View

Site Survey Report

As discussed previously, the information gathered over the course of the site survey must be documented, and compiled into a final report for presentation to the client, and to the system designer. It is important that the information is presented neatly, and in a format that is easy to navigate, read, and understand.

Enterprises undertaking site surveys will typically have their own reporting templates to complete. In general, a formal site survey report should include the following sections:

Site Survey Final Report		
Section		**Contents**
1.	Overview	• Summary of the site survey objectives, purpose and goals. • Scope and objectives of the site survey.
2.	Site Details	• Location – street address, latitude and longitude. • Size, boundaries, ownership and land use.
3.	Methodology	• Brief description of the methods used to survey the site. • Sources and types of data to be collected.
4.	Existing Energy Infrastructure	• Details of existing energy services. • Details of existing electrical infrastructure.
5.	Energy Assessment	• Evaluation of energy needs and usage patterns at the site. • Recommendations for reducing energy usage at the site (if required).
6.	Photovoltaic (PV) Assessment	• Evaluation of solar resource. • Proposed locations for PV array, inverter and BoS equipment (including photographs). • Details of roof structure and/or ground mounting methods (including photographs). • Approximate PV sizing options based on available space. • PV system options, including technology, upfront costs, payback period etc.

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7.	Battery Storage Assessment	• Proposed locations for batteries, inverter and BoS equipment (including photographs). • Approximate battery system sizing options. • Battery system options, including technology, upfront costs, payback period etc.
8.	Regulatory Requirements	• Details of required permits and approvals. • Details of applicable regulations and standards.
9.	Appendices	• Relevant site plans or other installation drawings. • Relevant equipment specifications. • Relevant detailed calculations (e.g. for determining solar resource, system sizing, payback periods etc.).

Client Consultation

Upon completion of the final site survey report, a copy should be provided to the client. The structure of the report should be clearly explained, as well as the associated PV and battery system options.

During the consultation, the upfront costs, energy savings, and estimated payback periods should be explained for each of the specified options. Any questions the client has should be answered and the relevant section of the report referenced.

This learning activity consists of 2 parts designed to develop your understanding of how to document and present site survey information for the client and system designer.

Topic 6.3 Learning Activity

In this skills practice, you are required to undertake a site survey, document outcomes and present them to the client (teacher/trainer).

Topic 6.3 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the techniques to survey a premises to determine viability for a grid-connected solar and/or battery installation, including evaluating solar resource and roof structure.

Topic 6 Content Quiz

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Solar Radiation Parameters

The quantity of electrical energy produced by a photovoltaic (PV) cell depends on:

- The quantity of solar energy arriving at the surface of the PV cell.
- The system losses.

In order to maximise the quantity of solar energy collected by a PV cell, the cell must be positioned so that it is facing the optimal direction, at the optimal angle. Shading and the build-up of dirt on the surface of a PV cell can reduce the quantity of solar energy collected.

Irradiance and Irradiation	
Irradiance (G)	The quantity of solar power available at a surface at any instant in time, measured in watts per square meter (W/m^2).
Irradiation (H)	The quantity of solar energy available at a surface over a given time period, measured in kilowatt hours per square meter (kWh/m^2).

Solar Radiation Terms

The following table defines some terminology that you will need to know to understand this topic.

Solar Radiation Terms	
Term	**Definition**
Sunshine hours	Sunshine hours are the average hours of sunlight received at a location (e.g. a city) over a given time period (e.g. a day, a month or a year).
Solar window	The solar window is the area of the sky through which the sun moves throughout each yearly cycle.
Latitude	Latitude is a coordinate indicating the north-south position of a point on the earth.

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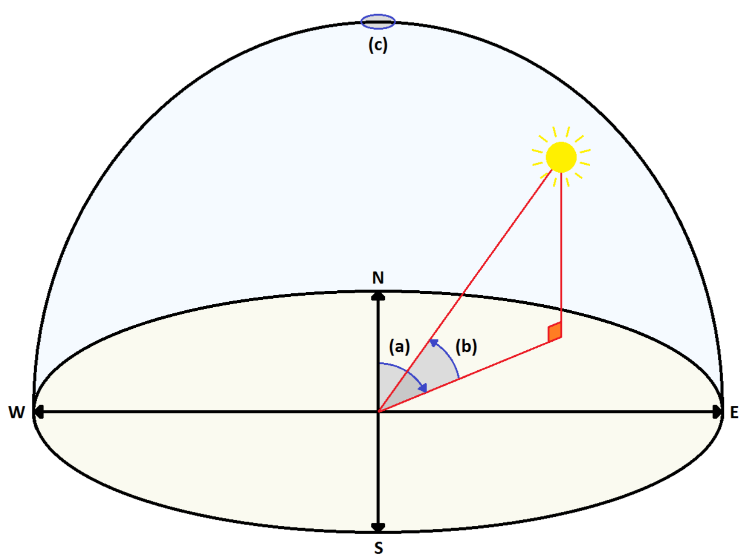
Longitude	Longitude is a coordinate indicating the east-west position of a point on the earth.
Zenith	The zenith is a point directly above a location.
Azimuth angle	The azimuth angle is the angle between the sun and true north in a clockwise direction. Applied to a PV array: • An azimuth angle of 0 degrees indicates that the array faces due north. • An azimuth angle of 180 degrees indicates that the array faces due south.
Altitude angle	The altitude angle is the angle between the horizon and the sun.
Tilt angle	The tilt angle is the angle between the horizontal plane and the plane of a photovoltaic module.

The following diagram shows how the Zenith, azimuth and altitude angles relate to a given point.



(a) Azimuth Angle (b) Altitude Angle (c) Zenith

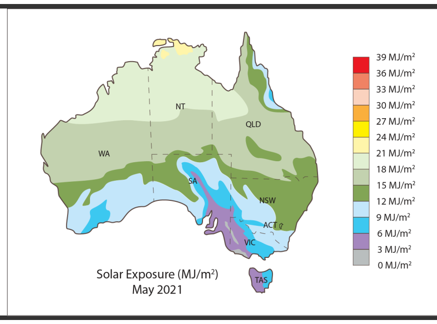
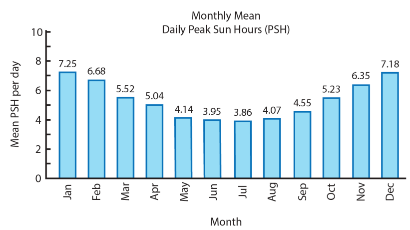
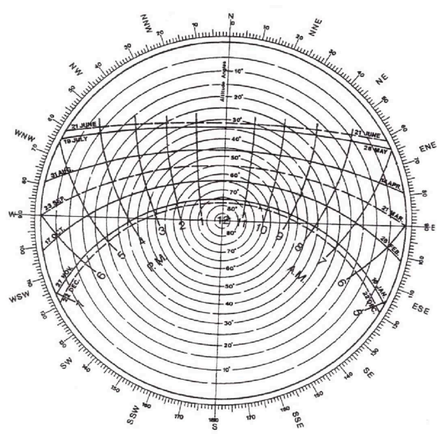
Solar Radiation Data

Solar data is available in a range of forms, for a number of purposes. The primary reasons for analysing solar radiation data in relation to a PV installation are to:

- Determine optimal locations and positioning of PV arrays.
- Estimate or analyse PV system power output.

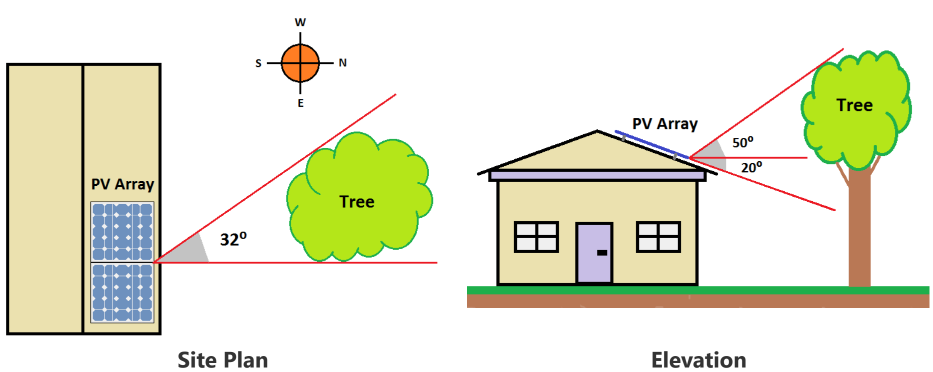
Some common methods of presenting solar data are shown in the following table.

Solar Radiation Data

Type	Example	Description
Solar Contour Maps		Solar contour maps can be sourced from the Bureau of Meteorology (BOM), to show data such as daily solar exposure and average daily irradiation.
Irradiation Charts		Solar analysis software/apps can be used to produce charts of average irradiation across a given span of time. The chart pictured shows the monthly mean irradiation at a given site over a 12 month period.
Sun Path Diagrams		A sun path diagram shows the path of the sun at a given latitude. Sun path diagrams are useful during the design of a PV installation as they can be used to determine the times and dates at which a PV array will become shaded by objects in the vicinity. Guidance on the use of sun path diagrams is provided below.

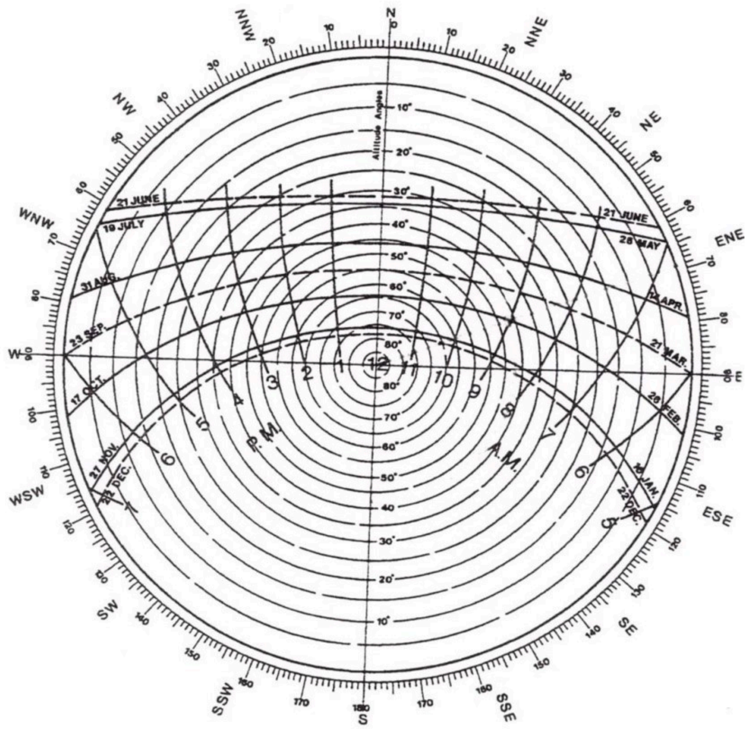
Sun Path Diagrams

To examine how to use a sun path diagram, consider the following scenario of a PV system installed at a latitude of 35^0 south.



A sun path diagram for the given latitude can be used to determine when the array will be shaded by the tree (for the purposes of this exercise, we will assume that the tree is regularly maintained so that its size remains the same throughout the year).

A sun path diagram at a latitude of 35^0 south is shown below. The curved lines across the circular dial represent the solar window, with specific curves representing the specific path of the sun across the sky for particular dates.

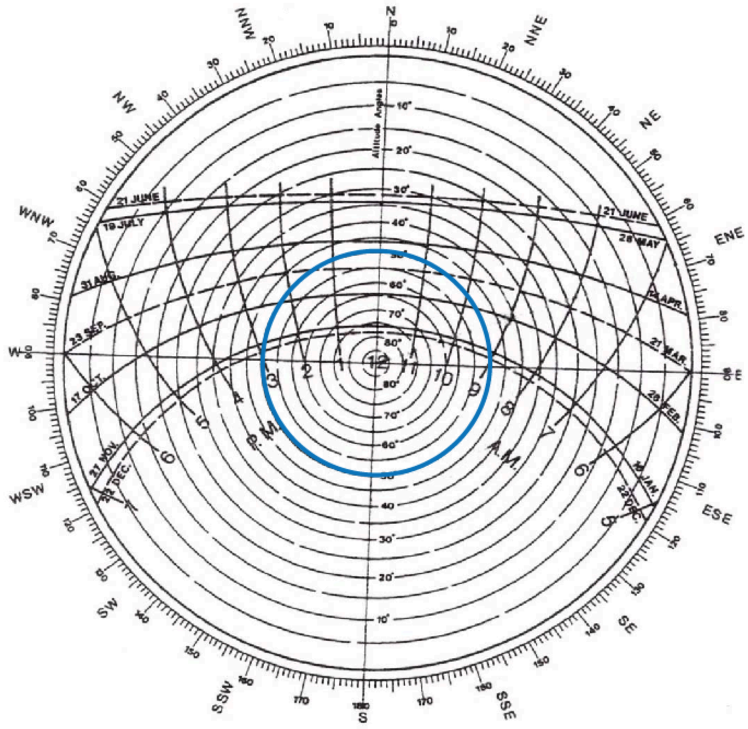


Latitude 35^{o} south

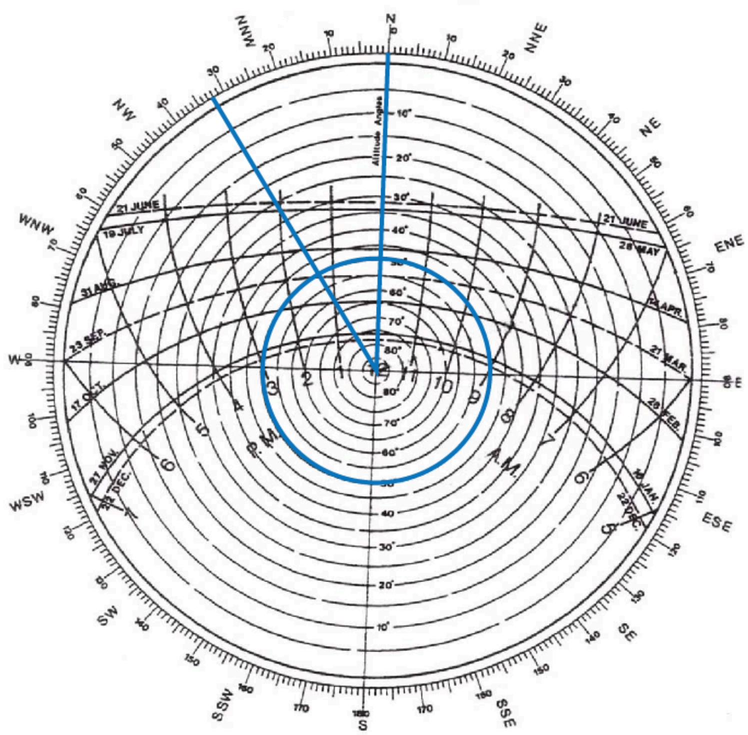
To determine shading, we must take the altitude angle and the azimuth angle into account. In this scenario, the array will become shaded at any time when both of the following occur:

- The altitude angle of the sun is less than 50^0, i.e. when the sun drops below the angle of elevation between the array and the tree.
- The azimuth angle of the sun is between 0^0 (N) and 32^0 (NNW), i.e. when the sun is at a point that puts the tree between the sun and the array laterally.

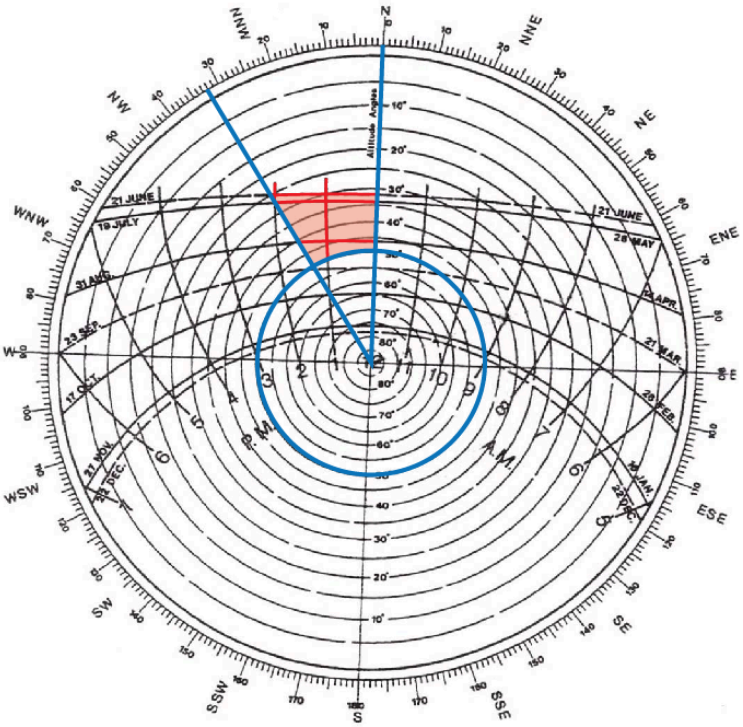
The altitude angle of the sun is indicated by the concentric rings of the diagram, so we can indicate the angle of tree elevation on the diagram by drawing a circle at the 50^0, shown below:



Next, we can indicate the lateral angle by drawing lines from the centre of the diagram out to the edges in the appropriate cardinal directions (i.e. North, South, East, West etc.). Noting the orientation of the site plan, it can be seen that the lateral angle in this scenario stretches from dead North (0^0) to 32^0 West of North. This is indicated as follows:



From this, we can highlight the portion of the solar window during which the array will become shaded – that is when the altitude angle of the sun is less than 50^0 ***and*** the azimuth angle of the sun is between 0^0 (N) and 32^0 (NNW) – indicated in red below:



From here we can determine the actual times and dates during which the array will be shaded (assuming the tree is maintained at its current size throughout the year). The following table summarises the results.

Months	Shading
1st Jan – 21st Mar	The array is not shaded by the tree.
21st Mar – 14th Apr	The array starts to become shaded for a short period each day, increasing to a period of approximately 1.5 hrs on 14th April – between 12 pm and 1:30 pm.
14th Apr – 28th May	Shading starts at 12 pm each day, and increases from 1.5 hrs per day to 2 hrs per day on 28th May.
28th May – 19th Jul	The array is shaded for approximately 2 hrs per day – between 12 pm and 2 pm.
19th Jul – 31st Aug	Shading starts at 12 pm each day, reducing from 2 hrs per day to 1.5 hrs per day on 31st August.
31st Aug – 23rd Sep	Shading reduces from 1.5 hrs per day to nothing on 23rd of September.
23rd Sep – 31st Dec	The array is not shaded by the tree.

Positioning PV Arrays

The solar radiation arriving at the surface of a particular fixed PV panel can vary throughout the year due to various factors. The following factors need to be taken into consideration:

PV Array Setups	
Seasonal change	Seasonal changes will result in variations in the angle of incident solar radiation on the panel.
Shading and soiling	Shading and soiling will act as a barrier to solar radiation arriving at the surface of the panel.
Cloud cover	Cloud cover will reduce the amount of direct solar radiation arriving at the panel.
Time of day	The quantity and angle of incidence of solar radiation will vary throughout each day as the sun moves through the solar window.

To obtain maximum irradiation on any given day in Australia, PV arrays should be mounted facing (true) north, at a tilt of approximately 20^0 to 30^0. If north facing roof space is not available, the following factors should be considered when selecting the most appropriate location:

- Shading.
- Ventilation.
- Ease of maintenance.
- Method of mounting.
- Length of the cable run.
- Aesthetics.
- Council regulations.
- Heritage considerations.

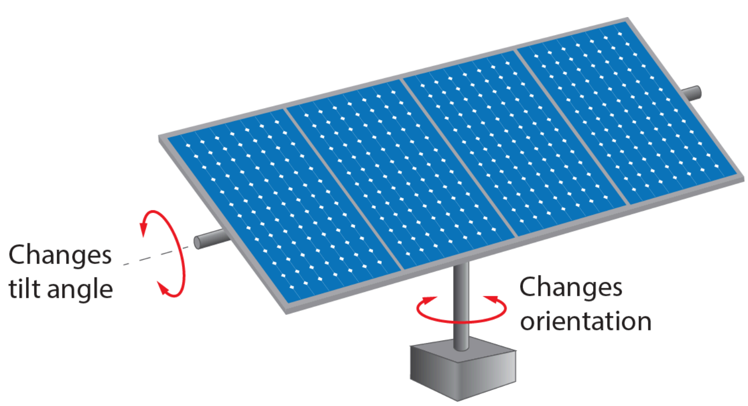
Solar Tracking

Solar tracking systems are designed to automatically adjust the tilt and orientation of a PV array to follow the position of the sun throughout the day.

There are two main types of solar tracking systems:

- Single-axis – adjusts orientation from east to west to follow the sun's path across the sky.
- Dual-axis – adjusts both orientation and tilt to track the sun's movement throughout the day and throughout the year.

The following diagram shows an example of dual-axis tracking:



The effect of solar tracking is to optimise irradiation of the array throughout the day, thereby increasing total energy production. However, there are also some downsides to solar tracking, such as:

- Higher cost.
- More maintenance required.
- Consumes some energy.

Due to these downsides, solar tracking is typically only practical and cost effective for large-scale PV installations.

This learning activity consists of 9 parts designed to develop your understanding of solar terminology, methods used to determine the availability of solar energy, factors affecting the irradiation of PV arrays, and how irradiation can be maximised.

Topic 6.2 Learning Activity

In this skills practice, you are required to determine the solar access for a PV array installation site at your location, and to determine an appropriate position, orientation and tilt angle for a proposed PV array.

Topic 6.2 Skills Practice

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Introduction

In this topic you will learn about how to undertake a site survey to determine viability for grid-connected solar and/or battery storage. This will include evaluating the solar resource at the site, evaluating the roof for suitability to support a PV array, and evaluating the site for suitability for battery storage.

PV Survey Factors

There are several key factors that will determine how suitable a given site is for the addition of a grid-connected PV array. The following table describes what to look for when surveying a site.

PV Survey Factors		
Factor	**Questions to Answer**	**Methods**
Solar Resource	• What is the irradiance at the site? • What is the longitude and latitude?	• Review solar and GPS data.
Climate	• What temperature range will the panels need to operate at? • Will the panels be exposed to strong winds? • Will the panels be exposed to hail or snow?	• Review historical climate data. • Consult the client.
Available Space	• Can the array be placed in a north-facing position? • For a roof space, what is the pitch of the roof? • Are there any obstructions or potential sources of shading? • How many panels would fit in the available space? • Are roof structures capable of supporting an array? • What type of structure and material will the array be fixed to? • Are there suitable locations for inverters and BoS equipment?	• Walk-through inspection of the site. • Safely access the roof and internal roof space.
Access to Equipment	• Will there be any issues accessing equipment for safe operation and ongoing maintenance?	• Walk-through inspection. • Consult the client.

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Economic Factors	• What is the client's budget for the system? • Are there any government incentives, credits or rebates? • What are the import and export tariffs? • What is the projected lifespan of the array? • What are the potential costs and payback periods?	• Consult the client and relevant authorities. • Review equipment specifications. • Perform calculations.
Local Requirements	• Will the energy metering at the site need to be upgraded? • Are there any local network provider requirements or restrictions? • Are there any applicable local council rules, regulations or permits?	• Inspect metering. • Consult relevant authorities.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Battery Storage Survey Factors

There are several key factors that will determine how suitable a given site is for the addition of grid-connected battery storage. The following table describes what to look for when surveying a site.

Battery Storage Survey Factors		
Factor	**Questions to Answer**	**Methods**
Energy Usage and Needs	• What is the energy usage pattern at the site? • What is the peak demand? • Does the site require continuity of supply in the event of grid failure? • Will the batteries be interconnected with other alternate energy supplies (e.g. PV array)?	• Consult the client. • Review energy bills.
Location and Climate	• Are there suitable locations for the batteries and BoS equipment? • What temperature range will the batteries be exposed to? • Will auxiliary cooling systems be required? • Will the batteries be exposed to rain, hail, snow or strong winds?	• Walk-through inspection of the site. • Review climate data. • Consult the client.
Access to Equipment	• Will there be any issues accessing equipment for safe operation and ongoing maintenance?	• Walk-through inspection. • Consult the client.
Economic Factors	• What is the client's budget for the system? • Are there any government incentives, credits or rebates? • What is the projected lifespan of the batteries? • What are the potential costs and payback periods?	• Consult the client and relevant authorities. • Review equipment specifications. • Perform calculations.
Local Requirements	• Are there any local network provider requirements or restrictions? • Are there any applicable local council rules, regulations or permits?	• Consult relevant authorities.

The viability of adding grid-connected battery storage to an installation will depend mainly on the load profile of the installation. Batteries can be used to offset the import of electricity, in particular flattening peak import costs. When used in conjunction with a periodically generating renewable power supply, such as PV or wind, batteries provide a way of shifting the time of use from the time of generation. For example, you can generate PV energy during the day, store it in the batteries, and use it at night when the PV system is no longer generating.

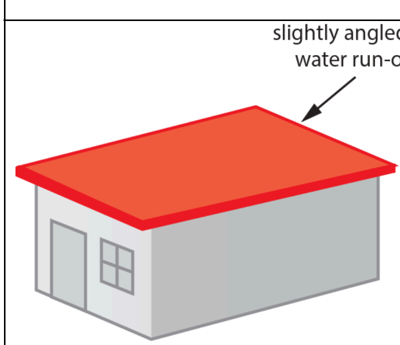
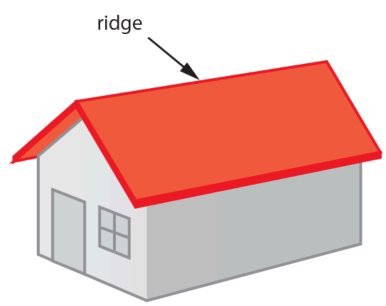
Check your understanding of the content by clicking the link below then undertaking the activity.

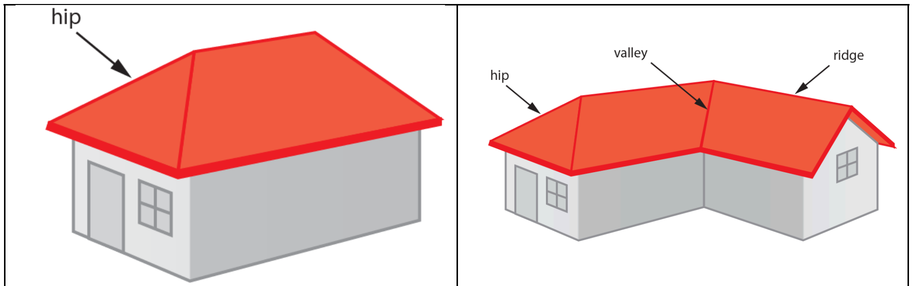
Load the Activity

Evaluating the Rooftop

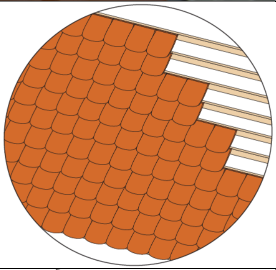
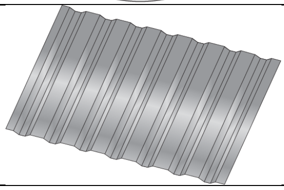
When conducting a site survey, it's important to check the physical layout and condition of the roof. This may require inspecting the roof from the top, and from within the roof space, to confirm the structural integrity, and identify any areas that are deteriorated or may otherwise pose increased risk.

In general, a roof structure will either be a concrete slab or consist of roofing material on a timber or metallic frame. There are a variety of common roof shapes, as shown in the following table.

Basic Roof Structures	
 Flat Roof (slab or frame)	 Gable Roof (frame)



Care must be taken to avoid damaging roofing materials whilst walking on the rooftop, particularly for old buildings. Weak points in roof structures that are in poor condition can pose a risk of collapse resulting in workers falling through. Particular care must also be taken around skylights. Some common types of roofing materials that may be encountered in Australia are shown below.

Common Roofing Materials		
Type	**Appearance**	**Material**
Tiles		• Ceramic • Concrete • Clay • Slate
Shingles		• Asphalt • Fiberglass • Hardwood (older houses)
Sheet		• Flat steel • Corrugated steel • Corrugated asbestos

Rooftop Safety Equipment

There are two main categories of fall protection equipment, these are:

- Passive equipment.
- Active equipment.

Passive fall protection equipment is set up as a static part of the work environment – examples include guardrails, safety gates, and safety netting set up around hazardous edges.
Active fall protection equipment is used or worn directly by the worker. The main type of active fall protection is a safety harness with an anchored lanyard.

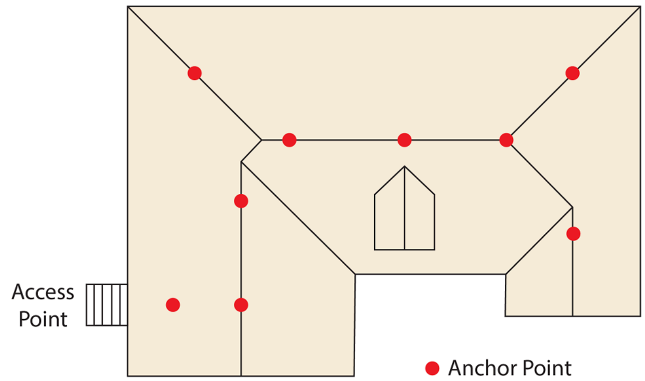
Active Fall Protection

Fitted Safety Harness

Safety Lanyard

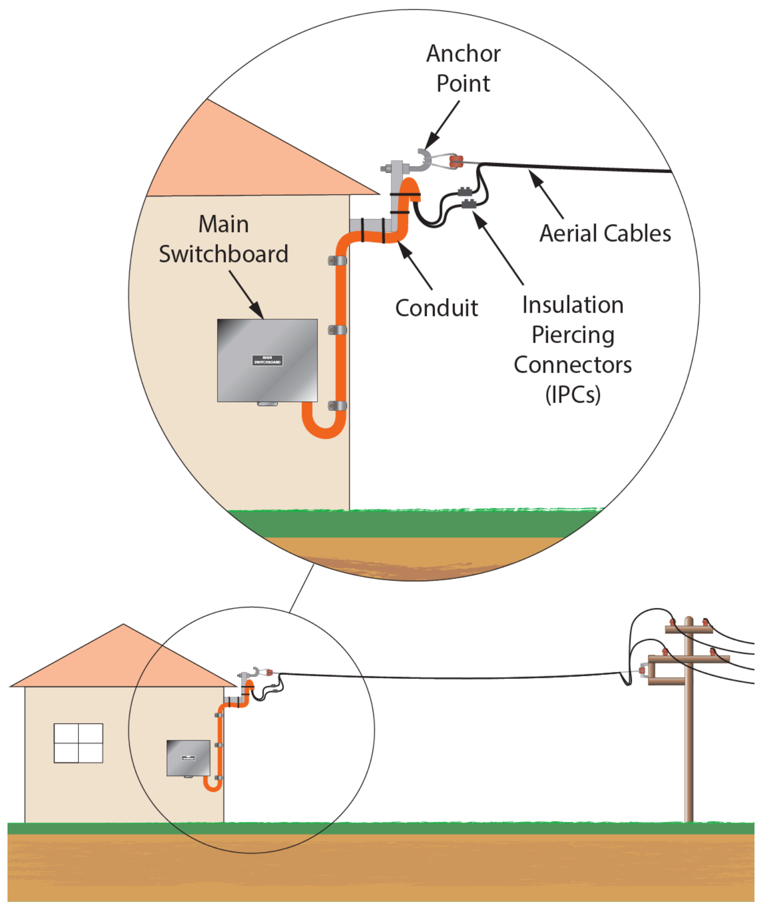
The following signage indicates that active fall protection is required in a given area:

It’s important that the length of the lanyard and the locations of anchor points allow the worker to reach the required work areas but will also prevent the worker from hitting the ground if they fall – taking into account the fully extended length of the shock absorber. The shock absorber is a coiled-up section of lanyard that will extend under shock to reduce the degree of impact on the body when stopping a fall.
An example of an anchor point layout is shown below:



Overhead Services

Another hazard to be aware of whilst working on roofs is the presence of overhead electrical services. Coming in contact with overhead electrical services can result in death from electric shock or resulting falls. Particular care should be taken around the 'point of attachment' – where an electrical overheard service attaches to a building.



To reduce the risk of electric shock, minimum clearance distances should be maintained. Safe Work Australia recommends maintaining the following clearances when working near energised low voltage services:

Minimum Clearances to Live LV Services	
Hand-held tools	0.5 m
Operating a crane or mobile plant	3.0 m
Handling metal materials	4.0 m

Handling non-conductive materials	1.5 m
Driving or operating a vehicle	0.6 m

You should always confirm the local requirements in your State/Territory before commencing work.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

This learning activity consists of 7 parts designed to develop your understanding of how to safely evaluate and document the suitability of a premises for a grid-connect PV and battery system.

Topic 6.1 Learning Activity

In this skills practice, you are required to demonstrate the correct safety procedures to check the layout and physical condition of a rooftop.

Topic 6.1 Skills Practice

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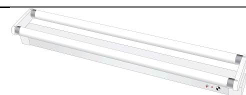
View

Energy Usage

The average Australian household uses energy for a range of purposes, primarily for lighting, cooking, cleaning, heating and cooling, and entertainment. In fact, heating and cooling accounts for around 40% of energy used by the average Australian household!

Commercial premises use energy in an even wider variety of ways in order to provide services and products to consumers.

The following table provides some examples how energy is consumed in these different areas.

