Building Management Systems

Summary

A well designed and managed Building Management System (BMS) provides great opportunities for improvements in energy efficiency by:

- Enabling building managers to provide an optimal working environment consistent with maintaining a building’s energy efficiency rating;
- Early identification of equipment failure;
- Identification of unusual patterns of energy usage, such as equipment being left on out of office hours;

This document is only intended as background information and is current as at October 2010.
Introduction

Effective well utilised Building Management Systems (BMS) provide the core management tool required by building managers to ensure compliance with, and achievement of, Green Lease requirements, such as the target NABERS rating, monitoring of the Energy Management Plan (EMP), and reports for the Building Management Committee (BMC). It enables Building Managers to provide the optimal working environment consistent with maintaining the required NABERS rating while minimising the costs to both landlords and tenants. Effective BMS utilisation allows for optimal building performance by extending the operational life of equipment and systems through reducing loads and operating hours. Maintenance and capital costs are therefore reduced and less embedded energy is consumed through equipment replacement and upgrades.

When a building has been completed the impact of its structure on its energy consumption performance is normally fixed until refurbishment occurs. Base Building and Tenant Light and Power energy consumption can however be increased or decreased by the performance of both building systems and tenants. A BMS will show increases in energy use due to equipment failure or adjustments to operating parameters. For example, heating valves opening when the building requires cooling or whole floors of lights being left on for extended periods of time due to cleaning activity. A BMS may also indicate that air-conditioning is starting up hours before the building is fully occupied due to activities of security staff. With this information in hand, the building manager may be able to rectify such issues through consultation or engineering solutions.

In the absence of a BMS, the impact of such events can be disguised by seasonal variations, changes in occupancy levels or technology upgrades. A correctly configured BMS with an adequate number of correctly located monitoring points is the only way a building manager can be quickly alerted to problems which could otherwise remain undetected until annual inspections or external audits are undertaken. A BMS is also a primary tool for identifying energy intensity improvement opportunities, for example refining the size and number of lighting time blocks, providing meaningful reports to the Building Management Committee on issues and opportunities, and enabling identification of faults, maintenance planning, and energy saving upgrades.
NABERS Rating

The Australian Government Energy Efficiency in Government Operations (EEGO) policy requires new buildings, major refurbishments and new leases to meet a minimum energy performance standard of 4.5 star NABERS energy rating. NABERS is an actual performance based rating that underpins the Green Lease Schedule.

The BMS is the major diagnostic tool for both owner and tenant when issues regarding NABERS ratings arise. It can be used to assess changes in usage patterns, environmental settings, or equipment performance. This can inform either an upward revision of NABERS rating or a rectification program to achieve agreed outcome. The BMS should be configured to identify small tenancy areas or individual plants performing outside agreed parameters.

Green Lease Schedules require the owner and tenant to collaborate in management of the building and in data collation, to enable an accredited NABERS assessor to formally rate the building after detailed modelling, with an approved computer program. The lease schedules detail the mechanisms to achieve, then sustain and improve the rating over time. Standard reports and graphic presentation of trends in data can be set up in the BMS and automatically prepared at set times. Regular use of this material will ensure that if slippage in energy efficiency starts to occur it will be identified quickly with the cause clearly identified.

Green Lease Schedule negotiations and their relationship to BMS

All of the commonly utilised BMS models in Australia have the inherent capability to effectively manage a fairly complex building. However, the manner in which they have been installed, commissioned and updated can affect the performance and effectiveness of a BMS. Building Managers also need to take into consideration changes to BMS software, building systems, and tenant usage which can lead to significant shortcomings in practice.

