The HVAC and common area lighting systems of a 45 year old 5,400m² commercial office building in Canberra (Figure 1) were upgraded in 2010, resulting in a NABERS Energy Rating improvement from 2 to 4.5 stars. This resulted in a reduction in annual energy usage saving $120,000, a 70% reduction in annual greenhouse gas emissions, and an increase in occupant comfort. One facet of the retrofit included an update of the BMS; other components of the retrofit are detailed in companion factsheets.

**Figure 1: Street view of 4 Mort Street, Canberra, ACT**

What is a Building Management System?

Building Management Systems (BMS) control and monitor the large energy consuming systems within a building, such as HVAC, lighting, fire and security systems. The aim of a BMS is to maintain occupant comfort and ensure occupant safety, whilst delivering energy efficiency and lower operating costs. The correct operation of a BMS is essential for optimal building performance and offers the most cost effective option to achieve energy savings in typical buildings.

HVAC systems are made up of various items of equipment including boilers for heating, chillers for cooling, air handling systems for air-conditioning and a range of ancillary components such as pumps and fans. The BMS controls the operation of the various HVAC elements based on information received from sensors which monitor key parameters such as temperature, relative humidity, carbon dioxide levels (as a measure of indoor air quality), system pressure and occupancy.

In high performing buildings, achieving and maintaining a good NABERS Energy rating is now integral to retaining a building’s rental income and asset value. A BMS is an essential tool for diagnostic purposes should building performance drop.

The BMS also assists with a number of other HVAC functions:

- providing useful data for scheduling service visits by maintenance contractors
- providing data for on-charging occupants for after-hours use and for energy consumption where the tenancy power supplies are provided by the landlord
- ensuring NABERS Energy targets are met
- providing diagnostic capabilities to proactively improve any non-performance.

**Some BMS Basics**

The BMS in most buildings have a number of direct digital control (DDC) systems located with the separate HVAC equipment or in plant rooms. These controllers are linked together using a local area network that is connected to a head end (or supervisor) station which typically provides the user interface for monitoring and altering control settings.

BMS use communication protocols, which are rules that electronic components or microprocessors use when communicating with one another¹. There are several types of communication protocols, and it is important to specify an open standard protocol rather than a propriety or closed protocol².

The specification of ‘open standard protocols’ for BMS offer interoperability across different building services systems with advantages to operational, energy and water efficiency. Open standard protocols also simplify the integration between components and between systems such as HVAC, lighting controls, security/access and elevators with provisions for future planning.

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¹ BACnet, LONtalk and Modbus are examples of protocols used by typical building services equipment in office buildings.
² A proprietary or closed protocol is one which the manufacturer of the equipment does not share or publish openly.
When to Replace a BMS

Factors for consideration when deciding whether to upgrade an existing system include:

- how old is the system? BMS systems older than 10 years are likely to be obsolete\(^3\) and would benefit from replacement
- are the software versions and the controllers still supported by the vendor?
- is the vendor able to restore the system in the event of a software crash and able to either replace or repair controllers?
- are the sensors and actuators sufficient and in good condition
- can the BMS be configured for web access to provide remote monitoring and diagnostic capability?
- does the BMS give you the ability to communicate with equipment such as chillers and energy meters using high level interfaces (including wireless technologies), which enable information to be exchanged without a multitude of cables?
- does your BMS have the ability to collect and store data for the purposes of energy monitoring and active optimisation of HVAC equipment?

Developing Specifications for a BMS

The replacement of a BMS is an ideal opportunity to consider features for the optimisation of HVAC and other systems, including energy monitoring capabilities and interfaces (such as intuitive graphics, exception reports and trending capabilities).

To enable optimal functionality, BMS specifications should include the following:

- a comprehensive functional description including an accurate points list of all items
- monitoring, reporting and exception reporting functions
- commissioning and fine tuning over a period of at least 12 months
- training of end users on how to operate and optimise the system.

These areas are explained in more detail below.

Functional Description

A functional description details control sequences and optimisation strategies to be programmed by the BMS specialist. A points list details these requirements in table form, as inputs and outputs to be connected to the BMS from various sensors, actuators and equipment (these are referred to as ‘field items’).

When producing a functional description, it is important that the requirements of all potential users of the BMS are considered, including the HVAC Maintenance Contractor who is in the key position to deliver reliability and energy efficiency.

During the early stages of construction of a project, it is important that the BMS contractor meet with all stakeholders to determine the functional description, before commencing engineering on the BMS and programming.

