



Part of Energy Queensland

Substation Standard

Standard for Substation Lighting

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Abstract: The aim of this document is to outline the considerations and requirements for the design of lighting systems in Energy Queensland substations.

Keywords: lighting, illuminance level, glare ratio, colour rendering, luminaires, lighting structure, area lighting, fixture.

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1 Overview

1.1 Purpose

This document provides guidelines and establishes criteria for the design of a lighting system in Energy Queensland substations and switching stations for safety, work and security purposes.

Queensland legislation and national standards require that Energy Queensland, as an employer has obligations with respect to health, safety and amenity for the workplace. Electric lighting to provide a visual environment for safety, performance and comfort for personnel working in substations is a part of the obligation.

This standard shall be applied to new installations and covers the following:

- Design considerations
- Design criteria include illuminance level, uniformity, glare rating and colour rendering
- Required documentation

This document does not cover:

- The nature of light
- The structure, capability and anomalies of human visual system
- Technology of light sources, luminaires and control gear
- Design methods and steps

For brownfield sites refer to Grid Projects team for scope of works for substation lighting.

2 References

2.1 Legislation, regulations, rules, and codes

Environmental Protection Act 1994 (Queensland Government)
Electrical Safety Act, 2002 (Queensland Government)
Electrical Safety Regulation, 2013 (Queensland Government)
Electricity Act, 1994 (Queensland Government)
Electricity Regulation, 2006 (Queensland Government)
Work Health and Safety Act, 2011 (Queensland Government)
Work Health and Safety Regulation, 2011 (Queensland Government)
National Electricity Rules, 2023 (Australian Energy Market Commission)

2.2 Energy Queensland controlled documents

Enterprise Risk Management Standard R271 - 689958
Risk Evaluation Matrix R056 - 691861
Standard for Clearances in Air STNW3013 - 3054141

2.3 Other sources

AS/NZS 1158:2020, All parts – Lighting for roads and public spaces

AS/NZS 1680.0, 2009, Interior and workplace lighting. - Part 0: Safe movement

AS/NZS 1680.1, 2006, Interior and workplace lighting. - Part 1: General principles and recommendations

AS/NZS 1680.2.4, 2017, Interior and workplace lighting. - Part 2.4: Industrial tasks and processes

AS/NZS 1768, 2021, Lightning protection

AS 2067, 2016, Substations and high voltage installations exceeding 1kV a.c

AS/NZS 2219.3:2018, Emergency lighting and exit signs for buildings, Part 3: Emergency luminaires and exit signs

AS/NZS 2219.2:2018, Emergency lighting and exit signs for buildings, Part 2: Routine service and maintenance

AS/NZS 2219.1:2018, Emergency lighting and exit signs for buildings, Part 1: System design, installation and operation

AS 2293.2:2019, Emergency escape lighting and exit signs

AS/NZS 3000:2018, Electrical Installations - Wiring rules

AS 60947.1:2021, Low-voltage switchgear and control gear, Part 1: General rules (IEC 60947-1:2020 (ED. 6.0)

AS 4282:2019, Control of the obtrusive effects of outdoor lighting

AS 60598.1:2017, Luminaires, Part 1: General requirements and tests (IEC 60598-1, Ed.8.0 (2014) MOD)

AS/NZS 60598.2.1:2014, Luminaires, Part 2.1: Particular requirements - Fixed general purpose luminaires

AS/NZS 60598.2.3:2015, Luminaires, Part 2.3: Particular requirements - Luminaires for road and street lighting (IEC 60598-2-3, Ed. 3.1 (2011) MOD)

AS/NZS 60598.2.5:2018, Luminaires, Part 2.5: Particular requirements - Floodlights (IEC 60598-2-5:2015 (ED. 3.0), MOD)

AS/NZS 60598.2.22:2005, Luminaires Part 2.22: Particular requirements - luminaires for emergency lighting

AS 61347.1:2016, Lamp control gear – General and safety requirements

AS CISPR 15:2017, Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

SLL Lighting Handbook, The SLL Lighting Handbook 2009 edition Society of Light and Lighting

4 Definitions and abbreviations

4.1 Definitions

For the purposes of this standard, the following definitions apply.

