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National Construction Code

Case Study

Lighting refurbishment of an office building

Energy efficiency

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Case study: Lighting refurbishment of an office building

General information

Topic	Lighting energy efficiency
Compliance solution	Deemed-to-Satisfy (DTS) NCC 2019, Volume One, Part J6
Performance Requirement	JP1 (part of)
Climate zone	Any
Building classification	Class 5

Contents

REMINDER

This case study is not mandatory or regulatory in nature and compliance with it will not necessarily discharge a user's legal obligations. The case study should only be read and used subject to, and in conjunction with, the general disclaimer at page i.

The case study also needs to be read in conjunction with the relevant legislation of the appropriate State or Territory. It is written in generic terms and it is not intended that the content of the case study counteract or conflict with the legislative requirements, any references in legal documents, or other documents issued by the Administration or any directives by the Appropriate Authority.

Introduction

This case study describes developing DTS Solutions for an interior lighting refurbishment of a Class 5 office building. The energy efficiency requirements for lighting form part of the broader energy efficiency requirements of the National Construction Code (NCC). The NCC DTS lighting provisions for Class 5 office buildings are in Part J6 of NCC Volume One. These DTS Provisions form part of meeting the Performance Requirement, JP1.

In this case study, there are references to the NCC. As the DTS lighting provisions for energy efficiency are in NCC Volume One Part J6, they are in the form of J6.x. To read these references, refer to the NCC, available from the ABCB website (ncc.abcb.gov.au).

The case study targets practitioners with a basic understanding of the NCC energy efficiency provisions and an overall understanding of the performance-based NCC.

Purpose and limitations

This case study aims to demonstrate the practical application of the NCC energy efficiency requirements when proposing to refurbish the lighting in an office building.

The brief given to the lighting designer is that all lights and control devices must satisfy, either in their own right or in conjunction with the appropriate adjustment factor, the minimum NCC DTS lighting provisions. The case study assumes the following steps have been completed.

1. The deficiencies of all existing lighting, switch zones, switch controls and perimeter controls are identified.
2. A detailed design to address the deficiencies is complete. For this case study, all components are to be replaced to meet the requirements prescribed in the NCC DTS lighting provisions.

The case study design is representative of an office building with a café on the ground floor.

The guidance in this case study is limited to the interior artificial lighting requirements of Part J6 and developing a DTS Solution using the relevant DTS Provisions. This does not demonstrate full NCC compliance, as all NCC Performance Requirements need to be met.

Users of the case study are encouraged to check for any relevant State and Territory NCC variations and additions that may apply in their jurisdiction. Furthermore, users should be aware of any applicable legalisation within their jurisdiction that may have a bearing on the content of this case study.

The Design

The interior lighting in a Class 5 office building is being refurbished for a new tenant. All lighting and control components are being replaced. The brief given to the lighting designer stipulates that all lights and control devices must comply in their own right or in conjunction with the appropriate adjustment factor prescribed in the NCC DTS lighting provisions.

A scenario with minimal control devices is presented in detail, showing the resolved lighting layout. Four additional scenarios are also examined. They provide suggestions for designs where the specified maximum illumination power density may not be appropriate for the design, including:

1. daylight sensors around the perimeter
2. motion sensors to all lighting
3. lighting with good colour rendering
4. daylight sensors around the perimeter, motion sensors and lighting with good colour rendering (i.e. a combination of the above elements).

