Building Energy Management

.....strategic planning for Education

TREND

Document contents

The fast-track guide to reducing energy and carbon emissions in an educational environment

The Education system is currently undergoing significant transformation and there is continuous pressure to keep costs down especially on non core areas. The cost of energy and other utility bills are increasingly impacting on expenditure as these costs are rising faster than any others. The need to reduce energy bills and save carbon are two of the major issues that face schools and higher education institutions today.

This guidance document outlines the considerations for the strategic development of an effective Building Energy Management System (BEMS) within the Education Sector.

A BEMS typically controls up to 80% of a building's energy requirements. By optimising and maintaing the system – getting it to perform consistently with the way a building is used - it can deliver significant energy savings which can be measured, monitored and be sustained.

Repeatedly, the installation of a BEMS has proved a highly cost-effective way for Schools, Colleges and Universities to cut their energy consumption – frequently making savings of more than 25%. This has often produced similar or greater cost reductions in maintenance expenditure.

...there is a pressing need in the education sector to reduce energy emissions...

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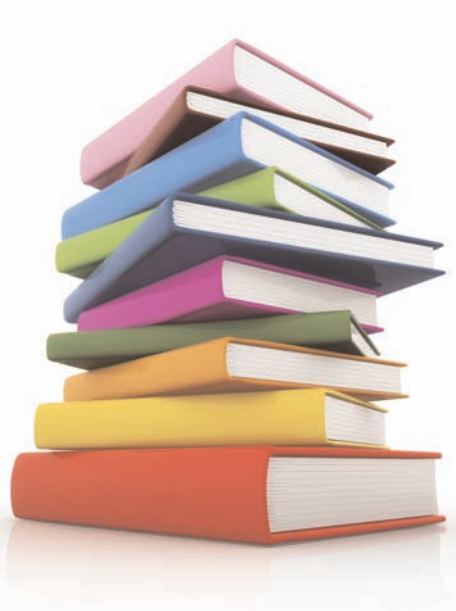


1.0 Introduction

This guidance document outlines the technical considerations for the strategic development of an effective Building Energy Management System infrastructure in the Education Sector.

Current business drivers across the sector mean that energy and carbon reduction is vital, but maintaining or improving comfort conditions for pupils and staff is equally important. Taking a strategic approach to the development of the BEMS will help educational facilities to deliver these targets.

A strategic overview must consider solutions which will meet the individual needs of the varied building types that make up a school or campus; from the local comfort conditions required in the teaching areas, the sustainable operation of support areas and offices to cost effective manageable control of sports halls and extended campus buildings.

Systems must be suitably flexible to meet the requirements of a single, small school whilst still offering more complex options which allow a larger educational facility to centrally manage all of its multi-purpose buildings.

A robust infrastructure is only one element of the strategy. Effective operation can only be realised if the sweep of data collected by the BEMS is transformed into useful information which can be delivered to users where and when they need it. The output can be tailored to individual user groups and web-served across the entire infrastructure if required.

.....providing evidence of the effectiveness of energy based investments

A range of services are available to support a strategic energy plan for education. These include energy controls audits, which have already made significant contributions to the carbon reduction of many schools in the UK, to BEMS energy data that can be linked to the educational curriculum and used to encourage a pro-active approach to energy saving that can be employed throughout the school.

Intelligent support tools can be used to monitor the ongoing system performance, target maintenance activity to deliver continuous improvement and provide unprecedented visibility of building performance.

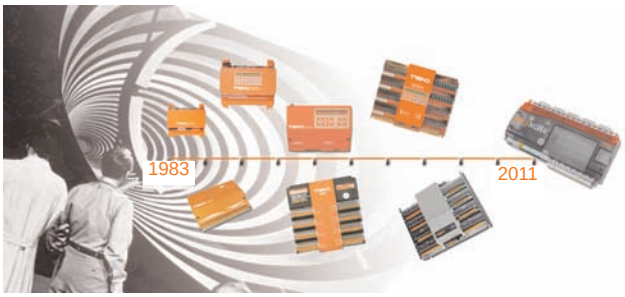
Sustainability can be further improved by ensuring that key building parameters are monitored through the BEMS and evaluated against industry benchmarks providing real-time measurement of a building's environmental performance. This can also help to inform the future designs of sustainable new buildings and systems, and provide evidence of the efficacy of energy based investments.

2.0 Sustainability

An effective BEMS can allow buildings to perform seamlessly and thus free-up businesses to focus on operational issues. This can have a significant impact on operational cost, which is often underestimated in design. The Royal Academy of Engineering estimates the cost ratio for a new building as 1:5:200 for construction, maintenance and operation. Any system which can help to reduce the operational element of the cost base will significantly reduce the whole life cost of the building

2.1 Future-proofing

A sustainable building design must include sufficient flexibility to meet all users needs, while remaining adaptable to design advances throughout the building's life.



