Information Kit

Building Management Systems (BMS) for Venues

Greener Live Performances

through energy efficiency

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1. Introduction

With rising energy prices in Australia, reducing energy consumption is no longer solely an environmentally focused objective for businesses. For most venues, energy consumption is one of their greatest operating expenditures. Luckily, energy consumption is also variable, measurable and controllable. As you read through this information kit, you will see how a Building Management System (BMS) can help you in achieving more energy efficient operations.

Who is this Information Kit for?

Live performance venues seeking to reduce their energy consumption by using their existing Building Management System (BMS) more effectively, or those considering installing a BMS.

Some of the key benefits of energy efficiency are:

- Saving costs on energy consumption;
- Extending the life span of fittings, equipment and appliances;
- Reducing your environmental impact and conserving resources;
- Enhancing your reputation and image.

Effective management of your building services is essential for environmental management, and can help to ensure operational efficiency and cost effectiveness.

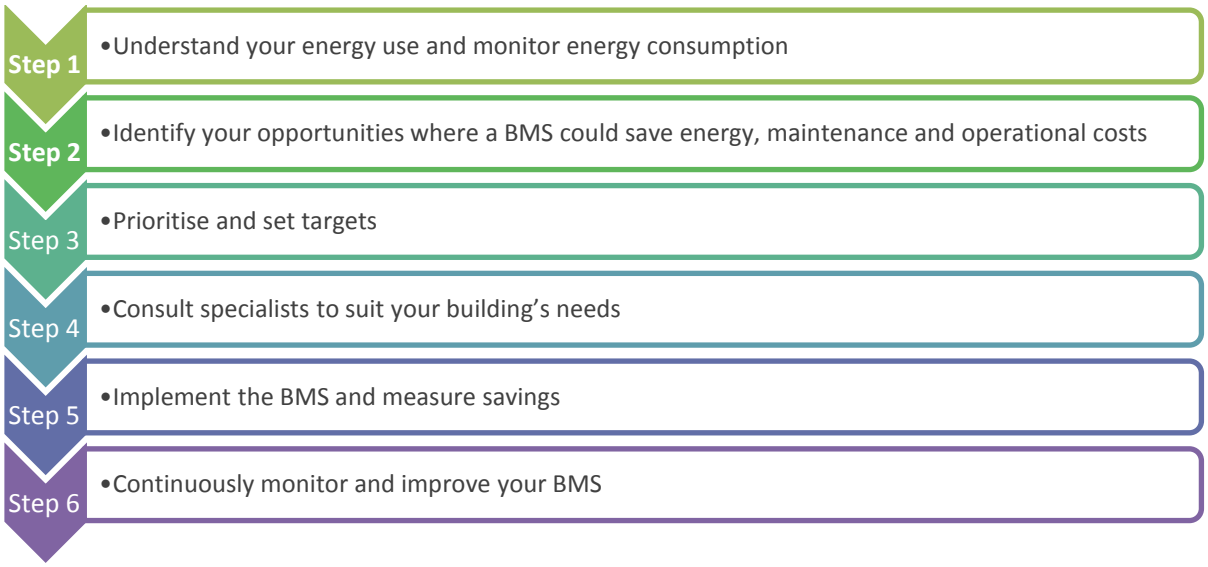

Figure 1 Steps towards BMS Implementation

This information kit has been developed to assist live performance venues to understand Building Management Systems (BMS) and to determine whether a BMS could help your particular venue to increase energy efficiency.

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2. Control Systems versus Building Management Systems (BMS)

Control systems typically manage individual building services such as heating and hot water, ventilation, cooling and air conditioning, lighting and shading systems. Essentially, a control system consists of three basic elements: a sensor, a controller and an actuator in the controlled device.

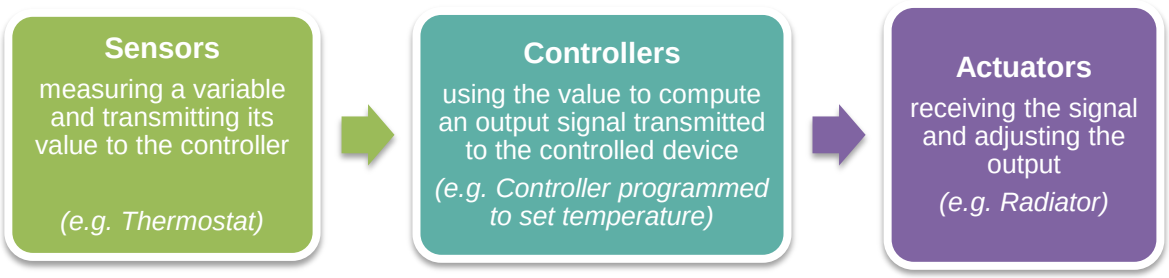

Figure 2 Basic Elements of a Control System [i]

