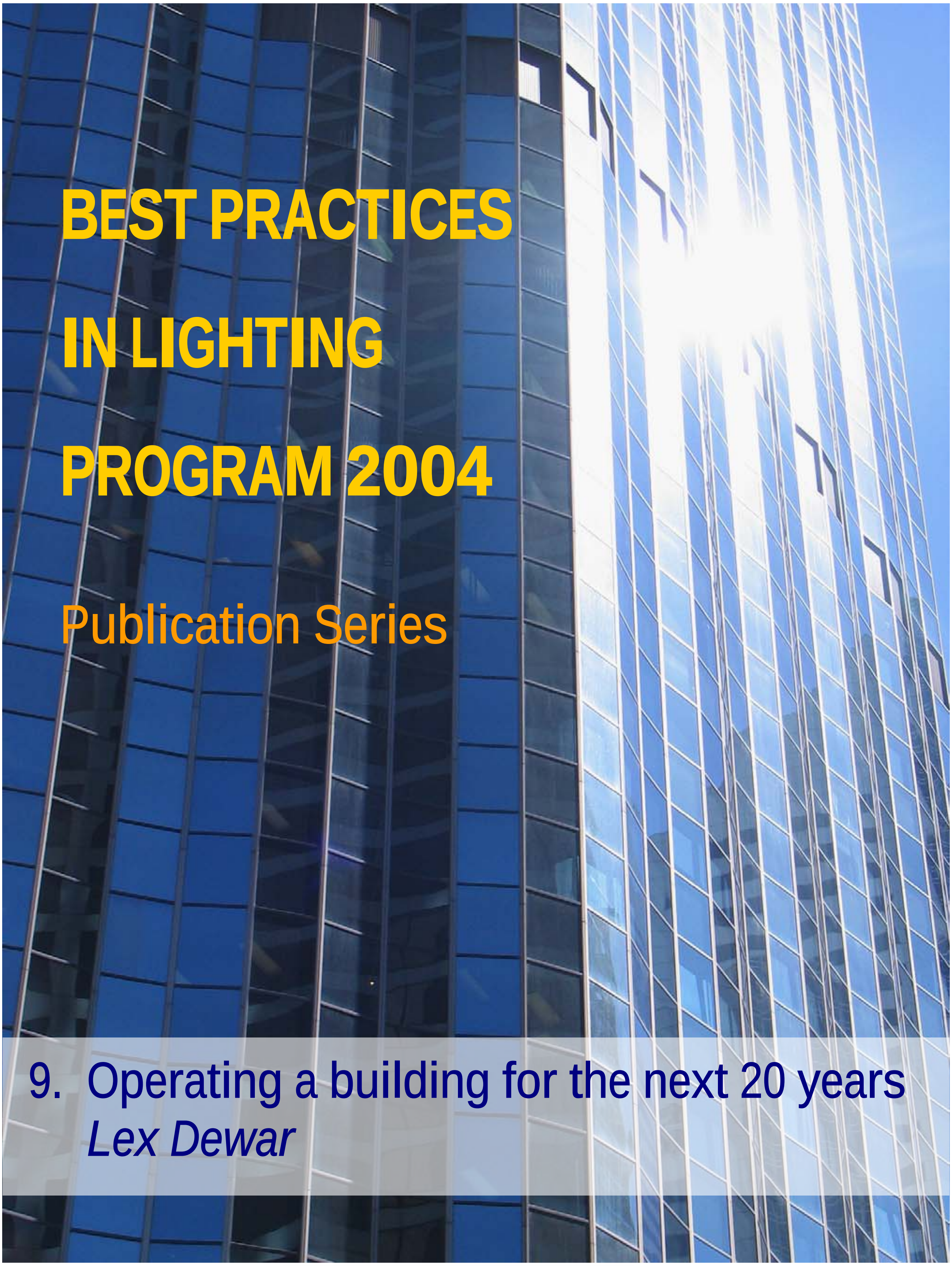

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9. Operating a building for the next 20 years

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OPERATING A BUILDING FOR THE NEXT 20 YEARS

Lex Dewar

The operational stage of a building accounts for up to 65% of the life cycle cost. However the ability of the Facility Manager to deliver a high performance building environment is largely governed by the initial design, construction and commissioning stage. This Paper provides strategies for the design of lighting systems that will enhance performance in use.

Introduction

The purpose of buildings is to provide meaningful places to support people and the activities that take place there. Often the design of a buildings environmental system is technically and structurally competent but fails to meet the changing demands over time of the users and managers.

The Facilities Management Context

What is unique about Facilities Management compared to other building related professionals is that it is focused on managing buildings in use. In this regard they are responsible for managing performance over time as much as they are for managing space. This requires a different perspective of buildings as a complex interrelationship of functions and activities focused on supporting the people who occupy them. A buildings capability is measured on how all the elements work together not on the performance of one isolated system.

Facilities management could be seen as operating at the interface between buildings, technology and the people and business that use them. As a stakeholder in the building delivery process they potentially can bridge the gap between the design / build process with the use / maintain phase of a building. In this role they are able to act as a conduit for the transfer of knowledge about what works in practice and what doesn't.

