling but also has the personal use issues.

Feasibility / Early Design

- Ensure the design team review use as part of the initial design.
- Ensure that integration with other traditional systems has been considered.
- Ensure that client has commitment to use system.
- Ensure evaluation of potential water uses has been undertaken.

Design Development

- Ensure that systems catchments and load profiles have been assessed in detail.
- Ensure that design and installation have been considered in relation to architecture, cost and solutions agreed.
- Ensure funding opportunities have been fully investigated and funding secured where available.
- Ensure that all appropriate health issues have been addressed.

Construction

- Ensure that interfaces between contractors are agreed before installation.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure that the client is aware of maintenance issues and fully trained in using system.

Drainage

Buildings can have a significant impact upon drainage patterns of a site. Reducing discharge will reduce the discharge costs paid to water authorities

Minimising water discharged to drains reduces local flooding along with erosion and flooding further downstream. Reducing water discharge also reduces the chances of sewage being discharged directly into water courses due to overcapacity of the drainage system.

The use of sustainable urban drainage systems (SUDS) assists this reduction. They replenish natural ground water reserves by allowing water to seep back into the ground rather than being run to drain.

The most common techniques are:

1. Porous hard surfaces for play areas and parking areas.
2. Storm water run-off and retention via swales and natural wetland. (These can also be used to deal with sewage treatment if correctly designed).
3. Potential re-use of surface water collected for irrigation.
4. Green roofs can attenuate discharge from roofs by 50%.

Each site needs to be considered on its merits. Ground conditions, site boundaries and existing run-off capacities need detailed consideration.

Feasibility / Early Design

- Ensure that client expectation's discharge capacities have been clearly identified.
- Ensure that integration issues with architecture have been considered.
- Ensure that attenuation measures are incorporated into planning application.

Design Development

- Ensure that calculations are undertaken to ensure adequate capacities.
- Ensure that design and installation have been considered and solutions agreed.
- Ensure that ecological issues have been adequately integrated into the design of the systems.
- Ensure funding opportunities have been fully investigated and funding secured where available.

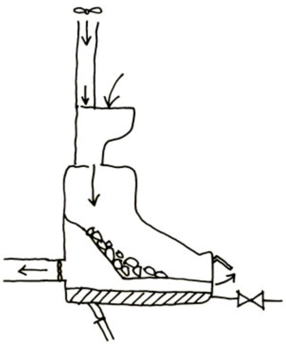
Construction

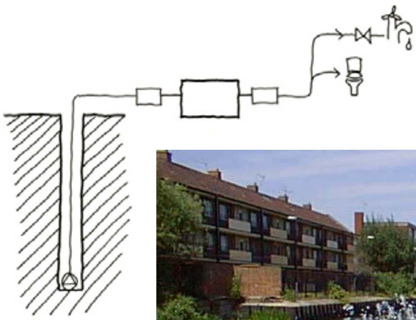
- Ensure that contractors are aware of individual responsibilities.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure that the client is aware of maintenance issues and adequate training is provided.
- Ensure a water savings management programme will be put in place.

Water Measures





Other Water Measures

Composting toilets

Toilet flushing accounts for the majority of water can in most buildings. Composting toilets avoid the use of water by storing the waste and allowing it to biodegrade. This material can then be used for composting.

They are clean and odour free. A small fan maintains a negative pressure that prevents smells from returning into the room. They are relatively inexpensive and avoid the need for large drain connections. Space is required to access the composted material.

It is a novel and environmentally friendlier solution but it is extremely simple and practical.

Ground Water

For certain building such as bioscience and research buildings, large volumes of water will be required. For other heavy demand users, such as the NHS, it is becoming more common to use groundwater either untreated for cooling operations, or treated for domestic use.

If there is a high use it can be an advantage economically. The costs of running and maintaining a pump is much lower than the cost of water supplied by the local water company. The restriction is the initial capital cost of drilling and testing the borehole which is the usual system for extracting water from the ground.

Water Efficient Gardens

Selecting the correct planting is the first priority. Plants and shrubs that need minimal water should be used.

Drippers let water drip into the soil and are controlled by the water pressures. They are best suited to watering plants directly around the roots so that they reduce losses due to evaporation.

A trickle hose, is a plastic hose which is pierced along its length to allow water to seep out. This is best used in long straight lengths.