Design plans

Figure 1 Ground level floor plan

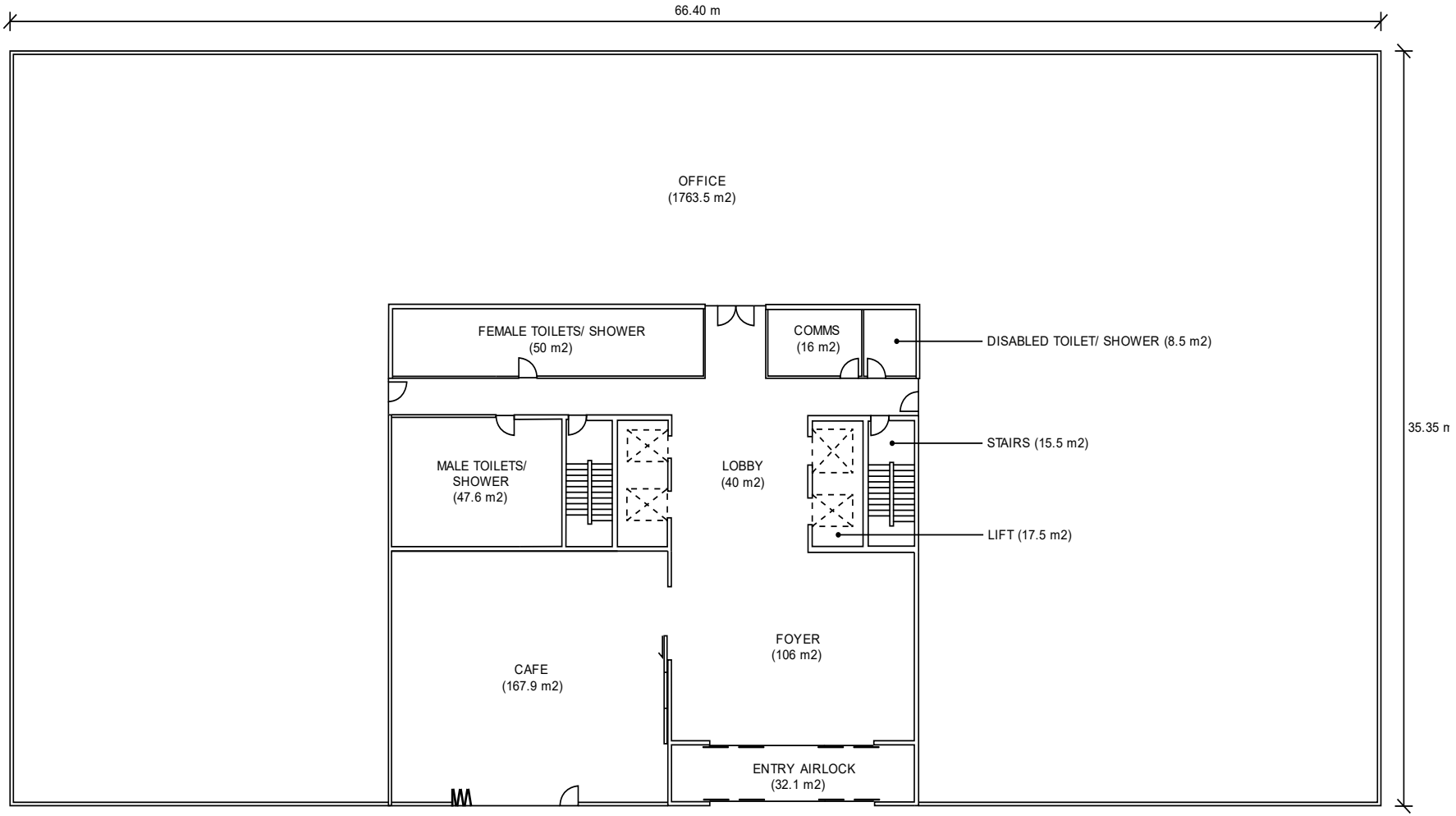
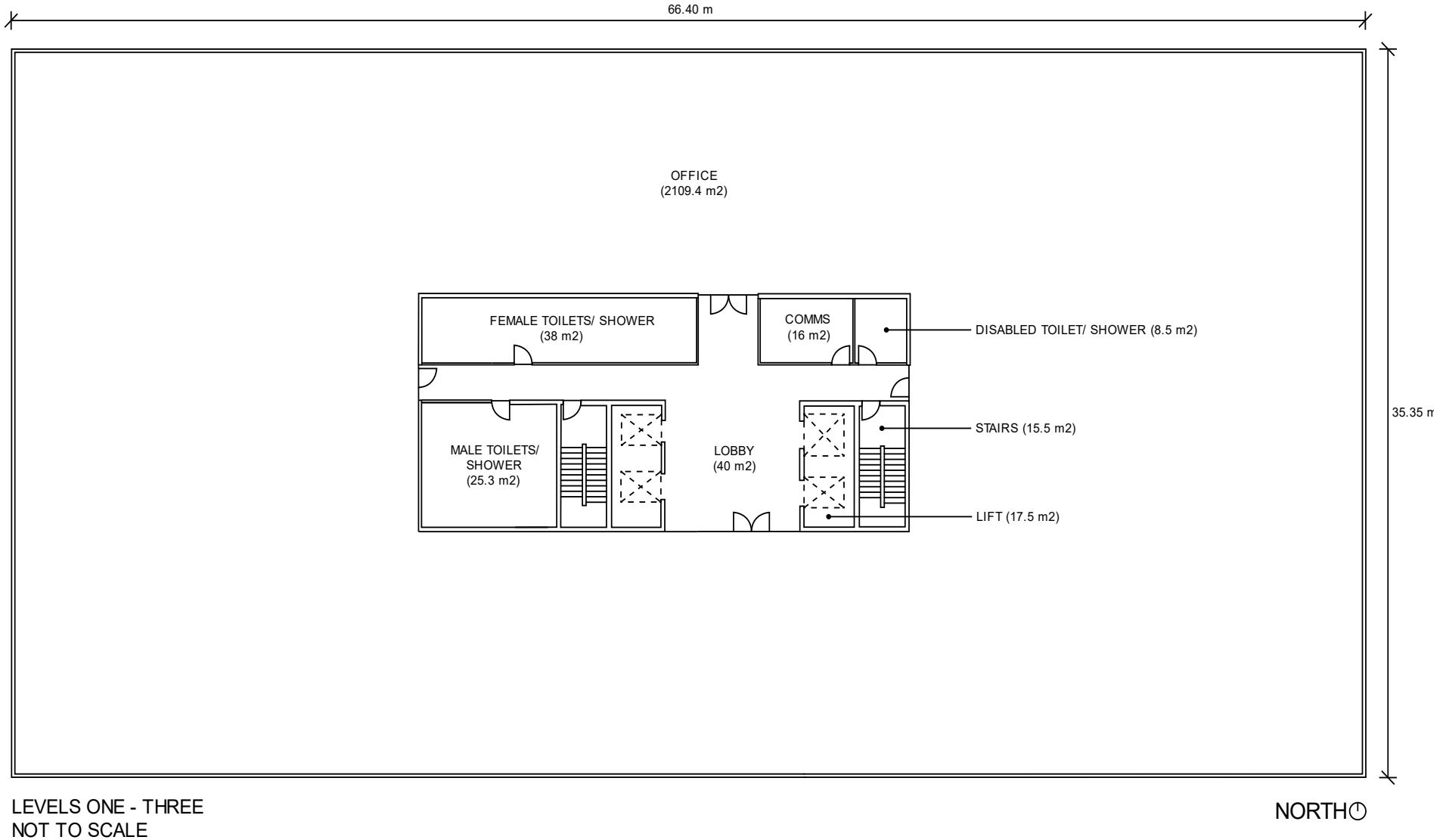


Figure 2 Levels 1 – 3 floor plan



The Solution

The lighting requirements for the small office building are dependent on the dimensions of each space, space type, control method and lighting colour. Multiple compliance options with different control methods and lighting options are examined.

Interior artificial lighting and power control

Before assessing the different control methods and lighting options for the design, there are several compulsory design features for the office outlined below.

Switches

As per J6.3(c)(i), all artificial lighting switches are located in a visible and easily accessible position in the room or space being switched, or in an adjacent room or space from which 90% of the lighting being switched is visible. This ensures all lighting switches are easily accessible and visible to encourage occupants to switch off lighting when it is not required. In addition, as per J6.3(c)(ii), all artificial lighting switches must operate an area of less than 250 m^2.

Time switch / occupant sensing device

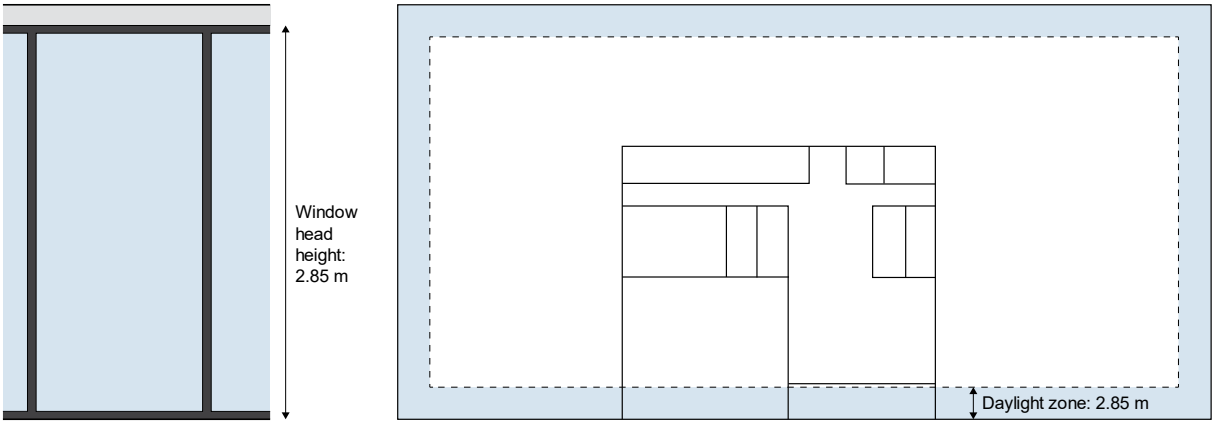
As per J6.3(d), at least 95% of the light fittings are controlled by a time switch in accordance with Specification J6, as each storey of the building is greater than 250 m^2. This ensures all lights are switched off when not in use. To meet the 95% for this office design, all light fittings except those within a staircase are controlled by a time switch. An alternative to a time switch is an occupant sensing device. This is explored in scenario 2 of this document.

Natural lighting zone

As per J6.3(e), separate controls for artificial lighting in the natural lighting zone adjacent to windows and for general lighting not in the natural lighting zone are provided. This ensures that when there is sufficient natural lighting, lights in the natural lighting zone are capable of being switched off. The natural lighting zone is

the distance from the window equal to the depth of the floor to window head height (see Figure 3). The natural lighting zone would apply to the office space and the café in the office design.

Figure 3 Diagram of window head height (section) and equivalence to natural lighting zone (plan)



Fire-isolated stairways

As per J6.3(f), artificial lighting in all fire-isolated stairways are controlled by a motion detector in accordance with Specification J6. Motion sensors are used in the staircases as they are often un-used and do not require lighting during these times. The specification requires that the motion detector must detect movement of 500 mm within the useable part of the space and before a person has entered 1 m into the space. The motion detector must be configured to dim the lights to 30% peak power or less when the space is unoccupied for more than 15 minutes.

Emergency lighting

All emergency lighting is designed in accordance with Part E4. Emergency lighting is required to facilitate safe evacuation in an emergency. This includes required illuminance levels and operation times for paths of travel to an exit, and floor levels and treads in fire-isolated stairways, fire-isolated passageways, fire-isolated ramps, non-fire-isolated stairways and non-fire-isolated ramps.

Interior artificial lighting illumination power density

Defining space types and dimensions

Understanding the dimensions and type of each space in the building provides an initial indication of the maximum illumination power density allowed in each space.

Space types

Table J6.2a provides the space types and applicable unadjusted maximum illumination power density. The relevant space types are presented in Table 1.

Table 1 Small Class 5 office building relevant space types

Space	Space type	Maximum illumination power density (W/m^2)
Office	Office - artificially lit to an ambient level of 200 lx or more	4.5
Office perimeter zone	Office - artificially lit to an ambient level of 200 lx or more	4.5
Female toilets	Toilet, locker room, staff room, rest room and the like	3
Male toilets	Toilet, locker room, staff room, rest room and the like	3
Accessible toilets	Toilet, locker room, staff room, rest room and the like	3
Café	Restaurant, café, bar, hotel lounge and a space for the serving and consumption of food or drinks	14
Corridor	Corridors	5
Comms room	Illuminance more than 400 lx and not more than 600 lx (see Table J6.2a Note)	10
Stairs 1	Stairways, including fire-isolated stairways	2
Stairs 2	Stairways, including fire-isolated stairways	2
Lift 1	Lift cars	3
Lift 2	Lift cars	3

Space	Space type	Maximum illumination power density (W/m^2)
Foyer	Entry lobby from outside the building	9
Entry / Air lock	Entry lobby from outside the building	9
Lobby (Ground level)	Entry lobby from outside the building	9
Lobby (Levels 1-3)	Corridors	5

Space dimensions

The maximum illumination power density may be increased for small, enclosed spaces. This is because walls absorb light energy and less illumination would be available at the working surface level unless some compensation is permitted. An equation for calculating the allowable increase permitted based on a Room Aspect Ratio is provided in Notes of Table J6.2a and is reproduced below. The Room Aspect Ratio is a ratio of the area of the enclosed space to the height and perimeter of the enclosed space. If the Room Aspect Ratio is less than 1.5 (i.e. a small enclosed space), the maximum allowable illumination power density may be increased.

The Room Aspect Ratio is calculated using the following equation.

$$room\ aspect\ ratio = \frac{A}{H \times C}$$

Where:

A = the area of the enclosed space

H = the height of the space measured from the floor to the highest part of the ceiling

C = the perimeter of the enclosed space

If the Room Aspect Ratio is less than 1.5, the maximum allowable illumination power density may be increased by dividing it by an adjustment factor for room aspect. The adjustment factor is equivalent to:

$$0.5 + \frac{Room\ Aspect\ Ratio}{3}$$

Table 2 and Table 3 detail the area, ceiling height, perimeter, Room Aspect Ratio and adjustment factor of each space.

Table 2 Ground level space dimensions and Room Aspect Ratio adjustment factors

Space	Area (m^2)	Ceiling height (m)	Perimeter (m)	Room Aspect Ratio	Adjustment factor
Office	1288.8	2.85	-	-	-
Office perimeter zone	474.7	2.85	-	-	-
Female toilets	50.0	2.85	37.1	0.47	0.66
Male toilets	47.6	2.85	28.3	0.59	0.70
Accessible toilets	8.5	2.85	11.8	0.25	0.58
Café	167.9	2.85	51.7	1.14	0.88
Corridor	49.6	2.85	61.9	0.28	0.59
Comms room	16.0	2.85	16.4	0.34	0.61
Stairs 1	15.5	2.85	17.3	0.31	0.60
Stairs 2	15.5	2.85	17.3	0.31	0.60
Lift 1	17.5	2.85	18.0	0.34	0.61
Lift 2	17.5	2.85	18.0	0.34	0.61
Foyer	106.0	2.85	41.5	0.90	0.80
Entry / air lock	32.1	2.85	29.4	0.38	0.63
Lobby	40.0	2.85	25.0	0.56	0.69

Table 3 Levels 1 – 3 space dimensions and Room Aspect Ratio adjustment factors

Space	Area (m^2)	Ceiling height (m)	Perimeter (m)	Room Aspect Ratio	Adjustment factor
Office	1563.1	2.85	-	-	-
Office perimeter zone	546.3	2.85	-	-	-
Female toilets	38.0	2.85	29.4	0.45	0.65
Male toilets	25.3	2.85	20.0	0.44	0.65
Accessible toilets	8.5	2.85	11.8	0.25	0.58
Corridor	44.0	2.85	53.5	0.29	0.60
Comms room	16.0	2.85	16.4	0.34	0.61
Stairs 1	15.5	2.85	17.3	0.31	0.60
Stairs 2	15.5	2.85	17.3	0.31	0.60
Lift 1	17.5	2.85	18.0	0.34	0.61

Space	Area (m^2)	Ceiling height (m)	Perimeter (m)	Room Aspect Ratio	Adjustment factor
Lift 2	17.5	2.85	18.0	0.34	0.61
Lobby (corridor)	40.0	2.85	25.0	0.56	0.69

Allowable illumination power load

As detailed in Tables 4 to 7, the aggregate design illumination power load for the office building is determined by firstly multiplying the maximum illumination power density of each space by the area of each space. The aggregate illumination power load is then the sum of each space.

