FUNDAMENTAL

The Continuing Professional Development programme SERIES

WELCOME

Energy in Buildings and Industry and the Energy Institute are delighted to have teamed up to bring you this Continuing Professional Development initiative aimed at energy managers.

This is the first module in the third series and focuses on the latest thinking in building energy management systems. It is accompanied by a set of multiple-choice questions. To qualify for a CPD certificate readers must submit at least eight of the ten sets of questions from this series of modules to *EiBI* for the Energy Institute to mark. ***Anyone achieving at least eight out of ten correct answers on eight separate articles qualifies for an Energy Institute CPD certificate***. This can be obtained, on successful completion of the course, for a fee of £15 (for members) or £25 (for non-members).

The articles, written by a qualified member of the Energy Institute, will appeal to those new to energy management and those with more experience of the subject. The following topics will appear in the next nine issues of EiBI: small-scale CHP; power quality; refrigeration; recent legislation; integrated renewables; fuel cells; the building envelope; water management; and lighting.

If you miss any of the modules during the year let us know (mark.thrower@btinternet.com) and we will send the missing modules to you by e-mail in 'pdf' format.

The previous 20 modules from the first two series are also available free of charge. Please contact me by e-mail if you would like to receive these.

MARK THROWER, MANAGING EDITOR

CURRENT THINKING ON...

BUILDING ENERGY MANAGEMENT SYSTEMS

By Christopher Andrew Norburn

For many years engineers have performed watch-keeping duties in places such as boiler rooms and mechanical equipment centres. They were responsible for monitoring instrumentation and machinery and also for starting up equipment or shutting it down either on a regular schedule or on demand.

As the size and complexity of modern buildings has increased, the efficient and economic operation of mechanical services has become a more complex issue. Assisting engineering staff to address these issues is a major role of the building energy management system.

Today 's commercial pressures demand that companies of all types and sizes reduce overall running costs, cater for more flexible working hours and provide higher levels of comfort. At the same time they are expected to deliver more control to the end- user, to give them the tools to monitor their own environment and to reduce emissions into the atmosphere. A BEMS is designed to fulfil all these and many more requirements.

What is a BEMS?

As the name suggests, the system is intended to manage various aspects of a building or building complex. However, the management and control of energy use in a building is a major consideration when installing such a system.

BEMS are computer-based systems which automatically monitor and control a range of building services such as heating, air conditioning, ventilation, boilers and lighting. An important part of their function, beyond controlling environmental parameters, is to provide data on energy performance to enable energy savings to be targeted.

There are two main types of BEMS: centralised and distributed intelligence (stand-alone). Centralised systems control all the connected site services from a single computer unit. These are the most appropriate for larger commercial or industrial buildings.

Distributed intelligence systems comprise a number of local intelligent outstations, which control individual areas of large buildings or small structures.

Energy efficiency improvements of 10-20 per cent can be achieved by installing a BEMS compared with independent control of individual services. However, there are a number of factors that may limit the actual savings which must be addressed before a system is installed:

- **suitability of existing buildings and equipment:** For a BEMS to work effectively in an existing building, it must be possible to zone the heating, ventilation and lighting systems according to the use made of different areas;
- **correct operation and maintenance:** If existing equipment is not properly maintained or its controls set up incorrectly, then substantial savings can be made by rectifying these areas of concern alone. This may prove a BEMS is no longer cost effective. A BEMS should not be installed to demonstrate how bad or inappropriate the building services are;
- **staff involvement and awareness:** It is essential that the staff who will be operating and maintaining the system are committed to its success. This may involve training on

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all features of a BEMS and how to utilise the information obtainable from the system. All reputable BEMS suppliers will provide continuous training and support.

Energy in the form of electricity, oil or gas is used to light, heat and cool the environment space inside a building. The efficient use of these fuels results in significant savings. In addition, all important comfort conditions within the building are retained. A reduction in the use of any fossil fuel will also considerably improve the environment outside the building.

The components of a BEMS

BEMS are based around microcomputer technology using modern communication techniques which allow multi-site working and remote monitoring using the public switched telephone network (PSTN), radio and satellite systems. There are three basic components: -

- the outstation;
- the operator's terminal;
- the communications.

