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Introduction

A Building Management System (BMS) is a computer-based control system that manages and controls the mechanical and electrical services of a single building, up to an entire portfolio of buildings. Successful implementation and operation of a BMS allows building performance to be optimised and substantial energy savings to be achieved.

Whether an entirely new installation or upgrades of an existing system, it is likely that significant financial commitment is required in order to pursue a BMS project. It is therefore important to ensure that the BMS is properly designed and specified and that the procurement process is closely controlled. This may be applied to the supply and installation of equipment alone or to an ongoing arrangement over many years with a service provider or contractor.

This document is primarily written for those with responsibility for energy, management of energy, decision makers and managers or estate / facility engineers with limited knowledge of BMS. It is designed to assist organisations through the process of procuring BMS and support services thus helping to ensure the following:

- The requirements of the BMS project are fully defined relative to management and operational needs.
- The organisation understands the drivers for change.
- Clients understand what sort of performance parameters need to be considered and specified.
- A robust investment business case can be developed.
- Key technical characteristic of BMS are understood so that it is possible to liaise confidently with suppliers and contractors.
- Procurement processes cover the factors and issues that are particular to BMS as well as the other commercial considerations when letting contracts.
- Innovation is sought in the tenders by suppliers and service providers.
- The performance of BMS service can be monitored and verified to ensure that optimised savings are being delivered.
- Adequate provision is made for the day to day management of the BMS.
- Different contract and procurement approaches can be assessed; for example full optimised management including on site management options.
- The organisation understands its own resource, competencies and constraints with regards to BMS operation and management capability.

A flowchart outlining the key steps in specifying and procuring a BMS project is provided. In the electronic version of this guide, this flowchart links to the relevant sections within the main body of the document. A glossary of terms are detailed in Appendix 1.
BMS Overview

Providing facilities to maintain a comfortable environment in all buildings requires some form of mechanical and electrical services, such as boilers, heating and ventilation plant. These have to be controlled by some means in order to ensure that, for example, sufficient heating is provided to maintain comfortable conditions in the occupied space. In some buildings, services are controlled by manual switches, time clocks and thermostats which provide “on” and “off” signals in order to operate the building services as required. In many buildings, however, BMS is used to ensure that variable signal responses are provided in an efficient and flexible manner to match a gradually changing environment.

The five basic functions of a BMS can be considered as the following:

- Management of an organisation’s building services from one central location through a user friendly interface.
- Controlling and optimising the operation of the building services to meet the requirements of the building occupants and in relation to other external variables such as prevailing weather conditions.
- The ability to monitor and manage building service equipment to ensure that it is run efficiently and reliably.
- Monitoring plant condition status and early identification of failure or wear and to provide diagnostic data.
- Providing management reports on building and plant performance using logged data on plant operation and environmental conditions.

Reductions of 10 to 30% in heating energy consumption can be realised for BMS that have been well designed, maintained to specification requirements and optimally operated / managed as compared with poorly performing systems.\(^1\)

- In addition to energy savings, BMS offer other advantages including:
  - Providing close control of environmental conditions to ensure that comfort levels are maintained can help to improve morale amongst the occupants which may ultimately boost productivity.
  - Rapid real time access to information allows the BMS operators to respond promptly to the requirements and comments of building occupants – frequently without the need to visit site or zones.
  - Generation of automatic alarms which inform the appropriate personnel of problems with equipment or changes to the building conditions that are outside of acceptable limits.
  - Preventative maintenance planning by, for example, counting the hours run by key plant or measuring changes in system pressure to detect fouled air filters in ventilation systems. This helps ensure that plant continues to operate reliably, avoiding unforeseen and disruptive breakdowns and helps to extend equipment life.

\(^1\) Potential impact of controls on the thermal energy savings for non-residential buildings relative to BSEN 15232 Reference Standard C
To obtain the full benefits and features of a BMS, it should be a centralised system with all the sites connected to a front end supervisor (this can then be accessed if required by multiple users via a web-browser). There are a number of well-established communication protocols employed for BMS, each with specialist uses including BACnet, LonWorks, MBus, Modbus and KNX. The BMS should be able to manage these protocols concurrently, creating a seamless joined-up approach to operating the full complement of the building services. More details are provided within Section 5.2 of this guide document.

The following BMS Procurement Flow Diagram guides the reader through ten key decision making stages or steps from boundary definition through business case development, determining a suitable commercial approach, development of performance specification and evaluation of solutions. It is recognised that individual organisations will have various skill sets and needs and will benefit from this guide document accordingly. The aim of the flow diagram is to assist different organisations in interfacing with different stages in a way that meets their particular needs. There is some explanation regarding each of the individual stages or steps within the edit boxes adjacent to the flow diagram.

The BMS Procurement Flow Diagram is configured to allow the user efficient access to relevant sections and resources by clicking on links. At the end of each section within the document, you can return, ‘Back to the flow diagramme’ to allow you to continue your research.

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2 BACnet – developed specifically for buildings: focusing on HVAC, fire control panels, security and access. BACnet was developed by AHSREA (American Society of Heating, Refrigeration and Air conditioning Engineers) and is the most widely used both in the UK and internationally. LonWorks – similar to BACnet. Meters-Bus (MBus) – MBus was developed specifically for remote reading of meters. Modbus – used to enable communication between devices such as an automation station and chillers. KNX – lighting systems, shading (automated blinds), room climate, security and BMS.
**BMS Procurement Flow Diagram**

**Step 1**
Define the scope and boundary of the BMS
Identify which buildings and which plant or equipment will be covered by the BMS project. Also determine the extent of control and functionality that would be required from the BMS.

**Step 2**
Define conceptual design criteria
Define the design criteria so that the most appropriate system(s) are provided to meet the organisations requirements can be selected.

**Step 3**
Identify existing systems on each site
To establish the scope of the BMS upgrade works it is necessary to establish what control systems are currently installed.

**Step 4**
Detailed evaluation of existing systems relative to design criteria
Construct a detailed picture which will inform the design criteria for the new system and provide the basis against which potential BMS equipment or service providers can develop proposals and commercial quotations.

**Step 5**
Carry out an assessment of potential systems and select the preferred solution
A specification for the BMS installation or upgrade is developed. It should include the system design requirements including the hardware, software and functionality as well as performance requirements such as target Key Performance Indicators. This specification can then be used to assess the merits of suppliers’ proposals.

**Step 6**
Define potential savings along with operational and investment budget costs and payback period
It is likely that cost savings achieved through improved energy efficiency will form a significant part of the financial justification for any BMS project. Therefore, reliably forecasting such efficiency gains and hence cost savings forms an important element in developing the business case.

**Step 7**
Prepare detailed business case
Some form of business case will need to be developed to secure project funding and commit to a procurement process cost savings forms an important element in developing the business case.

**Step 8**
Evaluate Commercial and Funding Options
Once the business case for a BMS upgrade has been developed consideration needs to be given to commercial and funding solutions. This should also consider the funding of maintenance for the system.

**Step 9**
Develop a performance specification
The tendering process provides you with the opportunity to specify the level of support that you require. This would be effectively consolidated and presented in the performance specification.

**Step 10**
Innovation and performance enhancement
This is all about how the supplier contractor can add value specifically with regard to performance of complete systems.
SECTION 1 Define Requirements

The first key step in planning a BMS installation is to develop definition of the requirements for the system. By constructing a clear picture of requirements you put yourself in the best possible position to correctly define the design and specification of the system to meet the particular needs of your organisation. This will help you to control tendering exercises and encourage suppliers to propose systems that are not over-specified and therefore incurring needless costs.

In cases where an existing BMS is being replaced or upgraded, it will be possible to call on the experience and lessons learned from the original system to help to fully define your requirements. Where an entirely new BMS is to be deployed or your experience is limited, it may be prudent to consult with independent specialists and/or colleagues from similar organisations.

In order to define the requirements that will dictate your BMS specification, it is necessary to determine the functionality of the system, together with how it will be managed and operated and by whom. This section explores these aspects in more detail and covers the following steps:

Step 1 Define scope and boundaries of the BMS.
Step 2 Define design criteria.
Step 3 Identify the existing system infrastructure.

This section also explores the Management and Operation of a BMS together with the requirements of different types of system users.
1.1 Define Scope and Boundaries of the BMS (Step 1)

It is important to define the scope and boundaries when considering embarking on a BMS upgrade, whether a comprehensive new installation, a system replacement or existing system upgrade. By this we mean clearly identifying which buildings and which plant or equipment will be included and required to be monitored and / or controlled by the BMS. As the BMS project is likely to be highly capital intensive, it is essential that expenditure is prioritised and targeted where it will be most effective at improving energy efficiency, occupant comfort and reporting requirements. Suitable criteria for selecting and prioritising BMS upgrades include consideration of the following:

- Annual energy expenditure – typically, BMS installations cost from around £10,000 upwards, therefore in order to be cost effective there may be a need to set a minimum cost threshold for the energy use controlled.
- Annual energy consumption of the site, building or portfolio.
- Annual CO₂ emissions of the site, building or portfolio.
- Type of buildings or facilities; some buildings may have a greater potential for savings or would benefit from greater central management, for instance, the flexibility of programming offered by a BMS would suit buildings that have irregular or infrequent occupancy patterns.
- System standardisation; where an organisation has exposure to a particular BMS or multiple BMS it is likely to be cost effective to standardise on preferable one BMS, providing the system(s) meets the design criteria (See Section 1.2).
- Age, condition, reliability of existing systems, e.g. prioritising sites where the existing system is unserviceable or redundant.
- BMS rationalisation of systems – standardising to a limited number of systems (ideally one or two) to optimise management and performance.