Energy Usage		
Usage Area	**Illustration**	**Types of Equipment**
Lighting		• General purpose lighting. • Spot/flood lighting. • Feature and special purpose lighting.
Cooking		• Ovens, stoves and cooktops. • Deep fryers and electric frypans. • Food processors and other kitchen appliances. • Water heaters.
Cleaning		• Washing machines and dryers. • Dishwashers. • Vacuum cleaners. • Water heaters.

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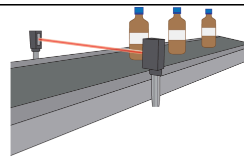
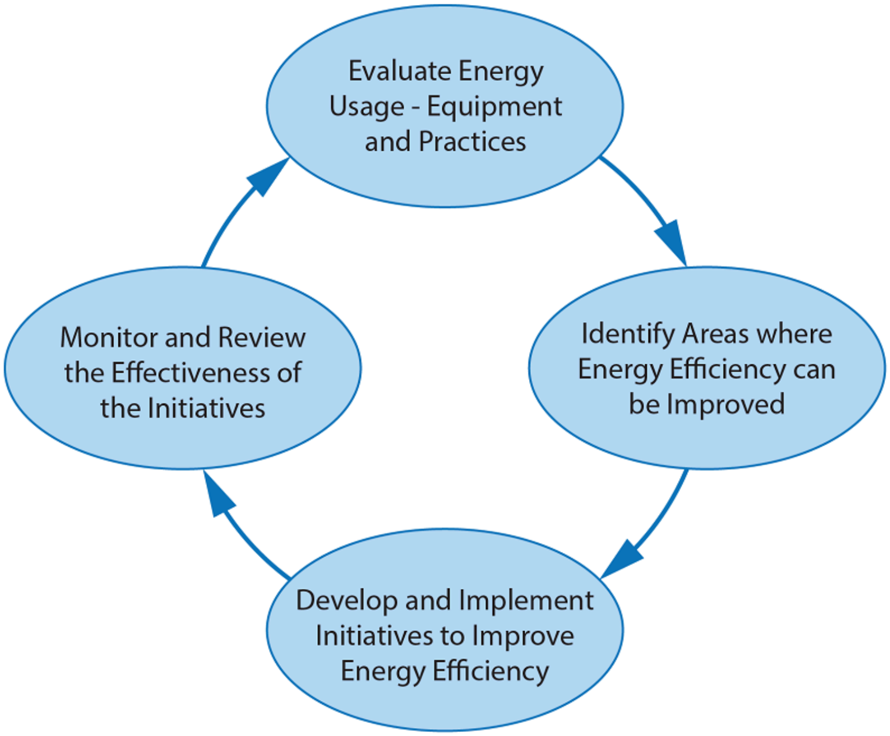
Climate Control		• Radiant heaters. • Ducted and reverse cycle air conditioners. • Refrigerators, freezers and cool rooms.
Entertainment		• Televisions and media players. • Computers and gaming systems.
Commercial Usage (in addition to the above)		• Conveyor belts and pumps. • Lifts and hoists. • Welders and compressors. • Various other specialised tools and machines.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Evaluating Energy Usage

An energy efficiency audit involves evaluating various characteristics and practices affecting energy usage at a given premises, identifying areas where energy consumption can be reduced, developing methods of achieving this, and monitoring/reviewing these methods.



There are three key methods for evaluating the energy usage at a particular site, as described in the following table:

Evaluating Energy Usage	
Method	**Description**
Review energy usage data	Review energy usage data for the site that has been previously collected. This could include energy bills and any other data that has been collected. Be sure to evaluate data that indicates peak demands, and usage across different seasons (e.g. both summer and winter), as patterns can change significantly throughout the year.
Consult the client/site occupants	Talk to the client and/or the site occupants about their energy usage needs and patterns over the course of the day, week, month and year.
Monitor energy usage patterns	If you are unable to access existing data, it may be necessary to monitor energy over a period of time.

Factors Affecting Energy Usage

There are a number of techniques for improving energy efficiency, including:

- Reducing the use or need for energy consuming equipment.
- Reducing the amount of energy needed to operate equipment.
- Reducing energy losses and wastage.
- Reducing reliance on the Electricity Network, e.g. through the use of PV power systems.

The amount of energy used at a given premises depends on a range of factors, including:

- Type of Premises.
- Local Climate.
- Building Design and Construction.
- Appliance Efficiency.
- Consumer Practices and Awareness.

Type of Premises

The type, quantity and times of energy usage depends largely on what people are normally doing at a given premises. For example, the energy usage at a house, shop and factory will vary widely. The usage between two different types of shops, or two different types of factories, will also vary. It is important to understand the specific energy needs of the customer when assessing their usage and efficiency.

Local Climate

The extremes of climate at any given location will determine the degree of heating or cooling needed to provide personal comfort. Ideally, the local climate should be considered in the building design and construction, as discussed below.

Building Design and Construction

There are various ways in which the design of a building has a significant effect on energy usage and efficiency:

- Sustainable building materials can reduce the environmental impact of the construction project.
- Building materials can be selected to have a thermal mass that compliments the given climate. For example, it may be effective to use a material that absorbs heat during the day and releases that heat at night.
- Building layouts can be arranged to facilitate natural air flow, reducing the need for artificial cooling.
- Windows and skylights can be used to reduce the need for artificial lighting during the day. The size and type of windows should also be considered, as this can affect the transfer of heat into and out from the building.
- Shades and screens can be placed at certain locations to reduce the impact of direct sunlight.
- Thermal insulation in ceilings, walls and under floors can reduce the need for artificial space heating and cooling.
- Energy efficient showerheads reduce hot water usage.
- ‘Smart’ controls, timer systems and sensors can be arranged to reduce energy wastage, for example by automatically switching off lighting or other equipment when not in use.

It should be noted that many of these factors will be determined by the architect during the design phase of a building project. However, items such as smart controls, thermal insulation, screens, shades, windows and skylights can be installed in existing buildings to improve energy efficiency.

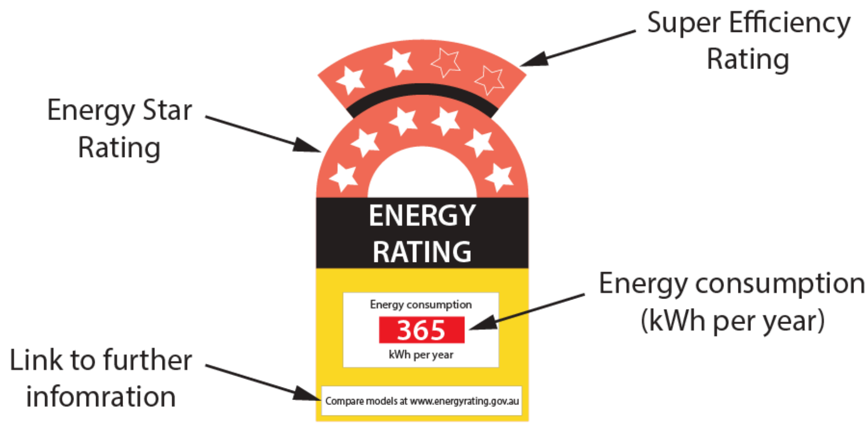
Appliance Efficiency

The types of electrical appliances used in a building will have a large impact on its overall efficiency. Some effective techniques for reducing the energy consumed by appliances and equipment include:

- Replacing incandescent lighting with more energy efficient types, such as CFLs or LEDs.
- Replacing conventional water heaters with solar water heating systems.
- Replacing existing appliances with more energy efficient models (particularly appliances that are used frequently, or even constantly such as a refrigerator).

Appliance Energy Ratings

The ‘Energy Star’ rating system requires certain appliances to be labelled to identify their efficiencies. The rating system is intended to inform consumers so that they can make more energy efficient choices. In turn, this gives further economic incentives to manufacturers to design more energy efficient products.



Energy Star Label

The following items are required to display an Energy Star rating sticker when being sold in Australia:

- Refrigerators and freezers.
- Single phase air conditioners.
- Televisions.
- Dishwashers.
- Washing machines and clothes dryers.

Consumer Practices and Awareness

Finally, changing the everyday practices and habits of the consumer can result in further energy savings. This can include:

- Turning off lights, televisions, computers, etc. when not in use.
- Performing tasks manually instead of using an energy consuming device, e.g. using a rake instead of a leaf blower.
- Only using air conditioning and heating appliances when absolutely necessary – could appropriate clothing warm you up or cool you down just as effectively?
- Closing doors and windows when using air conditioning or heating appliances.
- Closing blinds/curtains in the morning and evening to reduce heat transfer.
- Ensuring electrical equipment/appliances are regularly maintained.
- Having shorter showers to reduce hot water usage.
- Hanging clothes on a clothes line to dry rather than using a dryer.

Reducing Energy Use

A brief summary of some common methods to reduce energy use are detailed in the following table.

Summary – Reducing Energy Usage	
Method	**Examples**
Reducing the usage of energy consuming equipment	• Installing sensors and timers to de-energise equipment when it is not needed. • Installing skylights to reduce the need for artificial lighting.

Reducing the amount of energy needed to operate equipment	• Replacing incandescent lamps with compact fluorescent lamps (CFL) or with LED lamps, which are even more efficient. • Replacing existing appliances with more energy efficient models.
Reducing energy losses	• Installing thermal insulation in walls, ceilings and under floors. • Double glazing windows to prevent heat loss or transfer. • Sealing doors, windows and the like to prevent drafts.
Reducing reliance on fossil-fuels	• Installing solar hot water heating systems. • Installing photovoltaic (PV) arrays.

This learning activity consists of 7 parts designed to develop your understanding of how to evaluate the energy usage at a particular site and make recommendations for reducing usage.

Topic 5.2 Learning Activity

In this skills practice, you are required to identify key electrical infrastructure at a given site, undertake an energy assessment, and make recommendations for reducing energy consumption.

Topic 5.2 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the methods to evaluate and document a customer's electrical infrastructure and energy usage.

Topic 5 Content Quiz

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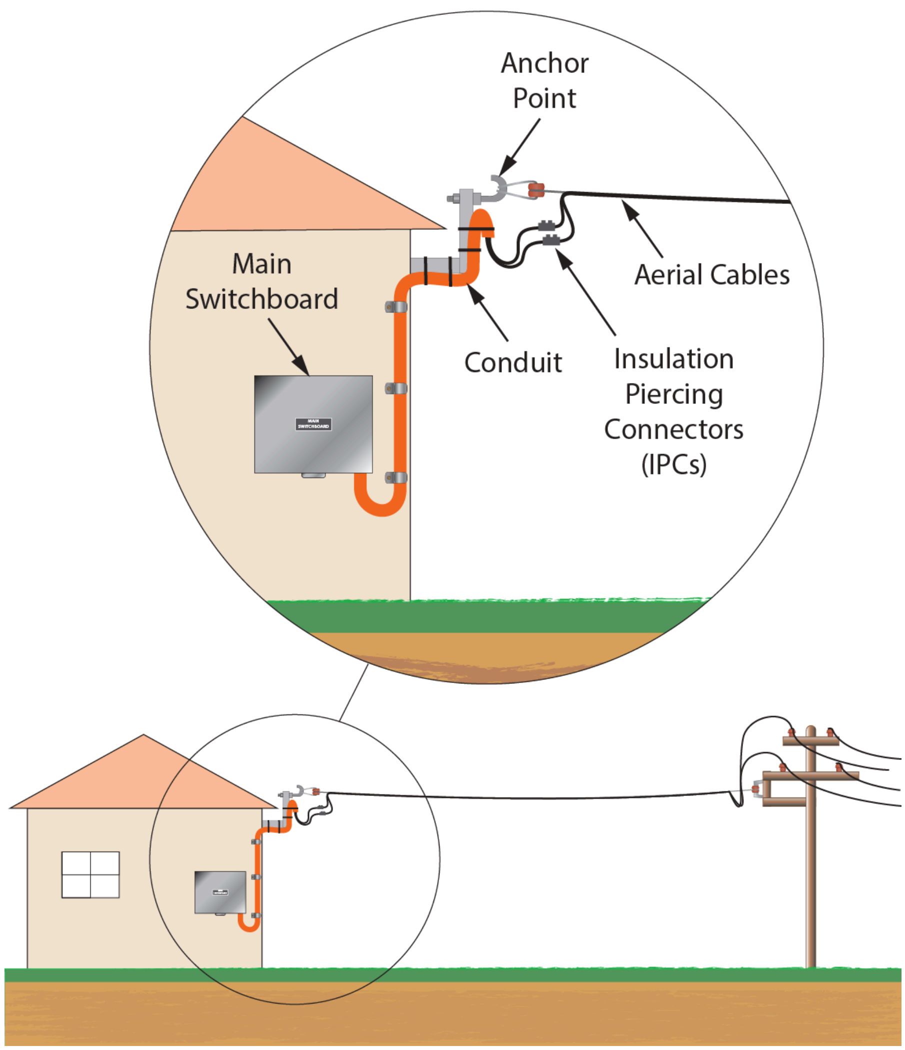
Introduction

In this topic you will learn about the methods to evaluate and document a customer's electrical infrastructure and energy usage.

Energy Services and Infrastructure

The primary form of energy supplied to a site will most likely be electricity, however gas is also available in many areas. Mains cables that connect a site to the electricity network enter the premises either as overhead or underground wiring, as shown below.



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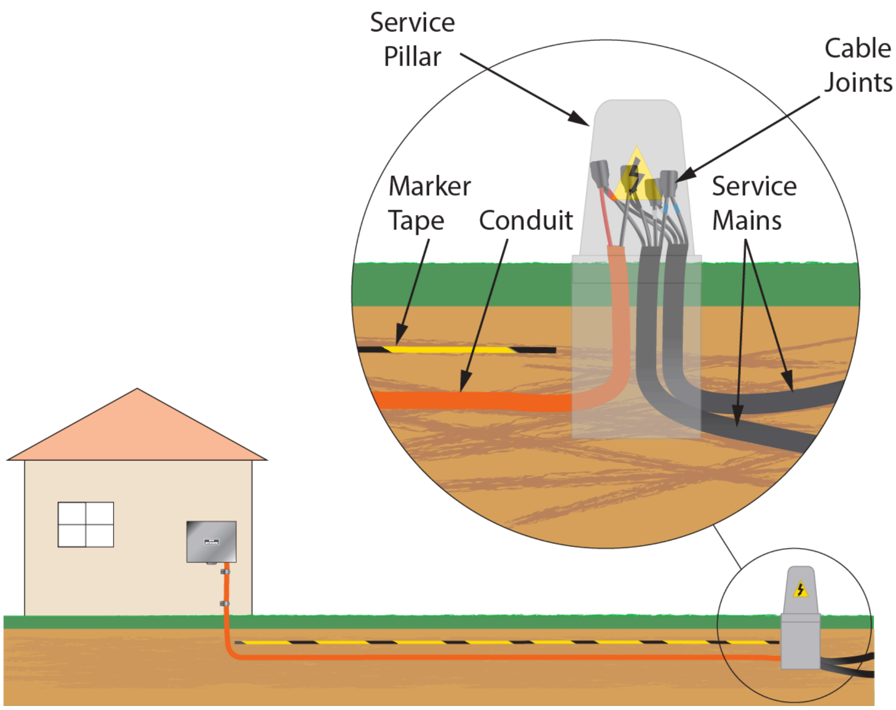
Overhead Service



Underground Service

Electricity is typically supplied either as a 230 V single phase service or a 400 V three phase service, however some commercial/industrial installations are supplied at higher voltages.

Evaluating Infrastructure

In order to evaluate the existing infrastructure at a given premises, you should consult the client/site occupants, review the installation drawings and documentation, and finally undertake a 'walk through' inspection of the site to identify and confirm arrangements. The following table describes each of the techniques in more detail.

Evaluating Energy Services and Infrastructure	
Method	**Description**
Consult the client/site occupants	Talk to the client and/or the site occupants about the energy infrastructure at the site.
Review the site drawings, diagrams and documentation	Check site plans and architectural drawings to identify key infrastructure such as: • Locations of overhead and underground energy services. • Points of supply, metering, connection and distribution (e.g. switchboards).

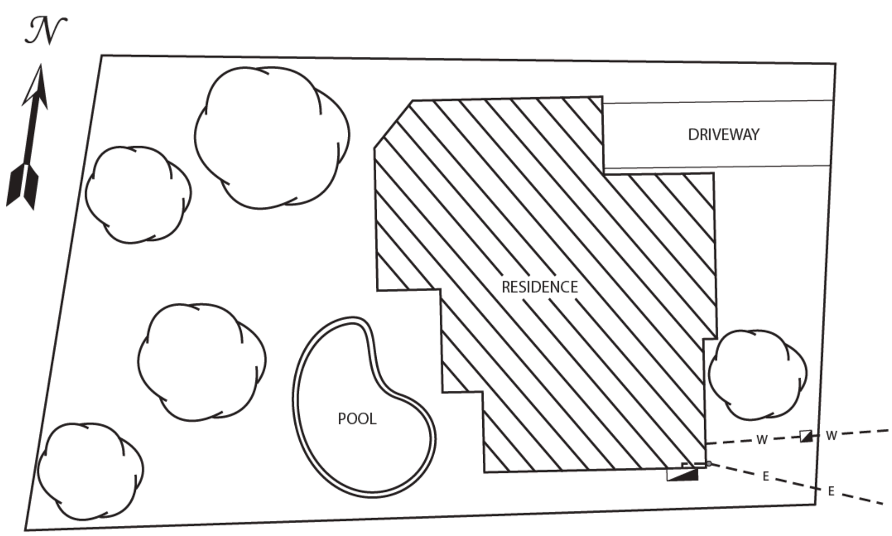
Walk through the site to identify and confirm arrangements	Look for and confirm the locations and arrangements of: • Energy services. • Points of supply. • Metering. • Switchboards. • Cable/pipework routes. • Types of appliances/equipment. Be sure to adhere to site and electrical safe working practices whilst checking electrical equipment.

Site Plans

A site plan shows the layout of structures and services on a block of land, as viewed from above. They are used routinely by electrotechnology workers, to determine:

- The routes of incoming underground and overhead services.
- The locations of switchboards and suitable routes for submains between buildings.

The diagram below is a site plan for a single domestic installation.

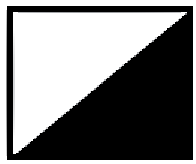
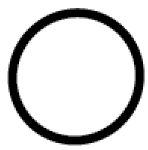


Site Plan – Single Domestic Installation

Standard Symbols

The following table shows some standard symbols commonly used on site plans.

Site Plan – Standard Symbols	
– – – E – – – E – – –	Electrical Service
– – – T – – – T – – –	Telecommunications Service

— — — W — — — W — — —	Water Service
— — — G — — — G — — —	Gas Service
	Switchboard
	Water Meter
	Point of Supply

Documentation

It’s important to document and update your findings at each point as you work through the evaluation process. The specific information will depend on the type of installation, but some general types of information to document include:

- Type of electrical supply – number of phases, overhead/underground, type of metering, cable size (if possible), cable routes and points of supply/attachment.
- Locations and types of switchboards – ratings, existing protection, space for additional equipment/protection, number and general types of circuits/equipment supplied.
- Other energy supplies – gas, alternate supplies etc., routes and points of supply/attachment.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

This learning activity consists of 10 parts designed to develop your understanding of how to safely evaluate and document the energy infrastructure at a given site.

Topic 5.1 Learning Activity

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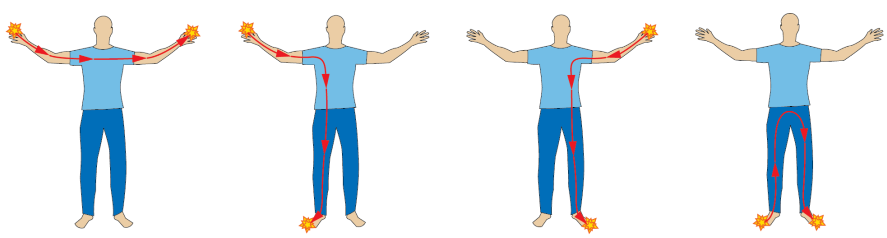
Effects of Electric Shock

The effects and severity of an electric shock depends on a number of factors, including:

- The magnitude of the shock current.
- The 'path' of the shock current through the body.
- The duration of the shock.
- Whether the shock current is alternating (a.c.) or direct (d.c.).

In general, the higher the shock current and the longer the duration of the shock, the more serious the injuries will be. An electric shock is also more likely to be fatal if the shock current passes through the heart.



Examples of Shock Current Paths

A general guide to the physiological effects of current is provided in the following chart.

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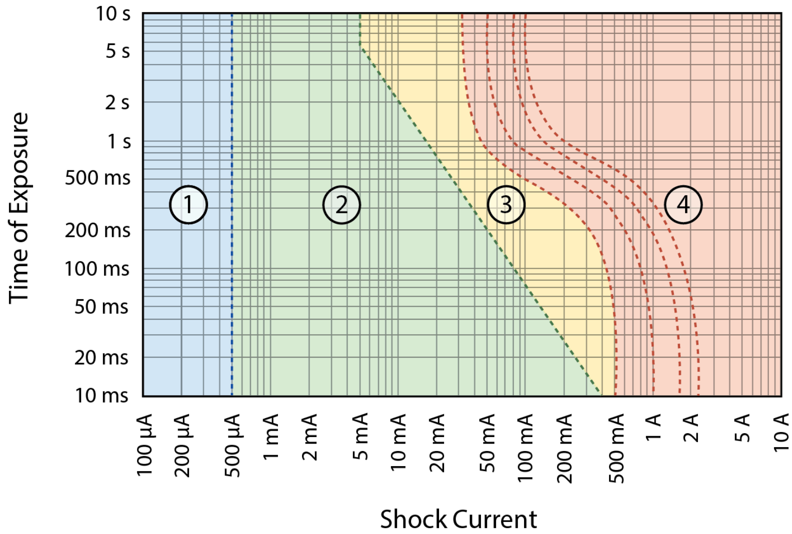

Zone	Typical Physiological Effects
1 (blue)	• Usually below the level of perception. • No noticeable physiological effects on the body.
2 (green)	• May startle a person causing them to pull away. • Minor discomfort. • No serious physiological effects on the body.
3 (yellow)	• Muscular tensing and the inability to let go. • Increased discomfort to severe pain. • Difficulty breathing. • Disturbance to heart rhythms. • Burns.
4 (red)	• Cardiac arrest. • Asphyxiation. • Ventricular fibrillation. • Severe burns.

Causes of Electric Shock

Common causes of electrical accidents include:

- Poor understanding of how electricity behaves.
- Overconfidence.
- Carelessness.
- Unsafe work practices.
- Stress and fatigue.

- Performing electrical tasks in a rush.
- Damaged insulation on electrical cables and equipment.
- Dodgy (non-compliant) electrical work.

For more information, try searching the Safe Work Australia website for the Model Code of Practice - Managing Electrical Risks in the Workplace. You can also try searching the website of your State/Territory Regulator using keywords such as ‘electricity’ or ‘electrical hazard’.

Safe Isolation Procedures
Prior to carrying out work on electrical equipment, the supply to the equipment should be isolated and tested to verify isolation. This is of extreme importance in order to reduce the risk of receiving an electric shock.

ONLY SHUTDOWN OR ISOLATE AN ELECTRICAL SUPPLY IF YOU ARE AUTHORISED TO DO SO

IF YOU ARE NOT AUTHORISED – SEEK THE HELP OF A LICENSED ELECTRICIAN

The procedure for safe isolation of a circuit is to:

1) Perform a job safety analysis.
2) Identify the isolation points.
3) Notify the relevant personnel of your intent to isolate.
4) Isolate, lock-off and tag isolation points.

5) Test to verify isolation.

6) Test your tester on a known live source to verify correct operation.

Electrical Safety Tags	
Front and Back	**Application**
 **Personal Danger Tag**	A personal danger tag is used to indicate that a circuit has been isolated so that work can be carried out on the connected equipment. This means that ignoring the tag and energising the circuit is likely to result in a fatal electric shock. Only the person who affixed the tag has the authority to remove it, or they can authorise another person to do so. These types of tags are typically affixed to control and protection devices such as isolation switches, circuit breakers and fuse holders.
 **Out of Service Tag**	An out of service tag is used to identify equipment that is damaged, faulty, or should not be used for some other reason. It is intended to ensure that a person does not attempt to operate the equipment. The person responsible for verifying the serviceability of the equipment removes the tag after any repairs or maintenance have been completed. It may commonly be seen affixed to faulty appliances such as power tools and machinery but can be used on any item that is not fit for service.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

This learning activity consists of 5 parts designed to develop your understanding of safety equipment, including types and applications.

Topic 4.4 Learning Activity

In this skills practice, you are required to complete a hazard assessment for a proposed grid-connect work site. For the given task, you will identify the hazards that could cause illness or injury to workers, assesses the risks and list the control measures to eliminate or reduce the risk as low as possible.

Topic 4.4 Skills Practice

Undertaking this topic quiz will help confirm your understanding of fundamental WHS principles, legislative roles and responsibilities, common industry hazards, and electrical safety practices.

Topic 4 Content Quiz

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Industry Hazards and Risks

Every work environment has hazards that present risks to workers and others. The following table lists some of the main hazards encountered on grid-connect worksites, and the methods used to control the associated risks.

Industry Hazards and Risks			
Hazard	**Example**	**Risk**	**Control Measures**
Electricity	Working on or near live cables, panels, switchboards etc.	Electric shock and burns	Safe isolation procedures
Manual handling	Unloading materials from a delivery truck	Sprains and strains	Correct lifting and handling techniques
Working at heights	Working on roofs or from scaffolds and elevated work platforms (EWPs)	Falling from heights resulting in serious injuries or death	Specific training and use of a tethered safety harnesses
Mobile Plant	Cranes, forklifts, EWPs, cars	Cuts, lacerations, and crush or impact injuries	Warning signs, exclusion zones and high visibility vests
UV radiation	Working in the sun	Sunburn, sunstroke, skin cancer	Sunscreen, hat, sunglasses, protective clothing
Industrial noise	Working on a construction site	Hearing loss and tinnitus	Use of ear plugs and ear muffs, and limiting time of exposure
Asbestos	Drilling into building panels and materials	Respiratory disease	Safe removal by an approved contractor

?

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

This learning activity consists of 2 parts designed to develop your understanding of common hazards, risks, and control measures in the solar industry.

Topic 4.3 Learning Activity

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The following table explains the meanings of ‘hazard’, ‘risk’ and ‘control measure’, in relation to risk management.

Risk Management Terms		
Term	**Definition**	**Example**
Hazard	Anything with the potential to cause harm to a person	Offcuts of materials lying around on the floor
Risk	The potential harmful consequences of a hazard	Trips, slips, sprains and strains
Control Measure	Methods used to reduce the potential severity and likelihood of harm	Sweep up and dispose of offcuts (housekeeping)

Risk Management

All workplaces are required to maintain a system of risk management in an effort to promote a safe work environment and reduce workplace illness and injuries.

Risk management consists of four main steps:

1) Identifying hazards
2) Assessing risks
3) Controlling risks
4) Monitoring and review

Identifying hazards

Hazards can be identified by:

- Using common sense – simply thinking about what might be harmful when work is carried out.
- Walking through the work area and using your senses – you might see, hear or smell a hazard.
- Talking with other workers – they might have noticed hazards that you haven’t.

Assessing the Risks

There are two main factors that are considered when assessing the risks posed by a hazard:

- The *likelihood* that the hazard will cause harm.

- The *severity* of the harm that could be caused.

A 'risk matrix', as shown below, is used to rank the risk posed by a hazard.

Severity \ Likelihood	Likely	Possible	Unlikely
Death or permanent disability	1	1	2
Serious injury or chronic illness	1	2	3
Minor injury requiring first aid	2	3	4

1 = Extreme risk
2 = High risk
3 = Medium risk
4 = Low risk

Controlling Risk

Controlling the risk posed by a hazard involves choosing and implementing measures that reduce the risk to an acceptable level.

The hierarchy of controls ranks the methods of risk control from the most preferred method (elimination) to the 'last resort' (personal protective equipment), as shown below:

Hierarchy of Controls		
Rank	**Control Measure**	**Description**
1	Elimination	The hazard, and therefore the risk, is removed entirely. This is the most effective method of risk control. Examples include: • Removing a dangerous machine from a workplace. • Backfilling an open trench.
2	Substitution	Hazardous equipment, substances or working practices are replaced with those that are less hazardous, thereby reducing the risk. Examples include: • Replacing a damaged extension cord with a new one. • Using a non-toxic glue instead of a toxic one.

3	Isolation	Workers and others at risk of harm are prevented from coming into contact with the hazard. Examples include: • Restricting access to a dangerous area. • Placing an 'out of service' tag on a faulty piece of equipment.
4	Engineering Controls	Installing or using parts that are designed to reduce the level of risk associated with a piece of equipment or activity. Examples include: • Safety railings at edges. • Safety guards on power tools.
5	Administrative Controls	Training, instruction and guidelines that reduce the risk are set out for the worker to follow. Examples include: • Undergoing a company or site induction. • Using standard work procedures (SWPs).
6	Personal Protective Equipment (PPE)	The last resort in risk control, PPE is used to reduce risk by offering some protection to various parts of the body that may be harmed as a result of the hazard. Examples include: • Wearing a hard-hat and safety boots whilst on a construction site. • Using safety glasses and ear plugs whilst operating a power drill.

Typically, combinations of these control measures are used to reduce the risks posed by hazards in the workplace.

Monitoring and Review

Monitoring and review of risk management is an ongoing process of discussion and analysis for the purposes of:

- Identifying new hazards.
- Checking that the level of risk posed by hazards has not changed.
- Evaluating the effectiveness of control measures.
- Improving the system of risk management.

Required Documentation

All risk assessment activities should be documented to clearly indicate:

- The location and date.
- Who carried out the risk assessment.
- The hazards that were identified.
- The risks posed by each hazard.
- How each risk is to be controlled.
- Who is responsible for implementing risk controls.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

For more detailed information on risk management, try searching the Safe Work Australia website for the Model Code of Practice: 'How to Manage Work Health and Safety Risks'. You can also try searching the website of your State/Territory Regulator using keywords such as 'risk management'.

This learning activity consists of 3 parts designed to develop your understanding of risk management, including the hierarchy of controls and risk assessment documentation.

Topic 4.2 Learning Activity

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Introduction

In this topic you will learn about workplace health and safety legislation and associated responsibilities, common hazards associated with grid-connect solar and battery storage site survey work. You will also learn about risk management principles and practices.

Underlying Principles

The fundamental principle of workplace health and safety (WHS) is to protect the health and safety of people in the workplace. This includes:

- Ensuring that workplaces are safe.
- Ensuring that workers are able to work safely.
- Reducing accidents and injuries in the workplace.
- Promoting good health and hygiene.

Legislation and Regulations

Each State and Territory of Australia is responsible for implementing WHS laws and regulations. The following diagram shows the State and Territory WHS regulatory bodies across Australia:

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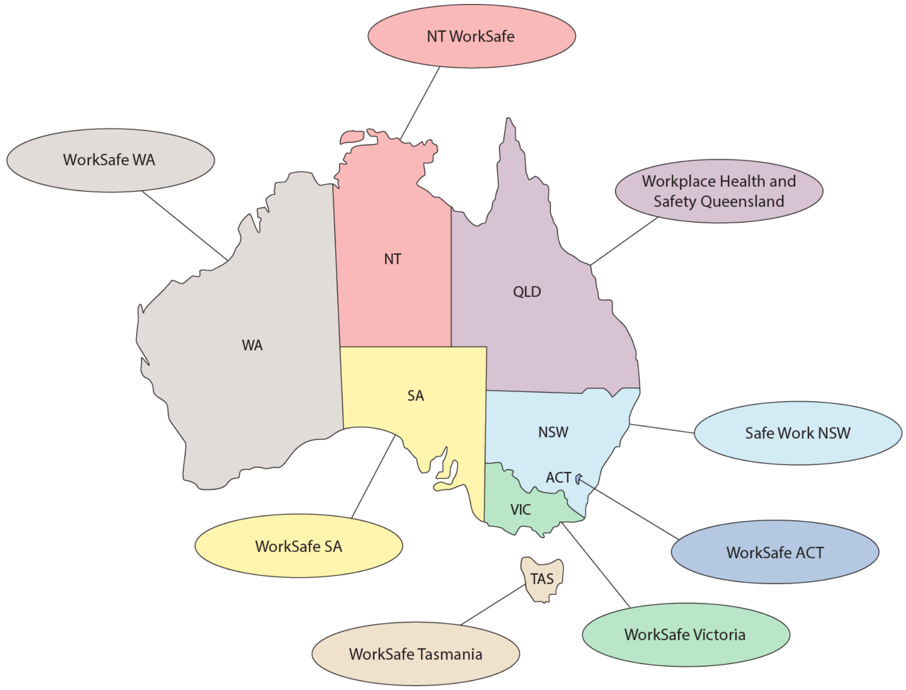

Australian Workplace Health & Safety Authorities

The role of WHS regulators is to ensure compliance with the applicable legislation and regulations in their jurisdiction. This typically involves activities such as:

- Providing advice and assistance.
- Carrying out workplace safety inspections.
- Investigating workplace safety incidents.
- Administering licenses and registrations for hazardous work or occupations.

Safe Work Australia is the national body overseeing WHS in Australia. The role of Safe Work Australia is to:

- Work towards harmonising WHS policy.
- Provide information and guidance.
- Conduct research.
- Publish documents (such as the Model WHS Act, Model WHS Regulations and Model Codes of Practice).

Roles and Responsibilities

It is important to understand workplace health and safety, as both workers and employers have a number of legal responsibilities under the applicable Acts and Regulations.

