Fundamental

CURRENT THINKING ON...

Building Energy Management Systems (BEMS)

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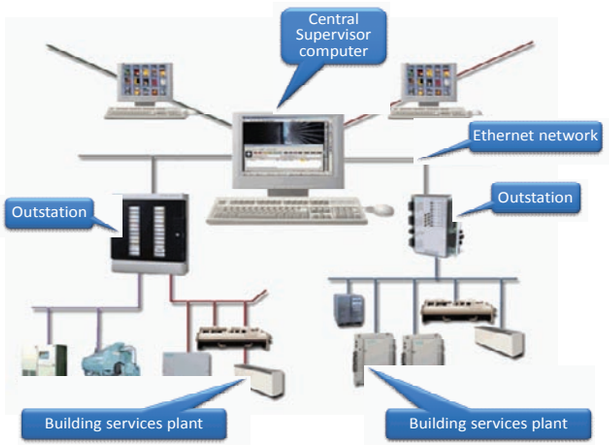
Building energy management systems (BEMS) are computer-based control systems that control and monitor a building's mechanical and electrical equipment such as heating, ventilation, lighting, power systems etc. Sometimes called building management systems (BMS), they connect the building services plant back to a central computer to allow control of on/off times, temperatures, humidity etc. Cables connect the plant through a series of hubs called outstations around the building back to a central supervisor computer where building operators can control the building. Software provides control functions, monitoring, alarms and allows the operators to optimise building performance. BEMS are a critical component to managing energy demand, particularly in large complex buildings and multi building sites.

Analogue and digital input signals tell the BEMS what temperature, humidity etc. the building is running at. Inputs might also include whether equipment like pumps, fans and boilers are running or not. Analogue/digital outputs then send signals from the central supervisor PC to valves, pumps fans etc to control their settings or to switch things on and off, resulting in changes to comfort conditions. BEMS can be used to control almost anything and it is becoming increasingly used to control lighting and to monitor critical systems.

Program automatically

Outstations provide the local hubs to connect these input and outputs into the central supervisor, see Fig. 1.

Figure 1 – Typical components of a BEMS



Source: Internet – suggest this is re-drawn as a line diagram

This allows the operator to program when things automatically turn on and off and what setting they operate at e.g. temperature, humidity. A BEMS is really a tool for controlling and monitoring the building and a good operator can use the BEMS to optimise settings to minimise energy consumption without compromising comfort and services.

The outstations are usually connected through a local area network (LAN), see Fig. 1. Software normally provides a user interface that is based on images of the plant being controlled like the one shown in Fig. 2. These dynamic displays show real-time temperatures and plant conditions that give an immediate window on what is happening in the building.

As a core function BEMS would control boilers, heating system, pumps and then locally control the mixture of heat to achieve the desired room temperature. In air-conditioned buildings BEMS would control chillers, cooling systems and the systems that distribute air throughout the building (for example by operating fans or opening/closing dampers). BEMS can also control lighting or any other energy using equipment and can also be used to log energy meters.

Modern systems have distributed intelligence in the outstations and also allow multi-site control with remote monitoring via the telephone network, wireless and satellite systems. They are increasingly becoming connected to hand held devices like palm top devices and mobile phones with alarms that tell on-call staff of problems in the building.

Building energy management systems (BEMS) can significantly improve the overall management and performance of buildings, promoting an holistic approach to controls and providing operational feedback. Energy savings of 10-20 per cent can be achieved by installing a BEMS compared with independent controllers for each system. However, BEMS cannot compensate for badly designed systems, poor management or incorrect maintenance.

Multi-building sites

These systems are ideal for getting control of multi-building sites and large complex buildings. They are also used by large organisations to control buildings spread across wide areas like whole local authorities, health trusts and even buildings across the whole country. Modern systems have intelligent outstations that can be interrogated locally in a plant room to track down local problems. They can also have wireless connections to some devices to reduce or avoid cabling. A BEMS needs to be well specified and engineered, with good documentation and an intuitive user interface if it is to be used effectively.