Tenant issues relating to BMS

There are a number of pertinent questions in relation to a BMS that tenants can ask when negotiating a Green Lease on a building. Issues that tenants, or those negotiating on their behalf, should consider include whether the BMS has:

- A current software version which is supported by the vendor;
- Support contract in place to ensure that software remains viable for duration of the tenancy. Most software requires upgrading at least annually;
- Software license covering a database size adequate for both tenant and base building current and future needs;
• The required data points for control and management built and connected to field devices;
• Sufficient graphics pages built which juxtapose relevant data;
• Intuitive and logical navigation between graphics for operators and maintenance personnel;
• Tenant pages such as time blocks for lighting and air conditioning which are fit for purpose;
• The ability to allow the building to continue to perform when the system is down, via standalone controllers;
• A functional disaster recovery plan in place;
• Remote access and alarm capability.

**BMS data**

For a BMS to function effectively it needs to reside on a computer that has adequate capacity and speed to support BMS function.

BMS related data storage of one year is required for all active control points. Computers and data storage hardware will normally require replacement at least once during an average tenancy.

The BMS data collection network should have capacity to provide data to the BMS at required frequency, via an industry open protocol such as a fully compliant BACNET.

**NABERS and performance issues relating to BMS**

Some of the NABERS and performance related issues of a BMS to consider include:

• The extent of historical data available;
• Whether programmed control strategies are efficient and tailored to tenancy requirements;
• Whether BMS control zones match anticipated tenant usage;
• The flexibility of programming and graphics to support fine tuning of building;
• Whether the BMS has a high level interface capability with key equipment including chillers, boilers, meters, zone controllers and key air conditioning devices;
• The capacity to cost effectively include additional monitoring and sub metering.
BMS Energy Intensity Enhancement opportunities

BMS energy intensity enhancement opportunities require free access of all parties to BMS data and agreement to share existing BMS capacity or fund required upgrades. Tenants need the capability to flexibly adjust time blocks and access to a tenant terminal to the BMS.

System reports need to be configured, accurate and informative with data that includes energy consumption, hours, temperature graphs, faults, water flows and air flows.

Owners and tenants’ responsibilities relating to BMS

The BMS is the building owner’s primary management tool to ensure the Base Building performs in accord with the Green Lease Schedule and for the tenant to ensure NABERS tenancy rating is maintained. It is critical to effective management and fault finding of the primary heating, cooling, and ventilation systems. On a day to day basis it will be under the responsibility of a party identified in the lease. The responsible party will be obliged under the lease to operate, repair and maintain the building, and freely provide access, data and reports to the tenant, owner and BMC.

The building owner’s responsibilities include providing:

- A fully functional BMS configured to manage systems, identify faults, and provide the required reports for the tenant, building owner and BMC.
- Adequate monitoring, zones, scheduling and so to enable the building to operate at maximum possible energy efficiency consistent with tenant lease provisions.
- Positive support to the BMC committee and the NABERS assessment process, including timely and regular availability of data to relevant parties.
- A commitment to a continuous improvement strategy to increase NABERS rating.

The tenant’s responsibilities include:

- Providing accurate and detailed information on tenant equipment loads.
- Providing a detailed schedule on occupation and equipment loads of tenanted areas.
- Early advice on changes to usage of tenanted areas.
- Providing positive support to the BMC committee and the NABERS assessment process, including timely and regular availability of data to relevant parties.
- A commitment to a continuous improvement strategy to increase NABERS rating of tenancy.
- Vetting staff requests for system adjustments to ensure energy impacts are considered.
• Identifying changes to tenant work practices which would reduce energy intensity.
• Ensuring tenant contracts take account of energy consumption impacts.

The responsibilities of the responsible party, as identified in the lease, include:
• Daily monitoring of the BMS for faults and exceptions relating plant and equipment.
• Maintenance of the BMS.
• Management of temporary or permanent adjustments to control parameters in accord with Green Lease provisions.
• BMS software and hardware upgrades.
• Providing reports to Building Management Committee.
• Manage upgrading of BMS as required by owner and tenants to support changes in space utilisation, equipment upgrades, or energy intensity improvement projects.
• Providing timely and accurate advice and reports to the BMC.

Comparison of BMS capabilities

The capability of installed BMS systems varies from the most basic being virtually a time clock (a device which turns equipment on and off) to that of a highly sophisticated and flexible management tool.

The additional software cost of a high level system is not substantial. Additional costs of high level BMS systems are mainly due to:

• Higher computer and data storage requirements.
• Connection of more sensing and monitoring points.
• Increased networking requirements.
• Building more graphics pages
• Configuring a more sophisticated alarm system.
• Configuring external access and reporting.
A high level BMS system will:

- Fully support Green Lease tenant requirements.
- Fully support a wide range of best practice control strategies.
- Have a detailed suite of automated reports.
- Support simple set up of ad-hoc reports for maintenance or enhancement activities.
- Have an alarm hierarchy that flags relative importance of alarms.
- Not constrain use of improved equipment or strategies.
- Have capabilities that continue to be enhanced and evolved by supplier.

When the power and capabilities of a properly configured high level BMS are fully utilised by maintenance staff, operators, and tenants, the payback period of the additional cost is normally very short. It can be less than one year, and is seldom more than five years from energy savings alone. Tenant satisfaction is generally higher through better environmental control, and ease of adjusting functional usage of the building.

Basic systems can be inadequate for a Green Lease agreed rating if they:

- Have a limited number of basic graphics.
- Lack high level interfaces.
- Store data for limited periods of weeks or one to two months.
- Have few automated reports.
- Monitor the minimum of control points.
- Be configured for simple control strategies such as time block control strategies.
- May not be true open system.

A basic system has limited fault analysis capabilities, and will seldom identify energy intensity improvements, nor will it facilitate their implementation. Failures causing excessive consumption or poor environmental conditions will seldom be clearly identified. While cheap, a basic system may lead to higher maintenance and energy costs. When renting an existing building an inadequate BMS must be rated as a very negative factor in negotiations.
Integration of BMS with other tools

Integration between a BMS and a business management system such as SAP requires a detailed configuration study. A high level interface between such systems can be implemented if care is given to the following.

Control of data consistency in a BMS is a live system continuously updating second by second. Business management systems typically batch by day, week, month or year.

Business management systems require data to be presented in very specific formats. Interfaces between two such systems often fall over when one or the other is upgraded.

From a business perspective the BMS is often collating the data required to allocate costs to tenant business units, or to charge sub tenants for services. It makes sound economic sense, and reduces the probability of error for data to be migrated from one system to another, provided the costs of maintaining the interface are commensurate with the benefits.

A satisfactory alternative to a high level interface given the normal batching needs of business systems is for the BMS to download its readings of hours run, energy used etc, into a spreadsheet format at agreed times. The business system can normally be easily programmed to populate its data fields by interrogating the spreadsheet at agreed times.

The manager of each system is then responsible when modifying or upgrading their system to ensure data moves as required. This is particularly relevant when systems are owned and operated by different parties.

High level interfaces between systems will seldom be cost effective in small or medium environments.

Best Practice Facades and Equipment Selection

The thermal performance of facades and energy efficiency limits of equipment are inherent in their design. They set the maximum efficiency a building can achieve without major refurbishment.

Facade optimization

It is important for new builds that the building envelope has good thermal characteristics, and that glazing and shading devices are selected to minimize heat loss in winter and gain in summer. They should conform to Section J of the Building Code of Australia [at the time of publication]. Design options could include:

- Minimum glazing to reduce summer heat gain and winter heat loss.
- Minimal use of floor to ceiling glazing, standard 800mm sill height preferable.
• Maximum use of correctly designed sun shading devices to northern, western, and eastern facades to optimally control solar gain and loss.

• Specifying high performance coated double glazing [Low U and low SHGC as required].

• Additional wall and ceiling insulation particularly in climatic extreme areas.

**Equipment and Lighting selection**

The efficiency and effectiveness of equipment is improving exponentially. Often designers and consultants can be very conservative and only consider equipment which has been marketed for some years. While proof of performance is required this should be balanced against the dramatic improvements in performance currently available on an annual basis.