Rain sensors can reduce watering. The system can be turned back on when hygroscopic sensors in the ground dry out.

Time clocks and pre-set flow limiters can be used to minimise over-use.

Monitoring can be used to identify leaks. This system can be stand alone systems or linked to a BMS system.

Feasibility / Early Design

- Identify if the client is interested in these alternative approaches.
- Ensure that ground water is considered in relation to open loop heating and cooling, and the planning application.
- Ensure that integration issues with architecture have been considered.

Design Development

- Ensure that ecological issues have been adequately integrated into the design.
- Ensure that installations and maintenance have been considered and solutions agreed.
- Ensure funding opportunities have been fully investigated funding and secured where available.
- Ensure that discussions with the Environment Agency and the British Geological Survey have been carried out and required notices have been issued.

Construction

- Ensure that interfaces between contractors are agreed before installation.
- Ensure that adequate commissioning has been programmed and undertaken.

Operation

- Ensure the client is aware of maintenance issues and adequate training is provided.

Introduction

The intention of this section is to identify the key targets that a project manager should ensure are on all projects.

As well as forming part of this document, elements of this section can also be downloaded as a separate Word document from the Energy Consortium website. It is hoped that this information will be adapted as required and incorporated into university project briefs to drive energy and water efficiency in buildings.

The targets will only be useful if they are used and policed. The project manager and the person nominated to champion energy and water efficiency should constantly refer to these targets. They should be used at design team meetings and strategic project reviews.

The information will be most effective if used as part of the brief. If it is used at a later stage it will only be aspirational and therefore less likely to be achieved.

If they are used with words like “aspire to” and “aim to”, design teams will see the targets as flexible therefore, and possible to avoid if required..

It is not intended for this information to form part of a specification. The aim is not to inhibit the designers to use their favoured design solutions.

Project managers have to be strong with these targets. They should not allow a building to fail. Failure would indicate that the design or the costings were flawed from the start of the project.

Modern architecture puts too low a value on energy and water efficiency. It should be considered as important as cost and appearance. When the budget is tight, it is usually the £100,000 efficiency measures that are lost rather than the £200,000 spent on the visual appearance.

Evidence

Updates on performance against these targets should be provided at each RIBA design stage and at appropriate stages in the project development. These should be issued by the design team and used as a record of progress on each topic. The report should be brief, easily understood by the client and no more than a page of A4 for each target. Where relevant, it should include information on simple paybacks or Whole Life Costs.

The project manager should compile these reports to act as a record of development. A copy should be issued to the client. The reports can be issued as part of a larger report but should be a section in their own right.

Target Simplicity

Through experience, a number of universities have identified that providing detailed targets does not achieve the desired effect. Energy and water efficiencies are not achieved. Simplicity is the key. Set simple targets that are easily identifiable.

Project managers have a range of issues that they need to address and it is unrealistic to expect them to be energy and water experts. Therefore these targets are intended to be easy to understand and policed. They should be the ammunition for a project manager to challenge a design team’s assumptions.

All of the targets are achievable. Achieving them may involve employing an alternative approach to traditional construction methods. This should not be used as an excuse not to achieve the targets.

Costs need to be addressed if energy and water efficiency is to be achieved. Quantity surveyors need to allow for these levels of efficiency in their original cost plan.

Targets

		New Build/ Large Refurbishment/ Small Refurbishment
1	The client should confirm in writing that they are committed to low energy and water design and that excellence in this area should not be compromised unless it jeopardises the viability of the project.	All
2	On all large scale projects, the client should be informed of the potential energy and water system solutions at each design stage. Whole life costing should be used. Systems with a payback of at least 15 years, or renewable systems with 20 years should be considered. Ideally 60 years should be used for payback analysis. The exact timescale should be defined by the client.	New Build/ Large Refurbishment
3	**15%** - The percentage that the Building Emission Rate (BER) should exceed the Target Emissions Rate (TER) for criterion 1 of Building Regulations Part L2A 2006. (i.e. Carbon Dioxide Emissions 15% below current requirements)	New Build
4	**25%** - The percentage of energy that should be supplied via low or zero carbon systems.	New Build/ Large Refurbishment
5	**20%** - The percentage that energy and water usage should be reduced in existing buildings irrespective of the new use.	Large Refurbishment/ Small Refurbishment
6	Air leakage to be set at 5 $m^3/h/m^2$ for all new build and improvement of 50% on all refurbishments.	All
7	Daylight linked dimming controls should be used on all spaces within 7m of a window.	All
8	**2** – Minimum number of credits to be achieved on BREEAM Water Consumption calculator (Max score 3). To achieve this only best practice low water use fittings and equipment to be used.	All
9	**50%** - The percentage of toilet flushing provided by recycled water subject to a financial viability study.	New Build/ Large Refurbishment
10	**90%** of all energy shall be metered in accordance with CIBSE Guide TM 39 Building Energy Metering. Water to be sub-metered to separate at least 90% of water use by zones.	All
11	The client should commit to using the Building Log Book in writing.	All
12	Updates on all of the above should be provided at each RIBA design stage and at appropriate stages in the project development.	All