In very small buildings it is possible to achieve reasonable control using stand-alone controls for heating, lighting etc and this may be a cheaper option than a full BEMS. However, costs of controls has come down such that mini BEMS are now competitive and hybrid systems that interconnect a series of local controllers are also available. So BEMS can be considered for controlling almost any size of building but the improvement

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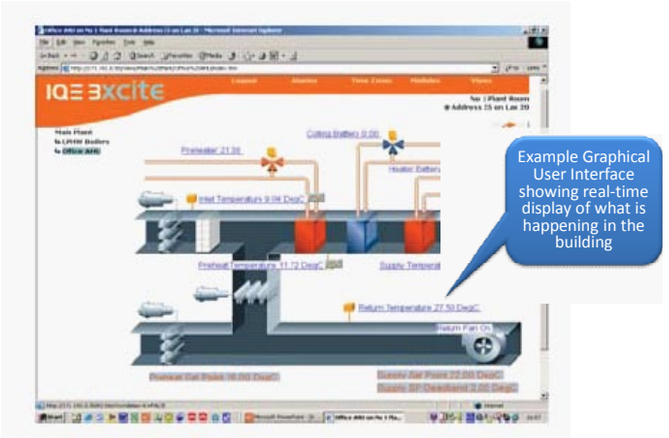
in management really becomes apparent in large distributed and complex sites/buildings.

Ensuring good user interfaces with a BEMS is essential. Modern BEMS can be accessed in a number of ways (see Fig. 3) for example, through web browsers via the internet, through hand-held tablets and laptops or through palm devices and smart mobile phones. Providing convenient access routes allows building operators to use the BEMS in a way that fits their role and the way they work and encourages them to utilise the system as a building optimisation tool. Poor access or a lack of feedback normally result in facilities managers leaving the BEMS sat ignored in a corner of the operations room as a silent controller rather than a window into the building's performance.

Figure 2 – Typical dynamic display showing real-time plant and building conditions



Source: Internet – this is highly recognisable as a TREND BEMS so the orange bar would need to be excluded – I have a contact at TREND that could provide a higher quality picture

Don't fit and forget

BEMS are too often wrongly regarded as a fit and forget system. To optimise internal conditions and make ongoing savings, BEMS need to be regularly maintained. BEMS settings need to be reviewed at least every month and check that settings match actual building use. When inspecting the system, focus on:

- general - check the integrity of any cabling and connections and any cabinets or panels in the installation;
- sensors - test accuracy and review the suitability of their locations;
- actuators - examine control outputs and ensure that controlled devices are working over their full operating range;
- digital inputs - confirm that inputs are operational and working correctly. Calibrate or adjust switching devices if necessary;
- controllers - verify that battery supplies are adequate and that controllers automatically restart following interruption to power supplies;
- record keeping - document key changes to the BEMS, including any alterations to set points and control strategies, software upgrades, additions to the network, any faults identified or maintenance performed.

Maintaining controls really matters and underpins the building performance. The preferred maintenance regimes need to be determined at the beginning of the project. The important question to be answered by the client is whether they want:

- an independent installation (independent of the control manufacturer) with a separate maintenance contract that can be moved according to contractual performance; or
- a manufacturer installation where the only option for maintenance is with the manufacturer.

It is important that the BEMS maintenance contractor is consulted at the start of the build, during the design, and retained by the client to provide maintenance for the finished building. The on-site maintenance team can then have a good relationship with the controls sub-contractor, allowing them to use continuous commissioning and rectify faults quickly.

BEMS can bring lower running costs, improved comfort, maintenance and building management through better feedback on how the building is performing on energy and comfort. The monitoring facilities of a BEMS allow plant status, environmental conditions and energy to be monitored, providing the building operator with a real-time understanding of how the building is operating. This can often lead to the identification of problems that may have gone unnoticed, e.g. high energy usage or plant left running continuously. Energy meters connected to a BEMS, providing real-time energy consumption patterns and ultimately a historical record of the buildings energy performance, can be logged and analysed in a number of ways both numerically and graphically. BEMS can, therefore, improve management information by trend logging performance, benefiting forward planning/costing. This can also encourage greater awareness of energy efficiency among staff.

Energy efficiency improvements of 10-20 per cent are common. However, it is important to establish the suitability of existing buildings and equipment to ensure the maximum savings. 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.

Review performance

The main advantage of a BEMS installation is the ease with which users can review the performance of controls and conveniently make adjustments. Other advantages include:

- close control of environmental conditions, providing better comfort for occupants;
- energy-saving control functions which will reduce energy bills (e.g. weather compensation);
- ability to log and archive data for energy management purposes;
- provision of rapid information on plant status (is it ON and working?);
- automatic generation of alarms to warn appropriate personnel of equipment failure or condition changes (has something gone wrong?);
- identification of both planned and reactive maintenance requirements (e.g. systems can record the number of hours that motors have run, or identify filters on air supply systems which have become blocked); and
- ease of expansion to control other plant, spaces or buildings.