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\(^3\) This is due to a number of factors including increased functionality with newer technology, increasing cost with decreasing availability of replacement parts, and being able to open up to the market.
Training of End Users

Training should ideally be provided in stages, over a period of several months. The training should cover:

- navigation of the BMS system
- field items installed
- basic control loops used
- establishing trending functions
- alteration of basic system parameters within pre-established limits as agreed by the Client.

It is also essential that end users have access to a help line during the warranty period and beyond.

Operation and Maintenance of BMS

It is essential for end users of BMS including the Facilities Manager and Maintenance Contractors to be familiar with the capabilities and operational parameters of the BMS. Where necessary, the services of a BMS specialist should be engaged to update information in operating and maintenance manuals. The services of a BMS specialist will also need to be engaged for the optimisation of control algorithms, re-programming, setting up reporting functions (such as for NABERS) and setting up monitoring and diagnostic screens.

It is important that diagnostic screens are set up for the verification of key HVAC system functions including:

- optimised operation of economy cycles
- correct operation of variable air volume terminals (with the goal of eliminating wasteful re-heating)
- modulation of fans and pumps through variable speed drives
- chiller and boiler operation including the re-setting of flow temperatures, and the detection of leaking control valves such as in re-heater batteries.

Occupancy times and control settings for space temperature and relative humidity (RH) must be selected to avoid over conditioning. Some considerations in setting the BMS include:

- public holidays should be programmed to eliminate wasteful operation
- after-hours operation should be restricted to those areas requiring operation
- in consultation with the end users temperatures for winter operation should be set at 20-21°C, and 24-25°C for summer
- RH can vary from 35-60%, without significant impact on occupant comfort
- transient areas where occupants spend relatively short periods of time can typically tolerate wide temperature deviations of 17°C-26°C.

The BMS should be serviced and kept in good working order. Sensors need to be calibrated at least annually and it is important to check that sensors are not affected by extraneous factors including solar gain, heat output from office equipment and air leakage through unsealed cable entries. Very few maintenance specifications comprehensively detail the servicing requirements for BMS, and this issue needs to be addressed if buildings are to deliver and maintain high performance.

4 Mort Street Retrofit

In order to ensure the building achieved the targeted 4.5 star NABERS Energy Rating, the engineers adopted a ‘belt and braces’ approach with the controls strategies. This involved the installation of specific field items which would enable alternative control strategies to be sequenced if the design strategy did not perform satisfactorily. Examples include:

- installation of velocity probes (pitot tubes) into the air supply branches to measure supply air
- installation of flow meters to monitor the thermal energy and water flow rates through the chilled and heating hot water circuits
- installation of twin sensors for controlling important functions such as the economy cycle
- temperature, RH and CO₂ sensors were configured to monitor the readings against one another and to raise an alarm should readings differ by a set amount, thus indicating a need for re-calibration
- energy meters were also set to monitor the chilled and heating water system efficiencies.

During an early part of the construction stage, a workshop session was held with important stakeholders (including the Facilities Manager, Design Engineer, BMS Contractor, Main Contractor, and Commissioning Contractor) to provide an opportunity for all parties to contribute ideas prior to updating the functional description and finalising the engineering design and programming. This avoided unnecessary work and re-programming.

Another key to the project’s success was the inclusion within the consulting engineer’s scope of work to monitor the BMS remotely and track the NABERS performance for 12 months following project completion (Figure 3). This enabled the fine tuning of the HVAC system in a structured manner, allowing problems to be addressed proactively before they had a major impact on energy consumption or occupant comfort. The engineers and the contractor avoided ‘quick fix’ solutions, where occupant comfort issues are resolved at the expense of energy consumption.
HVAC HESS

The Heating, Ventilation and Air-Conditioning High Efficiency Systems Strategy (HVAC HESS) is a ten year strategy under the National Strategy on Energy Efficiency that aims to drive long term improvements in energy efficiency of HVAC systems Australia wide.

The Strategy takes a whole of life perspective in targeting HVAC efficiency improvement, encompassing the design, manufacture, installation, commissioning, operation and maintenance stages of the HVAC lifecycle. The Strategy consists of a number of complementary measures that fall under the three broad initiatives - People, Practices and Systems. This BMS factsheet specifically relates to Systems. It is one of a suite of factsheets developed to provide a quick overview and reference to inform, educate, and encourage energy efficiency in the HVAC industry.

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This and other HVAC HESS factsheets can be found on the Department of Climate Change and Energy Efficiency website at: