Office of Industrial Relations
Workplace Health and Safety Queensland

Construction and operation of solar farms

Code of Practice 2019

Queensland Government

This Queensland code of practice has been approved by the Minister for Education and Minster for Industrial Relations under section 274 of the *Work Health and Safety Act 2011* and section 44 of the *Electrical Safety Act 2002*.

This code commenced on 13 May 2019.

This code was varied following section 73A (Work involving PV modules at solar farms) being omitted from the *Electrical Safety Regulation 2013*.The variation commenced on 30 September 2019.

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Foreword

The *Construction and operation of solar farms Code of Practice* is an approved code of practice under section 274 of the *Work Health and Safety Act 2011* (WHS Act) and section 44 of the *Electrical Safety Act 2002* (ES Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare and electrical safety required under the WHS Act, ES Act, *Work Health and Safety Regulation 2011* (WHS Regulation) and *Electrical Safety Regulation 2013* (ES Regulation).

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice will achieve compliance with work health safety and electrical safety duties in the WHS Act and ES Act. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The work health and safety and electrical safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act, ES Act, WHS Regulation and ES Regulation. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the WHS Act, WHS Regulation, ES Act and ES Regulation may be achieved by following another method, such as a technical or industry standard, if it provides an equivalent or higher standard of health and safety than the code.

An inspector may refer to an approved code of practice when issuing an improvement, prohibition or electrical safety protection notice. Under the WHS Act, an inspector may also issue an improvement notice if a person conducting a business or undertaking fails to comply with a code of practice and cannot demonstrate that an equivalent or higher health and safety standard than required under a code of practice has been implemented.

Scope and application

This code provides practical guidance to duty holders on how to comply with their work health and safety and electrical safety duties during the design, construction, commissioning, operation, maintenance and end of life management of solar farms. It should be read in conjunction with the WHS Act, WHS Regulation, ES Act, ES Regulation and other relevant codes of practice.

How to use this code of practice

In providing guidance, the word ‘should’ is used in this code to indicate a recommended course of action, while ‘may’ is used to indicate an optional course of action.

This code also includes various references to provisions of the WHS Act, WHS Regulation, ES Act and ES Regulation which set out legal requirements. These references are not exhaustive. The words ‘must’, ‘requires’ or ‘mandatory’ indicate that a legal requirement exists and must be followed.

This code also includes various references to Australian standards (referred to as ‘AS’) and joint standards (referred to as ‘AS/NZS’). In this code, unless otherwise stated, a reference to a standard (or joint standard) is a reference to that standard (or joint standard) as in force from time to time under that designation. For example, ‘AS/NZS 3000’ is a reference to the joint standard that is currently in force under that designation.

The terms ‘health and safety’ and ‘work health and safety’ are used in this code to indicate a wider application than just ‘electrical safety’ or ‘work health and safety’. However, ‘electrical safety’ should be taken as being included when the terms ‘health and safety’ and ‘work health and safety’ are used.

1 Introduction

1.1 What is a solar farm?

A solar farm is a large scale electrical generating system comprised of photovoltaic (PV) modules and associated electrical infrastructure.

For this code of practice, a solar farm is considered to have a system rating of at least 100kW and is, or will be, operated and maintained by a person conducting a business or undertaking (PCBU).

A solar farm may also be known as a PV power plant or solar park. PV modules may also be known as PV panels or solar panels.

Examples of solar farms include:

- PV power plants that generate electricity that is primarily supplied into a transmission or distribution network for the PCBU to on-sell
- PV power plants that generate electricity for a specific source such as a mine site or off-grid community
- a business that installs its own PV power plant to supply its business even if it still occasionally draws power from the distribution network
- a large commercial system (e.g. a system installed on the roof of a shopping centre, industrial estate or carpark; PV arrays floating over lakes, dams, or effluent or wastewater treatment ponds)
- specifically designed industrial or housing estate which has interconnected PV installations that result in a system that is greater than 100kW.

Individual residential or domestic dwellings with a PV solar system owned and operated by the homeowner are not captured by this code of practice. This is the case whether these sites are bulk metered sites (e.g. multiple PV installations on resident owned units in a retirement village connected at the one common point to the distribution network), or if the electricity output from a number of these sites is aggregated or combined for bulk on-sale (e.g. by residents using an app or other process to sell their excess electricity to the highest bidder rather than individual contracts with an electricity retailer), unless the PV installations are owned and operated by a PCBU and have a combined system rating of at least 100kW.

Where a PV installation does not fit within the definition of a solar farm but subsequent variations, additions or changes in ownership (e.g. a residential installation is leased to a PCBU), result in the installation being captured within the definition, this code will apply depending on the life cycle stage of the solar farm.

Importantly, if a PCBU is not captured by this code of practice, but they are operating a PV installation that has a system rating of less than 100kW, they still have duties to ensure their business is conducted in a way that is electrically safe and the health and safety of workers or other people is not put at risk by the conduct of the business.

1.2 Who must manage risks in relation to solar farms?

A PCBU has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking. This duty requires the person to eliminate risks to health and safety so far as is reasonably practicable, and if it is not reasonably practicable, minimise those risks so far as is reasonably practicable.

A PCBU also has a primary duty, under the ES Act, to ensure their business or undertaking is conducted in a way that is electrically safe. This includes:

- ensuring that all electrical equipment used in the conduct of the business or undertaking is electrically safe
- if the business or undertaking includes the performance of electrical work, ensuring the electrical safety of all people and property likely to be affected by the electrical work

- if the business or undertaking includes the performance of work, whether or not electrical work, involves contact with, or being near, exposed live parts, ensuring people performing the work are electrically safe.

Persons in control of electrical equipment must ensure the electrical equipment is electrically safe.

Designers of electrical equipment or an electrical installation must ensure the electrical equipment or installation is designed to be electrically safe.

Manufacturers of electrical equipment must ensure that the electrical equipment, when made, is electrically safe. This includes examining and testing the electrical equipment to ensure it is electrically safe.

Importers of electrical equipment must ensure the electrical equipment is electrically safe. This includes ensuring the electrical equipment is designed to be electrically safe and is tested and examined to ensure it is electrically safe.

Suppliers of electrical equipment must ensure when the electrical equipment leaves the supplier, it is accompanied by information about the way the electrical equipment must be used to ensure its use is electrically safe.

Installers of electrical equipment or an electrical installation must ensure the way in which the electrical equipment or installation is installed is electrically safe. This includes ensuring the electrical equipment or installation is electrically safe following installation and that testing and examination is undertaken.

People installing, constructing or commissioning plant (e.g. PV modules, transformers) or structures (e.g. PV solar array frames) must ensure, so far as is reasonably practicable, all workplace activity relating to the plant or structure, including its installation, use, decommissioning or dismantling, is without risks to health or safety.

Officers, such as company directors, have a duty to exercise due diligence to ensure the business or undertaking complies with the WHS Act, WHS Regulation, ES Act and ES Regulation. This includes taking reasonable steps to ensure the business or undertaking has, and uses, appropriate resources and processes to eliminate or minimise risks during the construction and operation of solar farms.

Workers and other people at the workplace must take reasonable care for their own health and safety, including electrical safety, co-operate with reasonable policies, procedures and instructions and not adversely affect the health and safety others at the workplace.

1.3 What is involved in managing risks?

ES Regulation section 11: A person conducting a business or undertaking must manage risks to health and safety associated with electrical risks at the workplace in accordance with the WHS Regulation.

WHS Regulation section 34-38: To manage risk, a person conducting a business or undertaking must:

- identify reasonably foreseeable hazards that could give rise to risks to health and safety
- eliminate risks to health and safety so far as is reasonably practicable
- if it is not reasonably practicable to eliminate risks to health and safety, minimise risks so far as is reasonably practicable by implementing risk control measures according to the hierarchy of control
- maintain and implement control measures so they remain effective, and
- review, and if necessary revise, control measures to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.

To properly manage risks, a PBCU must:

- identify hazards – find out the tasks and situations that could potentially cause harm
- assess risks that may result because of a hazard – consider what would happen if someone is exposed to a hazard and the likelihood of it happening
- decide on control measures to prevent, or minimise, the risks and implement control measures according to the hierarchy of controls
- monitor and review the effectiveness of control measures.

Some of the hazards associated with the construction and operation of solar farms include:

- falls from heights and trip hazards
- falling structures, loads or objects (e.g. during lifting operations)
- arc-flash and electric shocks
- physiological effects from manual tasks such as heavy lifting and repeated movements;
- mechanical hazards (e.g. contact with moving parts)
- use of incorrect equipment, or incorrect use of equipment
- use of unsafe or damaged equipment (e.g. equipment that has not been subject to regular inspection, testing and maintenance)
- heat stress
- step and touch voltages, and induction and drop-off voltages (e.g. from equipment within the solar farm and the associated transmission or distribution network infrastructure)
- fire or explosion
- remote or isolated work.

A risk management approach should be used when:

- establishing work processes before commencement of work
- changing work practices, procedures or the work environment
- purchasing new or used equipment or using new substances
- planning to improve productivity or reduce costs
- new information about workplace risks becomes available
- responding to workplace incidents (even if an injury has not occurred)
- responding to concerns raised by workers, health and safety representatives or others at the workplace required by the WHS Regulation or ES Regulation for specific hazards.

An up to date record of the risk assessment for a solar farm, including the risks identified and how they are to be controlled, should be retained on-site and made available throughout the life cycle of the farm. This will ensure PCBUs, workers and others are aware of the risks and are able to factor these risks into their safe work procedures.

If use of personal protective equipment (PPE) is part of the risk management approach, the PPE must be supplied by the PCBU. The PCBU must ensure:

- the PPE is suitable for the nature of the work and the hazard
- the PPE is maintained in good working order
- the workers using the PPE are trained in its proper use, storage and maintenance.

PPE, as a sole control measure, should only be used in circumstances where no other practicable control measures are available. However, PPE can be used in combination with other control measures to minimise risk if a single control measure is not sufficient for the purpose.

Further information on managing risks in relation to the construction and operation of solar farms is provided in sections 2 to 7 of this code of practice. Guidance on the general risk management process is available in the *How to manage work health and safety risks Code of Practice* and the *Electrical safety Code of Practice: Managing electrical risks in the workplace.*

Consulting workers

WHS Act section 47(1): The person conducting a business or undertaking must, so far as is reasonably practicable, consult with workers who carry out work for the business or undertaking who are, or are likely to be, directly affected by a matter relating to work health or safety.

WHS Act section 48(2): If the workers are represented by a health and safety representative, the consultation must involve that representative.

Consultation involves sharing of information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

Consultation with workers and their health and safety representatives is required at each step of the risk management process. In many cases decisions about work are made before engaging workers so it may not always be possible to consult with workers in these early stages. However, it is important to consult with workers as work progresses. By drawing on the experience, knowledge and ideas of workers it is more likely hazards will be identified and effective control measures implemented.

Workers should be encouraged to report hazards and health and safety problems immediately so risks can be managed before an incident occurs. Consultation with workers must be undertaken when proposing any changes to work that may affect their health and safety.

In the context of the construction and operation of solar farms, examples of when consultation with workers should occur include:

- before any scheduled electrical work or high risk construction work is to be carried out
- during the development of safety procedures such as safe work method statements, safety management systems or safe isolation procedures
- when alterations to the design, installation, commissioning or operation and maintenance procedures are made that may affect the health and safety of workers.

Consulting, cooperating and coordinating with other duty holders

WHS Act section 46: If more than one person has a duty in relation to the same matter, each person with the duty must, so far as is reasonably practicable, consult, co-operate and co-ordinate activities with all other persons who have a duty in relation to the same matter.

Sometimes PCBUs may share responsibility for health and safety matters when they are involved in the same tasks or share the same workplace. In these situations, the multiple duty holders must exchange information to find out who is doing what and work together in a cooperative and coordinated way so that all risks are eliminated or minimised so far as reasonably practicable.

Electrical work is often carried out at workplaces that are not under the management or control of the PCBU carrying out the electrical work (e.g. during the construction of a solar farm when a principal contractor uses electrical contractors to perform electrical installation work). In these circumstances, the PCBU carrying out the electrical work must, in addition to the general duty to consult, ensure the electrical work is only authorised after consulting with the person with management or control of the workplace.

Consultation should be used to ensure that all relevant duty holders are aware of any scheduled work to be carried out and any relevant risks to health and safety arising from that work. Procedures should also be established to ensure all duty holders receive information and instruction about the work being undertaken by other PCBUs (e.g. instruction about compliance with warning or safety signs and to stay out of exclusion zones).

Further guidance on consultation requirements is available in the *Work health and safety consultation, coordination and cooperation Code of Practice*.

1.4 Information, training, instruction and supervision

WHS Act section 19: A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out.

WHS Regulation section 39: A person conducting a business or undertaking must ensure that information, training and instruction provided to a worker is suitable and adequate having regard to:

- the nature of the work carried out by the worker
- the nature of the risks associated with the work at the time the information, training or instruction is provided
- the control measures implemented.

The person must ensure, so far as is reasonably practicable, that the information, training and instruction is provided in a way that is readily understandable by any person to whom it is provided.

Workers and other people who may be exposed to health and safety risks during the construction and operation of solar farms must be provided with information and training related to the workplace and work to be performed. This may include site induction training, supervisor and management training, work-specific training and ongoing or refresher training (see section 3.3.2 - Site induction and training).

Workplace specific training should include information on:

- hazards and control measures relevant to the site
- manufacturer or designer instructions on how the solar farm is to be constructed, installed, used, altered or dismantled
- site safety requirements and documentation including safe work procedures, safe work method statements, safety management systems and traffic management plans
- how to use and maintain equipment, including any conditions and prohibitions on the use of equipment and reference to operator manuals
- safety procedures for working in certain conditions (e.g. in remote locations, at night, or in high temperatures)
- how to ensure electrical equipment has been de-energised to enable electrical work to be undertaken and not inadvertently re-energise the equipment
- personal protective equipment requirements, including instruction on fitting, use, cleaning, maintaining and storing equipment
- workplace facilities, including their location, use and maintenance
- details of previous incidents involving similar workplaces and processes, including safety measures for managing similar risks.

Workers involved in the construction and operation of solar farms should also be provided with information and training on:

- work health and safety legislation and codes of practice
- the risk management process
- inspection and maintenance programs
- how to access information such as manufacturer's instructions
- first aid procedures, location of facilities and who to contact
- emergency procedures, including who to contact in an emergency.

The needs of workers should be considered when deciding the structure, content and delivery of training. This includes consideration of literacy levels, work experience and skills required to carry out the work.

Training for workers involved in electrical work on solar farms

Workers performing electrical work on a solar farm must be licensed to perform the work, and the PCBU employing the licensed worker must ensure the worker is competent in the type of work being performed.

There are several types of electrical work involved in the construction, operation and maintenance of solar farms and PCBUs must ensure workers have appropriate training to ensure these tasks are performed in a manner that is safe and results in an electrically safe installation.

Electrical work on solar farms that may require specific expertise and training include:

- electrical work involving direct current (DC) voltage and current generated by the PV modules and the associated cabling, switching, isolation or protection devices
- high voltage installations
- electrical work in hazardous area installations (particularly if energy storage devices are being used)
- repair and maintenance of electrical equipment and installations
- testing and verification of electrical equipment and installations, including general electrical installations, solar PV parts of the installation, high voltage installations and hazardous area installations.

Training for workers must include:

- emergency response training for electrical hazards
- competency in rescue and resuscitation for all people involved in, or assisting in, electrical work. This competency must be current (i.e. conducted within the last 12 months).

Training options for worker competency include:

- post trade qualifications
- undertaking national units of competency
- on the job training and mentoring, including task specific training
- refresher training (e.g. refresher training in testing and verification processes)
- training on equipment as provided by equipment manufacturers and suppliers.

Electrical installation work requires specific qualifications including a Certificate III in Electrotechnology Electrician (UEE30811) or an equivalent qualification and a current electrical work licence. Other training courses relevant to the construction and operation of solar farms include a Certificate IV in Electrical – Renewable Energy (UEE41911) and a Certificate IV in Electrical – Photovoltaic Systems (UEE42011). A full list of relevant and up to date courses can be found at www.training.gov.au.

Regular refresher courses in key safety tasks such as polarity testing, lockout procedures, testing and verification and other similar tasks should also be considered.

Where electrical work is performed by an electrical contractor, the work must be performed under the supervision of the qualified technical person (QTP) as nominated on the electrical contractor licence. The electrical contractor should ensure effective supervision occurs (see section 3.5.2 - Licensing and competency of electrical workers).

Where the electrical work is performed by a licensed electrical worker employed directly by the PCBU who owns and/or operates the solar farm, the PCBU should ensure adequate supervision is provided for the electrical work to be performed safely.

Qualifications of workers involved in professional engineering services at solar farms

The *Professional Engineers Act 2002* places requirements on who can provide *professional engineering services* (as defined in Appendix 1) in Queensland. This includes electrical, structural and mechanical (including for wind loadings), geotechnical (for foundations) and civil engineering services related to solar farms. Under the *Professional Engineers Act 2002,* an engineer who is registered to

perform an engineering service (e.g. civil engineering) is required to either carry out the service or directly supervise the work of anyone undertaking the service during the design, construction, operation, maintenance and end of life management at solar farms. Compliance with these requirements should be factored into worker selection and management.

Where an engineer is also performing electrical work, licensing requirements in the ES Act will also apply.

More information on professional engineering services and registration requirements can be found on the website for the Board of Professional Engineers Queensland (https://www.bpeq.qld.gov.au/).

2 Safe design of solar farms

Eliminating hazards at the design or planning stage is often easier and more cost effective to achieve than making changes later when hazards become real risks in the workplace. Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of a solar farm.

ES Act section 31: A person conducting business or undertaking that designs electrical equipment or an electrical installation must ensure that:

- the electrical equipment or installation is designed to be electrically safe; and
- if the designer gives the design to another entity who is to give effect to the design, the design is accompanied by information about the way the electrical equipment or installation must be used and installed to ensure the equipment or installation is electrically safe.

WHS Act section 22: A person conducting a business or undertaking that designs a structure or plant that will be used, or could reasonably be expected to be used, as or at a workplace must ensure, so far as is reasonably practicable, that the structure or plant is without risks to health and safety. This duty includes carrying out testing and analysis and providing specific information about the structure or plant.

2.1 Designers of solar farms

An ‘engineer’ (as defined in Appendix 1), such as a registered electrical engineer, should oversee the safe design of a solar farm. This engineer is the ‘designer’ responsible for the safe design of the solar farm. This includes ensuring the electrical equipment or installation is designed to be electrically safe and that the design of structures or plant at the solar farm are without risk to health and safety.

In addition to core design capabilities relevant to the designer’s role, a designer of a solar farm should have:

- knowledge of work health and safety and electrical safety legislation, codes of practice and other regulatory requirements
- an understanding of the intended purpose of the solar farm and location factors that may impact the safety of the farm (e.g. is the farm in a cyclone prone area)
- knowledge of risk management processes
- knowledge of technical design standards
- knowledge of solar farm construction methods and operation, including the impact on the design.