Controllers can control by:

- Time (timers),
- Occupancy (sensors), and
- Condition (temperature, daylight levels, humidity, and carbon dioxide levels).[ii]

In larger buildings with interacting services, these control systems are often linked together through one overarching control system, which is referred to as the Building Management System (also referred to as Building Automation System (BAS) or Building Energy Management System (BMES)). Here, all controllers are linked to one comprehensive user interface facilitating monitoring and control through one access point. A BMS can be considered as a building's brain.

Did you know?

A building management system can reduce energy costs by up to 10%!

(Carbon Trust, 2007)

3. Why is a BMS important for Energy Efficiency?

Building Management Systems are used in commercial, industrial and institutional facilities and are more commonly installed in newer facilities.
Excessive energy consumption in large buildings is often traced back to poor control of heating, ventilation, cooling and/or lighting systems. Hence, to increase energy efficiency in your venue, dynamic control of your building services to suit real-time conditions is essential. This is especially the case in the live performance industry as real-time conditions tend to change rapidly during performances (e.g. audience enters and leaves the venue at set times which can be controlled by flexible HVAC systems).

Efficiency of building services is reduced when each system needs to be monitored separately, and the individual systems cannot interact with each other. A BMS can facilitate interactions between all or selected control systems within a building or venue.

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The four basic functions of a BMS are:

- Controlling,
- Monitoring,
- Optimizing, and
- Reporting on the building's facilities, mechanical, and electrical equipment for consistent comfort, safety, and energy efficiency.

Whereas in the past the main function of a BMS was to control building services, newer BMS also have built-in energy management functions. More recent BMS also have the capacity to integrate existing control systems or software.

Simplified, a BMS consists of the following elements:

- **Hardware** – such as sensors, actuators and controllers,
- **Software** programs displaying and recording real-time information, programs to design control strategies, and
- **Networks** – including interfaces with other control systems.[iii]

4. How does a BMS work?

A building management system can link multiple control systems and facilitate the control of any building service through a communication network connected to software. Through the software, real-time performance can be observed and settings can be adjusted. Often, the system is translated to web-based software making the system intuitive to a broad range of users and sometimes allows the system to be monitored and adjusted from remote locations.

The hardware of a BMS comprises the following aspects:

Sensors read conditions throughout the building through digital inputs, analogue inputs or pulse inputs. *Digital inputs* can detect whether a device is switched on or off. *Analogue inputs* provide information on variables and can pick up conditions in the building such as temperature, day-lighting, humidity, and even carbon dioxide levels. *Pulse inputs* can provide information on consumption levels through devices such as metres. Sensors can be used for multiple control systems reducing initial and operational costs - for example motion detectors can provide automated lighting control during the day and intrusion detection for the security system at night. Placing sensors strategically around the building to suit purpose is crucial – for example, a temperature sensor closely located to heat or steam generating devices (e.g. coffee machine) in your venue can send incorrect information on room conditions back to the controllers. A BMS can help to identify misplaced or defective sensors and the need for additional sensors for fine tuning.

Controllers are the core element of a BMS and the capability of a BMS depends on the amount of controllers linked to the system. Controllers have interfaces to the sensors and actuators.

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Actuators perform the actions in the system and control through digital outputs and analogue outputs. *Digital outputs* can control devices with two states, e.g. turn equipment on or off. *Analogue outputs* can fine-tune devices to certain positions, such as dimming light.

Information from the **sensors** is transmitted to the **controllers**, which translate the information to commands to be performed by the **actuators**. The user interface is connected to the controllers and allows monitoring and adjustment of these actions. [iv] For example, if the sensors detect a change in day lighting levels, the system will react by adjusting lighting, and in turn, reduce energy usage.

What is a BMS capable of doing?

The capability of a BMS varies largely on its intended use(s); ranging from the most basic being a time clock (a device which turns equipment on and off) to that of a highly sophisticated and flexible management tool. [v] Its capability also depends on the number of building services which need to be integrated into the system. Control systems already in use in the building can be integrated but may require new hardware components in order to be linked to the BMS.