Some guides to selection include:

• Use of high efficiency variable speed centrifugal chillers, water cooled, with a good co-efficient of performance across the full anticipated load range.

• High efficiency gas fired condensing boilers, with Variable Speed Drive (VSD) pump sets.

• Use of co-generation or tri-generation where appropriate.

• Use of Variable Air Volume (VAV) or chilled beam high efficiency mechanical systems, with good zone selection (separating perimeter areas with different solar conditions, and special purpose area)] and without terminal reheats.

• Intake dampers sized for economy and night purge modes particularly in areas with cooler days and in particular nights.

• Fresh air dampers linked via the control strategy to return air CO sensors for reducing energy consumption in low occupancy periods.

• High efficiency fans, pumps and motors, maximizing use of VSD’s.

• Local standalone systems if small 24 hour calls for conditioned air genuinely exist. Running central Ppant for a single small load is energy intensive, and shortens major equipment life expectancy.

• High efficiency solar or gas domestic hot water systems with water conservation devices.

• Lifts with variable voltage, variable frequency, AC drives including regenerative braking, and low use modes such as lighting which turns off.
• Metering incorporated in all key equipment with reporting capability to the BMS.

• Car parks to have VSD controlled fans and CO sensors

• Lighting to common areas (fire stairs, car parks, corridors, foyers) with two stage occupancy control where allowed.

• Lobbies and toilets on occupancy control.

• Light fittings to have high efficiency reflectors

• Lighting systems to have power consumption of 1.5W/m² or less per 100 Lux of light level.

• Lighting levels are even through zones and do not exceed specified levels.

• All ballasts and controls to DALI or equivalent standard.

Best Practice control strategies and their optimization

Control strategy optimisation requires a well configured high level BMS coupled with correctly chosen and located sensing equipment.

Below is a list of control strategies, and the BMS configuration (points, graphs and trends) to support them, which are normally most appropriate for the majority of office blocks. Some exclude use of others or best apply in specific climatic zones, or for particular tenancies and usage patterns. Technical analysis and careful selection of those strategies most applicable to particular buildings in its climatic zone is essential.

During refurbishment projects some compromise might be suggested because of heritage listing or the physical constraints of otherwise sound built structure. In such cases the impact on Green Lease requirements, can often be negated by skilled design and compensating through other mechanisms. The presumptive assumption should always be that full compliance will be achieved.

Mechanical Services

It is recommended that software be optimised for start and stop schedules. Rather than starting to pre-condition a building at a set time, each zone starts just in time to reach minimum set condition as occupants start to arrive. For example, a cold winter’s night may need an extra hour of air flow compared to a milder night. Tenant complaints led to fixed settings for earlier starts than actually required. This typically means that energy requirements for heating and cooling greater will be extended, on average, by several hours per day. For example, many buildings provide full heating and cooling to 5.30 or 6 pm. In well built and insulated buildings, chillers and boilers can turn off at 4pm or earlier,
and remain within agreed temperature parameters for two hours or more utilising the heating or cooling energy within the water loops.

Other mechanical service considerations include:

- An open system such as a fully compliant BACNET enables a wide range of compliant sensors controls and equipment which can flexibly plug and play without special programming having to be added or written.

- Automated seasonal temperature adjustment, lowering set point temperature at low temperatures and gradually raising through the seasons, giving immediate savings.

- Remote alarming to pager, mobile, I-phone, blackberry or fixed line as needed.

- Secure remote access as agreed for fault response, diagnosis, and tenant emergency need. For example, the tenant may need to set up a crisis response unit over a weekend or out of hours. Maintenance contractor may need to drive isolation valves to isolate a water leak, or remotely isolate equipment which has failed to the ‘on’ position.

- Scheduling calendar to be highly sophisticated so as to be able to check and adjust for daylight saving, Easter and other events which can be adjusted without programming skills. For example, shutting down unoccupied zones or temporarily varying working hours.