In the case of a Trend system, this is enabled by products that are designed to be future proof. New products are largely modular, making expansion and upgrades simple and cost-effective. Migration of communications infrastructure to TCP/IP now allows established protocols to be used and significantly reduces network costs.

The Trend ethos of backward compatibility also means that old and new systems remain compatible and complete replacement is unnecessary. Security of investment is provided by comprehensive warranties which can be extended to match the appropriate life-cycle, or expanded as part of a service level agreement from a range of service providers.

2.2 Service & Support

The Government's advice on sustainable development recommends that, while intelligent systems 'can control virtually every aspect of the building operation' they should be flexible enough to accommodate the specific service requirements of different buildings. It also advises that 'where highly sophisticated systems are used it is important that they are professionally maintained to gain maximum benefit'.

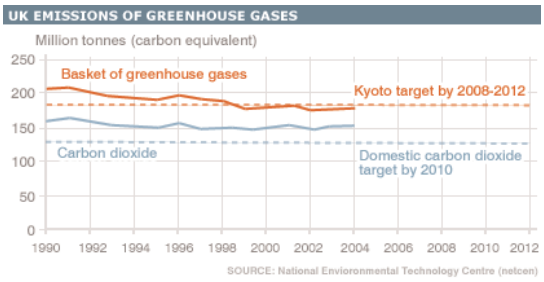
The education sector needs to be satisfied that they can competitively procure a professional maintenance function, which adds value to the operation of the system and helps to optimise performance. It is also critical that system operators be given the knowledge, resources and tools to drive the system effectively.

.....the BEMS will make a significant contribution to minimising CO^2 emissions and assist in compliance of building regulations

Choice of supply is vital and Trend systems are supplied and installed by a network of systems integrators offering a range of services in a competitive marketplace. Operator training is also advised, enabling end users to drive the BEMS effectively to optimise their systems.

2.3 Carbon Reduction

The UK Government's sustainable development policy requires that buildings are constructed to maximise energy efficiency and minimise their impact on the environment. This forms part of the strategy to reduce greenhouse gas emissions in line with the Kyoto Protocol and domestic targets.



The application of intelligent building systems can help address these issues and meet environmental key performance targets. A BEMS which is designed to incorporate energy efficiency best practice will make a significant contribution to minimising CO2 emissions, contribute towards compliance of Part L of the Building Regulations and provide the environmental control, energy data and management procedures measured by BREEAM.

Intelligent building systems can be designed to form an integral part of an Environmental Management Systems such as ISO14001. They can provide a safe and comfortable working environment, reduce consumption of resources, and can provide:

- > Fuel and water consumption data
- > Building performance feedback
- > Emissions data
- > Environmental records
- > Life-cycle assessments
- > Staff awareness tools

A BEMS is also ideal as a monitoring and targeting system (M&T), since it is typically deployed in all parts of the building where energy is consumed, has the technical capacity to monitor and record the field data and, perhaps more importantly, can analyse and react to the information to improve the performance of the building.

To get the best out of a system it is advisable to source a remote energy management service such as that provided by Trend, which applies monitoring and targeting techniques to reduce energy costs and improve building performance. Web-based analysis of building energy performance with consumption profiles and exception reporting can be accessed via a standard web-browser. System performance can also be improved by a remote response service, where specialist engineers with remote access can fault find, monitor and adjust control strategies to maximise the effectiveness of the BEMS.

3.0 Building Energy Management Systems

Modern Building Energy Management Systems are formed from distributed intelligent controllers linked together via a network such as an IT backbone.

In order to control, one has to understand what is happening and therefore there is a requirement to gather information. Certain values are analogue such as temperature, CO2 and light. Other signals are digital such as relay close and DP Switches and some are pulsed like water and gas meters. The controller holds calibration information for each sensor.