5. What Services can be managed with a BMS?

Building management systems can control a variety of services within a building. The most commonly integrated components are HVAC systems and Lighting control systems.
Other services that can be integrated are:

- Energy and power monitoring (metering),
- Close circuit video (CCTV),
- Building access (e.g. card and keypad),
- Alarm systems,
- Elevators and escalators,
- Plumbing and water monitoring.

5.1. BMS and HVAC Systems

Heating, ventilation and air conditioning (HVAC) systems are used to achieve heating and cooling, as well as conditioning the air by removing dust and dirt and adjusting the humidity within a space. While HVAC and BMS can be separate systems, the interaction between them is vital for energy efficiency, which is why they should be considered holistically. Based on the conditions measured by sensors around the building, a BMS can control the operation of the various HVAC components. Linking your HVAC system to your BMS allows you to control and monitor air conditioning throughout the venue conveniently through one common interface. The HVAC system can be scheduled to suit your venue's operating times and areas can be controlled individually.

Did you know?

Estimations suggest that the installed base of non-residential HVAC systems in Australia make up about 9% of total electricity produced in Australia accounting for more than 3.6% of Australia's greenhouse gas emissions.

(Australian Department of Industry, 2010)[v]

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A BMS can control common spaces such as public areas and performance areas of a venue that require a system to respond quickly to a range of thermal comfort requirements. Especially for performance areas, a well-functioning HVAC system is of crucial importance as the system has to handle a large mass of air in frequently changing conditions. Patrons and technical equipment such as stage lights are generating heat and the HVAC system must be able to adjust to these wide variations with short reaction times. The audience expects to enjoy the performance in optimal conditions requiring adequate temperature, humidity levels and no air currents. Hence, the challenge is to provide ambient and acoustic comfort for the audience, whilst keeping energy consumption, maintenance and costs as low as possible. Although a self-adapting HVAC system can achieve these conditions, a BMS allows for full manipulation of temperature settings and the operation of HVAC from a common interface.

Most BMS include functions to track the conditions in rooms which can assist management to understand the benefits of other changes or additions to room controls. For example, with BMS data the fresh air output per person can be calculated allowing the adjustment of HVAC output for performances based on visitor numbers. A BMS can record hourly measurements of outside temperatures and humidity levels as required HVAC outputs depend on weather conditions and conditions inside, which are influenced by occupancy levels, indoor lighting and equipment.

Optimal starting times of HVAC

Heating and cooling of areas always requires time to pre-heat or pre-cool before comfort conditions can be reached. Instead of setting fixed times for pre-cooling or heating, a BMS can base the starting times on a function of ambient temperature as it depends on external weather conditions how long it takes to reach optimal internal conditions. A similar setting can be used at night, as it is more cost effective to pre-cool an area while the outside temperature is low.

Case Study
Frankston Arts Centre

The Frankston Arts Centre has recently upgraded their BMS system. With their previous system, the HVAC system could not be adequately controlled for individual areas around the venue and its control was limited to a simple on/ off functionality.

Now, the Frankston Arts Centre can flexibly schedule the HVAC system from a web-based interface for different areas of the venue suited to their event bookings schedule. The system also allows them to configure holidays and temporary exceptions for HVAC operations with a start and end date. With the increased control, excessive HVAC usage could be reduced by an average of around three hours a day.

Next steps: Frankston Arts Centre is in the process of integrating their event management system with their BMS, which will enable the BMS to automatically program the HVAC according to the event schedule without the need for manual control.

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Is your HVAC system suitable for your operating conditions?

It is important to consider air conditioning energy efficiency under different operating conditions. If your air conditioning system will be operating for long periods, during which time the cooling or heating requirements (or load) will vary considerably, the system's compressors should be able to operate effectively at part loads. Venues with compressors operating inefficiently at part loads should investigate the viability of replacing the compressor or installing a Variable Speed Drive (VSD) that will adjust the compressor's motor speed to continually match the load.

Do you avoid air leakage and solar radiation?

The state of doors and windows is crucial for HVAC efficiency to avoid cooling or heating leakage - a BMS can program the HVAC to turn off if windows or doors are left open throughout the building.

Simple steps such as the automated closing of blinds on the sunlit side of a building can also have a significant impact on energy consumption. By reducing solar access into air conditioned spaces, the output of your air conditioning can be reduced.

Did you know?