The design of solar farms can be large and complex and may require various people with specific skills and expertise to be included in the design team or to be consulted during the design process (e.g. registered civil and mechanical engineers should be engaged to ensure the solar farm is designed in a way that is structurally safe).

Examples of areas where additional knowledge may be required include:

- knowledge of different types of PV modules
- different systems of inverter connection

- equipment selection, including civil works and physical layout of electrical parts
- wind ratings and loadings, including structure wind ratings and the PV module wind ratings
- building of control rooms
- high voltage installations
- earthing systems
- lightning protection systems
- energy storage considerations (if used).

Designers of solar farms must consult with relevant parties (e.g. the PCBU who commissioned the design or technical experts) throughout the design stage to ensure potential safety risks are identified and design solutions are agreed to.

2.2 Safe design of solar farms

Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of the electrical installation. Design, in relation to an electrical installation, includes the design of all or part of the installation and the redesign or modification of a design. Design output includes any hard copy or electronic drawing, design detail, design instruction, scope of works document or specification relating to the installation.

Designers should consider how their design will affect the health and safety of those who will interact with the solar farm throughout its life. This includes considering design solutions for reasonably foreseeable hazards that may occur as the solar farm is built, commissioned, used, maintained, repaired, refurbished, modified, decommissioned, demolished, dismantled, disposed of or recycled.

Safe design must be considered during the design stage of solar farms and should begin at the concept development stage when making decisions about:
- the design and its intended purpose
- possible methods of construction, operation, maintenance or dismantling
- materials to be used
- what legislation, codes of practice and standards must be complied with.

Safe design can result in many benefits including:
- a reduction in risks to health and safety
- more effective prevention of injury and illness
- improved useability
- improved productivity and reduced costs
- better prediction and management of production and operational costs over the lifecycle of the solar farm
- innovation (e.g. safe design can demand new thinking to resolve hazards).

Factors that should be considered as part of the safe design of solar farms include:
- buildability
- life cycle considerations such as safe construction, use and maintenance
- system configuration
- removing risk of arc flashes
- environmental conditions such as the effect of hot climates on equipment (e.g. batteries and isolators), previous asbestos dumping at the site location and exposure to corrosive atmospheres (e.g. salt)
- exposure to natural disasters or weather events such as heavy rain, cyclones or flooding, and need for adequate drainage
- protection against overcurrent, insulation faults, lightning, overvoltage and fire.

Electrical equipment and electrical installations

When designing the electrical installation of a solar farm the designer must ensure the installation is designed to be electrically safe and ensure that:

- electrical equipment specified for installation and use at the solar farm complies with relevant safety standards (see section 2.3 Materials and equipment)
- the design of the electrical installation complies with AS/NZS 3000 *Electrical installations* [AS/NZS 3000 (the wiring rules)]
- where applicable, the design of the electrical installation complies with any other relevant Australian Standard or, where no Australian Standard exists, any other relevant international electrotechnology commission (IEC) standard or technical specification for solar installations having regard to local conditions and jurisdictional safety requirements. For example, in the absence of more specific Australian safety standards, AS/NZS 5033 *Installation and safety requirements for photovoltaic (PV) arrays* and AS/NZS 4777 *Grid connection of energy systems via inverters (series)* are relevant Australian standards that may be applicable.

Many safety standards have different classifications and ratings to allow for different installation situations and some international standards may not address all electrical safety risks relevant for Australian conditions. Simply relying on an international safety standard, without ensuring the requirements in the standard adequately address the circumstances for a solar farm's location and conditions, may result in the installation becoming electrically unsafe. To ensure a safe installation the designer should consider the location and conditions the equipment will be installed in and apply appropriate classifications and ratings from the relevant safety standard.

Factors that should be considered when applying safety standards include:

- PV modules complying as Class A to IEC 61730-1 ed 1 and IEC 61730-2 ed 1, or as Class II to IEC 61730-1 ed 2 and IEC 61730-2 ed 2, for use in Australia are not considered to be classified as having electrical insulation properties of Class II (double insulation) as stated by those standards and are classified as having electrical insulation properties of Class I (basic insulation). In Australia, installation standards indicate accessible metal parts of PV modules must be earthed when installed
- PV modules complying as Class B to IEC 61730-1 ed 1 and IEC 61730-2 ed 1 or as Class 0 to IEC 61730-1 ed 2 and IEC 61730-2 ed 2 are not acceptable for use in Australia as Class B (Class 0) does not provide sufficient insulation for safe usage
- electrical cables need to be compliant to a relevant safety standard for the expected voltages. PV cables must have correct voltage ratings to operate safely under normal conditions, and to withstand the full array voltage across the cable in the event of an earth fault. These ratings must include:
  - a DC conductor to earth voltage rating that is greater than the maximum open circuit array voltage (or additional engineering processes/insulation from earthed parts so the cable can safely withstand the full open circuit array voltage)
  - a DC conductor to conductor voltage rating between positive and negative cables that is greater than the maximum open circuit array voltage.
- connectors for modules or cabling are verified as being compatible and having the correct ratings
- the means of fixing electrical equipment is suitable for Australian conditions. For example, in Australia, installation standards indicate plastic cable ties are not accepted for use as a primary means of support for cables. Plastic cable ties can degrade within 2 and 5 years if exposed to ultraviolet radiation (UV), including reflected UV if located under an array
- any equipment nameplate labelling or equipment labelling related to safety is legibly and indelibly marked and, if exposed to sunlight, is suitably UV resistant
- ingress protection ratings, pollution degree rating, indoor/outdoor use, UV ratings, duty cycles, ambient operating temperature and relative humidity ranges
- switch-disconnector utilisation categories applicable to PV-specific applications, load breaking and isolation capabilities.

In applying the requirements of AS/NZS 3000 (the wiring rules) and any relevant standards for solar installations the designer should also consider:

- if clause 1.9.4 (Compliance by specific design and installation) of the wiring rules is being used, the solution is formally acknowledged by the owner/operator of the installation and signed off by personnel with appropriate competence. This includes certification as required in Section 2.5 (Solar farm design certification)
- in the absence of any specific Australian or international safety standard for solar farm installation, other Australian or international electrotechnology commission (IEC) standards or technical specifications for solar installations are considered to inform safe equipment selection and installation requirements specified in the design.

The designer must ensure details of the use of clause 1.9.4 of the wiring rules, other solar installation standards and equipment specifications are included in the design documentation for the solar farm and made available, and communicated, to the electrical contractor responsible for the electrical installation and commissioning.

In addition to applying AS/NZS 3000 (the wiring rules), and any relevant safety standard for solar farm installations, the designer should also consider:

- the specific requirements for any high voltage installation parts (e.g. for connecting to the transmission or distribution network) including:
  - ensuring the part of the solar farm electrical installation that is above 1 kV AC, is designed in accordance with requirements of AS 2067 *Substations and high voltage installations exceeding 1 kV a.c*
  - designing so there is no part of the solar farm electrical installation above 1.5 kV DC and no high voltage DC installation. If this is not possible then the design and installation processes should ensure clearances, restricted access, all earthing, cable insulation ratings and any other relevant safety measure for the voltages present are adequate
  - ensuring electrical equipment and cables for high voltage DC installations are correctly specified, comply with relevant Australian safety standards, and are appropriately rated for the DC voltage and current
  - ensuring the earth grid design addresses the potential for rise in voltages resulting from high voltage or low voltage fault events
  - ensuring prospective step and touch voltages are within acceptable limits
  - having an adequate number of earthing points for earthing and short-circuiting of all sides of high voltage equipment and all parts of the high voltage installation, to enable work to be performed safely during construction, operation and maintenance
  - identifying which parts of the installation need to be connected to the earthing grid [such as high voltage alternating current (AC) cable screens, power conversion units (PCE), DC earthing systems and fencing]
  - designs for clearances (exclusion zones) to maintain safe distances for workers and plant from hazardous voltages during construction, operation and maintenance
  - ensuring the design includes adequate access and lighting to enable safe operation and maintenance of equipment and plant
  - ensuring high voltage blast walls and blast vents do not create hazards (e.g. the design ensures of the walls and vents is not directed into walkways or where workers may be and blast walls are designed to engineering standards)
  - ensuring adequate bunding of transformers
  - ensuring all high voltage signage is correctly specified
  - ensuring high fault current issues are adequately addressed
  - ensuring insulation coordination is achieved with the transmission or distribution electricity entity the solar farm will connect to
  - ensuring the network connection high voltage line conductor and cable support structures and conduits comply with the configuration and clearance requirements of the transmission or distribution electricity entity the solar farm will be connected to.
- where an energy storage system is used, the system is designed to remove electrical risks such as arc flash, explosion, fire and emissions of hazardous gases. If the system results in a hazardous area installation, the area:
  - is correctly classified for the relevant hazardous area zone
  - correctly rated equipment is used for the zone.

- specific hazards and requirements if the solar PV modules are installed in a non-standard location (e.g. if the PV modules are installed over water then the potential risk of water or moisture ingress with DC voltages and currents should be considered)
- the selection of compatible materials and connections to achieve and maintain earthing continuity
- ensuring the location of isolation switching devices enables safe isolation of parts for future repair and maintenance work
- ensuring all protective devices are specified and rated for the intended use
- ensuring the number of circuit protective devices used, and their location, protects PV modules, sub array string cables and array cables from overload if shading issues or reverse currents occur, or AC faults are transferred into the DC circuitry
- ensuring all safety signage is correctly specified (e.g. wording, layout and location specified is compliant with relevant standards or legislation, including ensuring signage is legible and durable for the location and, if signage will be exposed to sunlight, specifications to ensure the signage is UV resistant).

The designer should develop a commissioning plan for the installation detailing any requirements to verify the installation will operate safely. The commissioning plan should include information on requirements during construction, at the end of construction and work to complete prior to final energisation. Development of the plan should involve consultation with relevant transmission or distribution networks to ensure requirements for safe connection to the network are met. Further information on commissioning is provided in section 4 (Commissioning).

Hazards related to civil and mechanical work that could affect the safety of the electrical installation must be considered. This includes means for securing PV modules to frames, frames to support structures, attachment of those structures to the ground or other structures, and environmental factors such as high winds, storms or cyclones. Wind forces applied to the PV array may generate a significant load for the mounting frame and associated support structure. This loading should be included in the assessment of the capability of the support structure to withstand resulting forces.

The designer should also consider measures for controlling flora and fauna. This includes wildlife, livestock or pest control and prevention to ensure animals and insects such as cattle, sheep, goats, ants, cockroaches, geckos, bugs, possums, kangaroos and birds etc. do not interfere with, or compromise, the safety of the electrical installation.

On-going monitoring of the operation of the solar farm including on-site monitoring, remote monitoring and monitoring of faults including earth faults) should be considered. The design should include processes to enable monitoring to be conducted in a way that is safe for the workers on site and ensures the installation is electrically safe.

Designers should remain aware of the development of any Australian and international standards in relation to solar farms as there is on-going work at the international level to publish further standards.

2.3 Materials and equipment

ES Act section 30-34: A person conducting a business or undertaking must ensure the person's business or undertaking is conducted in a way that is electrically safe. This includes ensuring all electrical equipment used in the conduct of the person's business or undertaking is electrically safe.

Manufacturers, importers and suppliers of electrical equipment must also ensure the electrical equipment is electrically safe. This includes manufacturers and importers ensuring the electrical equipment, at each stage, is tested and examined to ensure it is electrically safe and suppliers providing information about the way the electrical equipment must be used to ensure its use is electrically safe.

WHS Act section 23-25: A person conducting a business or undertaking that manufacturers, imports or supplies a structure or plant that will be used, or could reasonably be expected to be used, as or at a workplace must ensure, so far as is reasonably practicable, that the structure or plant is without risks to

health and safety. This includes carrying out testing and analysis and providing specific information about the structure or plant.

All materials and equipment used in the construction of solar farms should be fit for purpose and meet design specifications. This includes being designed to conform to relevant Australian Standards, or where there is no Australian standard, relevant international standards with the application of any local requirements. Where material or equipment is designed to an international or other standard, a registered engineer should certify that the material or equipment conforms to relevant Australian Standards or, if there is no Australian standard, the international standard has been applied in accordance with Australian and Queensland requirements.

Only materials and equipment that comply with relevant standards, and design drawings and documentation, should be used. Do not use materials, and equipment that are damaged, excessively worn or not fit for the intended use.

Evidence verifying materials comply with relevant Australian standards, or international standards where no Australian standard exists, should be available on site in a central location (this may include the documentation being electronically available). Evidence may include:

- a dossier or compliance folder listing all materials, equipment and their relevant certifications, test reports, or manufacturers' statements of compliance
- evidence a registered engineer has confirmed the material or equipment is compliant for the intended use and local requirements
- processes used to ensure the on-going compliance of materials or equipment supplied after initial acceptance of design specifications.

Importers of material and equipment

Importers have a duty to ensure, so far as is reasonably practicable, that materials and equipment are electrically safe and are without risks to health and safety. This includes, ensuring that electrical equipment is designed to be electrically safe, and that testing and examinations are carried out.

Importers must confirm imported materials and equipment are safe (e.g. they must have a process to ensure inspection and testing has been conducted on the materials and equipment). This may include the importer conducting their own testing or obtaining third party verification of the manufacturing testing processes. The level of inspection and testing carried out by an importer should be based on the ability to confirm the materials and equipment are safe and comply with relevant safety standards.

When dealing with a new manufacturer, or one whose products have been previously identified as non-conforming, the inspection and testing of the supplied materials and equipment should be more extensive.

Importers should remain up to date with Australian and international standards applicable to the materials and equipment they import.

Asbestos

Importing goods containing asbestos into Australia is prohibited under the Federal Government *Customs (Prohibited Imports) Regulations 1956*.

More information can be found on the website of the Australian Government Asbestos Safety and Eradication Agency (https://www.asbestossafety.gov.au).

Non-conforming building product

Non-conforming building products and materials are those that present a safety risk and do not meet the required standards for the use in which they are intended. The *Queensland Building and*

Construction Commission Act 1991 places requirements on everyone in the building product supply chain, to ensure products used are fit for their intended purpose.

More information on non-confirming building products and materials can be found on the website of the Queensland Building and Construction Commission (https://www.qbcc.qld.gov.au/non-conforming-building-products/non-conforming-building-products).

2.4 Documentation

Designers must give adequate information about the way materials, electrical equipment and the electrical installation is to be used and installed to ensure solar farm installations are electrically safe and without risks to health and safety during construction, use, maintenance and end of life management.

Design documentation should be completed during the initial design stage and consider the life cycle of the solar farm.

Documentation should be available in a central location. This may include hard copy or electronically with on-site access to the documentation during all stages of the solar farm (i.e. construction, commissioning, operation and maintenance, and de-commissioning).

The documentation should be updated when new information is known or amendments to existing information are required.

Design documentation for a solar farm may include, but is not limited to:

- design and site condition parameters
- identification of means to connect to the transmission or distribution network and safety requirements for connection
- identification of system designer [e.g. person(s), company(s), contact details]
- list of required sign offs and at what stage each sign off is required (e.g. when a registered engineer, electrical contractor, designer or high voltage auditor is required to sign off)
- details of electrical equipment and major components, including:
  - bill of materials
  - identifying part numbers
  - rating details
  - specifications and data sheets
  - certifications or test reports
  - manufacturer, importer and supplier details and any ISO 9001 or ISO 14001 certifications
  - factory acceptance testing results, routine testing of equipment, details of requirements for acceptance of equipment onto site (e.g. user acceptance testing)
  - installation instructions or manuals, including commissioning details
  - user manuals, including details for operation, maintenance and disposal
- recommended spare or alternative parts list
- procurement and acceptance criteria for materials, components and equipment
- justifications for use of materials, components or equipment complying with standards other than relevant Australian standards
- electrical diagrams (e.g. wiring diagrams, line diagrams) identifying components, equipment and their locations, including array and sub array designs as applicable
- site plan and layout of equipment and routing of cables
- mounting structure designs, including design calculations and certification of the PV module and array mounting and support system
- installation procedures
- design decisions and information regarding:
  - PV array type used (e.g. fixed tilt, adjustable tilt, single axis tracking, two axes tracking and density)
  - shading issues (if any) for PV modules
  - total number of modules

    - number of strings
    - number of modules per strings
    - inverter types and configurations (e.g. central inverter, or string or module level inverter configurations)
    - which strings connect to which PCE (e.g. inverter)
    - cable specifications
    - connector specifications
    - disconnector or isolator devices
    - earthing schemes
    - allowances for thermal expansion of structures
    - lightning protection
    - DC and AC protection systems (e.g. over current, over voltage, fault current and arc flash)
    - site conditions [e.g. high winds, corrosive environments, soil conditions, presence of chemicals (e.g. ammonia in agricultural areas and sulphates in soil), flood zones, accessibility, humidity]
- design calculations and tolerances (e.g. electrical and mechanical, including allowances for movement over time of moving parts and associated structures)
- information on energy storage if used (e.g. detail of the type, specifications, locations and protections required including protections from overload, short circuit, overcharge, undercharge, arc flash, fire, shock or explosion)
- identification of arc flash potential at relevant termination and connection points
- detail of requirements to ensure accessibility for each stage including construction, commissioning, operation and maintenance
- means to prevent unauthorised access for each stage including construction, commissioning, operation and maintenance
- actions to manage livestock, pest and vegetation management (as applicable), including how to manage damage to materials, components and equipment that may cause safety issues
- commissioning criteria
- specifications for safety signage
- specifications to identify and label isolation devices
- operation manuals, shut down procedures and switching procedures
- procedures for verifying correct system operation, including correct operation of protective devices
- processes to manage system failures
- emergency shut down or isolation procedures
- maintenance and cleaning schedules and recommendations, including any periodic tests and verifications to ensure ongoing safety of the electrical installation
- end of life or decommissioning plan to ensure the site is left electrically safe and without risk to health and safety.

2.5 Solar farm design certification

The designer of a solar farm should ensure that the design has been certified before construction of the farm commences. Certification should involve signoff by a registered engineer that the design of the solar farm:

- complies with applicable legislation, codes and standards for work health and safety and electrical safety
- includes a site plan that incorporates the layout of equipment and routing of cables
- includes electrical diagrams identifying components, equipment and their locations
- ensures that all system components and equipment have been specified to withstand expected external influences and are compliant with the design parameters relevant to their installation and function (including civil, mechanical and electrical issues, as well as DC and AC low voltage and high voltage installations)
- addresses the safety requirements for any energy storage being used (where applicable), including type, specifications, locations and protections required (including for overload, short circuit, overcharge, undercharge, over discharge, chemical or toxic fume discharge, arc flash, fire, shock and explosion)
- addresses structural safety, including confirming that factors such as wind and the likelihood of exposure to cyclonic conditions have been considered as part of the design

- includes testing and commissioning procedures
- includes procedures for verifying correct system operation
- includes content on the required maintenance schedule
- includes procedures for system failures, including emergency shut down and isolation procedures.

