EiBI

“Energy in Buildings and Industry and the Energy Institute are delighted to have teamed up to bring you this Continuing Professional Development initiative”

MARK THROWER MANAGING EDITOR

energy institute

MODULE NINE

BEMS

Building Energy Management Systems

Mark Hobbins, senior energy manager at Mitie Technical Facilities Management

The term building energy management control is the general term for a control system that is controlling multiple elements in a building.

Some knowledge of control systems, what they do and how they function, is now imperative for an energy manager. Without this it is difficult to ask for the right level of control in the first place, or to operate the controls successfully.

Building Energy Management Systems (BEMS) bring two major benefits that conventional controls cannot. First, 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. Second, they are software based and are almost entirely configurable to the user's requirements. This ensures an exact fit to the building requirements while offering scope for the application of energy efficient control techniques.

Before we provide an overview of control techniques, it is important to remember what good controls are - essential for the safe and efficient operation of modern buildings.

Well-designed and operated control systems should :

- create and maintain a comfortable indoor environment;
- prevent systems from being on when not needed, and prevent heating and cooling operating simultaneously for the same space;
- keep HVAC plant operating safely and efficiently;
- reduce energy consumption and running costs;
- prevent energy wastage;
- help meet Building Regulation requirements for energy efficiency and conservation; and
- provide feedback data that can, for example, be used for monitoring system performance and planning maintenance requirements.

Any control (control system) needs to be effective before it can help to improve efficiency. Its goal is to ensure that the system/service it controls meets the requirements placed upon it (for example the temperature set point on a boiler). Controls do this by first meeting a desired set point, then measuring and adjusting the system to achieve this in the best way (through control algorithms).

Looking for simplest system

Ideally, a BEMS and any controls should be the simplest system that meets building owner, operator and user needs and capabilities, while efficiently delivering the required quality of system operation. The more complex a system is, the greater the understanding that is required, the more resources required to maintain and operate it, the more opportunities there are for error, and the harder it is to diagnose problems.

Controlling building services can fall into two main brackets: by time or by condition. Controlling by time may involve time switches, preheat, optimum start & stop, override switches and boost or advance controls. Controlling by condition may involve weather compensation, demand based control, free cooling, night set-back, frost protection, fabric protection, dead bands and zoning.

Time switches are simple clocks that determine when items should be on. This may be in the form of a 24-hour clock, or a seven day clock. It is also possible for those on some older system to be analogue but generally digital time clocks are used now. In a BEMS the time periods are inputted with the option in most cases to have several on or off periods each day. In systems with optimum start/stop, it is the occupancy periods that are entered. As a result, it is important to know if you are putting an occupancy period into a BEMS or a time setting – it is common for time settings to be entered when it should be the occupancy. This results in the heating (or cooling) coming on earlier than required and being on for longer. One of the most important functions of a control system is time control to ensure that the plant is switched off when not needed.

The preheat time for a building is the

CPD FUNDAMENTALS » SERIES 12 » MODULE 9 » PUBLISHED IN EIBI MAGAZINE MARCH 2015

time that has to be allowed for the heating system and the building to warm up before the start of the occupied period. In systems that have optimum start and stop, this is calculated and controlled by the control algorithms. In systems that do not have this, time needs to be located to allow for preheating of the building. In more heavyweight buildings the heat up and cool down periods can be significant. It will also vary with the seasonality of the outside temperature and weather.

An optimum start controller learns how the building reaches the desired temperature and brings the heating on at just the right time to achieve the correct temperature for the start of an occupancy period. Installing these controls typically results in the heating switching on later on mild days, as shorter warm-up times are required. It also takes the guesswork out of heat up times and removes the need for regular manual adjustment. The optimum stop works in the opposite way, adapting the turning off of equipment for the cooling down of the building.

Override facilities are present on most timer-based controls. The manual setting is commonly described as 'on-hand' but this really means constantly on. Their use should be discouraged wherever possible to prevent services from being permanently left on. They are there mainly for working safely on an item in the event of failure or in checking performance (associated with routine maintenance).