Air conditioning an office for one extra hour a day uses enough energy in a month to power a TV for a year! Monitoring and controlling your HVAC can make a big difference!

(Carbon Trust, 2008)[xv]

Piggy Bank on Top of a Pile of Dollar Bills by Ken Teegardin (flickr.com)/ CC

Are air conditioning thermostats set for optimal energy savings?

A major cause of excessive energy usage is the operation of cooling and heating at the same time, which is why controls should be set with a wide span between temperatures at which cooling and heating systems turn on. Thermostats set at 24C in summer and 19-21C in winter provide optimal comfort and energy savings. Consider conducting trials adjusting the thermostat settings on your air conditioning system. For every 1C decrease in temperature during winter you can reduce energy use by 5-10%. Similarly in summer every 1C temperature rise will decrease energy use by 5-10%. [vi]

5.2. BMS and Lighting Control Systems

Besides using energy efficient bulbs, lighting control systems can help to significantly reduce energy wastage. In an office environment, lighting controls can offer reductions in energy use between 30% and 50%.[vii] By integrating existing lighting control systems into your BMS, lighting controls can be programmed and monitored centrally to optimise energy efficiency. If a BMS is already in place, consider if the integration of lighting is useful.

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Lighting controls include:

- Energy saving **voltage control** for fluorescent lamps - allows the overall power supply to the lighting system to be reduced
- **Timer control** for areas with set occupancy times.
- **Occupancy/Motion detectors** that switch on light when occupants are identified in the room. Three main types are:
    - Passive infrared that sense movement of a heat-emitting body;
    - Ultrasonic and Hybrid Passive Infrared/Ultrasonic sense changes in sound wave patterns.
- **Daylight compensation control** - these controllers can turn lamps off and on, or dim them depending on the ambient daylight received in a space. [viii] Ensure that daylight sensors are located within or near to the controlled lights.

Linking lighting control systems to your BMS allows you to control and monitor lighting throughout the venue conveniently through one common interface. Aligning lighting control systems with HVAC and shading systems can further increase energy efficiency. The option to control the lighting in a space provides an opportunity to reduce cooling or heating loads on the HVAC system servicing the same space. Older, inefficient light bulbs can produce a lot of waste heat, which puts unnecessary pressure on the HVAC system. For more information on lighting efficiency, please refer to the *Lighting Efficiency in Venue Public Areas Fact Sheet.*

Show and Stage Technology as part of BMS

Depending on the BMS system employed, stage control systems may also be integrated into the BMS. This allows for a wide range of stage and show technology functions to be automated through the same PC Control system as the remaining building services.

This may include:

- Lighting (such as stage lighting, hall lighting, intelligent lighting including dimming);
- Over stage machinery (such as hoists, portal systems and pulley lofts);
- Under stage machinery (such as stage platforms, revolving stages or trap lifts);
- Show effects (such as moving props and scenery, cameras and other special effects).[ix]

Through the integration of stage and show equipment into a BMS, HVAC and lighting for the performance area can be adjusted through a common interface and energy data of the performance can be monitored accurately through the system.

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6. What to consider before implementing a BMS?

Not all buildings require the same type and complexity of control. A complex BMS is particularly cost-effective for large venues with extensive electrical systems and high energy bills. One of the key benefits of a BMS is being able to monitor and control costs more accurately. Prior to acquiring a BMS, it needs to be investigated whether, where and how much energy could potentially be saved – therefore, a building's energy consumption needs to be monitored. It is important to determine economic and environmental targets that could be achieved prior to acquisition.

Integrating Control Systems

Assessing which building controls should be integrated into the BMS may initially be a question of costs. Not all systems have to be integrated at once and systems can be added or excluded over time. Most control systems are "backward compatible"; allowing the integration of older systems into a BMS. Therefore, implementing a BMS does not require all existing systems to be replaced. It is important to choose a supplier, who is able to match solutions to your building specific challenges.

Set-up and Maintenance

End users, including the Facility or Technical Manager and maintenance contractors need to be trained how to use the system. Initially, a specialist BMS contractor is required to optimise control algorithms and to set-up reporting functions, monitoring and diagnostic screens. Introducing a BMS is a process which will require regular maintenance as conditions and needs in your building change. Maintenance, including calibration and fine tuning of sensors, must be performed by skilled contractors to ensure that the system performs optimally.

Ask yourself…

- ✓ Are there any control systems in place yet that require linkage to the BMS?
- ✓ Does our energy usage justify the implementation of a BMS?
- ✓ Do you have sufficient budget, time and expertise to acquire, run and maintain such a system?
- ✓ How much could you potentially save by implementing a BMS? And what would be the return on investment?
- ✓ If you link other control systems to the BMS, how can we maximise the systems' capabilities?
- ✓ If you do already have a BMS in place – how old is your system? If it is older than 10 years it may require an update.

7. Benefits of a BMS

A well-implemented BMS brings a number of benefits to the building, with the main benefit being the easy and convenient monitoring of the individual building control systems and the ease with which adjustments can be made. A BMS can also serve as a diagnostic tool to identify if and why a building's energy performance has changed. There are a number of benefits in terms of increased control and comfort, and the ease of maintenance and monitoring which are outlined in the Figure below.

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Control	• Effective monitoring and targeting of energy consumption • Reviewing performance of individual building services • Tuning and optimising systems at common interface • Integrated energy saving control functions reducing energy costs • Identify after-hour running of equipment
Comfort	• Increased level of comfort and time saving • Minimised intervention by staff in daily operations • Good control of internal conditions providing more comfort for building occupants • Possibility of individual room control • Effective response to HVAC-related complaints
Maintentance	• Ease of information availability • A BMS can monitor specific parameters for condition based maintenance • Identification of regular and reactive maintenance requirements by recording the number of hours motors have run or identifying equipment faults or failure
Monitoring	• Ability of monitoring and collecting building performance data for analysis • Logging and archiving data for energy management • Linking your BMS with your Energy Management Plan • Monitor effectiveness of energy management plans/ Key performance indicators

Figure 3 Benefits of a BMS

Compliance with Energy Rating Systems

A BMS creates an ideal framework for meeting energy efficiency standards as it can serve as a management tool to ensure compliance with targets of building energy rating systems such as NABERS. The National Australian Built Environment Rating System (NABERS) serves as a methodology for measuring the ongoing level of energy efficiency of office buildings. According to the Australian Government Energy Efficiency in Government Operations (EEGO) policy new buildings, major renovations and new leases have to conform to a minimum energy performance standard of 4.5 star NABERS energy rating.[x]

Sub-metering

General metering of energy use across your entire building does not help you to understand how power is distributed throughout the building. By installing sub-meters, real-time energy information can be collected. And when integrated with a BMS, sub-meters can help identifying opportunities to save energy by revealing where energy performance is poor. Sub-meters provide the base for effective energy monitoring and management control and allow monitoring energy consumption for individual areas of the venue. [xi]

Case Study

Brisbane Powerhouse

Brisbane Powerhouse have installed sub-metering in their venue. A total of 11 meters monitor the usage of individual lighting, sound and mechanical services for their two theatres and one public stage as well as the chiller plants for the air-conditioning. The sub-metering system is reporting back to their Building Management System (BMS) allowing Brisbane Powerhouse to track their energy usage more accurately and to adapt procedures accordingly.

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8. Common Issues

The most common issues with BMS arise due to a lack of attention and value assigned to the system, a lack of maintenance and optimisation, a lack of knowledge amongst operators and technical issues due to the complexity of systems.

Lack of Staff Familiarity

- Insufficient training and knowledge transfer for operators
- Considerable amount of effort and knowledge needed from BMS specialists
- Lack of value assigned to the system due to unfamiliarity with complex functions
- System is dependent on expert programming knowledge and controls tend to be poorly understood

Lack of Maintenance and Optimisation

- Often systems continue to run on default settings as optimisation measures are rarely adjusted
- Inadequate usage hindering the full potential of BMS to be exhausted (e.g. reduced to basic functions such as timers)
- Errors occur during the initial installation and the system fails to deliver the desired functionalilty
- Lack of regular recommissioning

Lack of Monitoring and Data Logging

- Lack of trend-logs for key-parameters hinder the identification of mal-performance
- Changes made to the system cannot be measured due to a lack of documentation
- No regular assessment is performed to ensure functionality and performance of controls

Technical Issues

- Poor installation of sensors and controllers may affect system efficiency
- Compatibility issues with existing control components
- The building design needs to be compatible with the hardware and software to be installed

Figure 4 Common Issues with BMS[xii]

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9. Get the most out of your BMS

While a BMS could reduce your total energy consumption by 10%; a BMS's success greatly depends on its appropriate usage.[xiii] Estimations suggest that up to 90% of heating, ventilation and air conditioning building control systems are improperly configured which costs industry over £500 million in additional energy costs per year in the UK[xiv] (equivalent Australian data is not yet available). Therefore, it is of crucial importance that optimal operation procedures are in place. The familiarity of staff operating the system on a daily basis is of crucial importance for the efficiency of the BMS. A BMS has to be correctly specified, installed, commissioned and tuned to deliver its full potential of optimising energy consumption. A BMS is only as good as its users – the identification of key performance indicators is crucial to implement changes as you can't manage what you don't measure.