Table 4 Ground level maximum illumination power load

Space	Initial maximum illumination power density (W/m^2)	Area (m^2)	Maximum illumination power load (W)
Office	4.5	1288.8	5799.6
Office perimeter zone	4.5	474.7	2136.1
Female toilets	3	50.0	150.0
Male toilets	3	47.6	142.8
Accessible toilets	3	8.5	25.5
Café	14	167.9	2350.6
Corridor	5	49.6	248.0
Comms room	10	16.0	160.0
Stairs 1	2	15.5	31.0
Stairs 2	2	15.5	31.0
Lift 1	3	17.5	52.5
Lift 2	3	17.5	52.5
Foyer	9	106.0	954.0
Entry / air lock	9	32.1	288.9
Lobby	9	40.0	360.0

Table 5 Ground level aggregate illumination power load

Aggregate illumination power load (W)
12782.6

Table 6 Levels 1-3 maximum illumination power load

Space	Initial maximum illumination power density (W/m^2)	Area (m^2)	Maximum illumination power load (W)
Office	4.5	1563.1	7034.0
Office perimeter zone	4.5	546.3	2458.3
Female toilets	3	38.0	114.0
Male toilets	3	25.3	75.9
Accessible toilets	3	8.5	25.5
Corridor	14	44.0	220.0
Comms room	5	16.0	160.0
Stairs 1	10	15.5	31.0
Stairs 2	2	15.5	31.0
Lift 1	3	17.5	52.5
Lift 2	3	17.5	52.5
Lobby (corridor)	5	40.0	200.0

Table 7 Levels 1-3 aggregate illumination power load

Aggregate illumination power load (W)
12782.6

Solution scenarios

There are five scenarios detailing different DTS Solutions based on this office building design. The first scenario considers a simpler lighting design with minimal control devices used. Four additional scenarios are also examined for the same office building design. They assess the impacts of different control devices and lighting types for designs that may require maximum illumination power densities above those specified in Part J6. Reasons for this approach may include:

- Higher lux levels for specific tasks within the office (e.g. drafting)
- Specific correlated colour temperature or colour rendering index for particular tasks within the office (e.g. design work)
- Higher lux levels for architectural lighting.

Scenario 1 - Minimal control devices

To meet the NCC requirements, this solution considers a design with no additional control devices (other than the motion detectors required in the fire isolated stairways and time switches on at least 95% of the lighting) or improvement of lighting colour. All lighting has a correlated colour temperature (CCT) between 3500 K and 4500 K (i.e. neutral white lighting) and a colour rendering index (CRI) of less than 90 (i.e. a CRI that may display some colours dissatisfactory or alter colour perception). Therefore, only the Room Aspect Ratio adjustment factor and control device adjustment factor (where applicable) are used in each space.

To determine the maximum illumination power density, the power density identified in Table J6.2a (or Table 1 in this document) is divided by both the Room Aspect Ratio adjustment factor and the control device adjustment factor (where applicable). The allowable maximum illumination power load for each space is detailed in Tables 8 to 10. The total maximum illumination power load for all spaces combined is in Table 11.

Table 8 Ground floor adjusted maximum illumination power density and load

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (time switch – programmable dimming)	Adjustment factor (motion detector control device)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.85	-	5.3	6823.1
Office perimeter zone	4.5	-	0.85	-	5.3	2513.1
Female toilets	3.0	0.66	0.85	-	5.4	268.3
Male toilets	3.0	0.70	0.85	-	5.1	241.1
Accessible toilets	3.0	0.58	0.85	-	6.0	51.3
Café	14.0	0.88	0.85	-	18.7	3143.1
Corridor	5.0	0.59	0.85	-	9.9	491.4
Comms room	10.0	0.61	0.85	-	19.1	306.3
Stairs 1	2.0	0.60	-	0.6	5.5	85.4
Stairs 2	2.0	0.60	-	0.6	5.5	85.4
Lift 1	3.0	0.61	0.85	-	5.8	100.6
Lift 2	3.0	0.61	0.85	-	5.8	100.6
Foyer	9.0	0.80	0.85	-	13.3	1405.2
Entry / air lock	9.0	0.63	0.85	-	16.9	541.5
Lobby	9.0	0.69	0.85	-	15.4	616.4

Table 9 Ground level adjusted aggregate power load

Aggregate illumination power load (W)
16773.0

Table 10 Levels 1 – 3 adjusted maximum illumination power density and load

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (time switch – programmable dimming)	Adjustment factor (motion detector control device)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.85	-	5.3	8275.3
Office perimeter zone	4.5	-	0.85	-	5.3	2892.1
Female toilets	3.0	0.65	0.85	-	5.4	206.0
Male toilets	3.0	0.65	0.85	-	5.4	137.8
Accessible toilets	3.0	0.58	0.85	-	6.0	51.3
Corridor	5.0	0.60	0.85	-	9.9	434.1
Comms room	10.0	0.61	0.85	-	19.1	306.3
Stairs 1	2.0	0.60	-	0.6	5.5	85.4
Stairs 2	2.0	0.60	-	0.6	5.5	85.4
Lift 1	3.0	0.61	0.85	-	5.8	100.6
Lift 2	3.0	0.61	0.85	-	45.8	100.6
Lobby (corridor)	5.0	0.69	0.85	-	8.6	342.4

Table 11 Levels 1-3 adjusted aggregate power load

Aggregate illumination power load (W)
13017.6

A proposed solution that meets the above requirements and those of AS 1680 Interior and Workplace Lighting (an Australian Standard lighting that designers are commonly requested to comply with), is detailed in Tables 12 to 15 and Figures 4 and 5.

Table 12 Ground level lighting design

Space	Area (m^2)	Allowable maximum illumination power density (W/m^2)	Allowable maximum illumination power load (W)	Lighting	Illumination power density calculation	Illumination power density (W/m^2)	Illumination power load (W)
Office (Total)	1763.5	5.3	9336.2	311 X 27W Troffer lighting	311 X 27 / 1763.5	4.8	8397.0
Female toilets	50.0	5.4	268.3	12 X 10W Downlights	12 X 10 / 50	2.4	120.0
Male toilets	47.6	5.1	241.1	12 X 10W Downlights	12 X 10 / 47.6	2.5	120.0
Accessible toilets	8.5	6.0	51.3	2 X 10W Downlights	2 X 10 / 8.5	2.4	20.0
Café	167.9	18.7	3143.1	36 X 20W Downlights	36 X 20 / 167.9	4.3	720.0
Corridor	49.6	9.9	491.4	11 X 10W Downlights	11 X 10 / 49.6	2.2	110.0
Comms room	16.0	19.1	306.3	6 X 30.5W Battens	6 X 30.5 / 16.0	11.4	183.0

Space	Area (m^2)	Allowable maximum illumination power density (W/m^2)	Allowable maximum illumination power load (W)	Lighting	Illumination power density calculation	Illumination power density (W/m^2)	Illumination power load (W)
Stairs 1	15.5	5.5	85.4	3 X 10W Downlights	3 X 10 / 15.5	1.9	30.0
Stairs 2	15.5	5.5	85.4	3 X 10W Downlights	3 X 10 / 15.5	1.9	30.0
Lift 1	17.5	5.8	100.6	*	*	*	100.6
Lift 2	17.5	5.8	100.6	*	*	*	100.6
Foyer	106.0	13.3	1405.2	16 X 20W Downlights	16 X 20 / 106	3.0	320.0
Entry / air lock	32.1	16.9	541.5	6 X 20 Downlights	6 X 20 / 32.1	3.7	120.0
Lobby	40.0	15.4	616.4	9 X 10W Downlights	9 X 10 / 40	2.3	90.0

Notes:

* Lift lighting is as determined by the lift manufacturer. The illumination power load is assumed as the maximum allowable for this case.