The outstation is the field device to which all systems to be controlled are connected. It comprises two parts:

- a central processing unit (CPU) which monitors and controls the building services;
- a communication device (or node) which handles all data transfers between the CPU and other connected devices on the system.

The operator's terminal (often called the System Manager) is indicated in Fig 1. The operator's terminal runs the BMS software and also allows the operator to initiate requests to the outstation, e.g. point condition, temperatures etc.

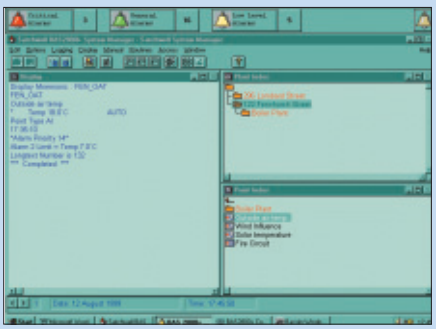

FIG 1- TYPICAL DISPLAY REQUEST SCREEN

It is possible to assign alarms of varying priority to the building services connected to the BEMS. These alarms are configured to be routed to a specified terminal(s). There are many types of alarm that can be configured into the system. Two are:

• **temperature alarms.** These alarms can automatically generate a printout of the emergency procedure to be carried out in the event of an out of range temperature.

• **hours-run alarms.** These relate to the elapsed operating time of plant items and enable accurate maintenance records to be kept.

A BEMS system can be programmed using a variety of point types. These are sub-divided into two groups:

- hardware points (physically connected and wired to the outstation);
- software points (non-physical points and software routines resident in the CPU memory).

These points are set-up and interconnected using an edit point option in the system manager. Points typically available are:

Hardware Points

1. *Status Point* (ST) Also referred to as a digital input point. It is used to monitor the condition of volt-free contacts (for example, relays, airflow switches etc).
2. *Command Point* (CMD) Also referred to as a digital output point. It is used to switch items of machinery on and off.
3. *Analogue Input* (AI) This point measures analogue values comprising resistance, voltages and current inputs.
4. *Analogue Output* (AO) This point gives out a signal which is used to position the actuators of modulating valves and dampers, frequency converters and thyristors to control variable speed drives etc.

Software Points

5. *Rotation Point* (ROT) The rotation point can be used to sequence multiple items of machinery (for example boilers, chillers etc). It also allows the automatic changeover of lead/standby configurations.
6. *Control Point* (CTL) The control point contains algorithms, which are fully selectable. It gives an output in the range of 0-100 per cent.
7. *Calculation* (CAL) Multiple analogue inputs can be fed into this point. It will then calculate the minimum, maximum, or mean output. Recursive action can also be applied to slow down the response of a system using this point.
8. *Meter Point* (MET) This point allows the user to enter a maximum demand limit. The software will then automatically monitor instantaneous energy usage over the maximum demand period and shed or reinstate configured loads as and when required.
9. *Pulse Totalisation* (PLS) Utility meters can be monitored and their outputs totalised to give usage reports and localised billing etc.
10. *Time schedule* (TIM) The Standard Time schedule point provides weekly switching times.

These can be used to automatically switch the system on or off. Additionally, time schedules can be set up in relation to the calendar. They can provide different switching times depending on the time of the year. Further time schedules relative to a master time schedule can be programmed if required. Changing the master time schedule will have a consequential effect on all other time schedules relative to it.

BEMS are based around microcomputer technology using modern communication techniques

11. *Holiday Point* (HOL) The holiday point has multiple available entries in which annual holidays can be pre-programmed to automatically override the system on or off.
12. *Optimiser* (OPT) The optimiser allows systems to be switched on at the latest time possible to achieve occupancy conditions. It has self-adaption algorithms available which allows it to adapt to the thermal characteristics of a building and hence adjust the switch on times accordingly. Three types of optimiser can be programmed into the BEMS: heating, cooling or a combination of both. The optimiser allows for a linear or an enhanced logarithmic algorithm to be utilised
13. *Programmable* (PRG) This point allows complete programming flexibility. It employs a form of basic programming which enables the user to set up complex control schemes, by 'writing down' what the system is required to do. This is limited only by the syntax available.
14. *Degree Day* (DDY) The BEMS allows the user to obtain localised degree-day readings which will enable the close monitoring of fuel consumption through a succession of heating seasons. Energy signature lines and correlation coefficients can then be plotted for the building.
15. *Standby Generator* (SBG) This point allows a power up sequence to be initiated after a site mains failure. This prevents the possibility of the generator picking up the full site load at switch on and then 'tripping out' as a consequence.
16. *Set Point* (SPA) The set point allows the user to have a fixed set point in a control loop or to be able to change the set value according to prevailing weather conditions (for example outside air temperature, solar and wind influence etc). Remote and reset control is also available within the set point.