Workplace Health and Safety – Responsibilities	
Worker Responsibilities	**Employer Responsibilities**

• To take reasonable care for their own health and safety at work. • To take reasonable care for the health and safety of others in the workplace. • To cooperate with workplace health and safety policies and procedures provided by the employer. • To comply with all reasonable instructions from the employer relating to health and safety.	• To take reasonable care to ensure the safety of workers. • To provide workers with safe systems of work. • To provide workers with safe plant and equipment. • To provide workers with adequate facilities. • To provide any required information, training, instruction, and supervision to allow workers to work safely. • To monitor and maintain the conditions of the workplace.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Codes of Practice

Each State and Territory WHS regulator publishes a range of Codes of Practice (CoP) that provide guidance on managing hazards and risks in the workplace. These are typically adapted from the 'model' CoPs published by Safe Work Australia.

CoPs are intended to provide practical, industry-approved methods of dealing with hazards and risks. Some examples of CoPs that are highly relevant to grid-connect work include those addressing:

- Risk management.
- Hazardous manual tasks.
- Working at heights.
- Asbestos and crystalline silica.
- Electrical work.

Try searching your State/Territory WHS regulator website for Codes of Practice that apply in your jurisdiction.

Australian Standards

The Australian Standard that sets out the requirements for working safely around low voltage (LV) electrical systems is:

- *AS/NZS 4836:2023 Safe working on or near low-voltage and extra-low voltage electrical installations and equipment*

This standard includes a range of requirements on issues such as risk management, safe isolation of equipment, tools and equipment, use of safety observers, test equipment, and competency.

This learning activity consists of 6 parts designed to develop your understanding of the underlying principles and objectives of workplace health and safety in Australia.

Topic 4.1 Learning Activity

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Installation Standards

The following two standards, in addition to AS/NZS 3000:2018, provide the requirements related to the installation of grid-connected battery storage systems:

- AS/NZS 5139:2019 Safety of battery systems for use with power conversion equipment.
- AS/NZS 4777.1:2024 Grid connection of energy systems via inverters – Installation requirements.

The intent of these standards is to ensure safety, correct functionality, long life and ease of maintenance for the system.

AS/NZS 5139:2019 Overview

The use of battery systems to compliment photovoltaic or other alternative supply systems is becoming more and more prevalent. AS/NZS 5139:2019 has been developed largely for the purpose of ensuring the safety of these installations. Some of the key issues and requirements are summarised in the following table.

Overview of AS/NZS 5139:2019	

Key Terms and Definitions	• Power Conversion Equipment (PCE), e.g. inverters, charge controllers etc.
	• Battery Energy Storage System (BESS), consists of:
	  ○ Battery bank.
	  ○ PCE.
	  ○ Isolation and protection equipment.

Section 2 – BESS configurations	• Provides diagrams and descriptions of the various types of BESS configurations.
Section 3 – BESS hazards	• Specifies the key types of hazards a BESS can present in an installation, including electrical, energy, mechanical, fire (levels 1 and 2), explosive gas, chemical and toxic fumes. • Indicates how to determine battery system prospective fault current and arc flash energy. • Provides guidance on required PPE for working on different systems.

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<table>
<tr><td>Section 4 – Pre-assembled integrated BESS*</td><td rowspan="3">Installation requirements relating to location, external influences, and protection against fire and seismic activity.
Hazards associated with the installation.
Electrical protection and earthing requirements.
Requirements for overcurrent protection devices and switch disconnectors.
Wiring requirements, including acceptable types, mechanical protection, selection and segregation.
Commissioning and documentation requirements including inspections and tests, information to be recorded in the system manual, and information to be provided to the customer.</td></tr>
<tr><td>Section 5 – Pre-assembled battery systems**</td></tr>
<tr><td>Section 6 – Other BESS and battery systems</td></tr>
<tr><td>Section 7 – Labels and safety signage</td><td>States the requirements for system labelling and signage.
Note – examples of acceptable labels and signs are provided in Appendix B.</td></tr>
</table>

*A pre-assembled integrated BESS incorporates PCE and therefore has an a.c. output.

**A pre-assembled battery system does not incorporate PCE, and therefore has a d.c. output.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Decisive Voltage Classifications (DVC)

The decisive voltage classification (DVC) of multimode inverters/PCE is based on the rated operating voltages and the degree of separation between the battery port and ports for other energy sources (e.g. the grid port). The requirements for protection and enclosure of battery equipment will vary depending on the DVC of the system.

DVCs are defined in IEC62109-1 and some guidance is provided in Section 3 of AS/NZS 5139:2019. The following table shows the key voltage limits associated with the different classifications:

Decisive Voltage Classifications (DVC)		
Class	**a.c. Voltage Limit**	**d.c. Voltage Limit**
DVC-A	≤ 25 V r.m.s.	≤ 60 V d.c.
DVC-B	≤ 50 V r.m.s.	≤ 120 V d.c.
DVC-C	> 50 V r.m.s.	> 120 V d.c.

Earthing Requirements

Some key AS/NZS 5139:2019 requirements to consider in relation to earthing of battery systems include:

- If the installation earthing is not capable of carrying the battery system fault current then the BESS earthing cable should be connected directly to the earth electrode.
- A pre-assembled BESS that doesn’t have electrical separation between the d.c. and a.c. ports must not be earthed.

- Size of earth cables should be determined using AS/NZS 3000:2018 Table 5.1 (or by calculation in accordance with AS/NZS 3000:2018 Clause 5.3.3.1.3).
- For DVC-B and DVC-C systems, all metallic enclosures must be equipotentially bonded with 6 mm^2 (minimum) cable.
- Floating or resistive earthed systems operating at DVC-B or DVC-C require earth fault monitoring and alarm.

Switchgear Requirements

Battery system protection devices and switch disconnectors must be selected in accordance with AS/NZS 3000:2018 and the additional requirements of AS/NZS 5139:2019. Some key requirements include:

- Battery isolators must disconnect all live conductors, including the battery system conductor that is earthed.
- Overcurrent protection devices and disconnectors must:
  - Be non-polarised.
  - Be rated for d.c.
  - Be rated to withstand maximum system voltage and short circuit current.
- In addition, switch disconnectors must:
  - Be rated to interrupt the full load current.
  - Have at least a pollution degree 3 classification.
  - Have a utilisation category of at least DC21B.

Wiring Requirements

Battery system d.c. wiring must be selected and installed in accordance with AS/NZS 3000, and must be:

- Double insulated flexible cables.
- Segregated from a.c. wiring.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

AS/NZS 4777 Requirements

An overview of the grid-connect inverter requirements specified in AS/NZS 4777.1:2024 were covered in the previous topic and can be reviewed here: Topic 2.3 PV Installation Requirements.

Multimode Inverters – Additional Requirements

There are also some additional requirements for multiple mode inverters stated in *AS/NZS 4777.2:2020 Grid connection of energy systems via inverters – Inverter requirements*. When the multiple mode inverter is operating as an independent supply:

- All active conductors must be isolated from the grid-interactive port, but the neutral conductor must not be interrupted (i.e. the grid protection should operate in the active conductors only).
- The total harmonic distortion (THD) of the independent supply must not exceed 5%, and no individual harmonic may exceed 5%.

This learning activity consists of 8 parts designed to develop your understanding of the installation requirements and standards that apply to grid-connected battery storage systems. You will need to have access to a copy of AS/NZS 5139:2019 to complete this activity.

Topic 3.3 Learning Activity

In this skills practice, you are required to identify and compare and contrast the benefits of two different grid-connected battery storage system options.

Topic 3.3 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of installation load profiles, energy monitoring and reduction techniques, and battery system components and configurations.

Topic 3 Content Quiz

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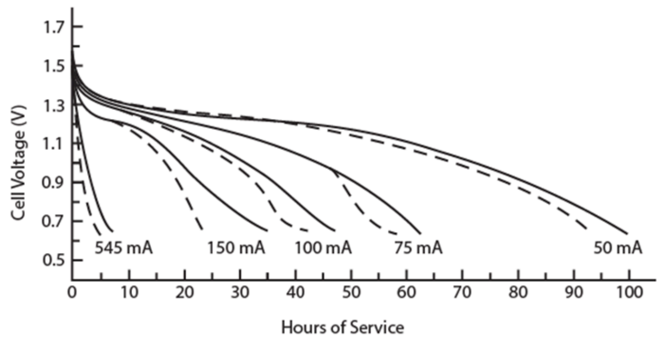
Battery Parameters

The following table explains the key parameters and ratings associated with grid-connect storage batteries.

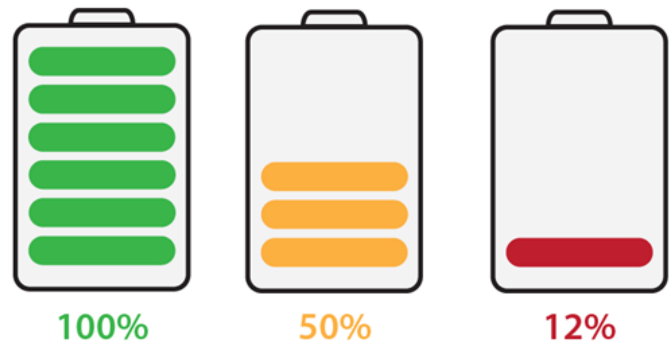
Battery Parameters	
Nominal voltage	The average voltage that will be available at the terminals of the battery is referred to as the nominal voltage.
Ampere-hour capacity	Ampere-hour (Ah) capacity represents the amount of current a battery can supply for a given duration. An ideal cell with a capacity of 1 Ah can supply a current of 1 ampere for 1 hour, 2 amperes for 0.5 hours or 4 amperes for 0.25 hours.
Watt-hour capacity	Watt-hour (Wh) capacity represents the amount of power a battery can supply for a given duration, and can be calculated as follows: *Nominal voltage x ampere-hour capacity = watt-hour capacity* *(normally quoted in kWh for grid-connect storage systems)* For example a 12 V, 100 Ah battery has a watt-hour capacity of 1,200 Wh (12 x 100 = 1,200 or 1.2 kWh).

?

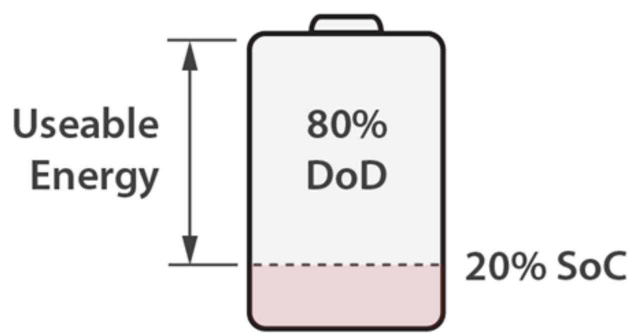
Charge/discharge rate	The charge/discharge rate represents the voltage and current characteristics of a battery when being charged and discharged.
	
	In order to charge a battery, a d.c. voltage that is slightly higher than the nominal battery voltage is applied to the terminals. As the battery charges, its terminal voltage increases until it exceeds that of the charging voltage, at which point charging stops.
	
	As a battery discharges, its internal resistance increases due to the chemical reaction occurring in the electrolyte, causing the battery's terminal voltage to drop.
	
	The following graph is an example of a discharge characteristic for a particular battery:
	
	
	
	Points to note about the discharge curves:
	
	• As the cell discharges, its terminal voltage decreases.
	• The hours of service are greater at a low rate of discharge compared to a high rate of discharge, for example:
	  ◦ At 50 mA discharge, hours of service are approximately 95 hours.
	  ◦ At 545 mA discharge, hours of service are approximately 5 hours.

Cycle life	The cycle life of a battery represents the number of charge/discharge cycles the battery can undergo before its capacity degrades. A complete charge and discharge represent one cycle.

<table>
<tr><td>State of charge</td><td>
The state of charge (SoC) indicates how much energy is left in a battery, i.e. the percentage of capacity available. When a battery is full, its SoC is 100%. When a battery is half full, its SoC is 50%.



[[state of charge]]
Most people will be familiar with this concept from looking at their smartphone – when the battery icon in the top corner of your screen indicates ‘83%’, this is indicating the SoC of your phone battery.
</td></tr>
<tr><td>Depth of discharge</td><td>
The depth of discharge (DoD) indicates how far a battery can be discharged before the battery life will be negatively affected. Essentially this indicates how much of the battery energy is useable in practice.
For example, a DoD of 80% means the life of the battery will be reduced if the SoC drops below 20%.



[[depth of discharge]]
Batteries designed for grid-connect solar applications commonly have a DoD of 90% or more. Some even have a DoD of 100%.
</td></tr>
<tr><td>Useable capacity</td><td>
The useable capacity is equal to the DoD percentage of the total battery capacity, for example:

A 100 Ah battery with a DoD of 90% has a useable capacity of 90 Ah.
Working: 100 x 0.9 = 90 Ah
A 40 Ah battery with a DoD of 75% has a useable capacity of 30 Ah.
Working: 40 x 0.75 = 30 Ah

</td></tr>
</table>

Grid-Connect Batteries

Battery technology is a rapidly evolving field that has seen significant advancement in the past decade. The advent of electric cars and photovoltaics (PV) has created huge financial incentives for the research and development of lightweight high-capacity batteries.

At this current moment, lithium battery technology is the most commonly used type for grid-connect storage applications. However other types have been used historically, and some promising alternate battery technologies are currently in development.

Types of Grid-Connect Batteries	
Type	**Features**
Lead-acid Batteries	Types include: • Flooded lead-acid. • Valve regulated lead-acid (VRLA). Open-circuit cell voltage (OCV) is 2 V. Batteries are commonly available with nominal voltages of 6 V and 12 V. DoD is around 60% and expected service life is around 300 to 500 charge/discharge cycles. Lead-acid batteries have been used widely in the past for energy storage systems as they are reliable and relatively inexpensive. However flooded lead-acid batteries pose particular safety hazards and require more maintenance than other types of batteries.
Lithium Batteries	Types include: • Lithium-ion (Li-ion). • Lithium-polymer (LiPo). • Lithium iron phosphate (LiFePO4). Lithium cells typically have an OCV of around 3.3 V to 3.7 V, depending on the particular type. Batteries are commonly available with nominal voltages of 6 V, 12 V, 24 and 48 V. DoD is around 80 to 90%. When compared to lead-acid batteries, advantages of lithium batteries include: • Higher energy density. • Longer service life – around 1000 cycles (Li-ion) up to 5000 cycles (LiFePO4), depending on the quality of the battery. • Less maintenance required.

Flow Batteries	Flow batteries are an emerging technology that uses two electrolytes stored in separate tanks. The electrolytes are circulated in and out of a reaction cell where they react to produce electricity. Flow batteries have several advantages compared to other batteries, including: • Scalability – the capacity of the battery can be increased simply by increasing the size of the storage tanks. For this reason, their main application is currently for large-scale energy storage. • DoD of 100%. • Good service life – around 4000 cycles. • Ability to be charged and discharged simultaneously. • Can be produced without using hazardous materials. Some of the disadvantages of flow batteries include: • Low energy density. • More expensive. • Require various auxiliary equipment (pumps etc.).
Sodium Batteries	Sodium-based battery technology is currently in development as a potential replacement for lithium batteries in the future. When compared to lithium batteries, advantages of sodium battery technology include: • Cheaper and less environmental impacts – due to the abundance and relative ease of obtaining sodium. • Improved energy density. • Comparable and possibly improved service life. However, there are currently still some downsides to sodium battery technology, including: • High operating temperatures (300 to 350°C). • High self-discharge rate, meaning they lose their charge over time, e.g. whilst being stored.

Charging Modes

The three main charging modes used in grid-connected PV storage systems are:

- Constant voltage (CV) charging.
- Constant current (CC) charging.
- Smart/adaptive charging.

When in CV mode, the charger applies a constant voltage across the batteries until the SoC reaches the maximum charge voltage (or other pre-set value). This means that the charging current varies as the batteries charge.

When in CC mode, the charger delivers a constant current to the batteries until the SoC reaches the maximum charge voltage (or other pre-set value). This means that the charging voltage varies as the batteries charge.

When in smart/adaptive mode, the charger monitors a range of battery parameters (e.g. SoC, temperature, etc.) and automatically adjusts the charging voltage and current for optimal performance and battery life.

When batteries are at 100% SoC, the charger will switch over to trickle charging, which provides a continuous, constant charging current to maintain the battery at its nominal voltage. This is designed to compensate for the natural self-discharge rate of the batteries.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Factors Affecting Battery Life

All batteries will deteriorate over time, but there are several points to consider that can help to get the most out of a battery installation. The following table explains the various factors that can reduce the life of PV storage system batteries, and the ways to reduce their impact.

Factors Affecting Battery Life		
Factor	**Description**	**Solution**

<table>
<tr><td>Environmental Conditions</td><td>High temperatures, humidity and the build-up of dust or other contaminants can accelerate the deterioration of a battery, thereby reducing their service life.</td><td>Installation location – batteries should be installed in cool, dry conditions where there is good ventilation.

Maintenance – environmental conditions should be checked, and batteries should be cleaned periodically.</td></tr>
<tr><td>Charge/Discharge Rate</td><td>Discharging or charging batteries at a high rate can cause overheating which can damage battery components and reduce battery life.</td><td rowspan="2">System design – the battery installation should be suitably sized for the given load requirements. This will help to reduce the likelihood of excessive discharge rate/depth.

Charger settings – the charger should be set to ensure that charge/discharge rates and allowable DoD are suitable for the batteries and the installation conditions.

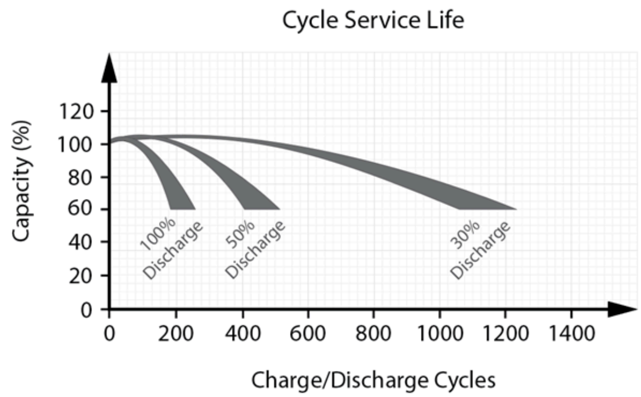
Battery Monitoring – monitoring systems will help to optimise the operating conditions of batteries, thereby improving their service life.</td></tr>
<tr><td>Depth of Discharge (DoD)</td><td>Discharging batteries beyond their rated DoD will reduce their service life. In general it is good practice to avoid discharging batteries beyond 80% DoD.</td></tr>
</table>

Estimating Battery System Life

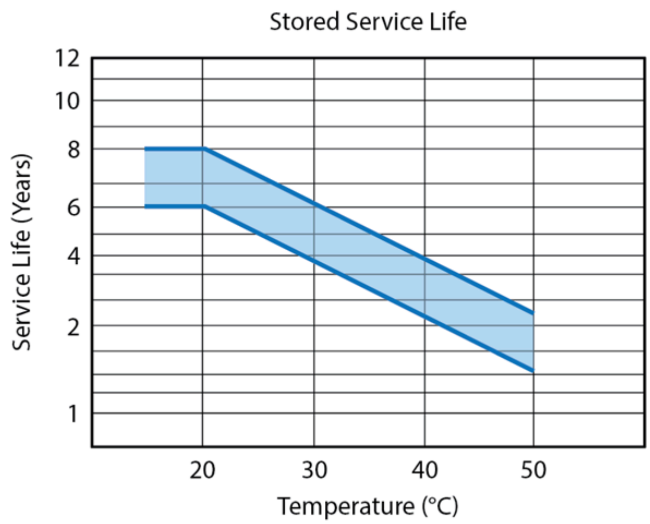
When installing a battery system, it's important to inform the customer of its expected service life. There are several factors to consider when developing an appropriate estimate of a system's service life, including:

- Battery type and ratings:
  - Rated service life cycles.
  - Rated DoD.
- Operating conditions:
  - Environmental conditions – temperature and humidity.
  - Frequency and depth of charge/discharge cycles.

The manufacturer data sheet should provide information about how to de-rate service life based on particular conditions. Some examples of manufacturer data relating to service life are shown below:



From this graph you can see that increasing the depth of discharge significantly reduces the number of effective charge/discharge cycles for this particular battery.



From this graph you can see that storing these particular batteries in temperatures above 20°C significantly reduces the service life.

This learning activity consists of 8 parts designed to develop your understanding of the different battery technologies currently available for grid-connected storage systems, including terminology, battery types, charging modes and factors affecting battery life.

Topic 3.2 Learning Activity

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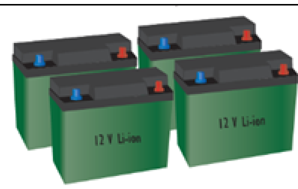
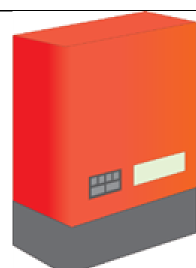
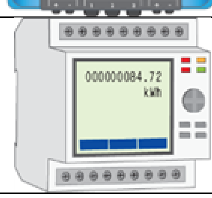
Introduction

In this topic you will learn about the arrangement and features of grid connected battery storage systems, including components, configurations, types of batteries, and key installation requirements.

Battery Storage Systems

A basic battery storage system for a grid-connected PV installation has the following key components:

Battery Storage System Components		
Component	**Illustration**	**Function**
Batteries		Stores energy for use when needed.
Multimode Inverter		Converts direct current into alternating current.
Charge Controller		Controls the charging parameters applied to the batteries.
Metering / Monitoring		Monitors and logs system parameters for analysis.

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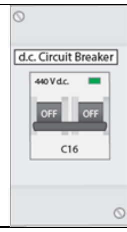
Controls and Protection		Protects equipment against overcurrent and provides a point of isolation.

Battery Energy Storage System (BESS)

A battery energy storage system (BESS) is an assembly of components that makes retrofitting battery storage into an existing installation quick and easy. Depending on the manufacturer, a BESS will include some or all of the following components:

- Batteries.
- Power Conversion Equipment (PCE) – battery inverter, charge controller.
- Cooling system.
- Isolation and protection devices.
- Battery management controls and indicators.

Network Provider Requirements

Due to potential impact on the electricity network, network providers have various requirements for grid-connected battery systems. These requirements may vary by State/Territory, but can cover issues such as:

- Minimum quality standards for output voltage and frequency.
- Access to remote monitoring/controls.
- Acceptable types of batteries and inverters.
- Limitations on the size of the system.
- Minimum protective requirements.

Many of these will be addressed simply by adhering to Australian Standards such as AS/NZS 5139 and AS/NZS 4777, however some additional requirements may apply in your jurisdiction. Theoretically these factors should've been factored in to the system design brief, but it's always best to confirm and understand the local requirements before starting a job.

Battery System Configurations

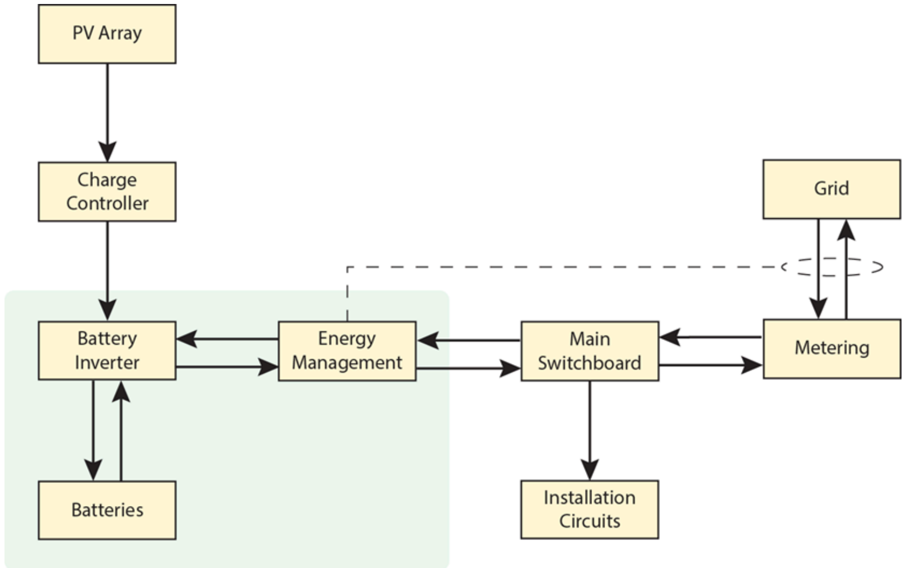
There are several different ways of arranging battery storage into a grid-connected PV power system. The best arrangement for a particular situation will depend on factors such as:

- Desired functionality, e.g. standalone operation.
- The arrangement of the existing PV system.
- The particular manufacturer/products used.

d.c. Coupled Systems

A PV battery system is said to be 'd.c. coupled' if the PV array and the battery system are connected via a d.c. circuit.

The following block diagram shows a typical arrangement for a d.c. coupled PV battery system, without emergency power capability:

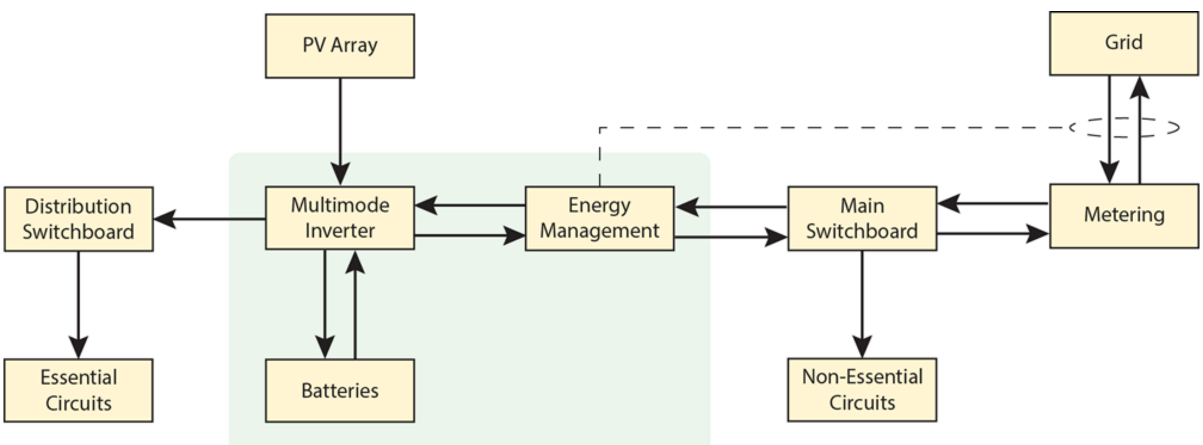


Battery Energy Storage System (BESS)

In this arrangement:

- The PV array is coupled to the battery system via a solar charge controller.
- The BESS energy management unit monitors the PV array, batteries and grid import/export, and adjusts the system parameters as necessary.
- In the event of a grid outage, a grid protection device in the BESS energy management unit will disconnect the alternate supplies from the grid, and so no supply will be available to the installation circuits.

This next diagram shows a similar system, except that this one is designed to be capable of maintaining supply to a set of essential circuits during a grid outage:



Battery Energy Storage System (BESS)

In this arrangement:

- The PV array is coupled to the battery system via a multimode inverter.
- The BESS energy management unit monitors the PV array, batteries and grid, and adjusts the system parameters as necessary.
- During normal operation, both the essential and non-essential circuits are supplied with energy, either from the array, batteries or grid.
- During a grid-outage, the BESS energy management system isolates the alternate supplies from the grid (grid protection), but continues to supply the essential circuits.

These arrangements can be a good option for customers who don't have an existing PV system.

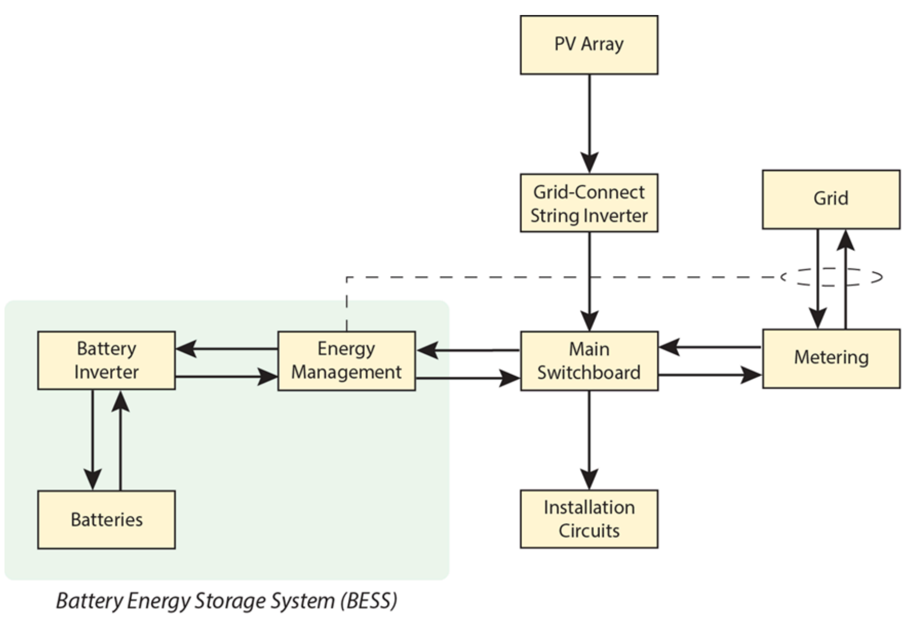
Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

a.c. Coupling

A PV battery system is said to be 'a.c. coupled' if the PV array and the battery system are connected via an a.c. circuit.

The following block diagram shows a typical arrangement for an a.c. coupled PV battery system, without emergency power capability:

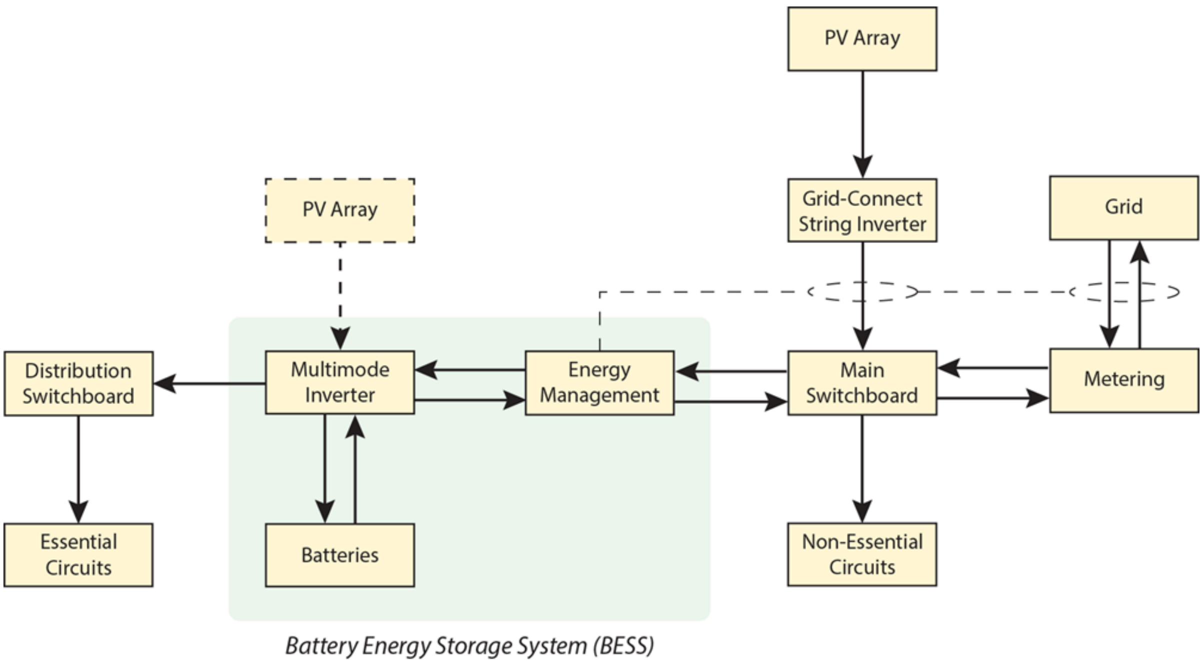


In this arrangement:

- The PV supply and the battery supply have both been inverted before they are connected together in the main switchboard – therefore the system is a.c. coupled.
- The BESS energy management unit monitors the PV array, batteries and grid import/export, and adjusts the system parameters as necessary.
- During a grid-outage, grid protection in the string inverter will disconnect the PV supply and grid protection in the BESS energy management unit will disconnect the battery supply, and therefore no supply will be available to the installation circuits.

This is a good arrangement for an installation with an existing grid-connect PV system, as it's relatively simple to retrofit.