Table 13 Ground level aggregate illumination power load

Allowable aggregate illumination power load (W)	Achieved aggregate illumination power load (W)
16773.0	10461.2

Table 14 Levels 1 – 3 lighting design

Space	Area (m^2)	Allowable maximum illumination power density (W/m^2)	Allowable maximum illumination power load (W)	Lighting	Illumination power density calculation	Illumination power density (W/m^2)	Illumination power load (W)
Office (Total)	2109.4	5.3	11167.4	372 X 27W Troffer lighting	372 X 27 / 2109.4	4.8	10044.0
Female toilets	38.0	5.4	206.0	12 X 10W Downlights	12 X 10 / 38	3.2	120.0
Male toilets	25.3	5.4	137.8	9 X 10W Downlights	9 X 10 / 25.3	3.6	90.0
Accessible toilets	8.5	6.0	51.3	2 X 10W Downlights	2 X 10 / 8.5	2.4	20.0
Corridor	44.0	9.9	434.1	11 X 10W Downlights	11 X 10 / 44	2.5	110.0
Comms room	16.0	19.1	306.3	6 X 30.5W Battens	6 X 30.5 / 16.0	11.4	183.0
Stairs 1	15.5	5.5	85.4	3 X 14W Downlights	3 X 10 / 15.5	1.9	30.0
Stairs 2	15.5	5.5	85.4	3 X 14W Downlights	3 X 10 / 15.5	1.9	30.0
Lift 1	17.5	5.8	100.6	*	*	*	100.6
Lift 2	17.5	5.8	100.6	*	*	*	100.6
Lobby (corridor)	40.0	8.6	342.4	9 X 10W Downlights	9 X 10 / 40	2.3	90.0

Notes:

* Lift lighting is as determined by the lift manufacturer. The illumination power load is assumed to be the maximum allowable for this case.
* All lighting timers and motion detectors satisfy Specification J6

As demonstrated in Table 15 and 16 each space individually meets the required maximum illumination power density and therefore meets aggregate design illumination power load requirements of J6.2b(i).

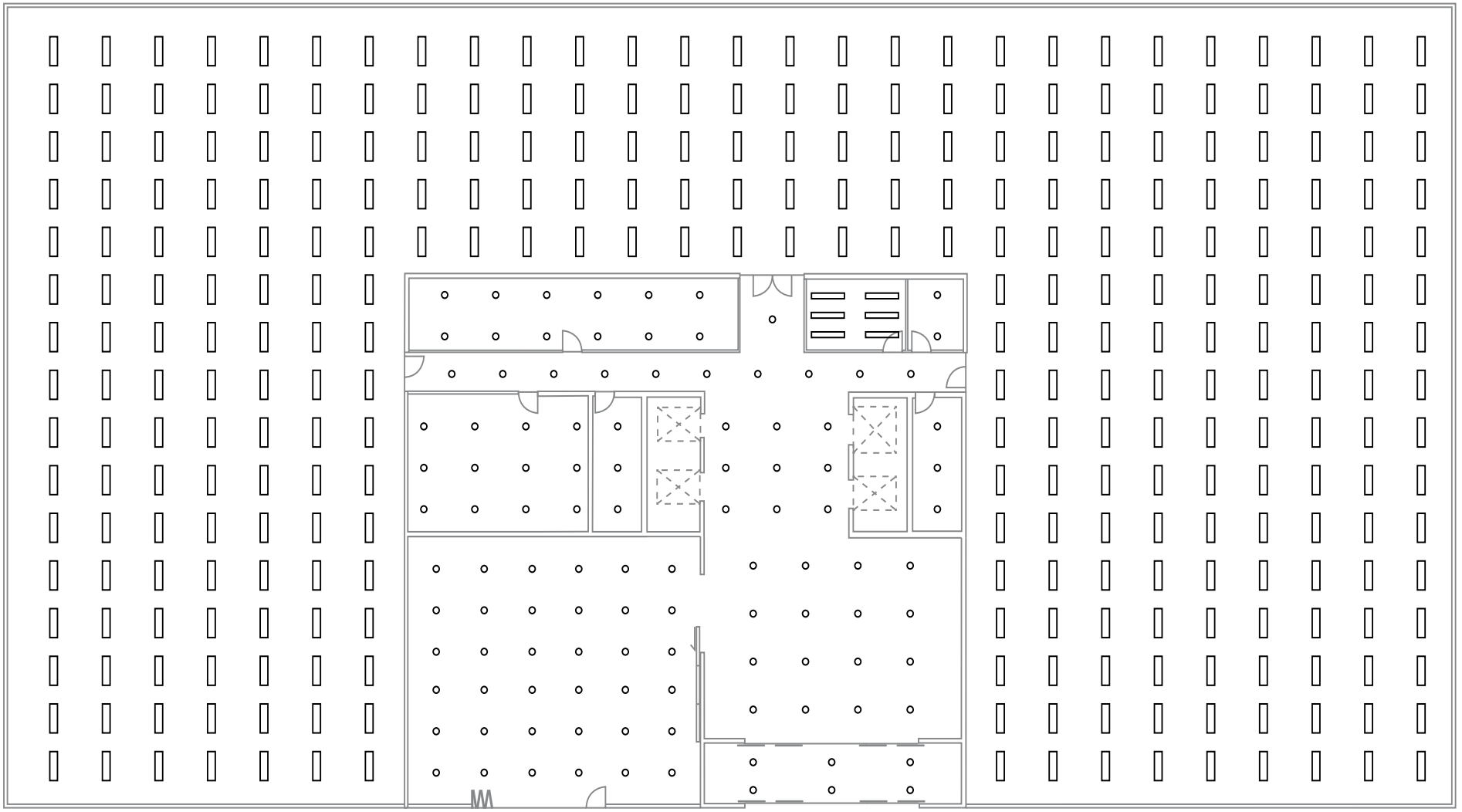
Table 15 Levels 1-3 aggregate illumination power load