Once a BEMS has been installed and fully commissioned properly it can be used as a tool to optimise building performance. Even the best designed and commissioned control strategy is likely to evolve with the user's and the building's requirements. A well-trained BEMS operator can carry out regular reviews of BEMS settings to gradually reduce room set points, operating times and energy consumption without compromising comfort conditions. This fine-tuning of the building controls often requires one or two full heating seasons to reach optimum settings. But the process doesn't end there, as the building usage and requirements change then so will set points and times so this optimisation is a continuous process as the building use changes.

This optimisation process is particularly important where BEMS are controlling large multi-building sites and buildings spread across a wide area. The BEMS operator can keep a watchful eye on operations and energy use from afar without having to visit the buildings. This central BEMS bureau approach is highly cost effective and common in large estates and through FM providers.

As a result of this continuous optimisation it is important to maintain records of all changes to the system during the lifetime of the building with good reasons as to why changes have been made. Too many buildings have high operating hours and set points that have been badly programmed many years ago often

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as a result of occupant complaints. It is still very common to find buildings fully ON running everything at high levels for 24 hours a day, 7 days a week where just a little optimisation can save a lot of energy, money and carbon emissions with little or no investment.

A BEMS is only as good as the people who use it. It is essential that any staff who will be operating and maintaining the system are trained appropriately. All reputable BEMS suppliers can provide and do encourage training as it is in their interest that the system works well. If installing a new BEMS, involve key staff at the beginning of the project, ensure that they are aware of what the system can do and how to keep it performing efficiently.

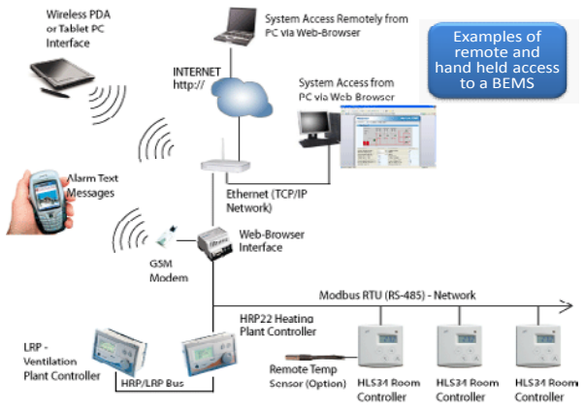
Access through mobiles

It is essential to train staff to use the BEMS as a tool to manage the building. Ensuring staff have easy access through mobile devices can encourage this. The greater the understanding, the more likely are the energy savings. This will involve training on the BEMS hardware and the software built into the BEMS. BEMS is powerful tool for managing buildings but is still only as good as the staff operating it!

All staff with access to the BEMS should develop experience in managing the building using it on a routine basis. Most BEMS have alarms set and staff should know what to do when these alarms show on the central supervisor.

As discussed earlier, in existing systems an annual review of control settings is essential also important to ensure that the system is optimised in relation to the occupancy and requirement of the building. However, too many building operators leave this to the maintenance contractor under an annual contract. This often results in the building management relinquishing their responsibilities to the BEMS contractor and the building gradually drifts away from optimised settings. The provision for future re-training in the event of staff changes is very important to minimise this day-to-day reliance on suppliers for simple maintenance measures. Ensuring suitable BEMS user documentation for system fault finding and maintenance also plays a key part in this common mistake.

Figure 3 – Typical BEMS user interfaces



Source: Internet – suggest this is re-drawn as a line diagram and simplify the labelling

A BEMS installation is very site specific. Larger systems may require a feasibility study to identify the size, shape and complexity of the BEMS required. This will establish what is to be controlled and monitored, the connections, hardware and cabling required and the resulting benefits. It will also establish the architecture of the system, ring shaped, star shaped etc and the location and capacity required in outstation.

The financial justification for a BEMS should ideally include a full life-cycle costing calculation based on discounted cash flow. Estimates of potential savings should, where possible, account for contributions from improved maintenance and increased reliability, in addition to reduced energy consumption.