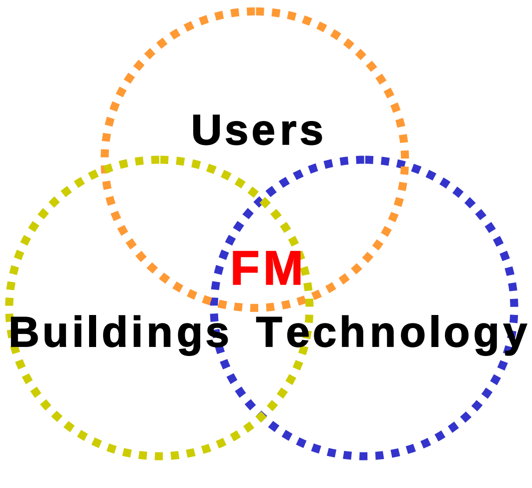

Figure 1. The FM Context

The case for a user driven approach

Design and construction costs for a typical commercial building account for only about one-third of the total cost over the life of the building with operation and maintenance contributing two thirds of the expenditure. Consideration of ongoing running costs should therefore be an integral part of the decision making process in the design and construction stage.

When you then add into this equation the investment in human capital (the building users) over the same period, the costs attributed to the procurement and management of the physical infrastructure are comparatively small representing only about 9%.

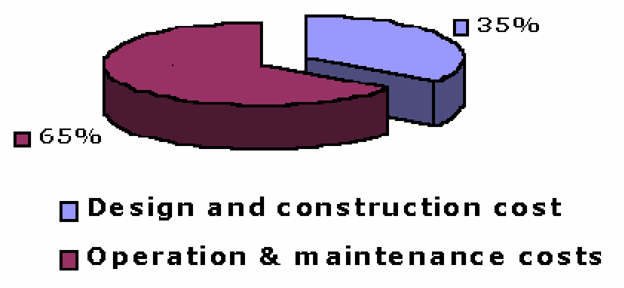

Figure 2 . Whole-of-life cost of buildings

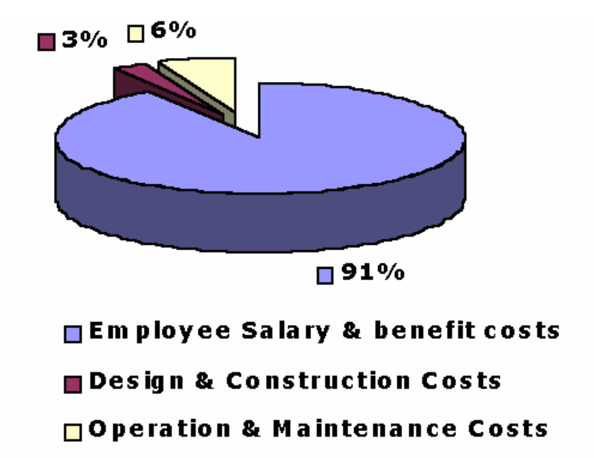

Figure 3. Whole-of-life cost of buildings (including human capital)

What this tells us is that the effectiveness of buildings and their environmental systems should be measured by their ability to support the building users. An incremental increase in productivity attributable to the environmental systems will have a significant cost benefit over the life of the building. This creates a completely different value proposition when making decisions about capital expenditure on buildings. Viewed in this way the physical assets can be an integral part of the value creation process of the tenant / owner.

It is generally accepted that occupant performance and productivity are linked to the quality of the indoor environment. Research has more recently focused on trying to understand the relationship between human response and exposure to the primary interior environmental stressors – thermal, lighting, acoustic and air quality.

Occupants' perception of the indoor environment is likely to be a collective response to all these stressors acting simultaneously. The difficulty for building designers is the availability of guidelines that address these interrelationships. Current practice is largely based on fragmented and prescriptive regulations designed to ensure minimum compliance standards. In the case of lighting this would include minimum illuminance levels, acceptable contrast levels and the like. Although necessary, they fall short in ensuring successful indoor environments by failing to cater for the complexity in perception of building occupants.

More recent guidelines for lighting design are addressing the perception of light rather than simply the mechanics of light. An example is the recent policy on ceiling illuminance from the Society of Light and Lighting (the professional body for lighting in the United Kingdom) that recommends the average illuminance on the ceiling be at least 30% of the average horizontal illuminance across the working plane. Although the illuminance level at the working plane may be acceptable the users may still have the perception that it is dark due to appearance of a dark ceiling. Until these types of considerations are embedded in lighting design practice then the focus will remain on simply alleviating user discomfort rather than enhancing user comfort.

Building Life cycle

Typical stages of a building life cycle are planning, design, construction, occupancy / use, refurbishment and disposal. Consideration for all these stages when planning and designing buildings can result in a more sustainable outcome.

Typical components of buildings and their design life are represented in table 1 below. The higher up the table the longer the design life and the more difficult and costly they are to change. Conversely the lower down the table the shorter the life span and more adaptable to change they need to be. Criteria for design and selection of each element should be based on its use over time. For example structure and building skin would be designed to accommodate changing demand over time but without need for modification, whereas criteria for design of the "scenery" (furniture & fittings) may be to accommodate frequent changes over its life.

Table 1. Building Component life

Building element	Life	Change profile
Site	Infinite	Low
Structure	50 years +	Low
Envelope / skin	30 – 50 years	Medium
Services	10 – 25 years	Medium - high
Settings (fitout)	7 – 10 years	High
Scenery	5 years +	Very high

Life Cycle Costing (LCC)

Definition

The principle of life cycle costing (LCC) is to consider the total cost of an asset over its effective life. This would include the initial design and installation cost but also the ongoing running costs. A definition of LCC is "the sum of the acquisition cost and ownership cost of a product over its lifecycle"[1].

Expressed as an economic equation:
LCC = (AC – TD) + (OC +RC) – RV.

LCC – Life cycle cost
AC – Acquisition cost
TD – Tax depreciation entitlements
OC – Operating and maintenance cost
RC – Replacement / disposal / upgrade cost
RV – Residual or salvage value

Establishing the effective life of an asset relies on economic and performance predictions and establishing a life expectancy. This will vary depending on the definition of "life" that is adopted and could include component life, operational life, functional life, technical life, economic life and so on. The use of a triple bottom line accounting approach (using economic, environmental and social measures) will help to ensure that a more balanced view of what constitutes the life of an asset.

LCC of lighting

When applied to lighting systems a simple model can be developed to assess their total life cycle cost (figure 4). When we overlay historical data on the costs for lighting installations we see that the capital cost (including design, installation and maintenance) accounts for about 35% of the total life cycle cost. The remaining 65% is attributed to the ongoing cost to use and maintain it.

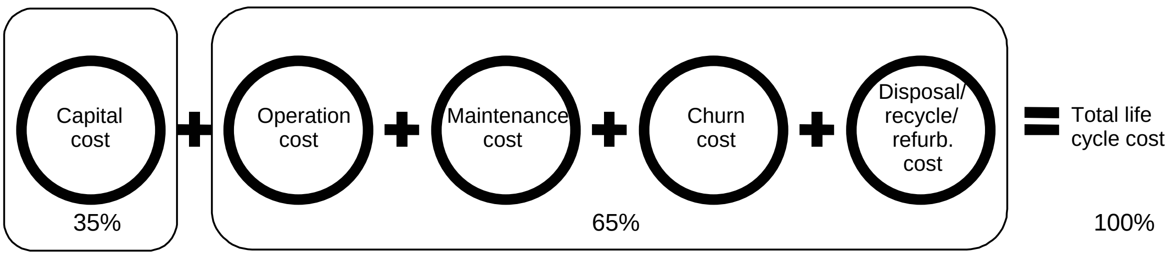

Figure 4. Lighting life cycle cost

What is significant about this is:

- Decisions made in the initial stage of design, installation and commissioning will have the greatest bearing on the ability to manage the other 65% of the costs over the life of the lighting system
- The most value is gained through the application of LCC techniques in the early design phase however this is also often when the least amount of information is known about the ongoing operation of the building. This can be addressed by:
  - inclusion of stakeholders in the design process who are responsible for design, operation and maintenance of the lighting
  - Use of predictive modeling tools
  - Inclusion of consultants skilled in the use of LCC techniques.

Areas of Influence for Lighting Performance

There are many areas of influence the lighting engineer or designer can have over the ongoing performance of the lighting system. This Paper focuses on four key areas:

1. Occupant Comfort,
2. Occupant change,
3. Maintenance, and
4. Operations.

These can further be classified as either demand drivers or supply influences as shown in figure 5.

The *demand drivers* contribute to the service level requirement. These help to articulate what the lighting system is expected to do and its required level of performance. The *supply influences* are the factors that contribute to the lighting system meeting these expectations on an ongoing basis.

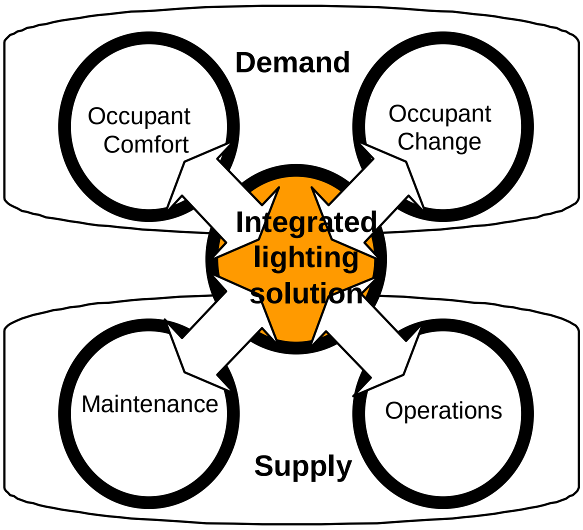

Figure 5. Areas of Influence for lighting performance

Occupant Comfort

According to Dr Jacqueline Vischer, a leading behavioural psychologist, "Comfort as a basis for setting environmental standards developed out of recognition of peoples need to be more than simply healthy and safe in buildings they occupy. Once health and safety are assured, users need environmental support for their work. Comfort links the psychological aspects of workers likes and dislikes with concrete outcome measures such as improved task performance and worker productivity".[2]

Vischer further identifies three levels of comfort – physical, psychological and functional. Table 2 shows suggested lighting responses that could support these varying levels of comfort.

Table 2. Lighting Responses to Occupant Comfort Needs

Level of Comfort	Description	Lighting response
Physical	Minimum compliance approach aimed at ensuring buildings are habitable and occupants are not exposed to extreme environmental conditions.	• Compliance with statutory requirements – building codes, standards and regulations.
Functional	Considers how effective the space is in helping users perform their task. Views the environment as a tool for work.	Lighting design that is fit for purpose by specifically addressing and responding to the tasks and activities within the building. Related comfort dimensions include spatial comfort, visual comfort and lighting quality. Specific responses include • Consideration of task lighting balanced with ambient lighting • Access to natural light • Correct balance of luminance & contrast to suit the task • Reduction of glare and gloom • Use of lighting to enhance spatial definition and way-finding
Psychological	Considers higher order needs for social, intellectual and cultural fulfillment. A main psychological factor influenced by the physical environment is territoriality. This encompasses aspects of privacy, status, empowerment and control.	Lighting design that reinforces psychological needs of the users for privacy, control and visual variance Specific responses could include: • Localised (personal / team) control over lighting conditions • Sensory variance in light quality • Visual interest across the lit "landscape" • Use of lighting design to reinforce the perception of visual enclosure.

Increased control of interior environmental conditions by building occupants can result in improved user satisfaction. Research in this area suggests productivity gain on average of 7.1% with increased lighting control[3].

The importance of perceived lighting control however decreases as overall satisfaction with the environmental condition increases[4]. In other words if lighting conditions are generally good then the presence (or absence) of controls is less important.

Similar research has also identified that building occupants are acutely aware of elements in the physical environment that are below optimal. More importantly they can determine the changes necessary to improve the conditions. The absence of a means to improve these conditions can itself become a stressor. Conversely the ability to make choices about the physical environment can enhance feelings of environmental competence and control [5]. Tolerance of conditions also increases with more control opportunities. This allows for a broader range in comfort conditions without detriment to occupant satisfaction.

Direct control options for lighting include the use of localised switching, dimming controls, operable window blinds and task lighting. Other more indirect strategies include providing flexibility in furniture and equipment. The ability to move a desk or computer to reduce the effects of glare can equally give the occupant control to improve a lighting related problem.

Table 3. Summary of Lighting Strategies for Occupant Comfort

STRATEGY	BENEFIT	IMPLEMENTATION
Task oriented lighting design.	Lighting solution is suited to the task required to be performed in the space and provides appropriate lighting level, degree of control and lighting quality.	• Involve end user in lighting design process. • Selection of light fittings and lighting layout design that match lighting quality with activities and tasks.
Greater user control of lighting.	Improves user satisfaction with the lighting and extends the threshold of tolerance when conditions are below optimal.	• More light switches and dimmer controls including the ability for localised control. • Intelligent control systems with user interface. • Use of occupancy sensors. • Daylighting control mechanisms. • Consideration of user controlled task lighting in conjunction with ambient lighting.
Enhanced understanding by building users	Improves understanding of the purpose of the lighting system and ultimately greater ownership and responsibility for its effectiveness.	• Establish a user-operating guide. • Provide education and training on the features, capabilities and how to use the lighting system as part of a building orientation program.
Improved responsiveness	Improved response time to change and/or dealing with complaints increases user satisfaction with the building services.	• More intuitive control systems for both users and facilities managers. • Establish agreed service levels with users. • Provision of management resources commensurate with the building complexity.
Optimise daylighting	Access to daylight has both positive physiological and psychological benefits for building occupants.	• Design of building massing, orientation and “skin” to optimise daylight access and negative impacts of thermal loading and glare.
Reduce glare	Glare can cause visual discomfort through eye strain & headaches with a resultant negative impact on productivity.	• Control mechanisms for natural light including diffusers and blinds. • Consideration of contrast and reflectivity of both interior and exterior surfaces. • Use of low glare fittings.
Spatial definition and orientation	Lighting can assist to define building form and function as well as enhance orientation.	• Use lighting design to articulate different activity zones, enhance way finding and reinforce spatial hierarchies.
Visual variance	Variation in visual field can reduce visual fatigue.	• Utilise different lighting levels across the building spaces that are appropriate to the use. • Build in the opportunity for distant views.

Occupant Change

The ability of building systems to respond to change has emerged as a key performance indicator for buildings in use. Inability to effectively adapt can contribute to both direct cost (cost of the physical change) and indirect cost (cost of disruption to people and business) of managing a building.

This is largely driven by the need for organisational agility – the degree to which a business can respond to the market. Change drivers may be organisational, functional, technological, economic and regulatory or user initiated. Lighting systems must be capable of responding and adapting to the demands of change over the life of the facility.

The physical result of change is churn. Churn is defined as
"Internal accommodation rearrangements undertaken in response to changing organizational and functional requirements" [6]

The *Office Churn Research Report*[7] classifies three types of churn:

1) Internal moves – Moving people only not physical elements
2) Reconfigurations – Involves some relocation of furniture and minor fitout works
3) Building works – Includes space reworks including change to ceilings, walls, furniture and building services

Costs associated with changes will increase significantly between simple internal moves compared to changes requiring building works. Not surprisingly then there is a demand within building design to accommodate change without significant building works. To achieve this requires a well considered building fitout design that is adaptable to change. Building services are traditionally expensive to alter and disruptive to occupants in the process. This can be improved in a number of ways.

Firstly, developing a planning rationale with the lighting layout that will allow for a degree of physical change to occur with little or no change to the light fittings. This may mean establishing the parameters within which the physical changes can be made based on a limited palette of variables. In this scenario change is limited to the "scenery" without the need to change the "setting".

Secondly, create flexibility in the lighting design. Flexibility in this case being the ability to easily and cost effectively change the characteristics of the lighting to suit new layouts and functions. Criteria for flexibility include:

- Interchangeability – The degree of compatibility with other building elements (such as ceilings, furniture and walls) as well as other light fittings.
- Adaptability - The ability of the light fittings to be modified to suit a change in demand. This may be as simple as changing the lamp or diffuser to create different lighting characteristics.
- Usability – De-skilling lighting changes can help to reduce the cost associated with making alterations. Using a "plug and play" approach could provide the ability for occupants to make their own changes and hence improving response time and offering a sense of control.

