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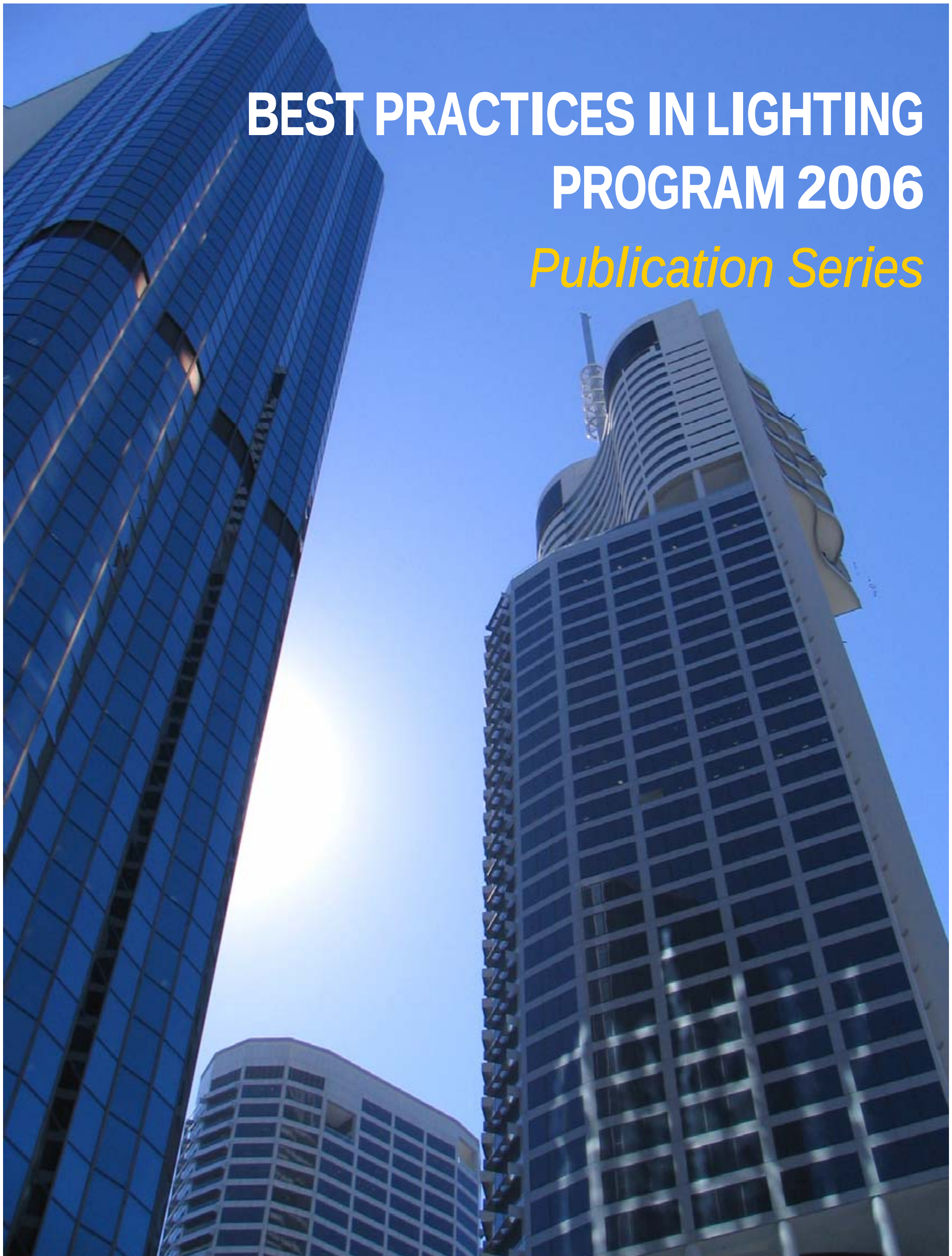

12. **Understanding How to Achieve Good Lighting Solutions Within The Framework Of The Building Code Of Australia**

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UNDERSTANDING HOW TO ACHIEVE GOOD LIGHTING SOLUTIONS WITHIN THE FRAMEWORK OF THE BUILDING CODE OF AUSTRALIA

Peter McLean, Lighting, Art + Science

The energy component of the Building Code of Australia (BCA)$_1$ was born from an increasing and imminent need for Australia to reduce its greenhouse emission. The energy requirements do not only apply to the lighting of buildings but also the physical design of the building envelope, the mechanical and hydraulic systems.

The energy requirements, in particular the lighting requirements of the BCA, represent a new approach to building approvals. Prior to the energy code, the approval of buildings had been based around the building classification. The system of classification was usage based and mainly related to the fire and life safety and structural requirements of the building. These classifications are function based.

Lighting requirements are generally based on the task to be performed rather than the overall usage of the building. As a result, it was impractical to try to control the energy used by lighting on an overall building use basis.

Lighting requirement in the BCA has therefore needed to be based on a combination of both function and task.

The BCA has therefore introduced an additional layer of task-based categories for the lighting energy limits.

Energy usage is the product of power consumption and time. Although the overall aim is to control energy usage, as the time of use is difficult to determine at the design stage, the BCA regulates power consumption on the justification that irrespective of the time of use, if the power consumption is reduced, the energy consumption will be reduced.

Application of the Code

The Building Codes Board is a Commonwealth organisation whose charter is to prepare the regulations. The states and territories, however, are responsible for determining how the regulations are to be applied and implemented.

In designing a lighting installation under the BCA Energy Provisions there are three distinct aspects that should be considered:

1. The BCA Energy Provisions and the mechanism for compliance,
2. The manner in which your state and building certifier will apply the BCA Energy Provisions to your project, and
3. The design of a lighting installation that provides the appropriate visual environment while meeting the energy criteria.

THE BCA ENERGY PROVISIONS AND THE MECHANISM FOR COMPLIANCE

This paper does not attempt to teach or interpret the energy provisions. There is no substitute for reading Section J of the BCA and the appropriate state amendments/legislation.

Although most architects, structural and fire engineers are used to working with the mechanism of the BCA, most lighting designers have had very little involvement in its application other than the emergency lighting deemed-to-satisfy provisions.

The introduction of the task based classifications in the lighting provisions has also introduced new requirements to categorise the spaces within the building that do not yet have accepted methods of interpretation.

The BCA allows several methods to demonstrate compliance.

Deemed-to-Satisfy

These are a series of rules that are set out in the document. If you can demonstrate that you have followed these rules then the installation is “deemed-to-satisfy” the requirements of the BCA.

The ‘Artificial Lighting and Power’ provisions contained in Part J6 of the BCA are the Deemed-to-Satisfy Provisions for lighting. These provisions stipulate maximum lamp power densities and illumination power densities for different spaces in different classifications of buildings, together with adjustment factors for additional controls and specific situations.

The BCA allows for the averaging of the power consumption between areas. While the code provides a calculation method as to how the average is to be calculated, there is no guidance as to how it should be applied in many situations.

It is important to read not only the provisions, but also the exceptions and the specifications for the equipment that are required before they can be used to justify an adjustment factor. For example a daylight sensor cannot be placed in a room which has no windows or skylights and yet still claim the adjustment factor or an occupancy sensor can only be claimed if it detects a person within a specified distance of entering the room.

Alternative Solutions

The Deemed-to-Satisfy provisions are included as the simple means to compliance. The lighting solution is not limited to these provisions and the designer is able to propose whatever solution they want, provided that it can be demonstrated that it is equivalent to the performance requirements of the BCA.

Clause A0.9 and A0.10 of the BCA[1] set out the methods of assessment for an alternative solution. They are:

a) Evidence to support that the ………design meets a *Performance Requirement* of *Deemed-to-Satisfy Requirement*…..”
b) *Verification Methods* such as-:
   i. The *Verification Methods* in the BCA; or
   ii. Such other *Verification Method* as the appropriate authority accepts for determining compliance with the *Performance Requirements*.
c) Comparison with the *Deemed-to-Satisfy* Provisions.
d) Expert Judgement

The difficulty in the application of the Alternative Solutions in the lighting provisions is that there are no overall *Performance Requirements* specified, or methodology for comparing a design with the *Deemed-to-Satisfy* Provisions.

To some extent the Alternative Solutions for the lighting has already been addressed by the averaging provisions between spaces already included in the Deemed-to-Satisfy Provisions.

Although any of the above options are available to the designer, before embarking along this path, it is important to agree the method of demonstration of compliance and verification with the building certifier, as they are the people who will accept or reject the Alternative Solution.

Whole of Building Assessment

Section J and JV of the BCA set out the requirements for the whole of building assessment. The BCA does provide Performance Requirements for the energy performance of the whole building. The Performance Requirements give an overall energy limit that includes the building façade, heating and cooling, lighting and power.

Under this provision energy can be traded between the services and the building performance and it does not matter how much energy is used by the lighting, as long as the overall limit is not reached. This may also work against the lighting in some situations. The building façade, however, has to always stand alone so that the lighting cannot be required to compensate for the poor thermal performance of the building façade.

This does not mean that the lighting may not be expected to compensate for the poor visual environment created by an inappropriate façade and interior design. However it is reliant on you as the designer to communicate these issues and any difficulties associated with producing a satisfactory lighting/visual experience.

Whole of building assessment requires not only computer modelling of the building but also a close liaison and understanding between the various design disciplines to achieve the best compromise between energy usage, functionality and cost.

It is important that the BCA Energy Code has to be read in conjunction with other parts of the BCA and Mandatory Standards. For example the minimum Illuminance levels required in Clause F4.4: Artificial lighting of the BCA and AS1735: Lifts, escalators and moving walkways[2], still apply.

THE MANNER IN WHICH A STATE CONTROLLING BODY AND THE BUILDING CERTIFIER WILL APPLY THE BCA ENERGY PROVISIONS TO THE PROJECT

While the States are responsible for the application of the BCA, there has been very little published on where the provisions are to be applied and how the provisions are to be interpreted.

It is important before starting the design that you determine how the BCA is to be applied to the building. It may be relatively straightforward for new buildings, but the BCA Energy Code represents a totally new form of compliance and there are many situations that will arise that people have not considered.

The following check-list gives an indication of the types of questions that should be asked of the certifier or the controlling body:

Item	Description	
	NEW BUILDINGS	
1	When are you required to demonstrate compliance? • With the Development Application? • With the Construction Certificate? • For Practical Completion?	
2	If only part of the works covered by the Development Application or the Construction Certificate is to be initially constructed, does each stage have to stand alone for compliance, or can they be averaged over the whole building?	
	EXISTING BUILDINGS	
3	Do the provisions apply to existing buildings, or only new buildings?	
4	If the provisions are applied to existing buildings, do they apply to: • Any works on the building? • Any works that involve the re-lighting of a space? • Any works that require a Development Application or Construction Certificate? • Any works that require a Development Application or Construction Certificate and involve the relighting of a space?	
5	Do the provisions apply to individual tenancies in a building? If so: • Can the Illumination Power Density (IPD) be averaged over multiple tenancies? • If a tenancy exceeds the average IPD for their space can they utilise savings made on another space? • If a tenancy exceeds the average IPD and causes the building's average IPD to be exceeded, who is responsible? • Can the IPD be averaged over different tenancies and common spaces where they have different certifiers?	
6	The BCA Energy Provisions apply to the building façade and mechanical services, as well as to lighting. In many cases of partial refurbishment of a building, it would not be feasible to redesign the façade of the building, or the common mechanical system, as it is shared by other tenants and is probably not owned by the person doing the refurbishment. Will the BCA Energy provisions be applied to specific services and not to others?	

7	Is there any exemption for heritage buildings?	
8	If the building's original compliance was based on the average IPD over the whole building and a tenant changes their lighting, do they need to submit a recalculation of the whole of building assessment, based on the current situation or are they limited to use the same IPD as their previous installation?	
9	If the building is based on a Whole-of-Building assessment, does the model have to be rerun each time there is a modification to an area?	
10	There is a relatively high level of uncertainty in lighting design. Is there a tolerance to be applied to compliance?	
11	Can an area in a Class 2, 3 or 9c building that has a classification in the Table J6.2b be calculated under that classification? e.g. A *lounge or dining room* in Table J6.2a has a LPD limit of 8 Watts/m^2 while a Restaurant, café or hotel lounge has an IPD limit of 20 Watts/m^2.[1]	

Classification of Spaces

The BCA Lighting Provisions give specific IPD limits for different spaces. Previously the names of rooms were not particularly important in a design, other than determining if they were habitable spaces. With the lighting provisions in the BCA, it is important to select the appropriate name for a space and make sure that the certifier will agree with that classification.

A few examples:

- A *Circulation space or corridor* is allowed 6 Watts/m^2 while an *Entry lobby* is allowed 15 Watts/m^2.[1] Does an *Entry lobby* have to connect to the outside of a building or can it be a lift lobby or the entry to a tenancy?
- Is the public space in a shopping centre *Retail space,* with an allowance of 25 Watts/m^2,or *Circulation space or corridor* with an allowance of 6 Watts/m^2?[1]
- With an atrium or staircase, what is the area that is used for calculation of the IPD:
    - The area of the floor?
    - The area of the floor multiplied by the number of floors?
    - The sum of the horizontal areas of floor in the space?

It is also important to be aware of the spaces that are exempt from the minimum illumination levels specified in clause F4.4 of the BCA. These include "A discotheque, nightclub or the like, where to create an ambience and character for the space, low lighting is used". The classification of a room can have an effect on the level of light and the uniformity required that can then affect the energy consumption.

Negotiate the classification of the rooms with the certifier early in the process. This is a learning process for both designers and certifiers alike.

DESIGNING LIGHTING TO MEET THE PROVISIONS OF THE BCA

There are two approaches that can be taken to designing lighting to comply with the provisions of the BCA:

- Design by energy limit
- Design of the lit environment

Design by Energy Limit

The BCA is not a lighting design guide and does not profess to be so. It does not specify lighting levels beyond the provisions of F4.4 and does not specify the quality of the lighting.

As a result, the person specifying the lighting can:

- Light the space with high efficiency fluorescent fittings, with additional controls, which in some circumstances would give a generally uninteresting design or,
- Reduce the illumination level in the space to achieve the energy limit with less expensive equipment.

Both may be appropriate in some circumstances, but as a general solution these are not responsible approaches to lighting design. This is not a new situation that has been brought into being by the BCA. Other than the BCA provisions in F4.4 there is no mandatory requirements that specify illumination levels or quality of lighting, nor should there be; however, it is the responsibility of the lighting designer to select the lighting solution and equipment that creates the best visual environment for that application.

Design of the lit environment

Lighting has never been separated from the overall design of the space, although in the past, many installations have been designed with this premise. There is not sufficient allowance within the IPD provisions to permit the lighting design to be used to overcome issues caused by poor non-lighting design of the space. The problems associated with sky glare and luminance distribution within the space have to be addressed as part of the overall design, not just lighting.

There is no right or wrong way to approach lighting design to meet the BCA Provisions. This is a suggested approach.

0. Team orientation

Participate in the design team discussions with the owner/client, facility manager, architect, mechanical & electrical engineers in order to gain an understanding of the goals within the project which they wish to attain. Also ascertain any perceived issues identified by team members with regards to meeting the gaols.

1. Start with the largest areas and move onto the smaller areas.

These areas will need to meet the provisions in their own right and any additional energy saving will be available to use on other spaces.

2. Schedule the spaces

Make a schedule of all the spaces, their areas, their IPD limit and leave a space for any adjustment figures that might be applied. It may be worthwhile to maintain a running assessment of the average IPD for the design so that you can see the effect that your progressive decisions are having.
Appendix A includes an example of a typical schedule

3. Identify the lighting criteria

- Identify the function of the room, the tasks, the location of the tasks and the illumination levels that would be required.
- Identify potential glare sources and the luminance distribution that will best assist the achievement of the appropriate visual environment.
- If the function or layout of the tasks in the space has not been determined yet, work out what lighting you are going to provide now and what will become layout specific lighting.

4. Glare Control

Glare comes in many forms:

- Disability Glare
- Gloom
- Sky Glare
- Veiling Reflections
- Discomfort Glare
- High angle glare

The common factor with all forms of glare is that they reduce visual performance and visual comfort. There is no real order of importance in glare and a simplistic solution to one form may exacerbate the effect of another, with the overall result being a reduction in visual comfort.

Although there is a general understanding of the mechanism of glare and there are some algorithms for prediction of glare, the prediction of the models often does not agree with the perception of the occupants.

Glare is often more related to the design of the room than the selection of a specific luminaire. Ultimately the control of the glare in the space will rely on the experience and understanding of the lighting designer and the experiences of others, rather than a detailed modelling of the space.

Control of glare is paramount in the designing of a space as it avoids the need to increase the illumination level to compensate by way of increasing the relative brightness of (particularly vertical) surfaces.

The deliberate lighting of walls may prove a more energy efficient solution to a gloom problem than a general increase in the illumination.

It should be remembered that glare is not an absolute sensation but a relative one. The aim of lighting design is to control glare not obliterate it. Many of the worst visual environments in the past have been created by a fanatical obsession with the removal of glare which spurned a simplistic solution involving the development of lighting products taking advantage of the ‘market’ hype.

The same components that produce glare when used in an uncontrolled fashion, can produce visual interest and sparkle when used in lesser amounts.

5. Create a Pleasant Visual Environment

Illuminance is highly overrated as a guide to the adequacy of lighting. The vast majority of problem lighting installations that have been assessed by the author have been glare related problems, rather than illuminance related. These problems are often expressed by the complainant as either a lack of, or excess of, light.

Generally, if the space has a comfortable environment, there is far less emphasis on the absolute illuminance and uniformity.

What are the keys to creating a pleasant visual environment?

- Control of glare
- Visual interest in terms of highlights and colour within the space
- Removal of excessive contrast in the near work space
- Removal of distractions (eg strong light, colour or movement, particularly in the peripheral vision)
- Provision of the opportunity for distance focussing, to relax the eyes

A visual environment should be designed with the purpose of the space in mind.

Strong contrast and colour can create a ‘wow’ factor for someone entering the space, but can be very tiring for someone trying to work in the space all day. Conversely, a space that is designed for comfortable sustained work may look rather bland when you initially enter.

Decide who you are lighting for - the visitor, or the occupant. It is often better to confine the ‘wow’ to the lobbies and transition areas, rather than the work places.

6. Rational Approach to Illuminance

Probably the greatest cause of wasted energy in lighting is due to an underlying irrational approach to illumination.

The difficulty is that this approach is often being driven by people without expertise or understanding of lighting.

At the IES National Conference in 2004, Kit Cuttle$_3$ noted that when Dr Blackwell presented his research for the illumination recommendations for the North American IES Lighting Handbook, he found that for printed matter, 10 lux was required for 10 point font, 12 lux for 8 point and 6 lux for 12 point. Dr Blackwell then went on to recommend levels from 323 and 1100 lux for schools and office work respectively.

This was mainly due to the poor quality tasks involving fifth carbon copies, poor quality duplication and pencil documents. Most of these difficult tasks have vanished from the modern workplace and been replaced with laser printed documents and screen based tasks.

So why do we still light to relatively high levels of illumination? The major reason is that unless a proactive approach is taken to the control of gloom, the spaces appear gloomy at lower illumination levels. While not proposing that we drop to the original levels indicated by Dr Blackwell, it does highlight that there is a large safety margin in the current recommended illumination levels before they result in unsafe or inadequate levels to conduct the specified visual tasks.

Other than running the lights all the time the second most significant waste of energy in lighting is ‘safe’ designs for the designer.

There is an increasing propensity to measure illuminance levels in interiors. The reason for this can be a requirement of the project manager’s or client’s quality assurance requirements, the occupational health and safety requirements or the union, in an attempt to have some quality control.

There is nothing wrong with measuring the illumination, provided the interpretation of the results is appropriate.

The physical requirements for taking illuminance measurements include:

- The quality and calibration of the light meter
- The accuracy of the horizontal plane of measurement
- The effective age of the lamps at the time of measurement
- The stability and level of the voltage and temperature

Over and above these there are some fundamental considerations in the interpretation of illumination acceptance testing:

a) Average illumination and uniformity is not a reliable indicator of the visual comfort of a space. Under laboratory conditions there is a strong correlation between visual performance, task luminance, task contrast and task size. In many work situations there are other factors that have an equal or greater effect on visual comfort and performance than horizontal illuminance.

b) The levels of illuminance required for safety are more than an order of magnitude below common office lighting levels, therefore such measurements are usually meaningless from an OH&S perspective.

c) AS/NZS1680.1.2006 'Interior and workplace lighting'[4] uses a range of 'Recommended maintained illuminance' levels in Table 3.1. that increase in multiples of 2. For example: 40, 80, 160, 320 etc. There are some intermediate levels in the higher ranges, but these are there for mainly historic reasons.