This next diagram shows a similar arrangement that is capable of providing emergency supply to a set of essential circuits, and provides the option of having a second d.c. coupled PV array added:



In this arrangement:

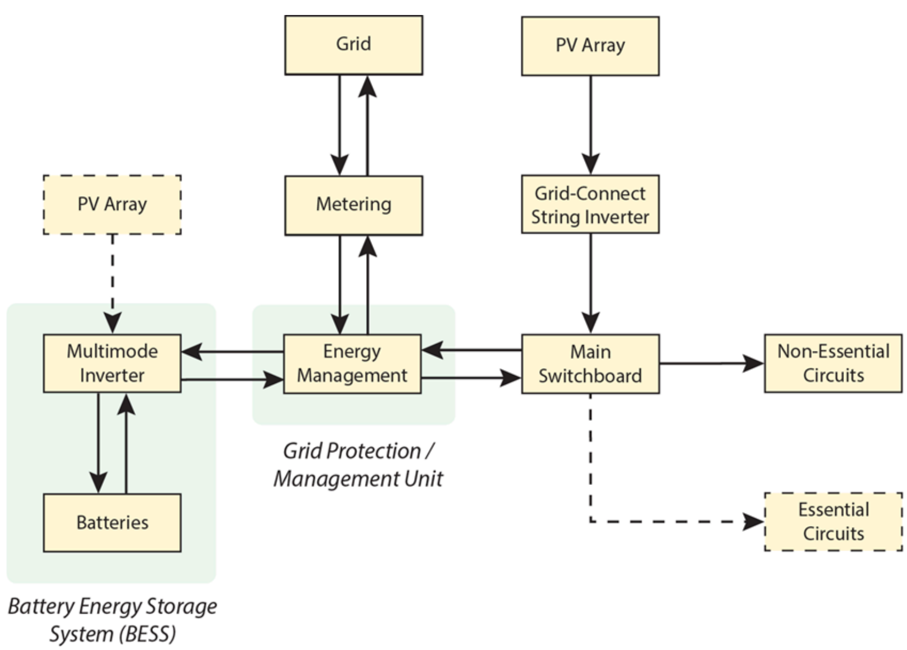
- The BESS energy management unit monitors the PV array(s), batteries and grid, and adjusts the system parameters as necessary.
- During normal operation, both the essential and non-essential circuits are supplied with energy, either from the array(s), batteries or grid.
- During a grid-outage:
  - The grid protection in the string inverter will disconnect the a.c. coupled PV supply.
  - The grid protection in the BESS energy management unit will isolate the battery and any d.c. coupled PV array from the grid.
  - The essential circuits will continue to be supplied via the multimode inverter from the battery and any d.c. coupled PV array.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Alternate System Arrangements

As mentioned above, the particular arrangement of components will depend on the specific product selected. This last block diagram shows the arrangement for a different battery system product that incorporates two separate modules:



For this installation:

- The energy management module is connected between the installation's metering and main switch(es).
- This arrangement allows any or all of the installation circuits to be provided with emergency power in the event of a grid outage (provided enough battery capacity is installed).

This learning activity consists of 7 parts designed to develop your understanding of battery storage system components and arrangements.

Topic 3.1 Learning Activity

In this skills practice, you are required to draw block and circuit diagrams of various grid-connected battery storage system arrangements.

Topic 3.1 Skills Practice

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Australian Installation Standards

In addition to AS/NZS 3000:2018, there are a number of Australian Standards containing requirements related to the installation of low voltage grid-connected PV power systems, including:

- AS/NZS 5033:2021 Installation and safety requirements for photovoltaic (PV) arrays.
- AS/NZS 4777.1:2024 Grid connection of energy systems via inverters – Installation requirements.

The intent of these standards is to ensure safety, correct functionality, long life and ease of maintenance for the system.

AS/NZS 5033:2021 Overview

Some of the main factors and requirements affecting the installation of PV arrays are summarised in the following table.

AS/NZS 5033:2021 Overview	
Installation Factors	**Summary of Requirements**
PV Array Characteristics	PV array mounting frames are required to be: • Resistant to corrosion, including that caused by contact between dissimilar metals. • Capable of withstanding the required mechanical load. • Capable of withstanding any expected weather effects such as wind, snow or ice. • Installed in accordance with applicable building codes, regulations and standards.
PV Array Configurations	Any domestic PV system must not exceed a maximum d.c. circuit voltage of 1,000 V d.c. The standard also illustrates permissible connection configurations for arrays and grid-connected inverters, and sets out the need for: • Bypass diodes. • Blocking diodes. • Switch disconnectors.

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Electrical Protection and Earthing	The standard sets out specific requirements for isolation, overcurrent protection, earth fault protection, overvoltage protection, protective earthing, and equipotential bonding. Disconnectors (isolation switches or circuit breakers) are required for the a.c. and d.c. sides of the grid-connected inverter, and either a disconnector or disconnection point (non-load break d.c. disconnection device) is required for the PV array. This is to ensure that these components can be safely disconnected from one another and from the grid. Some of the main requirements for switch-disconnectors are that they must: • Have a utilisation category of DC-PV2. • Break all live conductors at the same time. • Be capable of being locked in the open position. • Be rated to break the PV array prospective fault current. • Have at least one pole per polarity and must **not** be polarised. Appendix H provides guidance and example calculations for selecting suitably rated PV system switch-disconnectors.
PV System Cable Selection	All PV system wiring must: • Be suitable for the environmental conditions (e.g. UV, wind, rain, temperature etc.). • Be rated for direct current (d.c.). • Be rated to withstand the maximum d.c. circuit voltage. • Have a minimum cross-sectional area (c.s.a.) of 4 mm^2. • Be double insulated (where the maximum d.c. circuit voltage exceeds 35 V d.c.). • Have minimum current carrying capacity in accordance with Table 4.2 and AS/NZS 3008.1:2017. • A temperature rating of 40^{o}C above ambient temperature should be considered for cables that will be in close proximity to PV modules.
PV System Low Voltage Wiring	Low voltage PV system wiring must be installed in accordance with the Wiring Rules (AS/NZS 3000:2018). Care must be taken to ensure that wiring systems installed on roofs don’t obstruct water drainage or cause the accumulation of debris (e.g. leaves). PV arrays must be wired using flexible cables, and must **not** be primarily supported by plastic cable ties. PV array d.c. wiring must be segregated from a.c. wiring, and any d.c. wiring within wall cavities, roof spaces, under a floor, or installed externally in an accessible location must be enclosed in metal or HDPVC conduit (or equivalent wiring enclosure).
Identification and Documentation	PV system documentation must be prepared and provided to the owner of the system in the form of a system manual. Clause 6.2 lists the information required to be included.

System Commissioning	Clause 6.3 and Appendix E set out the minimum inspection and testing activities required for commissioning a grid-connected PV power system. Appendix F provides details of additional commissioning procedures that may be required in some circumstances.

AS/NZS 4777.1:2024 Overview

Some of the main factors and requirements affecting the installation of grid-connected inverter systems are summarised in the following table.

Overview of AS/NZS 4777.1:2024	
Installation Factors	**Summary of Requirements**
Phase Balance	To avoid phase imbalances on the grid, the combined rating of IES in an installation connected to a single phase point of supply (POS) must not exceed 30 kVA (130 A). IES installations connected to a multiple phase POS (typically three phase) may consist of one or more three phase inverters, or multiple single phase inverters. Generally speaking, there must not be more than 10% difference between phases – see Appendix C for more details.
Interface Protection	For IES rated at 200 kVA or more, interface protection is required. Note that the network provider may have stricter requirements relating to when interface protection in required.
Equipment Selection	Any inverter used in an IES that is connected in parallel with the grid must comply with the requirements of AS/NZS 4777.2. IES wiring and equipment must be selected in accordance with AS/NZS 3000, AS/NZS 3008.1.1, AS/NZS 4777.1, and the manufacturer’s instructions. Current carrying capacity of cables must be rated for full possible load current (not based on export limit settings). In addition to the voltage drop requirements of AS/NZS 3000, the voltage rise between the POS and the IES a.c. terminals must not exceed 2% (see Appendix B for voltage rise calculation).
System Arrangement	There must not be any variable voltage or frequency devices (e.g. double conversion UPS) connected between an IES and the POS as this renders the inverter protective functions ineffective. Where an installation includes a backup generator, the IES must be connected on the grid side of the generator changeover switch, unless it is either: • Designed to operate in parallel with the generator. • Interlocked with the changeover switch to prevent parallel operation.

Inverter Power Sharing Device (IPSD)	IPSDs are used in multiple tenancy installations (e.g. a block of units) with shared IES, to allow power sharing between tenants. The ISPDs are installed between inverters and the installation main switches, and there are several requirements that apply (see Clause 3.6, and Figures 3.3 and 3.4).
Vehicle to Grid (V2G)	Mode 3 and mode 4 EV supply equipment capable of reverse power transfer may be used as an IES. Mode 1 and mode 2 EV supply equipment is not permitted for reverse power transfer.
Installation Requirements	IES installations must comply with AS/NZS 3000, as well as with the additional and varied requirements in AS/NZS 4777.1:2024, and any local network provider rules. Inverters must be installed: • In accordance with the manufacturer's instructions. • In a well-ventilated location that is suitable for the IP rating. • In a way that allows safe operation, inspection, testing, maintenance and repair. • So that they are protected against external influences. Inverters are not permitted to be installed in a restricted switchboard location, as defined in AS/NZS 3000.
Wiring Systems	The IES wiring must be: • Supported to prevent mechanical strain on terminations. • Protected against any external influences (wind, rain, snow, direct sunlight etc.). • Enclosed when installed along roofs or floors. Wiring enclosures and supports must have a lifetime that exceeds that of the inverter system.

Inverter Wiring and Connection	The IES must be connected to a dedicated circuit on the connecting switchboard.
	
	Connections at the inverter must be either by:
	• Fixed installation wiring.
	• Heavy duty flexible cord with type 3 connectors/couplings ensuring IP2X both when connected and disconnected.
	
	The a.c. and d.c. cables of IES energy sources must be segregated from other cables and from each other:
	• Outside of an enclosure, this can be by either:
	  ◦ A minimum 50 mm separation.
	  ◦ Medium duty wiring enclosure.
	• Within an enclosure, where the d.c. maximum voltage exceeds 35 V, this can be by either:
	  ◦ Double insulation.
	  ◦ An insulating barrier.

a.c. Control and Protection	A main switch (inverter) for the IES must be provided on the connecting switchboard that: • Operates in all active conductors. • Is capable of being secured in the open (OFF) position. • Is rated to break the total rated current of the IES (not based on export limit settings). A maximum of 2 inverter main switches is permitted on any switchboard that also supplies final subcircuits. If more than two main switches are needed, then an aggregation board is required (note AS/NZS 4777.1:2024 Figures 3.1 and 3.2). Separate external isolators must be provided on the supplementary and alternative supplies of an IES. Some exceptions apply: • If the inverter is within 3 m and visible from the connecting switchboard, then the isolator in the switchboard satisfies this requirement. • If a flexible cord with type B plugs is used then the plug connector satisfies the requirement, provided the plug is labelled and meets certain conditions (this method is not permitted for multiple mode inverters). Overcurrent protection must be provided for all IES wiring in accordance with AS/NZS 3000.

d.c. Control and Protection	An isolation device must be provided between the energy source and the inverter, either by:
	• An integral isolation device provided as part of the inverter that complies with AS/NZS 4777.2.
	• A separate isolator that complies with AS/NZS 3000, installed adjacent to the inverter, that is:
	  ◦ Capable of safely breaking the maximum possible voltage and current
	  ◦ Capable of being secured in the open (OFF) position.
	
	A semi-conductor device is not permitted for isolation purposes.

Multiple Mode Inverters – Substitute Supply	Some multiple mode inverters have provision for a separated socket outlet (as per AS/NZS 3000:2018 Clause 7.4). Maximum permitted current rating for the substitute supply socket it 15 A.
Multiple Mode Inverters – Alternative Supply	Refer to AS/NZS 4777.1:2024 Figures 5.1, 5.2 and 5.3. Where the alternative supply from a multiple mode inverter is capable of supplying overcurrent, the alternative supply cable must be provided with overcurrent protection in accordance with AS/NZS 3000. Final subcircuits supplied by the alternative supply must be located in a dedicated alternative supply switchboard that is controlled by a main switch (alternative). All alternative supply final subcircuits must be protected in accordance with AS/NZS 3000 requirements for overcurrent and RCD protection.

Multiple Mode Inverters – Independent Supply	Refer to AS/NZS 4777.1:2024 Figure 5.4. Note that in this arrangement, the independent supply inverter does not permit energy to be exported back to the grid. Where a second inverter is used in conjunction to provide a supplementary supply to the independent supply switchboard, it must be compatible with the independent supply inverter. Connection of the independent IES must be a MEN arrangement. The independent supply must have a main switch and be labelled accordingly e.g. "MAIN SWITCH (INDEPENDENT)". If the independent IES automatic disconnection device interrupts the neutral conductor, then an arrangement must be used to maintain continuity of the neutral in the interests of ensuring correct operation of downstream RCDs. Final subcircuits supplied by the independent supply must be located in a dedicated independent supply switchboard that is controlled by a main switch (independent). All independent supply final subcircuits must be protected in accordance with AS/NZS 3000 requirements for overcurrent and RCD protection.
Commissioning and Documentation	A system manual must be provided with each installation. Section 7 provides a list the required information to be included. Compliance and functionality of the installation must be verified in accordance with AS/NZS 3000:2018. This is done by visual inspection, mandatory testing, and some specific operational testing. Note that there are some additional specific details and parameters that must be noted on the verification report, as detailed in Section 8.

This learning activity consists of 5 parts designed to develop your understanding of the installation requirements and standards that apply to grid-connected PV power systems.

Topic 2.3 Learning Activity

In this skills practice, you are required to identify and compare and contrast the benefits of two different grid-connected PV power system options.

Topic 2.3 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the PV system configurations and diagrams, array wiring and arrangements, and general installation requirements for grid-connected PV systems.

Topic 2 Content Quiz

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PV Array Configurations

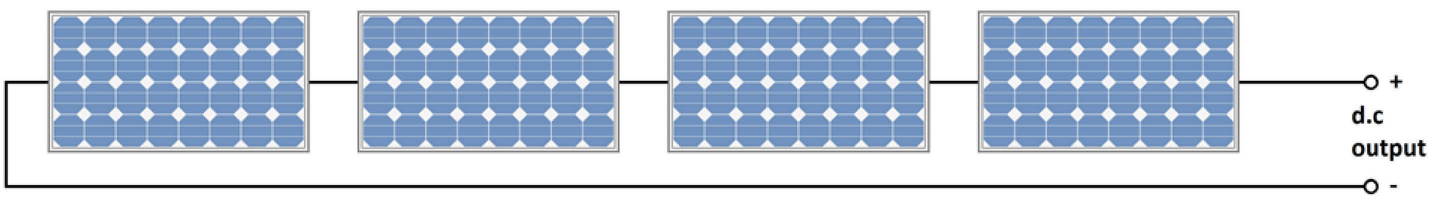
An array consists of a number of PV modules connected in series, parallel, or series-parallel.

- Connecting PV modules in series increases the output voltage, whilst the output current remains the same.
- Connecting PV modules in parallel increases the output current, whilst the output voltage remains the same.

Care should be taken to accurately match module types and ratings that are to be connected together into an array. The output current of a string is limited to the lowest output current of any individual cell within the string.

Worked Example 1 – Modules in Series

The following diagram shows four PV modules connected as a series string. Each module has a power rating of 120 W, a nominal voltage of 24 V, and a rated current of 5 A.



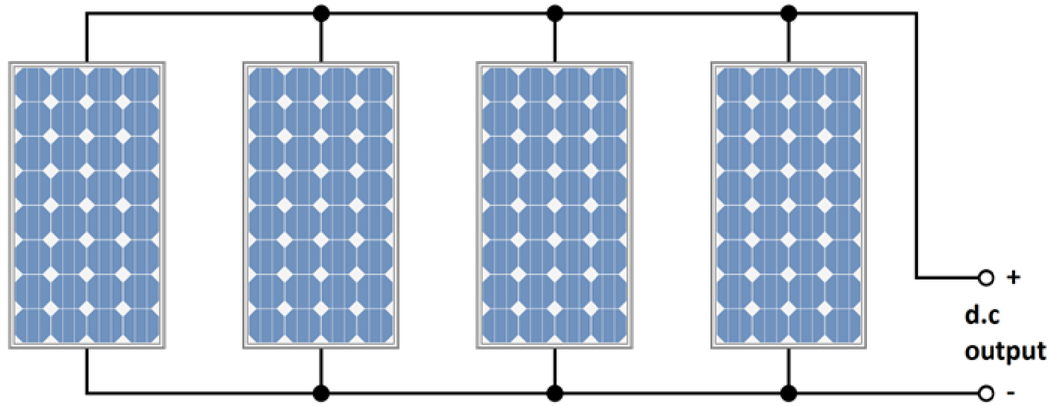
When connected in series:

- The nominal voltage of the string is equal to the sum of the voltages of each module, i.e. 24 + 24 + 24 + 24 = 96 V d.c.
- The rated current of the string is equal to the current of each module, i.e. 5 A d.c.
- The rated power of the configuration is determined either by adding the module power ratings or by multiplying the total voltage by the tota current, i.e.
    - 120 + 120 + 120 + 120 = 480 W
    - 96 x 5 = 480 W
- So we end up with a 480 W, 96 V, 5 A array.

?

Worked Example 2 – Modules in Parallel

The following diagram shows four PV modules connected in parallel. Each module has a power rating of 120 W, a nominal voltage of 24 V, and a rated current of 5 A.

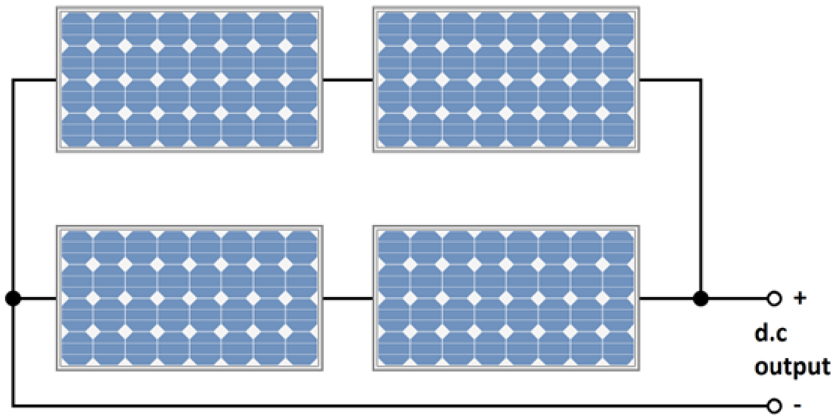


When connected in parallel:

- The nominal voltage of the configuration is equal to the voltage of each module, i.e. 24 V d.c.
- The rated current of the configuration is equal to the sum of the currents of each module, i.e. 5 + 5 + 5 + 5 = 20 A d.c.
- The rated power of the configuration is determined either by adding the module power ratings or by multiplying the total voltage by the total current, i.e.
    - 120 + 120 + 120 + 120 = 480 W
    - 24 x 20 = 480 W
- So we end up with a 480 W 24 V, 20 A array.

Worked Example 3 – Modules in Series-Parallel

The following diagram shows four PV modules connected in series-parallel – two parallel strings, each consisting of two series connected modules. Again, each module has a power rating of 120 W, a nominal voltage of 24 V, and a rated current of 5 A.



When connected using this series-parallel configuration:

- The nominal voltage of the configuration is equal to the voltage of each string, i.e. 24 + 24 = 48 V d.c.
- The rated current of the configuration is equal to the sum of the currents of each string, i.e. 5 + 5 = 10 A d.c.
- The rated power of the configuration is determined either by adding the module power ratings or by multiplying the total voltage by the total current, i.e.
  - 120 + 120 + 120 + 120 = 480 W
  - 48 x 10 = 480 W
- So we end up with a 480 W, 48 V, 10 A array.

Shading

Shading of modules can occur due to a variety of factors, such as:

- Soiling.
- Trees.
- Buildings and other structures.

Shading or failure of a single PV cell can reduce the output current of a string to zero, and can even result in the string becoming a load on other parallel connected strings.

Bypass Diodes

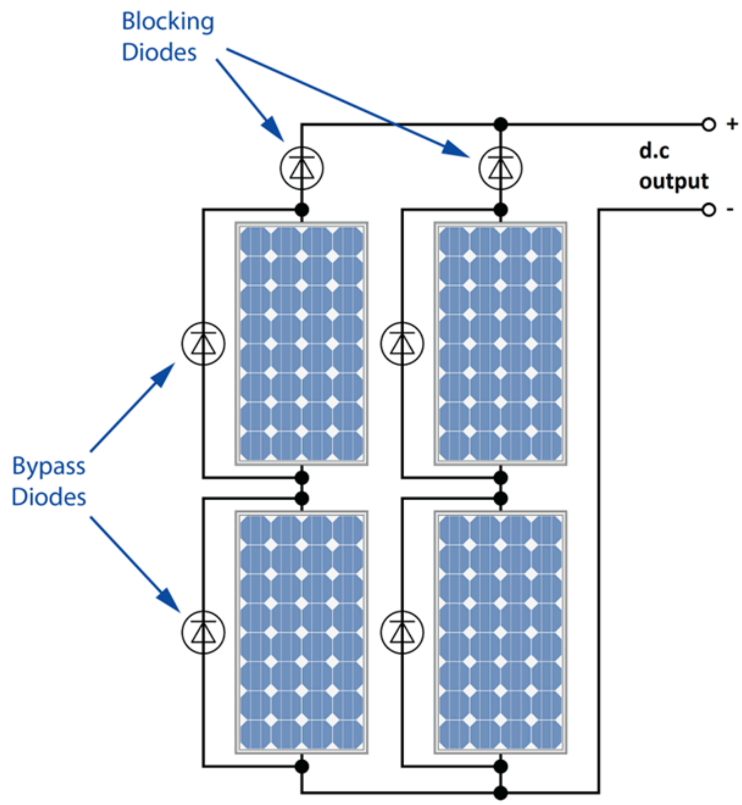
Bypass diodes are connected in parallel with each module, so that modules containing one or more shaded or failed cells are bridged out of the circuit. This allows the string to continue generating current (although at a reduced voltage). Bypass diodes are typically embedded into modules, but may also be located in the module connection box.

Blocking Diodes

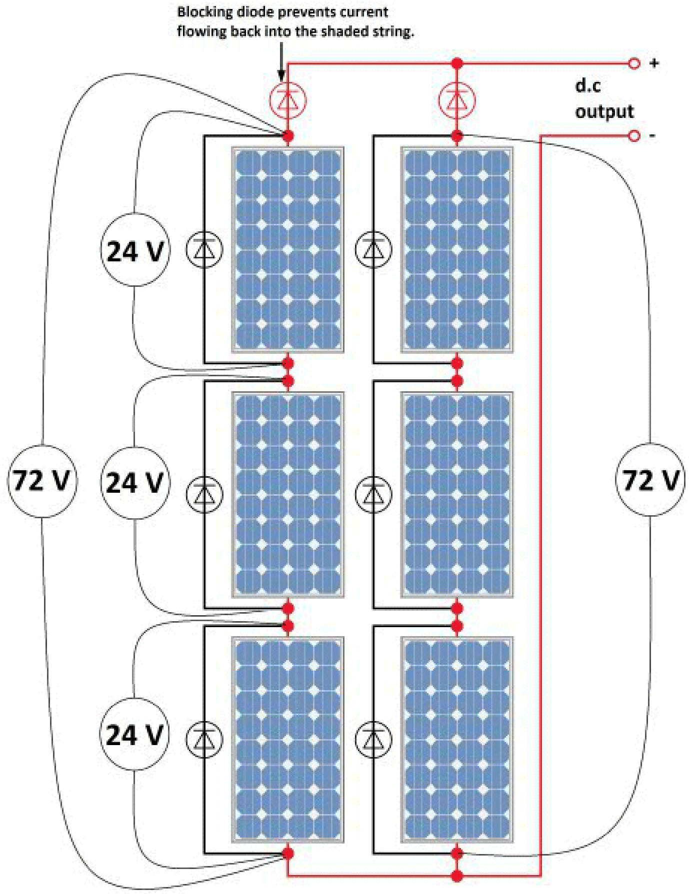
If part of a string becomes shaded, the bypass diode effectively removes the shaded module from the circuit, meaning that the string keeps operating, but at a reduced voltage. If a second string, connected in parallel, is operating at full voltage, then the difference in output voltage between the two strings would cause current to 'back-feed' into the shaded string from the unshaded string.

To prevent this, blocking diodes are connected in series with each string. The blocking diode allows current to leave the shaded string, but prevents current from back-feeding into it.

The following diagram shows the arrangement of a PV array with blocking and bypass diodes.



This next diagram shows the operation of an array that consists of two 72 V d.c. strings (each consisting of three 24 V d.c. modules):



Notice how the bypass diode has effectively removed one of the modules from the circuit, thereby reducing the string voltage to 48 V, whilst the voltage of the other string remains at 72 V. The blocking diode in the shaded string prevents current flowing back into the shaded string.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

AS/NZS 5033:2021 states the requirements for selecting, arranging and installing blocking and bypass diodes in PV arrays.

PV Array Selection Factors

There are a number of factors that need to be considered in the design of a PV array. Some of the main factors are described in the following table.

PV Array Selection	
Factor	**Impact**
Energy yield	The desired energy yield from an array will be central to the total size of the array, as well as the type of modules used. It could also determine the need for axis tracking and/or monitoring systems.

Type of installation	Arrays in domestic installations must not have an open circuit voltage exceeding 1000 V, which can affect the arrangement of modules for these arrays. The location/environment for installation can also have an effect on the type of modules to be selected. Building integrated PV products may be better suited to certain situations.
Available space	The space available for the installation of the array will be a limiting factor as to the size.
Cost	The initial cost, available rebates and expected 'payback' period typically play a significant role in determining the size of an array desired by a customer. This consideration must also extend to ensuring compatibility with the other system equipment, such as inverters, in a way that provides the most cost-effective system as a whole.

Positioning PV Arrays

The solar radiation arriving at the surface of a particular fixed PV panel can vary throughout the year due to various factors. The following factors need to be taken into consideration:

PV Array Setups	
Seasonal change	Seasonal changes will result in variations in the angle of incident solar radiation on the panel.
Shading and soiling	Shading and soiling will act as a barrier to solar radiation arriving at the surface of the panel.
Cloud cover	Cloud cover will reduce the amount of direct solar radiation arriving at the panel.
Time of day	The quantity and angle of incidence of solar radiation will vary throughout each day as the sun moves through the solar window.

To obtain maximum irradiation on any given day in Australia, PV arrays should be mounted facing (true) north, at a tilt of approximately 20^0 to 30^0. If north facing roof space is not available, the following factors should be considered when selecting the most appropriate location:

- Shading.
- Ventilation.
- Ease of maintenance.
- Method of mounting.
- Length of the cable run.
- Aesthetics.
- Council regulations.
- Heritage considerations.

Local Requirements

In the case of PV power systems, the cost of the system is balanced against the cost of obtaining electricity from the grid. The continuing trend has been for PV power to become cheaper, and grid power to become more expensive. There have been a range of government policies, such as rebates, taxes and subsidies that have been implemented to either slow or quicken this process.

Local council rules can also affect the permissible designs and locations of PV systems within that local area. You should always check with the local council regarding any local rules and permits that may be required, prior to providing advice to the customer.

Environmental Factors

When surveying a site, several environmental factors should be considered when determining suitability for a grid-connect system. Factors to consider include:

- Whether there will be any negative effects on nearby ecosystems.
- Whether the installation will cause any soil erosion or other land degradation.
- The carbon footprint associated with the components, transport, and associated installation work.
- End-of-life management – ease of maintenance, component replacement and recycling.
- Whether there will be a negative visual impact on the aesthetics of the site (e.g. this may be particularly important on heritage sites).

This learning activity consists of 8 parts designed to develop your understanding of PV array arrangements and connection configurations.

Topic 2.2 Learning Activity

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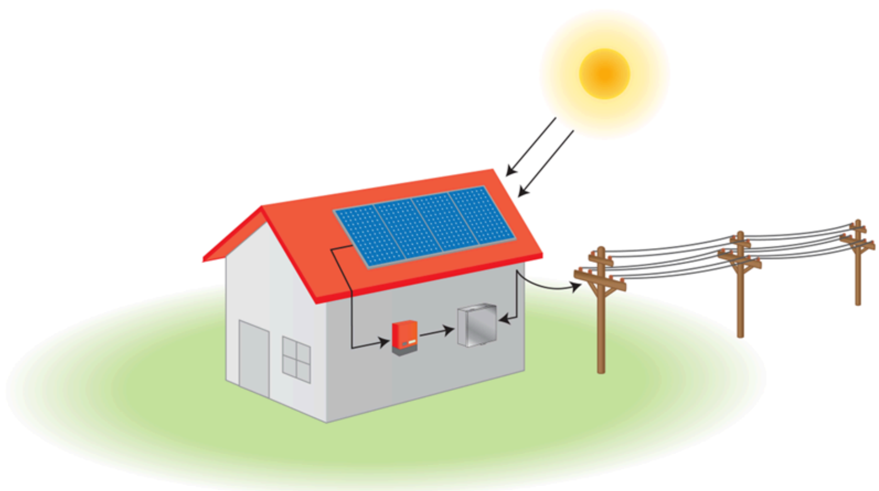
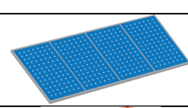
Introduction

In this topic you will learn about the arrangement and operational features of grid connected PV power systems, including components, configurations, PV arrays, and installation requirements.



Photovoltaic (PV) Power Systems

A basic grid-connected PV power system consists of the following components:

PV Power System Components		
Component	**Illustration**	**Function**
PV array		Converts radiant energy into electrical energy.
Inverter		Converts direct current into alternating current.
Metering		Measures the imported and exported electrical energy.

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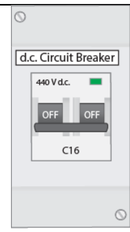
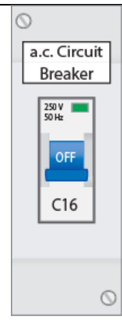
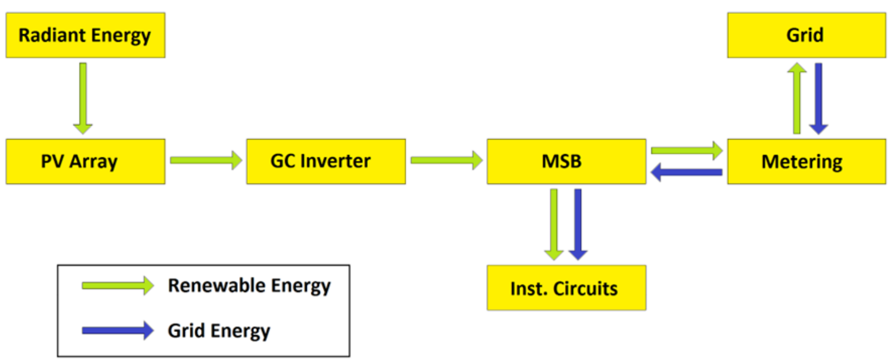
d.c. Controls and Protection		Protects d.c. equipment against overcurrent and provides a point of isolation.
a.c. Controls and Protection		Protects a.c. equipment against overcurrent and provides a point of isolation.

In addition, PV power systems may include:

- Batteries – to store excess electrical energy.
- Charge controller – to control the battery charging parameters.
- Voltage regulator – to maintain the d.c. voltage within a set tolerance.
- System monitoring – to monitor and log system operating parameters for analysis.

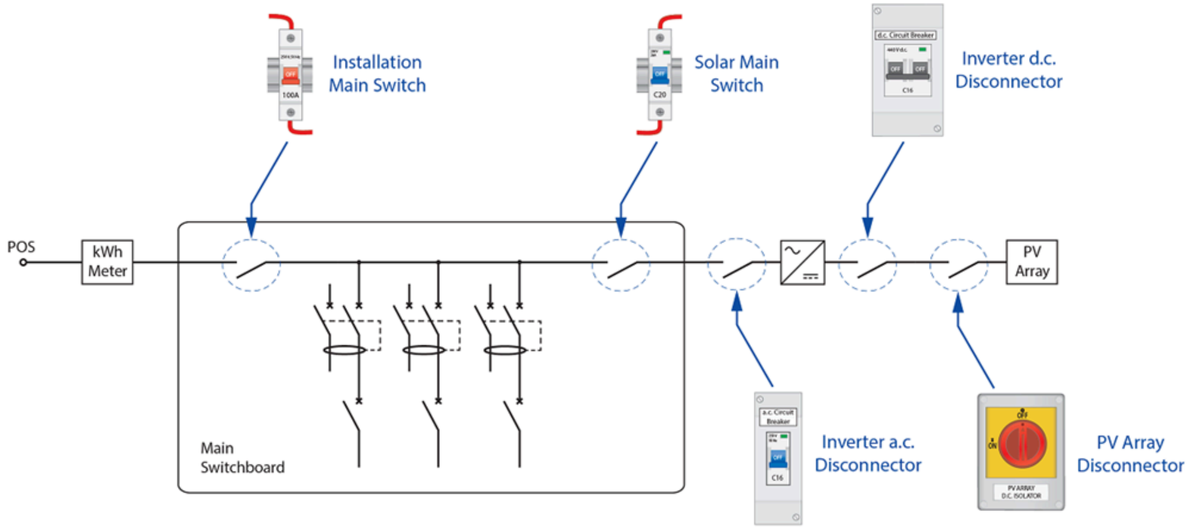
PV System Relationships

The following block diagram shows the basic relationships and power flow between the major components in a grid-connected PV system.

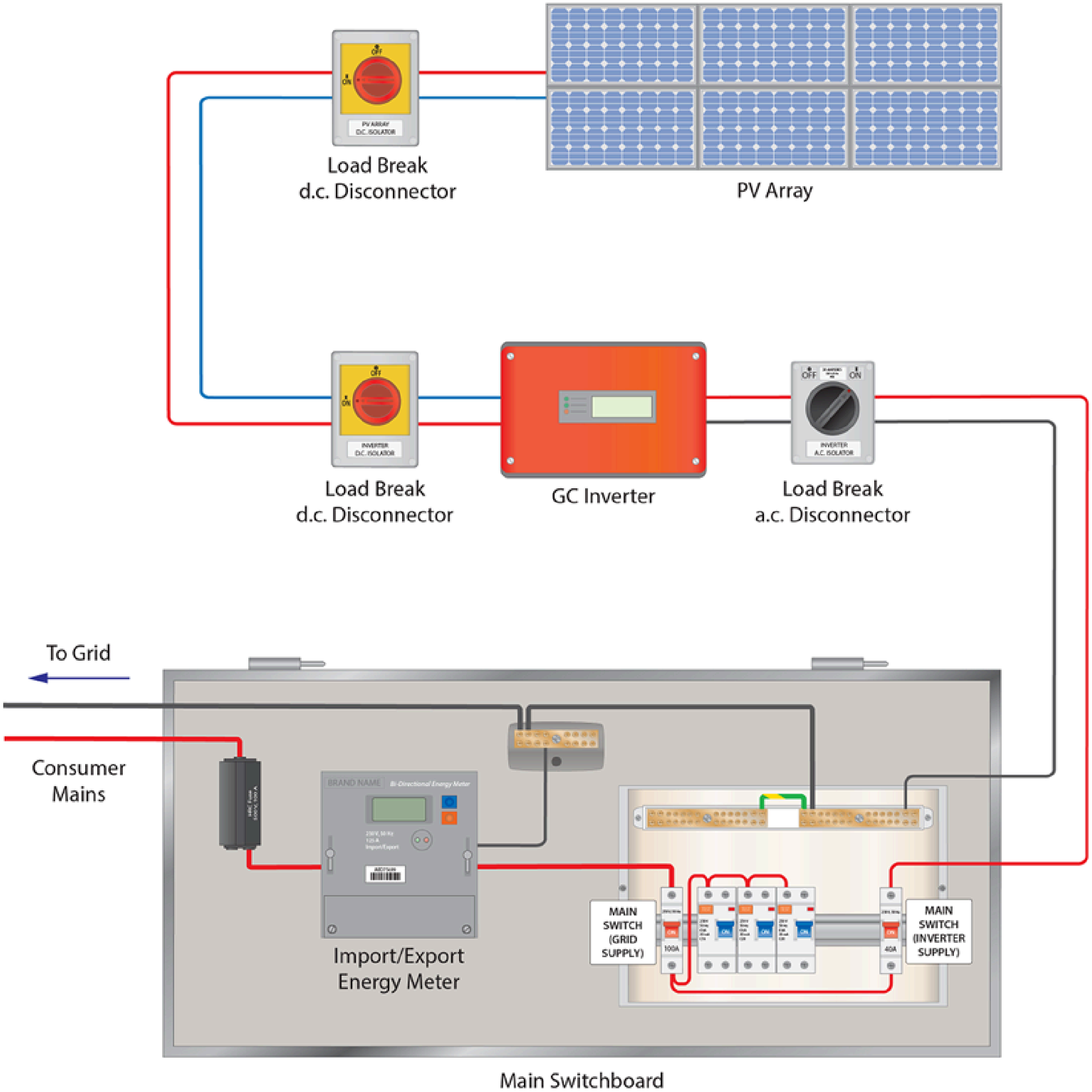


PV System Configuration

The following diagram shows a typical arrangement of control and protection in a basic grid-connected PV power system.



This next diagram shows typical connections for a basic grid-connected PV power system.



Since the implementation of AS/NZS 5033:2021, most installations will no longer require a roof-top load-break isolator. Use of a 'disconnection point' (DP) is now an acceptable arrangement, and in practice, this will simply be the plug and socket connection of the PV module.

It's important to note that these plug and socket connections are not suitable to be disconnected under load conditions, and so there are some particular requirements that apply to installations using DP arrangements, including labelling and identification (e.g. see AS/NZS 5033:2021 Clause 4.3.5.2.1).

PV System Features

The following table highlights the various features of grid-connected PV power systems.

PV Power System Features	
Synchronisation	A grid-connected PV power system provides a high quality, synchronised PWM true sine wave output to the grid and to the installation.

Maximum Power Point (MPP) Tracking	MPP tracking adjusts the load resistance placed on the PV system to maintain maximum efficiency for the given irradiation and operating temperature at the time.
Passive Anti-islanding Protection	Passive protection disconnects the PV system when abnormal grid voltage or frequency is sensed. The voltage and frequency limits are specified in AS/NZS 4777.2:2020 Table 4.1 and Table 4.2. One of the primary reasons for anti-islanding protection is to prevent the grid from being supplied by PV systems in the event that it has been shut down (e.g. for maintenance).
Active Anti-islanding Protection	Active protection produces a voltage or frequency shift in the event that the grid goes off-line (e.g. due to maintenance or power outage), causing passive protection to disconnect the PV power system.
Metered Energy	Energy metering is used to determine how much energy is exported/imported to and from the grid. This can be achieved by the use of separate import and export meters, or by a single meter that indicates resultant import/export.

This learning activity consists of 5 parts designed to develop your understanding of grid-connected PV system features.

Topic 2.1 Learning Activity

In this skills practice, you are required to draw block and circuit diagrams of various grid-connected PV power system arrangements.

Topic 2.1 Skills Practice

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View

Concept of Energy

Energy is a measure of the ability to do something. You can consider this in terms of your own energy levels – if you have a lot of energy then you can get a lot done, but if you have no energy you can't do much at all.

The SI unit of measure for energy (E) is the joule (J), however 1 joule of energy is a relatively small amount, so kilojoules (kJ) or megajoules (MJ) are typically used in practice. There are a few exceptions to this, such as electrical energy which is typically expressed in kilowatt-hours (kWh).

Conversion of Energy

The laws of thermodynamics tell us that energy cannot be created or destroyed, but that it can be converted from one form into another. The following table describes some of the various forms of energy.

Forms of Energy	
Type	**Description**
Electrical	Energy associated with the movement or buildup of electrons.
Mechanical (kinetic)	Energy associated with the movement of a physical object, such as the rotating part of a motor.
Thermal (heat)	Energy associated with the vibration of atomic particles.
Chemical	Energy associated with the bonds between atoms that make up molecules.
Nuclear	Energy associated with the bonds between sub-atomic particles in the nucleus of an atom.
Electromagnetic	Energy of electromagnetic radiation, such as radio waves, microwaves and visible light.
Gravitational	Potential energy stored in an object when it is suspended above the ground. This energy is released when the object is allowed to fall.

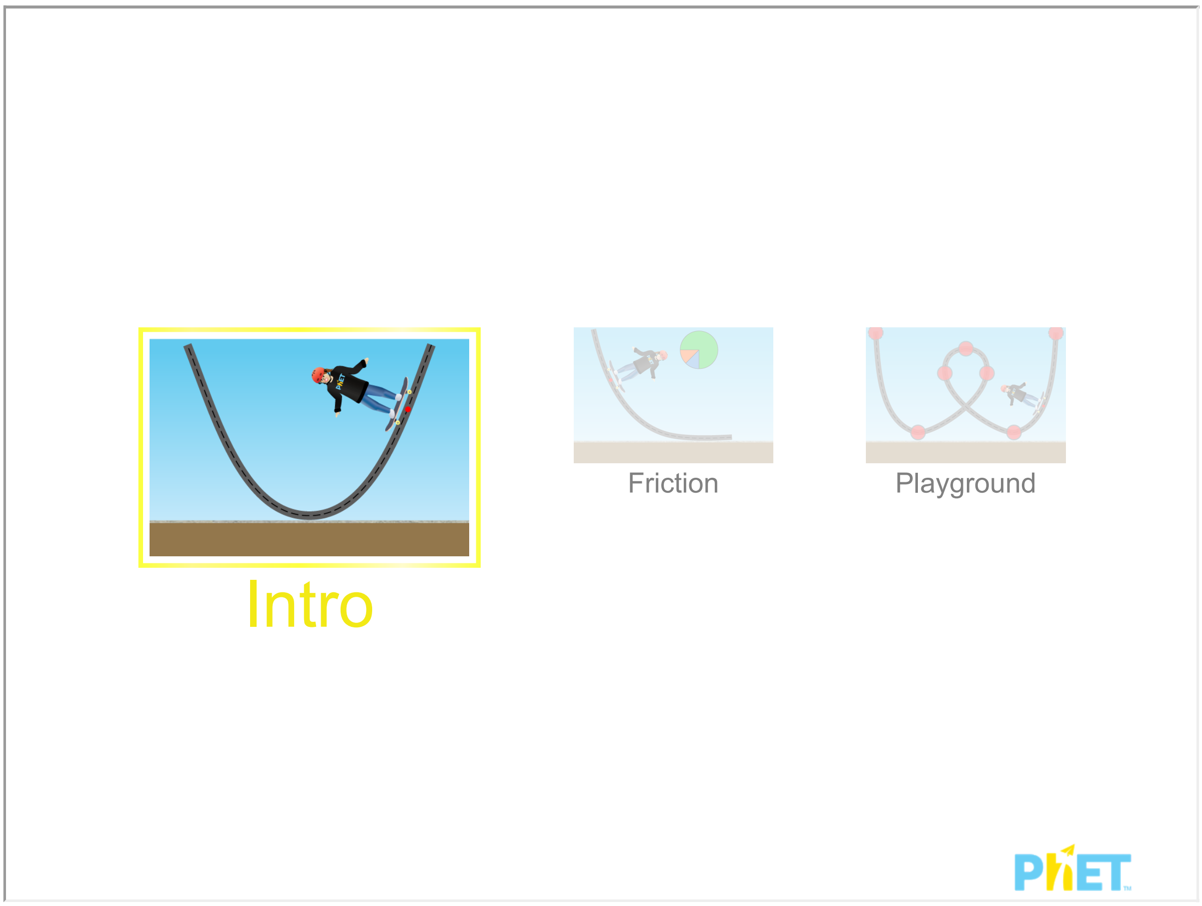
Over the course of history, a huge range of devices have been developed that allow us to harness and convert one form of energy into another for some useful purpose, for example:

- A battery converts chemical energy into electrical energy.
- An electric motor converts electrical energy into mechanical energy.
- A nuclear reactor converts nuclear energy into thermal energy.
- A radio transmitter converts electrical energy into electromagnetic energy.

Most of the equipment we use on a day-to-day basis converts electrical energy into some other form – to make our lives easier or simply for entertainment.

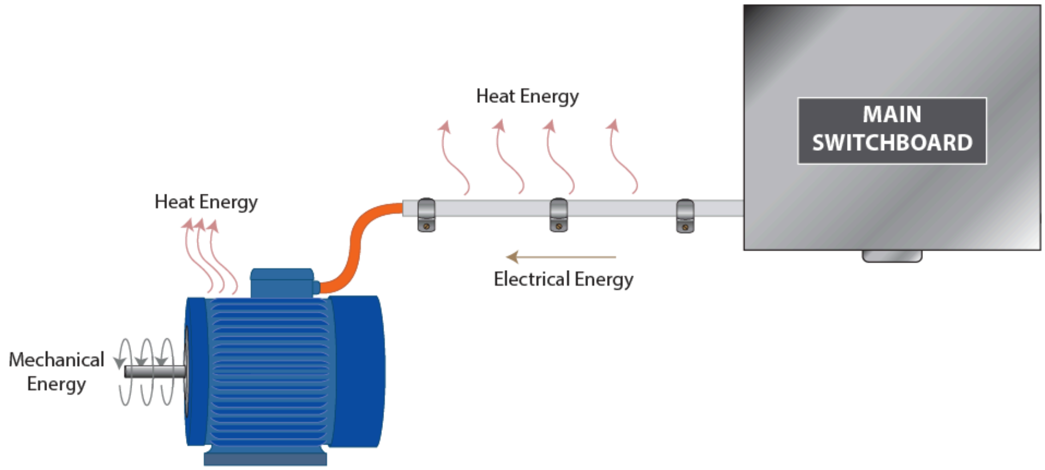
Try using this simulation:

- Drag the skater to the ramp.
- Enable the bar graph to see the relationships between kinetic and potential energy.
- Try adjusting the mass and observe the results.
- Try adjusting the friction and observe the results.



Energy Losses

Whenever we transport or convert energy, some of the energy unavoidably gets 'lost' in the process. For example when electricity flows through a copper conductor, the resistance of the conductor causes some of the electrical energy to be converted into thermal energy. This energy radiates out along the length of the cable as heat, and therefore does not reach the intended target (i.e. the appliance).



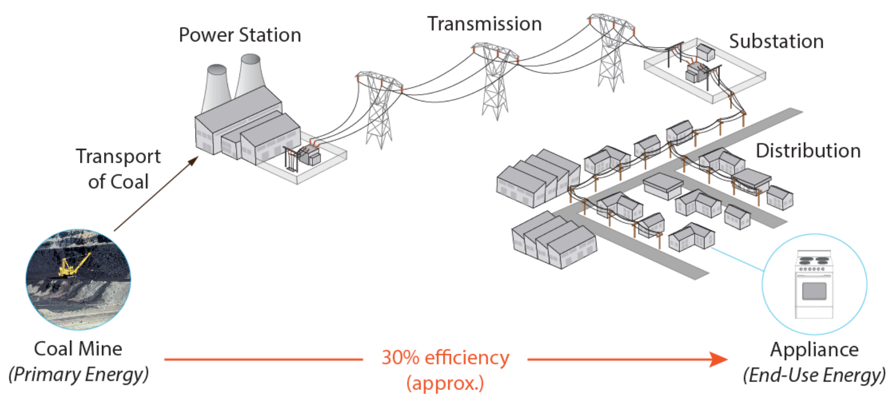
Energy in an Electric Motor

In the motor diagram above, electrical energy is put into the motor and mechanical energy is given out, but some power is also lost in the form of heat. In reality, there would also be other magnetic and friction losses associated with the motor.

No method of energy transport or conversion is perfect and so losses are unavoidable, however we can try to minimise them as far as possible.

Energy Efficiency

The efficiency of an energy conversion device or system represents the ratio of how much useable output energy you get for the energy you put in. The following diagram represents the end-to-end process of utilising electrical energy from coal.



Due to the losses at each stage of energy conversion and transport, the total efficiency is only around 30%. This means that around 70% of the energy contained within the coal is lost in the system.

Energy Terms and Definitions	
Primary Energy	The original energy contained in the natural resource used in the initial stage of conversion (e.g. coal).
End-Use Energy	The particular energy that is utilised for a particular purpose by the end user, i.e. by an appliance.

Embodied Energy	The total energy needed for a particular purpose, including all stages of energy conversion and transportation.

Considering the above, this means that every 3 kWh of electrical energy you use in your home (end-use energy) actually requires 10 kWh worth of coal (primary energy).

Energy and Power

Power (P) is a measure of the rate at which energy is converted, measured in watts (W). The power rating of an appliance indicates the rate at which it is capable of utilising energy, for example a 2 kW hotplate will convert twice as much electrical energy into heat energy each second than a 1 kW hotplate. Therefore the 2 kW hotplate will be able to boil a given pot of water *faster* than the 1 kW hotplate.

The relationship between energy and power is represented in the following equation:

$$E = Pt$$

Where:

- E = energy measured in joules (J)
- P = power measured in watts (W)
- t = time measured in seconds (s)

Worked Example – Calculating Energy 1

Calculate the amount of electrical energy that is converted into light (and heat) energy when a 60 watt lamp is left on for 200 seconds.

$$E = Pt$$

$$E = 60 \times 200$$

$$E = 12{,}000 \text{ joules}$$

As mentioned above, electrical energy is often considered in terms of kilowatt-hours (kWh), i.e. Energy = kilowatts x hours. Note that this is still the same relationship indicated by the energy equation above as kilowatts are a unit of electrical power and hours are a unit of time.

Worked Example – Calculating Energy 2

Calculate the amount of electrical energy that is converted into heat energy when a 4.8 kilowatt water heater operates for 3 hours.

$$E = kWh$$

$$E = 4.8 \times 3$$

$$E = 14.4\ kWh$$

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Calculating Efficiency (η)

As stated above, efficiency is the ratio of how much useable output energy you get for the energy you put in. Efficiency is expressed as a percentage, and is typically calculated from values of input and output power* as follows:

$$\eta = \frac{E_{OUT}}{E_{IN}} \times 100 \quad \textit{or} \quad \eta = \frac{P_{OUT}}{P_{IN}} \times 100$$

The associated energy losses can be determined simply by subtracting the output value from the input value:

$$\text{Losses} = E_{IN} - E_{OUT} \quad \textit{or} \quad \text{Losses} = P_{IN} - P_{OUT}$$

Where:

- η = efficiency (%)
- E_{OUT} = output energy in joules (J) or kilowatt-hours (kWh)*
- E_{IN} = input energy in joules (J) or kilowatt-hours (kWh)*
- P_{OUT} = output power in watts (W)
- P_{IN} = input power in watts (W)

*Note: When using energy, the same units of energy must be used for both input and output values, i.e. either both must be in joules, or both must be in kilowatt-hours.

Worked Example – Calculating Efficiency and Losses

Calculate the efficiency and losses of an electric motor that draws 5 kW of power from the supply and outputs 4.5 kW of useable power to drive a mechanical load.

$$\eta = \frac{P_{OUT}}{P_{IN}} \times 100$$

$$\eta = (4500 \div 5000) \times 100$$

$$\eta = 90\ \%$$

$$\text{Losses} = P_{IN} - P_{OUT}$$

$$\text{Losses} = 4500 - 5000$$

$$\text{Losses} = 500\ W$$

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

There are three main forms of energy that are relevant to understanding grid-connected PV and battery storage systems, these are:

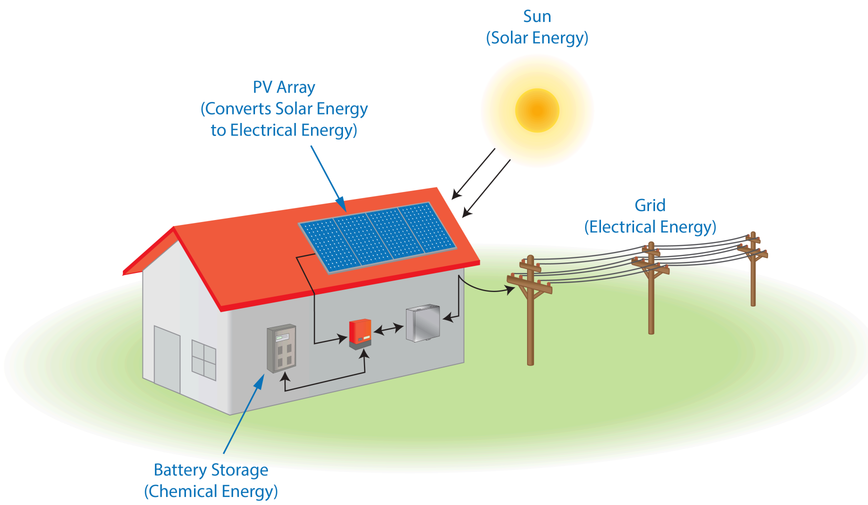
- Electrical energy.
- Solar energy.
- Chemical energy.

The following table explains these different types of energy.

Electrical, Solar, and Chemical Energy	
Type	**Description**
Electrical Energy	• A form of kinetic energy contained within atoms. • Can be harnessed by allowing electrons (negatively charged subatomic particles) to flow in a conductor, such as a copper wire. • Used widely for a broad range of purposes, such as lighting, air-conditioning and various appliances.

Solar Energy	• A form of radiant energy emitted from the sun in the form of electromagnetic waves. • Can be used directly for various purposes, such as heating water in solar-thermal systems. • Can be converted into electrical energy using photovoltaic (PV) cells.
Chemical Energy	• A form of potential energy that is stored within the chemical bonds of molecules and atoms. • Batteries are designed to store potential energy in chemical form. • Batteries convert the chemical energy to electrical energy when a circuit is connected.

The following diagram shows these different forms of energy in a grid-connected PV system with battery storage:



Benefits of PV and Battery Storage

The reliable and constant availability of energy may seem normal, but is actually incredibly abnormal in the context of human history. Fossil fuels such as coal have allowed societies to develop under the assumption that energy will be available '24/7', whilst the availability of renewable energy is often dependent on the occurrence of natural phenomena such as wind or sunlight. For this reason, energy storage has become a major focus of research and development over the past few decades.

It is only with the use of renewable energy technologies in conjunction with effective energy storage technologies, that we will be able to maintain our current energy expectations.

The addition of a grid-connected PV power system to an installation allows the owner to convert solar energy into electrical energy. This energy can then be utilised in the installation, or exported to the grid for others to use. Owners will be reimbursed from exporting energy to the grid, however it is generally much more economical to use the energy to offset energy import costs.

Adding battery storage to a grid-connected PV power system allows excess energy generated during sunlight hours to be stored for use at a later time (i.e. at night). This will significantly increase energy savings as:

- It further reduces the amount of energy the installation will need to import from the grid.
- It allows more of the generated PV energy to be used in the installation rather than exporting it (note that the cost of importing energy from the grid is higher than the price received for exporting that same amount of energy).

Another advantage is that supply can be maintained in the event of a grid outage. However, note that this capability needs to be specified in the design phase, as not all inverters and system configurations provide this function.

This learning activity consists of 9 parts designed to develop your understanding of energy principles, including electrical energy, solar energy, chemical energy, conversion and efficiency.

Topic 1.2 Learning Activity

In this skills practice, you are required to identify stakeholders and personnel, and to effectively communicate site survey processes and requirements to a customer (role play).

Topic 1.2 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of roles and responsibilities of personnel involved in grid-connect work, the site survey process, and the fundamental principles of energy.

Topic 1 Content Quiz

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View

Introduction

In this topic you will learn about the survey process and the roles and responsibilities of those involved in grid-connect work, and about the fundamental principles of energy.

Stakeholders and Personnel

There are a range of stakeholders and personnel who will either participate or have an interest in the installation of a grid-connected photovoltaic (PV) or battery storage system, as described in the following table.

Stakeholders and Personnel	
Type	**Roles and Responsibilities**
Clients	• Consults with surveyor and designer. • Provides access to site.
Site Surveyor	• Consults with client and designer. • Performs the site survey. • Prepares site survey report.
Designer	• Consults with client and surveyor. • Reviews site survey report. • Prepares PV and/or battery system design brief.
Installer	• Reviews PV and/or battery system design brief. • Installs the system equipment. • Commissions and documents the system.
Maintenance Personnel	• Performs maintenance to specified schedule – vegetation control, cleaning, repairs and/or replacing equipment. • Documents maintenance activities.

Site Survey Procedures

Surveying the site is the first step in the process of adding a grid-connected alternate energy source to a given installation. The purpose of surveying the site is to gather information on:

- Current energy usage patterns.
- Current and future energy needs of the installation.
- The nature of the structure – building materials and methods etc.

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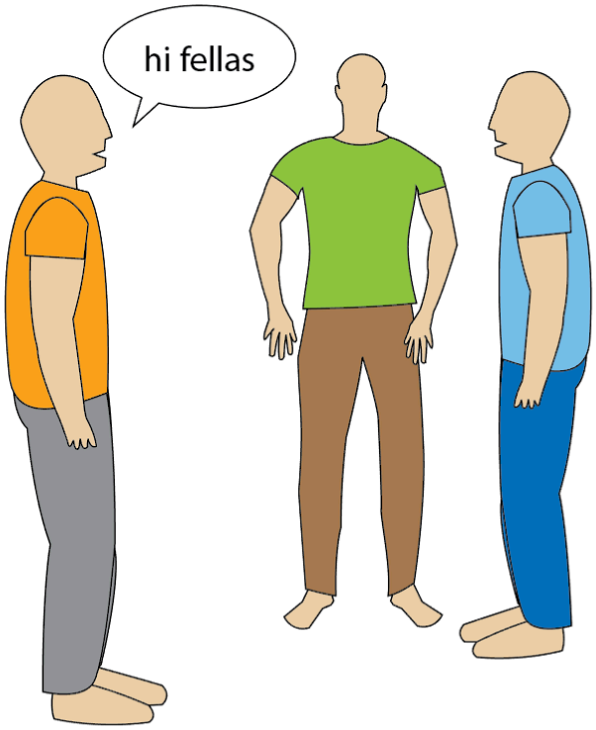
- The existing building structure and electrical installation.
- The available solar resource at the site.
- Potential locations for grid-connect equipment – PV arrays, inverters, batteries etc.

The basic general procedure for undertaking a site survey is described in the following table.

Basic Site Survey Procedure		
Step		**Description**
1.	Consult the customer.	• Determine what the customer's goals are – what they want. • Explain the benefits of PV and/or battery systems. • Explain the site survey process. • Arrange for access to the site – relevant infrastructure etc.
2.	Evaluate existing electrical infrastructure.	• Check the grid supply to the installation, e.g. single or multiphase. • Check the existing switchboard(s), e.g. switchgear, protection, available space. • Check number and types of circuits/loads.
3.	Evaluate energy usage/needs.	• Consult customer regarding energy usage. • Monitor energy usage and evaluate usage data. • Identify areas where energy usage could be reduced.
4.	Evaluate site and structures.	• Check the layout of the site, access, location of structures, trees, obstructions etc. • Check the type and condition of structures, e.g. roof spaces suitable for supporting arrays. • Identify potential locations for grid-connect equipment.
5.	Evaluate the solar resource.	• Access solar data to determine latitude, irradiance, sunshine hours etc. • Identify optimal orientation and tilt, options for positioning/mounting. • Identify any potential for shading.
6.	Produce a final report.	• Document the outcomes of the site survey. • Consult the customer regarding potential methods to reduce energy usage and potential grid-connect options.

Consultation Techniques

When speaking with others, it's important to be positive, open minded and non-judgmental. Listen carefully and don't jump to conclusions or assume things – always seek clarification if you are unsure.



Whenever communicating with customers, it's important to be polite, patient and courteous. It's generally best not to use technical jargon – keep things simple.

It's also important to be mindful of who you are talking to. Factors such as race, religion, culture and gender may need to be taken into consideration when determining how to get your message across effectively.

The following table provides some general techniques for effective communication.

Communication Techniques – Summary	
When attempting to communicate something to somebody else:	• Think before you speak – consider the key information you need to communicate and arrange it into a logical order. • Get to the point – be specific, and use as few words as necessary to convey all the required information. • Seek confirmation – ask the other person if they have understood, or if they would like anything explained further.
When somebody else is attempting to communicate something to you:	• Listen carefully – look at the person when they are speaking to you and concentrate on what they are saying. • Ask questions – if anything is unclear, ask questions to confirm. • Confirm your understanding – summarise what the other person has said so they can confirm that you've understood correctly.

Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

This learning activity consists of 4 parts designed to develop your understanding of the basic site survey process, including stakeholders, personnel and responsibilities.

Topic 1.1 Learning Activity

Last modified: Tuesday, 27 August 2024, 1:07 PM

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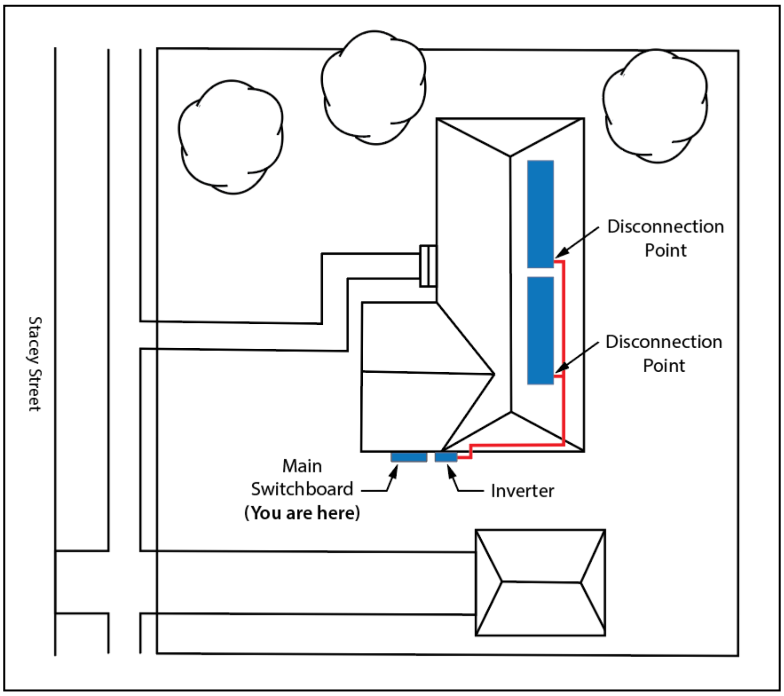
Unit Learning Plan

UEERE0054 – Conduct site survey for grid-connected photovoltaic and battery storage systems

September 2023
Release No. 1.0



A division of ENERGY SKILLS AUSTRALIA ABN 22 070 582 017

Contents

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A. Overview

<table>
<tr><td>Competency Standard Unit (CSU)</td><td colspan="2">UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems</td></tr>
<tr><td>CSU Application</td><td colspan="2">This unit involves the skills and knowledge required to complete site surveys for grid-connected photovoltaic and battery storage systems.
It includes safe work practices, site inspection processes and procedures, service provider responsibilities, consulting with qualified people to assess client energy demand requirements and assessing grid-connected equipment options to meet client requirements and site conditions. It also covers provision of advice to the client on battery storage standards, codes of practices, government/utilities incentive schemes, and information related to the installation of a grid-connected photovoltaic and battery storage systems.
No licensing, legislative or certification requirements apply to this unit at the time of publication.</td></tr>
<tr><td>Purpose of ULP</td><td colspan="2">The purpose of the Unit Learning Plan (ULP) is to define the depth and breadth of the knowledge and skills required to address the Competency Standard Unit (CSU) Assessment Requirements. It also indicates the recommended sequence and duration for the structured learning program, and provides a list of resources suitable for the delivery of the material using a blended approach.
In the context of this ULP, the term ‘structured learning program’ encompasses both the imparting of knowledge and skills and the completion of evidence gathering activities designed to address the Assessment Requirements. The structured learning program is generally undertaken off-the-job in a controlled learning environment.</td></tr>
<tr><td rowspan="3">Unit aspects addressed in this ULP</td><td>PC-UEERE0054</td><td>Performance Criteria</td></tr>
<tr><td>PE-UEERE0054</td><td>Performance Evidence</td></tr>
<tr><td>KE-UEERE0054</td><td>Knowledge Evidence</td></tr>
<tr><td rowspan="5">Suggested Durations</td><td>Completion of ULP topics 1 to 6</td><td>27 hours</td></tr>
<tr><td>Completion of Unit Knowledge Test</td><td>1 hour</td></tr>
<tr><td>Completion of Unit Skills Test</td><td>2 hours</td></tr>
<tr><td>Total duration of structured learning program</td><td>30 hours</td></tr>
<tr><td colspan="2">Note: These durations do not include the necessary workplace experience and final assessment of all evidence that must occur before competence can be determined.</td></tr>
<tr><td>Sequence</td><td colspan="2">Before undertaking this ULP a learner is to have completed the following Competency Standard Units or equivalent:
• Nil</td></tr>
</table>

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B. Knowledge and Skills Delivery

1 Site Survey Principles

Purpose:	In this topic you will learn about the survey process and the roles and responsibilities of those involved in grid-connect work, and about the fundamental principles of energy.
Duration:	This topic represents around 7% of the knowledge and skills specification contents, and should take the learner approximately 2 hours to achieve the topic requirements.

Knowledge and Skills Specification Content Areas	Unit Mapping[1]			Energy Space Resources
	KE	PC	PE	
1.1 Stakeholders and Personnel				
Knowledge				
Explain the roles and responsibilities of the various stakeholders and personnel relevant to grid-connected PV and battery systems, including: • Customers/clients. • Surveyors. • Designers. • Installers. • Maintenance personnel.	5	-	-	Topic 1 Content Quiz Topic 1.1 Learning Activity
Explain the basic site survey process, including: • Need for site access. • Evaluation of infrastructure. • Evaluation of energy usage/load profile. • Evaluation of solar resource.	8	-	-	
Describe effective methods of consulting and communicating with customers.	8	-	-	
Skills				
Identify stakeholders and qualified personnel required to complete the site survey.	5	1.1	2	Topic 1.2 Skills Practice

1 Site Survey Principles				
1.2 Energy Principles				
Knowledge				
Define the following terms: • Energy • Power • Energy efficiency • End use energy • Primary energy • Embodied energy	2	-	-	Topic 1 Content Quiz Topic 1.2 Learning Activity
State the SI units and symbols for energy, power, temperature and time.	2	-	-	
Explain the concepts of energy conversion and efficiency.	2	-	-	
Explain the fundamental benefits of PV and battery storage systems.	2	-	-	
Skills				
Communicate effectively with customers (role play) to discuss the site survey process, including: • Access and safety requirements. • Information to be collected. • Roles and responsibilities of stakeholders. • Any relevant standards and regulations. • Benefits of PV and battery storage systems.	4, 8	1.4	3.1, 3.2, 3.3, 3.4	Topic 1.2 Skills Practice

Reference Text:

- Photovoltaic Power Systems – Resource Book, Commonwealth of Australia and Brisbane Institute of TAFE.
- Pethebridge, K. and Neeson, I., Electrical Wiring Practice, McGraw-Hill.

2 Grid-connected Photovoltaic (PV) Systems				
Purpose:	In this topic you will learn about the arrangement and features of grid connected PV power systems, including components, configurations, PV arrays, and key installation requirements.			
Duration:	This topic represents around 17% of the knowledge and skills specification contents, and should take the learner approximately 5 hours to achieve the topic requirements.			

Knowledge and Skills Specification Content Areas	Unit Mapping[1]			Energy Space Resources
	KE	PC	PE	
2.1 PV Systems Features				
Knowledge				
Describe the components and installation configurations for a grid connected PV power system.	11.1, 14.1	-	-	Topic 2 Content Quiz Topic 2.1 Learning Activity
Describe the basic operation of grid interactive PV systems.	11.4	-	-	
Skills				
Draw the block diagram of a grid connected PV system.	14.1	-	-	Topic 2.1 Skills Practice
Draw schematic diagrams of common grid connected inverter circuit configurations including metering arrangements, isolation and connection with respect to RCDs in accordance with AS/NZS 4777.1.	11.1	-	-	
2.2 PV Arrays				
Knowledge				
Describe how PV arrays can be configured to achieve specified operating parameters.	3, 11.1, 11.5	-	-	Topic 2 Content Quiz Topic 2.2 Learning Activity
Describe methods used in wiring and connecting PV arrays in accordance with AS/NZS 5033.	3, 11.4	-	-	
Explain the effect of partial shading of a PV module or array, the impact of bypass diodes and the	3, 11.4, 11.5	-	-	

2 Grid-connected Photovoltaic (PV) Systems				
significance of their configuration on output current in typical operating conditions.				
State the factors that impact PV equipment type selection related to site and usage characteristics.	11.2	-	-	
Explain the local requirements, environmental considerations and required approvals for grid-connected PV systems.	11.6, 7	-	-	
2.3 PV Installation Requirements				
Knowledge				
State the fundamental requirements for the design, installation and maintenance of a grid-connected PV power system.	11.3, 13	-	-	Topic 2 Content Quiz Topic 2.3 Learning Activity
State the major installation requirements for a grid-connected PV power system, to ensure correct operation, long life, safety and ease of maintenance.	4, 7, 11.4, 13	-	-	
Skills				
Identify and compare the benefits of two different grid-connected PV power system options.	3, 11.1, 11.2	1.6, 2.8	3.4	Topic 2.3 Skills Practice

Reference Text:
- Photovoltaic Power Systems – Resource Book, Commonwealth of Australia and Brisbane Institute of TAFE.
- Pethebridge, K. and Neeson, I., Electrical Wiring Practice, McGraw-Hill.

Standards:
- AS/NZS 5033 Installation and safety requirements for photovoltaic (PV) arrays.
- AS/NZS 4777 (series) Grid connection of energy systems via inverters.

Equipment:
- Manufacturer's catalogues.

3 Grid-connected Battery Systems					
Purpose:	In this topic you will learn about the arrangement and features of grid connected battery storage systems, including components, configurations, types of batteries, and key installation requirements.				
Duration:	This topic represents around 17% of the knowledge and skills specification contents, and should take the learner approximately 5 hours to achieve the topic requirements.				

Knowledge and Skills Specification Content Areas	Unit Mapping[1]			Energy Space Resources
	KE	PC	PE	
3.1 Battery Systems				
Knowledge				
List and explain the purpose of each major component in a grid-connected PV battery storage system.	12.1, 12.2, 12.3, 12.4	-	-	Topic 3 Content Quiz Topic 3.1 Learning Activity
Explain the common types of local requirements relating to grid-connected battery storage imposed by network providers.	4, 7	-	-	
Describe the different functional arrangements and configurations of grid-connected PV battery storage systems.	12.1, 12.2, 12.3, 12.7, 14.1	-	-	
Skills				
Draw functional block diagrams of various grid-connected PV battery storage systems.	12.1, 12.2, 12.7, 14.1	-	-	Topic 3.1 Skills Practice
3.2 Battery Storage Technology				
Knowledge				
List the major types and features of commercially available batteries suitable for grid-connected PV battery storage systems.	3, 12.3	-	-	Topic 3 Content Quiz Topic 3.2 Learning Activity
Explain the different charging modes used with grid-connected PV battery storage systems.	3, 12.3	-	-	

3 Grid-connected Battery Systems				
State the factors that can affect the life of commercially available storage system batteries.	12.5	-	-	
Explain the factors and techniques for estimating the service life of a PV battery storage system.	3, 12.5	-	-	
3.3 Battery Installation Requirements				
Knowledge				
State the major requirements for grid-connected PV battery storage systems, relating to the design, installation, maintenance and operation of: • Battery storage devices. • Charge controllers. • Inverters. • Essential circuit supply. • Balance of system (BoS) equipment.	4, 7, 12.6, 13	-	-	Topic 3 Content Quiz Topic 3.3 Learning Activity
Skills				
Identify and compare the benefits of two different grid-connected battery storage system options.	3, 12.1, 21.2, 12.3, 12.5	1.6, 2.8	3.4	Topic 3.3 Skills Practice

Standards:

- AS/NZS 5139 Safety of battery systems for use with power conversion equipment.
- AS/NZS 4777 (series) Grid connection of energy systems via inverters.
- AS/NZS 5033 Installation and safety requirements for photovoltaic (PV) arrays.

Equipment:

- Manufacturer's catalogues.

4 WHS/OHS Requirements	
Purpose:	In this topic you will learn about workplace health and safety legislation and associated responsibilities, common hazards associated with grid-connect solar and battery storage site survey work. You will also learn about risk management principles and practices.
Duration:	This topic represents around 13% of the knowledge and skills specification contents, and should take the learner approximately 4 hours to achieve the topic requirements.

Knowledge and Skills Specification Content Areas	Unit Mapping[1]			Energy Space Resources
	KE	PC	PE	
4.1 Objectives and Responsibilities				
Knowledge				
State the fundamental principles and objectives of workplace health and safety legislation.	1.3, 4, 7	-	-	Topic 4 Content Quiz Topic 4.1 Learning Activity
State the obligations of employers and employees under workplace health and safety State/Territory legislation and regulations.	1.3, 7	-	-	
List the key Codes of Practice and standards applicable to workplace health and safety.	1.3, 4, 7	-	-	
4.2 Risk Management				
Knowledge				
Describe the principles and process of risk assessment/management.	1.1, 1.2	-	-	Topic 4 Content Quiz Topic 4.2 Learning Activity
List the hierarchy of WHS/OHS hazard control measures.	1.1, 1.2	-	-	
Describe the required documentation for risk assessment.	1.1, 1.2	-	-	
Explain the concept of standard safe work procedures for grid-connect site survey work.	1.1, 1.2	-	-	

4 WHS/OHS Requirements				
4.3 Common Hazards and Risks				
Knowledge				
List the types of injuries that are common in the grid-connect solar and battery storage industry.	1.1, 1.2	-	-	Topic 4 Content Quiz Topic 4.3 Learning Activity
Describe typical hazards associated with a range of solar worksites.	1.1, 1.2	-	-	
Describe the procedures used to control the risks associated with these hazards.	1.1, 1.2	-	-	
4.4 Electrical Safety Practices				
Knowledge				
State the effects that electric shock can cause to the human body.	1.5	-	-	Topic 4 Content Quiz Topic 4.4 Learning Activity
Describe common causes of electrical accidents.	1.5	-	-	
State the requirement to ensure the safe isolation of an electrical supply.	1.5	-	-	
Skills				
Undertake a hazard assessment for a potential grid-connect solar/battery storage worksite.	1.1, 1.2, 1.3, 1.5, 7	1.2, 1.5, 2.3	1, 4.1	Topic 4.4 Skills Practice

Reference Text:

- Pethebridge, K. and Neeson, I., Electrical Wiring Practice, McGraw-Hill.
- Hampson, J. and Hanssen, S., Electrotechnology Practice, Pearson Education.
- Berry, R. and Chadwick, P., Electrical Trade Practices, Cengage Learning.

Standards and codes:

- AS/NZS 4836 Safe working on or near low-voltage and extra-low voltage electrical installations and equipment.
- State/Territory Codes of Practice (CoP) relating to risk management, working at heights and working near low voltage equipment.

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5 Energy Assessment				
Purpose:	In this topic you will learn about the methods to evaluate and document a customer's electrical infrastructure and energy usage.			
Duration:	This topic represents around 13% of the knowledge and skills specification contents, and should take the learner approximately 4 hours to achieve the topic requirements.			
Knowledge and Skills Specification Content Areas	**Unit Mapping[1]**			**Energy Space Resources**
	KE	**PC**	**PE**	
5.1 Evaluating Existing Infrastructure				
Knowledge				
State the types of energy services commonly used in customer premises.	10	-	-	Topic 5 Content Quiz Topic 5.1 Learning Activity
Explain the methods of identifying the existing electrical infrastructure at customer premises, including the use of architectural and site drawings.	6, 14.2	-	-	
Describe the methods of documenting the electrical infrastructure at customer premises.	6	-	-	
Skills				
Interpret site drawings to identify the locations of services, and electrical wiring, fittings and equipment.	14.2	1.3, 1.8	1, 4.2, 4.4	Topic 5.2 Skills Practice
Evaluate and document the energy services and associated infrastructure at a given premises.	6	2.1, 2.3, 2.4	1, 4.2, 4.4, 4.7	
5.2 Evaluating Energy Usage				
Knowledge				
Describe the techniques for undertaking an energy audit/assessment at customer premises, including: • Consultations to determine energy use patterns and future needs. • Monitoring energy usage patterns.	9.1, 9.2, 9.4	-	-	Topic 5 Content Quiz Topic 5.2 Learning Activity

5 Energy Assessment				
• Evaluating energy usage data.				
State the various methods of reducing energy use, including: • Reducing the usage of lighting and appliances. • Replacing lighting and appliances with more energy efficient types. • Reducing energy losses. • Harnessing renewable energy sources.	9.3	-	-	
Skills				
Undertake a basic energy assessment at a given site and make recommendations for reducing energy consumption.	9.1, 9.2, 9.3, 9.4, 10	1.2, 1.3, 1.4, 1.7, 2.1, 2.2	1, 4.4, 4.5, 4.6, 4.7	Topic 5.2 Skills Practice

Standards:

- AS/NZS 5139 Safety of battery systems for use with power conversion equipment.
- AS/NZS 4777 (series) Grid connection of energy systems via inverters.
- AS/NZS 5033 Installation and safety requirements for photovoltaic (PV) arrays.

Equipment:

- Access to a premises for energy assessment.

6 Site Survey Practices	
Purpose:	In this topic you will learn about how to undertake a site survey to determine viability for grid-connected solar and/or battery storage. This will include evaluating the solar resource at the site, evaluating the roof for suitability to support a PV array, and evaluating the site for suitability for battery storage.
Duration:	This topic represents around 23% of the knowledge and skills specification contents, and should take the learner approximately 7 hours to achieve the topic requirements.

Knowledge and Skills Specification Content Areas	**Unit Mapping[1]**			**Energy Space Resources**
	KE	**PC**	**PE**	
6.1 Evaluating the Premises				
Knowledge				
State the factors that will affect the suitability of a given site for grid-connected PV and battery storage systems.	6, 8	-	-	Topic 6 Content Quiz Topic 6.1 Learning Activity
State the factors impacting battery equipment selection related to site and energy usage characteristics.	12.4	-	-	
Describe the techniques for undertaking a site survey.	8	-	-	
Explain the safety equipment required when checking the suitability and condition of roofs, including: • Work positioning systems. • Passive fall prevention systems. • Fall arrest systems.	1.1, 1.2, 1.4	-	-	
State the regulatory requirements and typical clearances required when working in the vicinity of overhead services.	1.3, 1.5, 7	-	-	
Skills				
Demonstrate the correct safety procedures to check the layout and physical condition of a rooftop.	1.1, 1.2, 1.4, 6, 8	2.1, 2.3, 2.4, 2.5	1, 4.1, 4.2, 4.3, 4.4	Topic 6.1 Skills Practice

6 Site Survey Practices				
6.2 Evaluating the Solar Resource				
Knowledge				
Define the following terms: • Sunshine hours. • Irradiance. • Irradiation. • Latitude. • Azimuth and altitude angles. • Tilt angle.	8	-	-	Topic 6 Content Quiz Topic 6.2 Learning Activity
State the types of commonly available solar data.	8	-	-	
Describe how radiation varies throughout the year on the surface of a fixed collector.	8	-	-	
Explain the factors affecting the optimal tilt and orientation of PV arrays.	8	-	-	
Explain the principle and effect of solar tracking.	8	-	-	
Skills				
Determine the solar access for a given site.	8	2.1, 2.4	4.3	Topic 6.2 Skills Practice
Select an appropriate location and tilt angle for a PV array at a given site.	8	2.1, 2.9	4.3	
Determine whether any shading will occur at a given site, and estimate its effect on the system.	8	2.1, 2.4	4.3, 4.11	
6.3 Documentation and Reporting				
Knowledge				
Explain the site survey documentation needed for presentation to the customer and to the grid-connect system designer.	8	-	-	Topic 6 Content Quiz Topic 6.3 Learning Activity

6 Site Survey Practices				
Explain the methods of discussing solar and battery options with the customer, including associated costs and 'pay-back' periods.	8	-	-	
Skills				
Check the layout and physical condition of a premises to determine suitability for a battery storage system.	6, 8	2.1, 2.3, 2.4, 2.5	4.1, 4.2, 4.4	Topic 6.3 Skills Practice
Provide options for grid-connected PV and battery storage systems for the site, in consultation with teacher/trainer, to suit customer needs, site conditions, and taking any potential installation issues into account.	11.2, 12.4, 13	2.6, 2.7, 2.8	4.7, 4.8, 4.9, 4.11	
Specify the locations and layout of proposed grid-connected PV and battery storage system components.	11.1, 11.3, 12.3, 12.6, 13	2.9	4.10	
Produce a final site survey report and present data and grid-connect options to teacher/trainer.	8	2.10	5	

Reference Text:

- Photovoltaic Power Systems – Resource Book, Commonwealth of Australia and Brisbane Institute of TAFE.

Equipment:

- Access to a premises for site survey.
- PPE, including fall arrest system.

Legend:

KE	Knowledge Evidence	**PC**	Performance Criteria
PE	Performance Evidence		

Mark as done

Unit Introduction

This unit consists of 6 topics, exploring the process of surveying a site to determine suitability for a grid-connected photovoltaic (PV) or battery storage system. This includes a range of aspects, such as identifying stakeholders, PV and battery storage principles, health and safety considerations, how to evaluate energy usage, and types of information to collect.

Each topic includes technical explanations, diagrams and activities designed to help you develop and reinforce your understanding. Topic skills practices give you the opportunity to practice the skills you'll need on the job, such as consulting customers and evaluating site infrastructure. Finally, a quiz at the end of each topic allows you to check your progress against the topic requirements.

When you feel you have achieved the knowledge and skills in each topic, ask your teacher/trainer if you can sit the unit tests. The Unit Knowledge Test (UKT) is designed to determine your understanding of the unit concepts, whilst the Unit Skills Test (UST) gives you the opportunity to demonstrate the planning, carrying out and completion of the practical tasks in the unit.

The experience you gain in the workplace can contribute to the completion of this unit. This can be achieved through the use of a compliant profiling system such as *Exemplar Profiling*. If you are using Exemplar Profiling, remember that it's important to review and discuss your progress regularly with your teacher/trainer.

Unit of Competence:

This course has been designed to facilitate blended delivery of the knowledge and skills contained in the Competency Standard Unit:

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Unit Learning Plan

The **Unit Learning Plan** (ULP) specifies the assessment requirements, and defines the depth and breadth of knowledge and skills required for the Unit. It lists related learning and assessment resources, and provides a structured framework for delivery that is suitable for both traditional and blended approaches.

LMS Learner Components

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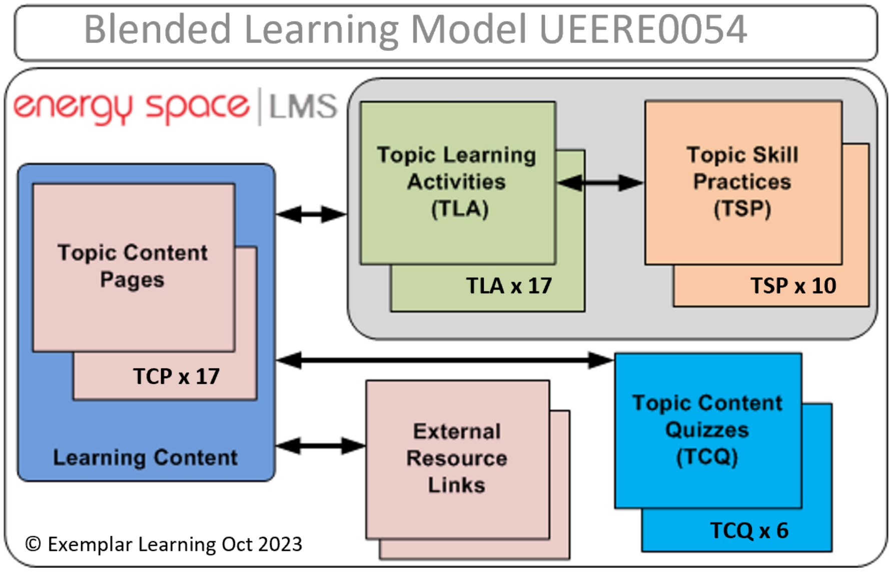

Topic Content Pages present the topic technical content using simple explanations, diagrams and interactive objects. These pages also provide links to external resources, learning activities, skills practices and quizzes, positioned like 'checkpoints' throughout the learning journey.

Load the Activity **Check Your Progress** activities provide short answer, drag and drop, and other interactions designed to assist in understanding the content.

External Resource Links and videos provide related information from external sources. All links to third party content are correct at the time of this course's publication.

Topic Learner Activities are intended to work in combination with RTO activities to support and reinforce learning..

Topic Skills Practices provide structured opportunities for the learner to develop their skills in an RTO or workplace environment.

Topic Content Quizzes provide the student with a way to confirm their understanding of the topic in preparation for the Unit Knowledge Assessment. The Topic Content Quiz contains multiple choice, matching and calculation questions that cover all aspects of the topic knowledge content. It is recommended that each Topic Content Quiz is completed prior to progressing to the next topic, and all quizzes should be completed prior to attempting the Unit Knowledge Assessment.

The Performance Indicator light will show according to your Topic Content Quiz score:

Score below 65% | Score between 65% and 85% | Score over 85%

Course Navigation

Navigate course content by selecting the required sub topic pages from the Home page, clicking on a link within the left hand navigation pane, or by clicking on the page navigation icons within each sub topic page, as per example below:

Previous

Home

Next

Get Started

Last modified: Tuesday, 27 August 2024, 12:58 PM

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0022 Solve basic problems in photovoltaic energy apparatus and systems
Topic Title:	Solar Radiation

Skill Practice Number:	1.1
Skill Practice Name:	Solar Irradiance

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 1.1

UEERE0022 Solve basic problems in photovoltaic energy apparatus and systems

Topic 1. Solar Radiation

Skills Practice 1.1: Solar Irradiance

Task:

To locate and interpret meteorological data, measure solar irradiance, determine the average daily and monthly irradiation at your location, and determine the times and dates of the year when a given PV array will become shaded.

Objectives:

At the completion of this skills practice, you should be able to:

- Determine the latitude of a given location.
- Interpret solar radiation maps.
- Measure solar irradiance using a solarimeter.
- Determine solar irradiance from sunshine hour data.
- Determine the dates and times that a PV array will become shaded.

Topic Skills Practice 1.1

1. Planning the Skills Practice

1.1 Equipment

- Solarimeter
- Sun path diagram
- Computer

1.2 Suggested Materials

- GPS
- Solar configuration software

1.3 Miscellaneous Items

- Pens/pencils
- Calculator
- Internet access

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B)
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L)
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision Level (D, G or B)	Risk Classification (H, M or L)	Control Measure/s
Material / equipment	D	M/L	House Keeping
UV rays	D	M/L	Sunscreen

	Feedback Have your teacher/trainer check your risk assessment	Teacher/Trainer Initials and Date	✓

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Topic Skills Practice 1.1

2. Carrying Out the Skills Practice

2.1 Solar Exposure Data

2.1.1 Use a GPS or internet site, such as http://www.ga.gov.au, to determine your current latitude and record your result below:

Location	Latitude
9 Mavis Street, Revesby, Sydney	-33.936670/151.019140

2.1.2 Go the Bureau of Meteorology website at http://www.bom.gov.au to locate the latest solar exposure map (yesterday). Daily solar exposure maps can be located by clicking on the links:

- 'Climate and past weather', then
- 'Maps – history to now', and then
- 'Solar exposure'

2.1.3 Interpret the map data to determine the daily solar exposure for your location in MJ/m^2. Then use this value to calculate the daily irradiation in kWh/m^2, showing your working and answers in the space provided below:

Remember: 1 Joule is equal to 1 watt for 1 second.

Solar Exposure

Working:

Highest Daily Exposure

Example 2/2/ 2021 is 21 MJ/m

21/3.6= 5.83 Kw/m

www.bom.gov.au

Climate & Past weather

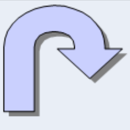
Maps- History to now

Solar exposure / MAP – Solar exposure period – 1 day

11 September 2023 Record 18MJ/m^2

$$Kw/m = \frac{MJ/m^2}{3.6} = \frac{18}{3.6} = 5\ Kw/m$$

Date:	2/2/ 2021	Solar Exposure:	21 MJ/m	Daily Irradiation:	5 Kw/m

	 Feedback	Have your teacher/trainer check your answers	Teacher/Trainer Initials and Date	✓

Topic Skills Practice 1.1

2.2 Determine Solar Exposure

2.2.1 Use a solarimeter to measure the solar irradiance at your location. Record your results below:

Date	Time	Irradiance
18/09/2023	1:22PM	6.79 w/m^2 969 LUX

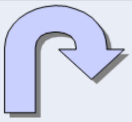
Install Solar Radiation Meter (ORJA) APP Google Store, Play

2.2.2 Return to the Bureau of Meteorology website to obtain the sunshine hour data for your location. Maps indicating average sunshine hours can be located by clicking on the links:

- ‘Home page’, then
- ‘Climate and past weather’, then
- ‘Maps – averages’, and then
- ‘Sunshine duration’

2.2.3 Use the sunshine hour data to determine the yearly and monthly average irradiation at your location. Record your values in the table below:

Average Daily Irradiation			
Location	**Electrical Trade College**		
Yearly	**6-7 hours**		
January	**8**	**July**	**7**
February	**8**	**August**	**8**
March	**7**	**September**	**8**
April	**7**	**October**	**8**
May	**6**	**November**	**8**
June	**6**	**December**	**8**

	 ***Feedback*** **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 1.1

2.3 Shading of PV Arrays

2.3.1 Examine the PV array, pictured below in figures 2.4.1(a) and 2.4.1(b). Assuming the array is installed at your location, use the data you have collected so far, the measured angles indicated, and the appropriate sun path diagram, to identify the times and dates when the PV array will become shaded.

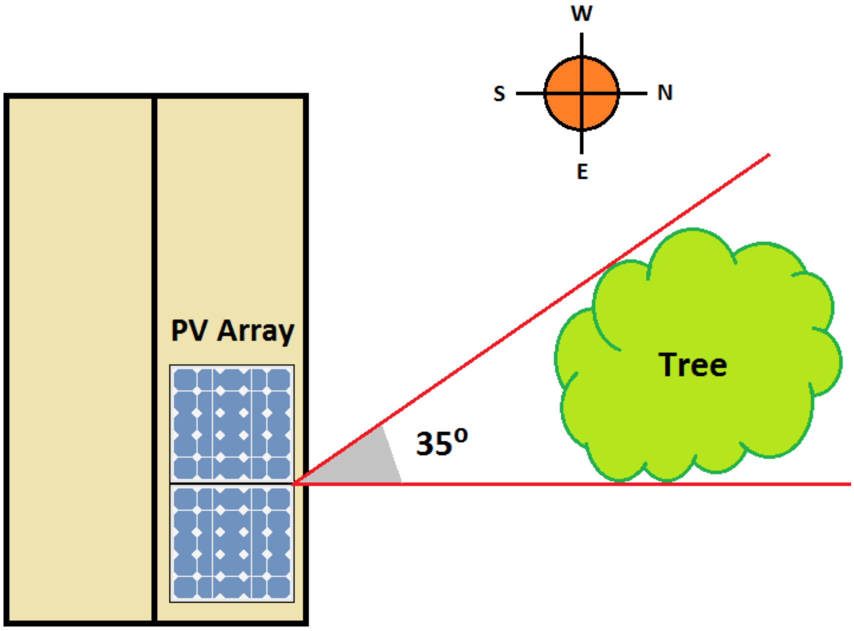


Figure 2.3.1(a) - Overview

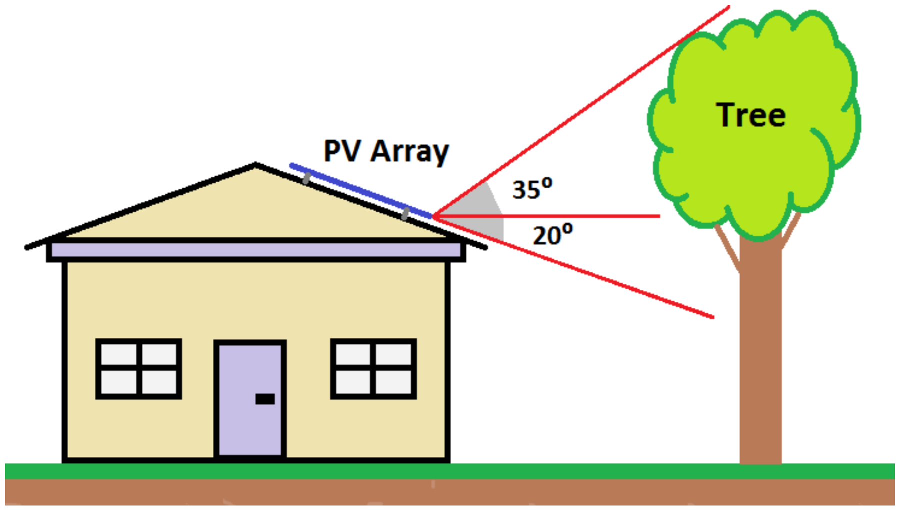


Figure 2.3.1(b) - Elevation

Topic Skills Practice 1.1

2.3.2 Record the times and dates of shading in the space provided below:

19 July from 1PM to 2PM

28 May from 1PM to 2PM

	Feedback Have your teacher/trainer check your answers	Teacher/Trainer Initials and Date	✓

3. Completing the Skills Practice

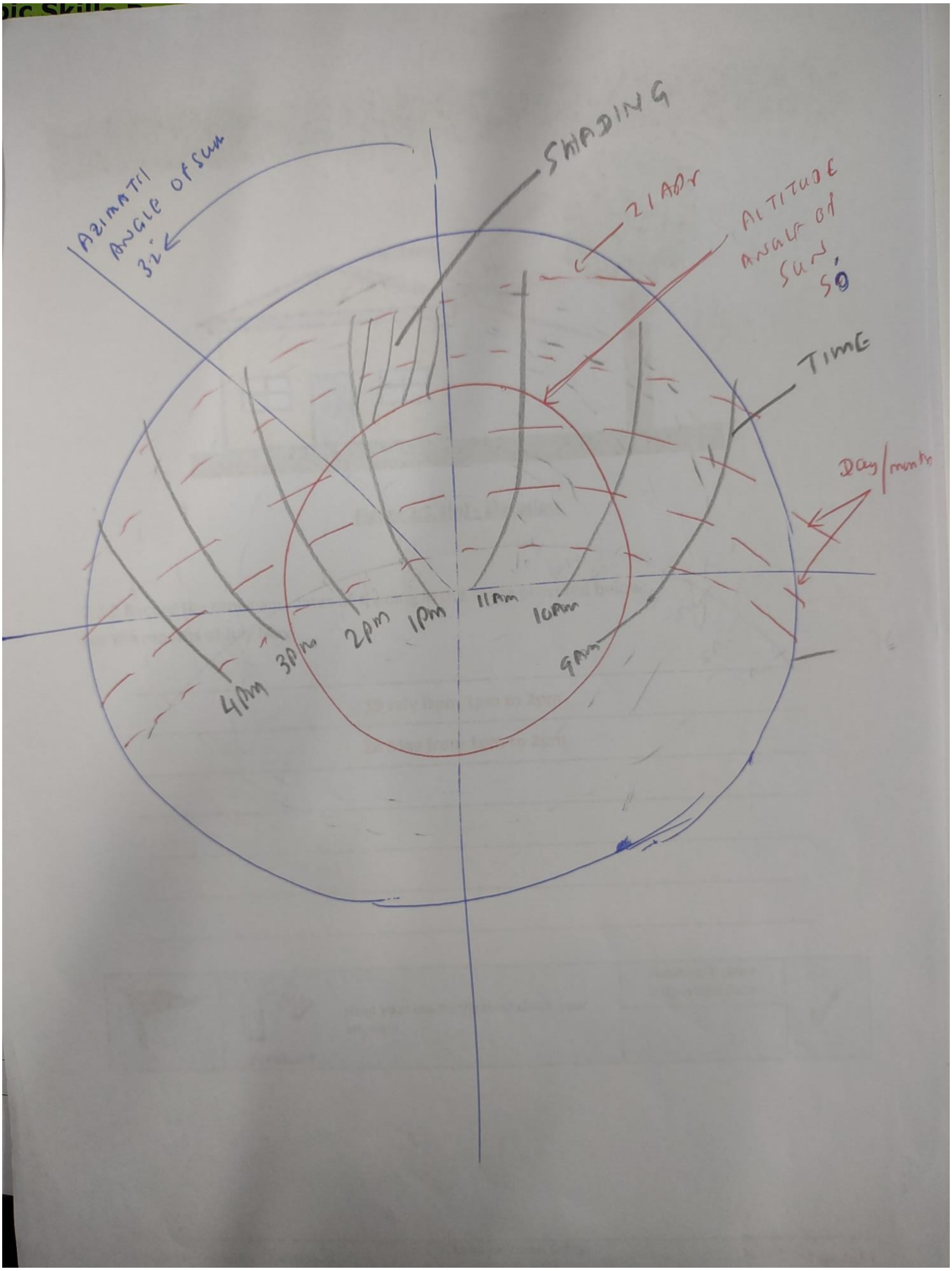
3.1 Skills Practice Review Questions

3.1.1 Return all equipment to the correct storage areas as directed by your teacher, and then complete the following questions.

1. Describe four factors that cause variations in the daily irradiation of a fixed PV array.

Topic 1.2

- Season change
- Shading and soiling
- Cloud cover
- Time of day


SHADING
AZIMATH ANGLE OF SUN 32°
21 Apr
ALTITUDE ANGLE OF SUN 50°
TIME
Day/month
4pm
3pm
2pm
1pm
11am
10am
9am

Check out "ScanTheSun"

https://play.google.com/store/apps/details?id=com.scanthesun

solar irradiance app - Google Search

SOLAR RADIATION METER (ORJA)

https://www.google.com/search?q=solar+irradiance+app&oq=&gs_lcrp=EgZjaHJvbWUqCQgAECMYJxjqAjIJCAAQIxgnGOoCMgkIARAjGCcY6gIyCQgCECMYJxjqAjIJCAMQIxgnGOoCMgkIBBAjGCcY6gIyCQgFECMYJxjqAjIJCAYQIxgnGOoCMgkIBxAjGCcY6gIyCQgIECMYJxjqAjIJCAkQIxgnGOoCMgkIChAjGCcY6gIyCQgLECMYJxjqAjIJCAwQIxgnGOoCMgkIDRAjGCcY6gIyCQgOECMYJxjqAjIRCA8QABgDGEIYjwEYtAIY6gIyDwgQEC4YAxiPARi0AhjqAjIRCBEQABgDGEIYjwEYtAIY6gIyDwgSEC4YAxiPARi0AhjqAjIPCBMQLhgDGI8BGLQCGOoC0gEGLTFqMGo3qAIUsAIB&client=ms-android-vf-au-revc&sourceid=chrome-mobile&ie=UTF-8

Solar Panel Tilt Angle Calculator

https://footprinthero.com/solar-panel-tilt-angle-calculator

Metrology

http://www.bom.gov.au

Latitude

www.latlong.net

	Feedback Have your teacher/trainer check your answers	Teacher/Trainer Initials and Date	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Principles

Skill Practice Number:	1.2
Skill Practice Name:	Prepare for Site Survey

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 1.2

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 1. Site Survey Principles

Skills Practice 1.2: Prepare for Site Survey

Task:

To identify stakeholders and personnel involved in a proposed grid-connect installation, and to communicate with a client (as a role play) in preparation for undertaking a site survey associated with the work.

Objectives:

At the completion of this skills practice, you should be able to:

- Identify stakeholders and qualified personnel relevant to proposed grid-connect work.
- Communicate effectively with clients regarding the site survey process and the general benefits of grid-connected alternative energy systems.

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Topic Skills Practice 1.2

1. Planning the Skills Practice

1.1 Site Scenario

You have been contracted to undertake a site survey to determine viability of grid-connect photovoltaic (PV) and battery storage energy systems at a particular site.

Your teacher/trainer will specify the particular location and nature of the site (e.g. this could be your own home, at the RTO campus, or some other suitable location).

Note that the person playing the role of the client will need to have answers ready relating to the personnel/contractors proposed for the design, installation and ongoing maintenance of the grid-connect project.

2. Carrying Out the Skills Practice

2.1 Client Consultation

2.1.1 In this section, you are required to carry out a roleplay consultation with another person playing the role of the client. This could be your teacher/trainer, a classmate, or other suitable person – as specified by your teacher/trainer.

In the first part of the consultation, you must identify the different stakeholders and personnel relevant to the project.

In the second part of the consultation, you are required to discuss the site survey process with the client to ensure the survey can run smoothly. Items to discuss include:

- Need for and arrangements for access to the various areas of the site.
- The types of information that need to be collected and evaluated.
- Relevant standards, regulators and regulations.
- Roles and responsibilities of the client and the surveyor.
- Potential benefits of installing a photovoltaic (PV) array at the site.
- Potential benefits of installing battery storage at the site.
- What the client can expect to receive upon completion of the survey.
- The general benefits and advantages of adding PV and battery storage to an installation.

Take notes throughout the consultation to document the outcomes in the spaces provided on the following page.

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Topic Skills Practice 1.2

Client Initial Consultation			
Surveyor:		**Client:**	
Type of Site:	Workshop	**Date:**	
Location:	9 Mauisst, Revesby 2212		
Part 1 – Stakeholders and Personnel			
Proposed designer(s) – PV: SOALR CHIEF			
Proposed designer(s) – batteries: SOLAR EDGE			
Proposed installer(s) – PV: SUN POWER			
Proposed installer(s) – batteries: CAN STAR BLUE			
Proposed maintenance contractor: SOLAR WATER WIND			
Part 2 – Site Survey Process			
Notes:			
Gather the information on			
- Current energy usage patterns			
- Current and future energy need of installation			
- The Nature of structure building materials and methods etc.			
- The existing building structure and electrical installation			
- The available solar resources at the site			
- Potential location for grid connection equipment PV array inventor batteries			

Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice 1.2

3. Completing the Skills Practice

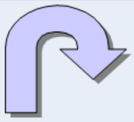
3.1 Skills Practice Review Questions

3.1.1 Now discuss your consultation with the person who was playing the role of the client, and answer the following questions.

1. Ask the client how well they feel that you explained the site survey process, on a scale of 1 to 10, with 1 being very poorly and 10 being outstanding.

2. Ask the client if there were any improvements you could make in the way you communicated with them. Note down any feedback below.

   - Think before you speak
   - Get to the point
   - Seek confirmation
   - Listen carefully
   - Ask questions
   - Confirm your unclear standing

	 ***Feedback***	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Design grid-connected photovoltaic power supply systems
Topic Title:	Grid-Connected Battery Systems

Skill Practice Number:	3.1
Skill Practice Name:	Battery Storage System Diagrams

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 3.1

UEERE0054 Design grid-connected photovoltaic power supply systems

Topic 3. Grid-Connected Battery Systems

Skills Practice 3.1: Battery Storage System Diagrams

Task:

To draw the block diagrams of various configurations for grid-connected PV battery storage systems.

Objectives:

At the completion of this skills practice, you should be able to:

- Draw and label block diagrams of grid-connected PV battery storage systems without the capacity for providing emergency power.
- Draw and label block diagrams of grid-connected PV battery storage systems configured to provide emergency power to essential circuits.
- Draw and label block diagrams of d.c. coupled grid-connected PV battery storage systems.
- Draw and label block diagrams of a.c. coupled grid-connected PV battery storage systems.
- Draw and label block diagrams of grid-connected PV battery storage systems with both a.c. and d.c. coupled PV array.

1. Planning the Skills Practice

1.1 Research Grid-Connected PV Battery System Arrangements

1.1.1 Research grid-connected PV power systems using reference material, such as:

- Energy Space Content Page 3.1.
- AS/NZS 4777.1 Grid connection of energy systems via inverters – Installation requirements.
- AS/NZS 5139 Safety of battery systems for use with power conversion equipment.
- Manufacturer installation guides (e.g. Tesla, Sonnen, etc.).

1.1.2 Once you feel you have sufficient knowledge of the subject matter, obtain the following materials to assist you with carrying out this skills practice:

- Pens/pencils.
- Ruler.

2. Carrying Out the Skills Practice

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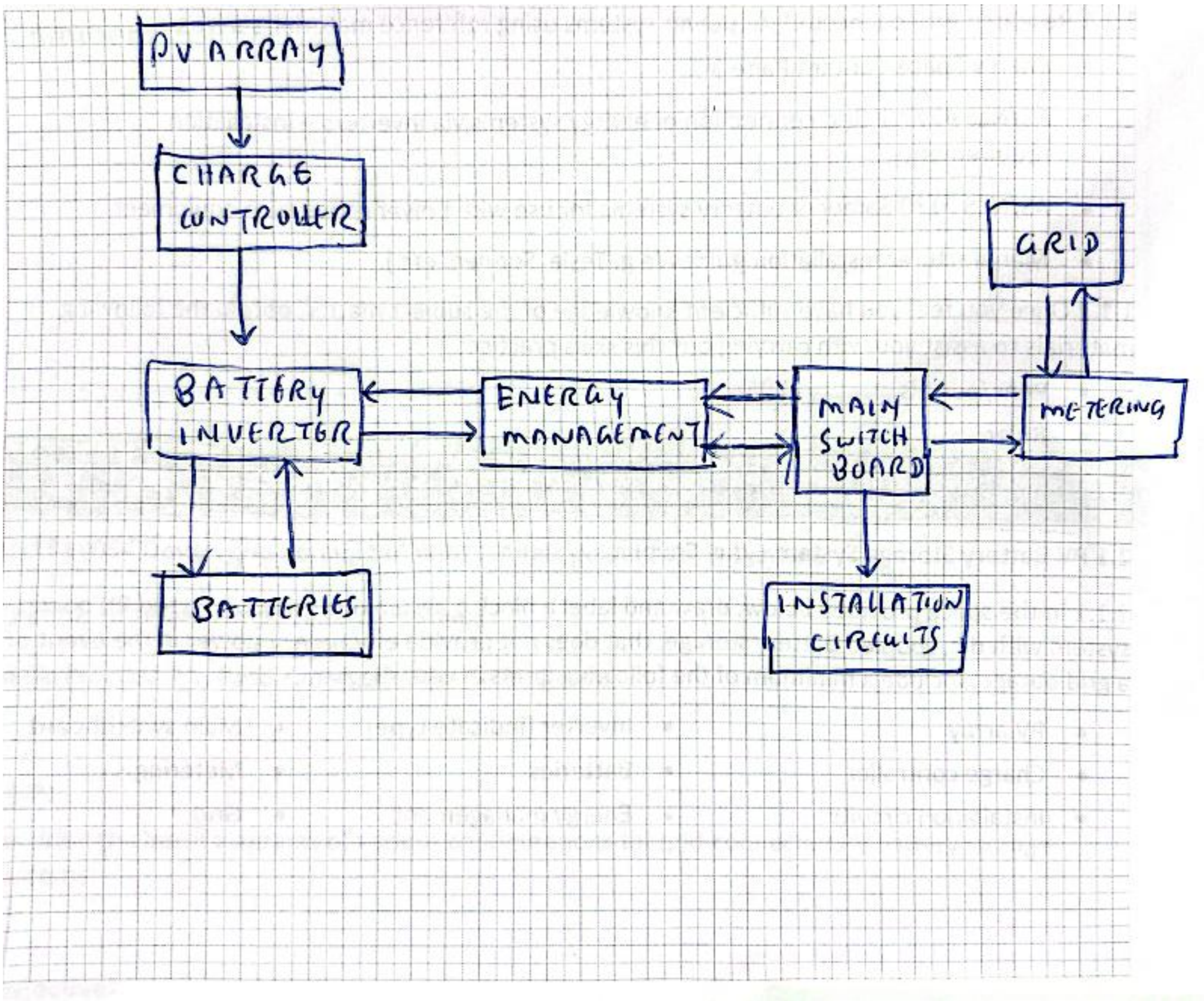
Topic Skills Practice 3.1

2.1 PV Battery Storage System – d.c. Coupling

2.1.1 In the space provided below, draw and label a block diagram of a grid-connected PV power system with d.c. coupled battery storage, that does *not* provide emergency power in the event of a grid outage. Include a minimum of the following items in your diagram:

- PV array
- Charge controller
- Installation circuits
- Inverter (indicate type)
- Batteries
- Energy management
- Main switchboard
- Metering
- Grid



			Teacher/Trainer Initials and Date	
	Feedback	**Have your teacher/trainer check your work**		✓

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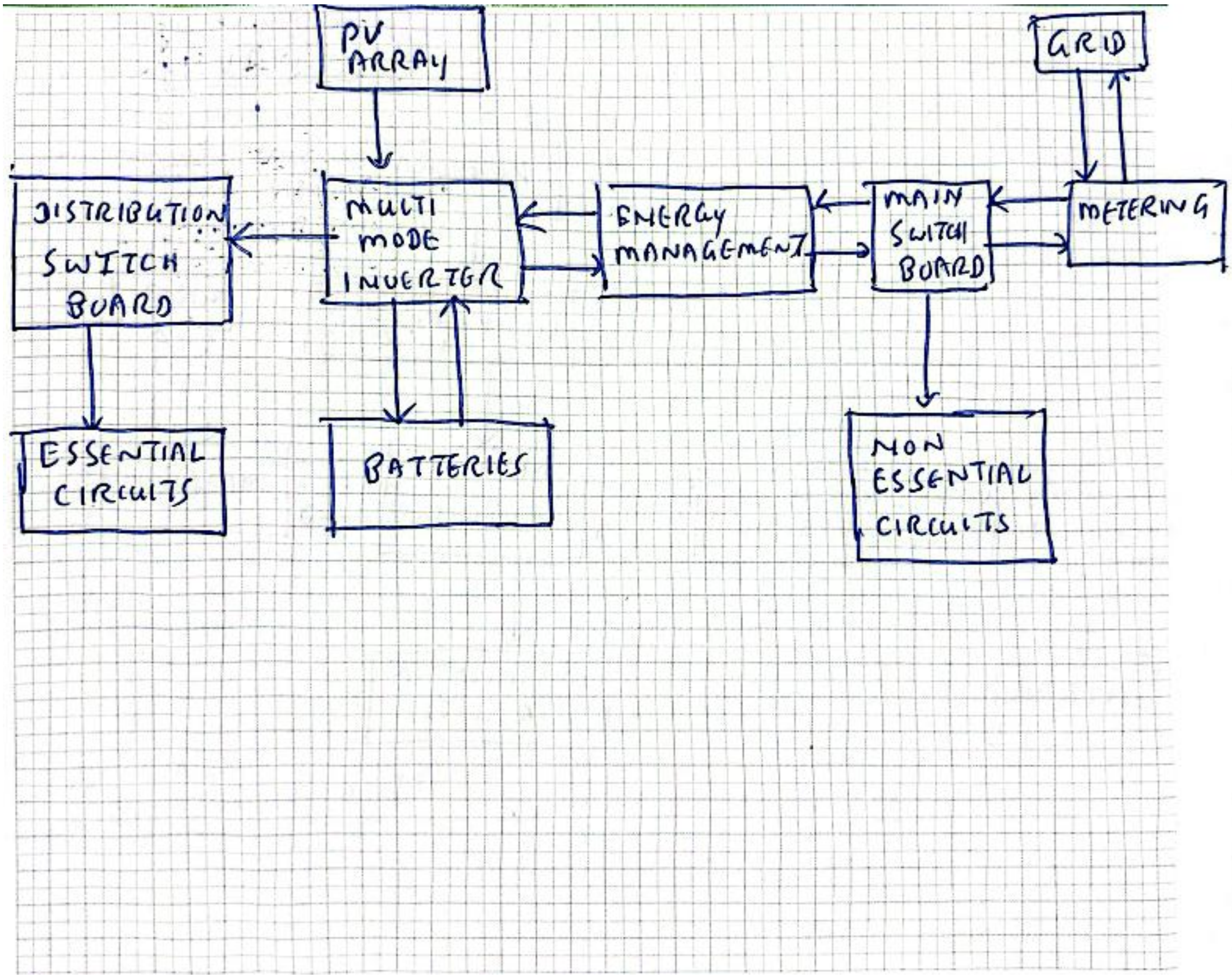
Topic Skills Practice 3.1

2.1.2 In the space provided below, draw and label a block diagram of a grid-connected PV power system with d.c. coupled battery storage, that *does* provide emergency power to a set of essential circuits in the event of a grid outage. Include a minimum of the following items in your diagram:

- PV array
- Inverter (indicate type)
- Batteries
- Energy management
- Main switchboard
- Distribution board
- Non-essential circuits
- Essential circuits
- Metering
- Grid



Feedback	Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓

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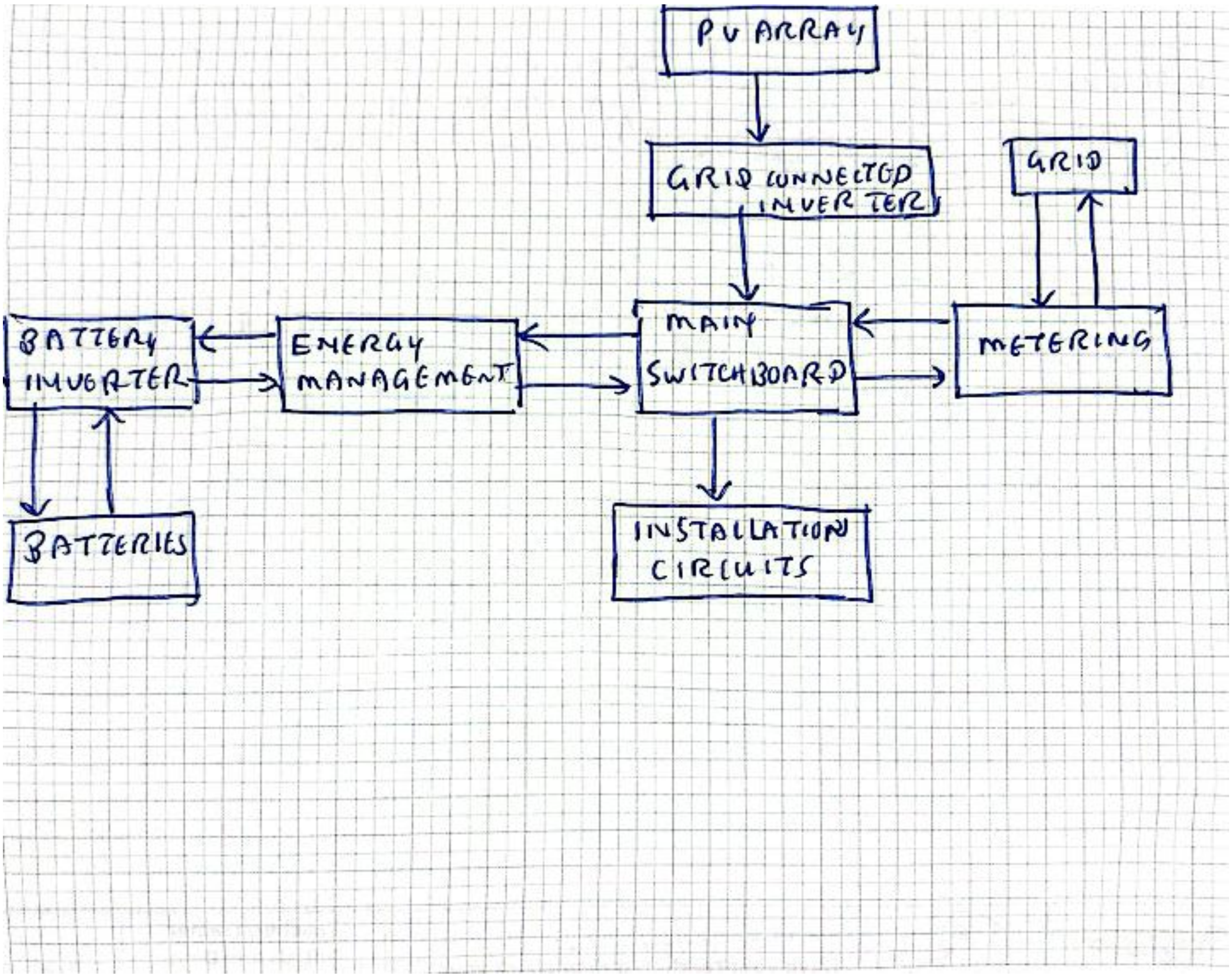
Topic Skills Practice 3.1

2.2 PV Battery Storage System – a.c. Coupling

2.2.1 In the space provided below, draw and label a block diagram of a grid-connected PV power system with a.c. coupled battery storage, that does *not* provide emergency power in the event of a grid outage. Include a minimum of the following items in your diagram:

- PV array
- Inverters (indicate types)
- Batteries
- Energy management
- Main switchboard
- Installation circuits
- Metering
- Grid



	Feedback — Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓

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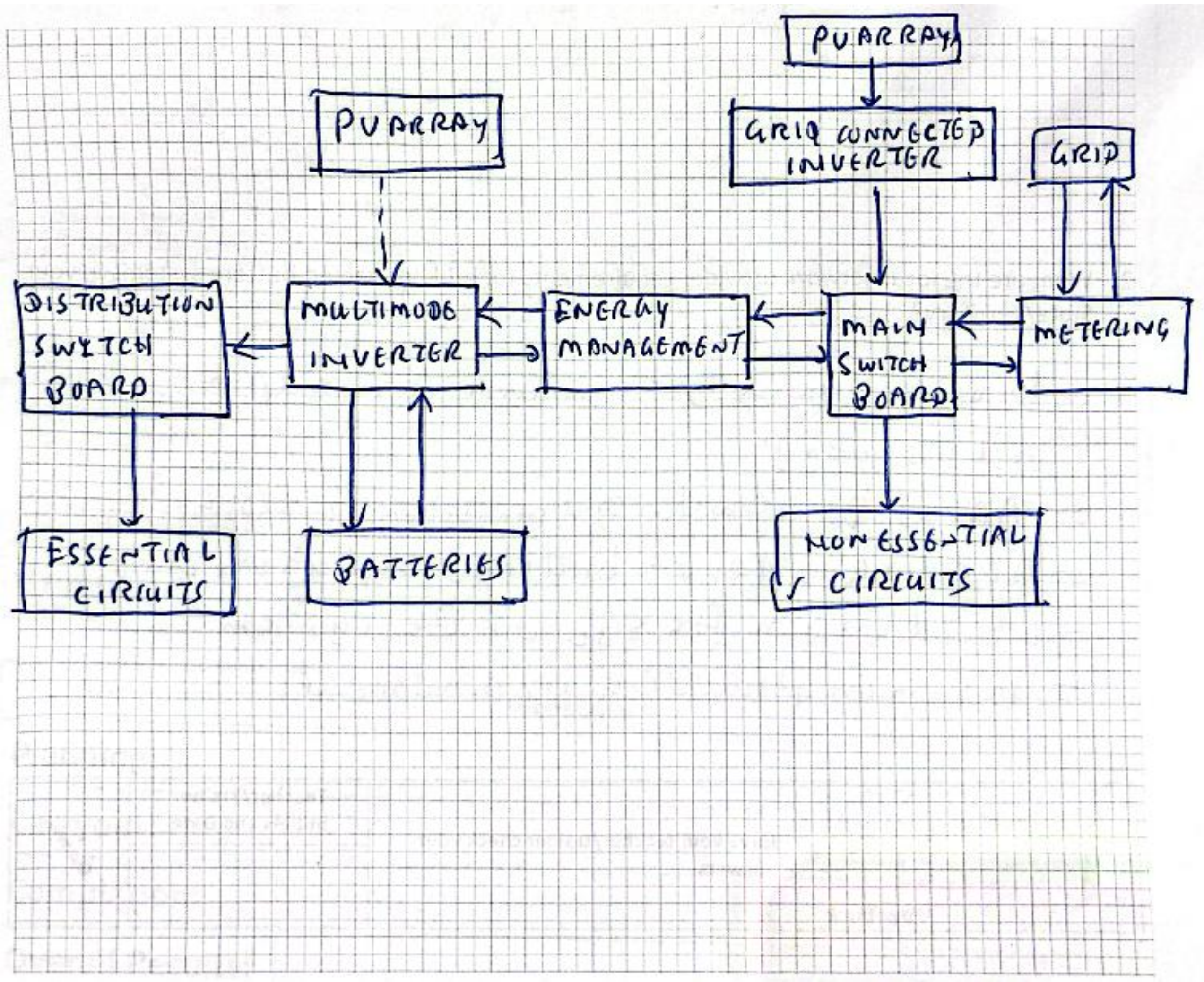
Topic Skills Practice 3.1

2.2.2 In the space provided below, draw and label a block diagram of a grid-connected PV battery storage system with both a.c. and d.c. coupled PV arrays, that provides emergency power to a set of essential circuits in the event of a grid outage. Include a minimum of the following items in your diagram:

- Batteries
- Inverters (indicate types)
- Energy management
- Main switchboard
- Distribution board
- Non-essential circuits
- Essential circuits
- Metering
- PV arrays (a.c. and d.c. coupled)
- Grid



			Teacher/Trainer Initials and Date	
	Feedback	Have your teacher/trainer check your work		✓

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Topic Skills Practice 3.1

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

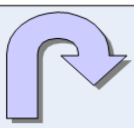
3.1.1 Complete this section after successfully drawing and labelling the diagram in section 2.

1. What is the purpose/advantages of adding battery storage to a grid-connected PV system?

   - Stores energy for use when needed

2. What are the local network provider requirements for grid-connected battery systems in your State/Territory?

   - Minimum quantity standards for output voltage and frequency
   - Access to remote monitoring/control
   - Acceptable types of batteries and inverters
   - Limitation on the size of the system
   - Minimum protective requirements

	 **Feedback**	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Design grid-connected photovoltaic power supply systems
Topic Title:	Grid-connected Battery Systems

Skill Practice Number:	3.3
Skill Practice Name:	Grid-connected Battery System Comparison

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

Topic Skills Practice 3.3

UEERE0054 Design grid-connected photovoltaic power supply systems

Topic 3. Grid-connected Battery Systems

Skills Practice 3.3: Grid-Connected Battery System Comparison

Task:

To compare and contrast the benefits of two different grid-connected battery storage system options.

Objectives:

At the completion of this skills practice, you should be able to:

- Identify different options for a grid-connected battery storage system for a given site.
- Document the key ratings and features of grid-connected battery storage systems.
- Compare and contrast key ratings and features of grid-connected battery storage systems.
- Explain the benefits and drawbacks of different grid-connected battery storage system options to customers.

1. Planning the Skills Practice

1.1 Research Grid-Connected Battery Storage Systems

1.1.1 Research two currently available grid-connected battery storage systems, suitable for a proposed installation at a location indicated by your teacher/trainer. It may be helpful to use the following sources of reference material:

- The internet.
- Manufacturer catalogues.
- Retailer promotional materials.

1.1.2 Once you feel you have sufficient knowledge of the subject matter, obtain the following materials to assist you with carrying out this skills practice:

- Pens/pencils.

Topic Skills Practice 3.3

2. Carrying Out the Skills Practice

2.1 Grid-Connected Battery System – Option 1

2.1.1 Identify the first grid-connect battery storage system and fill out the relevant product data in the spaces provided below.

Battery System 1 – Details

Description: **Grid connected PV power system with dc coupled battery storage**
That does not provide emergency power

Manufacturer: **SOLAR CHIEF**

Product No:

Cost: **$5000**

Battery Parameters **0.086 KWH, MK BEKA AG M Battery E57-12**

Chemistry/Type:	Lithium Nickel	No. of Batteries:	**54**
Nom. Voltage:	12V	Ah Capacity:	**7.2 AH**
Wh Capacity:	86 WH	Max Discharge:	**69 Watt**
Cycle Life:	20 Hour	DoD:	**80 %**

Inverter Parameters

Inverter Type:	5G 3K-D NI	No. of Inverters:	**14**
Max d.c. Power:	6700 watt	Max d.c. Voltage:	**120V**
d.c. Window:	90-120V/25-40 A	Max d.c. Current:	**25 A**
Max a.c. Power:	4999VA	Efficiency:	**97.7%**

Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 3.3

2.2 Grid-Connected Battery System – Option 2

2.2.1 Identify the second grid-connect battery storage system and fill out the relevant product data in the spaces provided below.

Battery System 2 – Details

Description: Grid connected PV power system with dc coupled battery storage
That does provide emergency power to a set of essential circuit

Manufacturer: SOLAR CHIEF

Product No:

Cost: $8000

Battery Parameters

Chemistry/Type:	Lithium Nickel	No. of Batteries:	54
Nom. Voltage:	12V	Ah Capacity:	7.2 AH
Wh Capacity:	86 WH	Max Discharge:	69 WH
Cycle Life:	20 Hr	DoD:	80%

Inverter Parameters

Inverter Type:	5G 5k – D - NI	No. of Inverters:	14
Max d.c. Power:	6700 w	Max d.c. Voltage:	120 V
d.c. Window:	260v – 480 v	Max d.c. Current:	25 A
Max a.c. Power:	4999 VA	Efficiency:	98 %

	Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 3.3

2.3 Grid-Connected Battery System Comparison

2.3.1 Answer the following questions to compare and contrast the features of the two battery system options.

1. Which of the two systems will produce more energy to the installation?

System 2

2. Which of the two systems has higher upfront costs?

System 2

3. Which of the two systems will have a shorter 'payback period'?

System 1

4. Describe three advantages of system 1 compared to system 2.

- Cheaper
- Simpler
- No needs to use multimode because battery inverter alone can provide the ac power conversion

Topic Skills Practice 3.3

5. Describe three advantages of system 2 compared to system 1.

- It can supply the essential ac power
- It can manage the energy more effectively
- Multimode inverter can also regulate the charge. No additional charge controller is needed.

2.3.2 Now present the two systems to your teacher/trainer (or other person as directed by your teacher/trainer), explaining the features, benefits and drawbacks of each when compared with each another.

	 *Feedback*	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

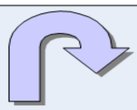
3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Complete this section after you have successfully completed Section 2.

1. What factors need to be taken into account when estimating the service life of a given battery system?

- Average current drawn out by device
- Capacity of battery
- Discharge rate and depth of discharge

	 *Feedback*	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	WHS/OHS Requirements

Skill Practice Number:	4.4
Skill Practice Name:	Undertake a Hazard Assessment for a Worksite

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 4.4

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 4. WHS/OHS Requirements

Skills Practice 4.4: Undertake a Hazard Assessment for a Worksite

Task:

To undertake a hazard assessment on a given site as part of the site survey for a grid-connect project.

Where possible, this skills practice should be completed in your normal workplace, for actual work you intend to carry out.

If you do not have access to a proposed grid-connect site, you may complete this skills practice on a simulated site, or base your work on a scenario provided by your teacher/trainer.

Objectives:

At the completion of this skills practice, you should be able to:

- Identify and document the hazards associated with proposed grid-connect work.
- Identify and document the risks associated with each identified hazard.
- Assess and document the level of risk.
- Select and document control measures to eliminate or control risks.
- Implement control measures to eliminate or control risks.
- Review the risk management process.

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Topic Skills Practice 4.4

1. Planning the Skills Practice

1.1 Work Site & Job Task Information

Proposed Work: Solar Electrical	Type of Work Site: Workshop
Location of Work Site: 9 mavis ST Revesby NSW 22/2	
Assessment Conducted By:	Date:
Required Qualifications/Work Permits: Electrical License Solar Installer Accreditation	
Applicable Legislation & Regulations: AS/NZS 5033;2021	
Applicable Standards & Codes of Practice: Clause 4.3.5.2.1	

2. Carrying Out the Skills Practice

2.1 Types of Hazards at the Worksite

Types of Hazards Present: (☑ tick each applicable box)

☐ high voltage	☑ work at heights	☐ foreign bodies	☐ explosive gases
☑ low voltage	☐ hot works	☐ asbestos	☐ toxic gases
☐ extra-low voltage	☐ confined spaces	☑ dust	☐ explosive chemicals
☐ high currents	☐ UV radiation	☑ noise	☐ corrosive chemicals
☑ working 'live'	☐ mobile plant/traffic	☑ manual handling	☑ toxic chemicals
☑ housekeeping	☑ power tools	☐ mechanical handling	☐ flora/fauna
☐ other:			

2.2 Risk Matrix

Severity \ Likelihood	Likely	Possible	Unlikely
Death or permanent disability	1	1	2
Serious injury or chronic illness	1	2	3
Minor injury requiring first aid	2	3	4

1 = Extreme risk
2 = High risk
3 = Medium risk
4 = Low risk

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Topic Skills Practice 4.4

2.3 Work Hazards, Risks & Control Measures

Work Tasks	Potential Hazards	Associated Risks	Risk Level	Control Measures	Adjusted Risk Level
Install Solar panel	Falling	Physical injury	H	Fall protection	H → L
Electrical Installation	Electrical shock	Death	H	Test & tag	H → L
Battery acid burn	Eye and skin injury	Chemical fumes	H	Safety goggle, safety glove	H → L
Heavy Solar panel fall	Back injury	Physical injury	H	Use material handling equipment	H → L

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Topic Skills Practice 4.4

3. Completing the Skills Practice

3.1 Hazard Assessment Checklist

◻ Hazard assessment has been approved by works manager.

◻ Required work permits identified.

◻ Hazard assessment has been communicated to relevant personnel.

◻ Required first aid facilities identified.

3.2 Declaration

I confirm by my signature below that I have read, understood and been briefed on the attached Hazard Assessment.

Name	Signature	Date
1.		
2.		
3.		
4.		

	 *Feedback* — **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Energy Assessment

Skill Practice Number:	5.2
Skill Practice Name:	Evaluate Energy Usage

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 5.2

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 5. Energy Assessment

Skills Practice 5.2: Evaluate Energy Usage

Task:

To identify the electrical infrastructure at a site, undertake a basic energy efficiency audit at a given site, and make recommendations for reducing energy consumption.

Objectives:

At the completion of this skills practice, you should be able to:

- Interpret site drawings to identify electrical infrastructure.
- Document the energy services and key infrastructure at a site.
- Identify areas of excessive energy consumption.
- Identify methods of reducing energy consumption.
- Develop practical strategies for improving energy efficiency.

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Topic Skills Practice 5.2

1. Planning the Skills Practice

1.1 Equipment

- Building/premises.

1.2 Suggested Materials

- Light meter.
- Thermometer.

1.3 Miscellaneous Items

- Relevant PPE.
- Pens/pencils.

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B)
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L)
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision (D, G or B)	Risk Class (H, M or L)	Control Measure/s
Electrical potential live cable	D	H	Isolation
Material on the floor	D	L	Housekeeping
Potential sharp objects tools cable	D	L	PPE gloves

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Topic Skills Practice 5.2

		Teacher/Trainer Initials and Date	
	Feedback — Have your teacher/trainer check your risk assessment		✓

2. Carrying Out the Skills Practice

2.1 Conduct an Energy Assessment

2.1.1 Your task is to undertake an energy assessment at a given site, including identification of key electrical infrastructure, evaluation of energy usage and determining techniques to reduce energy usage. This should be done by:

- Consultation with the occupiers of the site.
- Review of site drawings and documentation (e.g. site plans, electricity bills/usage logs).
- A 'walk through' visual inspection of the site.

2.1.2 Use the following checklist to carry out an energy evaluation of the premises/building, as directed by your teacher/trainer.

Part 1 – Building/Premises Details				
Auditor:			**Date:**	9 am → 5 pm
Type of Premises:	Workshop		**Operating Hours:**	
Location:	9 Mavis St, Revesby 2212			
Part 2 – Electrical Supply (Consumer Mains)				
No. of Phases:	3		**Voltage:**	240V
Cable Route:	13m		**Cable Size:**	2.5mm^2
Max Demand:	11A		**Metering Type:**	Net meter
Part 3 – Energy Usage				
Average Daily Energy Usage:	**Summer**	**Autumn**	**Winter**	**Spring**
	20.04 kWh	18.66 kWh	23.34 kWh	20.03 kWh
Notes: Heat source operated in winter drawing more power				
Summer and spring, aircon are operated . Autumn energy usage is less				

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Topic Skills Practice 5.2

Part 4 – Lighting Systems				
Types of Lighting (*tick*):	☑ Incandescent	☐ Gas Discharge	☐ LED	☑ *Other*:
No. of Lamps:	4			12

Part 4 – Items		**Yes**	**No**	**Comments/Improvement Strategies**
4.1	Can existing lamps be replaced with more energy efficient types?	☑	☐	
4.2	Could sensors or timers be used to reduce energy wastage?	☑	☐	
4.3	Could windows/skylights be utilised and/or installed to reduce the need for artificial lighting?	☑	☐	
4.4	Do inhabitants regularly turn off lighting when not in use?	☑	☐	
4.5	Do inhabitants regularly utilise existing natural lighting instead of artificial lighting where possible?	☑	☐	
4.6	Is any external lighting on during daylight hours?	☑	☐	
4.7	Do any luminaires, windows or skylights require cleaning?	☑	☐	

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Topic Skills Practice 5.2

Part 5 – Climate Control Systems					
Avg. Temperatures:	Summer (^{o}C): 25		Winter (^{o}C): 20		
Types of Climate Control (*tick*):	☐ Radiant Heating	☐ Ducted	☑ Reverse Cycle	☐ *Other*:	
No. of Units:	4				

Part 5 – Items		**Yes**	**No**	**Comments/Improvement Strategies**
5.1	Does the natural climate require the use of heating/cooling?	☑	☐	
5.2	Could appropriate clothing or other methods be used to reduce the need for heating/cooling?	☐	☑	
5.3	Can existing heating/cooling appliances be replaced with more energy efficient types?	☑	☐	
5.4	Could thermostats or other controls be adjusted to reduce energy wastage?	☑	☐	
5.5	Is thermal insulation installed in walls, ceilings and under floors?	☑	☐	
5.6	Are external doors and windows effectively sealed to reduce heat transfer?	☑	☐	
5.7	Could screens/shades be utilised to reduce the effects of direct sunlight?	☑	☐	
5.8	Are doors and windows kept closed when heating/cooling appliances are operating?	☑	☐	
5.8	Is any heating/cooling equipment in need of maintenance?	☐	☑	
5.9	Could natural air flow be utilised to reduce the need for climate control?	☑	☐	

Topic Skills Practice 5.2

Part 6 – Electrical Appliances	
Types of Electrical Appliances: (Indicate Energy Star Rating if applicable)	

Part 6 – Items		**Yes**	**No**	**Comments/Improvement Strategies**
6.1	Are any appliances regularly left ON or in standby mode when not in use?	☐	☑	
6.2	Could timers be utilised to reduce energy wastage?	☑	☐	
6.3	Can any existing appliances be replaced with more energy efficient types?	☐	☑	
6.4	Do inhabitants know how to use energy saving features and/or switch off appliances?	☑	☐	
6.5	Are refrigerator thermostats set at 3 to 4^{o}C and freezer thermostats set at -15 to -18^{o}C?	☑	☐	
6.6	Is there scope for replacing conventional water heating with solar water heating?	☑	☐	
6.7	Are refrigerators and freezers defrosted regularly?	☑	☐	
6.8	Are any appliances in need of maintenance?	☑	☐	

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Topic Skills Practice 5.2

Part 7 – Other Practices and Awareness		**Yes**	**No**	**Comments/Improvement Strategies**
7.1	Are tasks done manually instead of using energy consuming devices wherever possible?	☐	☑	
7.2	Is hot water usage kept to a minimum?	☑	☐	
7.3	Are there posters/signage to remind inhabitants of energy efficient practices?	☑	☐	

Part 8 – Final Comments and Summary of Recommendations

General purpose lighting, features of special purpose lightings are good.