Another consideration for building change is the availability of light fittings and lamps. Maintaining the integrity of the lighting design over the life of a building or tenancy relies on the ongoing availability of product and technical support. It is unlikely that this can be assured for the entire life of the building however there are means to improve the outcome during the design and construction phase including:

- Selecting fittings with anticipated (or warranted) long term availability. Consider using a standing offer arrangement that requires the supplier to continue to offer the product to an agreed specification and cost for a specified period. An alternative is to purchase and retain a stock of fittings or components for future use.
- Use suppliers with a proven history of continuity of supply and after sales support.
- Obtain detailed product specifications and operating data at handover stage. This will assist in sourcing replacement product at a later stage.

Table 4. Summary of Lighting Strategies for Occupant Change

STRATEGY	BENEFIT	IMPLEMENTATION
Flexibility	Provides the ability to quickly and cost effectively re-configure lighting to meet occupant driven changes.	• Adopt a "plug & play" approach where appropriate to allow changes by non-skilled personnel. • Design in the ability to change the characteristics of the lighting design to suit new activities and tasks.
Planning modularity	This can significantly reduce the cost of churn by eliminating the need to make expensive alterations to building services.	• Develop a planning rationale for the building spaces that can allow churn to occur without the necessity to change building services.
Continuity of supply	Avoiding early redundancy of fittings and components can extend the operating life and maintain consistency when new fittings are required.	• Utilise recognised suppliers with a history of long term product support. • Consider using a standing offer supply arrangement and/or retaining maintenance stock of fittings.
Adaptability of fittings	The ability to change fittings in response to new and changing demands will reduce premature redundancy	• Select fittings of simple robust design that allow for future retrofitting / upgrades due to such demands as technology and regulatory changes.
Interchangeability	Interchangeability of fittings and components can increase re-useability when change occurs	• Consider using a "family of fittings" rather than one offs. • Ensure light fittings will interface with other related building elements such as ceiling and furniture systems without the need for modification.

Maintenance

From the point of commissioning of a building the components and systems enter into a path of continual degradation. Studies in the United States have found that around 20 – 30% of existing building stock has degraded to a state that causes excessive occupant symptoms.[8]

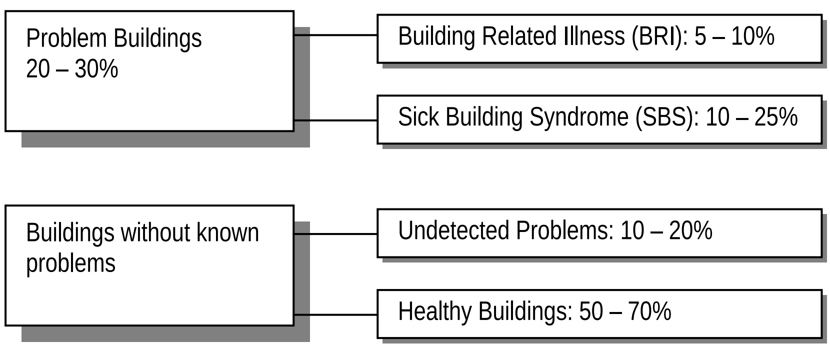

Figure 6. Building stock comparison of healthy vs. unhealthy

Furthermore the research has shown that when a building has reached Problem Building classification:

- More than 20% of occupants will have acute discomfort complaints and report hampered performance.
- More than 50% of occupants will report loss of confidence in management
- The associated cost of recovering good will may exceed the cost of mitigation. In the case of BRI this may exceed the original cost of the facility.

Avoiding the negative impacts of building degradation requires both detection and intervention. Detection is the ability to identify and evaluate a problem through diagnostic techniques. Intervention is the action of mitigating or eliminating a problem through maintenance and remediation activities.

Best practice asset maintenance management aligns the maintenance policy with an overall asset strategy. The policy is aimed at ensuring value for money, protection of the asset / resource value and satisfying statutory and legal obligations. The benefits of maintenance planning include long term reduction in the cost of maintenance, increased performance, longer asset life and improved perception by building users.

Maintenance performance is assessed in terms of the current state compared to an agreed standard. An agreed standard may be measured in terms of economic criteria, functionality, statutory compliance, service level (such as response time or downtime) or other measurable performance indicators.

All lighting requires maintenance in order for it to satisfy the agreed service standard. Specific considerations for lighting include:

- Effectiveness – Lighting should continue to meet the requirements of the activities and tasks performed in the building.
- Efficiency – Maintaining an acceptable light output to energy consumption ratio is dependant on lamp replacement and luminaire cleaning regimes.
- Compliance – Ability to maintain statutory compliance should not require high maintenance input and subsequent increased risk for the asset owner.
- Responsiveness – Maintenance of the lighting can be achieved within acceptable response times and with minimal downtime.
- Maintainability – Lighting maintenance is cost effective without undue reliance on specialist equipment or technical expertise.
- Disposability – At the end of the service life the lighting should provide opportunities for recycling or reuse of components / materials and contain no hazardous or toxic substances.