   The justification behind the magnitude of these steps is that the eye has difficulty in recognising lesser differences in illumination. This means that variations in illuminance of a few percent are irrelevant to the occupant of the room.

   It is pointless to therefore say that a room designed to an average maintained illuminance of 320 lux is deficient because the average illuminance that is measured is 319lux, 300 lux or even 270 lux.

d) The average illuminance in a space varies considerably with the number of measurement points and the relationship between the points and the walls and luminaires. The only real way to achieve consistency between the design and the measurement is to measure the illuminance at the exact calculation points, and all the calculation points. In addition, the room should be free of furniture.

e) When preparing the latest edition of AS/NZS 1680.1, we tried to find a measurement grid that could be used, that was conservative. That is, a grid that if a design gave a particular average illuminance, then the measurement of that installation would always give an average illuminance that was equal to or greater than the design illuminance. We could not find one other than all the exact calculation points. As a result, there is always a chance that a lighting design, designed in good faith, will fail to produce a complying average illuminance, totally based on the selection of the measurement grid.

f) Finally AS/NZS3827.1.1988 Lighting system performance - Accuracies and tolerances,[5] sets out the uncertainties in the lighting design process from the initial photometric testing, through tolerances of equipment and manufacture, to the accuracy of the lighting calculation process. In some types of interiors the uncertainty of design could be in excess of ±30%.

The consequence of this is that the designer is faced with a choice of:

Designing an installation accepting the risk of the uncertainty and acknowledging that even if the negative uncertainty is realised it will have only a small effect on the visual performance in the space. This can result in the designer trying to convince the people who have taken the measurements of the factors listed above after the event, when it looks like the designer is trying to justify what they see as a deficient design.

or

Over-designing the installation to the extent that even if the lowest design uncertainty and measurement uncertainty is realised, the installation will still yield a set of compliant readings. The consequence of this is that the installation can also yield a set of very high readings.

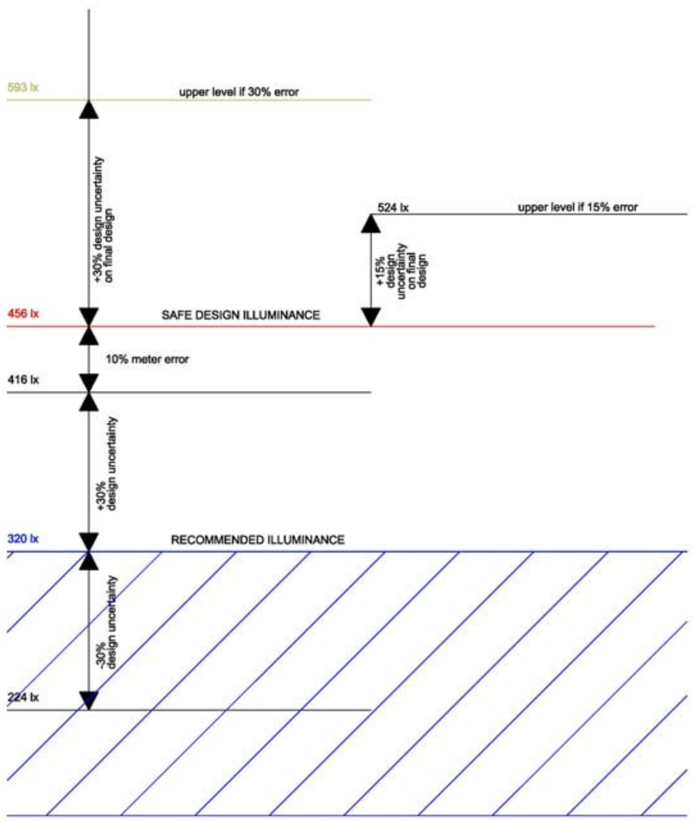

Figure 1 – Safe Design Scenario

Figure 1 shows the Safe Design scenario. The consequence of this design is that the installation is over-designed, in the worst case, to around 40% - to protect the designer against spurious claims. If the uncertainty is realised at the high end, the average illuminance could be as high as 590 lux to ensure an average of 320 lux.