Note: Scotland and Northern Ireland have not yet adopted iSBEM as a compliance requirement. However similar tools are to be adopted. These or the iSBEM should be used to confirm compliance with points 2 & 3.

Energy Use

Benchmarks

Benchmarks are a good source of information for understanding how well a building is performing against other similar buildings. Their limitation is the statistical information that they are based on.

They tend to be confusing and often the generic title makes it difficult to know whether the correct benchmark is being used.

It is therefore recommended that benchmarks are not generally used to set specific targets.

They should only be used in broad comparison terms. They should not be used to define success of failure of a project.

The following benchmarks are provided for information only.

Carbon Trust Energy Use Table

Building Type List	Electricity (kWh / m² / year)		Gas or Oil (kWh / m² / year)	
	Typical	Good Practice	Typical	Good Practice
Car Park - enclosed	-	15	-	
Catering	-	650	-	1100
Lecture hall	-	108	-	412
Library	-	50	-	150
Office	-	36	-	95
Other				
Recreation	-	150	-	360
Research	-	105	-	150
Residential	-	85	-	240
Teaching	-	22	-	151

While these are formal good practice figures, well designed buildings can achieve much lower figures than these. New buildings should be able to perform better than these figures.

Source: 2006 Carbon Trust University Guidance Figures

Energy Use

Table 5: Summary HEEPI Energy Performance Indicators kWh/m²/year

Building category	Sample Size (for mean)	Fossil Fuel Performance kWh/m2				Electricity Performance kWh/m2			
		Best	Good	Typical	Range	Best	Good	Typical	Range
Admin/support	22	88	107	166	70-591	28	46	90	17-331
Sports centres	8	138	ID	325	138-826	88	ID	199	58-643
Libraries	3	73	ID	176	73-296	73	ID	186	73-234
Residences	37	126	198	240	30-387	35	47	57	35-271
Teaching	36	46	88	240	46-844	31	41	118	22-518
Labs –medical & biosciences	15	75	121	256	24-569	177	250	325	75-606
Labs – Engineering – phys sciences	24	15	92	148	12-338	66	93	130	58-259
Labs – chemical sciences	7	97	ID	242	41-400	156	ID	287	156-408
Computing - Maths	11	40	ID	105	40-175	114	ID	106	27-217

Note the data excludes extreme values
Note the 'good' fossil fuel and electricity values do not add up to the 'good' total value
Note best examples are for the building with the best total energy performance in each category, and the corresponding fossil fuel and electricity. This means there may be better fossil fuel and electricity performance for different buildings, i.e. the range for fossil fuel and electricity may reflect better (i.e. lower) values

Source: 2006 HEEPI, Higher Education Environmental Performance Improvement

Energy Use

Table 7: Comparison of HEEPI "Good" Buildings with "Good" National Yardsticks

Building Template	Fossil Fuel kWh/m²/year			Electricity kWh/m²/year		
	HEEPI	**Value for Money (1)**	**Carbon Trust**	**HEEPI**	**Value for Money**	**Carbon Trust**
1. Offices	107	90	75-92 (2)	46	60	32-188 (2)
2. Sports Centres	Insufficient Data	158-238 (3)	100-573 (4)	Insufficient Data	69-158 (3)	64-167 (4)
3. Libraries	Insufficient Data	104-156 (5)	150 (6)	Insufficient Data	41-263 (5)	50 (6)
4. Residences	198	180-216 (7)	240 (8)	47	41-77 (7)	85 (8)
5. Mixed HE	No data	No data	185 (9)	No data	No data	75 (9)
6. Teaching	88	90 (10)	151 (11)	41	60 (10)	22 (11)
7. Support (Admin/support)	As for offices	52-80 (12)	As for offices	As for offices	34-104 (12)	As for offices
8. Laboratories	121 (13)	99	No data	250 (13)	140	No data