The BEMS system incorporates the use of Local and Wide Area Networks (LANs & WANs). This gives great flexibility when controlling and monitoring large and sophisticated complexes. The local area network is a physical bus, connected via approved data cabling.

Data logging and presentation

The ability to monitor and manually override, or manipulate, the control of a building's services from any BEMS terminal is of considerable use to those responsible for those services. However, the great strength of a BEMS system lies in its ability to record the sensor readings, intermediate calculations and control responses that it is concerned with. Most current systems have data logging facilities. The key issue is how to present this logged data in a way that enables users to understand how the building is performing and to make modifications to improve performance. The BEMS is concerned with both the gathering and storage of logged information and its subsequent manipulation and presentation to users.

The BEMS gathers data at the outstations. This data is determined by a template from the operator's terminals. The template details which points are to be logged and whether this logging should occur on a regular basis or based on an event (such as an alarm being generated).

The operator may use logged information for a variety of purposes.

- for preventative maintenance using 'hours run' information;
- for corrective maintenance from alarm information;
- for energy monitoring and cost calculations (oil, gas, electrical sub-metering within a building are examples).

Selection from and manipulation of the logged data is a key task of the BEMS.

Trend logging

The trend logging facility built into the BEMS software allows the user to produce dynamically updating, graphical trend logs. The system uses a diagnostic tool to chart the performance of control loops within the system.

A BEMS can make use of a powerful spreadsheet running in a graphical environment. With this facility the user is able to extract data from the BEMS and create spreadsheets tailored to specific management information needs. Software such as Microsoft Excel allows graphs, charts and histograms to be produced and facilitates formatted output with high quality colour printing if required. Figure 2 indicates an example layout.

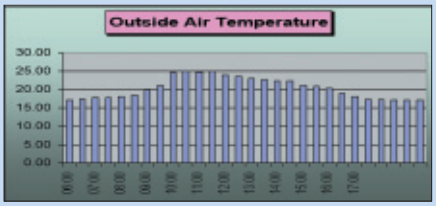

FIG 2 – TREND CHART

Graphical presentation

It is possible to monitor or manually adjust system conditions by a graphical display. Most BEMS graphic-led software puts you in control of your assets and gives the building manager a very clear picture of comfort levels plant performance and energy usage. Easy-to-use interfaces allow occupants to adjust their own comfort levels by simply touching on a graphic.

There are four types of graphic interfaces:

- **dynamic graphics.** This allows the user to obtain a dynamically updating representation of the system in the form of a graphical display on the screen. By positioning 'Navigation bars' (shortcuts) within each graphic, it is possible to call up other system displays. This allows the user 'shortcut' between the various areas of the BMS controlled system.
- **active graphics.** This allows the user to manually adjust the condition of the system by simply clicking on a representation of the desired item (a pump or fan for example). This will cause a selection box to appear prompting for the value or condition desired (Fig 3). In addition to this feature, under certain conditions, it is also possible to enable items of text or machinery to be displayed. A failure in airflow, for example, could be arranged to result in a piece of warning text to be displayed.

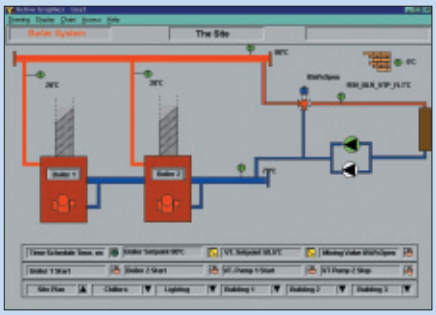

FIG 3- ACTIVE GRAPHICS

- **animated graphics.** This allows movement (animation) to be added to graphics; i.e. dampers could be made to move, fan blades to rotate and boiler flames to flicker. Animation can be added to active graphics.
- **bitmap support.** Bitmaps can also be referenced in graphics. This enables scanned media and digital photographs to be displayed. Typically, this information can be photographs of buildings and floor layout plans scanned into the software.