From this level of analysis it should be possible to identify and prioritise sites to be included in the BMS upgrade programme based on potential energy and cost savings as well as BMS resilience including vulnerability to existing system obsolescence. Some sites may need to be omitted from an upgrade programme if there is uncertainty over their long term future or where the organisation has no direct control over their use, for example a Public Finance Initiative (PFI) site or leased sites etc.

1.2 Define Design Criteria (Step 2)

There are a wide range of BMSs on the market with varying levels and performance, functionality and system support. It is therefore important to define the design criteria so that the most appropriate system(s) that meets the organisation’s requirements can be selected.

The higher the level of specified automatic control with a system design then the greater the potential benefits of the system, although such systems will incur greater costs and potentially higher exposure to maintenance reliability issues. To act as a guide for BMS design, there is a European and British Standard (BSEN15232) which provides a structured classification of building automation and control technologies. The Standard identifies four classes (A, B, C and D) of control systems and details of their potential energy saving impact for a range of buildings. Full details of these classifications with potential savings are provided in Appendix 2.
1.2.1 Suggested BMS Design Criteria Requirements

BMSs are very flexible and can be designed to meet the specific requirements of an organisation. Functionality ranges from basic level of heating, ventilation and air conditioning (HVAC) control with no energy monitoring activities through to a high level of energy performance with energy monitoring, room level automation, scheduled maintenance and change logging etc. Review of the requirements of the system should be made as part of the development of the BMS strategy, which should also consider the following functionality criteria:

- Software package – flexible, able to meet a wide range of applications and able to provide a wide range of energy analysis and maintenance functions
- Network capabilities using local area networks, wide area networks and standard browser technology to utilise the organisation’s IT networks
- Supports multi-users with appropriate levels of access
- Supports open protocol technologies commonly used for BMS applications including BACnet, MODbus and KNX
- Gateways to communicate with third party equipment
- Manufacturer committed to on-going support and development of product
- Commitment to backward compatibility to support existing BMS equipment

These issues are discussed in more detail in the Technical Overview – Section 5 and details of low energy control strategies are also included within Appendix 3.

In addition, you may wish to consider whether the organisation wants to use a system supplied and installed through an extensive well established network of Approved Partners. This will ensure that the organisation is not restricted to using one, or a limited number of contractors, or alternatively a manufacturer who predominately markets their products directly to the end user. It is recommended that an organisation should try to standardise on a limited number of systems (one or two) in the interest of in-house knowledge and expertise, availability of spares and access to trusted third party support.

1.3 Identify Existing BMS Infrastructure

To establish the scope of the BMS upgrade works it is necessary to determine what control systems are currently installed on the sites included within the boundary of the upgrade programme.

By following this step, the organisation will be able to identify their exposure to each system and identify sites that have obsolete or unserviceable systems that may be particularly vulnerable. These can be ranked for example by percentage of sites with each system, percentage of energy consumption or percentage of energy costs or carbon dioxide emissions for each system etc. Ranking the existing BMSs and control systems in such a way will provide useful information to prioritise where investment in BMS is likely to be most beneficial and cost effective.

Also part of an existing system review will need to include current communication links and protocols, for example ethernet or dedicated wired transmission, as system upgrade communication compatibility will have a noticeable impact on the system upgrade budget.

Where it is found that there are a range of different manufacturer’s BMSs installed, it is recommended that the systems are rationalised. Organisations with a multitude of systems
find it difficult to manage their BMSs effectively as the operator needs training on the use of each system which often requires the support of a number of specialist BMS contractors. In addition, multiple systems require a wider range of spares and it is difficult to implement a uniform controls or reporting approach where an organisation has multiple systems. For organisations where a particular BMS or BMSs is predominant this may be a key selection factor, provided that the system meets the design criteria (Section 1.2) as it is more expensive to carry out a full system replacement than upgrade and enhance.

1.4 Management, Operation and BMS Users (Step 3)

A well-managed system is essential to realising the benefits of a BMS, otherwise the return on investment will be diminished. A modern well designed BMS can greatly simplify the day-to-day management of an organisation’s control systems. For organisations with a large portfolio of buildings, it is possible to utilise wide area networks (WANs) to connect several sites so that they can all be controlled from a remote supervisor(s). The organisation may choose from a range of options on how the system is to be managed, including:

- Running the BMS in-house using its own staff.
- Outsourcing to a service bureau, who will supervise efficient operation from a remote supervisor, deal with occupant requests and organise maintenance.
- A combination of the above.

More details concerning how systems can be managed are covered in Section 3 Step 8 of this guide and day-to-day user issues are covered in Section 6.

When considering system design requirements, it is vital that the preferred approach to operation and management has been defined beforehand. There are a range of potential users for the system including facilities management (FM), estates departments, maintenance staff and end users. Following the decision on the approach to management and operation of the system, consideration needs to be given to the appropriate level of access and tools for each user. For an end user this may range from a local BMS supervisor workstation or access to a specific site (or department) through a web browser, local Liquid Crystal Display (LCD) operator console, or even a simple localised time extension switch.

Each individual user’s access can be set up to meet their specific requirements so that, for example, they can only get access to their specific site or department. User levels can be set to meet their level of responsibility and competency so that only designated users have the authority to adjust set-points and time schedules etc.
2 SECTION 2 Develop Business Case

Developing or upgrading a BMS requires significant financial commitment and it is therefore vital that a sound business case for such a commitment is presented to decision makers. Such a case may be wholly based on the cost effectiveness of the BMS in relation to forecast energy cost savings. Alternatively, the business case may be influenced by other benefits such as the ability to maintain and control comfort levels in critical buildings, minimise the disruption of providing a service to occupants or improvements to maintenance scheduling and consequent benefits to plant life and reliability. In practice, it is likely that the business case for developing or upgrading BMS will be a balance of many quantitative or qualitative benefits to the organisation.

This section looks at the construction of a business case for implementation of BMS. It is likely that this would take place in conjunction with the definition of requirements outlined in Section 1 as well as consideration of technical aspects discussed in Section 5.

This section explores these aspects in more detail covering the following steps:

Step 4 Detailed evaluation new system design criteria
Step 5 Assessment of potential system solutions
Step 6 Evaluate savings, investment levels and operational costs relative to available budget
Step 7 Prepare detailed business case proposal
2.1 Evaluation of New System Design Criteria (Step 4)

Using the findings of steps 1, 2 and 3 it is possible to construct a detailed picture which will inform the design criteria for the new system and provide the basis against which potential BMS equipment or service providers can develop proposals and commercial quotations.

Table 2.1.1 below provides guidance on some of the main aspects that normally need to be evaluated as part of system design criteria.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Assess the current BMS infrastructure.</td>
<td></td>
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<tr>
<td>How many BMSs or control systems will be covered by the project?</td>
<td>This will be determined by the findings of Step 3.</td>
</tr>
<tr>
<td>What is the age, condition, functionality and capability of the existing BMS(s)?</td>
<td>Characterising the status of the existing system’s components will enable you to determine which items will be retained and which upgraded or replaced.</td>
</tr>
<tr>
<td>Communication systems with existing equipment.</td>
<td>Defining the existing communications infrastructure will enable potential suppliers determine the level of compatibility with their systems and thus determine where communication network modifications or enhancements are required.</td>
</tr>
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</table>
| Is there adequate monitoring and control relative to buildings and zones? | Increasing the level of monitoring and control – and potentially adding zones will improve the flexibility of the BMS but will add to capital costs. Ask questions such as:  
  - Do the existing BMS arrangements contribute to complaints over comfort problems?  
  - Are vacant areas being heated needlessly?  
  - Do heating and cooling systems run at the same time in competition with each other? |
<p>| What sort of variable flow controls are currently in place?            | The existing control systems may use valves or dampers to vary flow rates. Upgrading these systems to use variable speed drive controllers may provide significant energy savings as well as more refined control of comfort. Focus on plant with larger electric motors or those with demand flows that are subject to high levels of variability. |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence Control</td>
<td>Do boilers or other plant require sequence control?</td>
<td>Effective sequence control helps key plant to run at the highest efficiency levels as well as reducing needless wear and tear on equipment.</td>
</tr>
<tr>
<td>Alarm Capabilities</td>
<td>What alarm capabilities does the existing BMS have?</td>
<td>Does the existing BMS allow problems with plant and equipment to remain undetected for long periods? High flexibility when determining and setting alarms is important to prevent important alarms being ignored due to high frequency of other alarm functions. Modern BMSs can rapidly alert users to problems through emails or text messages.</td>
</tr>
<tr>
<td>User Access</td>
<td>How many and what type of user have access to the existing BMS and will this need to change in the future or at least have the system flexibility to change?</td>
<td>Consider how the existing system is operated and by whom and then determine if these arrangements function appropriately. BMS replacement or upgrade may offer the opportunity to change the profile of system users. Depending on your strategy, this may involve increasing the number of users to, say, reduce the burden on a single BMS operator; or reducing the number of users so that unregulated local control is replaced by centralised control by users with appropriate training and authority.</td>
</tr>
<tr>
<td>Local vs Centralised Control</td>
<td>Does the BMS have local or centralised control over plant or buildings and will this need to change in the future?</td>
<td></td>
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</tbody>
</table>
| Analysis and Reporting                          | Does the existing BMS system support useful and adequate management reporting and what is likely to be required in the future? | Modern BMSs have the capability and flexibility of producing a variety of management reports on building and plant performance using logged data on plant operation and environmental conditions. Consider the type of reporting that would be of value to your organisation, including:  
  - Exception reporting noting events that require further investigation. Monitoring and profiling of environmental and comfort conditions (such as outside or room temperature) as well as plant operation (pump status or valve position) etc.  
  - The ability to record changes to BMS settings may be useful for the day-to-day management of the system. The ability to export data (such as temperature profiles) for use in spreadsheets etc. may also be of use for management reporting, detailed investigation of plant operation or feasibility studies.  
  - The ability to easily set up operating logs such as pump run or speed profiles and zone temperature profiles etc. |
### What system diagnostics required?