- High turndown capability utilising VSD’s for reduced airflow in low occupancy periods. This generally should go to 20 per cent or less of full flow.

- Use of CO₂ sensors in car parks and return air ducts to sense when air requirements are reduced. For example, in many car parks it may be sufficient for fans to run for one to two hours per day rather than 12 or 24 hours.

- Occupancy sensors, many areas have minimal occupancy at any time or highly variable loads such as conference rooms. In such cases it may be appropriate to provide minimal conditioned air during normal hours, and ramp up only when space is fully occupied. Ramp up can sometimes be most effectively provided by standalone units to avoid over sizing the central plant to respond to low frequency situation.

- Utilise enthalpy control in low humidity environments. This can improve air quality and lower energy consumption as air cools when moisture is added.

- Economy cycle to fully utilise free cooling. In many environments the outside air temperature is lower than return air temperature when cooling is required. Even when this is the case, the energy intensity of many buildings is such that during spring and autumn they may need cool air to maintain required conditions. If the fresh air intakes can provide more than minimum fresh air requirements then “free”
cooling is available from the atmosphere.

- **Night Purge.** In many hot climatic zones several hours of low overnight temperatures occur. If fans are run in this period this cold air can pre cool the internal structure reducing the day time cooling load at minimal cost during off peak tariff periods.

- **Control zones to be limited in size, in the order of 100m², and of uniform thermal need.** Do not mix perimeter and core space in a single zone or low heat generating offices with more densely populated open plan equipment intensive areas.

- **Ensure sensors are correctly located.** Sensors must be at the correct height, not above heat generating equipment, or hidden behind office fit-out, within supply air flow, or where external events can effect. For example, a thermostat mounted on an external wall must be insulated from the wall cavity, or it will read cold in winter, and hot in summer. A thermostat used as a coat rack will have a delay in registering actual room temperature. A thermostat above a photo copier may consistently read four degrees higher than actual temperature when copier is at full power to correct temperature when it is in sleep mode.

- **Calibrate sensors.** While many modern sensors do not suffer accuracy drift over time, a base line error of up to one degree can occur. It is essential that offset to correct occurs at the zone or at the BMS so that control strategies utilise a true reading at all times.

- **Calling after hours air conditioning.** The ability to call must be limited to genuine operational needs in small areas, and turn off after a limited period or as soon as no occupation is detected. Many systems lack the turn down capacity to service small areas, so entire floors or wings are turned on for the comfort of one or two people. Consider providing airflow only and activate heating or cooling when two-four out of hours calls are made.

- **C0₂ sensors for system control in low occupancy periods.**

- **Control strategies to have proportional control tailored to building needs, combined with adequate dead bands and predictive control algorithms.** Systems must not overheat and then enter cooling mode (particularly in winter), nor over cool in summer then call for heating.

- **Ideally no or minimal heating should be called by the system in summer, and similarly in winter minimum or no cooling should be required.**
Electrical Services

- Lighting controlled in zones by occupancy sensors, whose area will generally not exceed 100m² unless special circumstances exist.
- Fire stairs on occupancy sensors with automatic override to full lighting during fire alarm events.
- Car park daylight adaptation lighting to be dual dimmer controlled by photoelectric (PE) cell and occupancy sensors.
- Car park lighting to have two stage occupancy sensor control covering normal and out of hours lighting levels.
- Perimeter office zones to have PE cells operating dimmer controls in addition to occupancy sensors.
- Entry lobbies to revert to occupancy sensor control outside of operating hours.
- General security lighting to minimum level required by security cameras. With modern cameras this is very low and less than human eye requires.
- Responsive security lighting to be event activated with time controlled manual over ride for emergency situations.
- External lighting as required by code and assessed safety need under PE control.
- Toilet lights under PE control.
- Metering of equipment and zones to be integrated through BMS to required reports.
- Lift operation to be optimised via intelligent lift controllers, with activity and consumption reports to BMS.