Allowable aggregate illumination power load (W)	Achieved aggregate illumination power load (W)
13017.6	10918.2

Table 16 Ground level aggregate illumination power load

Allowable aggregate illumination power load (W)	Achieved aggregate illumination power load (W)
16773.0	10461.2

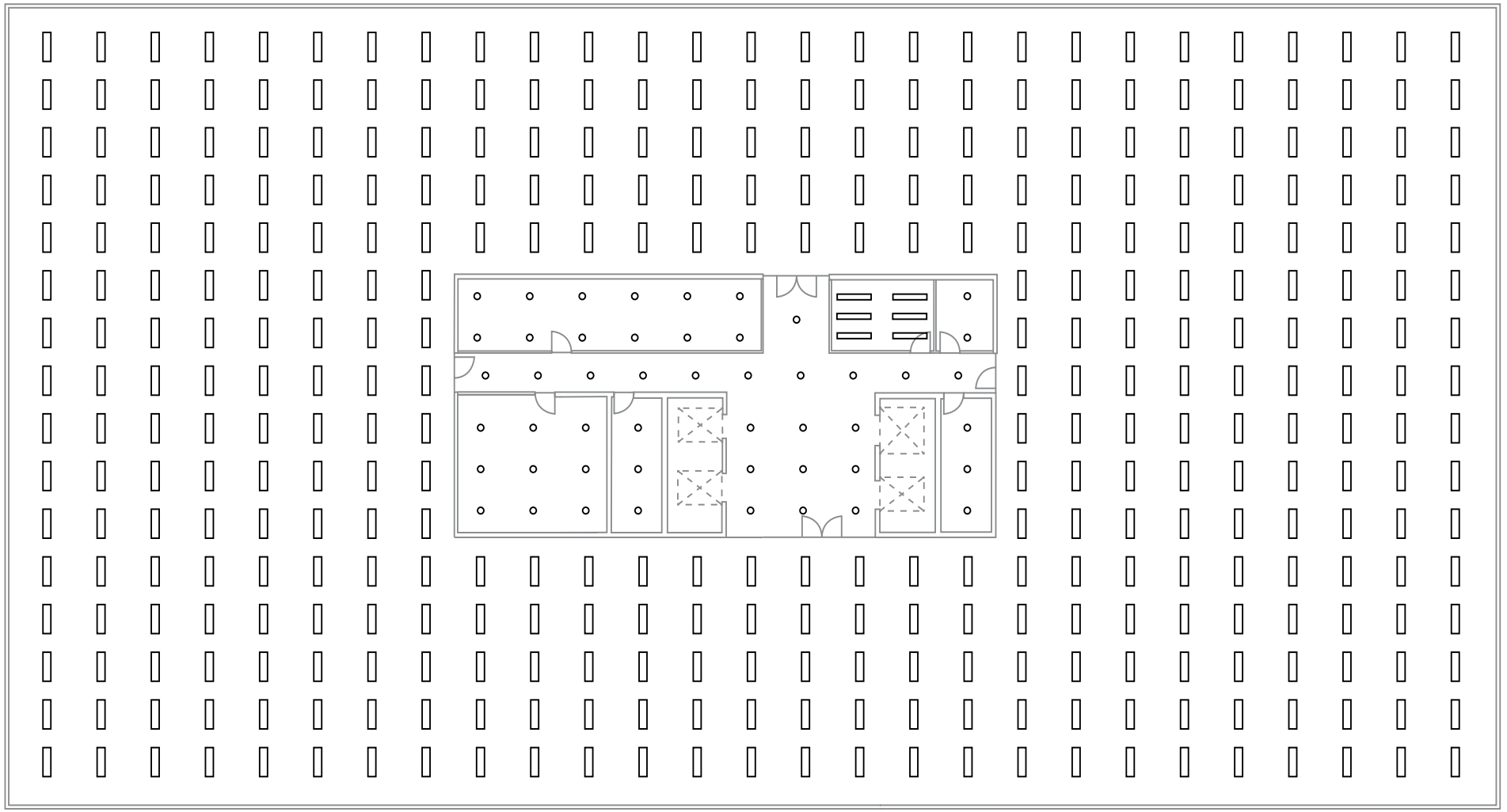
Figure 4 Ground level lighting layout



GROUND FLOOR
NOT TO SCALE

NORTH

Figure 5 Levels 1-3 lighting layout



LEVELS ONE - THREE
NOT TO SCALE

NORTH

Alert

This case study does not consider exterior lighting (i.e. external lighting attached to or directed at the façade of the building). Exterior lighting must be controlled by a daylight sensor or a time switch. If the exterior lighting load exceeds 100 W, LED luminaires must be used for 90% of the lighting load and be fitted with a motion detector or, when used for decorative purposes have a separate time switch.

Scenario 2 – Daylight sensors

Scenario 2 considers daylight sensors around the perimeter of the office space (office perimeter zone). The daylight sensors control the lights adjacent to windows for a distance from the window equal to the depth of the floor to the window head height. For this design, it is assumed that the window head height is equal to the ceiling height, 2.85 m and all lighting has a CCT of between 3500 K and 4500 K and a CRI of less than 90.

For daylight sensors fitting the above description, the adjustment factor is in Table J6.2b and equals 0.5.

In the office perimeter zone, two adjustment factors now apply (i.e. the required time switch and the daylight sensors). In an area where more than one adjustment factor for a control device applies, they are combined using the following equation.

$$A \times (B + \frac{1-B}{2})$$

Where:

A = the lowest applicable illumination power density adjustment factor
B = the second lowest illumination power density adjustment factor

Note: A maximum of two illumination power density adjustment factors for a control device can be applied to an area.

To determine the maximum illumination power density, the power density identified in Table J6.2a (or Table 1 within this document) is divided by both the Room Aspect Ratio adjustment factor and the control device adjustment factor (or combined

adjustment factor for the perimeter zone) where applicable. The total maximum illumination power load in this scenario is detailed in Tables 17 to 20.

Table 17 Ground level adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (time switch – programmable dimming)	Adjustment factor (motion detector control device)	Adjustment factor (daylight sensor control device)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.85	-	-	5.3	6823.1
Office perimeter zone	4.5	-	0.85	-	0.5	9.7	4618.7
Female toilets	3.0	0.66	0.85	-	-	5.4	268.3
Male toilets	3.0	0.70	0.85	-	-	5.1	241.1
Accessible toilets	3.0	0.58	0.85	-	-	6.0	51.3
Café	14.0	0.88	0.85	-	-	18.7	3143.1
Corridor	5.0	0.59	0.85	-	-	9.9	491.4
Comms room	10.0	0.61	0.85	-	-	19.1	306.3
Stairs 1	2.0	0.60	-	0.6	-	5.5	85.4
Stairs 2	2.0	0.60	-	0.6	-	5.5	85.4
Lift 1	3.0	0.61	0.85	-	-	5.8	100.6
Lift 2	3.0	0.61	0.85	-	-	5.8	100.6
Foyer	9.0	0.80	0.85	-	-	13.3	1405.2
Entry / air lock	9.0	0.63	0.85	-	-	16.9	541.5
Lobby	9.0	0.69	0.85	-	-	15.4	616.4

Table 18 Ground level aggregate illumination power load

Allowable aggregate illumination power load (W)
18878.6

Table 19 Levels 1 – 3 adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (time switch – programmable dimming)	Adjustment factor (motion detector control device)	Adjustment factor (daylight sensor control device)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.85	-	-	5.3	8275.3
Office perimeter zone	4.5	-	0.85	-	0.5	9.7	5315.2
Female toilets	3.0	0.65	0.85	-	-	5.4	206.0
Male toilets	3.0	0.65	0.85	-	-	5.4	137.8
Accessible toilets	3.0	0.58	0.85	-	-	6.0	51.3
Corridor	5.0	0.60	0.85	-	-	9.9	434.1
Comms room	10.0	0.61	0.85	-	-	19.1	306.3
Stairs 1	2.0	0.60	-	0.6	-	5.5	85.4
Stairs 2	2.0	0.60	-	0.6	-	5.5	85.4
Lift 1	3.0	0.61	0.85	-	-	5.8	100.6
Lift 2	3.0	0.61	0.85	-	-	5.8	100.6
Lobby (corridor)	5.0	0.69	0.85	-	-	8.6	342.4

Table 20 Levels 1-3 aggregate illumination power load

Allowable aggregate illumination power load (W)
15440.7

All lighting timers, motion detectors and daylight sensors satisfy Specification J6.

It should be noted that as the only change to the lighting design in this scenario from Scenario 1 is the addition of daylight sensors, this scenario meets aggregate design illumination power load requirements of J6.2b(i). The intent is to illustrate the additional power load that would be available when daylight sensors are installed.

Scenario 3 – Motion detectors

Scenario 3 considers motion sensors for all lighting. Therefore, the time switches controlling at least 95% of the lighting are not required in this option. It assumes all lighting has a CCT of between 3500 K and 4500 K and a CRI of less than 90.

For motion sensors, there are two applicable adjustment factors for the office building found in Table J6.2b. For a group of light fittings serving less than 100 m^2 controlled by one or more detectors, the adjustment factor is 0.6. For a group of light fittings serving 100 m^2 or more controlled by one or more detectors, the adjustment factor is 0.7.

To determine the maximum illumination power density, the power density identified in Table J6.2a (or Table 1 within this document) is divided by both the Room Aspect Ratio adjustment factor and the control device adjustment factor where applicable. The total maximum illumination power load in this scenario is detailed in Tables 21 to 24.

Table 21 Ground level adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (motion detector control device)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.7	6.4	8285.2
Office perimeter zone	4.5	-	0.7	6.4	3051.6
Female toilets	3.0	0.66	0.6	7.6	380.2
Male toilets	3.0	0.70	0.6	7.2	341.6
Accessible toilets	3.0	0.58	0.6	8.6	72.7
Café	14.0	0.88	0.7	22.7	3816.6
Corridor	5.0	0.59	0.6	14.0	696.2
Comms room	10.0	0.61	0.6	27.1	434.0
Stairs 1	2.0	0.60	0.6	5.5	85.4
Stairs 2	2.0	0.60	0.6	5.5	85.4
Lift 1	3.0	0.61	0.6	8.2	142.6
Lift 2	3.0	0.61	0.6	8.2	142.6
Foyer	9.0	0.80	0.7	16.1	1706.3
Entry / air lock	9.0	0.63	0.6	23.9	767.1
Lobby	9.0	0.69	0.6	21.8	873.2

Table 22 Ground level aggregate illumination power load

Aggregate illumination power load (W)
20880.6

Table 23 Levels 1 – 3 adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (motion detector control device)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.7	6.4	10048.6
Office perimeter zone	4.5	-	0.7	6.4	3511.9
Female toilets	3.0	0.65	0.6	7.7	291.8
Male toilets	3.0	0.65	0.6	7.7	195.2
Accessible toilets	3.0	0.58	0.6	8.6	72.7
Corridor	5.0	0.60	0.6	14.0	615.0
Comms room	10.0	0.61	0.6	27.1	434.0
Stairs 1	2.0	0.60	0.6	5.5	85.4
Stairs 2	2.0	0.60	0.6	5.5	85.4
Lift 1	3.0	0.61	0.6	8.2	142.6
Lift 2	3.0	0.61	0.6	8.2	142.6
Lobby (corridor)	5.0	0.69	0.6	12.1	485.1

Table 24 Levels 1-3 aggregate illumination power load

Aggregate illumination power load (W)
16110.3

All motion detectors satisfy Specification J6.

It should be noted that as the only change to the lighting design in this scenario from Scenario 1 is the addition of motion sensors, this design meets aggregate design illumination power load requirements of J6.2b(i). The intent is to illustrate the additional power load that would be available when motion sensors are installed.

Scenario 4 – Good colour rendering

Scenario 4 considers lighting with a high CRI (≥90). CRI is the measurement of how colours look under a light source compared with sunlight and is measured from 0-100. A CRI of 100 means that the colours appear the same as they would under sunlight. It assumes all lighting has a CCT of between 3500 K and 4500 K.

For lighting with a CRI fitting the above description, the adjustment factor is found in Table J6.2c and equals 0.9.

To determine the maximum illumination power density, the power density identified in Table J6.2a (or Table 1 within this document) is divided by both the Room Aspect Ratio adjustment factor, the time switch adjustment factor and the adjustment factor for lighting with good colour rendering, where applicable. The total maximum illumination power load in this scenario is detailed in Tables 25 to 28.

Table 25 Ground level adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (time switch – programmable dimming)	Adjustment factor (motion detector control device)	CRI adjustment factor (light colour)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.85	-	0.9	5.9	7581.2
Office perimeter zone	4.5	-	0.85	-	0.9	5.9	2792.3
Female toilets	3.0	0.66	0.85	-	0.9	6.0	298.2
Male toilets	3.0	0.70	0.85	-	0.9	5.6	267.9
Accessible toilets	3.0	0.58	0.85	-	0.9	6.7	57.1
Café	14.0	0.88	0.85	-	0.9	20.8	3492.3
Corridor	5.0	0.59	0.85	-	0.9	11.0	546.0
Comms room	10.0	0.61	0.85	-	0.9	21.3	340.4
Stairs 1	2.0	0.60	-	0.6	0.9	6.1	94.9
Stairs 2	2.0	0.60	-	0.6	0.9	6.1	94.9
Lift 1	3.0	0.61	0.85	-	0.9	6.4	111.8
Lift 2	3.0	0.61	0.85	-	0.9	6.4	111.8
Foyer	9.0	0.80	0.85	-	0.9	14.7	1561.3
Entry / air lock	9.0	0.63	0.85	-	0.9	18.7	601.6
Lobby	9.0	0.69	0.85	-	0.9	17.1	684.9