Maintaining comfort

Planning and designing good controls at the outset is essential to achieving a good building. A client's brief for a good control system aims for energy efficiency while maintaining comfort. Designers' specifications need to set out the key energy features so contractors appreciate what the control system needs to do. Low-carbon buildings are best achieved when clients state an aim to have a low carbon building in operation in the client brief. The design, selection, installation and operation of the resultant control system relates directly to these initial statements. Without such clear directions to the design team, a low carbon building is seldom achieved.

The scope for system expansion at each outstation should be carefully considered. Often the addition of a single point may require a complete outstation at considerable cost if all points on the original are occupied.

If you already have a BEMS then an upgrade or even extending it may bring very significant advantages. Really old systems may well need full replacement and may no longer be supported the manufacturers.

It is possible to connect meters to a BEMS for logging energy to provide a valuable tool for identifying savings. However, where larger buildings/sites are being sub-metered it may often be better to have a dedicated automatic meter reading system with specialist software for meter logging, analysis and reporting. How well your BEMS performs is reliant on a clear brief, good design followed by good installation/commissioning. Some BEMS manufacturers offer their own design/installation service and some may even insist on this; others work with approved contractors. Either way, you should ask for references from sites similar to your own. You can find suppliers of BEMS through the Building Controls Industry Association www.bcia.co.uk and the controls group of the Energy Services & Technology Association www.esta.org.uk

Key lessons to learn

- **check that specified equipment is actually procured as per the contract and specification;**
- **ensure equipment is installed correctly, especially with regard to sensor positioning and control functionality;**
- **ensure that 'value engineering' exercises have not resulted in a system that cannot perform the functions designed;**
- **make sure any low and zero-carbon technologies are fully integrated into the main control strategy;**
- **allow budget and time for commissioning, including a full year of fine-tuning during the warranty period;**
- **commission the plant and controls system as a whole, rather than individual components;**
- **involve the building operators in the commissioning process so that they understand how the building actually works at an early stage and form relationships with the installation contractors;**
- **record the system and settings in the Building Log book and O&M manuals**

Further reading

- Specifying building management systems, BSRIA Technical Note TN 6/98
- Standard specification for BMS, BSRIA Application Guide AG9/2001.
- BMS Maintenance Guide plus a model maintenance specification, BSRIA Guidance note BG4/2003.
- Building controls technology overview (CTV032), The Carbon Trust.
- Heating control technology guide (CTG002), The Carbon Trust
- How to implement a building energy management system (CTL019), The Carbon Trust
- Automatic Controls, Commissioning Code C, CIBSE
- Building Control Systems, Guide H, CIBSE

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MARK THROWER, MANAGING EDITOR

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SERIES 9 MODULE 05: QUESTIONS

Building Energy Management Systems (BEMS)

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. The main computer controlling the BEMS is usually called the:

- ☐ central station
- ☐ central supervisor
- ☐ fat controller
- ☐ backup server

2. The hubs located around the building connecting the plant into the BEMS are usually called:

- ☐ BEMS hubs
- ☐ nodal controllers
- ☐ workstations
- ☐ outstations

3. Which of the following will BEMS not control:

- ☐ occupant behaviour
- ☐ heating systems
- ☐ lighting systems
- ☐ cooling systems

4. Energy/cost savings through BEMS are typically in the range:

- ☐ 30-40 per cent
- ☐ 5-10 per cent
- ☐ 10-20 per cent
- ☐ 2-5 per cent

5. Which of the following is not a common user interface with BEMS:

- ☐ main frame computers
- ☐ internet browsers
- ☐ portable tablet computers
- ☐ mobile phones

6. One common example of a BEMS being used to identify maintenance requirement is:

- ☐ logging line voltage to servers
- ☐ establishing the optimum start settings
- ☐ identifying the number of occupants in the building
- ☐ logging the number of hours that motors have run

7. BEMS should be used to:

- ☐ keep the building running 24/7
- ☐ optimise set points and operating hours
- ☐ ensure plant comes on when not occupied
- ☐ reduce occupant comfort conditions

8. When inspecting BEMS, do not focus on:

- ☐ sensor accuracy
- ☐ digital inputs/outputs operation
- ☐ the number of sensors
- ☐ actuator operation

9. BEMS implementation often fails due to:

- ☐ poor briefing and specification
- ☐ incorrect cable routing
- ☐ poor connection to the internet
- ☐ excessive maintenance

10. A more effective alternative for logging energy meters in larger/complex buildings might be:

- ☐ manual meter reading
- ☐ an automatic meter reading system
- ☐ improved actuator responses
- ☐ better sensor location