The registered engineer who certifies the design should be competent and suitably experienced to perform the task and engage other expertise as required. They should also be independent of the project but may still work for the same organisation or company commissioned to design the solar farm.

Note: the original designer retains responsibility for all duties and obligations as a designer and these duties are not transferrable to the registered engineer who certifies the design.
Certification should be documented and signed by the registered engineer and kept with records of the solar farm design.

2.6 Design variation

All proposed variations from the design of a solar farm should be approved by the original designer or, if the original designer is no longer available, an engineer who is registered in the area relevant to the design variation. For example, if the variation relates to electrical aspects then an engineer registered in electrical professional engineering services should be engaged. The variation should be:

- certified in writing by the designer or registered engineer as being acceptable
- verified by the designer or registered engineer as not having adverse safety effects on other parts of the solar farm
- altered in accordance with the written directions of the designer or registered engineer.

Design variation includes any ‘re-design’ or modification of the original solar farm design. This may include change to the layout of the installation, change of components or equipment used (types or specifications) or their location, or change of method of installation.

Where the design variation is conducted by the original designer, the designer must ensure the ‘re-design’ or modification is electrically safe and information is supplied to ensure the installation will be installed to be electrically safe. Where the ‘re-design’ or modification is conducted by a person other than the original designer, the other person becomes the designer for the relevant part of the installation and assumes the duty of the designer for that part and for any effect it has on the rest of the solar farm. All processes and documentation identified at the initial design stage should continue to be followed subject to new information being provided to address the design variation.

When design variations are made:

- they must be documented, including what change is made, validation of the safety of the change, recording of the person who approved the change and their position or authorisation, and the date the change was authorised
- there should be a process (including check, review and sign off) for updating of drawings and documents. This may include:
  - electrical diagrams identifying components, equipment and their locations, site plan and layout of equipment
  - installation procedures to correctly execute the design
  - safety and emergency procedures
  - safe work method statements
- the design variations should be communicated to all relevant workers involved in the construction, operation or maintenance of the solar farm
- any changes that could affect tests and assessments required for commissioning are communicated to commissioning personnel, including the high voltage accredited auditor where applicable
- if the design variations alter the means, methods or energy profile that is transmitted to the network, the variations to the design should be reviewed with the network operator the solar farm will supply, or supplies, energy

- a record of the design variation documentation, including certification documentation for the design variation, is to be kept and made available for inspection by the regulator.

2.7 Network connection interface

Connection of the solar farm to the transmission or distribution network should be conducted in a way that ensures the safe operation of the solar farm, the safe operation of the network the solar farm is connected to, and the safety of workers and others at the solar farm and the network. Transmission or distribution network service providers may have specific requirements for connection that must be followed to ensure they meet the technical performance and access standards of the National Electricity Rules. The requirements for registration of solar farms with the Australian energy market operator (AEMO) are available in the AEMO Generator Exemption and Classification Guide.

During the design stage of a solar farm, the designer must consult with the transmission or distribution electricity entity responsible for the network the solar farm will be connected to. This consultation should be conducted early in the design process and ensure the specifications of the solar farm's electricity generation is within the requirements of the transmission or distribution electricity entity for connection to their network to avoid risks including:

- destabilisation of the network due to voltage, frequency or harmonic issues
- risk of electric shock to line workers repairing powerlines that should be de-energised but are re-energised by the solar farm
- the solar farm energising the network powerlines after the network protection systems have operated due to a fault on the network (e.g. a fallen powerline).

Control measures introduced to manage these risks should ensure the safety of line workers and operation and maintenance staff, as well as ensuring the safety of supply is maintained, and may include:

- requirements for evidence of commissioning and testing to verify the solar farm electrical installation is safe to connect to the electricity entities network. This may include evidence of:
  - the medium voltage or high voltage installation having been tested to ensure it meets relevant safety standards and does not cause a fault in the network when connected
  - voltage, frequency, harmonic tolerances
  - load capability of the network
- development of switching procedures and sign off to ensure the solar farm does not inject power into the network when the transmission or distribution electricity entity has the line de-energised for maintenance or repair work
- requirements for verification of anti-islanding options to ensure automatic disconnection of the solar farm in situations required by the transmission or distribution electricity entity
- development of a communication protocol to ensure solar farm operators and the transmission or distribution electricity entity have effective communication for normal operation, planned emergency outages and other emergency situations
- ensuring interface panels between the solar farm and the transmission or distribution electricity entity (e.g. SCADA, protection and metering panels) are located outside any designated high voltage area
- extending high voltage earth grid design to ensure step and touch potential is safe for workers accessing any interface panels.

3 Construction

Construction of solar farms includes several different trades with varying skill sets and qualification requirements that conduct a range of different tasks from earthworks to electrical installation work.

Although construction work is temporary, the electrical and work health and safety risks associated with this stage of the life cycle of a solar farm must be managed. Typical construction on solar farms includes site establishment, site clearing, materials delivery and construction and installation of frames, modules and other electrical equipment.

Solar farm construction crews face many of the same conditions found in typical construction trades with the notable exception that exposure of the PV modules to sunlight creates electrical energy not present in other construction trades. Managing this energy safely is an important aspect of solar farm construction.

In this code of practice, a construction site is the area of land where a solar farm is being built, usually within the confines of security fencing to prevent unauthorised site access during construction. A construction site includes site offices, cloak rooms, meeting room, dormitories, canteens, toilets, appliances and other facilities provided, and located within the construction site perimeter, while the construction work is being completed.

3.1 What is construction work and high risk construction work?

'Construction work' is defined in the WHS Regulation as any work carried out in connection with the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, maintenance, and refurbishment, demolition, decommissioning or dismantling of a structure.

In the context of the construction of solar farms, construction work includes, but is not limited to:

- any installation or testing carried out in connection with an activity referred to in the above definition
- the assembly of prefabricated elements to form a structure, or the disassembly of prefabricated elements forming part of a structure
- any work connected with site preparation including landscaping.

In some circumstances, construction work at solar farms is high risk construction work. These circumstances may include construction work that:

- involves, or is likely to involve, the disturbance of asbestos (e.g. where the land the solar farm is being constructed on has previously been used as a site for asbestos waste disposal or the farm is being built on top of an old industrial building that may contain asbestos)
- is carried out on or near energised electrical installations or services
- is carried out in an area at a work place where there is any movement of powered mobile plant (e.g. where a crane is being used).

See section 291 of the WHS Regulation for a full list of work that is high risk construction work. Where work involves high risk construction work, a safe work method statement must be prepared.

3.2 Safe work method statement and work health and safety management plan

WHS Regulation section 299: When carrying out high risk construction work, a person conducting a business or undertaking must ensure that a safe work method statement is prepared or has already been prepared by another person.

When the construction of solar farms involves work that can be classified as high risk construction work, a safe work method statement (SWMS) must be prepared before the work commences.

Where a SWMS is required, it must:

- identify the type of high risk construction work being done
- specify the health and safety hazards and risks arising from the work
- describe how the risks will be controlled
- describe how the control measures will be implemented, monitored and reviewed.

A SWMS must be developed in consultation with workers and their representatives who are carrying out the high risk work. The content of a SWMS should provide clear direction on the control measures to be implemented. There should be no statements that require a decision to be made by supervisors

or workers. For example, the statement ‘use appropriate personal protective equipment’ does not detail the control measures. The control measures should be clearly specified.

A generic SWMS may be prepared and used for high risk construction work carried out on a regular basis. However, a generic SWMS must be reviewed to address the hazards and risks for the specific workplace and be revised as necessary. Any revision of a SWMS should be conducted prior to the high risk construction work commencing.

A PCBU who is involved in high risk construction work at a solar farm must implement arrangements to ensure the work is carried out in accordance with the SWMS and ensure that a SWMS is readily accessible to any workers engaged in high risk construction. Workers should:

- understand the hazards and risks arising from the work
- understand and implement the risk controls in a SWMS
- know what to do if the work is not being conducted in accordance with the SWMS.

Further information on the preparation and implementation of safe work method statements can be found at https://www.worksafe.qld.gov.au/construction/health-and-wellbeing-at-work/safe-work-method-statements.

WHS management plan

WHS Regulation section 309: The principal contractor for a construction project must prepare a written WHS management plan for the workplace before work commences.

Under the WHS Regulation solar farm construction projects where the cost of the construction work is $250,000 or more must have a principal contractor and a WHS management plan.

The WHS management plan must contain:

- names, positions and health and safety responsibilities of workers at the workplace whose positions or roles involve specific health and safety responsibilities, for example site supervisors, project managers, first aid officers
- arrangements for consultation, cooperation and coordination
- arrangements for managing work health and safety incidents that occur
- site-specific health and safety rules and how workers will be informed of the rules
- arrangements to collect, assess, monitor and review safe work method statements.

The WHS management plan may also include information on:

- the provision and maintenance of a hazardous chemicals register, safety data sheets and hazardous chemicals storage
- the safe use and storage of plant
- the development of a construction project traffic management plan
- getting and providing essential services information
- fatigue management
- remote and isolated work management
- sun and heat safety measures
- workplace security and public safety
- ensuring workers have appropriate licences and training to undertake the construction work.

The principal contractor must ensure, so far as is reasonably practicable, every individual who is required to carry out construction work at a solar farm is made aware of the content of the WHS management plan and their right to inspect the plan at any time. It is the responsibility of the principal contractor to review and revise the WHS management plan to ensure it remains up to date.

3.3 Licensing and competency of workers

WHS Regulation section 81: A person must not carry out a class of high risk work unless the person holds a high risk work licence for that class of high risk work.

ES Act section 55: A person must not perform or supervise electrical work unless the person is a holder of an electrical work licence that authorises the person to perform the work.

Depending on the work being undertaken at a solar farm, workers may be required to have a high risk work licence or electrical licence.

Work requiring a high risk work licence includes, but is not limited to, dogging and rigging work and crane and hoist operation. A full list of high risk work requiring a licence, and the relevant competency requirements, is in Schedule 3 and 4 of the WHS Regulation.

A high risk work licence is not required if the work is carried out in the course of training towards a certification to be licensed and is undertaken under the supervision of a person who is licensed to carry out the high risk work.

Where work being undertaken at a solar farm involves electrical work (see section 3.5.1 - Electrical work during the construction of solar farms) the worker must hold an electrical licence or be otherwise permitted or authorised to perform the work under the ES Act (e.g. an electrical apprentice). More information on electrical licence requirements is in section 3.5.2 (Licensing and competency of electrical workers).

3.3.1 General construction induction training

WHS Regulation section 317: A person conducting a business or undertaking must not allow a worker to carry out construction work unless the worker has successfully completed general construction induction training and where the training was completed more than two years ago the worker has carried out construction work in the previous two years.

General construction induction training provides basic knowledge of construction work, the work health and safety laws that apply, common hazards likely to be encountered in construction work, and how the associated risks can be controlled.

Any person who is to carry out construction work at a solar farm must successfully complete general construction induction training before starting work.

General construction induction training must be delivered in Australia by a registered training organisation and cover the content set out in the VET course for general construction induction training.

3.3.2 Site induction and training

Site-specific training should be provided to workers prior to the commencement of construction at solar farms. Site-specific induction training should provide information about work health and safety issues and safe work practices specific to the workplace (e.g. site-specific training may cover how on-site traffic will be managed and how handover to other trades will be conducted). It should be provided by the PCBU who has management or control at the workplace or by the principal contractor for the project.

Site-specific induction training may include information on:

- hazards and control measures relevant to the site [e.g. the risk of snake bites in a rural location, exposure to heat stress, and exposure to live (energised) electrical parts such as the solar PV modules once removed from the box]
- location of underground services
- site-specific safety documents, policies and plans (e.g. traffic management plans and the WHS management plan)
- supervisory, consultation and reporting arrangements
- site safety rules
- workplace facilities (e.g. location, use and maintenance)
- first aid provisions and emergency procedures including after-hours emergency contact details
- health monitoring requirements and procedures (if required)

- access, egress and security
- how safety issues are resolved.

Other people who visit the site (e.g. cleaners, general building maintenance staff, or people tending livestock or managing wildlife or vermin) may also require site-specific induction training.

3.3.3 Supervision of workers

WHS Act section 19(f): A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking.

PCBUs involved in the construction of solar farms must provide relevant information, training, instruction and supervision to protect workers from risks to their health and safety arising from the work carried out.

Supervisors should provide specific workplace instructions during the work, including directions for health and safety. They should be aware of, and provide the level of supervision necessary to ensure, the health and safety of workers (including checking workers' competency to undertake the work).

Workers in a supervisory role (e.g. leading hand or foreman) should be trained and authorised to ensure the work is carried out in accordance with relevant policies, procedures and the SWMS.

See section 3.5.1 (Electrical work during construction of solar farms) and section 3.5.2 (Licensing and competency of electrical workers) for more information on supervision in relation to electrical work and work that must be performed under supervision.

3.4 Non-electrical risks associated with the construction of solar farms

In this code of practice health and safety risks during the construction of solar farms are classified as either non-electrical risks or electrical safety risks. Information on electrical safety risks is provided in section 3.5 (Electrical safety risks).

Non-electrical risks that must be managed include:
- falling from heights
- slip, trip and fall hazards
- falling structures, loads or objects (e.g. during lifting operations)
- manual handling and physiological effects because of heavy lifting and repeated movements
- operation of plant
- on-site traffic management
- exposure to sun, heat, noise and vibration
- excavation work.

These risks must be managed through all stages of construction including during site establishment, site clearing, materials delivery, construction and installation of frames and modules, construction of transmission infrastructure and grid connection, and commissioning.

Risks such as remote and isolated work, heat stress and fatigue must also be managed during the construction stage. Information on how to manage these risks is provided in section 6 (General risk and workplace management).

3.4.1 Falls from heights

WHS Regulation section 78(1) and (2): A person conducting a business or undertaking must manage risks to health and safety associated with a fall by a person from one level to another that is reasonably likely to cause injury to the person or any other person. This includes the risk of a fall:

- in or on an elevated workplace from which a person could fall
- in the vicinity of an opening through which a person could fall
- in the vicinity of an edge over which a person could fall on a surface through which a person could fall, or in any other place from which a person could fall.

WHS Regulation section 306C and 306D: A person conducting a business or undertaking who intends to do construction work where the risk of falling is at least two metres must, before work starts, use control measures to:

- prevent a person falling any distance, or
- if prevention is not practicable to arrest a person's fall to prevent or minimise the risk of death or injury.

Falls from height are a common hazard during the construction of solar farms. Examples of risks of a fall from height during solar farm construction include exposure to open trenches, use of ladders to access or exit platforms (noting work should not be performed while on the ladder), penetrations that a worker could fall through (e.g. a skylight on the roof of a shopping centre), or working close to an edge (e.g. off a roof or platform).

A PCBU has an obligation under the WHS Regulation to manage the risk of someone falling from one level to another as far as is reasonably practicable. This includes:

- ensuring any work involving the risk of a fall is carried out on the ground or on a solid construction
- providing safe means to access and exit a workplace, and
- minimising the risk of falls by providing a fall prevention device, work positioning system or a fall arrest system.

Installing fall prevention systems should be considered at the design and planning stage. Examples include roof safety mesh, guard railing, barriers, scaffolding or elevating work platforms. Work procedures should be developed on how to correctly install, use and maintain the system.

More information about the prevention of falls and installation of fall prevention systems is available in the *Managing the risk of falls at workplaces Code of Practice*.

3.4.2 Slips, trips and falls

WHS Regulation section 40: A person conducting a business or undertaking at a workplace must ensure, so far as is reasonably practicable, that:

- the layout of the workplace allows, and the workplace is maintained to allow, for persons to enter and exit and to move about without risk to health and safety, both under normal working conditions and in an emergency;
- work areas have space for work to be carried out without risk to health and safety;
- floors and other surfaces are designed, installed and maintained to allow work to be carried out without risk to health and safety;
- lighting enables each worker to carry out work without risk to health and safety, persons to move within the workplace without risk to health and safety, and safe evacuation in an emergency.

Slips, trips and falls are a common hazard on all construction sites, including solar farms. They can happen anywhere on the site, including off ladders, while wiring conduit is being installed, or while work is being conducted on rough or uneven ground. Good housekeeping practices such as keeping all work areas dry and clear of obstructions, removing any leaves or debris and limiting vegetation growth can reduce the risk of slip, trip or fall injuries. Other methods for controlling the risk of slips, trips and falls include:

- providing, and regularly maintaining, level accessways and work areas

- providing adequate lighting to enable pathways and any hazards or changes in walking surface to be seen
- using safety steps on ground surfaces to improve stability and reduce the loss of balance when stepping back onto the ground
- providing boot cleaning stations to reduce build up on soles of work boots.

More information on managing the risk of slip, trips and falls in the workplace can be found at https://www.worksafe.qld.gov.au/injury-prevention-safety/workplace-hazards/slips-trips-and-falls.

3.4.3 Falling structures, loads or objects

WHS Regulation section 54: A person conducting a business or undertaking at a workplace must manage risks to health and safety associated with an object falling on a person if the falling object is reasonably likely to injure the person.

WHS Regulation section 55: If it is not reasonably practicable to prevent the risk of falling objects the risk must be minimised by providing and maintaining a safe system of work that prevents an object from falling freely or if that is not reasonably practicable a system to arrest the fall of the object.

Working under structures like a solar array, or performing work overhead (e.g. electrical installation work on a solar array), can result in objects falling on a worker's head or body. Lifting loads over work areas or near workers may also create a risk of heavy objects falling and injuring workers. Injuries that result from falling objects may be severe, particularly if sharp objects are present.

PCBUs have a duty to manage the risk of falling objects, including to prevent or minimise the risk. Control measures implemented to manage the risk of falling objects should aim to prevent objects from falling (i.e. eliminate the risk) or, if not reasonably practicable, prevent injury if an object has fallen.

Small objects such as bolts and tools falling from a height can cause serious injury.

Control measures that can be implemented to manage the risk of falling objects during the construction of solar farms include:
- securing and properly bracing structures
- securing loose material such as plywood, iron sheets and off-cuts against the wind
- enclosing areas where loads are being lifted
- use of tool lanyards
- use of exclusion zones
- use personal protective equipment such as hard hats.

Lifting loads

WHS Regulation section 219: The person with management or control of plant must ensure, so far as is reasonably practicable, that no loads are suspended or travel over a person unless the plant is specifically designed for that purpose. The person must also ensure that loads are lifted or suspended in a way that ensures the load remains under control during the activity.

During the installation of large-scale solar farms, cranes may be necessary to lift heavy equipment which may create a risk of heavy objects falling onto workers if not lifted correctly and safely. Extreme care should be exercised when lifting loads near workers and other people.

Where loads are being lifted during the construction of solar farms, the person with management or control of the crane should ensure that:
- the hoist has been properly maintained
- the load is properly secured
- the crane is operated within its load chart and is not overloaded
- an exclusion zone prevents workers or other people walking under the lift.

Further information on the safe lifting of loads can be found in the *Mobile crane Code of Practice*.

3.4.4 Hazardous manual tasks

WHS Regulation section 60(1) and (2): A person conducting a business or undertaking must manage risks to health and safety relating to a musculoskeletal disorder associated with a hazardous manual task. In determining control measures for hazardous manual tasks, a person conducting a business or undertaking must consider all matters that might contribute to a musculoskeletal disorder including:

- postures, movements, forces and vibration relating to the hazardous manual task;
- duration and frequency of the hazardous manual task;
- workplace environmental conditions affecting the task or worker;
- design of the work area;
- layout of the workplace;
- system of work used;
- the nature, size, weight or number of persons, animals or things involved in carrying out the hazardous manual task.

During the construction of solar farms workers may be exposed to several hazardous manual tasks that can lead to musculoskeletal disorders (MSDs). Work that may be a hazardous manual task includes:

- lifting PV modules above shoulder height which may have risk factors of repetitive or sustained force, high and sudden force, awkward posture and repetitive movements
- working overhead to install and secure a PV module to its support frame or tracking system which may have risk factors of awkward and sustained postures, repetitive movements and exposure to vibration from using power tools
- manual handling of piles during the piling process which may have risk factors of high or sudden forces.

A task may involve more than one risk factor that can contribute to MSDs. Where several risk factors are present the risk of MSD increases significantly.

When conducting a manual handling task risk assessment, consider sources that are causing the risk factors. Examples include:

- the systems of work and the way the work is organised can contribute to fatigue
- shift arrangements
- duration of the task or project deadlines
- environmental factors such as gusty winds, or rough ground conditions
- the design and layout of the work area (including PV module support frame or tracker system structure)
- the nature, size, weight or number of things to be handled (e.g. frequent handling of PV modules).

A PCBU must carry out a risk assessment for any manual tasks that have been identified as being hazardous, unless the risk is well-known and appropriate control measures are known. Workers on solar farms must be consulted as part of this process as they can provide valuable information about work that results in discomfort and muscular aches and pains.

Examples of control measures for hazardous manual tasks include:

- designing the solar farm in a manner that minimises exposure to hazardous manual tasks
- having materials, tools and items delivered and suitably located to minimise the amount of carrying required over long distances
- using mechanical equipment to eliminate or reduce the need for workers to lift, carry or support materials and equipment. Wherever practical use mobile cranes, telehandlers, lifting hoists and trolleys, but ensure that an additional risk is not introduced when working with these aids in the same workspace as other workers
- selecting tools that are suitable for the task, including ensuring that attachments to power tools are provided to avoid over-reaching when operating tools.

Further information on managing the risk of hazardous manual tasks can be found in the *Hazardous manual tasks Code of Practice*, the Hazardous manual task worksheet or at

https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-manual-tasks/participative-ergonomics-for-manual-tasks-perform.

3.4.5 Plant

Mechanical hazards such as contact with moving parts of plant, movement of mobile plant around the workplace, and the effects of wind on crane operation are all examples of plant-related risks that must be managed during the construction of solar farms.

A person with management or control of plant at a workplace must manage risks to health and safety and should ensure that:

- plant is used and operated by a competent, or licensed (where required), person
- contact with or access to dangerous parts is prevented, for example by using guards and protective structures
- the plant has fail safe operation
- operator protective devices are fitted
- that the safe working load is displayed and any load measurement devices are operating correctly
- plant is maintained in accordance with the manufacturer instructions or relevant Australian Standards
- the plant incorporates measures to minimise risks during use, for example minimising noise through the application of sound-absorbing materials
- solar modules are handled carefully and installed in accordance with manufacturer's instructions. The photovoltaic cells in solar modules can contain hazardous substances, for example lead and cadmium, which may be released if the modules are damaged during installation.

Powered mobile plant

WHS Regulation section 214 and 215: A person with management and control of powered mobile plant must manage the risks of the plant overturning and/or colliding with any person or thing and must ensure so far as is reasonably practicable that the plant has a warning device to warn persons at risk from the movement of the plant.

Use of powered mobile plant during construction of a solar farm is high risk construction work and a SWMS must be prepared before work commences (see section 3.2 - Safe work method statement and WHS management plans). A wide range of powered mobile plant, including earthmoving machinery and cranes, may be used during construction of a solar farm. To select plant that is suitable for the task, the following factors should be considered:

- site access and restrictions
- site hazards such as overhead powerlines and underground services
- the size of loads to be lifted
- ground conditions
- the type and depth of excavations
- the volume of material to be excavated and transported.

A high risk work licence is required to operate some types of powered mobile plant (see section 3.2 - Licensing and competency of workers). However, in relation to earth moving machinery, in most cases a licensed operator is not required if the machine is being used for the purpose for which it was originally designed. Earthmoving machinery operators must be able to demonstrate they are competent to operate the type of plant being used and any attachments fitted to the plant.

Operators of powered mobile plant can often have severely restricted visibility of ground workers or nearby pedestrians, particularly those close to the plant. Powered mobile plant operating near workers or other powered mobile plant should be equipped with warning devices (e.g. reversing alarm and a revolving light).

An effective system of communication based on two-way acknowledgement between mobile plant operators and ground workers should be established before work commences. Relevant workers should also be trained in the communication procedures prior to the work commencing. The

communication system should stop ground workers from approaching mobile plant until the operator has agreed to their request to approach. Similarly, the system should stop operators from moving plant closer than a set distance from ground workers until the operator has been advised by ground workers that they are aware of the proposed movement.

Mobile plant operators and ground workers should be provided with and wear high-visibility clothing. Powered mobile plant should not operate or travel near the edge of an excavation unless the ground support system installed has been designed by a competent person to carry such loads. Physical barriers, such as wheel stoppers, can be one way of restricting plant movement near an excavation.

Mobile cranes are not to be operated in winds exceeding that specified by the manufacturer. Information on the maximum permissible wind speed should be available on site where the crane is being operated. This information should be either on the manufacturer's identification plate on the crane or in the operating manual for the crane.

Further guidance on managing the risks of plant, including inspection and maintenance requirements, can be found in the *Managing risks of plant in the workplace Code of Practice*.

3.4.6 On-site traffic management

Managing traffic is an important part of ensuring the workplace is without risks to health and safety. Powered mobile plant and vehicles moving in and around the workplace, reversing, loading and unloading is often linked to worker injuries and fatalities.

The most effective way to protect workers and other people in the workplace is to eliminate traffic hazards. This can be done by designing the layout of the workplace so that interactions between pedestrians and vehicles is eliminated. Examples include, prohibiting vehicles from being used in pedestrian spaces or providing separate traffic routes so pedestrians cannot enter areas where vehicles are used.

Where this is not possible, risks must be minimised so far as is reasonably practicable. This can be done by planning and controlling vehicle operations and pedestrian movements in the workplace. Key issues to consider for managing traffic include:

- keeping pedestrians and vehicles apart including on site and when vehicles enter and exit the workplace
- minimising vehicle movements
- eliminating reversing vehicles or minimising the related risks
- ensuring vehicles and pedestrians are visible to each other
- using traffic signs
- developing and implementing a traffic management plan.

Planning can help minimise vehicle movement around a workplace. To limit the number of vehicles at a workplace consider:

- locating storage areas so delivery vehicles do not have to cross the site
- providing vehicle parking for workers and visitors away from work areas
- controlling entry to work areas (e.g. by using boom gates)
- scheduling work to minimise the number of vehicles operating in the same area at the same time.

One-way road systems and turning circles can minimise risks, especially in storage areas. Where this is not possible other control measures should be considered including:

- using mirrors, reversing warning alarms, sensors and cameras
- ensuring a signal person wearing high visibility clothing assists the driver who cannot see clearly behind their vehicle – the driver should always be able to see the signaller
- ensuring workers and other people are familiar with reversing areas and these areas are clearly marked
- ensuring plant operators are aware of workers who may be near the swing radius, articulation points and overhead load movement of their vehicle.

Signs should be used to alert workers and pedestrians to potential hazards when vehicles are entering and exiting the workplace. Signs should also be used for pedestrian exclusion zones.

Traffic routes should also be clearly signed to indicate restricted parking, visitor parking, headroom, speed limits, vehicle movement, key site areas and other route hazards. Standard road signs should be used where possible and speed limits should be implemented and enforced.

Traffic management plans

A traffic management plan documents and explains how risks will be managed during construction of a solar farm. This may include details of:

- designated travel paths for vehicles including entry and exit points, haul routes for debris or plant and materials, or traffic crossing other streams of traffic
- pedestrian and traffic routes
- designated delivery and loading and unloading areas
- travel paths on routes remote from the workplace including places to turn around, dump material, access ramps and side roads
- how often and where vehicles and pedestrians interact
- traffic control measures for each expected interaction including drawings of the layout of barriers, walkways, signs and general arrangements to warn and guide traffic around, past or through the workplace or temporary hazard
- requirements for special vehicles like large vehicles and mobile cranes
- requirements for loading from the side of road onto the site
- the responsibilities of people managing traffic at the workplace
- the responsibilities of people expected to interact with traffic at the workplace
- instructions or procedures for controlling traffic including in an emergency
- how to implement and monitor the effectiveness of the traffic management plan.

The traffic management plan should be monitored and reviewed regularly, including after an incident, to ensure it is effective and adapts to changes at the workplace. Workers should be aware of and understand the traffic management plan and receive information, instruction, training and supervision about it. Site induction training should include providing information on the traffic management plan.

Further advice is available in the *Traffic management for construction or maintenance work Code of Practice*.

3.4.7 Exposure to noise

WHS Regulation section 57: A person conducting a business or undertaking must manage the risk to health and safety relating to hearing loss associated with noise. The person conducting a business or undertaking must ensure that the noise a worker is exposed to at the workplace does not exceed the exposure standard for noise.

The use of plant and equipment at solar farms (e.g. piling machines) can create significant noise and vibration which should be measured and monitored to ensure workers are not exceeding their exposure limits and the correct PPE is selected.

Exposure to high noise levels can cause permanent hearing loss. The exposure standard for noise in relation to hearing loss is defined in the WHS Regulation as an LAeq,8h of 85 dB(A) or an LC, peak of 140 dB(C). There are two parts to the exposure standard for noise because noise can either cause gradual hearing loss over time or be so loud that it causes immediate hearing loss.
The most effective control measure is to remove the source of noise completely. If this is not possible, equipment should be modified and procedures implemented to reduce the noise, or isolate the source of noise from people. This can be done by using distance, barriers, welding bays and sound absorbing surfaces. If these measures are not reasonably practicable, administrative control measures should be implemented which limit the amount of noise people are exposed to and how long they are exposed to it. Personal hearing protection must also be provided to protect workers from any remaining risk.

Further guidance on managing the risk of noise in the workplace is available in the *Managing noise and preventing hearing loss at work Code of Practice*.

3.4.8 Excavation work

WHS Regulation section 305: A person conducting a business or undertaking must manage risks to health and safety associated with excavation work. This includes the risk of a person falling into an excavation, a person being trapped by the collapse of an excavation, a person working in an excavation being struck by a falling thing, a person working in an excavation being exposed to an airborne contaminant.

Excavation work can present a risk of injury to workers as excavations (e.g. trenches, tunnels or shafts) may collapse, objects near the excavation may fall onto workers, or workers may fall into the excavated area.

Excavation work should be carefully planned before work starts so it can be carried out safely. Planning involves identifying the hazards, assessing the risks and determining appropriate control measures.

Potential hazards associated with excavations and excavation work include:
- ground collapse
- falls
- hazardous manual tasks
- airborne contaminants
- buried contaminants (e.g. asbestos)
- exposure to underground services.

Control measures to manage these risks may include:
- installation of ground support (e.g. shoring)
- use of ramps or steps to enable safe access and egress from the excavation
- rotating tasks between workers
- providing adequate ventilation to remove airborne contaminants
- provision of training and information to enable identification of buried contaminants and what action to take.

Structural or geotechnical engineers should be consulted in relation to excavation work and plans to manage risk associated with excavations and excavation work.

If excavation work is or involves high risk construction work, PCBUs must prepare a SWMS before the high risk construction work starts.

More information about managing the risks related to excavation work is available in the *Excavation work Code of Practice*.

3.5 Electrical safety risks

Workers at solar farms may be exposed to various electrical safety risks including:
- AC and DC electricity
- different voltage levels
- different sources of electricity (e.g. high voltage electricity from the transmission or distribution network and the solar array that is absorbing the sun's light)
- different conductive material including the PV solar array and modules which are considered to be live (energised) as soon as they are removed from packaging
- PCE that convert the PV array's direct current to alternating current.

When components of a solar farm are ‘live’ (energised), they can cause injuries associated with electric shock and arc-flash. This is the case even in low-light conditions where sufficient voltage can still be created.

The most significant risk associated with working with electrical equipment and electrical installations is the risk of electric shock. The higher the voltage, the higher the risk. Muscle contraction from electric shock is particularly dangerous as it can result in the inability to release live (energised) conductors, which may result in death. Hazards associated with transmission of high voltage electricity to the transmission or distribution network (i.e. hazards similar to a transmission terminal or substation) must also be managed.

Arcing is another significant electrical safety hazard that involves electricity ‘jumping’ through air, smoke or water. Arcing may generate significant heat and may result in fire, damage to equipment or injury to workers. Arc tracking, where electricity tracks across a surface between electrical connections or through damaged installation, may also cause heat, fire and damage to equipment. Arc tracking occurs when insulation between parts of different polarity is damaged, or is compromised by ingress of moisture or other foreign matter.

Overheating of electrical equipment, switches and cables may cause deformation or degradation of insulation that exposes live (energised) parts or creates a fire hazard. This can result from not being rated for the electrical currents in the circuit, or from incorrect installation. Examples include not adhering to required clearances or causing blocking of cooling vents, or from poor or loose terminations of cables into connectors or equipment.

Electrical safety hazards associated with solar PV systems include:
- PV array and PV modules being live (energised) as soon as they are exposed to light
- PCE (e.g. inverters) having hazardous voltages once connected to the PV array
- wiring being live (energised) once connected
- the risk of electrical faults causing fires
- DC voltages and current sources of PV modules causing series arcing that may not be identified by automatic protection devices and so remain in place unless physical action to remove the fault occurs
- DC arcing caused by disconnection of DC connectors under load
- rapid energy release from energy storage (if used) if an insulation fault occurs or contact is made between live (energised) circuits, resulting in arc flash hazards.

Control measures to manage electrical safety risks include:
- ensuring only licensed electrical workers, where required under the ES Act, undertake electrical work
- ensuring, where possible, all PV equipment is isolated before work commences
- ensuring all electrical interconnections between the inverter and the switchboard or distribution panel are installed by a licensed electrical worker and the inverter is disconnected from the source of electricity before work is performed
- using appropriate tools when working on electrical equipment
- ensuring electrical equipment used for measurements or testing has suitable insulation properties and ratings for the voltages (AC or DC) present
- using appropriate protection devices
- adequate earthing
- ensuring safe working procedures are developed, applied, audited and followed
- ensuring electrical parts are de-energised when making or breaking connections
- ensuring equipment for lock out procedures are designed to lock out facilities and that lock out procedures are implemented for sections being worked on
- using appropriate warning labels on all electrical equipment
- wearing personal protective equipment, including insulated gloves and appropriate arc-rated protective clothing
- ensuring high voltage AC transmission lines from the solar farm to the transmission or distribution network are de-energised and earthed until they are ready for commissioning and the earthing system or grid is complete.

To manage exposure to electrical risks at solar farms duty holders should:

- determine what work is electrical work (see section 3.5.1, Electrical work during the construction of solar farms)
- undertake risk assessments and planning and preparation before work commences
- ensure workers are licensed to undertake electrical work
- ensure compliant equipment is selected and installation requirements are followed (including compliance with any equipment and installation standards)
- ensure electrical equipment and tools are inspected and tested
- ensure PV modules are safely connected and the work is signed off by a licensed electrical mechanic
- ensure risks of working near energised electrical parts, high voltage areas, and arc flash are appropriately managed.

Information provided in this code of practice on managing electrical safety risks during the construction of solar farms should be read in conjunction with the *Electrical safety code of practice Managing electrical risks in the workplace*.

3.5.1 Electrical work during the construction of solar farms

ES Act section 18: Electrical work means:

- connecting electricity supply wiring to electrical equipment or disconnecting electricity supply wiring from electrical equipment; or
- manufacturing, constructing, installing, removing, adding, testing, replacing, repairing, altering or maintaining electrical equipment or an electrical installation.

During the construction of solar farms there are several types of work that are considered electrical work for the purposes of the ES Act. These include electrical installation work, electric line work and electrical equipment work. Construction of solar farms, even if conducted in phases alongside operating parts of the solar farm, is not considered to be works of an electricity entity. All electrical work during construction of a solar farm must be performed by an appropriately licensed electrical worker (see section 3.5.2 - Licensing and competency of electrical workers).

Electrical installation work is work associated with installing or altering an item or a group of items of electrical equipment that are permanently connected and can be supplied with electricity from a generating source. This work must be performed by a person licensed or authorised to perform electrical installation work under the ES Act.

Electrical line work is work associated with an electric line. Electric line work includes connecting the electric cables of overhead lines. This work must be performed by a person licensed or authorised to perform electrical line work under the ES Act.

Electrical equipment work is work associated with electrical work other than electrical installation work or electric line work. Electrical equipment work includes testing and maintaining electrical equipment. This work must be performed by a person licensed or authorised to perform electrical equipment work under the ES Act.

Electrical equipment is any apparatus, appliance, cable, conductor, fitting, insulator, material, meter or wire that is used for controlling, generating, supplying, transforming or transmitting electricity at a voltage greater than extra low voltage. This includes, but not limited to:

- supply conductors
- any parts in the installation required for earthing.

A supply conductor includes any cable, conductor or wire supplying or transmitting electricity where, after installation is complete, the voltage is greater than extra low voltage. This includes individual PV module cables that are connected, even if the individual PV module is only producing electricity at extra low voltage.

Parts used for earthing include earthing conductors and any other fitting or material required for effective earthing, even if the part is not normally associated with being part of the earthing circuit (see section 3.5.3 - Earthing).

Factors to consider when determining what electrical work is during the construction of solar farms

There are several unique characteristics that should be considered when determining what electrical work is during the construction of solar farms, these include:

- solar farms may have systems with components of AC and DC systems and voltages at extra low voltage (ELV), low voltage (LV) and high voltage (HV) on the one site
- parts of the solar farm design and operation may be similar to traditional transmission terminal stations or substations
- solar farms need to have adequate protective earthing and earth grid design and installation for fault current situations, step and touch voltage potentials and issues related to the effect of dissimilar metals of the structures and connections
- solar farms have parts operating at extra low voltage connected to other low voltage or high voltage parts via PCE. Where the PCE are 'transformerless' type they are not fully isolated. All parts of the installation connected to transformerless PCE should be considered to be at the higher of the voltages present
- solar farms have components of electrical equipment that operate individually at extra low voltage but when installed operate or transmit electricity at above extra low voltage. For example, a PV array of extra low voltage PV modules connected in series will result in the wiring systems of PV modules transmitting at voltage higher than extra low voltage
- solar farms generate DC from PV modules that, due to the technology used, will likely have fault currents that are not greater than normal full load current, even under short circuit conditions. Consequently, traditional overcurrent protective devices may not be effective. Some designs to address this have earth fault monitoring circuitry that requires effective earthing circuits on all metal parts
- solar farms have apparatus that generate electricity (PV modules) that cannot be isolated. They will generate electricity whenever the module is exposed to light (sunlight or any other light source). This creates an inherent electrical safety risk as the terminals and cables will always have an electrical safety risk present
- solar farms may include installation of assemblies of large pre-installed switchboards or switch rooms incorporating pre-installed PCE and other associated electrical equipment and other installation wiring.

In addition, solar farms are often commissioned in stages. Where construction of part of a solar farm is complete and commissioned, any subsequent electrical work on the commissioned part of the solar farm is operation and maintenance work and the requirements in section 5 (Operation and maintenance) apply. However, when construction of a new section of the solar farm commences, any electrical work involved in the construction of the new stage is captured by this section, regardless of whether parts of the farm are already commissioned and operational. Where a solar farm contains both operational parts and parts under construction, PCBUs should ensure there is a clear delineation between each section and that access to operational parts of the solar farm is restricted.

Based on these factors, work during the construction of solar farms is categorised as either:

- electrical work
- work performed under the supervision of a licensed electrical worker
- other work.

Electrical work

Work that is 'electrical work' for the purposes of the ES Act must be performed by an appropriately licensed electrical worker (see section 3.5.2 - Licensing and competency of electrical workers).

Examples of electrical work during the construction of a solar farm include:

- installing low voltage or high voltage electric cable, wire or supply conductors, including laying, placing or fixing the wire or supply conductors in position either on, or in, a structure or in the ground
- fixing, connecting and interconnecting PV module cables even if the individual PV module output is below low voltage
- installing, cutting, joining, sealing or terminating cables
- connecting and terminating supply conductors to electrical equipment
- making earthing connections
- mounting electrical equipment where making or terminating electrical connections occurs as part of the installation of the equipment. This may include equipment where access to live (energised) parts or terminals is prevented by the mounting method (e.g. socket-outlets, wall switches, switchgear, circuit breakers, safety switches, fuse holders or busbars)
- installing switchboards, including assemblies of pre-installed parts of switchboards or installing combiner boxes or switch rooms with various pre-installed electrical equipment
- connecting or disconnecting connection devices attached to PV modules, cables or other parts of the PV array that are plug-in type connectors. This includes plug-in type connectors that can be connected or disconnected with or without the use of a tool
- connecting or disconnecting parts required for earthing (including bolts, clamps, grounding plates etc.)
- building, altering, repairing, maintaining an overhead line
- building or repairing ducts, conduits or troughs (channels) where electrical wiring will be or is installed and the ducts, conduits, troughs or channels are intended to be earthed
- testing and verifying the installation, including verifying the earthing continuity of every structural part in the earthing circuit.

Electrical work during construction of a solar farm is primarily electrical installation work that requires the worker to hold an electrical mechanic licence. Some work may be electric line work (e.g. electrical work involved in building an overhead electric line) that requires the worker to hold an electrical mechanic licence or an electrical linesperson licence. There may also be some work that is electrical equipment work (e.g. repairing or maintaining already installed electrical equipment) that requires the worker to hold an electrical mechanic licence or electrical fitter licence. For more information see section 3.5.2 (Licensing and competency of electrical workers).

For PV module installation, any connection or disconnection of supply conductors, or connections that form part of earthing circuits, must be performed by a licensed electrical mechanic.

Work performed under the supervision of a licensed electrical worker

There are several tasks, related to electrical work, during the construction of solar farms that can be undertaken by an assistant under the supervision of a licensed electrical worker.

Supervision, be it 'direct supervision' or 'supervision' as referenced in the ES Act, relates to the amount of oversight and presence of the supervising person during the performance of, or carrying out of, the work (see section 3.5.2 - Licensing and competency of electrical workers). This supervision should consider the verified training, skills, competency and licensing of the person being supervised and the work to be performed.

The assistant may be another licensed electrical worker in which case supervision may only be minimal, dependent on the identified competency of the worker.

The assistant may also be an electrical apprentice in which case the supervision will be dependent on several factors to ensure the safety of the apprentice and the safety of the work completed (see section 3.5.2 - Licensing and competency of electrical workers).

The assistant may also be a person who is not a licensed electrical worker, or electrical apprentice, but is verified as being a competent person to perform elements of the tasks (e.g. a 'trades assistant'). This assistant cannot perform electrical work but, under supervision, may assist the electrical worker who is performing the electrical work. In this situation, work under the supervision of a licensed electrical worker means:

- the licensed electrical worker is present to supervise the carrying out of the work. This means the licensed electrical worker is in the immediate vicinity, working on related tasks alongside the assistant, able to observe or watch over or direct the work being performed
- the licensed electrical worker is performing electrical work and the assistant is helping in aspects of that work.

The licensed electrical worker should ensure the work the assistant performs is suitable for a non-electrically licensed person to perform, meaning it is not work that only a licensed electrical worker is permitted to perform, and the work is being performed safely and will result in a safe electrical installation.

An assistant who is not a licensed electrical worker, or electrical apprentice, must not make any connections of conductors, including earthing connections, or perform work where there is a possibility of contact with energised electrical equipment.

Examples of work that may be performed by an assistant who is not a licensed electrical worker, or electrical apprentice, include:

- helping to install electric cables where the licensed electrical worker is in the process of laying, placing or fixing the cables in position, including assisting in building ducts, conduits, troughs or channels, but not including cutting or sealing cables or making connections for any supply conductors or earthing connections
- helping install electric cables in the ground by operating specialist machines designed for this task, and that the assistant is trained to use, to assist the licensed electrical worker who is laying, placing, fixing the cables in position
- supporting equipment while electrical connections are being made by the licensed electrical worker
- cutting openings for electrical equipment to be mounted to, or for cables to be run though or placed
- assembling the PV array structures, in conjunction with the licensed electrical worker who is required to be present to make the earthing connections.

Other work

Mounting of other equipment and large assemblies of pre-installed electrical equipment are examples of other work, related to electrical work, involved in solar farm construction that must be performed safely.

Mounting of large assemblies of pre-installed switch rooms

Use of a crane for mounting or positioning large assemblies of pre-installed switchboards, switch rooms or other enclosures in position must be performed by licensed crane operators, riggers and doggers. However, a licensed electrical worker should be present to ensure the mounting or positioning of the switchboard, switch room or other enclosure (e.g. the pre-installed parts of the electrical installation) is correct to enable safe connection to other installation wiring.

Mounting of other equipment

Locating, mounting or fixing empty cabinets for electrical equipment, mounting of transformers, mounting of motors or other complete discrete electrical equipment may be performed by a competent person that does not have an electrical work licence. However, work undertaken in these

circumstances must not include connecting or disconnecting conductors, including earthing connections, or fixing supply conductors or cables as this work must be done by a licensed electrician.

Despite the mounting of other equipment being able to be performed by non-licensed workers, the safety of workers and the electrical installation must still be considered. Factors to consider include:

- ensuring clear instruction on mounting location and orientation are provided, including details on positioning of cable entry points to ensure subsequent cable installation or connections can be safely performed by a licensed electrical worker
- ensuring a licensed electrical worker verifies the mounting is electrically safe and that any rectifications required from the inspection and testing are completed prior to connection of supply conductors
- ensuring an assessment of electrical safety risks is undertaken prior to the mounting work commencing.

Further information on managing risks and undertaking a risk assessment is provided in section 1.3 (What is involved in managing risks) or in the *How to manage work health and safety risks Code of Practice* and the *Electrical safety Code of Practice Managing electrical risks in the workplace*.

3.5.2 Licensing and competency of electrical workers

ES Act section 56: a person must not conduct a business or undertaking that includes the performance of electrical work unless the person is the holder of an electrical contractor licence that is in force.

ES Act section 55: a person must not perform or supervise electrical work unless:

- the person is the holder of an electrical work licence in force under the ES Act; and
- the licence authorises the person to perform the work.

ES Act section 57AA: A person conducting a business or undertaking that conducts the performance of electrical work must ensure the electrical work is performed by the holder of a licence that authorises the performance of the work and the supervision of the electrical work is carried out by the holder of an electrical work licence that authorises the performance of the work.

ES Act section 57AB: A person conducting a business or undertaking conducting the performance of electrical work must ensure they keep a register of any persons they engage to conduct electrical work. This register must include the details of the electrical work licence held by each person engaged to perform or supervise electrical work and the person conducting a business or undertaking must maintain records of those workers for 5 years after the person ceases to be engaged by the person conducting a business or undertaking.

A PCBU that is contracting to perform electrical work on a solar farm must have a current Queensland electrical contractor licence with a suitable number of nominated Qualified Technical Persons (QTP) to enable the supervision of all electrical work being performed (see supervision section below). The QTP(s) must be competent in the type of electrical work they are supervising.

Electrical work undertaken during solar farm construction is either electrical installation work, electric line work or electrical equipment work (see section 3.5.1 – Electrical work during the construction of solar farms). All electrical work must be performed by licensed electrical workers or a person who is otherwise permitted or authorised to perform the work under the ES Act. Examples include:

- the holder of a licence relevant to the electrical work to be performed, for example:
  - an electrical mechanic licence which authorises the holder to perform all electrical work (i.e. electric line work, electrical equipment work and electrical installation work)
  - an electrical linesperson licence which authorises the holder to perform all electric line work
  - an electrical fitter licence which authorises the holder to perform all electrical equipment work
- the holder of an electrical work training permit issued by the regulator which authorises performance of the type of electrical work to be conducted. This work must be performed under supervision of an electrical worker licensed to perform the electrical work
- a training person (e.g. an electrical apprentice) who is under supervision of an electrical worker licensed to perform the electrical work.

The licensed electrical worker, or the person who is otherwise permitted or authorised to perform the work, must be competent in the type of electrical work being performed or be being trained and/or under supervision by a licensed electrical worker who is licensed and competent in the type of electrical work being performed.

The PCBU performing the electrical work must ensure electrical workers are appropriately licensed and competent in the electrical work being performed. They must also keep a record of the licence holder, and the details of the electrical work licence held. This includes while the person is working for them and for five years after employment ceases. Details that must be kept include:

- the licence number
- the licence class
- any conditions or restrictions on the licence
- the licence expiry date
- if the licence was not issued in Queensland, the jurisdiction in which the licence was issued
- current competencies in rescue and resuscitation for workers who are required to perform, or help in performing, electrical work.

Where electrical work is sub-contracted to other licenced electrical contractors, the PCBU must ensure the contractor also complies with record keeping requirements. This includes retaining the licence holder details and current competencies outlined above.

The PCBU should ensure that the competency of licensed electrical workers to perform electrical work on a solar farm is assessed prior to work commencing. This includes assessing the competency of QTPs to perform electrical work on a solar farm where the PCBU is an electrical contractor.

Competency assessment should include assessing each workers knowledge and understanding of the electrical risks involved with the work, the electrical equipment used to construct a solar farm and their competence to perform the work. Assessment outcomes should be recorded and kept with the register of licensed workers.

Competency in electrical safety risks related to solar farm construction can be obtained by formal studies, on-job mentoring and experience, specific training in equipment by the manufacturer or supplier of the equipment, or participation in continuous professional development related to solar farms, PV systems, high voltage systems and safety aspects of DC systems. Further information on specific or specialised training is provided in section 1.4 (Information, training, instruction and supervision).

Supervision

ES Regulation section 48: To be issued an electrical contractor licence, the applicant must satisfy the regulator the electrical work will be performed by, or supervised by, a qualified technical person (QTP) who is authorised to perform the work under the persons electrical work licence.

ES Regulation section 279: A person conducting a business or undertaking must ensure that a training person who performs electrical work is supervised at all times by a licensed electrical worker licensed to perform the work.

The holder of a Queensland electrical contractor licence must have at least one QTP and ensure the electrical work is performed by the QTP or is supervised by the QTP. To perform or supervise the electrical work, the QTP must be authorised to perform the electrical work under their electrical work licence. The electrical contractor must also ensure procedures are implemented to enable adequate supervision of the electrical work being carried out.

Examples of supervision include:

- being present at the location where electrical work is being performed to ensure the work is being conducted safely and correctly
- being aware of the details of the electrical work being performed and providing detailed instruction and direction on how to perform the electrical work

- providing guidance on electrical work requirements for solar installations (e.g. earthing connections for PV modules and structures)
- reviewing and auditing work performed by electrical workers and apprentices to ensure the installation is electrically safe.

Where a training person (i.e. an electrical apprentice – see Appendix 1) is performing electrical work, the training person must be supervised at all times. This will assist with ensuring the safety of the training person and the work completed is electrically safe. The level of supervision required must be appropriate having regard to:

- the type of electrical work being performed
- the adequacy of the training and competency of the trainee.

A training person who has completed less than 6 months of their training must not work in the immediate vicinity of a high voltage exposed part or work in circumstances where there is a risk they could contact live (energised) low voltage exposed parts.

Where a non-electrically licensed worker is assisting a licensed electrical worker, supervision requirements are provided in section 3.5.1 (Electrical work during construction of solar farms). Where non-electrical work is being conducted then general supervision requirements are provided in section 3.3.3 (Supervision of workers).

3.5.3 Electrical equipment and electrical installations

The electrical contractor responsible for the electrical installation of a solar farm must ensure the installation is electrically safe and workers are not exposed to electrical safety risks during construction.

This includes:

- following equipment manufacturers installation instructions
- following design requirements for equipment specifications and installation
- complying with AS/NZS 3000 (the wiring rules) requirements, including any clause 1.9.4 (Compliance by specific design and installation) requirement if applicable
- complying with any relevant solar installation standards identified and used in the design stage
- ensuring construction wiring complies with AS/NZS 3012 *Electrical installations – Construction and demolition sites*
- ensuring safe work procedures are documented and followed by all workers
- ensuring restricted access and isolation/lock out procedures are implemented for locations where there may be hazardous live (energised) parts.

Only materials and equipment that comply with design specifications are to be used during the installation. Materials and equipment that are damaged, excessively worn, not fit for intended use or do not comply with design specifications must not be used. Evidence to verify that that materials and equipment installed conform to design specifications should be documented and kept on site (see section 2.3 - Materials and equipment).

Electrical Contractors should ensure electrical design documentation is followed, including that any variations are approved, and that records for installation and testing showing compliance to the design and relevant safety standards are kept. Records should be available for all PCBUs.

Electrical contractors should remain aware of the development of Australian and international standards in relation to solar farms as there is on-going work at an international level to publish standards to address safety of equipment and installations in this sector.

3.5.4 Earthing

Earthing is a critical part of an installation to protect equipment from damage, and workers and others from electric shock.

Earthing may include:

- earthing of structures for mounting of PV array
- earthing of PV modules
- earthing to enable a PCE earth fault detection system to operate
- the earth grid to protect the installation from high voltage parts of a solar farm.

Earthing must be conducted in accordance with design specifications. This includes consideration of specific earthing requirements for Australia and Queensland (See Section 2 - Safe design of solar farms).

All accessible metal parts of PV arrays must be earthed and connected to the earthing system of the electrical installation to prevent electric shock. All parts to be earthed (including earthing of PV modules, module support frames and array structures, combiner boxes, isolator enclosures and PCE enclosures) must have their earth connections completed before live connections are made.

There may be multiple paths available for the protective earth circuit or to earth other structures. Irrespective of the earth path used:

- there must be at least one means of connection (bolt, nut, clip, lug, earth plate or similar for either fixed, moving or adjustable parts in a PV module support structure, or other structures) identified as the protective earth path circuit
- the earth connection must be clearly identified, and legibly and indelibly marked, to ensure future maintenance or other work does not result in inadvertent removal of the earth circuit
- constructional components need to be specified and verified as suitable for being part of the earthing circuit
- where constructional components used for earthing continuity move or adjust, the earthing continuity during movement or adjustment needs to be verified before installation
- where only one constructional component is used to mount a PV module, that part cannot be used for the earthing path, and a separate earthing conductor is required
- all earthing circuits will need to be verified and tested after installation. This includes testing and visual inspection of all parts that have been earthed to verify:
    - correct connections have been made (e.g. correct means have been used to break any painted or anodized surface to ensure reliable earthing contact)
    - no dissimilar metals that could cause corrosion of the connection have been used
    - correct sized conductors have been used
    - earthing continuity is maintained though all range of movement or adjustment
    - each earthed part is within limits of resistance allowed.

Initial verification of an earthing component as being suitable for earthing continuity may be conducted as type testing. Once verified, processes should be implemented to ensure all future product is made the same. This includes testing to confirm the component maintains earthing continuity.

For high voltage installation parts of a solar farm, including transmission parts to the network, associated earthing systems or grids must be adequate to prevent unsafe step or touch potentials occurring and to provide an effective and reliable low impedance fault path capable of carrying any earth fault currents. Examples of parts that require assessment for suitable earthing include solar module trackers and structures, substation fences or gates, and solar farm security fences, gates and buildings.

Earthing systems and grids for high voltage installations must comply with AS 2067 *Substations and high voltage installations exceeding 1 kV a.c.*

Lightning protection systems, and their associated earth bonding, that are external (i.e. isolated) from the structure to be protected are not part of the electrical installation and their installation is therefore not considered to be ‘electrical work’. However, to ensure these types of systems are safely installed, PCBUs should ensure workers conducting this work are competent in the lightning protection system design and installation requirements. Where the lightning protection system is designed to connect to the same parts of a structure that are earthed for protective earthing or equipotential bonding then that

part of the wiring and connections is part of the electrical installation and must be undertaken by a licensed electrical worker.

3.5.5 Safe connection of solar PV modules

Connection of solar PV module wiring, including any required earthing connections, and installation and connection of isolation devices and connections in combiner boxes and connectors is electrical installation work. Where a PCBU is contracting to perform electrical installation work, the work must be performed under a Queensland electrical contractor licence and the work performed by licensed electrical mechanics. Where the electrical work is performed by a licensed electrical worker employed directly by the PCBU who owns and/or operates the solar farm the worker must be a licensed electrical mechanic.

Hazards that may occur during the connection of solar PV modules include:

- faults that cause series arcing not identified by protection devices, resulting in electric shock, burn or fire hazards
- exposure to live (energised) PV modules due to the PV modules generating electricity when exposed to sunlight and the individual modules not being able to be isolated
- incorrectly installed equipment leaving live (energised) parts exposed
- electric shock or burn hazards from making or breaking connections under load
- incorrect earthing of parts resulting in unsafe exposed metal parts in the event of a fault, and protection devices not operating to remove the fault.

Control measures to manage unsafe connection risks include:

- developing a safe work method statement (SWMS) for the work. The SWMS should address the risk of solar modules generating electricity as soon as they are exposed to light as this will occur during daylight and when lighting is used at night to enable work to take place
- implementing safe work procedures to:
  - manage the risk of higher voltages as modules are interconnected and the voltage level systematically increases
  - ensure safe connection and disconnection of the wiring from the modules to other modules, combiner boxes, isolating devices or other equipment connectors. This should include consideration and management of voltage levels
- ensuring electrical work is performed by a licensed electrical worker and is overseen by an appropriately licensed person with relevant expertise in the work to be performed. If the work will not be visible for final inspection and testing, the work should be tested and examined immediately after the work is performed
- ensuring relevant installation documentation is available to enable the electrical contractor to verify the work and certify testing and compliance for the electrical work performed
- ensuring non-electrical workers only assist electrical workers and do not perform any electrical work or work involving physical contact with energised electrical equipment. This includes ensuring only licensed electrical workers make and identify structural connections used as part of protective earthing circuits.

3.5.6 Working near energised electrical parts

Working near energised electrical parts creates a risk of electric shock, arc flash and explosion if inadvertent or accidental contact is made with the live (energised) parts or there is encroachment within an unsafe distance of those parts. Examples of tasks that may expose workers to energised electrical parts during the construction of solar farms include:

- making terminations of the PV module array wiring into combiner boxes where other array wiring is already connected
- installing fuses for PV module arrays
- installing protection or control devices in switchboards or other enclosures where existing electrical equipment is installed
- working near other energised electrical equipment
- conducting tests on electrical circuits.

Exposure to electrical risks from working near energised electrical parts must be identified through a risk assessment and appropriate control measures implemented. Control measures may include:

- identifying all live (energised) parts, the voltage levels present, prospective short circuit currents and arc flash potential
- ensuring safe work method statements include safe work procedures for working near exposed live (energised) parts
- applying protective procedures such as:
  - isolation, including testing, prior to work being conducted
  - covers placed over live (energised) parts
  - clearances from live (energised) parts being identified and maintained
- ensuring, where practicable, procedures are implemented to ensure isolation of electrical parts near the work being conducted.

Further information on working near energised electrical parts can be found in the *Electrical safety Code of Practice - Managing electrical risks in the workplace* and the *Electrical safety Code of Practice - Working near overhead and underground electric lines (exclusion zones).*

3.5.7 High voltage electrical work

High voltage electrical work on solar farms poses risks to workers from increased voltage levels and energy that can be released if a fault occurs. Other risks also include contact with live (energised) high voltage parts or flashovers resulting from exclusion zones being breached.

High voltage electrical work includes constructing and installing the infrastructure required to transmit generated electricity from the solar farm to the transmission network. This includes connecting and testing high voltage transformers, installing and connecting high voltage cables, and installing and testing current transformers and high voltage switchgear. This type of electrical installation work must be performed by licensed electrical workers who are verified as being trained to perform such work (see section 3.5.2 - licensing and competency of electrical workers).

Risks associated with high voltage electrical installations and associated electrical work include:

- inadequate earthing arrangements for the possible fault currents
- step and touch potential issues
- flashovers due to workers and plant not maintaining safe distances from high voltage energised parts
- high fault current potential.

Control measures to manage risks associated with high voltage electrical work include:

- ensuring adequate earthing design and that earth grids are installed prior to electrical parts being energised
- ensuring parts of the solar farm electrical installation that are above 1 kV AC are installed in accordance with AS 2067 *Substations and high voltage installations exceeding 1 kV a.c*
- where practicable, designing the solar farm to ensure no part of the electrical installation is above 1.5 kV DC. This will ensure there is no high voltage DC installation
- for any part of the installation that is operating at high voltage, there is appropriately rated components, adequate clearances, restricted access, earthing and any other relevant safety measures for the voltages present
- ensuring electrical equipment and cables in both low voltage and high voltage DC installations are checked before installation to verify they are appropriately rated for the DC voltage and current. Cable ratings need to be closely scrutinised and verified to ensure correct ratings are applied for voltages between conductors and between conductors to earthing
- ensuring any electrical installation work (AC or DC) associated with a high voltage installation is inspected and verified as electrically safe by a high voltage accredited auditor prior to final connection to the network. The high voltage accredited auditor should be engaged as soon as practicable after the design process has been completed so a program of audit can be established to ensure all aspects of the high voltage installation are assessed.

Further information and guidance on high voltage installation safety can be found in the *Electrical safety Code of Practice - Managing electrical risks in the workplace*, the *Electrical safety Code of Practice - Working near overhead and underground electric lines* (exclusion zones), and the *Electrical safety Code of Practice – Works*.

3.5.8 Exclusion zones

ES Regulation section 68: A person conducting a business or undertaking at a workplace must ensure, so far as is reasonably practicable, that no person, plant or thing at the workplace comes within an unsafe distance of an overhead or underground electric line. If it is not reasonably practicable to ensure the safe distance of a person, plant or thing from an overhead or underground electric line, the person conducting the business or undertaking at the workplace must ensure that:

- a risk assessment is conducted for the proposed work; and
- control measures implemented are consistent with the risk assessment and if an electricity entity is responsible for the electric line—any requirements of the entity.

ES Regulation section 69: A person comes within an unsafe distance of an overhead electric line if the person is within the exclusion zone for the person for the line. Any operating plant, or vehicle, comes within an unsafe distance of an overhead electric line if the operating plant or vehicle is within the exclusion zone for the operating plant or vehicle for the line.

An exclusion zone is a safety envelope around an overhead electric line. Areas at a solar farm that may require an exclusion zone include the electrical infrastructure that transmits generated electricity from the solar farm to the transmission network.

Exclusion zones keep people, operating plant and vehicles at a safe distance from energised overhead lines. No part of a person, operating plant or vehicle should enter an exclusion zone while the overhead electric line is energised (live). Exclusion zones extend in all directions, not just sideways. The exclusion zone will vary depending on:

- the voltage of the line
- whether the line is insulated or bare
- the level of competence, training and authorisation of the person carrying out the work.

It is important to ensure no person, plant or thing comes within an unsafe distance of an underground electric line. Areas at a solar farm that may require an exclusion zone for underground electric lines include areas where underground cable is part of the electrical infrastructure used to transmit generated electricity from the solar farm to the transmission network.

Workers, and anything associated with a work task, must keep out or be kept out of the exclusion zone and at a safe distance from both overhead and underground lines unless it is not reasonably practicable to do so and the PCBU must comply with section 68(2) of the ES Regulation in relation to:

- conducting a risk assessment
- implementing control measures
- adhering to any requirements of an electricity entity responsible for the line.

Further information and guidance on exclusion zones can be found in the *Electrical safety Code of Practice - Working near overhead and underground electric lines* (exclusion zones).

3.5.9 DC voltage and current specific issues

Solar farms may have components of equipment that operate individually at a DC voltage that is below extra low voltage but when connected with other equipment operate above extra low voltage. For example, the standard PV array consists of PV modules with individual output which may be below low voltage, however, when connected in series, the PV array system may operate above extra low voltage.

In addition, DC voltages and currents are different to conventional AC voltages and currents. In conventional AC power systems, the AC cycles from a peak value down to zero then to the opposite

polarity peak and back to zero. For the Australian supply system this occurs 50 cycles per second (50Hz supply). For DC there is no cycling though zero and the current remains at the same peak value while there is a complete circuit. Breaking DC safely requires specifically designed devices. This means switch contacts for DC must be designed differently to those for AC and, due to the continuous arc across its contacts, AC rated switches may be destroyed if used on a DC circuit.

Another characteristic of PV modules, as distinct from a conventional power system or battery system, is the ability of the PV module to produce and sustain an electric arc with currents that are not greater than normal operating currents. They do not produce a higher overload current when a short circuit occurs (that is, PV modules can be considered as a 'constant current source'). This means there will be faults in the PV module circuits that will not produce an electric current fault level different to normal operation current, and so traditional overcurrent protection devices will not be effective in these situations.

The combination of DC voltages above extra low voltage, the nature of the electric current remaining at constant value, and no overcurrent occurring in some situations can result in the risk of fire or electric shock that need to be addressed and managed in the design and installation stages.

Control measures to manage these issues include:

- developing and implementing safe work procedures to ensure safe installation
- having suitable load break disconnector devices at appropriate places within the PV array
- having earth fault monitoring circuitry. For this circuitry to operate effectively the earthing circuit needs to be correctly installed
- use of arc fault detection and interruption devices as appropriate
- use of trained and licensed workers who are competent to perform the work, and who ensure the work results in:
  - properly torqued terminations
  - well installed and seated PV connectors of matching types
  - safe wiring installation
  - the weatherproof protection level being maintained once mounting is complete.

3.5.10 Arc flash

Arc flash is a specific electrical hazard that is present in high voltage installations and installations that have a high fault current or energy release. Arc flash occurs when electrical current passes though air between electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Arc flash can result in a significant release of energy and has the potential to cause catastrophic injury to people and damage to property.

Intensity, and the resultant harm to workers or other people nearby, of arc flash is dependent on various factors including the voltage, the arcing current, the arcing time, the amount of energy available, the distance from the arc, the location of the arc and other barriers that may direct the arc.

Arc flashes can be dangerous causing serious burns and electrocution and control measures must be implemented to avoid the risk. Control measures to manage the risk of arc flash include:

- ensuring terminals are insulated or shrouded to prevent inadvertent short circuiting of conductors and having adequate distances between terminals to reduce flashover possibility
- ensuring overcurrent protective devices are as close to the source of energy as possible and, if required, also placed inter-string to reduce the arc flash energy
- restricting access to areas of the installation where there is arc flash potential, such as fencing or separate rooms for the energy storage devices (separate rooms and enclosures should have fire ratings calculated based on arc flash potential)
- de-energisation of areas of the installation being worked on to prevent arc flash occurring
- where possible, designing the installation so it can be broken down into smaller segments to enable safer installation or maintenance
- signage indicating the calculated arc flash potential (in cal/cm^2) are located in the relevant parts of the installation to raise awareness of the risk

- use of appropriately rated personal protective equipment when working in areas that have potential for arc flash to occur. The PPE should be rated in accordance with the available energy from the flash, in cal/cm^2
- having, and ensuring maintenance of, adequate clearances between equipment and access ways to enable space for movement of people and plant ensuring all wiring and equipment insulation is rated to the highest voltage present in that part of the installation to prevent a breakdown of insulation
- adequate earthing
- ensuring swarf, dust and other materials are cleaned from switchgear during construction process and this is checked again prior to energisation
- implementing procedures to ensure equipment used in areas of arc flash potential are suitable (e.g. insulated to prevent inadvertent short circuiting).

4 Commissioning

Commissioning should be considered throughout the construction of solar farms due to the various inspections, tests and verifications required before the farm can become operational. While most commissioning occurs once the entire system is ready to be energised, commissioning may also occur in stages as separate parts of the installation are completed.

Commissioning may include physical commissioning (e.g. verifying PV modules are earthed and measuring voltage outputs of transformers) and digital commissioning (e.g. checking firmware and software versions and settings, and conducting software testing including operational and fault or scenario testing). Safe system of work must be established and implemented for all commissioning work.

A commissioning plan should be developed during the design of a solar farm and be included in the documentation provided by the designer. This plan should be followed by the PCBU and workers undertaking the commissioning. Any amendments to the plan (e.g. due to design variations or new information being made available) should be approved by the designer and be made prior to the commissioning being conducted.

Commissioning of the electrical installation, including inspection and testing, should be undertaken by the Electrical Contractor or licensed electrical worker(s) who performed the installation work. Alternatively, a licensed electrical worker acting on behalf of the initial installers may undertake the commissioning work if they have been informed of the specifics of the installation. Some tests and verifications may be conducted by other workers, such as an electrical engineer, where the testing relates to their profession (e.g. testing and adjusting trip setting of protection equipment), or where the testing does not interfere with the integrity of the electrical equipment (e.g. testing of non-electrical functions of the equipment by an equipment specialist).

Commissioning should include verification by the designer, or an appropriately registered engineer, that the construction of the solar farm complies with the design (and any approved design variations). The results of inspection and testing during commissioning should also verify that the operation of the solar farm aligns with the design. Verification should be documented and signed by the designer or registered engineer.

If commissioning occurs in stages (e.g. one part of the solar farm is commissioned and energised while other parts are still under construction) then, as each part is commissioned, all components of that section, from the PV module to the high voltage connection, must be tested, examined and verified. This includes physically sighting and signing off that the electrical work is electrically safe.

Any high voltage components of the installation must be inspected and verified by a high voltage accredited auditor as being electrically safe and compliant with safety standards. This must occur prior to connection to the transmission or distribution network. When commissioning is conducted in stages, a high voltage accredited auditor must inspect and verify each new section, including any modifications to existing sections and the impact on the existing high voltage installation.

If the solar farm contains any hazardous area electrical installations (e.g. a chemical based energy storage installation) they must be verified by a hazardous area accredited auditor as being electrically safe and compliant with safety standards prior to connection.

Commissioning should verify the solar farm:

- is electrically safe
- complies with AS/NZS 3000 (the wiring rules) and any other applicable standards
- has electrical connections to equipment correctly made (e.g. correct clamping of conductors in terminals and correct polarity)
- has equipment and structure earthing continuity within required limits
- has been installed in accordance with electrical and structural requirements and ratings for the location, and those ratings have not been compromised by installation processes
- is sufficiently robust (structurally and electrically) to operate for the specified lifetime
- operates as designed and performs in line with pre-determined parameters, including having correct protective device settings and operation
- complies with the transmission or distribution network provider's connectivity and safety requirements.

Visual inspection, testing and verification of all parts of the electrical installation must be conducted to ensure the installation is electrically safe. This visual inspection and testing must be carried out in accordance with section 8 of AS/NZS 3000 (the wiring rules) and any other relevant standards. These tests and verification should include:

- continuity of earthing
- insulation resistance
- polarity
- correct circuit connections
- verification of impedance required for automatic disconnection of supply (e.g. earth fault-loop impedance)
- correct operation of residual current devices (RCDs, also known as safety switches).

In addition, inspection and testing of high voltage installation parts should include:

- visual inspection
- continuity testing
- earth resistivity testing
- earth potential rise (EPR) measurement
- current distribution measurement
- transfer, touch and step voltage testing.

Other critical elements of a solar farm that should have inspection and testing include:

- power conversion equipment
- transformers
- switchgear
- lightning protection systems
- earthing protection systems
- earthing grids
- electrical protection systems
- grid connection protection systems
- control systems
- digital and software settings and operation
- monitoring systems (including meteorological sensors)
- communication systems
- support structure and tracking systems (where employed)
- PV modules, PV arrays and PV strings.

Visual inspection and testing of all modules, frames, and strings on the DC side of the PCE should include:

- polarity of all connections

- continuity of strings, sub-array and array connections
- suitability and continuity of all earth connections, including that all modules are earthed and that module frame earth connections are sufficient
- open circuit voltage and polarity of all string, sub-array and array voltages
- string short circuit current
- operational voltage and current of the PV array and strings
- insulation resistance between polarities of array wiring and array wiring to earth
- any earth fault protection, over current protection or fuses are correctly rated, have correct settings applied and operate in accordance with the design
- labelling is as specified in the design
- verification that the PV array switch-disconnector safely isolates the PCE from the array (including under load)
- verification of any sub-array switch-disconnector safely isolates the sub-array (including under load).

Test results from commissioning should be recorded and kept as part of the commissioning record. Commissioning records should be signed by the person(s) responsible for commissioning, be provided to the owner and operators of the solar farm, be kept for the life of the solar farm and be available for inspection by the regulator.

IEC standard 62446:2016 *Grid connected photovoltaic systems—Minimum requirements for system documentation, commissioning tests and inspection* is a useful reference for commissioning of PV solar farms.

During commissioning, consideration should be given to managing risks identified in section 3.4 (Non-electrical risks associated with the construction of a solar farm), section 3.5 (Electrical safety risks) and section 6 (General risks and workplace management), as these risks may also be applicable during commissioning. The requirements in section 1.3 (What is involved in managing risks), section 1.4 (Information, training, instruction and supervision), and section 3.2 (Safe work method statement and WHS management plan), may also apply.

4.1 Use of a high voltage accredited auditor

ES Regulation section 221: A person must not connect a high voltage electrical installation to a source of electricity after the electrical installation work has been performed unless the electrical work has been inspected by an accredited auditor and the accredited auditor has confirmed that the electrical installation, to the extent it is affected by the electrical work, has been tested to ensure it is electrically safe and complies with the requirements of the wiring rules and any other standard applying under the ES Regulation to the electrical installation.

Any electrical installation work associated with a high voltage installation at a solar farm must be inspected and verified as electrically safe by a high voltage accredited auditor prior to connection to the network. The high voltage accredited auditor must be independent (i.e. not involved in the design, installation or commissioning process) and should be engaged as soon as practicable after the design process is complete to enable a program of audit to be established.

Where a solar farm is developed in stages a high voltage accredited auditor should confirm that the additional stage has not compromised the electrical safety of the original stage. For example, where additional supply is being added to an already commissioned and operating high voltage transformer, the high voltage accredited auditor should confirm the transformer is not being overloaded, the isolation points remain adequate, clearance distances are not compromised and protection settings remain adequate.

A list of high voltage accredited auditors is available at https://www.worksafe.qld.gov.au/laws-and-compliance/accredited-electrical-auditors/high-voltage-installations-audits/find-a-high-voltage-installation-accredited-auditor.

4.2 Connection to the electricity network

Where a solar farm is being connected to an electricity network, the PCBU will need to meet the requirements agreed with the transmission or distribution electricity entity they are connecting to. These requirements should be established during the design stage in consultation with the transmission or distribution electricity entity (see section 2.7 - Network connection interface).

As part of the requirements for connection, the transmission or distribution electricity entity will need to verify the operation of their network remains electrically safe. This may include verification that the installation complies with the design and that all commissioning tests have been conducted.

Where commissioning is conducted in stages the transmission or distribution electricity entity may require re-verification of the electrical safety of the installation as each stage is connected.

5 Operation and maintenance

During the operation and maintenance of a solar farm PCBUs continue to have duties to ensure, so far as reasonably practicable, the farm does not pose a risk to the health and safety of people, property and livestock. This includes operational and maintenance workers and other people who are not employed at the solar farm but who may be affected by the conduct of the business or undertaking (e.g. farmers moving livestock between the frames).

Factors that should be considered during the operation and maintenance of solar farms include:

- electrical work performed during operation and maintenance
- inspection and testing requirements
- system monitoring and fault-finding requirements
- scheduled or preventative maintenance requirements, including:
  - cleaning requirements for PV modules and arrays
  - checking tightness and corrosion of electrical connections (to prevent arcing and fire)
  - checking integrity of structures (including PV module mounting)
- requirements for safe storage of excess generation
- security measures so members of the public cannot access the installation
- safety measures for other people who may be impacted by the operation and maintenance of the solar farm.

While standard operation or maintenance work is addressed in this section, upgrades or additions to an operational solar farm is not. Upgrades or additions should be undertaken as electrical installation work and apply the requirements of section 2 (Design), section 3 (Construction) and section 4 (Commissioning). Examples of upgrades or additions include:

- adding further PV arrays to the solar farm
- repositioning an existing PV array
- adding energy storage facilities
- upgrading parts of the solar farm with newer components that are not ‘like for like’ asset replacement (e.g. upgrading PV modules for newer more efficient modules that may affect the layout, number, or generating capacity of arrays).

During operation and maintenance, consideration should be given to managing risks identified in section 3.4 (Non-electrical risks associated with the construction of a solar farm), section 3.5 (Electrical safety risks) and section 6 (General risks and workplace management) as these risks may also be applicable during operation and maintenance. The requirements in section 1.3 (What is involved in managing risks), section 1.4 (Information, training, instruction and supervision), and section 3.2 (Safe work method statement and WHS management plan), may also apply.

5.1 Electrical work during operation and maintenance

ES Act section 29: An electricity entity has a duty to ensure that its works are electrically safe and are operated in a way that is electrically safe. This includes the requirement that the electricity entity inspect, test and maintain the works.

ES Act section 30: A person conducting a business or undertaking must ensure the business or undertaking is conducted in a way that is electrically safe.

ES Regulation section 195: A person, including an electricity entity, who designs, builds, maintains or operates works of an electricity entity must ensure that the requirements of this part for the works of an electricity entity are complied with.

During operation solar farms generate and supply electricity and electrical work performed may be either electrical installation work, electric line work, electrical equipment work, or works of an electricity entity.

Irrespective of the type of electrical work being performed during operation and maintenance the PCBU must ensure safe systems of work are established and implemented. The PCBU should also develop and implement a safety management system for the work (See section 5.2 - Safe systems of work and safety management systems).

Works of an electricity entity

Electrical work during operation and maintenance is works of an electricity entity if the solar farm is operating as a generation entity under an authority or special approval under the *Electricity Act 1994*. In this situation the requirements of 'works of an electricity entity' in the ES Act and ES Regulation apply. Solar farm operators operating as an electricity entity are not prescribed electricity entities under the ES Act as generation entities are excluded from the criteria for becoming a prescribed electricity entity.

Electrical work during operation and maintenance that is undertaken as 'works of an electrical entity' involves the same requirements as section 3.5.1 (Electrical work during construction of a solar farm) except for electrical work related to line work that is performed under the supervision of the electricity entity. As such, the following tasks are exempt from being electrical work:

- work associated with building an overhead line on structures that do not already carry an energised overhead electric line
- laying, cutting or sealing underground cables before initial connection to an electricity source
- recovering underground cables after disconnection from an electricity source.

Where electrical work during the operation and maintenance of solar farms is performed as 'works of an electricity entity', PCBUs must comply with the requirements of Part 9 of the ES Regulation. Further information on works of an electricity entity is provided in the *Electrical safety Code of Practice – Works.*

Electrical installation work, electric line work, electrical equipment work

If a solar farm is not operating as a generation entity under an authority or special approval under the *Electricity Act 1994* then electrical work performed during operation and maintenance continues to be electrical installation work, electric line work or electrical equipment work. As such, the requirements in section 3.5.1 (Electrical work during construction of a solar farm) continue to apply.

Despite not being a generation entity, PCBUs should ensure they also comply with Part 9 of the ES Regulation as part of their safe systems of work and safety management systems.

5.2 Safe systems of work and safety management systems

WHS Act section 19(3)(c): A person conducting a business or undertaking must ensure the provision and maintenance of safe systems of work.

ES Act section 29: An electricity entity has a duty to ensure that its works are electrically safe and are operated in a way that is electrically safe. This includes the requirement that the electricity entity inspect, test and maintain the works.

ES Act section 30: A person conducting a business or undertaking must ensure the persons business or undertaking is conducted in a way that is electrically safe.

All PCBUs operating a solar farm must ensure that safe systems of work are developed and implemented and ensure the business is conducted in a manner that is electrically safe. If a solar farm is operating as a generation entity under an authority or special approval under the *Electricity Act 1994*, the electricity entity must also ensure the 'works' are, and operate in a way that is, electrically safe. The 'works' must also be inspected, tested and maintained to be electrically safe.

To ensure safe systems of work, PCBUs should develop and implement a safety management system.

Safety management systems

The safety management system for a solar farm should address all safety hazards and control measures identified during the design phase and through risk assessments undertaken prior to work commencing. During operation and maintenance this includes content on:

- the hazards and risks identified and procedures for how these risks must be managed
- the level of qualifications, skill, experience or knowledge required to perform operation or maintenance work (e.g. when a licensed electrician is required to perform a task). This includes identifying required competencies and any training to be undertaken (including refresher training)
- procedures for isolation, switching and access to electrical installations and equipment where work is to be conducted on or near the electrical installation or equipment
- procedures for vegetation management, including around PV modules and arrays, high voltage equipment and overhead powerlines
- procedures for management of livestock, wildlife or vermin, if relevant
- procedures for inspecting and testing electrical connections for tightness and corrosion (to prevent arcing and fire)
- procedures for inspecting and testing the integrity of structures (including PV module mounting)
- procedures for fault condition monitoring and response
- procedures for cleaning PV modules by competent persons. This includes content on use of insulated equipment during cleaning and a competent person conducting safety inspections of PV modules prior to cleaning
- emergency response procedures
- a schedule for review and updating of safety procedures and processes, including when a design variation occurs or when safety standards are updated.

The safety management system should also include information on:

- processes for consultation, communication and reporting on the system. This includes during development, implementation and review of the safety management system
- identification of key personnel for approvals and sign off (including key responsibilities, accountabilities and authority levels)
- timeframes for initial and subsequent periodic assessment and validation of the safety management system by a competent person. This includes verifying the system is being implemented
- procedures for investigating and reporting safety incidents to management. This includes processes for obtaining management approval of corrective or preventative measures to be implemented.

5.3 Inspection, testing and maintenance

During operation and maintenance, the electrical installation and equipment must be inspected, tested and maintained to ensure it is electrically safe. Frequency of inspection, testing and maintenance is determined by several factors including the technology selected, manufacturer's instructions, environmental conditions at the site, warranty terms and seasonal variances. Maintenance and

equipment inspection and testing should be recorded and carried out at intervals planned in accordance with the manufacturer's recommendations and instructions, and as required by equipment warranties.

Scheduling of inspection, testing and maintenance should ensure that:
- the manufacturer's instructions for inspection, testing and maintenance are followed
- maintenance on equipment, cables, connections and structures is conducted based on the outcomes of system monitoring or a review of previous incidents and faults (see section 5.4 - System monitoring and fault finding)
- cleaning of insulators and verification of earthing connections is conducted on a regular basis factoring in local environmental conditions such as dust accumulation, humidity, rainfall, and vegetation growth
- required levels of electrical insulation and earthing is maintained
- asset maintenance, replacement and retirement plans are established
- safety related issues such as corrosion, stray currents and damage to earthing connections are periodically inspected.

Inspection, testing and maintenance should be undertaken by qualified, trained and, where required, licensed workers (noting it is mandatory for any electrical work to be performed by licensed electrical workers). Safe systems of work must also be established. This should include procedures for:
- maintaining safe clearances from live (energised) parts
- isolation and lock out to ensure equipment is de-energised and isolated before commencement of inspecting, testing and maintenance work
- electrical safety testing and verification before re-energising after electrical work is performed
- removal of workers from locations that may result in electric risk prior to re-energisation.

To ensure the safety of workers and other people on site, inspection, testing and maintenance work related to connecting or disconnecting from the transmission or distribution network, or that could affect the networks operation or safety, should be conducted in conjunction with the transmission or distribution electricity entity. Requirements for this type of inspection, testing and maintenance should be included in the agreement made with the transmission or distribution electricity entity at the design stage as a condition of connection to the electricity entity's network (see section 2.7 - Grid connection interface).

Records of inspection, testing and maintenance work and results should be kept on site and made available for inspection by the regulator.

Further information on inspection, testing and maintenance requirements is available in the *Electrical safety code of practice – Managing electrical risks in the workplace* and the *Electrical safety code of practice – Works*.

5.4 System monitoring and fault finding

Operation and maintenance of a solar farm must be conducted in a way that is electrically safe. This should include monitoring the installation to identify hazards such as:
- insulation faults in equipment due to over voltages
- overloads leading to overheating and fire or creating insulation failure
- loosening of connections or oxidization of contacts resulting in high resistance joints and subsequent overheating
- movement of structures or mechanical damage to moving parts causing misalignment, stress on connections or locking of motors resulting in overload, overheating or extended movement beyond design parameters
- water ingress into equipment and connections or moisture build up in sealed enclosures due to temperature fluctuations causing possible short circuit or DC arcing
- failure of fixings or cables and equipment causing electrical parts to dislodge and rub, wear or have live (energised) parts become exposed

- damage from environmental conditions, cyclones, hail, storms or lightning strikes causing breakdown of insulation, exposure of live (energised) parts, reduction or loss of earthing protection or reduction in clearance distances or insulating properties due to dust accumulation
- damage to PV modules causing water ingress and leaching of hazardous substances such as lead and cadmium that may be within the PV module if the PV module is not quickly replaced
- damage from wildlife or vermin
- damage from vandalism
- failure of protection or switching equipment
- ageing equipment failing at end of life or failing prematurely due to design or manufacturing tolerances or imperfections including:
  - solar module degradation
  - blocking diode failures
  - switchgear (DC isolator) failures
  - high voltage equipment failures.

Electrical faults should be investigated and rectified to avoid the risk of electric shock, fire, arc flash or explosion from:
- repeated failure of the electrical equipment due to the existing unrectified fault conditions
- re-energising while the existing fault is still present
- damage to electrical equipment that is not visible resulting in failure later
- further damage to other parts of the electrical installation due to excessive fault currents.

The operator of a solar farm should implement procedures to ensure:
- monitoring and fault finding is undertaken at regular intervals
- monitoring and fault finding is conducted by qualified, trained and, where required, licensed electrical workers
- all electrical equipment is operating within its design parameters and has not degraded (including from electrical, mechanical or environmental changes)
- the safe investigation, identification and rectification of faults prior to reconnection and energisation
- risk assessments for hazards are conducted, and safe work procedures are implemented, prior to any work being performed for monitoring and fault finding, or because of the monitoring and fault finding
- records are kept of all faults and a periodic review is undertaken to identify any systemic safety issues that need to be managed or to determine if current maintenance procedures and schedules require updating.

Procedures for emergency management during unscheduled failures or incidents (e.g. storm damage to PV modules or fires in or around the solar farm) should be identified, documented and provided to workers (see section 6.3 - Emergency planning and management).

5.5 Safe storage of excess generation

Energy storage systems may be used on solar farms to store excess electricity generated or to store electricity for later release to the transmission or distribution network. Energy storage may be part of the initial design of the solar farm or it may be installed on an existing solar farm. The type of risks resulting from energy storage will depend on the type of technology used and can include risk of:
- electric shock from exposed parts operating above extra low voltage
- fire from overheated parts not being rated for the electrical current released
- fire due to overcharge, undercharge, excessive discharge and overheating
- explosion from sudden uncontrolled release of energy or from ignitable gasses
- arc flash
- chemical hazards
- toxic vapours or fumes
- overload and damage to the network if energy release is not controlled in conjunction with the network operator.

The procedures for the installation and operation of energy storage systems should be recorded as part of the safety management system for the solar farm and ensure:

- the system complies with relevant equipment and installation safety standards or accepted industry guides
- manufacturer's installation instructions are followed
- operation (e.g. the amount and timing of energy export to the transmission or distribution network) is as agreed with the network operator
- overload protective devices are located as close as practicable to the output terminals of the energy source
- appropriate monitoring and alarms are used, to ensure no undercharge, overcharge, overheating or excessive discharge beyond the design parameters of the energy storage
- disconnection devices are installed to ensure isolation occurs before any maintenance work commences
- firefighting equipment and procedures are available
- emergency procedures are established to manage worker and equipment safety in the event of equipment failure or other unexpected situations.

5.6 Health and safety of other people at solar farms

WHS Act section 19(2): A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.

During solar farm operation and maintenance there may be other people on site other than electrical workers and operational staff, including:

- cleaners and general building maintenance staff (e.g. plumbers, air conditioning technicians and general maintenance workers)
- delivery drivers
- grounds staff (e.g. for lawn mowing and weed eradication)
- people tending livestock or managing wildlife or vermin
- people entering high voltage substation areas such as telecommunications repairers, meter readers and ground staff.

Depending on the activities undertaken, risks to other people may include:

- electrocution
- arc-flash and electric shocks
- mechanical hazards (e.g. contact with moving parts)
- vehicle collisions
- being trapped between or in equipment
- heat stress
- exposure to chemicals, fire, toxic fumes or explosion
- snake bites.

Other people should be informed of hazards relevant to the areas of the solar farm they are accessing and procedures to follow in an emergency. Clear instructions and safety signage should be provided to enable identification of restricted areas of the farm.

Means to control health and safety risks to other people may include:

- use of physical barriers (e.g. fences and locked gates) to prevent access to unauthorised areas
- implementing an access or permit process
- provision of information, training and instruction (including site specific induction training)
- a trained and authorised person accompanying the person while on site
- clear signage for vehicle and pedestrian pathways
- consideration during the design stage of the location of telemetry and telecommunications equipment so HV areas do not need to be accessed by other people such as repairers, meter readers and green keepers
- the provision of safety guidelines or safety pamphlets

- provision of information on emergency procedures.

6 General risk and workplace management

6.1 Remote and isolated worker management

WHS Regulation section 48: A person conducting a business or undertaking must manage the risks associated with remote or isolated work, including ensuring effective communication with the worker carrying out remote or isolated work.

The location and size of solar farms, and minimal staffing requirements once operational, often result in work on solar farms being remote and/or isolated from the assistance of other people. Assistance from other people includes rescue, medical assistance and emergency services.

Exposure to heat stress, snake bites and poor access to emergency services and first aid treatment are some of the main hazards that increase the risk of remote and isolated work at solar farms.

Examples of remote and/or isolated work at solar farms include:
- maintenance or field work carried out alone
- working in an area of the farm that is several kilometres from co-workers
- vegetation management
- site security patrols.

Planning is vital to ensure the health and safety of workers when working in remote or isolated locations or situations. Factors to consider when planning for remote work or isolated work include:
- suitability of communication equipment available for workers
- the training and competence of remote workers and the availability of safety equipment at the location
- means for managers to track the location of workers
- access to suitably qualified first aid personnel and emergency services.

Where workers are exposed to remote or isolated work PCBUs must provide a system of work that includes effective communication with the worker. This may include providing access to a telephone, radio or satellite communication system. Other mechanisms for controlling health and safety risks include:
- implementing a buddying system (e.g. maintenance is undertaken in teams of two or more workers)
- utilising distress beacons (e.g. activation of the beacon indicates that an emergency exists)
- maintaining worker movement records (e.g. implementing a call-in system with supervisors or colleagues)
- ensuring workers are trained in remote first aid (including treatment of snake bites)
- other training, information and instruction (e.g. training in communication systems and obtaining emergency assistance).

Further guidance on remote and isolated worker management is available in the *Managing the work environment and facilities Code of Practice*.

6.2 First aid

WHS Regulation section 42: A person conducting a business or undertaking must ensure the provision of first aid equipment for the workplace, that each worker has access to the equipment, and access to facilities for the administration of first aid.

An adequate number of workers must also be trained to administer first aid at the workplace or workers must have access to an adequate number of other persons who have been trained to administer first aid.

The size, location (often remote) of solar farms, and limited workforce once operational, mean standard methods for providing first aid and access to first aid facilities and equipment may not be suitable. The nature of the work being carried out at solar farms, which can often be high risk or involve risk of electric shock, and the nature of the hazards at the workplace (e.g. the potential of being bitten by a snake), also create variables which require consideration for the provision of first aid.

How access to first aid equipment and treatment is provided may vary during the life cycle of solar farms. For example, during the construction stage of the farm, there may be more workers on site which will mean more first aid resources are required. The size of the farm may also mean that first aid will need to be available in multiple locations (e.g. first aid facilities may be centrally located however first aid kits may be provided in each separate work area). Alternatively, once the farm is operational, and less workers are involved, a risk assessment may indicate that individual workers will need training in first aid and use of first aid equipment.

The distance of some solar farms from ambulance services, hospital and medical centres must be considered when determining first aid requirements. This is due to the potential for life-threatening injuries or illnesses to occur (e.g. electric shock) and that timely access to emergency services cannot be assured. Where distance to emergency facilities is an issue, a worker trained in more advanced first aid techniques (such as the provision of oxygen) is required.

Consideration should be given to providing access to an automated external defibrillator at solar farm worksites. Providing an automated external defibrillator can reduce the risk of fatality from cardiac arrest and is a useful addition for workplaces where there is a risk of electrocution. Importantly, automated external defibrillators should:

- be located in an area that is clearly visible
- be accessible
- not be exposed to extreme temperatures
- be clearly signed
- be maintained in accordance with manufacturer's instructions.

Where a solar farm is remotely located, consideration should be given to ensuring emergency personnel are able to access the farm (e.g. during the design stage, consideration should be given to providing a location on site that can be accessed by a helicopter for emergency retrieval).

Workers must be made aware of the location of first aid facilities and who is trained to administer first aid.

Further guidance on determining first aid requirements is available in the *First aid in the workplace Code of Practice*.

6.3 Emergency planning and management

WHS Regulation section 43: A person conducting a business or undertaking must ensure that an emergency plan is prepared for the workplace that provides for:

- emergency procedures, including an effective response to an emergency which includes evacuation procedures, notification of emergency services at the earliest opportunity, medical treatment and assistance, and effective communication between the person authorised by the person conducting the business or undertaking to coordinate the emergency response and all persons at the workplace
- testing of the emergency procedures, including how often they should be tested
- information, training and instruction to relevant workers in relation to implementing the emergency procedures.

Fire or explosion, dangerous chemical release, traumatic injury, medical emergency, arc flash and natural disasters (e.g. lightning strikes, flooding, storms, hail or cyclones) are some of the circumstances that may require an emergency response during the construction and operation of solar farms.

A PCBU must ensure that an emergency plan is prepared for the workplace. In preparing and maintaining an emergency plan, the following must be considered:

- work being carried out at the workplace
- specific hazards at the workplace
- size and location of the workplace
- number and composition of the workers and other people at the workplace.

The emergency plan should be tailored to the solar farm location and include emergency contact details and emergency response procedures that address each stage of the solar farm (i.e. construction, commissioning, operation and maintenance, and end of life). The plan should also address issues such as remote and isolated work if these circumstances apply. If the site does not always have workers present, emergency contact information should be displayed at the site entry on signage that is legible, durable and, if exposed to sunlight, UV resistant.

Emergency procedures should include details for access to, or from, the location, as well as access requirements for different parts of the installation. This includes:

- procedures for access by emergency responders
- procedures for evacuating people from the site
- procedures for both electrical and non-electrically licensed workers to safely access different areas of the site to repair damage after an incident
- location specific information such as:
  - helicopter landing facilities for evacuation of injured workers in remote or isolated situations
  - roof top installations having accessible stairways for emergency responders and evacuation.
- site control measures for during and after any emergency and for any part of the site that is damaged.

The emergency plan should also identify the hazards (e.g. electric shock, contact with hazardous substances, toxic fumes) that may occur following an incident and how to safely manage those hazards during the emergency. It should also include information on safe remediation procedures or clean-up work after the emergency.

Since most solar PV systems cannot be completely shut down, procedures should be implemented to ensure emergency responders are informed that all wiring and solar module components should be treated as though they are electrically energised.

The emergency plan should be reviewed annually and all workers trained on emergency procedures. A copy of the emergency plan should be provided to the local fire department and/or emergency responders. It is also beneficial to invite local emergency responders to visit the site to familiarise themselves with the solar farm, potential hazards, shut down procedures and emergency procedures. Further guidance on preparing emergency procedures is provided in the *Managing the work environment and facilities Code of Practice*.

6.4 Heat stress management

WHS Regulation section 40: A person conducting a business or undertaking must ensure, so far as is reasonably practicable, workers carrying out work in extremes of heat or cold are able to carry out work without risks to health and safety.

Exposure to heat stress-related injury and illness must be managed during the construction and operation of solar farms. Summer temperatures are often high and can increase in northern Queensland or inland locations where several solar farms may be located.

If not properly managed, exposure to high temperatures, high thermal radiation or high levels of humidity may cause heat-related injury and illness to workers. Hazards related to exposure to heat extremes include dehydration, heat exhaustion, heat stroke, and death. Symptoms of exposure to heat

stress include dizziness, fatigue, headache, nausea, breathlessness, clammy skin or difficulty remaining alert.

If it is not reasonably practicable to eliminate exposure to heat or cold, risks must be minimised. Control measures may include installing shade structures, task rotation, rest breaks, isolating workers from heat, or working during cooler hours of the day. Workers must have access to adequate, cool, clean drinking water (see section 6.6 - Work environment and facilities).

Outdoor workers should be provided with protection in adverse weather conditions (e.g. sunshades, sheds, caravans, tents and windbreaks). Protection against solar ultraviolet exposure is also important. This can be achieved by:

- organising outdoor work so workers carry out alternative tasks or work in shade during hot periods of the day
- providing personal protective clothing and equipment, such as a wide brim hat, long sleeved and collared shirt, long pants, sunglasses and sunscreen, and hard hat attachments.

PCBUs should monitor workers and ensure workers are trained to identify and report early symptoms of any heat-related illness.

Further guidance on identifying and managing the risks of working in heat can be found at https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-exposures/heat-stress or in the Safe Work Australia *Guide for managing the risks of working in heat*.

6.5 Fatigue management

PCBUs must ensure, so far as is reasonably practicable, workers are not exposed to health and safety risks. This includes ensuring that the risk of fatigue is managed.

Long construction hours, fly-in, fly-out or drive-in, drive-out worker contract arrangements, or maintenance undertaken at night or during off-peak hours, all create a risk of worker fatigue during the construction and operation of solar farms. Other factors that may increase the risk of fatigue include:

- early shift starts
- late finishes
- short breaks between shifts
- long hours due to emergency response (e.g. during natural disasters)
- work requiring continued physical effort
- environmental conditions such as working in hot climates.

Fatigue can adversely affect safety at the workplace through reduced alertness and may lead to errors and an increase in incidents and injuries. The following are signs or symptoms that may indicate a worker is fatigued:

- excessive yawning or falling asleep at work
- short term memory problems and an inability to concentrate
- noticeably reduced capacity to engage in effective interpersonal communication
- impaired decision-making and judgment
- reduced hand-eye coordination or slow reflexes
- other changes in behaviour (e.g. repeatedly arriving late for work)
- increased rates of unplanned absence.

The best way to control the risk of fatigue is to eliminate factors causing fatigue. However, if elimination is not reasonably practicable, the risks must be minimised. Control measures to minimise the risk of fatigue include:

- developing a working-hours policy including maximum daily work hours, maximum average weekly hours, maximum hours over a selected period (e.g. three months) and policies for on-call work and work-related travel including consideration of the impact of long travel requirements (e.g. fly-in fly-out flight times) on worker fatigue
- developing procedures to manage and limit excessive working hours (e.g. requiring minimum breaks on a regular basis, especially during longer shifts)

- avoiding work arrangements which provide incentives to work excessive hours
- considering if night work is necessary and rearranging schedules so non-essential work is not carried out at night
- encouraging workers to report work-related fatigue concerns
- developing contingency plans for situations where workers unexpectedly need to work longer hours, more shifts or a long sequence of shifts (e.g. in response to natural disasters)
- avoiding work during periods of extreme temperature or minimise exposure time through job rotation
- developing a fatigue policy for all workers including managers and supervisors.

Further guidance on identifying and managing the risks of fatigue is available in the Safe Work Australia *Guide for managing the risk of fatigue at work*.

6.6 Welfare facilities including drinking water

WHS Regulation section 41: A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the provision of adequate facilities for workers, including toilets, drinking water, washing and eating facilities. These facilities must be in good working order, clean, safe and accessible.

When considering how to provide and maintain facilities that are adequate and accessible, a person conducting a business or undertaking must consider all relevant matters including:
- the nature of the work being carried out at the workplace
- the nature of the hazards at the workplace
- the size, location and nature of the workplace
- the number and composition of the workers at the workplace.

Access to adequate facilities must be provided to all workers at a workplace. Key facilities that must be provided include toilets, drinking water, washing and eating facilities. This applies during all stages of a solar farm when workers are present, including during construction, commissioning, operation and maintenance and end of life management.

All welfare facilities should be provided within a reasonable distance of where work is being performed.

Drinking water

The potential for exposure to heat stress-related injury and illness while working at solar farms means that access to an adequate supply of clean drinking water is a priority.
A readily accessible and plentiful supply of drinking water must be available to all workers. Ice, or an alternative method for cooling the water, should also be provided. The site water tapping, complete with hose bib-tap, should be installed at the earliest opportunity.

Where a mains water supply connection is not possible, drinking water may be provided using flasks, labelled water containers, water bottles or similar. However, mains water supply should be provided at the earliest possible time if reasonably practicable to do so.

Drinking water facilities should be separated from toilet facilities to ensure adequate hygiene.

Further guidance on drinking water and welfare facility requirements can be found in the *Managing the work environment and facilities Code of Practice*.

6.7 Working with hazardous chemicals

WHS Regulation section 346: A person conducting a business or undertaking must ensure that a register of hazardous chemicals at the workplace is prepared and kept up to date. The register must be

readily accessible to workers involved in using, handling or storing hazardous chemicals and to anyone else who is likely to be affected by a hazardous chemical at the workplace.

WHS Regulation section 344 (1): A person conducting a business or undertaking must obtain the safety data sheet (and any amended version) for a hazardous chemical from the manufacturer, importer or supplier no later than when the chemical is first supplied at the workplace or as soon as practicable after it is first supplied but before it is used at the workplace.

WHS Regulation section 344 (3): A person conducting a business or undertaking must ensure the current safety data sheet is readily accessible to workers who use the hazardous chemical at the workplace and an emergency service worker, or anyone else, who is likely to be exposed to the hazardous chemical.

Solar farms may incorporate energy storage facilities to enable solar energy to be stored and sent to the transmission or distribution network when it is needed or when there is no generation of solar energy, for example at night. Energy storage systems can contain hazardous chemicals, for example nickel and cobalt, depending on the type of storage system used.

A hazardous chemical register must be kept listing all product names of hazardous chemicals used, handled or stored at the workplace accompanied by a current safety data sheet for each hazardous chemical listed. It must be updated as new hazardous chemicals are introduced to the workplace or when the use of a hazardous chemical is discontinued.

The safety data sheet contains information on the identity of the product and any hazardous ingredients, potential health effects, toxicological properties, physical hazards, safe use, handling and storage, emergency procedures, and disposal requirements specific to the chemical.

If the safety data sheet for a hazardous chemical is not supplied, you must contact either the manufacturer, importer or supplier to obtain one before the chemical is used at the workplace.

Further information on managing the risks of hazardous chemicals can be found in the *Managing risks of hazardous chemicals in the workplace*.

6.8 Access during construction, operation and maintenance

Various PCBUs and workers will require access to a solar farm during its life cycle. Access to a solar farm should be restricted to minimise the risk of unauthorised or uncontrolled entry to the farm. Control measures to minimise the risk of unauthorised access should be implemented prior to construction of the solar farm commencing. These measures should be regularly reviewed and if necessary revised to ensure the method of restricting access is appropriate for the life cycle stage of the farm.

Different levels of access for different areas of the solar farm may need to be instigated to manage specific risks. For example, there are different risks associated with high voltage areas in the substation section of a solar farm, high DC voltages in the PV array sections of the solar farm and potential hazardous areas if there is energy storage used at the solar farm.

Procedures for access during emergencies should also be developed (See section 6.3 - Emergency planning and management).

During construction

WHS Regulation section 298: A person with management or control of a workplace at which construction work is carried out must ensure, so far as is reasonably practicable, that the workplace is secured from unauthorised access.

During construction of a solar farm, the workplace (or ‘construction site’) must be secured from unauthorised access. This may include ensuring the site is adequately fenced off, clearly indicating the perimeter of the site with signage, or implementing an access or permit system.

In considering what measures should be implemented to prevent unauthorised access, the person with management or control of the workplace should have regard to:

- the risks to health and safety arising from unauthorised access to the solar farm
- the likelihood of unauthorised access occurring
- to the extent that unauthorised access cannot be prevented, how to isolate hazards within the solar farm.

During operation and maintenance

Once the solar farm is operational, procedures for accessing the site should be included in the safety management system.

Restriction of access should factor in the location and ongoing risks at the solar farm. For example, perimeter fencing, security patrols and/or remotely monitored surveillance cameras may be suitable.

Where unauthorised access cannot be prevented, or methods to restrict access are circumvented, consideration should be given to isolating hazards to minimise risks to health and safety.

6.9 Q fever risk at solar farms

Q fever is an infectious disease that is spread from animals to people by the bacteria *Coxiella burnetii*. Where solar farms are constructed in a remote or regional location there is a potential for exposure to Q fever if work is conducted on land that was previously grazed by livestock (e.g. cattle, sheep, goats) or was previously, or is currently, inhabited by kangaroos and wallabies.

The bacteria that cause Q fever can survive in soil and dust for months for years and the risk of being exposed to Q fever occurs if contaminated soil becomes airborne and is inhaled by someone who does not have immunity to Q fever. Immunity is acquired from previous infection with, or vaccination against, Q fever.

The potential to be exposed to Q fever is highest during construction (e.g. during earthworks). There is also a risk during operation, although less likely, when soil is disturbed (e.g. from mowing or slashing grass in areas inhabited by kangaroo or wallaby).

In determining whether there is a risk of exposure to Q fever at a solar farm PCBUs should consider:

- Has the land previously been used by livestock (e.g. cattle, sheep, goats)?
- Has the land previously been, or is it currently, inhabited by kangaroos and wallabies?
- Does the work cause soil disturbance (e.g. earthworks or lawn mowing)?
- Have steps been taken to manage the potential risk of Q fever (e.g. seeking medical advice about Q fever vaccination, implementing a Q fever screening and vaccination program for at-risk workers where indicated, and using supporting control measures such as dust suppression to minimise airborne dust)?

Further information on the risk of exposure to Q fever, and prevention and control measures, can be found at https://www.worksafe.qld.gov.au/construction/workplace-hazards/q-fever-risks-and-construction-work.

6.10 Waste management

PCBUs should ensure risks to health and safety associated with the storage, movement and disposal of materials and waste at solar farms is managed during each stage of development, including operation and end of life management. This may include:

- disposal of cardboard waste from PV modules by bundling and binding the cardboard for recycling
- ensuring waste materials are not stored in a manner that could cause build up around transformers and compromise exclusion zones

- ensuring excess metal structural parts (e.g. metal poles, rods or the like) are not moved, stored or lifted in areas where contact with overhead powerlines could occur
- management of exposure to hazardous substances (e.g. damaged PV modules leaching lead or cadmium).

There may also be other legislative requirements applicable for waste management depending on the type of waste and processes used to manage the waste (e.g. if burning off waste products there may be permits or other requirements related to health regulations, environmental protection or fire management).

7 End of life management

The operational lifespan of a solar farm typically ranges from 20 to 30 years depending on the climatic conditions of the site, the maintenance regime employed and any maximum timeframe for use conditioned in the planning approval.

End of life management acknowledges that there are options and decommissioning may not be the only outcome. This is due to large-scale solar technology being relatively new in Queensland and few examples to date where a large-scale solar farm has been decommissioned. It is therefore assumed that at the end of the solar farm's operational lifespan, the solar farm will be either:

- refurbished and upgraded for continued operation
- decommissioned by removing the PV modules, infrastructure and remediating the land.

The health and safety risks associated with end of life management of solar farms are the same as the risks associated with the construction and installation of solar farms and therefore the same duties and obligations to manage risks to health and safety apply.

Depending on the approach to end of life management, work involved in refurbishing or decommissioning a solar farm may include:

- installing newer and more efficient collectors (either PV modules or mirrors) as technology evolves
- removal of infrastructure from the site
- disposal of components
- recycling or re-use of PV modules
- stabilisation of land and soil remediation
- revegetation works
- returning the site to its previous use.

A decommissioning plan should be developed as part of the solar farm design to enable the farm to be left electrically safe. This includes procedures for the safe disconnection of high voltage installations, transmission terminals, substations and the general electric installation.

Due to the unique generation aspect of solar farms (i.e. if there is sunlight on the solar modules they will generate electricity), a safe system of work for de-commissioning or installing newer modules is required to ensure the work can be undertaken in a manner that is electrically safe. The PCBU should also ensure the farm is left in a way that will not cause harm to health and safety after end of life or when the generating capacity is no longer required.

Simple disconnection from the transmission or distribution network and isolation of inverters from the transmission systems will not remove all electrical safety risks. Similarly locking out switchgear (DC isolators) controlling the PV arrays will not stop the PV modules from generating electricity.

Procedures for de-commissioning should ensure electrical risk from the PV module is removed. Simply breaking down the PV strings to extra low voltage may not remove all the risk. Additionally, in the event of an insulation fault, PV modules, even at extra low voltage, can still produce sufficient electrical current to produce electrical arcing and subsequent fire risk.

Factors to consider for safe decommissioning and a safe electrical installation after decommissioning include:

- site security and access restrictions
- isolation from the transmission or distribution network and the generation of electricity
- methods to disconnect from the transmission or distribution network
- shut down procedures for the PV array, string, and modules
- safe isolation of any energy storage equipment
- safe isolation and removal of parts of the installation (other than the PV modules)
- safe procedures for removal of the PV modules noting that PV modules will generate electricity while they are exposed to sunlight and that even at extra low voltage there may still be a risk of arcing
- use of appropriately trained, experienced and licensed workers, as appropriate, to perform the work
- if the PV modules are not removed, the installation must be left electrically safe so that the modules are not affected by age, environmental conditions, or the requirement for any further maintenance
- PV modules should be carefully handled during decommissioning as damaged modules may release hazardous substances used in the manufacture of PV cells, for example lead and cadmium.

During end of life management consideration should be given to managing risks identified in section 3.4 (Non-electrical risks associated with the construction of a solar farm), section 3.5 (Electrical safety risks) and section 6 (General risks and workplace management) as these may also be applicable during this stage. The requirements in section 1.3 (What is involved in managing risks), section 1.4 (Information, training, instruction and supervision), and section 3.2 (Safe work method statement and WHS management plan), may also apply.

Appendix 1: Dictionary

Competent person	A person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.
Earthing connection	A connection for: • protective earthing for a path for fault currents, or • equipotential bonding to avoid uneven potentials across an installation. It applies to exposed metal or exposed conductive parts.
Electricity entity	means: • a generation entity, transmission entity or distribution entity, or • a special approval holder that is authorised under the *Electricity Act 1994* to do something that a generation entity, transmission entity or distribution entity may do under that Act.
Engineer	A person who is: • a registered professional engineer under the *Professional Engineers Act 2002*, and • is competent to perform the task.
Generation entity	means: • a person who holds a generating authority under the *Electricity Act 1994*, or • a special approval holder that is authorised under the *Electricity Act 1994* to do something that a generation entity may do under that Act.
Hazardous manual task	A task that requires a person to lift, lower, push, pull, carry or otherwise move, hold or restrain any person, animal or thing involving one or more of the following: • repetitive or sustained force; • high or sudden force; • repetitive movement; • sustained or awkward posture; • exposure to vibration. (WHS Regulation, schedule 19)
Person conducting a business or undertaking (PCBU)	See section 5 of the *Work Health and Safety Act* 2011 and section 21 of the *Electrical Safety Act 2002*.
Power conversion equipment (PCE)	An electrical device converting one kind of electrical power from a voltage or current source into another kind of electrical power with respect to voltage, current and frequency. Examples include DC to AC converters (also known as inverters), DC to DC converters and charge controllers.
Prescribed electricity entity	An electricity entity, other than a generation entity, declared under a regulation to be a prescribed electricity entity (see schedule 6 Prescribed electricity entities, *Electrical Safety Regulation 2013*).
Professional engineering service	An engineering service that requires, or is based on, the application of engineering principles and data to a design, or to a construction, production, operation or maintenance activity, relating to engineering, and does not include an engineering service that is

	provided only in accordance with a prescriptive standard (see schedule 2 Professional engineers Act 2002).
PV array	An assembly of electrically connected PV modules including all components up to the DC input terminals of the power conversion equipment. It includes PV modules connected in series or parallel. It does not include the support structure or other such components except to the extent of any parts required for earthing circuits. PV array is also known as solar array, PV string, PV sub-array
PV module	The smallest complete environmentally protected assembly of interconnected photovoltaic cells that generates electrical power. PV module is also known as solar panel or PV panel.
Remote or isolated work	See section 4.2 Remote or isolated work in *Managing the work environment and facilities Code of Practice.*
Training person	A person who is undertaking, but has not finished— • an apprenticeship under the *Further Education and Training Act 2014*, in a calling that requires the person to perform electrical work; or • a training program approved by the regulator that requires the person to perform electrical work. A Training person includes an electrical apprentice.