Colour rendering (of a light source)	A general expression for the degree to which a lamp faithfully shows the colour of objects.
Colour rendering index (of light source) (Ra)	Measure of the degree to which the colours of objects illuminated by a given lamp conform to those of the same objects under an ideal light source of similar colour appearance.
Combined emergency luminaire	Luminaire contains two or more lamps, at least one of which is energised from the emergency lighting supply and the other from the normal lighting supply. The emergency lamp(s) in a combined emergency luminaire is/are maintained or non-maintained.
Correlated colour temperature (of a light source)	The single-number metric used to characterise the colour appearance of light emitted by a light source. (SLL Lighting Handbook, 2009)
Energy Queensland substation	Refers to bulk supply, zone or C&I substations owned by Ergon Energy or Energex DNSP's. Excludes assets owned by Yurika.
Emergency egress	A path or route that provides an immediate exit path or way out of an area in the event of a sudden, unexpected, or dangerous occurrence.
Emergency escape lighting	That part of emergency lighting that provides emergency lighting for the safety of people leaving an area or attempting to terminate a dangerous process before vacating an area (AS/NZS 60598.2.22, 2005)
Emergency lighting	Lighting for use when the supply to the normal lighting fails; it includes illuminated exit signage, emergency escape lighting, high-risk task area lighting and standby lighting (AS/NZS 60598.2.22, 2005)
Floodlighting	A specific form of luminaire e.g., floodlights, which emits light within a limited range of directions, i.e., a beam.
Glare	The presence of a luminance much above the average for the visual field will produce discomfort and is called glare. (SLL Lighting Handbook)
Illuminance	<p>The physical measure of illumination is illuminance. It is the luminous flux arriving of a surface divided by the area of the illuminated surface.</p> <p>Unit lux (lx) 1 lx = 1 lm/m²</p>
Luminaire	Apparatus which distributes, filters or transforms the lights transmitted from one or more lamps and which includes, except for the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries with the means for connecting to the electric supply.
Luminance	<p>The luminous flux emitted in a given direction divided by the product of the projected area of the source element perpendicular to the direction and the solid angle containing that direction, luminous intensity/unit area. Unit: candela/m². (SLL Lighting Handbook, 2009) (AS/NZS 1680.1, 2006)</p>

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Luminous flux	That quantity of radiant flux which expresses the capacity to produce visual sensation. Unit: lumen (lm) (SLL Lighting Handbook, 2009)
Luminous intensity	The luminous flux emitted in a very narrow cone containing the given direction divided by the solid angle of the cone, i.e., luminous flux/unit solid angle. Unit: candela (cd) (SLL Lighting Handbook, 2009)
Maintenance factor	The ratio of illuminance at the end of maintenance period to the initial illuminance. All luminaire maintenance factors are assumed as 0.8 as a worst-case scenario.
Normal supply failure	Where normal lighting can no longer provide a minimum illuminance for emergency escape purposes and when the emergency lighting should become operative. (AS/NZS 60598.2.22, 2005)
Room surface maintenance factor	The proportion of illuminance at the end of maintenance period to the initial illuminance taking account of the reduction in room reflectance because of dirt and dust
Spill light (stray light)	Light emitted by a lighting installation which falls outside the boundaries of the property on which the installation is sited.
Unified glare rating	Quantified value of discomfort glare in indoor lighting
Uniformity of illuminance	The ratio of the minimum illuminance to the average illuminance on a given plane within the calculation or measurement area. (AS/NZS 1680.1, 2006)

4.2 Abbreviations

This list does not include well-known unambiguous abbreviations, or abbreviations defined at their first occurrence within the text.

AC or a.c	Alternating current
CCTV	Closed circuit television
DC or d.c	Direct current
EPV	Elevated platform vehicle
EQL	Energy Queensland Limited
GPO	General power outlet
GR	Glare rating
HV	High voltage
LED	Light emitting diode
LPS	Lightning protection system
SPD	Surge protection device
UGR	Unified glare rating

5 Authorities and responsibilities

The responsibility for the management of substation lighting devices at EQL is as follows:

Table 1: Authorities and Responsibilities

Authority	Responsibilities
Asset Standards	Substation Standard for Substation Lighting Establish a minimum lighting performance
Asset Maintenance	Performance and maintenance of existing devices
Environmental Specialist	Review of environmental controls and legal obligations
Grid Projects	Scoping of lighting requirements for capital project works.
Substation Design	Electrical Engineering RPEQ Site-specific application of this standard, including performing the environmental risk assessment. Conduct a lighting audit to identify any issues

6 Existing lighting facilities

The replacement of any bulbs or light fittings shall utilise the standard LED version available.