(1) Value for Money Initiative, Energy Management Study in the Higher Education Sector, London: HEFCE, 1996. Figures normalized for degree day region.
(2) Range based on 4 office types: (a) naturally ventilated, cellular; (b) naturally ventilated, open plan; (c) air-conditioned, standard; (d) air-conditioned, prestige. Carbon Trust, 2000, Energy Use in Offices, ECG019
(3) Lower value for dry sports; higher value for wet sports
(4) Range based on 7 sports centre types: (a) local dry sports centre; (b) 25m swimming pool centre; (c) leisure pool centre; (d) combined centre; (e) fitness centre; (f) sports ground changing facility; (g) ice rink. Carbon Trust, 2001, Energy Use in Sports & Recreation Buildings, ECG078
(5) Lower value for naturally-ventilated libraries, higher value for air-conditioned libraries
(6) Carbon Trust, 1997, Energy Efficiency in Further and Higher Education, ECG054
(7) Lower value for self-catering residences, higher value for halls of residence.
(8) Value for Total Residential. Carbon Trust, 1997, Energy Efficiency in Further and Higher Education, ECG054
(9) Value for Total Academic, based on typical room usage at average HE Campus. Carbon Trust, 1997, Energy Efficiency in Further and Higher Education, ECG054
(10) Based on Academic, Arts
(11) Based on Teaching. Carbon Trust, 1997, Energy Efficiency in Further and Higher Education, ECG054
(12) Lower value for naturally-ventilated administration, higher value for air-conditioned administration
(13) Based on biosciences/medical excluding those with highly serviced animal housing

Source: 2006 HEEPI, Higher Education Environmental Performance Improvement

Lighting Levels

Table 1.12 Examples of activities/interiors appropriate for each maintained illuminance

Standard maintained illuminance (lux)	Characteristics of activity/interior	Representative activities/interiors
50	Interiors used rarely, with visual tasks confined to movement and casual seeing without perception of detail	Cable tunnels, indoor storage tanks, walkways
100	Interiors used occasionally, with visual tasks confined to movement, and casual seeing calling for only limited perception of detail	Corridors, changing rooms, bulk stores, auditoria
150	Interiors used occasionally, with visual tasks requiring some perception of detail or involving some risk to people, plant or product	Loading bays, medical stores, switchrooms plant rooms
200	Continuously occupied interiors, visual tasks not requiring perception of detail	Foyers and entrances, monitoring automatic processes, casting concrete, turbine halls, dining rooms
300	Continuously occupied interiors, visual tasks moderately easy, i.e. large details > 10 min. arc and/or high contrast	Libraries, sports and assembly halls, teaching spaces, lecture theatres, packing areas
500	Visual tasks moderately difficult, i.e. details to be seen are of moderate size (5–10 min. arc) and may be of low contrast; also colour judgement may be required	General offices, engine assembly, painting and spraying, kitchens, laboratories, retail shops
750	Visual tasks difficult, i.e. details to be seen are small (3-5min. Arc) and of low contract: also good colour judgement may be required	Drawing offices, ceramic decoration, meat inspection, chain stores
1000	Visual tasks very difficult, i.e. details to be seen are very small (2–3 min. arc) and can be of very low contrast; also accurate colour judgements may be required	General inspection, electronic assembly, gauge and tool rooms, retouching paintwork, cabinet making, supermarkets
1500	Visual tasks extremely difficult, i.e. details to be seen extremely small (1–2 min. arc) and of low contrast; visual aids and local lighting may be of advantage	Fine work and inspection, hand tailoring, precision assembly
2000	Visual tasks exceptionally difficult, i.e. details to be seen exceptionally small (< 1 min. arc) with very low contrasts; visual aids and local lighting will be of advantage	Assembly of minute mechanisms, finished fabric inspection