Table 5. Summary of Lighting Strategies to Improve Maintenance

STRATEGY	BENEFIT	IMPLEMENTATION
Optimise lamp life	Reduces frequency of lamp replacement.	• Specify lamp types appropriate to task / activity / service environment with consideration for maximum lamp life.
Maintain lighting performance	Ensures the lighting meets the agreed service standard on a continuous basis	• Establish programmed cleaning of the lamps and fittings to maintain light output. • Establish scheduled group relamping practices.
Condition assessment & preventative maintenance	Provides quantitative and qualitative information about lighting condition to establish a preventative maintenance program aimed at reducing costly unplanned / reactive maintenance.	• Use a recognised method for assessing the condition of the lighting systems. • Utilise the data to establish a whole-of-life preventative maintenance program.
Establish agreed service level	Enables the appropriate allocation of maintenance resources by avoiding over or under servicing. Promotes clear understanding between users and managers of buildings on service expectations.	• Establish a service level agreement with tenants for the lighting system including key performance indicators.
Maintainability	Minimises the cost of maintaining the lighting system through good design practices.	• Select fittings that are fit for purpose. • Consider ongoing maintenance requirements at the design stage including accessibility for servicing, durability and ability to replace components.
Disposability	Reduce the cost and environmental impact at end of life.	• Specify fittings that have been designed for disassembly to enable recycling of materials. • Specify (where possible) equipment & fittings that have materials with low embodied energy and do not utilise toxic or hazardous substances in their manufacture. • Use accredited maintenance contractors that dispose of redundant lamps responsibly.

Operation

Once installed and commissioned the ongoing operation of lighting systems is effectively handed over to two key stakeholders – the facility manager and the building users. Both have a joint responsibility for ensuring its effectiveness in use. However at best only the facility manager would typically be educated and trained in the attributes of the lighting systems. Not involving the users in the process may result in the lighting system never reaching its full design potential. Typical outcomes of a lack of understanding and ownership of the lighting can vary from increased complaints and reduced energy efficiency to more extreme cases of bypassing control systems and even deliberate sabotage.

Building Management Systems (BMS) have enabled greater integration of the separate services systems that collectively control a buildings interior environment. Integration of the systems through a common platform has realised substantial benefits for building diagnostics and control. It should however not be seen as a panacea.

When designing a lighting management system as part of an overall BMS some considerations include:

- Firstly understand what to measure to ensure the focus remains on "measuring what matters". A common problem with technology based systems is trying to measure too much. Having more information will not necessarily improve building performance but having the right information will.
- Build in the appropriate lighting system components and features to interface with the BMS. Typically this may require additional meters and sensors.
- Involve the people in the solution. Engaging the building managers and users in the process will help to ensure the right technology fit. New generation web based systems allow greater interface by both managers and occupants however will require education and training in how to use it effectively. From the tenants side this may be a simple demonstration on how to activate out-of-hours lighting whereas the building manager may require a detailed handover manual and comprehensive system training. The complexity of the system should be commensurate with the resources (skills, time and budget) required to manage it.
- Evolve the system in line with demand from the building. A "set and forget" approach can lead to underperformance and result in the system not achieving its full capability. Following commissioning it may be necessary to adjust or "tune" the lighting system to align the operation with the attributes of the space. Usage profiles can be identified based on time and activity patterns. These can be used to inform operational decisions on base lighting levels, start up / shut down times and maintenance scheduling.
- Utilise the technology as a management tool. The BMS can be used to monitor and report on a diverse range of lighting performance indicators used in management decision making such as:
  - Energy efficiency and improvements
  - Apportioning energy consumption costs
  - Maintenance planning
  - Energy purchase and tariff negotiations

Engaging the occupants in the operation of the buildings environmental systems can have the dual benefit of improving system performance and user satisfaction. Many buildings adopt a "black box" approach whereby functions rely heavily on automatic control with minimal user intervention. Concentrating control in this way creates a dependency on the system to firstly be responsive to the changing building demand and secondly to provide continuous reliable service. If either or both are not delivered then users can become increasingly frustrated with the level of service. In extreme cases occupants have been known to deliberately tamper with automatic control equipment in order to bypass or override it.

This type of behaviour is exacerbated by a lack of understanding of the building systems. Without this understanding users have little reason to trust that it will deliver and even less willingness to participate in improving its overall performance.

A common misconception is that increasing automatic control will decrease management resources. Quite the opposite can be true. As more functions are assigned to automatic control the complexity and concentration increases requiring greater management skill and often time and money to maintain it.

The main issues for consideration with respect to operation of the lighting installation are:

- Energy efficiency – Energy efficiency during the operational phase of the building is achieved through maintaining the design performance of the lighting and continually adjusting the systems with the usage profiles and patterns. This relies on the ability to measure and report on the performance of the lighting system made possible through lighting management systems.
- Control – Control can be viewed at two levels. Firstly localised control by building occupants, and secondly control at a whole of building / portfolio level. Localised control has been

covered under user comfort. Overall building control is largely dependant on the inclusion of lighting control software usually integrated within a building management system.

- Education and training – An orientation program covering the building and its environmental systems will encourage understanding and ownership for their ongoing performance.