Table 26 Ground level aggregate illumination power load

Aggregate illumination power load (W)
18636.7

Table 27 Levels 1 – 3 adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (time switch – programmable dimming)	Adjustment factor (motion detector control device)	CRI adjustment factor (light colour)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.85	-	0.9	5.9	9194.8
Office perimeter zone	4.5	-	0.85	-	0.9	5.9	3213.5
Female toilets	3.0	0.65	0.85	-	0.9	6.0	228.8
Male toilets	3.0	0.65	0.85	-	0.9	6.1	153.1
Accessible toilets	3.0	0.58	0.85	-	0.9	6.7	57.1
Corridor	5.0	0.60	0.85	-	0.9	11.0	482.4
Comms room	10.0	0.61	0.85	-	0.9	21.3	340.4
Stairs 1	2.0	0.60	-	0.6	0.9	6.1	94.9
Stairs 2	2.0	0.60	-	0.6	0.9	6.1	94.9
Lift 1	3.0	0.61	0.85	-	0.9	6.4	111.8
Lift 2	3.0	0.61	0.85	-	0.9	6.4	111.8
Lobby (corridor)	5.0	0.69	0.85	-	0.9	9.5	380.5

Table 28 Levels 1-3 aggregate illumination power load

Aggregate illumination power load (W)
14464.0

It should be noted that as the only change to the lighting design in this scenario from Scenario 1 is the substitution of lights with good colour rendering, this design meets aggregate design illumination power load requirements of J6.2b(i). The intent is to illustrate the additional power load that would be available when lights with good colour rendering are installed.

Scenario 5 – Combined case

Scenario 5 considers daylight sensors around the perimeter, motion sensors on all lighting, and lighting with good colour rendering.

The maximum number of allowable control devices for cases with multiple control devices and consideration for lighting colour must be acknowledged. In total, five adjustment factors can be applied to the maximum illumination power density. These include:

- Room Aspect Ratio;
- a maximum of two control devices from Table J6.2b;
- CRI adjustment factor from Table J6.2c; and
- CCT adjustment factor from Table J6.2c.

For Scenario 5, more than one adjustment for a control device applies to several areas. Therefore, they are combined using the following equation.

$$A \times (B + \frac{1-B}{2})$$

Where:

A = the lowest applicable illumination power density adjustment factor
B = the second lowest illumination power density adjustment factor

Note: A maximum of two illumination power density adjustment factors for a control device can be applied to an area.

To determine the maximum illumination power density, the power density identified in Table J6.2a (or Table 1 within this document) is divided by both the Room Aspect Ratio adjustment factor, the combined adjustment factor for control devices, and the adjustment factor for lighting with good colour rendering, where applicable. The total maximum illumination power load in this scenario is detailed in Tables 29 to 32.

Table 29 Ground level adjusted maximum illumination power density

Space	Initial maximum illumination power density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (motion detector control device)	Adjustment factor (daylight sensor control device)	Adjustment factor (combined control device)	CRI Adjustment factor (light colour)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.7	-	-	0.9	7.1	9205.7
Office perimeter zone	4.5	-	0.7	0.5	0.425	0.9	11.8	5584.7
Female toilets	3.0	0.66	0.6	-	-	0.9	8.5	422.4
Male toilets	3.0	0.70	0.6	-	-	0.9	8.0	379.6
Accessible toilets	3.0	0.58	0.6	-	-	0.9	9.5	80.8
Café	14.0	0.88	0.7	-	-	0.9	25.3	4240.7
Corridor	5.0	0.59	0.6	-	-	0.9	15.6	773.5
Comms Room	10.0	0.61	0.6	-	-	0.9	30.1	482.2
Stairs 1	2.0	0.60	0.6	-	-	0.9	6.1	94.9
Stairs 2	2.0	0.60	0.6	-	-	0.9	6.1	94.9
Lift 1	3.0	0.61	0.6	-	-	0.9	9.1	158.4
Lift 2	3.0	0.61	0.6	-	-	0.9	9.1	158.4
Foyer	9.0	0.80	0.7	-	-	0.9	17.9	1895.8
Entry / air lock	9.0	0.63	0.6	-	-	0.9	26.6	852.3
Lobby	9.0	0.69	0.6	-	-	0.9	24.3	970.2

Table 30 Ground level aggregate illumination power load

Aggregate illumination power load (W)
25394.7

Table 31 Levels 1 – 3 adjusted maximum illumination power density

Space	Initial maximum illumination power Density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (motion detector control device)	Adjustment factor (daylight sensor control device)	Adjustment factor (combined control device)	CRI adjustment factor (light colour)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Office	4.5	-	0.7	-	-	0.9	7.1	11165.1
Office perimeter zone	4.5	-	0.7	0.5	0.425	0.9	11.8	6426.9
Female toilets	3.0	0.65	0.6	-	-	0.9	8.5	324.2
Male toilets	3.0	0.65	0.6	-	-	0.9	8.6	216.9
Accessible toilets	3.0	0.58	0.6	-	-	0.9	9.5	80.8
Corridor	5.0	0.60	0.6	-	-	0.9	15.5	683.4
Comms room	10.0	0.61	0.6	-	-	0.9	30.1	482.2
Stairs 1	2.0	0.60	0.6	-	-	0.9	6.1	94.9
Stairs 2	2.0	0.60	0.6	-	-	0.9	6.1	94.9
Lift 1	3.0	0.61	0.6	-	-	0.9	9.1	158.4
Lift 2	3.0	0.61	0.6	-	-	0.9	9.1	158.4

Space	Initial maximum illumination power Density (W/m^2)	Adjustment factor (Room Aspect Ratio)	Adjustment factor (motion detector control device)	Adjustment factor (daylight sensor control device)	Adjustment factor (combined control device)	CRI adjustment factor (light colour)	Maximum illumination power density (W/m^2)	Maximum illumination power load (W)
Lobby (corridor)	5.0	0.69	0.6	-	-	0.9	13.5	539.0

Table 32 Levels 1-3 aggregate illumination power load

Aggregate illumination power load (W)
20425.2

All motion detectors and daylight sensors satisfy with Specification J6.

It should be noted that as the only change to the lighting design in this scenario from Scenario 1 is the addition of daylight sensors, motion sensors and substituting lights with good colour rendering; this design meets aggregate design illumination power load requirements of J6.2b(i). The intent is to illustrate the additional power load that would be available when daylight sensors, motion sensors and substituting lights with good colour rendering are installed.

Summary

This case study provides a detailed understanding of the DTS elemental provisions for lighting in NCC Volume One for a lighting refurbishment in an office building. Five solutions are provided as scenarios to demonstrate different approaches to satisfying the requirements.