Modern BMS generally have the capability to undertake self-checking by the “sending” test values to different functions or by remembering the last time calibration was carried out as part of a digital logging system etc.

- Transducer checking systems when operating outwith pre-set ranges
- Sensor calibration maintenance periods

### Management resources

Training and support functions may be critical in determining the most appropriate BMS for your needs.

- System training and support requirements
- Remote on line access with hierarchy and security
- Access and authority flexibility

### How susceptible or responsive does the system have to be to system failure

There will always be some system failures and when these occur they need to be identified quickly and the consequence of a failure should be minimised in terms of operation and safety implications.

- Fail safe requirements when for example communication systems fail
- Override facilities when system fails
- System back up for example logs and events etc.
2.2 Evaluation of Available Solutions (Step 5)

Having determined design requirements, it is recommended that a specification for the BMS installation or upgrade is developed. The specification should include the design requirements for the BMS (refer to Step 4). It should also include performance requirements or target Key Performance Indicators (KPIs), such as performance targets for example kWh/m² or £/m² etc.

This specification document may be passed to potential installers in order to help them construct proposals. In developing their proposals, suppliers are also likely to conduct visits and undertake surveys of candidate sites and hold meetings with key staff concerned with the operation of the existing BMS as well as decision makers within the organisation.

Suppliers’ proposals will set out how their systems would address the requirements of the specification together with the anticipated level of performance against KPIs. Assessment of the proposals using a scoring system will allow the selection of a limited number of suppliers who most completely meet the specification. This approach should be facilitated by using some form of evaluation tool that will help to rank the decision making by evaluating the importance of various design and performance criteria. An example of this is provided in Table 2.2.1 below whereby the importance or weighting is highlighted by the colour coding of each aspect and the individual aspects are each scored as shown below:

<table>
<thead>
<tr>
<th>BMS System</th>
<th>New System Evaluation Criteria</th>
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<td></td>
<td>Monitoring and Control</td>
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<td>System 1</td>
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<td>System 2</td>
<td>4</td>
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</table>

3 In order for such performance targets to be meaningful within the performance specifications it is necessary to define dependant variables such as space temperature presets, hours of occupancy etc.
2.3 Define Savings Potential (Step 6)

It is likely that cost savings achieved through improved energy efficiency will form a significant part of the financial justification for any BMS project. Reliably forecasting such efficiency gains and hence cost savings therefore forms an important element in developing the business case. Forecasting of energy savings through BMS requires a number of issues to be considered including:

- **The size, diversity and function of the candidate buildings in the portfolio.** Traditionally, only the energy savings available in larger buildings have been required to justify expenditure on BMS. With increasing energy prices combined with technology advances, there is however increasing scope to cost effectively extend BMS into smaller buildings.

- **The activity or occupancy patterns of buildings.** Generally buildings with periodic occupancy such as offices and libraries or variable activity levels such as leisure centres create operating conditions which run the risk of high levels of wasted energy due to service running when not occupied. This means that investment in BMS within such buildings may offer greater potential savings than buildings requiring more constant 24/7 activity or occupancy levels such as care homes or hospital wards.

- **Complexity of different zones, number of zones, different environmental requirements and complexity of systems** e.g. heat recovery systems can make it more difficult to accurately estimate what potential savings will be achievable.

- **The cost and carbon emissions associated with energy use in each building.** The largest buildings or those with the highest energy bills are not necessarily the best candidates for BMS. Whilst data on energy consumption may be readily available through existing Energy Management Systems or collation of invoices, consideration also needs to be given to the types of energy load served in each building. This is because some loads, for example some types of Hot Water Systems offer little scope for savings through the implementation of an upgraded BMS. In many cases, savings potential associated with different types of loads can be evaluated by analysing existing demand profiles relative to building occupancy or activity levels. **It is stressed that robust data for existing energy consumption will deliver greater accuracy when considering savings estimates.** The correlation and analysis of Half Hourly Data (HHD) is considered as being invaluable especially when analysed relative to building occupancy or activity schedules. Refer to Figure 2.3.1 below for an example of gas consumption HHD from one fiscal gas meter (MPRN) over the course of one week for an example office building.
Figure 2.3.1 shows a week of half hourly gas consumption, green is when building is occupied, amber is when building is being pre-heated for occupancy and red is when building is neither occupied or being pre-heated and is therefore potential wasted consumption.

The condition and efficacy of the existing plant and controls can also be established via a number of routes including:

- Anecdotal evidence from staff and contractors.
- Logged reports of problems or complaints by building users or inspection and test reports.
- Surveys of building controls by in-house staff or contractors.
- Assessment of energy consumption data with reference to drivers such as outside air temperature.
- Comparison of individual building energy performance against benchmarks may be also considered (e.g. kWh per m² per year). CIBSE document TM 46 provides energy benchmarks for various different building types, alternatively it may be possible to use data from internal energy management systems to create local benchmarks within an organisations portfolio and use this to provide savings estimates.

Estimations of energy savings can be derived applying rules of thumb (such as those outlined in Table 2.3.1 below) in order to develop determine the likely extent of savings in each building.
Table 2.3.1 Rules of thumb for % fuel saving through various BMS control improvements³

<table>
<thead>
<tr>
<th>Measure</th>
<th>Typical Saving – heating fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Align optimised operating times with requirements</td>
<td>8-10% per 1 hour reduction/day</td>
</tr>
<tr>
<td>Review room temperature set-point</td>
<td>10% per 1°C reduction</td>
</tr>
<tr>
<td>Effective Weather compensation</td>
<td>5%</td>
</tr>
<tr>
<td>Effective boiler sequencing</td>
<td>5%</td>
</tr>
<tr>
<td>Effective programming of holidays</td>
<td>Up to 10%</td>
</tr>
<tr>
<td>Extending heating plant shutdown period/turning off on warm days</td>
<td>Up to 10%</td>
</tr>
</tbody>
</table>

Note ³ CIBSE indicate energy cost savings between 10% and 20% by use of BEMS in their 1998 Energy Efficiency in Buildings Guide. As a rule of thumb, a retrofit BEMS can yield a 10% direct fuel cost saving against a reasonably well maintained conventional control system when properly designed, installed and commissioned.

Application of rules of thumb is most effective against a comprehensive and consistent BMS strategy incorporating low energy control strategies and defined comfort thresholds and limits, for instance only providing space heating up to a pre-set room temperature which is specified and limited within for example a controlled range of 19°C to 20°C.

2.4 Prepare and Finalise Business Case (Step 7)

Dependant on internal organisation procurement and approval protocols, it is expected that some level of business case will need to be developed to commit to a procurement process. When a resource efficiency programme including investment in BMS is considered then some key business case considerations should include the following aspects:

- Establishing and outlining the key drivers for change including cost savings, resource management, improved working environment, compliance issues etc.
- Cost / Benefit analysis - either through simple payback or preferably through more detailed financial analysis such as project Net Present Value (NPV) including sensitivity analysis of different capital investment ranges, variation of year on year savings and variation of operating or maintenance costs etc.
- Risk assessments including performance confidence, disruption risks and enabling risks etc.
- Review of other avoided costs such as manpower savings and maintenance of existing systems etc.
- Consideration of how operation and environment will be improved and other non-financial benefits.
- Procurement and funding recommendations.
- Commercial considerations in terms of how a supply contract will be set up.
- Management considerations of how the system will be managed including training, accountability, reporting etc.
A recommended approach to developing a business case requiring capital investment within the Public Sector in Scotland can be summarised by the following matrix Table 2.4.1 and is taken from the Scottish Capital Investment Manual (SCIM - http://www.scim.scot.nhs.uk).

There is no reason why the private sector cannot adopt a similar business case development approach when developing a BMS investment business case.

Table 2.4.1 Key criteria within a resource efficiency capital investment business case

<table>
<thead>
<tr>
<th>The Strategic Case</th>
<th>The Economic Case</th>
<th>The Commercial Case</th>
<th>The Financial Case</th>
<th>The Management Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the problem? Why do we need to invest in a new BMS?</td>
<td>What sort of BMS do we want to buy?</td>
<td>How do we want to buy it?</td>
<td>What will it cost? What will it save?</td>
<td>How will the BMS system be managed?</td>
</tr>
</tbody>
</table>

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3 SECTION 3 Commercial and Funding Solutions (Step 8)

Once the business case for a BMS upgrade has been developed, consideration needs to be given to commercial and funding solutions. System maintenance is essential if the full benefits of a modern BMS are to be realised and this is therefore included in this section as part of commercial considerations.

Funding and commercial arrangements are often linked together in one solution arrangement when clients are looking to source external funding.

This section explores the following:
- Procurement
- Funding options for organisations in Scotland
- Commercial options including maintenance.

This section explores these aspects in more detail covering Step 8 Evaluation of Commercial and Funding Options.

3.1 Procurement

The form of procurement chosen will depend on the type of organisation, the scope of works and whether the BMS installation is a specific programme or part of a wider construction project. Options can range from a traditional procurement where design and supply is separated from construction, to design and build where a single contractor takes responsibility for design, supply and installation.

For design and supply contracts it is essential that a well-written client’s brief is prepared to ensure a satisfactory controls solution.

A sample controls specification has been provided in Appendix 0. Key elements of the specification are:
- Mechanical and electrical installation requirements
- Low energy design description of operations
- Schedule of rates for both installation and maintenance, so that once the contract is let there is no need to go out to tender on future phases of works for the agreed contract period.