The advantage to the visual environment is minor, however if this scenario were adopted universally it would mean that up to 40% of the energy used in internal lighting was unnecessary.

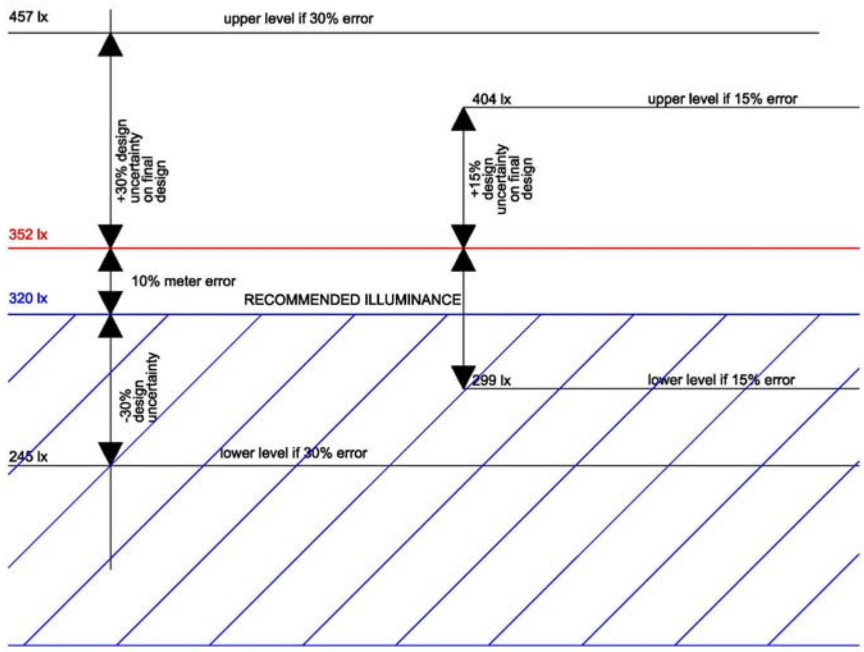

Figure 2 – Shared Risk Scenario

Figure 2 shows the effect when the uncertainty is accepted as what it is and the risk is shared with the designer and the owner. The effect is a controlled use of energy, the client does not pay for a lot of unnecessary lighting equipment and possibly a supplementary dimming system to bring the illumination levels back to a reasonable level. In the worst case scenario, there may need to be some supplementary lighting, but the cost is insignificant compared with the cost of the safe design.

All lighting design must be based on competent design, made in good faith, as there are too many aspects to good design that cannot be quantified or isolated.

The latest edition of AS/NZS1680.1[2] has included some new clauses 3.11.2 'Higher values of illuminance' and 3.11.3 'Lower values of illuminance'. These basically state that the recommended illuminance values in the standard are a guide only and that a competent lighting designer may, with good reason, elect to over or under illuminate a space to suit the specific situation.

7. Select a Lamp and Luminaire combination

It is important that this is the second last part of the selection process as it ensures that the luminaire selection is based on the lighting requirements rather than compromising the lighting design to use an inappropriate luminaire selection.

It is important to look at the lamp and luminaire combination, the lamp with the highest efficacy may not achieve the best lamp and luminaire efficiency, nor may it be the most efficient way to light a task. A low voltage tungsten lamp may still be the most efficient way of providing a small highlight.

8. Supplementary Controls

Supplementary controls such as occupancy sensors, timers, photoelectric controls and dimmers can all provide adjustments that allow a higher IPD. They may be provided for reasons other than energy saving, however their potential should not be overlooked.

As a general rule, it is better to start with an efficient design, rather than solve all the problems with controls.

9. Balance the schedule of spaces to achieve the average IPD

Return to your schedule of spaces and determine if there are any areas whose design you need to revisit to bring the installation into compliance.

Conclusion

The BCA Energy Provisions are a new area of regulation in the Australian Building Industry and represent a new learning experience for Designers, Certifiers and Regulators alike.