Boost controls are used to provide additional service without the need to override existing time controls. For example in heating and/or hot water circuits, the boost control will switch the hot water circuit on for a limited time period (usually one hour or multiples of on hour) outside its normal time control settings, allowing for the provision of additional hot water or space heating. This adds flexibility and also prevents heating large areas, if it is only an isolated area that is being used.

Reducing temperatures in heating systems during milder weather and during daily day/night variations in outside temperature makes for a more closely controlled system. Weather compensation will measure the external temperature and adjust the circulating temperature as a result. This is also good for improving comfort as it will also minimise the likelihood of overheating.

Night set-back is a reduction of service requirements overnight, usually applied to continuously occupied buildings. For example, not all spaces need to be maintained at daytime levels when the occupants are sleeping. It is also used for other building types during non-occupied hours to keep the building at a reduced level to minimise a preheat period for the start of occupancy

Risk of equipment damage

In cold conditions building plants and systems can cool down in non-occupied periods to temperatures where there is a risk of equipment damage due to frost or freezing. What temperature the frost protection is set to depends on the size of the circuits and also the weight of the building. A large lightweight building may need a higher temperature than a heavyweight smaller building. The key aspect is to protect the plant and system without incurring too high a penalty for doing so.

Fabric protection is another form of cold weather protection, but primarily aimed at protecting the building itself.

In order to avoid excessive 'hunting' by the controller, a so-called 'dead band' around the set point is set. In this range, no change of control action is made. It effectively separates the on and off signals so that the boiler or other plant is not continuously cycling. For example, heating an office to a set point of 21°C with a dead band of 2°C will only reactivate the heating again when the temperature drops to 19°C. There is no universal deadband setting as it will depend on the building characteristics, layout and occupants comfort levels (and tolerance).

In buildings that have both heating and cooling system installed, it is often typical to implement a dead band. This deadband prevents the heating and cooling systems simultaneously working (or sometimes called fighting each other). For example, a set point of 21°C with a dead band of 4°C means that the heating would not cut in until 19°C and cut out at 21°C, while the cooling would only start when the temperature reached 23°C and stop at 21°C. The dead band will vary according to the building characteristics as well as the feedback from occupants (you want to avoid too many temperature fluctuations in a short space of time). Ideally this would be set at 5°C but in practice this is often difficult to achieve.

Areas in buildings require different levels of heating, lighting, cooling and ventilation. A solution to this is to create 'zones' in the building where separate time, temperature and occupancy controls are installed for individual areas. Zoned areas will provide closer, more efficient control. This can improve local comfort and aid uniformity in larger areas (like large open plan offices). Zoning should be considered when there are: different occupancy patterns; different temperature requirements; different activities taking place; a number of floors (particularly where top floors are poorly insulated); and orientation of the building (for example a north/south divide).

Another example is grouping of fan coil units in open plan areas, to aid uniformity and prevent them acting against each other. When zoning it is necessary to think of all the system serving that area, rather than just the single system you are focussing on. For example in an office with mechanical ventilation, this would need to work along with the heating or cooling system, otherwise they will counteract each other.

Fans, motors and pumps rarely need to operate at full speed all of the time. Variable control can help to reduce costs by enabling the output speed of this equipment to match requirements at different times of the day, or at different stages of a process. The recent development of EC fans and motors in some cases presents an opportunity to refurbish ventilation systems. Similarly larger motors may benefit from retrofitting of variable speed drives. The scale of opportunity in both these cases

energy institute
For details on how to obtain your **Energy Institute CPD Certificate, see entry form and details on page 42**

will depend on the size of the motor and the operating hours.

In systems with cooling, at certain times of the year the outside air is at a low enough temperature to provide the cooling directly without use of the refrigeration system. This consequently takes load away from the compressors. Controls on the air handling system, including outdoor air sensors, together with information from the controller on the required cooling load, move dampers to provide sufficient air for the cooling needs. There is also an opportunity for free cooling in chilled water systems by simply using the condenser water from the air cooler or water cooler in the cold weather to meet the chilled water set point – again minimising the work by the compressor.