7 Design Principles

7.1 Design considerations

The following aspects of lighting design need to be considered:

- **Legal requirements** include emergency lighting in buildings, spilled light, building regulation/code, recognition and identification of hazards in workplace health & safety covenant.
- **Visual function** is related to lighting required for doing tasks without discomfort including illuminance level, uniformity, glare and colour rendering.
- **Visual amenity** that lighting can add to a space that can give pleasure to the occupants. Included in this area is the colour rendering and colour appearance of the lighting.
- **Lighting and architectural integration.** The dimensions, finishes, texture and colour of the materials forming the space to be illuminated and the appearance of the luminaires, lit and unlit, should be considered.
- **Energy efficiency and sustainability.** It is the responsibility of the designer to use energy as efficiently as possible but at the same time to provide lit environments that enable people to work effectively and comfortably, e.g., illuminance, lamp colour rendering.

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- **Maintenance.** As electric light will depreciate with time it is important for the designer to minimise the effects with selection of light sources, and provision of a maintenance program, e.g., lamp life.
- **Light trespass/spill and skyglow.** Light can be considered as a form of pollution; therefore, exterior lighting is a major source of light pollution. Light trespass can be the cause of complaints, for example light entering bedroom windows of the houses in the neighbourhood keeps the occupants awake. Skyglow is more diffuse than light trespass in that it can affect people over great distances. The problem this causes is that it reduces the luminance contrast of all features of the night sky thereby reducing the number of stars and other astronomical phenomena that can be seen. Care has been taken to minimise spill / obtrusive light into the neighbouring areas, by complying with AS/NZS 4282:2019.
- **Phase balance.** The operation of the lights (Stage 1 and Stage 2) shall not cause excessive phase imbalance on the low voltage load (ie no greater than 25A difference between phases)

7.2 Illumination levels

Maintained illumination levels, except where noted, not less than those listed in the table below are recommended.

Table 2: Recommended minimum illumination levels

Location	Maintained illuminance (lux)	Illuminance uniformity (minimum average)	Glare rating	CIE Colour rendering index (SLL Lighting Handbook)
Interior				
Control room (1.2m from the floor)	320 ¹	0.70	<19 (UGR)	>60
Switchgear room (1.7m from the floor)				
Face of switchboard panels	320 ¹	0.70	<22 (UGR)	>60
Rear of switchboard panels	80 ¹	0.70	<22 (UGR)	>60
Battery room	160	0.70	<22 (UGR)	>60
Cable galleries/room/basement	80	0.25	<22 (UGR)	>60
Storeroom	80	0.25	<22 (UGR)	>60
Stair ways	80	-	<22 (UGR)	>60
Passageways	80	-	<22 (UGR)	>60
Toilet	80	-	-	>60
Emergency lighting		-	-	-
Escape path lighting	11	0.10	-	>40

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Location	Maintained illuminance (lux)	Illuminance uniformity (minimum average)	Glare rating	CIE Colour rendering index (SLL Lighting Handbook)
Control room standing lighting	15 ²	0.10	-	>40
Switch room standing lighting	15 ²			
Outdoor – Stage 1				
Switchyard stage 1 (ground surface between pedestrian entrance and control building or switch for Stage 2 lighting)	5 ^{3 4}	0.25 ⁶	<30	
Building entrance	110 ³	-	-	-
Pedestrian entrance	22 ³	-	-	-
Vertical illuminance of windows of houses in substation vicinity	2 (max) ⁵	-	-	-
Outdoor – Stage 2				
Switchyard stage 2 – around work zones ⁷	22 ⁴	0.25 ⁶	<30	>60
Car park, roadways along the buildings	11 ³	0.25 ⁶	<30	>40
Vertical illuminance of windows of houses in substation vicinity	2 (max) ³⁵	-	-	-
Notes:				
1 Supplement lighting with portable lamps may be required during cable termination, maintenance or testing and commissioning.				
2 Switchroom and control room are considered as high-risk areas.				
3 Where CCTV surveillance is installed, the level of illuminance required for effective operation of CCTV cameras provided by the manufacturer should be used.				
4 Skyglow shall be kept <3%				
5 Trespass of light should be kept to a minimum. Maximum vertical illuminance of windows of houses in the substation vicinity should be kept below 2 lux.				
6. Illuminance uniformity shall only be calculated for the area under the criteria, not across the complete site.				
7. Work zones in an outdoor yard are defined as any area a substation technician may reasonably be expected to do maintenance or repair work, which is generally all items of plant and any associated panels or boards.				