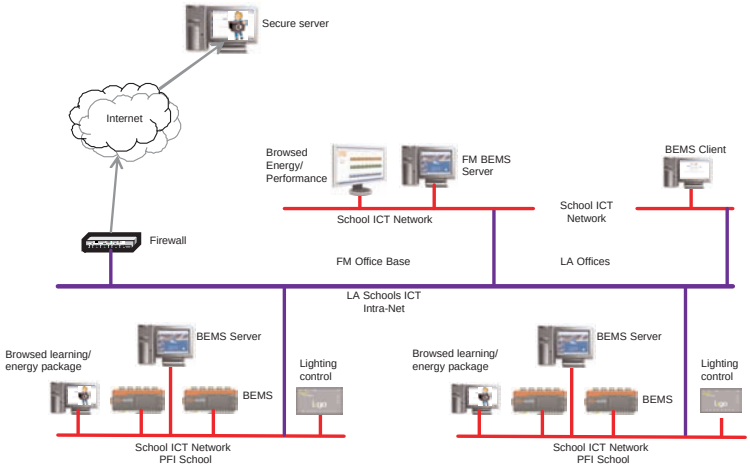
Intelligence is the control strategy, which is created from a sequence of standard firmware blocks that can be linked together. The controls engineer needs to understand the client's requirements in order to piece the strategy together to achieve efficiency and environmental excellence.

Once the strategy has determined the control decision, information is sent to the outputs which are either analogue or digital. But to know what's going on a system needs logging capability to see graphs of performance and alarms for preventative maintenance. Time control is also important in order to set the heating and cooling operations to run to building occupation.

The most effective controllers are fully configurable distributed devices, specifically designed to run on TCP/IP networks with embedded XML web capability to allow remote interrogation by web browsers.

This structure makes interrogation of the BEMS simpler since any PC residing on the site IT network could be given access to BEMS data. The intelligent controllers can be interrogated by a variety of user interfaces including a system supervisor, which can be a Microsoft Windows based graphical supervisor with a full suite of BEMS software functions. Graphical displays in web page format reside in each controller and can be accessed by a full colour touch screen display or by web browsers, such as Microsoft Internet Explorer.

This allows live and historic system information to be accessed and analysed either by the Facilities Management team, Energy Manager or any other building user via a standard PC with web-browser, without the need for proprietary BEMS software.



This graphical information displayed as web pages also makes it possible, perhaps for the first time, to allow all of the building users to interact with the building's systems and provides an excellent tool to promote staff and student awareness. Furthermore, the BEMS connectivity and its capacity to share information with other systems is greatly enhanced and not just limited to BEMS supervisory software.

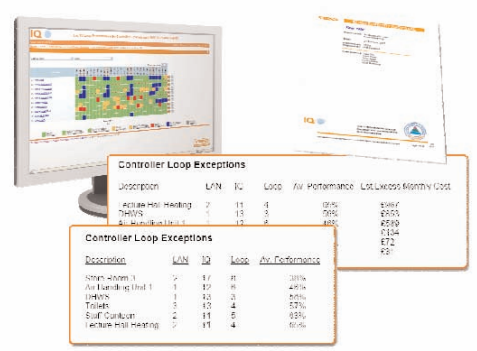
The data can be also used by proprietary maintenance packages (PPM), monitoring and targeting software (M&T), business software such as Microsoft Office, and business systems such as SAP and Oracle.

3.1 Energy Efficient Control Techniques

Building Management Systems bring two major benefits which conventional controls cannot. Firstly, they provide continuous feedback of building performance which allows the user to fine tune the operation of plant. This is further enhanced by alarm reporting and maintenance data which enables proactive management of the building.

Secondly, they are software based and are almost entirely configurable to the users requirements. This ensures an exact fit to the building requirements while offering scope for the application of energy efficient control techniques.

BEMS control strategies



On-line BEMS performance tool

Optimum Start & Stop

The occupancy profile of most buildings means that temperatures need to be achieved for a fixed time start. The length of time for which the heating or cooling must operate to achieve comfort will vary depending on the type of system, building structure and ambient conditions and will therefore constantly vary. An optimiser calculates the 'warm-up' or 'cool-down' time from room and outside temperatures and will continually adjust this calculation to match building needs and maximise energy efficiency.

Optimisers can also provide an optimum stop facility whereby the heating plant can be switched off before the end of occupancy if room temperatures are within comfort levels. This can be particularly effective with the increased use of computers and other heat sources. Most optimisers allow the 'cool-down' period to be overridden before the end of occupancy if there is too great a fall in room temperature.

Weather Compensation

The Building Regulations require weather compensated control to be provided, however, for compensated control to operate efficiently it is essential to incorporate above and below temperature room trim. This ensures that compensated flow temperatures are forced down when the room temperature reaches an upper limit. This control must also incorporate a time element or integral action to ensure that the flow temperature is continually reduced until the room temperature returns to acceptable limits.

The mechanical design allows for a variety of heating types which will be applied across the schools. This means that weather compensation must be sufficiently flexible to ensure that high and low temperature heating mediums are equally as effective. This would be achieved by providing a range standard and shallow slopes. All of the parameters can be made available for user adjustment to maximise efficiency.