3.2 Funding Options

As BMS is an energy saving investment there are a range of potential loans available and Energy Performance Contract (EnPC) options which are discussed below.
3.2.1 Loans

Salix

Salix finance in Scotland is funded by the Scottish Government to support energy efficiency savings within parts of the public sector. It has recently expanded its Salix Energy Efficiency Loans scheme (SEELS) offer to all of the Scottish public sector which is subject to the Public Bodies Duties Guidance. It should be noted however there are still governance and accounting issues associated with acceptance of Salix finance within the NHS in Scotland.

The Salix scheme allows eligible public sector organisations to apply for an interest free loan to finance up to 100% of the costs of compliant energy saving projects. The project funding criteria allows for up to an 8 year payback and up to a cost of £200 per tonne of CO\textsubscript{2} over the lifetime of the project. A BMS upgrade should be capable of meeting these criteria if specified properly. The loans are paid back over a 4 to 8 year period. For further details contact https://salixfinance.co.uk/loans/scotland-loans.

Carbon Trust – Energy Efficiency Financing Scheme

Through the Carbon Trust Implementation Services partnership with Siemens they have made a fund of £550m Energy Efficiency Financing available. The funding is available to all types of organisations who have been trading for 36 months and are seeking to reduce their own energy use. The loan option is designed to pay for itself as finance payments are calculated so that they can be offset by the anticipated energy savings. For further details contact Carbon Trust – it’s recommended that organisations check and satisfy themselves that individual projects are eligible. Also the scheme may change subject to conditions out with of Resource Efficiency Scotland control and organisations should therefore check if it is still fully operational.

3.3 Commercial Options

3.3.1 Energy Performance Contracting (EnPC)

EnPC’s are an alternative financing mechanism designed to accelerate investment in cost effective energy savings or renewable energy technologies for both the public and private sector. The EnPC provider proposes “guaranteed savings” such that the improvements will generate energy cost savings sufficient to pay for the project investment over the term of the contract. After the contract period, all additional cost savings accrue to the client. EnPC’s are commonly linked to management contracts and can be a way to access third party funding through contract procurement conditions. Under an EnPC, the contractor takes the performance risks, but the contract can be complex and can be financially onerous for clients.

It should be noted that “Guaranteed savings” type contracts, require some form of "measurement and verification plan (M&V plan)" (refer to Appendix 5) which will require knowledge of the system to be measured and its variables) and will form part of any “guaranteed savings” commercial contract. A number of organisations offer EnPC’s including equipment manufacturers and Energy Services Companies (ESCO’s): these include utility companies together with some large FM and construction companies.

3.3.2 Sharing the Benefits through Service Provision

If clients or contractors do not wish to enter into a “guaranteed savings” type contract, it is possible that a more straightforward “shared savings” contract can be set up whereby
“documented” savings are shared between the client and the BMS or service provider contractor.

As with “guaranteed savings” type contracts, this will require some form of “measurement and verification plan (M&V plan)” (refer to Appendix 5) which will require knowledge of the system and its variables and will form part of any “shared savings” commercial contract.

To set up a “guaranteed” or “shared” savings contract it will be necessary to establish a baseline period for the measurement of BMS system performance, for example, over a 12 month period. It will also be necessary to determine key “variables” such as weather and hours of occupancy and it will also be essential to identify and other factors (known as “static” factors) such as a requirement to increase temperature set points which may influence a performance change over a specified reporting period.

Once the savings have been determined by adopting the correct M&V format then a portion of these savings can be distributed to the contractor in lieu of standard contract type fees as agreed within the “shared savings” contract. Contract durations need to be agreed (normally a minimum of 2 to 3 years) along with commercial agreements based on a level of shared savings, performance reconciliation reviews and management of financial arrangements for example is the ‘banking’ of savings allowed from one year to the next.

3.4 Maintenance Contracts

Although modern controls are in general very reliable, components with moving parts such as valve and damper actuators are subject to wear and other components such as sensors may be subject to drift, damage or degradation. BMS maintenance is therefore essential to ensure that the control systems continue to operate efficiently and effectively.

There are a number of options for inclusion of maintenance within a BMS commercial arrangement including the following:

- Using in - house staff – for larger organisations with extensive or sophisticated systems, such as acute hospitals or universities, often maintenance is carried out by in-house technical staff. These staff may undertake the day-to-day maintenance activities and carry out initial investigation and repairs whilst calling on special BMS contractors for more complex work.
- Maintenance contractors – there are a number of organisations that provide maintenance contracts, these include the following:
  - Control System’s manufacturer – most manufacturers offer a maintenance service for their own equipment.
  - Systems Integrators – these range from small local companies to larger national organisations with regional offices and number of who are able to offer a 24 hour bureau service. A number of these companies are licensed to work with a number of manufacturer’s systems.
  - Mechanical & Electrical (M & E) companies – a number of M & E contractors operate a specialist BMS maintenance division which is often an autonomous company.
  - FM Contractors – a number of FM contractors undertake BMS maintenance either using their own in-house specialist team, or by sub-contracting to a BMS maintenance contractor.
There are several specific BMS maintenance contracts options including the following:

- Standard Service
- Fully comprehensive service
- Bureau Service
- Enhanced energy performance service

Whichever option is chosen it is important that the contract is carefully specified and should include the following elements:

- Software upgrades
- Data-back-up and archiving
- Periodic visits checking of sensors, actuators, valves and dampers
- Arrangements for emergency call outs
- Performance standard for the building control system
- Change logging

An example of a Maintenance Specification is provided in Appendix 6. Further guidance can also be obtained from CIBSE Guide M: Maintenance engineering and management which can be obtained through CIBSE publications, www.cibseknowledgeportal.co.uk.

Table 3.4.1 below details types of maintenance aspects within various types of commercial contract arrangements.

<table>
<thead>
<tr>
<th>Type of Contract</th>
<th>Scheduled maintenance visits</th>
<th>Provision installation of parts, software and consumables included</th>
<th>Breakdown / callouts included</th>
<th>Remote diagnostics / system optimisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Service</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fully Comprehensive Service</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Bureau Service</td>
<td>Yes</td>
<td>Optional</td>
<td>Optional</td>
<td>Yes</td>
</tr>
<tr>
<td>Enhance Energy Performance Service</td>
<td>Yes</td>
<td>Optional</td>
<td>Optional</td>
<td>Yes</td>
</tr>
</tbody>
</table>

With a fully comprehensive service contract the client benefits from greater certainty over maintenance costs with the risks being borne by the contractor. However without the correct performance contract in place and a pro-active overview of contractor management by the client, there is a risk that the contractor may not undertake costly replacements. Further benefits and savings may however be realised by an enhanced Energy Performance Service which is also covered in Section 4 of this guide.
It should be noted that irrespective of how a BMS operating and management contract is set up, experience shows that the best BMS outcomes are achieved where the BMS is ‘owned’ by someone within the client organisation, able to provide an overview to ensure that the maintenance contractor is meeting the desired operating performance objectives (refer also to section 6 of this guide document).

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4 SECTION 4 Performance Optimisation & Innovation

Whist the new BMS will provide energy savings and operational benefits; innovation in the scope of services offered by for example a bureau service may substantially increase the benefits offered by the BMS. The tendering process provides you with the opportunity to specify the level of “added value” support that you require, including a level of innovation which would enhance the value and benefit of BMS beyond that offered in standard support packages. This may for example include additional cost savings through the early identification of waste or rapid response to alarms and faults.

This section outlines some areas of innovation that you may wish to seek from potential suppliers as part of the tendering process. The ability and willingness of suppliers to respond to such innovation – and offer further innovation themselves – may indicate their suitability as a long term partner in the successful operation of the BMS.

This section explores these aspects in more detail covering the following Steps:

Step 9 Development of Performance Specification
Step 10 Innovation and Performance Enhancement

4.1 Development of Performance Specification (Step 9)

Details of specific aspects of monitoring and control specification are covered in Section 6 and Section 7 of the separate BMS Specification Manual. This section covers “gateway specification” dealing with system capacity type issues. This would for example specify the number and capacity of outstations, system communication capacity and protection requirements, control ranges, what types of communications systems will work within the site environment, what level of reporting outputs are required and the extent of log and alarm capacities and so on.

Predominantly, this section covers typical system performance requirements and therefore represents the types of system performance criteria which a user organisation needs to consider within a BMS specification and evaluation process.
4.1.1 Control and Operating Strategy

Note that more details are provided within Section 5 and Section 6 of the BMS Specification Manual.

The following is a brief summary of control and operating strategy for BMSs (Refer also to Appendices 3 & 4):

- A control strategy which recognises the specific relevant building and environment issues such as the importance of humidity, temperature and ventilation control.
- Develop a standard repertoire of control strategies for common plant.
- Develop standard alarm strategies.
- Develop a standard list of data points which should be monitored within each control strategy.

In addition to control strategy, other BMS specification and evaluation requirements should include a combination of some or all of the following:

- Compatibility with existing BMS as appropriate.
- Determination of rapid information on plant status.
- Ability to log and archive data for energy management purposes.
- Ability to import occupancy or activity data to provide building performance reporting.
- Ability to import other interdependent data to allow the BMS system to provide benchmarking reports etc.
- Identification of both planned and reactive maintenance requirements (for example, systems can record the number of hours that motors have run, or identify filters on air supply systems which have become blocked).
- Ease of expansion for building expansion or additional control zones.
- The ability to make widely known within an organisation the performance of elements within the BEMS in terms of reporting flexibility.
- Management and access into a BMS for example remote web based vs dedicated centralised console.

4.2 Innovation and Performance Enhancement (Step 10)

Many of the areas of innovation around BMS systems and support services are now focused on providing energy services type support to help building owners to manage the use of onsite energy and other resource consumption in a more efficient manner.

Many of the added value support services require a contract that allows for a performance based contract whereby the supplier or contractor is more responsible for the performance of complete systems. This could for example include aspects such as full parameter management, full maintenance provision, share of savings programmes etc. (Refer also to Section 3 of this guide document). Some examples of the types of innovative services on offer include the following.
4.2.1 Bureau with Enhanced Support Services

A number of BMS manufacturers and service providers have a “Bureau” service which enables them to monitor their client’s BMSs remotely and instantly 24 hours a day, 365 days per year. Through remote alarm monitoring the Bureau can respond and address site issues promptly, often before the client is aware that there has been a problem. Diagnosing problems remotely ensures that the maintenance engineer has the correct components to address the fault when attending site to respond to a breakdown and eliminates unnecessary or abortive visits. Also, the engineer’s time on site is reduced as they are able to go straight to a pre-diagnosed problem. The Bureau Service provider may also offer the option for an enhanced “Energy Performance Service” (although these may also be offered by smaller contractors who do not operate a bureau service).

Often Bureau Services have the facility to monitor automated metering reading (AMR) data and provide a range of management reports including consumption profiles (refer to Figure 4.2.1 below), benchmarking and exception reports etc. Such analysis and reporting services are normally underpinned by an interactive web based software package with agreed authority access levels to provide multiple site and hierarchical access levels as required.

Figure 4.2.1 Example of a typical half hourly weekly gas consumption report

![Gas Consumption Chart]

Where remote corrective actions have not been effective then clients may wish to consider the contractor offering onsite assessment to try to determine an improved methodology to achieve enhanced control performance. This will entail a site intervention by a controls expert to review the existing system and control parameters with the energy team / on site FM providers on a regular basis.
The site intervention (this could be at a central BMS location although may require plant room inspection) should include the following:

- Reviewing the suitability of the existing controls system or philosophy for the site.
- Identification of present parameter sets relative to building activity including for example:
  - Temperature pre-sets (refer to Appendix 4 for a typical time schedule control matrix).
  - Optimiser settings.
  - Day timer settings.
  - Summer / winter / holiday settings.
  - Compensation ramp review.
  - Heating / cooling conflicts.
  - Anomaly log for example unusual flow, room, OAT or valve status e.t.c..
  - System "change "logs and reporting of same and so on.

In discussion with onsite energy or estate teams, managed parameter changes can be agreed and implemented during this site intervention, the impact of which should be closely monitored by the contractor to evaluate the real cost and CO₂ impact of the changes implemented and these should be verified by the client. The contractor may also be able to provide support to monitor any impact of the changes on other “Environmental” performance levels (for example space temperature levels). In addition, the contractor or service provider may be able to support the management of any “user kick back” along with integration into a “behavioural change” programme, or help with the overall development of onsite environmental policy and building user manuals etc. This would represent a move towards a partnering approach as opposed to traditional client / sub-contractor relationships.

Whichever option for operation and management is selected it is vital that there is clear ownership of the control system with unambiguous responsibility for its operation. Where an outsourced service bureau is used they must be adequately managed and supported by the client organisation to ensure that the desired performance criteria are met. The service bureau contractor should report on a regular basis, typically monthly, on key performance indices including:

- Planned Preventative Maintenance (PPM) activities.
- Reporting of faults and alarms and actions taken.
- Reporting on complaints and remedial actions taken.
- Any changes in parameters set-points and time schedules with reasons.

Without this client organisation support and supervision, the BMS service provider may not be sufficiently motivated or indeed authorised to implement energy saving strategies, or have the authority to enforce the organisations heating and cooling guidelines and decline unreasonable requests from occupants etc.

A recent anecdote by an Energy Manager within the Scottish Public Sector summarised this by stating that “through experience, I have found that generally there is a tendency for FM engineers to adjust set-points in response to complaints rather than having the authority or motivation to challenge the requested changes”.
4.2.2 Awareness & Training

It is essential that relevant staff, based within the buildings, are trained in the use of the BMS. Even in buildings where local staff do not have permission to adjust settings, they should be able to monitor the condition and performance of the equipment controlled by the system.

All reputable BMS service providers should encourage training as it is in their interest that the system works well especially if linked to a contract performance element. All staff with access to the BMS should develop experience in using it to manage the building on a routine basis. For example most BMS have alarms set and staff should know what to do when these alarms are triggered.

Any contract designed to optimise performance should include regular awareness refreshers for BMS users likely to be co-ordinated with the three main heating seasons, that is, for winter, autumn/spring and summer conditions. This awareness should as minimum, incorporate aspects such as:

- A review of existing parameter settings.
- A log review of what parameter changes (and why) have taken place since the last review.
- A review of any system upgrades since the last review.
- A review of any proposed upgrades.
- A review of any new log or alarm amendments.
- A training aspect on system use.

4.2.3 Contract Performance Reviews

It is generally recommended that any “partnership contract” with BMS service providers should include regular performance reviews. It may also be possible to link performance reviews with staff trainings session refreshers etc.

Performance Reviews should include the following type of parameters:

- A review of any complaints log received and corrective action undertaken.
- Number of site attendance or hours spent at site.
- Numbers of overall hours allocated to the contract.
- Budget review for costs to maintain the system over the period (unless fixed price contract).
- Energy or Utility Performance Review (dependant on extent of service contract scope), for example a review of performance activity improvements (kWh/m2 or per pupil etc.) over the previous period and proposed performance activity improvements or targets over the forthcoming period.
5 SECTION 5 Technical Overview

Knowledge of the key technical aspects of BMS will help you define the design and specification of your systems with respect to your system requirements.

This section provides a brief outline of such aspects including an overview of a typical BMS, some of its features together with some key considerations when selecting a BMS which are as follows:

- Overview – what a BMS looks like, some key features
- BMS communications
- Interfacing with third party equipment – open protocols
- User interfaces for local users
- System selection
- Security

5.1 Overview

The purpose of a BMS is to maintain the desired internal environmental conditions by operating and controlling heating, ventilation and air-conditioning (HVAC) plant along with other building services plant to optimal efficiency.

A BMS comprises microprocessor controllers, known as outstations, which are linked via a communication network to a centralised PC computer or server, often called a “head-end” or “front-end” supervisor which is the user interface.

The outstations are generally located within the plant rooms and carry out the control of the equipment, with each outstation programmed to meet the specific requirements of the installation. For example, for a simple heating system it will operate and control the boilers, pumps and associated control valves by monitoring temperature sensors to meet the desired set-points. The outstation provides data on parameter levels and plant status to the “head-end” supervisor as discussed below.

To obtain the full benefits and features, the BMS will need to be a centralised system with all the connected sites to a “head-end” supervisor (this may then be accessed if required by multiple users via a web-browser as discussed below).

A modern BMS is navigated via dynamic schematic graphic slides which display live values of key parameters for the control and operation of each system. This includes plant status, faults, set-points and corresponding sensor readings. A typical graphic is shown below in Figure 5.1.1 below. They allow the operator to easily assess the operation of a system, for example allowing comparison of temperatures against set point, condition of plant and identification of faults.
The BMS also carries out alarm handling, prioritisation of alarms and relaying critical and non-critical alarms to the “monitoring person(s)”. This ensures that any critical alarm is responded to at the earliest opportunity. These alarms can also be transmitted via SMS and email on modern communication systems.

A further feature of a modern BMS is data logging. This allows a system’s performance to be monitored and analysed over time for diagnostic purposes, ensuring that any deviation from the norm can be identified and remedial actions taken at the earliest opportunity. This would tend not be apparent with a discrete control system. For example, data logging a Variable Temperature (VT) circuit, when a VT sensor reading significantly exceeds the set-point value with the VT control valve closed, indicates that it is likely that the control valve is faulty and has not closed correctly (see Figure 5.1.2 below). Obviously early intervention and resolution will minimise any consequential overheating and energy wastage.
5.2 BMS Communications

Reliable communications are essential for an effective BMS in order for the “head-end” to continuously receive live data and ensure that alarms are sent to the appropriate persons.

For a single site, BMS devices are traditionally linked by a dedicated Local Area Network (LAN). With newer installations however the use of Transmission Control Protocol/Internet Protocol (TCP/IP) is now well established utilising the client’s IT network to connect outstations distributed across a site together with remote sites to the “head-end” supervisor. The modern IT networks facilitate multi-user access through a web browser. Outstations distributed across a site together with remote sites can be connected to the central BMS PC or server through these existing IT networks. It should be noted that historically remote sites have been linked via modems which required a dedicated phone line and tended to be slow and somewhat unreliable – there may however, occasionally be an off IT grid site that may still require a modem for communications.

A key benefit for remote access is that it reduces and may eliminate unnecessary or abortive breakdown calls. On notification of a fault a service engineer can interrogate the site remotely via the internet, diagnose the fault and where possible address the problem remotely.

A typical BMS network schematic, also referred to as system architecture is shown in Figure 5.2.1 below.
5.3 Interfaces with Third Part Equipment – “Open” Protocols

There is an increasing demand for BMSs to communicate with a wide variety of third party equipment including boilers, chillers, air-conditioning, heat pump systems, smart meters and OEM equipment supplied with other BMS manufacturer’s equipment.

“Open” protocols allow the BMS and third party equipment to exchange data which improves control and management of the plant so that they can be fully integrated with the other site building services. For example, through an open protocol interface, a heat pump system with its own integral controls can provide the BMS with a wide range of parameter data on the plant operation, control, condition, fault alarms etc. This would mean that the heat pump temperature set points, time schedules and holiday settings can all be adjusted through the BMS.
A modern state of the art BMS will support the industry recognised “Open” protocol communication standards each of which tend to have specific applications. These include:

- **BACnet** – developed specifically for buildings: focusing on HVAC, fire control panels, security and access. BACnet was developed by AHSREA (American Society of Heating, Refrigeration and Air conditioning Engineers) is recognised as the most widely used both in the UK and internationally.
- **LonWorks** – similar to BACnet.
- **M-Bus** – Meter bus developed specifically for remote reading of meters.
- **Modbus** – used to enable communication between devices such as an automation station and chillers.
- **KNX** – lighting systems, shading (automated blinds), room climate, security and BMS.