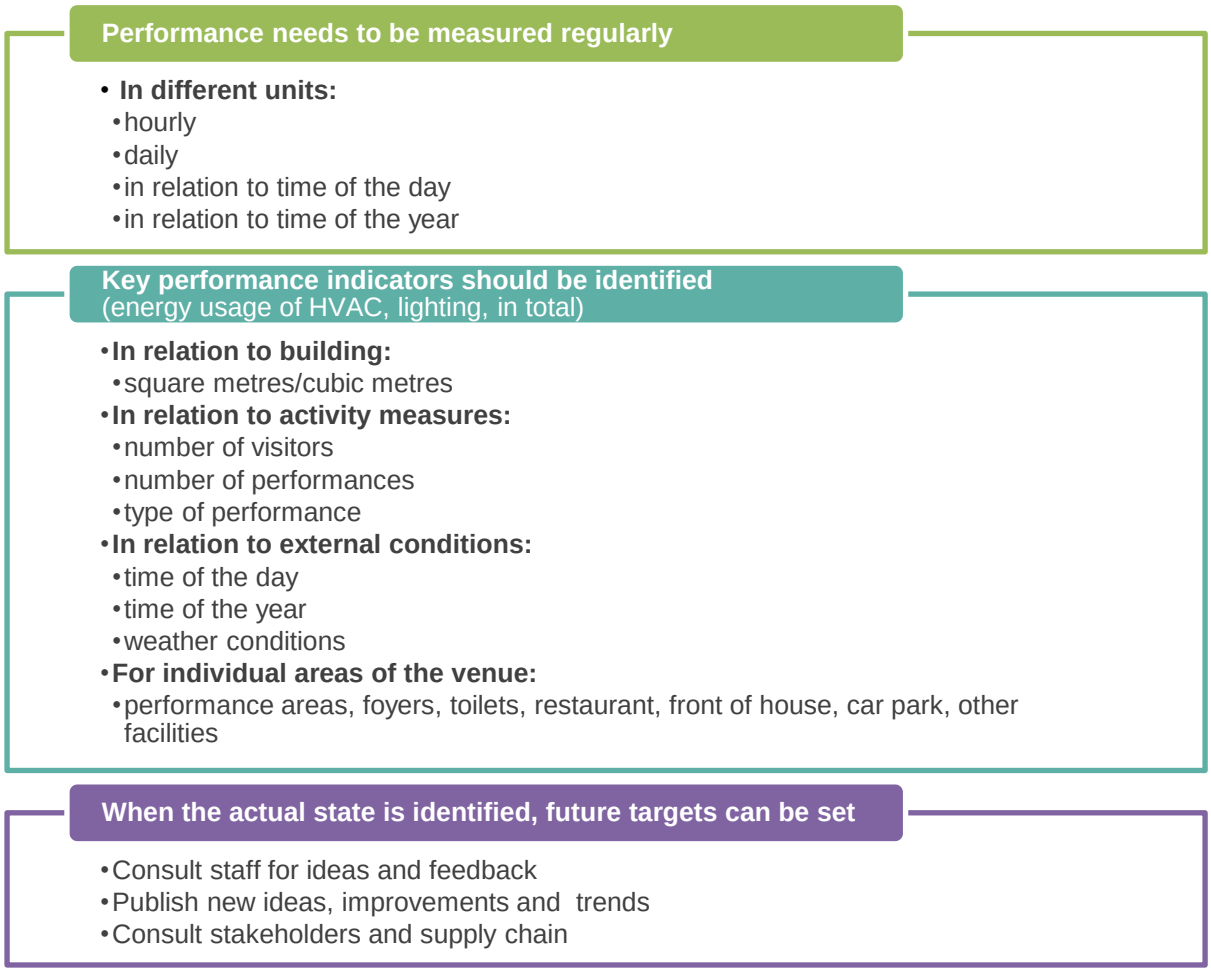

Figure 5 Key Performance Indicators for Optimal Operation

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