Legislation concerning BEMS

With the damage that is being caused to the environment, it is likely that further legislation will be introduced to save energy. Current UK legislation designed to avoid the waste of energy, include:

- **Office, Shops and Railway Premises Act 1963.** A building must achieve a temperature of 16°C (dry bulb), by the end of the first hour of occupation. Additionally the temperature of the building must not fall below 16°C during the remaining period.
- **Statutory Instrument (October 1980).** Offices and similar buildings must not be heated to a temperature exceeding 19°C.
- **Air Systems.** Controlled air dampers must always provide a minimum of 10 per cent fresh air at all times when a building is occupied.
- **Health and Safety at Work Act.** Cooling towers and spray washers on air conditioning systems must be regularly cleaned and maintained to prevent outbreaks of Legionnaires' Disease.
- **Building Regulations.** Buildings having an energy consumption of more than 100kW must employ certain controls to enable savings to be made. Some restrictions on loads under 100kW also apply.

In order to achieve all the benefits of integrated building management, and to give true inter-operability, the BEMS must be linked intelligently to other services. Building services such as chillers, lighting, fire detection, access and security have a relationship to energy usage and need to work together to ensure optimum comfort

A BEMS provides vital, up-to-date information for the control of plant

One of the key assets of a BEMS is the ability to record data and present it in a user-friendly format

levels and continuity of plant operation. An employee working late needs not only to activate local zone control but also the central plant and other support systems to obtain these comfort levels.

BEMS have become the middleware for seamless integration with other manufacturers' equipment. In this way they can share information and enable plant interaction. The system can also integrate with the building's communications network infrastructure, providing the benefits of data and resource sharing.

Accessible, up-to-date information is vital for the efficient control of plant and services. Decisions can be made at the right time to increase comfort levels, prevent energy wastage and correct failures before the occupants notice the problem. BEMS have been designed to deliver these decisions with functional graphical user interfaces, for all levels, which clearly display plant information, creating a simple, easy-to-use system for everyday use by all authorised occupants.

BEMS give full system visibility across the building's network, over telephone lines, private networks or the Internet. Information can be gathered from anywhere in the building using central or local interface units. Some users want only to adjust the temperature of their working environment, some need to compare actual energy consumption with budgeted levels and others need alarm analysis but at a remote site. A BEMS is the right tool to provide the right user interface for any situation.

SERIES 3: MODULE 01 TEST QUESTIONS

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

1. What per cent energy efficiency improvement can be expected by installing a BEMS compared with an independent control system?
☐ 5 per cent-10 per cent
☐ 10 per cent-15 per cent
☐ 10 per cent-20 per cent
☐ 15 per cent-25 per cent

2. What is the third component of a BEMS in addition to the operator's terminal and communications?
☐ modem ☐ graphics
☐ outstation ☐ logging

3. What part of the BEMS controls and monitors the building services?
☐ hardware pt ☐ software pt
☐ node ☐ CPU

4. What type of hardware point will control outputs to vary speed/positions of plant?
☐ status ☐ analogue out
☐ command ☐ analogue input

5. What type of software point is programmed to switch plant on at a time so as to achieve a desired temperature at occupancy with least energy expended?
☐ degree day ☐ optimiser
☐ holiday ☐ time schedule

6. According to the Premises Act 1963 what is the temperature a building must achieve within 1 hour of occupancy?
☐ 15°C ☐ 16°C
☐ 17°C ☐ 18°C

7. According to Statutory Instrument 1980 what is the maximum temperature a building (office or similar) should be heated to?
☐ 18°C ☐ 19°C
☐ 20°C ☐ 21°C

8. What is the minimum fresh air requirement for an occupied building?
☐ 1. 5 per cent ☐ 10 per cent
☐ 15 per cent ☐ 20 per cent

9. According to the Building Regulations most buildings must employ certain controls to assist with energy efficiency when exceeding what load?
☐ 50kW ☐ 75kW
☐ 100kW ☐ 200kW

10. What function of the BEMS stores collected data for viewing in graphical format for presentation of performance?
☐ active graphics ☐ metering
☐ trend logging ☐ alarm profiles

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