An interlocking control switches off services when triggered and can be used to minimise the risk of two systems operating in competition. It is also possible to install interlocking controls to prevent heating or cooling systems operating if any external doors or windows in the controlled space are open.

The ventilation requirements will depend on the carbon dioxide levels in an area, which are a good measure of air quality. In most buildings, ventilation rates are based on the worst case, but often in large buildings the occupancy level (the main cause of carbon dioxide) will differ. Additionally, depending on the layout of the building you may have higher concentration levels of carbon dioxide in some parts than other. Therefore, it is often recommended to connect a CO_2 sensor to a variable speed ventilation fan in order to help match the requirement of fresh air to the air provision. This will also have a knock on benefit for the amount of air needing to be cooled or heated.

A time lag occurs in most control systems. This is due to system inertia; it takes time for the system to respond and actually alter the controlled variable. This can lead to the measured value exceeding or failing to meet set points. It is important to understand this time lag in some buildings (particularly in heavy weight and large buildings) as it can often lead to overheating and, where cooling is installed, increasing the cooling loads unnecessarily. More sophisticated controllers can reduce this problem, but also require some degree of understanding from the operators.

Many BEMS can be used for monitoring and targeting. Many have a logging function so historical as well as real time information can be viewed. Examples that can be used for monitoring and consequently targeting are: the internal temperature profile of a zone, gas consumption, electricity sub-meters, external temperature and consequently degree days, or hours run for the individual boilers and for how long at a time. This provides insight into how your systems are operating, allowing for continuous improvements. In addition to viewing this on the BEMS platform, it is also possible to have this data exported on a regular basis, i.e., monthly or daily. This can then either be analysed in spreadsheet form or sent to a specific monitoring and targeting package – the latter doing the analysis or presenting the data in the form of a dashboard.

Handling the data

The key aspect in larger systems is handling the data. In larger buildings the information that is available could be vast. The rule in this case should be that the data collected should be both useful and meaningful, while still being manageable. It may be that key data is periodically exported, but a routine review of other data is carried out without exporting.

Now that we have gone through the main control techniques used in a BEMS, when specifying our system we need to have a clear control strategy specific to each building. To maximise functionality and occupant comfort, it is essential to form a clear and integrated control strategy at a very early design stage. The BEMS forms the main interface between the occupant and the building services, and it is therefore essential to include user controls within the strategy, whether this is some form of localised control or the building operators having the ability to change set points.

While most BEMS are very flexible and can provide efficient operation of the building services, they cannot compensate for poor design of the building and its services. Even the best and most expensive BMS system cannot make a poorly designed oversized heating system operate efficiently or make a leaky building perfectly comfortable. The design of the building, its services and their controls needs to be considered as an integrated whole, not as three separate and unconnected decisions. BEMS therefore require careful consideration when being commissioned as well as regular maintenance. The training and understanding of the operators will further affect the BEMS's success.

Finally, ensure that adequate thought is given to the building's occupants. Quite often the people that are in the building are overlooked - gauge feedback from them. Bear in mind that there is a perception and personal aspect to thermal comfort and you shouldn't be expecting everyone to have the same level of comfort, all the time. Quite often there may also be an underlying issue in small areas into which the occupants can provide insight. By engaging with the occupants, you can prevent the need for constant changes and ensure a pleasant working environment.

Further reading

- Understanding controls CIBSE Knowledge Series: KS4
- Carbon Trust guide CTV032 Technology Overview: Building controls
- Building control systems CIBSE Guide H
- Automatic controls CIBSE Commissioning Code C
- BSI 15232: Energy performance of buildings — Impact of Building Automation, Controls and Building Management
- Energy efficiency in buildings CIBSE Guide F
- Resource Efficiency Scotland Guide: Building Management System Procurement Guide

Reference

CIBSE Knowledge Series: KS4

For details on how to obtain your **Energy Institute CPD Certificate, see entry form and details on page 42**

CPD ENTRY FORM

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.