....a site can be monitored remotely to measure and record the savings achieved

Override Facilities

The characteristics of most heating systems are such that the heat output does not vary linearly with the heating medium flow temperature. To maintain an acceptable building condition in cold weather the compensator settings permit overheating in mild weather.

The simple solution to this problem is to use a weather dependent switch, which inhibits boilers and pumps on an outside air temperature high-limit to reduce over-heating and avoid the circulation of warm water in mild conditions. This considerably reduces energy usage during spring and autumn. A BEMS is ideally suited to this approach since it networks primary plant control with field demand conditions.

Demand Based Control

One of the benefits of a BEMS is that it can implement global control philosophies between associated plantrooms or on a site wide basis. This allows central plant to be controlled on a zone demand basis. An example of this is to inhibit compensated heating pumps and mixing valves when a room high-limit is reached. If all zones in an area are satisfied, allowing for the demands of domestic hot water, then the boilers can also be disabled which reduces the losses from dry-cycling (running boilers when there is no demand).

Free Cooling

Building Management Systems can be configured to optimise the control of any HVAC system. With air handling plant they can cascade room and extract temperatures to derive a demand based supply air temperature which can, in turn, be accurately controlled to avoid hunting between heating and cooling and to utilise the prevailing ambient conditions to maximum effect.

Free cooling is a simple means of ensuring that the first part of any cooling load is taken up by the available fresh air before forced cooling is introduced.

Enthalpy Control is a more sophisticated technique whereby the recirculation rate is controlled by enthalpy sensors which minimise fresh air intake in cold weather but allow 100% fresh air intake in summer to expand the availability of free cooling.

While remaining relatively simple, the control techniques discussed previously have been proven to make significant energy savings. Combining them with a clear understanding of building occupancy patterns has helped many organisations deliver effective carbon reduction strategies.

4.0 Energy saving by continuous improvement

4.1 Causes of energy waste

Altering control settings such as temperature set points and then not restoring them to their original values is a common cause of excessive energy use. The effect can be the same if parts of a system are manually overridden and then not returned to 'auto' – even to the extent of control linkages being permanently disconnected.

Most buildings undergo change, some very frequently. The use of a particular area could be altered, or floors might be repartitioned. Such changes will generally require system re-optimisation. Failing to do this can lead to heating or cooling of unoccupied areas, rooms being overheated and sensors being wrongly positioned – all of which can have expensive consequences.

Lack of maintenance is another common reason for reduced system performance and increased costs. Whilst BEMS have few moving parts and are generally very reliable, some components such as sensors, valves and actuators can gradually go out of calibration, resulting in lower control accuracy and an increase in energy use.

4.2 Regaining and maintaining control

First, an energy control specialist should be called in to conduct a thorough review of the BEMS and identify opportunities where energy savings can be made. It is very likely that some of these can be actioned on the day of the survey, thus providing an immediate payback.

.....avoid months or years of energy over-consumption

From past experience there is a general set of common control issues that result in energy waste, including:

- heating and cooling operating simultaneously
- inappropriate temperature and humidity setpoints
- demand led control strategies missing
- heating and cooling control loops in need of tuning
- heating and cooling dead bands not set up correctly
- sensors in inappropriate positions or not calibrated correctly
- incorrect time scheduling of plant
- lack of optimum start and stop routines

A survey might also identify how further savings could be made by carrying out more significant changes or additions to the BEMS – like fitting variable speed drives on air handling plant.

Following the survey, a report would be submitted detailing any issues identified, modifications made and expected energy savings - allowing the user to make informed decisions about how to proceed. However, any proposal for additional work should be presented as a fully costed business case, with predicted savings and payback on investment.

A BEMS can record and display energy consumption data. The information can be used as a tool to target specific problem areas or to automatically control plant on a demand basis. Cost centres can also be charged for their proportion of the site energy usage. This promotes ownership and can be very useful in encouraging the user to take simple but effective steps to reduce their own consumption.