The BMS can manage these protocols at the same time, creating a seamless joined-up approach to managing the buildings services allowing the sites to operate at improved efficiencies.

### 5.4 Local User Interfaces

Organisations need to consider what level of responsibility they want to be taken locally. Generally, it is considered that giving the local user some responsibility creates greater buy-in and ownership and it is more likely that the system will be well managed with fewer callouts (refer also to Section 6).

For large sites it may be appropriate to have a full BMS either as a dedicated workstation terminal or allowing access via a web browser over the network. For smaller sites, such as primary schools, LCD operator display units may be more appropriate.

Most manufacturers supply user friendly LCD operator display units which have schematic displays similar to the BMS graphics. These are typically mounted on the control panel within the plant room but could, if required, be mounted in a more accessible area such as the site manager’s office. These allow the user to carry out key functions such as:

- Review and adjust time schedules.
- Add holiday schedules.
- Review temperature readings and other parameters against corresponding set-points.
- Review alarms.

Where there is a degree of local control, the responsibility for management of the BMS should not necessarily be viewed as a purely technical activity. There is also a role for someone with particular interest in financial control or environmental issues to verify that appropriate settings are being maintained as detailed in the next Section of this guide document.
5.5 System Security

The ability to remotely access a BMS also unfortunately opens the site to potential cyber-attack or hacking. There are an increasing number of well-published instances of illicit remote access to buildings which could potentially have a catastrophic impact on the BMS or in some cases on the organisation more widely.

The threats can be malicious with intent to cause commercial harm, damage reputation or business disruption. Non malicious threats typically involve careless staff, visitors or contractors who may cause unintended significant damage, for example, by plugging in infected removable media into the BMS terminal.

These risks can be addressed by implementing the correct procedures such as management using an appropriate ‘firewall’ to ensure remote access is secure. It is essential that the IT department is consulted to ensure that the BMS upgrade meets with the organisation’s security requirements.

*It is also recommended that demonstration of an appreciation of best practice in BMS security be included as one of the selection criteria for the BMS contractors or service providers.*

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6 SECTION 6 Day-to-Day Management

For efficient BMS management, it is essential to define the responsibilities between the client’s estates or energy personnel, the site end-users and the BMS service provider. This section provides a brief outline of such aspects including considering BMS on-site ownership relative to other on-site responsibilities and also including other remote support functions.

For the effective management of an efficient BMS system it is essential to define the responsibilities between the client’s estates or energy personnel, the site end-users, and the BMS service provider. The level of support required from the BMS service provider will depend on a number of issues including the type and size of organisation and the resources available. Some sites may have in-house technical staff that carry out day-to-day maintenance activities and undertake initial investigation and repairs, whilst calling on BMS or controls service providers for more complex work. Other organisations with limited in-house technical resource will be more reliant on external contractors.

Whichever approach is taken it is essential that the organisation has a member of staff who takes ownership of the BMS. This person should have a good operational knowledge of the BMS and the organisation’s control objectives. It is preferable that the BMS lead has a good understanding of building services and is able to interpret the BMS data and make objective assessments on the system performance. It is therefore necessary for the appropriate levels of training to be provided for the tasks being undertaken.

The BMS lead is also in a position to manage the internal expectations of staff and ensure the organisation’s comfort and other environmental guidelines are being adhered to. In many cases there is no direct incentive for the BMS contractor to ensure that the system is operating to its greatest efficiency, and also they may not have the authority to challenge demands that have an adverse effect on the energy performance of the site. Having an informed client to challenge and motivate the BMS contractor, whilst managing staff expectations can therefore have a dramatic impact on the efficiency performance of the system.

Experience also shows that for the efficient BMS operation, it is essential that the end-user takes ownership of their individual sites at a site level. Sites where client’s anecdote that “the heating is operated by central office” often perform very poorly. It is therefore recommended that individual sites are encouraged to take ownership and responsibility for the efficient operation of their control systems. This approach should complement the central office staff and BMS service providers who may not have the resources to give the desired regular attention to each individual site.

Ideally this “site ownership” should be a shared responsibility and not just left to the maintenance or estates type staff. For example, some schools have appointed a member of their teaching staff, bursar, or business manager to assist or take overall responsibility for the role, usually because they have a particular interest in financial control, environmental or sustainability issues as well as operational issues.
# APPENDICES

## Appendix 1 – Glossary of Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication protocol</td>
<td>A system of rules for data exchange within or between computers and digital devices.</td>
</tr>
<tr>
<td>Compensation ramp</td>
<td>Heating systems may be fitted with weather compensation controls that allow the temperature of the hot generated by the boiler house to be adjusted according to the outside air temperature. This both conserves energy and avoids the discomfort of high radiant heat from a hot radiator in spring and autumn. The compensation ramp or slope determines the boiler house output temperature, frequently set to 80°C at an external temperature of 0°C and falling to 20°C at an outside temperature of 20°C.</td>
</tr>
<tr>
<td>Ethernet</td>
<td>A family of connected computer technologies and systems providing local area networks and/or wide area networks within an organisation.</td>
</tr>
<tr>
<td>Front end supervisor / Head end supervisor</td>
<td>The principal user interface for a BMS which centralises all control and monitoring functionality covered by the BMS across the estate. Changes to control settings can be implemented and data accessed via the front end supervisor which may reside on a dedicated centralised PC or accessed via many devices via a web-browser. The front end supervisor may be navigated via graphic screen which display system schematics together with live values of key parameters for the control and operation of each system (including plant status, faults, set-points and corresponding sensor readings).</td>
</tr>
<tr>
<td>Heating Ventilation and Air Conditioning (HVAC)</td>
<td>Mechanical and electrical systems which provide a comfortable internal environment within a building. In some buildings, the different elements of the system may all be separate - each with their own control system. In other applications however HVAC systems may be combined and integrated under one control system.</td>
</tr>
<tr>
<td>Key Performance Indicators (KPIs)</td>
<td>A type of performance measurement that may be used to evaluate the progress towards targets.</td>
</tr>
<tr>
<td>Local Area Networks (LANs)</td>
<td>A computer network that interconnects several computers within a limited area such as a school or office building.</td>
</tr>
<tr>
<td>Net Present Value (NPV)</td>
<td>The sum of a series of cash flows (both income and expenditure)</td>
</tr>
</tbody>
</table>
over time for a given project or investment.

<table>
<thead>
<tr>
<th>Open protocol</th>
<th>Communication protocols that have been made readily available to users (frequently via the developer's website).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimiser</td>
<td>A time-switch control which is linked to external (and sometimes internal) thermostats in order to determine the exact time at which a boiler should be fired in order to ensure that the building reaches the required internal temperature in time for occupation. An optimiser may also enable the boiler to be switched off early so that the internal temperature is maintained only when required. By matching boiler operation to the occupancy cycle of the building, an optimiser prevents excessive running hours (such as heating the building too early) and can provide savings of 5-10% of the overall energy consumption of the boiler plant.</td>
</tr>
<tr>
<td>Outstations</td>
<td>Outstations are generally located within the plant rooms and carry out the control of the local equipment. Each outstation is programmed to meet the specific requirements of the installation. For example, an outstation will control the boilers, pumps and associated control valves of a heating system by monitoring temperature sensors to meet the desired set-points. The outstation provides monitoring data on parameter levels and plant status to the front-end supervisor, which may also be used to adjust the parameters controlled by the outstation.</td>
</tr>
<tr>
<td>Performance Specification</td>
<td>A documented requirement that describes the functional performance criteria required for a particular product or service.</td>
</tr>
<tr>
<td>Planned Preventative Maintenance (PPM)</td>
<td>Planned Preventive Maintenance is scheduled maintenance to item of equipment to ensure that it is operating correctly and to therefore avoid any unscheduled breakdown and downtime.</td>
</tr>
<tr>
<td>Wide Area Networks (WANs)</td>
<td>A computer network that covers a broad geographical area often using the telecommunications network. A WAN can include several LANs.</td>
</tr>
</tbody>
</table>
Appendix 2 – British Standard BS EN 15232 Guide

BSEN15232 is a European and British Standards that provides a structured classification of building automation technologies and their potential energy saving impact for a range of buildings. The Standard identifies four classes, A, B, C and D of control systems which are summarised in 0.1. The higher the class the greater the potential for improved energy performance, however it will also add to the capital cost of the system and the resources required to manage it.

0.1 Classes of building control from BSEN 15232

<table>
<thead>
<tr>
<th>Class</th>
<th>Energy efficiency</th>
</tr>
</thead>
</table>
| A     | High energy performance building automation and controls  
• networked room automation with automatic demand control  
• scheduled maintenance  
• energy monitoring  
• sustainable energy optimization |
| B     | Advanced building automation and some specific controls functions  
• networked room automation without automatic demand control  
• energy monitoring |
| C     | Corresponds to Standard building automation and control  
• networked building automation of primary plants  
• no electric room automation, thermostatic valves for radiators  
• no energy monitoring |
| D     | Corresponds to non-energy efficient building controls. BSEN15232 recommends that buildings with this type of system should be retrofitted, and that new buildings should avoid this level of control  
• without networked building automation functions  
• no electronic room automation  
• no energy monitoring |

The following Graph 0.1 compares the thermal energy saving that can be anticipated for a range of building types against class C which is used as the standard reference.

---

4 BSEN 15232 was developed from research carried out to support the European Energy Performance Directive (EPBD). The standard has undertaken extensive modelling of different types of buildings such as offices, hospitals, schools, lecture theatres and retail buildings to calculate the impact of the different classes of control.
Graph 0.1 Potential impact of controls on the thermal energy savings for non-residential buildings relative to BSEN 15232 Reference Standard C which is represented at 0%.
Appendix 3 – Low Energy Control Strategy

Typical Operational Guidance

A.3.1. Description of Operation

The BMS control system should be designed to maximise the efficiency of the heating, ventilation and air-conditioning plant serving each building. The description of operations should be considered indicative and should be further developed to meet the specific requirements of the site.