Table 6. Summary of Lighting Strategies to Improve Operational Performance

STRATEGY	BENEFIT	IMPLEMENTATION
Reduce energy consumption	Reduce operating costs and minimise environmental impact (greenhouse gas emissions)	• Exploit natural daylighting and consider daylight sensors to reduce the need for artificial light sources. • Avoid over lighting. • Include automatic controls such as occupant sensors. • Provide local switching for occupant control. • Develop a space zoning lighting strategy that matches control measures with use patterns. • Specify high efficiency lamps, control gear and fittings. • Select interior colours that reduce the need for lighting.
Improve control	Provides the ability to track energy usage for the purpose of improving efficiency. Also provides the opportunity for internal charging (user pay) as a means to reduce overall consumption.	• Circuits should allow for sub-metering of individual zones and/or floors.
Enhance understanding of lighting management	Improves the ability to effectively manage and maintain the system at optimal levels. Improves ownership and responsiveness to deal with problems.	• Provide a comprehensive maintenance & operation manual on completion. • Include mandatory education and training by suppliers and/or installers at handover stage.
Improve integration with other building services & architectural systems	Demonstrates the interrelationship between the separate systems and how they perform as a combined building system. Enhances measurement, control and reporting to enable informed decisions about the lighting systems.	• Integration of the lighting with the overall Building Management System (BMS).

Improving the delivery process

Implementing a “whole of life” approach to lighting systems will challenge the traditional process of design and delivery of buildings. A new approach is needed that bases design and capital investment decisions on creating building capability for the owners, managers and users. To achieve this may require establishing a number of ground rules in the delivery process:

- Establish an integrated approach that avoids design professions operating within “silos” of expertise. Fragmentation can lead to a short-term problem focus rather than a long-term outcomes focus.

- Avoidance of highly contractual and adversarial relationships between the parties in the procurement process. These conditions can result in ‘lowest common denominator’ approach with short-term economic gain at the expense of long term building performance.
- Inclusion of stakeholders in the design process who are responsible for using, operating and maintaining buildings. Traditional entry point for Facilities Managers is at handover / commissioning stage at which point the majority of decisions have been made that will impact on the ability to operate and maintain the building. Reliable data on the performance of buildings is necessary to inform the design and specification process.
- Accept that buildings are a resource not simply a commodity. This approach recognises that buildings can be an integral part of the value creation process of the people and business that use them. The trend toward investor based ownership rather than owner / occupier has threatened this view of buildings.
- Adopting a broader perspective of building performance to include social and environmental as well as economic returns. Over emphasis on lowest capital cost solutions can result in the de-skilling of the design process and negative effect on long term building usability.
- Provide the opportunity for the transfer of knowledge between design and construction teams and the people who will manage and use the building. Orientation of new and refurbished buildings is essential for both building managers and users alike. Better understanding of how to use and maintain the lighting systems will create greater ownership and a shared understanding of performance expectations.

Planning Considerations

As mentioned, the design, installation and commissioning stage has a significant impact on the life cycle cost of a building. It is therefore important that the design decisions made at this stage consider the whole-of-life implications. This paper outlines a number of implementation strategies that could be considered however it is vital that they be designed in from the outset of the project. To achieve this requires the inclusion of a number key activities, information and/or processes at the appropriate stage of planning. Table 7 outlines these against each of the key phases of briefing / pre-planning, design, documentation, construction and handover / post occupancy.

Table 7. Planning Considerations

PHASE	KEY DESIGN ACTIONS, INFORMATION AND PROCESSES
Briefing	The brief document should clearly state high level “global” objectives and parameters (financial, time, process, physical) for the project. From this the design team should identify what can be achieved with the lighting system. This will help to establish early in the process the right “fit” between the lighting strategies and the project constraints / opportunities and allow the effort of the design team to be focussed on the most viable solutions. Where possible involve a diversity of stakeholders in the early briefing stage including suppliers, installers, facilities managers, owners and end users. Establish “ambassadors or sponsors” for any new or innovative ideas being proposed. They will help to ensure that the integrity of the design intent is maintained throughout the building delivery process.
Design	Establish cross discipline collaboration in the design process to ensure that benefits are leveraged. It is not uncommon for the actions of one building services design discipline to be working at odds with another. The reverse can also be possible through good collaboration resulting in compounding benefits.

Design (cont'd)	An example of this could be the use of an occupancy sensor system to control lighting but which also provides information for the air conditioning system and so reducing both lighting and HVAC energy costs. Be prepared to support your case particularly when it comes to new or innovative solutions that on the surface may have an up front capital cost impost. A common step in the design development process is value management whereby all aspects of the design are scrutinised to eliminate unnecessary expenditure. Developing a value proposition for your solutions can assist in justifying your position and avoiding it being cut from the project. Establishing interdependencies between the lighting and other building services systems can also help the lighting being recognised as an integral part of the whole-of-building performance. Keep in mind that a decision makers perception of "value" may vary significantly. A developer for example may not see any value in a lighting system that demonstrates significants savings on the running costs of the building. In this instance it may be necessary to demonstrate the value in attracting higher rents, better tenants or a higher price for selling the building.
Documentation	Most documentation will consist of : a) Drawings that show diagrammatically the spatial layout and schematics of the lighting solution, and; b) Specifications in written form that describe technical, compliance and functional requirements as well as quantities usually in the form of schedules. Product focussed lighting specifications can generally satisfied by meeting a minium compliance level (such as an Australian Standard) or other easily quantifiable measure. Performance based specifications can go one step further by allowing more qualitative criteria to be included. They are focussed on outcomes and so recognise alternative ways of achieving an overall desired result. Including process deliverables in the specification will help to ensure a performance-based solution can be successfully delivered in the absence of recognised compliance standards. Process deliverables could include computer modelling of illuminance levels, energy consumption and life cycle costs. Specific considerations for tender documents could include: • Ongoing supply service agreement or standing offer arrangement for a set period. Alternatively a quantity of reserve stock could be specified. • Nominate warranty and guarantee periods commensurate with the building life and quality. • Inclusion of as-built drawings and maintenance and operation manual at practical completion. This should include non-technical user operator guides if applicable. • Inclusion of training and orientation program for facilities manager and user representatives at handover stage • Selection of suppliers with a history of long term product support