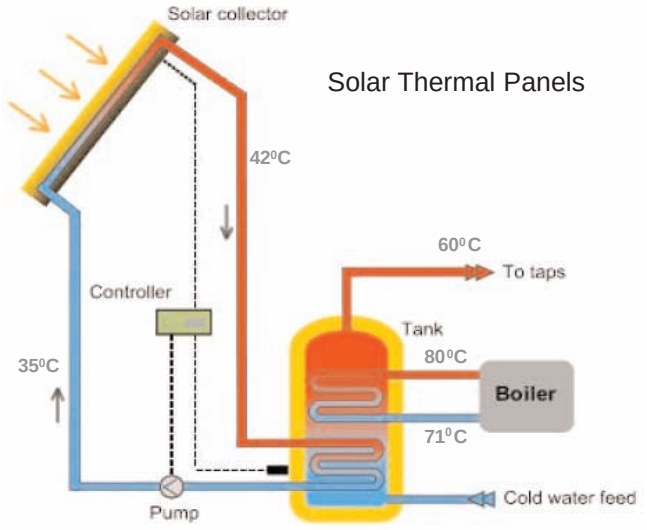
If necessary, other means can be deployed to quickly diagnose the exact cause of energy overuse. For this purpose a web-based BEMS 'performance tool' could be used. This is able to check the functioning of the system – including its control loops and sensors – and can also highlight events such as valves becoming stuck open, controls being manually overridden and other potential sources of energy waste.

The tools described in this section can allow a problem to be identified, diagnosed and rectified in a matter of hours and thus avoid months or even years of energy over-consumption.

5.0 Transforming education

The BEMS collects considerable amounts of useful data, as well as providing energy efficient control for schools, colleges and universities. So why not share the elements of that data that can be used for educational purposes with both students and tutors?

Using a teacher's interactive whiteboard via Internet Explorer, live data from the BEMS can be viewed and used to illustrate energy consumption both numerically and in graph formats and then calculated, helping students to develop an energy saving attitude for life and encouraging a responsible attitude to energy and water.



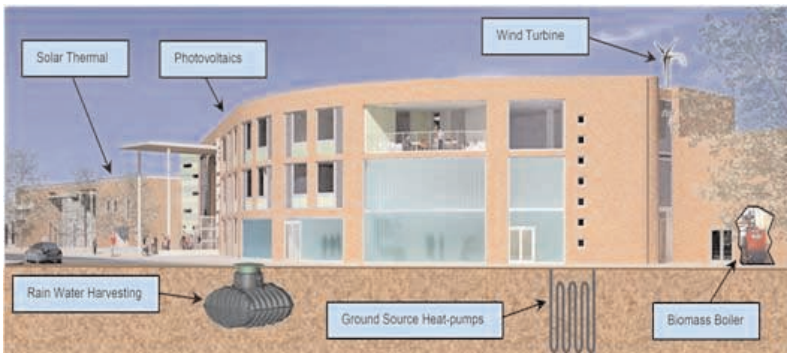
Solar thermal panels collect heat directly from the sun. Water is pumped through coils of pipe within the panel. The water heats up and is then stored in a tank ready to be used when a tap is turned on

Additional information such as that gained from a roof mounted weather station or alternative sustainable energy sources on site can also be accessed and used as part of the curriculum.

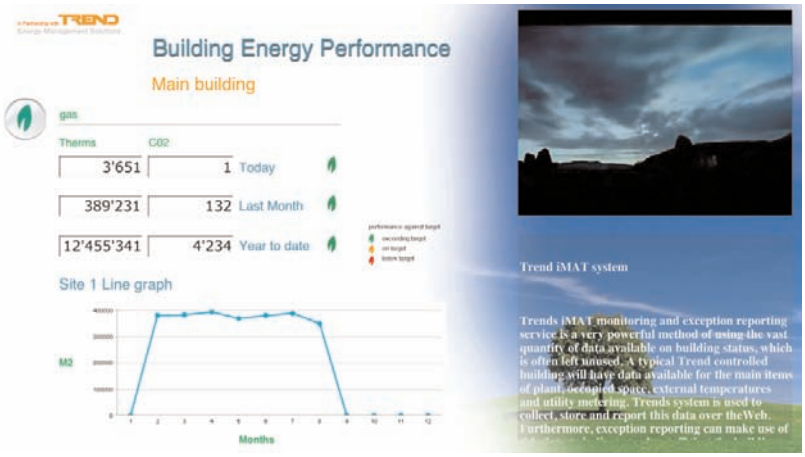
5.1 Sustainable Energy Sources

.....using your own energy data for educational purposes

Educational establishments can use their BEMS to demonstrate their commitment to CO2 reduction and show the impact of their energy saving measures. One way of doing this is through large format display panels that access utility meter readings from a BEMS and present a continually updated record of a building's energy consumption and carbon emissions, showing at a glance whether they are on, below or above performance targets.



Located within a reception area or other communal space, these displays 'bring to life' carbon reduction initiatives such as 'walk to school' days or recycling targets reached. They are a very effective way for schools to publicise their energy efficiency achievements, and thus project a positive image to stakeholders and the local community.



It also provides a highly visible reminder to staff and students that their actions have environmental consequences and should therefore encourage more energy conscious behaviour.

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v1.0 Dec 2010