7.3 Colour rendering

Light source colour properties are important for naming colours, which is significant for substations where colour coding is used for identification, e.g., wiring, push buttons, signage, etc.

7.4 EMC

Items in the HV switchyard, switchgear room and control room can cause interference, either by radiation or transients. The use of high frequency electronic light control gear could cause interference to control equipment in the switchgear and control room. Electromagnetic compatible (EMC) emission and immunity should be considered. Limits of emission disturbance from lighting equipment shall be in accordance with AS CISPR 15.

8 Interior lighting

8.1 General requirements

The switchgear and control buildings shall be provided with artificial lighting systems to allow safe movement of personnel and the safe operation of equipment.

- Interior lighting shall be Linear LED batten fixtures.
- Lamp correlated colour temperature should be between 3500 K and 5000 K (intermediate white to cool white).
- All lighting and wiring shall be arranged to be accessible to authorised persons by providing adequate working space, working facilities and clearances.
- All lighting shall be controlled and serviced from safely accessible locations.
- In the switchgear room all lighting, its wiring and access for inspection, maintenance and testing shall not be directly above the switchgear and shall be at a safe distance from the switchgear internal arc flash gas vents.
- Adjacent luminaires of the general lighting system should be supplied from different circuits so that the lighting is maintained should one circuit fail.
- Each light switch shall be labelled with multi-layered phenolic plastic sheets suitable for engraving showing the board and circuit number from which its supplied.
- All lighting circuits shall be protected by RCDs.

8.2 Emergency lighting

- Emergency lighting shall be provided in switchgear, control area and exit paths from all areas.
- The emergency lighting should be turned on/off when the general lighting system is turned on/off, or with motion sensors, i.e., turned on when the substation is attended.
- Emergency lighting shall be operated periodically, and test facilities shall be provided in the distribution board to ensure availability.
- The minimum duration after the loss of normal a.c. power supply should be at least 1.5 hours.
- Battery backup emergency lights are preferred, rather than AC/DC lighting.
- Emergency service wiring shall be kept independent of all other wiring and equipment

8.3 Emergency evacuation lighting

- The emergency evacuation lighting shall be connected to one local general lighting circuit within the same room so a failure in general lighting circuit(s) will activate the emergency lighting.
- Using the Substation Control and Protection batteries as a supply is not recommended
- Emergency evacuation lighting and exit signs shall be designed and installed in accordance with the National Construction Code and the relevant parts of AS 2293.

8.4 Battery areas/rooms

Lighting fixtures shall be of batten type protected from physical damage by guards or isolation (non-sparking light fitting is recommended). Refer to Figure 1

Lighting switches and GPOs shall be located outside the battery areas/rooms.



Figure 1: Example of a non-sparking linear batten

8.5 Panel lighting

Protection and control cubicles shall have a light installed at the top of the panel. A door switch shall operate the lights.

9 Outdoor lighting

Outdoor lighting systems shall be provided to enable staff to move around the switchyard safely. The level of the lighting shall be sufficient to allow switching and equipment identification to be performed between the hours of dusk to dawn or under poor light conditions during the day.

Additionally, outdoor lighting is a security measure, see Section 9.6.

9.1 Switchyard lighting design

Permanent switchyard lighting should be a two-stage design.

- Stage 1 should be optional to operate from dusk to dawn for fixtures at low mounting height.
- Stage 2 is switch-controlled for night works outdoors..

The purpose of Stage 1 lighting is to light the ground between the pedestrian gate and the control building for safe access. Stage 1 will be night time lighting turned on/off with a photocell mounted at one side of the control building and designed to meet minimum requirements for safe access. For a high risk sites identified during a substation security assessment, additional perimeter lighting may be added. Fixtures for Stage 1 should be of the cut-off or full cut-off type to reduce off-site glare.

The purpose of Stage 2 is to illuminate equipment in the switchyard to facilitate the plant operation and detail inspection. Control of stage 2 shall be inside the control room. For fine work, the lighting should be supplemented with portable lights and/or lights in the control cabinets.

9.2 General requirements

- Floodlight lamps shall be of LED type.
- Luminaires minimum degree of protection shall be IP64 (dust-tight & splash-proof).
- Luminaire minimum resistance to vandalism should be High (IK08).
- Luminaires shall be of the cut-off type and where required be provided with hood and/or visors to prevent light spill and skyglow.
- Lighting must illuminate all isolator contacts.
- Lighting system shall be protected from direct lightning strikes.

9.3 Lighting structures

Wherever practical, substation structures (landing span structures, lightning masts, antenna poles/towers, etc.) and buildings should be used for mounting lighting fixtures.

All clearances must be checked for compliance with EQL STNW3013 Clearances in Air, including the potential for personnel to maintain the lighting fixtures.

Where possible, swing-down design should be considered as an alternative to improve safety in the maintenance or replacement of substation lighting.

9.4 Lightning protection

Outdoor lighting equipment shall be protected from either direct or indirect lightning strikes. To reduce the chance of lighting equipment being directly hit AS/NZS 1768:

- Lighting fixtures installed on dedicated lighting standards/poles shall be protected by the substation lightning shielding system.
- Lighting fixtures installed on substation structures or lightning masts must be installed at least 1.5 m lower than the highest point of the structure or mast. Lighting fixtures installed on the building wall should be kept close to the wall.
- For lighting fixtures mounted on a lightning mast, surge protection devices (SPD) must be installed at ground level junction box assembly to protect the control & wiring from differential (L-N) and common (L-E & N-E) mode surge voltages, and at the load end of the switch/photocell to protect the open switch/cell. The SPD must be suitable for:
 - a surge current up to 10 kA, (can be 5 kA at the switch/cell) and
 - the substation auxiliary AC power distribution system.
- Connection of the SPD shall be in accordance with the requirements of the SPD manufacturer.
- The lighting fixture shall be bonded to the metallic pole/structure or the LPS down conductor with a minimum copper earth connection of 16 mm² and be as short as possible.
- Installation of an SPD at the a.c distribution board is recommended.

9.5 Cubicle lighting

Outdoor cubicles used for operation and control of the network (e.g., CB mechanism boxes, power transformer control cubicle) shall have a light installed. A door switch shall operate these lights. Marshalling boxes do not require lighting to be installed.

9.6 Security lighting

Where surveillance equipment is installed, security lighting shall be provided.

The function of security lighting is to:

- Provide illumination to the designated area to deter anti-social behaviour of the asset
- Provide lighting to improve the illumination of the designated area to the benefit of CCTV cameras for monitoring and detection purposes.

Use motion sensors and/or timed circuits to activate existing building or yard lighting.

For CCTV systems to adequately work, consider the lighting levels, colour rendering, glare and shadows. EQL security cameras are typically infra-red, which means they require no additional lamination for operation.

In addition to Section 9.1 it is recommended that the following lighting requirements be considered:

- Illuminating all sides and approaches to the substation, such as entry gates and common walkways leading to buildings.
- Where perimeter lighting is installed, light illumination should overlap to eliminate areas of total darkness if any one light fails.
- Lighting should be directed downward and away from the facility and cameras and from patrolling staff.
- Lights should be positioned to reduce shadows and blind spots.

10 Documentation required

Documentation on the design of the substation lighting systems shall take the form of a design report and is to include, but not be limited to the following:

- Values for the critical design factors e.g.
 - the minimum maintained illuminance, glare rating, colour rendering index,
 - Light sources and their characteristics,
 - Luminaire characteristics, maintenance factors, etc,
- The methods used and assumptions made in ascertaining values.
- Identification of possible environmental issues in the vicinity of the substation that require limiting light pollution and details of any mitigation measures taken to prevent the inadvertent light pollution and skyglow.
- Details of the lighting simulation software used for lighting designs and results of simulation.
- A drawing or series of drawings detailing the indoor and outdoor lighting such as:
 - Layout,
 - Lighting Renders
 - Types of luminaires, light sources and their power demand,
 - Power supply circuits, wiring schedule,
 - Light control,
 - Detail of wiring connections at junction boxes and at luminaires,
 - Detail of SPD and earthing connection,
 - Schedule of luminaires: types of luminaires, types of lamps, lamp wattage, lamp colour temperature.

Appendix A

Document History

Revision History

Revision date	Version number	Author	Description of change/revision
8/9/2022	2	Substation Design Standards	Common EQL Standard Issue
June 2023	3	John Lansley	Update to new template, links added
July 2025	4	John Lansley	Clarification on Stage 1 & 2 lighting requirements, uniformity requirements. Added note on phase balance.