* Maintained illuminance is defined as the average illuminance over the reference surface at the time maintenance has to be carried out by replacing lamps and/or cleaning the equipment and room surfaces

Source: 1999 Page 1-24 CIBSE GUIDE A

Carbon Dioxide Emissions

Table 2 CO2 emission factors

Fuel	CO_2 emission factor kgCO_2/kWh
Natural gas	0.194
LPG	0.234
Biogas	0.025
Oil	0.265
Coal	0.291
Anthracite	0.317
Smokeless fuel (inc. coke)	0.392
Dual fuel appliances (mineral + wood)	0.187
Biomass	0.025
Grid supplied electricity	0.422
Grid displaced electricity (1)	0.568
Waste heat (2)	0.018

Notes:
[1] Grid displaced electricity comprises all electricity generated in or on the building premises by, for instance, PV panels, wind-powered generators combined heat and power (CHP) etc. The associated CO_2 emissions are deducted from the total CO_2 emissions for the building before determining the BER CO_2 emissions arising from fuels used by the building's power generation system (e.g. to power the CHP engine) must be included in the building CO_2 emissions calculations.
[2] This includes waste heat from industrial processes and power stations rated at more than 10MWe and with a power efficiency >35%

These figures are taken from the 2006 Building Regulations. They are current but should be verified against the most up to date figures available.

Source: 2006 Page 15 of Part L2A 2006 Approved Document

Design Targets

Water Use

Water Use Table

	Typical	Best practice	Unit	Sample
Office	9.30	6.40	cu.m/person/yr	500
Prison with laundry	143.00	115.30	cu.m/prisoner/yr	144
Prison without laundry	116.60	92.40	cu.m/prisoner/yr	"
Primary school with pool	4.30	3.10	cu.m/pupil/yr	14,330
Primary school without pool	3.80	2.70	cu.m/pupil/yr	"
Secondary school with pool	5.10	3.60	cu.m/pupil/yr	"
Secondary school without pool	3.90	2.70	cu.m/pupil/yr	"
DEFRA laboratory	0.767	0.612	cu.m/m2 floor area/yr	14
Large acute or teaching hospital *1	1.66	1.38	cu.m/m2 floor area/yr	273
Small acute or long stay hospital *1 without personal laundry	1.17	0.90	cu.m/m2 floor area/yr	"
Hospital with personal laundry	1.56	1.24	cu.m/m2 floor area/yr	"
Court with catering facilities	0.54	0.35	cu.m/m2 floor area/yr	44
Court without catering facilities	0.25	0.20	cu.m/m2 floor area/yr	"
Museum and art gallery	0.332	0.181	cu.m/m2 floor area/yr	50
Nursing home	80.6	68.50	cu.m/resident/yr	70
College and University	0.62	0.40	cu.m/m2 floor area/yr	127
Public lavatory	10.70	6.00	cu.m/m2 floor area/yr	86
Sports centre	0.0385	0.0305	cu.m/visitor/yr	65
Library	0.203	0.128	cu.m/m2 floor area/yr	89
Community centre	0.326	0.173	cu.m/m2 floor area/yr	62
Fire station	15.08	9.38	cu.m/person/yr	61

Source: 2006 The Watermark project

Transport Energy

The energy required to construct a building can be 30% of its total lifetime energy use.

It is important to remember that achieving building emission targets is only part of the answer in terms of CO_2 emissions.

A limit should be set on the distance that any item of equipment (or for that matter any material) travels to the building.

A site record of all distances travelled by main building components should be recorded and logged in the Building User's Guide.

It is recommended that a sourcing should be limited to the UK if possible.

Typical figures below show the impact of travel distance on Carbon Dioxide Emissions.

Typical emissions table

3.5 $kgCO_2$	=	10 miles in a truck
70 $kgCO_2$	=	200 miles in a lorry
380 $kgCO_2$	=	1000 miles in a lorry, + transport across English Channel
3700 $kgCO_2$	=	Airplane journey from Asia (e.g. Singapore to Heathrow, 10877km)

Note: this final figure is equivalent to heating a 1000m2 building for a year using a gas boiler.

Source:
Lorry emissions taken from http://www.eco-logica.co.uk/WWFreport.pdf
Ferry emissions taken from http://coinet.org.uk/projects/challenge/measure
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