Documentation (cont'd)	•	Specification of fittings may include such criteria as: - Ease of cleaning and lamp replacement - Ease of replacement and availability of components - Durability - Moisture and dust resistance (where required) - Modularity of components and fittings - Adaptability - Efficiency (energy to light output)
	•	Requirement for suppliers / tenderers to demonstrate their environmental performance credentials. This could include both company performance (environmental accreditation, corporate governance etc.) as well as product performance (recyclability, embodied energy, energy efficiency etc.)
	•	Interoperability with other building elements and systems
	•	Selection and specification of control systems should consider how intuitive is it to use, level of redundancy (what happens if it fails?) degree of specialisation and compatibility with other systems such as the BMS.
	•	Consider an extended defects liability period where it is justifiable and nominate rectification timeframes
	•	Include a requirement for inspections at critical points in the construction phase to ensure installations are as specified.
Construction	•	If alternatives are offered ensure they are equal or better than the specified product and test them against the criteria used to initially select them.
	•	Inspect installations at key control points to ensure quality is maintained.
	•	Carry out a comprehensive
Handover / Post Occupancy	•	Ensure all documentation and training is completed at handover.
	•	Where possible conduct a post occupancy evaluation to determine actual performance against design performance. Identify actions required to address areas of under-performance and agree with facilities manager.

Case Studies

Case Study

TC Bierne Centre, Brisbane

Background:

TC Bierne Centre is a 4 level existing older style building in Brisbane with very large floor plates (approximately 2,500m2). Brisbane City Council as the major tenant was seeking an innovative and flexible solution to reduce energy consumption and improve long term flexibility of the lighting system as part of their building energy efficiency program (BEEP).

Solution

Implementation of a Managed Lighting System (MLS) integrated with a new HVAC DDC control system.

The MLS system is largely occupancy driven. Lighting within each space is automatically controlled using occupancy sensors. The information is shared with the lighting control system to ensure common areas and travel paths (main circulation corridors, lift lobbies etc.) remain illuminated whilst any space is still occupied. This same occupancy profile information is shared with the DDC to allow more accurate control of the multiple package HVAC units servicing the space.

Features:

- “optimum start” facility each day allowing variable start times depending on occupancy trends and ambient conditions.
- Provides occupancy status during normal hours to allow set pints to be automatically adjusted in areas with intermittent use.
- Automatic after-hours turn off for each zone

Outcomes and Benefits:

- Flexible and user updateable control of lighting zones to accommodate future change at reduced churn cost.
- Automatic on/off lighting control to minimise energy consumption.
- Automatic correlation of HAVC unit operation and set points with occupancy profiles.
- Reductions in energy consumption and greenhouse gas emissions.

Key Details:

Site:
TC Bierne Centre
Fortitude Valley, Brisbane

Tenant:
Brisbane City Council

Area:
10,000m2

Solution:
Managed Lighting System integrated with HVAC control.

Outcomes:
Energy Savings: 338,000 kwh
Greenhouse gas savings: 364 tonnes per annum

Delivery Team:
City Assets, Brisbane City Council
Energex Retail
Energy Conservation Systems

Information provided by:
Energy Conservation Systems

Case Study

Energetics Pty Ltd

Background:

Energetics head office in North Sydney was recently upgraded with a new state of the art lighting system

Solution

The luminaires were upgraded to TL5 lamp technology and incorporated dual function sensors that combine both movement and light level sensing. Movement sensors allow the lighting to only be on when the areas are occupied whereas the light level sensing allows the light output to be reduced when ambient light level (form other sources such as natural light) increases.

Each luminaire can be controlled individually or as a group using a hand held infrared controller. This allows the lighting system characteristics (zoning, illuminance levels, on/off profiles) to be reconfigured without the need for costly rewiring.

The system was installed under an Energy Performance Contract at no capital cost to the tenant and risk transferred to the contractor based on guaranteed savings.

Features:

- High efficiency luminaires with TL5 tr-phosphor lamps
- Electronic high frequency ballasts
- Automatic occupancy detection
- Automatic dimming control
- Calibrated illuminance

Outcomes and Benefits:

- Flexible and user updateable control of lighting zones to accommodate future change at reduced churn cost.
- Automatic on/off lighting control to minimise energy consumption.
- Individual user control.
- Reductions in energy consumption and greenhouse gas emissions.

Key Details:

Site:
Energetics Head Office

Tenant:
Energetics Pty Ltd

Solution:
High efficiency luminaires with state-of-the-art lighting control system

Outcomes:
Energy Savings: 85%
Energy cost reduced from $3,770 to $585 per annum
Greenhouse gas savings: 27 tonnes per annum
Achieved 5 star ABGR rating

Delivery Team:
Energetics Pty Ltd
Energy Conservation Systems

Information provided by:
Energy Conservation Systems

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