There are sure to be situations that have not been foreseen by the regulators, or where the method of application needs to be addressed. It is important that these situations be highlighted and reported as and when they are found, so that the documents can be improved over time.

From the lighting designer's perspective, I believe the secret of successful energy efficient design is to:

Design for the appearance and visual comfort of the space and top up the lighting where additional illumination is required

Rather than:

Design for illuminance and overlay additional lighting to correct the appearance

References:

1. **Building Code of Australia, Volume One, 2006 Edition:** Australian Building Codes Board, 2006

2. **AS1735: Lifts, escalators and moving walkways:** Standards Australia, 2003

3. **Cuttle, C. Criteria for Indoor Lighting in the 21st Century -** Transactions of the Illuminating Engineering Society of Australia and New Zealand, Broadbeach QLD 2004

4. **AS/NZS1680.1:2006 Interior and workplace lighting** Standards Australia, 2006

5. **AS/NZS3827.1.1988 Lighting system performance - Accuracies and tolerances** Standards Australia, 1988

Further Reading

i. Julian, WG. (2003). *Lighting: Basic Concepts*, 6th Edition, University of Sydney, Sydney, (ISBN 1 86487 033 8)
ii. www.lightcoe.com
    a. *Electric Lighting – Design Techniques.* McLean, P.
    b. *Electric Lighting – Technologies: Lamps and Control Gear.* Martin, D.

Appendix A
Room Schedule Example

Example 3	Mixed building				
Area No	Type of space		max IPD from table J6.2c	Area	IPD x Area
1	Warehouse		10	1500	15000
2	Carpark		3	1500	4500
3	General Office		10	400	4000
4	Small office (Room index 0.8)		10	9	90
5	Small office (Room index 0.8)		10	9	90
6	Small office (Room index 0.8)		10	9	90
7	Conference Room		8	14	112
8	Toilets and amenities		3	20	60
9	Corridor		6	60	360
10	Reception / lobby		15	12	180
11	Retail		25	300	7500
			TOTALS	**3833**	**31982**
				Maximum Average IPD	**8.3**
			=[Σ(IPD x Area)] /total Area		

Application of Adjustment Factors

Area No	Type of Adjustment	Factor from table J6.2b		Cumulative factors		Formula
				Normal floor	Daylight controlled	
1	Skylight daylight control	0.8		0.8		
2	Motion detection	0.9		0.9		
3	Motion detection / 6 lights	0.7		0.7		
	Daylight control	0.5	15% of floor		0.43	=0.5*[0.7+(1-0.7)/2]
4,5,6	Room Index	0.7				
	Motion detection / 6 lights	0.7		0.6		=0.7*[0.7+(1-0.7)/2]
7	Motion detection / 6 lights	0.7		0.7		
8	Room Index	0.7				
	Motion detection / 2 lights	0.55		0.47		=0.55*[0.7+(1-0.7)/2]

Lighting Design Check

Area No		Total Design Power	Area	% calculation area	calculation area	IPD for design	Cumulative Factor	Adjusted IPD	IPD x Area	max IPD
1	Base Lighting	32400	2500	100%	2500	12.96	0.8	10.37	25925	10
2	Base Lighting	900	350	100%	350	2.57	0.9	2.31	809	3
3	Base Lighting	2304	225	85%	191.25	12.05	0.7	8.44	1,614	10
	Daylight controlled	2304	225	15%	33.75	68.27	0.43	29.36	991	
4	Base Lighting	144	9	100%	9	16	0.6	9.6	86	10
5	Base Lighting	144	9	100%	9	16	0.6	9.6	86	10
6	Base Lighting	144	9	100%	9	16	0.6	9.6	86	10
7	Base Lighting	688	14	100%	14	49.14	0.7	34.4	482	8
8	Base Lighting	76	20	100%	20	3.8	0.47	1.79	36	3
9	Base Lighting	304	60	100%	60	5.07	1	5.07	304	6
10	Base Lighting	440	12	100%	12	36.67	1	36.67	440	15
11	Base Lighting	3709	300	100%	300	12.36	1	12.36	3708	25
				TOTALS	**3508**	**250.89**			**34,567**	

Adjusted IPD **9.85** **= [Σ(IPD x Area)] /total Area**

As this is < Average IPD of 10.5 calculated above the design complies