A.3.1.1 Heating Plant

Plant operation

The plant is to be operated by hand/off/auto switches located on the control panel fascia. In auto mode the heating plant is to be operated by the BMS under demand from individual zone optimised time schedules.

The boilers are to operate in sequence with the duty boiler being rotated on a weekly basis. Fault status for each boiler is to be monitored on the BMS raising an alarm and activating the next boiler in sequence.

The heating circulation pump-set are to operate on a duty/standby basis with the duty pump rotated on a weekly basis. A differential pressure switch installed across the pump set is to provide a flow status on the BMS and facilitates auto-changeover in the event of the duty pump failing.

Where applicable the flue dilution fan operates when there is demand from the heating plant and/or HWS heater. A differential pressure switch placed across the fan is to provide an air flow status on the BMS, providing a critical alarm in the event of air flow failure and automatic shutdown of the plant by hardwired interlock.

Plant Safety interlocks

Pressurisation unit – in the event of a fault on the pressurisation unit the heating plant will be shut down by hardwired interlock; fault status will be monitored by the BMS and a high-level alarm raised.

Emergency plant room safety circuit – in the event of an emergency knock-off button or thermal link being activated the gas valve and mechanical plant will be shut down by hardwire interlock; fault status will be monitored by the BMS and a high-level alarm raised.

Fire alarm – in the event of the fire alarm being activated the gas valve and mechanical plant will be shut down by hardwire interlock; fault status will be monitored by the BMS and a high-level alarm raised.
Control

i) Boiler start-up – the boiler is demand lead, and is to be enabled on demand from the individual zone optimiser time schedules.

ii) Optimisation – each heated zone (VT circuit, CT circuit or isolated sub-zone) is to have an individual optimiser. The BMS will monitor the ambient temperature and space temperatures for each zone to determine the optimum start and stop times. Where a zone serves more than one floor a room temperature sensor should be installed on each level in a representative location away from any external influence (heat source, solar gain, etc.). Each optimiser will generate a heating demand for the boiler plant and its associated zone pumps. Unless otherwise stated the optimiser will be set to match the zone’s core occupancy hours with a optimiser and room temperature set-points set at 19°C. An optimiser boost will allow the zone temperature to be met efficiently.

iii) High outside air temperature interlock – When the external temperature reaches or exceeds 16°C (operator adjustable) or the zone temperature is above 23°C (operator adjustable) the associated zone heating plant is to shut down.

iv) Summer/winter control – if a heating season policy has been implemented, shutdown the heating plant between 1st April and 1st October (operator adjustable).

v) Boiler sequencing

Condensing boilers - sequence the boilers to maintain a compensated common boiler flow temperature initially set up as shown in the table below. In addition the BMS also monitors the boiler return temperature. Facility should be provided for space temperature influence of the compensated temperature set-point.

<table>
<thead>
<tr>
<th>Outside air temperature °C</th>
<th>Compensated flow temperature set-point °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>20</td>
<td>50*</td>
</tr>
</tbody>
</table>

*Where boilers serve HWS calorifiers the minimum flow temperature should be 65°C

Non-condensing boilers may be controlled to maintain a compensated return temperature set-point, the manufacturer’s minimum return temperature requirements must be observed.

Boilers should be sequenced with approximately a 2 – 5°C differential to ensure stable control.

For new installations the boilers should be controlled by a 0 – 10V signal.
vi) VT circuit – modulate the VT valve to maintain a compensated flow temperature initially set up as shown in the table below. The BMS will monitor the VT return temperature; the temperature difference provides an indication of the circuit heating demand.

<table>
<thead>
<tr>
<th>Outside air temperature °C</th>
<th>Compensated flow temperature set-point °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Fan convector circuits – compensated flow temperature range: 50 – 80°C

Under floor heating – compensated flow temperature range: 35 – 50°C

vii) VT Circuit room influence

- Negative room trim: For every 1°C that the minimum space temperature falls below the space temperature set-point the VT flow set-point will be increased by 3°C. This is subject to a maximum set-point of 80°C.

- Positive room trim: For every 1°C that the minimum space temperature rises above the space temperature set-point the VT flow set-point will be reduced by 3°C. This is subject to a minimum set-point of 20°C.

eii) CT circuit – The CT pumps are to operate under demand from the AHU and reheat/fan coil unit valves; demand being defined as a valve open by 25% or more for 5 minutes.

ix) Frost and Fabric Protection –

- Stage 1 – activate circulation pumps when the outside air temperature falls to 1°C, and disable once OAT rises to 3°C.

- Stage 2 – activate heating system should the primary circuit pipe work temperature detect a temperature below 10°C. Open all AHU heat coil and zone heating valves to allow heated water to flow. Disable once the return temperature rises to 20°C.

- Stage 3 (fabric protection) - should the space temperature in any zone fall below 12°C the associated heating plant should be operated to raise the temperature by 1°C.

x) Dry Cycling control (For boilers with an output of 200kW or greater)] – the BMS is to monitor the flow and return temperatures for each boiler and calculates heat transfer rates and establishes a load profile for each boiler. Firing of the boiler is to
be inhibited for light load conditions or dry cycling (firing of the boiler due to standing loses).

A.3.1.2 Hot Water Supply (HWS) Plant

Plant Operation

HWS Heater
The HWS hot water heater is to operate by a dedicated BMS time schedule. Fault status is to be monitored on the BMS raising an alarm. A differential pressure switch is to be installed across the HWS secondary pump provides a flow status on the BMS (alternatively a current transformer may be used to prove pump status).

The time schedule will be set to meet the requirements of the site and should be set such that the hot water is utilised during the day so that there is minimal overnight HWS storage. Residential sites will require 24/7 provision. For schools sites only with HWS calorifiers it may be appropriate to heat the system up for two or 3 discrete periods of the day to match consumption requirements. This will avoid the heating plant running continuously.

HWS Calorifier
Primary HWS pumps are to operate in sequence on a duty standby basis with the duty pump rotated on a weekly basis. A differential pressure switch installed across the pump set to provide a flow status on the BMS and facilitates auto-changeover in the event of the duty pump failing. The de-stratification pump is enabled independently.

Plate Heat Exchanger
Operation as above. The BMS will monitor the PHE common fault status from the packaged unit.

Control
HWS Heaters - operate under its integral controls and is set to maintain a HWS flow temperature set-point of 60°C. The BMS is to monitor the flow temperatures and raise alarms should the flow temperature exceed 65°C or fall below 55°C (after a predetermined period, initially set to 30 minutes). The BMS is to monitor and logs the HWS return temperature.

HWS calorifiers – the BMS is to modulate the HWS diverting valve to maintain the HWS set-point of 60°C. A hi-limit thermostat fitted to the calorifier de-energise the HWS valve actuator activate spring safe function and close the valve in the event of detecting a HWS temperature of 70°C.

Plate heat exchange – the unit operates under its integral controls.
A.3.1.3 Ventilation Plant

Plant Operation

The ventilation plant is operated by hand/off/auto switches located on the control panel fascia. In auto mode the plant is to be operated by individual system optimised time schedules for air handling units (AHUs) plant or time schedules for fan only applications.

All fans motors above 2kW should be fitted with and VSD which is to be controlled by either temperature and/or CO2 control.

Differential pressure switches are to be installed across the supply and extract fans to provide air flow status’s on the BMS. A differential pressure switch is to be installed across the fresh air filters to provide a filter dirty status on the BMS.

Control

Temperature control
Frost control – the BMS will modulate the frost coil valve to maintain an off-frost coil temperature monitored by a duct sensor downstream. A capillary thermostat clipped to the downstream face of the frost coil is to shut down the AHU supply fan by hardwired interlock. The frost coil should be fitted with a spring-open actuator such that in the event of the frost thermostat being activated a hardwire interlock de-energises the actuator, with the spring mechanism opening the valve to allow flow through the coil. Activation of the frost coil stat is monitored on the BMS raising an alarm.

AHUs serving terminal units and re heaters
The heat reclaim unit, heating coil and cooling coil (where applicable) are to be modulated to maintain a compensated supply air temperature initial set as detailed below:

<table>
<thead>
<tr>
<th>Outside air temperature °C</th>
<th>Supply air temperature set-point °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

The heat reclaim unit; either recuperator or mixing dampers are to be modulated to provide free heating or cooling determined by comparing the fresh air and return air temperatures. (Where humidity is being controlled enthalpy control shall be used).

AHUs for ventilation systems without terminal units
The heat reclaim unit, heating coil and cooling coil (where applicable) are to modulate to maintain a space or return air temperature of 22 +/- 2°C. Heat reclaim control as detailed in paragraph above.
AHUs serving dedicated areas such as theatres, meeting room etc. – CO2 Control and Occupancy Control

Where VSDs are fitted, room or duct mounted CO₂ sensors are to be installed and monitored by the BMS to modulate the supply and extract fan VSDs to maintain satisfactory air quality initial as detailed below:

<table>
<thead>
<tr>
<th>Space CO₂ reading (ppm)</th>
<th>VSD speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>600ppm</td>
<td>50%</td>
</tr>
<tr>
<td>1,000ppm</td>
<td>100%</td>
</tr>
</tbody>
</table>

Presence detection sensors (microwave) are to be installed to provide occupancy control to rooms with intermittent occupancy. On morning start-up the AHU is to be operated to bring the room up to temperature (initially) set to 19°C. Once reached, should no occupancy be detected after a period of 15 minutes (adjustable) the AHU is shutdown. On detecting occupancy, the AHU is restarted and will continue to operate under presence detection control.