QUESTIONS

1. The main reason for installing a BEMS is

- ☐ So that systems can be controlled centrally
- ☐ So that building requirement can be met consistently
- ☐ So that services can be operated effectively and efficiently
- ☐ All of the above

2. Well designed and operated BEMS should

- ☐ Create and maintain a comfortable indoor environment
- ☐ Prevent operators from needing to review set points
- ☐ Provide an overview of how the systems are designed
- ☐ Negate the need for routine maintenance

3. Optimum start function does what?

- ☐ Learns how long it takes for the building to lose heat
- ☐ Learns how long it takes for the building to achieve a set point
- ☐ Programmes the start time of services to the be the same each day
- ☐ Allows for the heating to be turned down during the day

4. Free cooling on mechanical system saves energy by

- ☐ Automatically opening windows
- ☐ Reduces the work required by the compressor
- ☐ Turns off the fans and pumps of the cooling system
- ☐ Changes the flow rate of the refrigerant circuit with the internal set point

5. What building type would likely make use of night set back

- ☐ Hotel ☐ Office
- ☐ Warehouse ☐ Security Gatehouse

6. What would be an ideal deadband when there is both a heating and cooling system?

☐ 2°C ☐ 1°C ☐ 5°C ☐ 3°C

7. True or False: BEMS system should not be used to control variably control auxiliary items?

☐ True ☐ False

8. When should override switches be used?

- ☐ To allow occupants to have local control when they are not comfortable
- ☐ To allow occupants to have local control out with normal occupancy periods
- ☐ To allow maintenance and inspection to be carried out safely
- ☐ To allow prevent services hunting

9. Interlocking control are important as they

- ☐ Prevent occupants from cooling a building when not required
- ☐ Prevent operators from simultaneously heating and cooling
- ☐ Allow for precise deadband when we have heating and cooling in the one area
- ☐ Allow users to turn off the cooling if they are getting a draught from the fans

10. True or False: it is not important to gauge feedback from occupants?

☐ True ☐ False

Please complete your details below in block capitals

Name .... (Mr. Mrs, Ms) ....

Business ....

Business Address ....

....

....

....

Post Code ....

email address ....

Tel No. ....

Completed answers should be mailed to:

The Education Department, Energy in Buildings & Industry, P.O. Box 825, GUILDFORD, GU4 8WQ

Produced in Association with energy institute

CPD fundamentals

THE CONTINUING PROFESSIONAL DEVELOPMENT PROGRAMME

How to obtain a CPD accreditation from the Energy Institute

EiBI **Energy in Buildings and Industry** and the **Energy Institute** are delighted to have teamed up to bring you this **Continuing Professional Development** initiative.

This is the ninth module in the twelfth series and focuses on 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 and notification by the Energy Institute, 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.

Modules from the past 11 series can be obtained free of charge. Send your request to mark.thrower@btinternet.com. Alternatively, they can be downloaded from the EiBI website: www.energyzine.co.uk

SERIES 11

MAY 2013 - APR 2014

1. Renewable Heat Incentive
2. The Green Deal
3. Underfloor Heating
4. Voltage Optimisation
5. Heat Pumps
6. Thermal Imaging
7. Boilers & Burners
8. Data Centre Management
9. Building Regulations Update
10. Monitoring & Targeting

SERIES 12

MAY 2014 - APR 2015

1. AirConditioning
2. First Steps in Energy Management
3. Photovoltaics
4. Utility Purchasing
5. Drives & Motors
6. Behaviour Change
7. Small Scale Wind Turbines
8. Water Management
9. BEMS
10. Lighting*

DOWNLOAD

** ONLY available to download from the website after publication date*

Level 3: Advanced Energy Manager (AEM)

Continue your professional development in energy management by undertaking an advanced qualification with the Energy Institute.

ABOUT THIS COURSE

AEM is a 12-day course for experienced energy managers covering project management and key technologies. It is recommended for those with 3+ years' experience in a related role.

	DATES
Block One:	20-22 April
Block Two:	11-13 May
Block Three:	1-3 June
Block Four:	6-8 July
Assessment Day:	28 September
Price EI member:	£3,000 +VAT
Non-member:	£3,350+VAT

For more information, visit www.energyinst.org/Level3

energy institute