Hydraulics

- Meters to report to BMS (number must enable excess consumption to system or zone).
- Temperature optimisation control of boilers, by control strategy.
- Flow meters to alarm on abnormal consumption.
- Boiler temperature reset optimisation, to match actual and predicted loads.
• Automated shut down valves in critical areas to avoid waste and damage from major failure, with BMS over ride function

BMS Configuration Active Point Control

• Must default to safe condition on failure and trigger alarm.

• All events to be achieved.

• Points to be actively interrogated on status to ensure they are operating and reporting.

• Point trending and graphing to be flexible and comprehensive.

• Demand limiting algorithm in place and load shedding if indicated.

• Alarms have priorities set to at least three levels, are placed in permanent archive file, with name of operator who responded to alarm. Archive can only be by a person with highest authority level, and only when record is over one year old.

Graphics & User Interface

• To clearly present data required to check status of system or sub system without clutter and in logical visual presentation.

• Navigation from a graphic page either up to a system overview or down to sub unit or point history to be intuitive, point and click.

• Graphics available of all systems and sub systems.

• Temporary trend graphics able to be set up by all users, and not require high level skills or access.

• A full suite of reports is configured to enable effective management of system and building.

• Four level or equivalent user authorization level control. Programmer, system controller, maintenance staff, tenants.

• Simple click and point to data, graphics, and agreed control functions of each user.
BMS case studies

CASE STUDY 1 – Substantial reductions in energy consumption at Questacon, Canberra.

An enhanced and upgraded BMS was a major tool in identifying and implementing energy saving strategies at Questacon, the National Science and Technology Centre, located in Canberra. Effective use of the BMS lead to dramatic reductions in gas consumption and electricity consumption resulting in substantial reductions in greenhouse emissions and recurrent financial savings of some $100,000 per annum. The savings obtained would not have occurred without the BMS and its effective operation and utilisation.

The BMS was critical in identifying:

- Areas which reached temperature required up to one hour prior to occupation
- Areas within temperature control band up to two hours after occupants left
- Control sensors out of calibration
- Sensors incorrectly located
- Identifying additional sensors and controls required for fine tuning.
- Graphic data trend logs were utilised to assess and adjust control strategies

CASE STUDY 2 – BMS used to indentify increased gas consumption.

In a medium sized Australian Government public building in Canberra, a BMS was used to detect an increase in gas consumption. The Facility Management staff were actively monitoring consumption, and committed to implementation of energy conservation projects.

Previously the BMS system was only metering energy in large blocks at the main switchboard, and when an unusual increase in gas consumption was queried the system was not adequate to identify its source and the increased consumption was put down to climate extremes and usage variations.

A consultant was reviewing consumption reports and advised they indicated a 20 per cent increase in gas and a lesser increase in electricity which could only be explained by a problem or problems in the buildings mechanical systems or their controls and not climatic or usage variations. The conclusion was accepted and a detailed investigation ensued. It was discovered that three cooling valves were failing to fully close. This was leading to excessive cooling in winter in three areas which in turn was opening numerous heating valves further than normally required. The result was increased
consumption of both gas and electricity.

It is probable that at least one of these problems had existed for a significant period of time, but that the degree of metering and BMS data available was insufficient to raise an alarm. The Facilities Managers took immediate action to rectify the problems. In addition the funds for conservation projects were adjusted to enable installation of additional meters and BMS points for each plant room to commence as a matter of urgency. This event clearly demonstrated that measuring energy consumption solely at the main switchboard was inadequate. The impact of local faults was disguised, and it gave no help in locating the faulty valves.

The main gas meter to the site was read daily after rectifying the faults and showed an instant reduction of some 17 per cent.

This incident clearly demonstrates the need for adequate BMS and sub metering particularly in large buildings and those with complex or changing usage patterns. Meters were added at each air handler and control zone.