AHU serving VAV system fan speed control

The supply fan variable speed drive (VSD) is modulated to maintain a static pressure set-point (to be determined during commissioning with all theatres open). Velocity sensors are to be installed and located in the supply and extract ductwork monitor the air flow rates (m³/s). The extract fan VSD is to be modulated to maintain an air flow rate of 80% of the supply fan.

A.3.1.4 Chilled Water Plant

Plant operation

The plant is operated by hand/off/auto switches located on the control panel fascia. In auto mode the chilled water plant is to be operated under demand from AHU and fan coil units. Demand being defined as a cooling valve being open by 25% or more for 5 minutes,

The chillers are to operate in sequence, with the duty chiller being rotated on a weekly basis. Fault status for each chiller is to be monitored on the BMS raising an alarm and activating the next chiller in sequence.

The chilled water circulation pump set operate on a duty/standby basis with the duty pump rotated on a weekly basis. A differential pressure switch installed across the pump set is to provide a flow status on the BMS and facilitates auto-changeover in the event of the duty pump failing.

Plant Safety interlocks

Pressurisation unit – in the event of a fault on the pressurisation unit the heating plant will be shut down by hardwired interlock; fault status will be monitored by the BMS and a high-level alarm raised.
Control

i) Low outside air temperature interlock – When the external temperature falls to 12°C (operator adjustable) the chilled water plant is to shut down.

ii) Summer/winter control – if a heating season policy has been implemented, shutdown the heating plant between 1st October and 1st April (operator adjustable).

iii) Chiller sequencing

The chillers are to be sequence to maintain a compensated flow temperature set-point initial set as follows:

<table>
<thead>
<tr>
<th>Outside air temperature</th>
<th>Compensated flow temperature set-point</th>
</tr>
</thead>
<tbody>
<tr>
<td>10°C</td>
<td>9°C</td>
</tr>
<tr>
<td>25°C</td>
<td>6°C</td>
</tr>
</tbody>
</table>

For new installations the chillers should be controlled by a 0 – 10V signal or via BAC-net or equivalent.

A.3.1.5 Heat pump and air conditioning units

The BMS is to operate the heat pump and air conditioning units under individual time schedules.

Presence detection sensors (microwave) within each room shall switch off the units should no occupancy be detected for a period of 10 minutes (user adjustable). The BMS Contractor will be responsible for the provision of any necessary interface to achieve remote enable of the units.

A temperature sensor within each room will provided an alarm should the temperature fall below 18°C or exceed 25°C (when the unit has been enabled to operate).

Low ambient shutdown: the air-conditioning units are to be inhibited from operating when the ambient temperature falls below 12°C (user adjustable). This applies to units providing cooling only.

Where there is an installation with an extensive number of heat pumps installed an interface controller will be installed to allow communication to be carried out via BAC-net or equivalent communications protocol compatible with the Siemen’s PXM controllers or proposed systems controller.
A.3.1.6 Electrical storage heaters and panel heaters

**Plant operation and control**

Storage heaters are to be enabled by the BMS under demand from individual optimised zone time schedules.

Contactor will be installed to facilitate BMS operation, and space temperature sensors will be installed in each zone.

The optimiser will determine the required charging period to meet the requirements of the zone. The optimiser will be self-learning so that it can adapt to the requirements of the heating zone.

A.3.1.7 Plant extension facilities

Each heating zone is to be provided with a plant extension switch on the control panel fascia or mimic panel located in an area accessible to staff only.

The switches enable each zone to be extended for a 2-hour period (adjustable on the BMS). The switch will be a spring return unit, a one shot operation. If operated during the normal day the extension period will be added to the normal time schedule. If operated outside normal hours the plant will operate immediately. Status of the switches shall be indicated on the graphics.

Time extension switches should be provided for the HWS plant and ventilation plant.

A.3.1.8 Plant manual function

A plant Auto/Manual (Hand) switch will be provided on the control panel. Maintenance staff is to be instructed to use this switch only in a critical situation should they need to operate any plant in hand and although hi-level alarm will be raised on the BMS, contact the maintenance section.

A.3.1.9 Outside Air Temperature Sensors

Outside Air Temperature Sensors: Preferably, the sensor should come complete with an in-built radiation shield to a minimum accuracy level of PT100. It’s highly recommended that the sensor is positioned on a north facing wall away from the effects of direct sunlight.
### Appendix 4 – Sample Controls Specification for a Typical School

<table>
<thead>
<tr>
<th>Area</th>
<th>Set Temp (°C)</th>
<th>Prot Temp (°C)</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
<th>Comments/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Areas</td>
<td>21.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Corridors &amp; Walkways</td>
<td>18.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Main Assembly/Dining Hall</td>
<td>18.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td>After School &amp; Youth Clubs use these areas on Monday, Tuesday and Wednesday evenings.</td>
</tr>
<tr>
<td>Recreational Areas</td>
<td>18.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Ground Floor</td>
<td>21.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1st Floor</td>
<td>21.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>All Areas</td>
<td>21.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>All Areas</td>
<td>21.0</td>
<td>12.0</td>
<td>08:00</td>
<td>08:00</td>
<td>08:00</td>
<td>08:00</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>School</td>
<td>18.0</td>
<td>12.0</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>08:30</td>
<td>16:00</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Toilets</td>
<td>Gymnasium (East)</td>
<td>Gymnasium (West)</td>
<td>Changing Rooms</td>
<td>PE Dept Toilets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18.0</td>
<td>12.0</td>
<td>18.0</td>
<td>18.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>08:30</td>
<td>17:00</td>
<td>08:30</td>
<td>08:30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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</table>

After School Clubs on Tues, Wed and Thursday for: Netball, Hockey, Football Training and Athletics. Football Matches are scheduled for Saturday mornings.
Appendix 5 – Typical Measurement and Verification Plan

Client:

Project:

Version:

Date:

Prepared
By:

Introduction

The purpose of this plan is to enable measurement and later verification of energy savings due to the interventions discussed, whilst adjusting for changes in "Static Factors" and "Energy Drivers" between pre-installation and post-installation measurement periods.

1.1 Savings to Quantify

- Gas – unit: kWh/annum
- Electricity – unit: £/annum - based on unit costs for each fuel (in £/kWh) plus any reduction in peak capacity charges as applicable

1.2 Fuels to Consider

- Natural Gas
- Grid Electricity

1.3 Climate Data

Climate data for heating degree analysis

- University of Oxford ECI
  http://www.eci.ox.ac.uk/research/energy/degreedays-weekly-daily.php

Initial Base Line Review

Half hourly gas consumption has been plotted against Heating Degree Days (refer to section 3.1) for each day from 1st January 2012 to 31st December 2012 inclusive.

The results of this are as follows:

![Graph](#)
**Proposed Interventions**

The intervention set has not been finalised, but the following interventions have been considered in this plan:

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>Energy and Behavioural Management</td>
</tr>
<tr>
<td>I2</td>
<td>Energy Review – Data Management Services</td>
</tr>
<tr>
<td>I3</td>
<td>Control Intervention on Building HVAC Controls</td>
</tr>
</tbody>
</table>

**Energy Drivers & Static Factors**

The Energy Drivers & Static Factors that affect the demand on each system are presented in the following table.

<table>
<thead>
<tr>
<th>System Description</th>
<th>Energy Drivers</th>
<th>Static Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1: Management and Behavioural</td>
<td>Climate (degree days - kWh /dd)</td>
<td>Environmental Standards (Temp Pre- set)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usage of Intermittent Spaces (none teaching space (hours/yr))</td>
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<td>Occupancy Density (average pupil/m²)</td>
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<tr>
<td>I2: Data Management</td>
<td>Climate (degree days kWh /dd)</td>
<td>Environmental Standards (Temp Pre- set)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usage of Intermittent Spaces (none teaching space (hours/yr))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Occupancy Density (average pupil/m²).</td>
</tr>
<tr>
<td>I3: BMS / Controls Intervention</td>
<td>Climate (degree days kWh /dd)</td>
<td>Environmental Standards (Temp Pre- set)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usage of Intermittent Spaces (none teaching space (hours/yr))</td>
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<tr>
<td></td>
<td></td>
<td>Occupancy Density (average pupil/m²).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>System Management – remote vs local.</td>
</tr>
</tbody>
</table>
Proposed Monitoring Options

- I1, I2 & I3 - Whole Facility – Single Gas Meter MPRN XXXXXXXXXX. Aspects are low cost, low precision & accuracy.

Monitoring proposals with brief methodologies

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Measurement Point</th>
<th>Measurement Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1, I2, I3</td>
<td>Main Gas Meter</td>
<td>Profile Gas Consumption – Base Line (12mths) and Reporting Period (6months plus) – normalised for climate</td>
</tr>
</tbody>
</table>

I1, I2 & I3 - Gas saving for reduced demand on DHW & Heating circuits is calculated by:

- Measurement of gas usage during baseline, normalised for HDD over same period –
- Measurement of gas usage during reporting, normalised for HDD over same period and adjusted for reduced reporting period

Advanced Monitoring Options

- Add permanent meters or temporary electrical loggers to Pool Pumps, AHU supply and AHU Extract drives – Optional Requirement
- Add permanent heat or “strap on” heat meters to individual heating circuits, e.g. radiator (VT), AHU (CT), Under Floor, DHW feed – Optional Requirement.
- Add additional humidistat to AHU extract – Optional Requirement.
- Install temperature loggers (£60+VAT each) to check environmental standards – Optional

Appendix 6 – Maintenance Specification

Further Maintenance Specification guidance can be obtained from CIBSE Guide M: Maintenance engineering and management which can be obtained through CIBSE publications, www.cibseknowledgeportal.co.uk. Any purchase from CIBSE would be a one off cost to receive the reference book for future use.