Climate control is provided by reverse cycle aircon system.

Laptops are mostly used in the system.

The arrays are installed at north facing position.

There is no obstructions or potential source of shading.

The access to equipment for safe and ongoing maintenance is available

The energy metering at the site needs not to be upgraded

	 **Feedback**	Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓

3. Completing the Skills Practice

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Topic Skills Practice 5.2

3.1 Skills Practice Review Questions

3.1.1 Clean your work area and return all equipment to the correct storage areas as directed by your teacher/trainer.

3.1.2 Ensure that your documentation is complete, and then answer the following skills practice review questions.

1. What types of energy services were provided to the residential installation you evaluated?

Electricity

Gas

2. Determine the energy consumed if four 60 W lamps are left on for a period of 12 hours. Provide your answer and show all working in the space provided below.

$$\text{kwH} = \frac{60 \times 12 \times 4}{1000} = 2.88\ kwH$$

Energy Consumption: ____________________

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Topic Skills Practice 5.2

3. Determine the average daily energy consumption and cost of operating a 4.8 kW water heater if it operates for an average of 3.2 hours each day, and the service provider charges 28 c/kWh. Provide your answer and show all working in the space provided below.

Energy = 4.8 x 3.2 = 15.36 kwH

Cost 15.36 x $\frac{28}{100}$ = 4$ 30$ = 4.3$

Average Daily Energy Consumption: 15.36 KWH

Average Daily Cost: $4.30

4.

Feedback	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Practices

Skill Practice Number:	6.1
Skill Practice Name:	Safe Rooftop Procedures

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 6.1

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 6. Site Survey Practices

Skills Practice 6.1: Safe Rooftop Procedures

Task:

To demonstrate the correct safety procedures for working safely at heights in the solar industry, including the proper use of related safety equipment.

Objectives:

At the completion of this skills practice, you should be able to:

- Correctly fit a safety harness.
- Correctly attach a safety harness to a lanyard and anchoring system.
- Check the layout and physical condition of a rooftop structure.
- Demonstrate safe methods of working at heights.

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Topic Skills Practice 6.1

1. Planning the Skills Practice

1.1 Equipment

- Roof structure for inspection
- Anchor point(s)
- Safety harness and lanyard

1.2 Suggested Materials

- Barricades/barriers

1.3 Miscellaneous Items

- Pens/pencils

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below.
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B).
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L).
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision Level (D, G or B)	Risk Classification (H, M or L)	Control Measure/s
Falling from heights	D	H	Provide adequate training
Slippery surfaces	D	H	Maintain slip free walking space
Unprotected holes	D	H	Safeguard all holes
Electrical shock	D	H	Adequately maintain
Weak structure	D	H	Inspect structure components
Unsecured equipment	D	H	Store all tools when not in use

	 **Have your teacher/trainer check your risk assessment** ***Feedback***	**Teacher/Trainer Initials and Date**	✓

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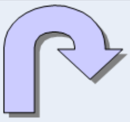
Topic Skills Practice 6.1

2. Carrying Out the Skills Practice

2.1 Fit Safety Harness

2.1.1 Your teacher/trainer will provide you with an approved safety harness and lanyard. Correctly fit the harness to your body and attach the lanyard.

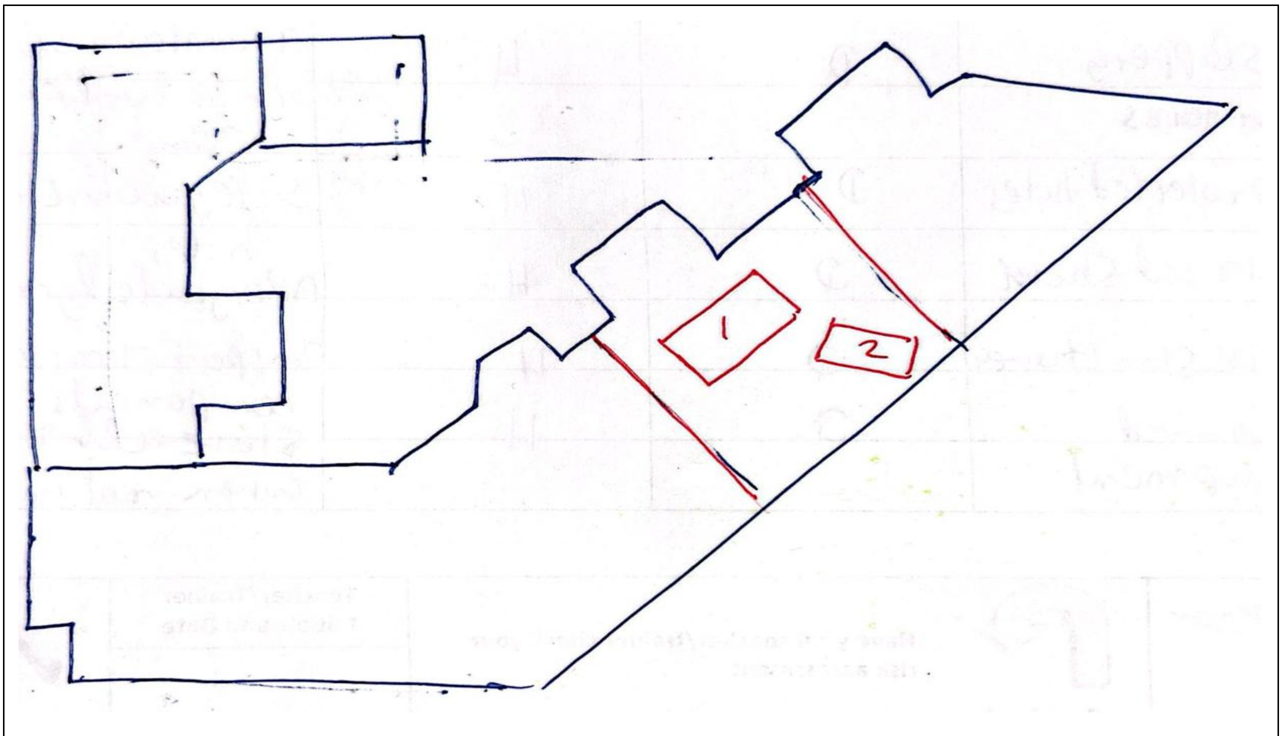
Safety Harness correctly fitted?	☑ Yes	☐ No
Lanyard correctly attached?	☑ Yes	☐ No

	 **Feedback** — **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

2.2 Inspect Rooftop

2.2.1 When you have gained permission from your teacher/trainer, ascend to the rooftop, and identify the layout and condition of the structure. Ensure safe working practices at all times.

2.2.2 Sketch the layout of the roof below, identifying any issues relating to deteriorated physical condition or particularly hazardous areas on your diagram.



2.2.3 Now identify an appropriate anchor point layout on your diagram that will allow safe access to all areas of the roof. Also include any barriers or other passive fall protection that may be

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necessary.

		Teacher/Trainer Initials and Date	
	Feedback — **Have your teacher/trainer check your work**		✓

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Return all equipment back to the correct storage areas as directed by your teacher/trainer, and then complete the following questions.

1. List at least three (3) types of passive fall protection.

    1. Fall protection
    2. Safe rail **barrier**
    3. Anchor points
    4. Platforms/walkways

2. List the regulatory requirements in your State/Territory and typical clearances required when working in the vicinity of overhead services.

Safe work Australia

Approach Distance

Hand held Tool	Operating crane	Handling Metal material	Handing Non conductive material	Driving Crane Vehicle
0.5m	3m	4m	1.5m	0.6m

		Teacher/Trainer Initials and Date	
	Feedback — **Have your teacher/trainer check your answers**		✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Practices

Skill Practice Number:	6.3
Skill Practice Name:	Undertake a Site Survey

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 6.3

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 6. Site Survey Practices

Skills Practice 6.3: Undertake a Site Survey

Task:

To undertake a survey of a given site to determine suitability for a grid-connect PV array battery storage system.

Objectives:

At the completion of this skills practice, you should be able to:

- Undertake initial consultation with client.
- Evaluate the existing electrical infrastructure at a site.
- Evaluate the energy needs and usage at a site.
- Evaluate site and structures.
- Determine suitability of the site for grid-connect PV and battery storage.
- Determine solar access.
- Identify local regulatory requirements related to grid-connect PV and battery storage.
- Specify grid-connect PV and battery storage options.
- Produce a final site survey report and present details to client (teacher/trainer).

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Topic Skills Practice 6.3

1. Planning the Skills Practice

1.1 Equipment

- Building/premises.
- Internet access

1.2 Suggested Materials

- Light meter.
- Thermometer.

1.3 Miscellaneous Items

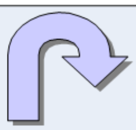
- Relevant PPE.
- Pens/pencils.

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B)
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L)
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision (D, G or B)	Risk Class (H, M or L)	Control Measure/s
Falling from height	D	H	Provide adequate training
Slippery Surfaces	D	H	Maintain slip free walking space
Unprotected hole	D	H	Safeguard all holes
Electrical shock	D	H	Adequately maintain
Weak structure	D	H	Inspect structure components
Unsecured equipment	D	H	Store all tools when not in use



Feedback

Have your teacher/trainer check your risk assessment

Teacher/Trainer Initials and Date

✓

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Topic Skills Practice 6.3

2. Carrying Out the Skills Practice

2.1 Conduct a Site Survey

2.1.1 Your task is to undertake a site survey, using the following checklist, to determine grid-connect solar PV and battery storage system options at a particular site. The location of the site will be indicated by your teacher/trainer.

The site survey must include:

- Consultation with the occupiers of the site.
- Review of site drawings and documentation (e.g. site plans, electricity bills/usage logs).
- A 'walk through' visual inspection of the site.
- Evaluation of the solar resource.

Part 1 – Building/Premises Details				
Surveyor:			**Date:**	
Type of Premises:	Workshop		**Coordinates:**	– 33.936070/– 151.019140
Address:	9 mavis street Revesby NSW 2212			
Part 2 – Energy Usage				
Network Provider:	Origin Energy		**Power Bills:**	$ 500 /qtr
Average Daily Energy Usage:	**Summer**	**Autumn**	**Winter**	**Spring**
	20.04 kWh	18.66 kWh	23.34 kWh	20.03 kWh

Recommendations for Reducing Energy Use:

To use natural lighting providing light penetrated roof.

To p[provide natural ventilation

Install timer to switch off the light

At non business hours (or) no occupant in the building, Use energy efficiency light and equipment.

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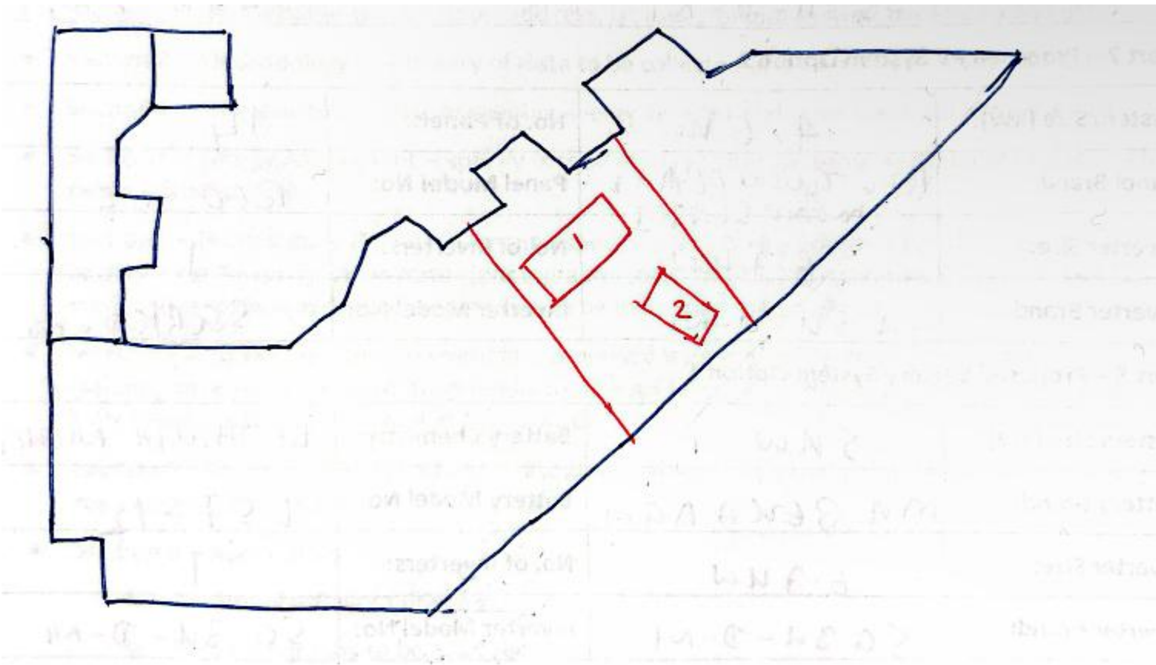
Topic Skills Practice 6.3

Part 3 – Premises			
Construction Type:	Concrete wall	**Levels/Storeys:**	2
Roofing Material:	Brick Tile	**Roof Orientation:**	North
Obstructions/Shading:	Non	**Roof Pitch:**	22.5

Roof Layout Drawing:



Part 4 – Existing Electrical Services				
Metering Type:	Digital Display meter	**Upgrade Required?**	☐ Yes	☑ No
Incoming Mains Phases:	3	**Cable Route:**	☐ UG	☑ OH
Incoming Mains Size:	$6mm^2$	**Inc. Mains Length:**		
Submains Size:	$4mm^2$	**Submains Length:**		
Switchboard Locations:	*Ground floor (note: photos to be taken)*			
Other Energy Services:	Gas			

Part 5 – Proposed Locations for System Equipment	
PV Array Location:	*Roof top (note: photos to be taken)*
Inverter Locations:	*PV Workshop (note: photos to be taken)*

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Topic Skills Practice 6.3

Battery Locations:	*In workshop (PV) (note: photos to be taken)*		
Part 6 – Proposed PV System Option 1			
System Size (kW):	5 KW	**No. of Panels:**	14
Panel Brand:	REC TWIN PEAK 2 mono series	**Panel Model No:**	REC 315
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG3k – D -NI	**Inverter Model No:**	SG3k – D - NI
Part 7 – Proposed PV System Option 2			
System Size (kW):	4.6 kw	**No. of Panels:**	14
Panel Brand:	REC TWIN PEAK 2 mono series	**Panel Model No:**	REC 305
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG 5k -D - NI	**Inverter Model No:**	SG 5K -D - NI
Part 8 – Proposed Battery System Option 1			
System Size (kW):	5 kw	**Battery Chemistry:**	LITHIUM NICKEL
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES7 - 12
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	5G 3 K – D - NI	**Inverter Model No:**	SG 3K – D -NI
Part 9 – Proposed Battery System Option 2			
System Size (kW):	4.6 KW	**Battery Chemistry:**	LITHIUM NICKEL
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES 7 - 20
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	5G 5K – D - NI	**Inverter Model No:**	Sa 5K – D NI

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Topic Skills Practice 6.3

	Feedback **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

2.2 Produce a Final Site Survey Report

2.2.1 Use your findings from the previous section to produce a final site survey report either using the template provided below, an alternate template provided by your teacher/trainer, or your own documentation.

Details to be included in the final report are:

- Section 1 – Overview – specify site survey scope, objectives, purpose and goals.
- Section 2 – Site Details – specify street address, latitude, longitude, size, ownership and use.
- Section 3 – Methodology – summary of data to be collected and associated survey methods.
- Section 4 – Infrastructure – specify existing energy services and main electrical infrastructure.
- Section 5 – Energy Assessment – specify current energy usage patterns and recommendations for reducing energy use.
- Section 6 – Photovoltaic (PV) Assessment – specify solar access, potential for shading, proposed locations for PV array and inverter (photographs to be included in Appendix B), at least two (2) actual PV system options (references/link to be included in Appendix C).
- Section 7 – Battery Storage Assessment – proposed locations for batteries and inverter (photographs to be included in Appendix B), at least two (2) actual battery storage system options (references/link to be included in Appendix C).
- Section 8 – Regulatory Requirements – list details of required permits/approvals and applicable regulations and standards.
- Section 9 – Appendices:
    - A – Site plan/layout drawings
    - B – Photographs to be attached:
        - Proposed location for PV array.
        - Proposed location for inverter.
        - Proposed location for batteries.
    - C – References/links to proposed PV and battery storage products

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Topic Skills Practice 6.3

		Teacher/Trainer Initials and Date	
	Feedback **Have your teacher/trainer check your work**		✓

Section 1 – Overview

1.1 Scope:

Installing solar panel, installing inverter DC wiring, AC wiring, switch board, Battery system and wiring safety protection.

1.2 Objectives:

Grid connected PV power system with dc coupled battery storage that does not provide emergency power

Section 2 – Site Details

2.1 Address:

9 Mavis street, Revesby, NSW 2212

2.2 Latitude and longitude: — 33.936670/ 151.019140

2.3 Site size: Building size 2317 m^2 , Land Size 3902m^2

2.4 Site ownership: ETC

2.5 Land use: Industrial

Section 3 – Methodology

3.1 Data to be collected:

- Solar irradiance, longitude, GPS data
- Temperature, Availlable space, obstruction
- Determine number of panel needed and can be installed. Structural materials, location for Inverter and battery access to equipment
- Local requirement

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Topic Skills Practice 6.3

3.2 Survey methods:

- Consult with the client/site occupants
- Review site drawing, diagram, documentation
- Walk through the site to confirm and identify arrangment

Section 4 – Infrastructure

4.1 Existing energy services:

- Origin energy, Sydney water
- Origin Gas

4.2 Electrical infrastructure:

(AC) 5 Kw, 240V 50Hz 23A, 2.5mm^2 (AC) PVC Cable

(DC) 6.7 kw 10.19A 40.8V, XLPE 38A cable

C.B SAAA – 181240 – LA, PV Switch BYH 32

C.B ISA GO, PV Disconnector 15A, 450V

Section 5 – Energy Assessment

5.1 Current energy usage patterns:

Summer 20.09 kwh. Autumn 18.66kwh

Winter 23.34 kwh ,Spring 20.03 kwh

5.2 Energy usage recommendations

Off peak system should be utilized as the classes are conducted beyond office hours.

Time switches should be provided for switching off unnecessary lights when the site is not used

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Topic Skills Practice 6.3

Section 6 – Photovoltaic (PV) Assessment

6.1 Irradiance/sunshine hours: Yearly average 6-7 hours

6.2 Optimal tilt/orientation: 29.5 degree from horizontal

6.3 Potential shading: Non

6.4 Proposed array location: Roof top, North orientation

6.5 Proposed inverter location: PV Workshop

6.6 PV system option 1 – details:

- REC Twin Peakx2 PV Arrays are to be installed XLPE Dc wiring, 4620 watt, 14 modules, output dc voltage 40.8v, Nominal current 9.02A
- AC inverter 6700w, max dc voltage 600v, MPPT voltage 90-500v, No of string 1
- Outputs 50 Hz, 180-276V Current = 21.7A
- AC power 5000 VA
- Inverter Type SG 5K – D - NI

6.7 PV system option 2 – details:

Rec Twine PEAK x PV Arrays are to be installed. XLPE DC wiring, 4620w, 14 module, 9.62A 40.2V

- AC inverter 0700w, max dc voltage 600v MPPTvoltage 90-560v, No of string = 1
- Output 50 Hz 180-276V current 21-7A AC power 5000 VA

Inverter Rype SG5K -D-NI

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Topic Skills Practice 6.3

Section 7 – Battery Storage Assessment

7.1 Proposed battery unit location:

7.2 Proposed inverter location:

7.3 Battery storage option 1 – details:

Lithium Nickel MK BEKA AGM Battery ES7-12, 12V 7.2 AH ,DOD 80% ,Cycle life 20Hr.

No of batteries 54

7.4 Battery storage option 2 – details:

Lithium Nickel ME BAKA AGM Battery ES8-22 , 12V, 8AH ,100 watt Maximum discharge 80watt

DOD 80% ,Cycle life 20 Hr, Number of batteries =54

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Topic Skills Practice 6.3

Section 8 – Regulatory Requirements

Local council area: FAIRFIELDS COUNCIL

Required permits/approvals: Solar installation Permit

By ACCREDITED SOLAR INSTALLER

Network provider: Origin Energy

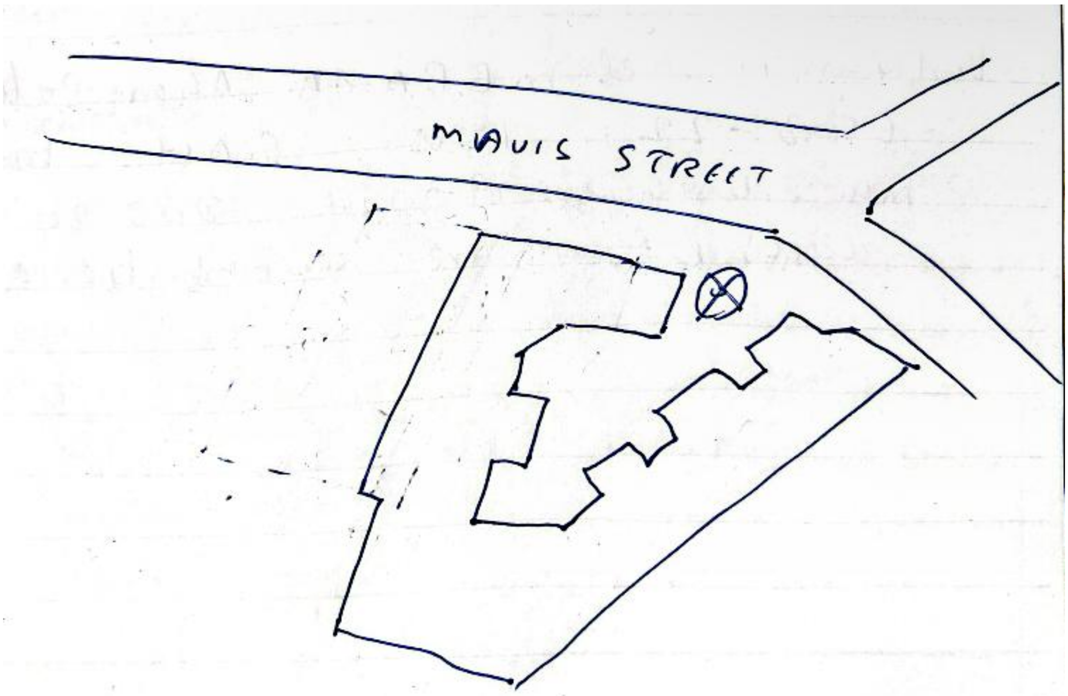
Network provider requirements: Minimum quality standard for output voltage and frequency access to remote monitoring, acceptable type of battery/inverter /Limitation on size of system

Applicable regulations: AS 3000:2018, AS/NZS S033:2021 ,Minimum protective requirement

Applicable standards: AS/NZS 4777:1.2016, AS/NZS SO33:2012

Section 9 – Appendices

Appendix A – Site plan/layout drawing (*include dimensions, key electrical infrastructure and proposed installation locations)*



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Topic Skills Practice 6.3

Appendix B – Site Photographs

- ☑ Proposed location for PV array photograph attached.
- ☑ Proposed location for inverter photograph attached.
- ☑ Proposed location for batteries photograph attached.

Appendix C – References/Links

PV System Option 1:

Grid connected DC power system with dc coupled battery storage that does not provide emergency

Power to essential equipment In the event of a grid failure.

PV System Option 2:

Grid connected dc power system with dc coupled battery storage that does provide emergency

power to essential equipment in the event of a grid failure

Battery Storage Option 1:

Lithium nickel battery 12V ,86 WH, 69WH 54 batteries DOD 80%. Cycle life 20HR , MK BEKA AGM

Battery ES7- 12

Battery Storage Option 2:

Lithium Nickel Battery 12V 86watt 100wH 80WH DOD 80% MK BEKA AGM Battery ES 8-20

	Feedback — **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice 6.3

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Submit your completed site survey report to your teacher/trainer and present/explain your findings.

3.1.2 Answer the following skills practice review questions.

1. List any potential site hazards that may impact the installation of proposed PV and/or battery storage equipment below.

- Falling hazard
- Electrical shock
- Battery Acid Burn
- Heavy solar panel fall

2. List any potential issues or problems that may impact the installation of proposed PV and/or battery storage equipment, and proposed solutions, below.

- Weather situation - Provide Strong installation and structure
- String wind
- Debris impact - Provide appropriate access
- Potential shading - Assess shade
- Ambient temperature - Design the system to meet temperature variation

	 *Feedback*	Have your teacher/trainer check your answers	Teacher/Trainer Initials and Date	✓

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0022 Solve basic problems in photovoltaic energy apparatus and systems
Topic Title:	Solar Radiation

Skill Practice Number:	1.1
Skill Practice Name:	Solar Irradiance

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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February 2022

Topic Skills Practice 1.1

UEERE0022 Solve basic problems in photovoltaic energy apparatus and systems

Topic 1. Solar Radiation

Skills Practice 1.1: Solar Irradiance

Task:

To locate and interpret meteorological data, measure solar irradiance, determine the average daily and monthly irradiation at your location, and determine the times and dates of the year when a given PV array will become shaded.

Objectives:

At the completion of this skills practice, you should be able to:

- Determine the latitude of a given location.
- Interpret solar radiation maps.
- Measure solar irradiance using a solarimeter.
- Determine solar irradiance from sunshine hour data.
- Determine the dates and times that a PV array will become shaded.

Topic Skills Practice 1.1

1. Planning the Skills Practice

1.1 Equipment

- Solarimeter
- Sun path diagram
- Computer

1.2 Suggested Materials

- GPS
- Solar configuration software

1.3 Miscellaneous Items

- Pens/pencils
- Calculator
- Internet access

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B)
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L)
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision Level (D, G or B)	Risk Classification (H, M or L)	Control Measure/s
Material / equipment	D	M/L	House Keeping
UV rays	D	M/L	Sunscreen

	Feedback	Have your teacher/trainer check your risk assessment	Teacher/Trainer Initials and Date	✓

Topic Skills Practice 1.1

2. Carrying Out the Skills Practice

2.1 Solar Exposure Data

2.1.1 Use a GPS or internet site, such as http://www.ga.gov.au, to determine your current latitude and record your result below:

Location	Latitude
9 Mavis Street, Revesby, Sydney	-33.936670/151.019140

2.1.2 Go the Bureau of Meteorology website at http://www.bom.gov.au to locate the latest solar exposure map (yesterday). Daily solar exposure maps can be located by clicking on the links:

- 'Climate and past weather', then
- 'Maps – history to now', and then
- 'Solar exposure'

2.1.3 Interpret the map data to determine the daily solar exposure for your location in MJ/m^2. Then use this value to calculate the daily irradiation in kWh/m^2, showing your working and answers in the space provided below:

Remember: 1 Joule is equal to 1 watt for 1 second.

Solar Exposure

Working:

Highest Daily Exposure

Example 2/2/ 2021 is 21 MJ/m

21/3.6= 5.83 Kw/m

www.bom.gov.au

Climate & Past weather

Maps- History to now

Solar exposure / MAP – Solar exposure period – 1 day

11 September 2023 Record 18MJ/m²

$$Kw/m = \frac{MJ/m^2}{3.6} = \frac{18}{3.6} = 5 \text{ Kw/m}$$

Date:	2/2/ 2021	**Solar Exposure:**	21 MJ/m	**Daily Irradiation:**	5 Kw/m

	Feedback	Teacher/Trainer Initials and Date	
	Have your teacher/trainer check your answers		✓

Topic Skills Practice 1.1

2.2 Determine Solar Exposure

2.2.1 Use a solarimeter to measure the solar irradiance at your location. Record your results below:

Date	Time	Irradiance
18/09/2023	1:22PM	6.79 w/m^2 969 LUX

Install Solar Radiation Meter (ORJA) APP Google Store, Play

2.2.2 Return to the Bureau of Meteorology website to obtain the sunshine hour data for your location. Maps indicating average sunshine hours can be located by clicking on the links:

- 'Home page', then
- 'Climate and past weather', then
- 'Maps – averages', and then
- 'Sunshine duration'

2.2.3 Use the sunshine hour data to determine the yearly and monthly average irradiation at your location. Record your values in the table below:

Average Daily Irradiation			
Location	**Electrical Trade College**		
Yearly	**6-7 hours**		
January	**8**	**July**	**7**
February	**8**	**August**	**8**
March	**7**	**September**	**8**
April	**7**	**October**	**8**
May	**6**	**November**	**8**
June	**6**	**December**	**8**

Feedback	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 1.1

2.3 Shading of PV Arrays

2.3.1 Examine the PV array, pictured below in figures 2.4.1(a) and 2.4.1(b). Assuming the array is installed at your location, use the data you have collected so far, the measured angles indicated, and the appropriate sun path diagram, to identify the times and dates when the PV array will become shaded.

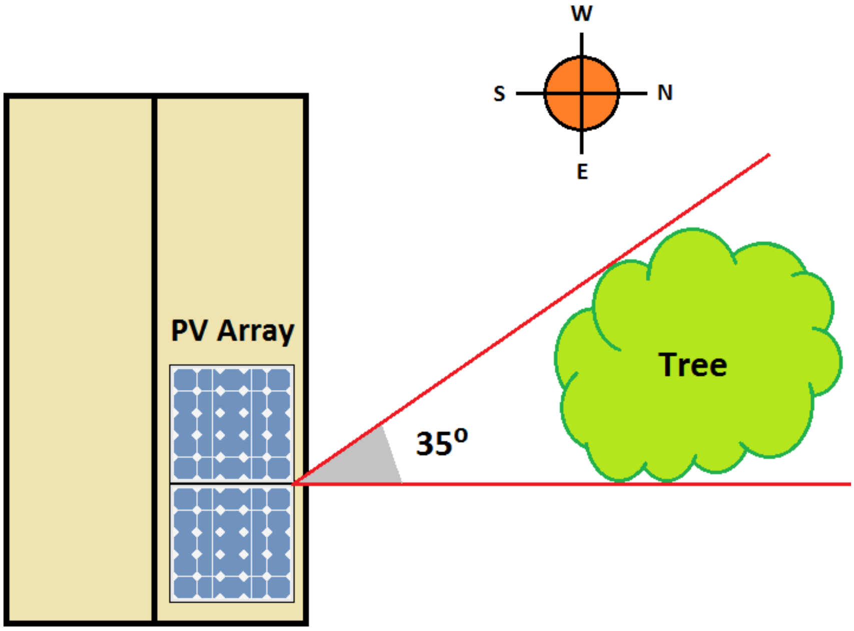


Figure 2.3.1(a) - Overview

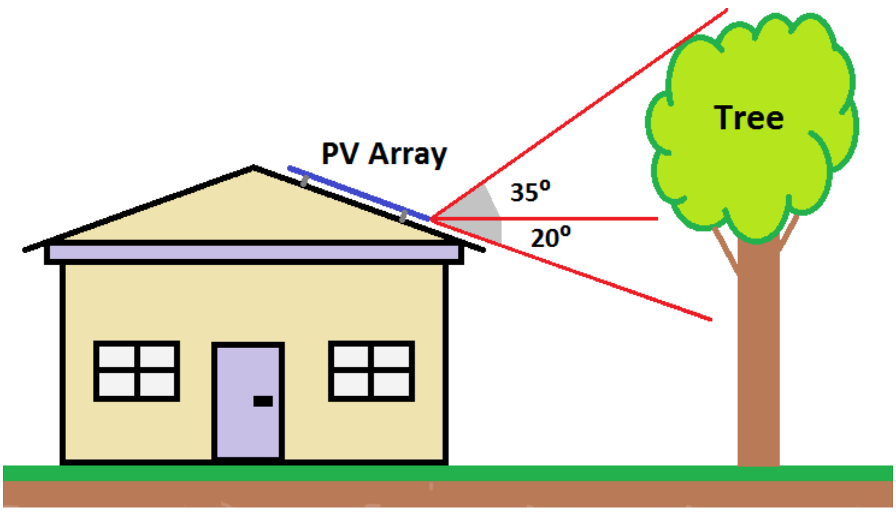


Figure 2.3.1(b) - Elevation

Topic Skills Practice 1.1

2.3.2 Record the times and dates of shading in the space provided below:

19 July from 1PM to 2PM

28 May from 1PM to 2PM

		Teacher/Trainer Initials and Date	
	Have your teacher/trainer check your answers *Feedback*		✓

3. Completing the Skills Practice

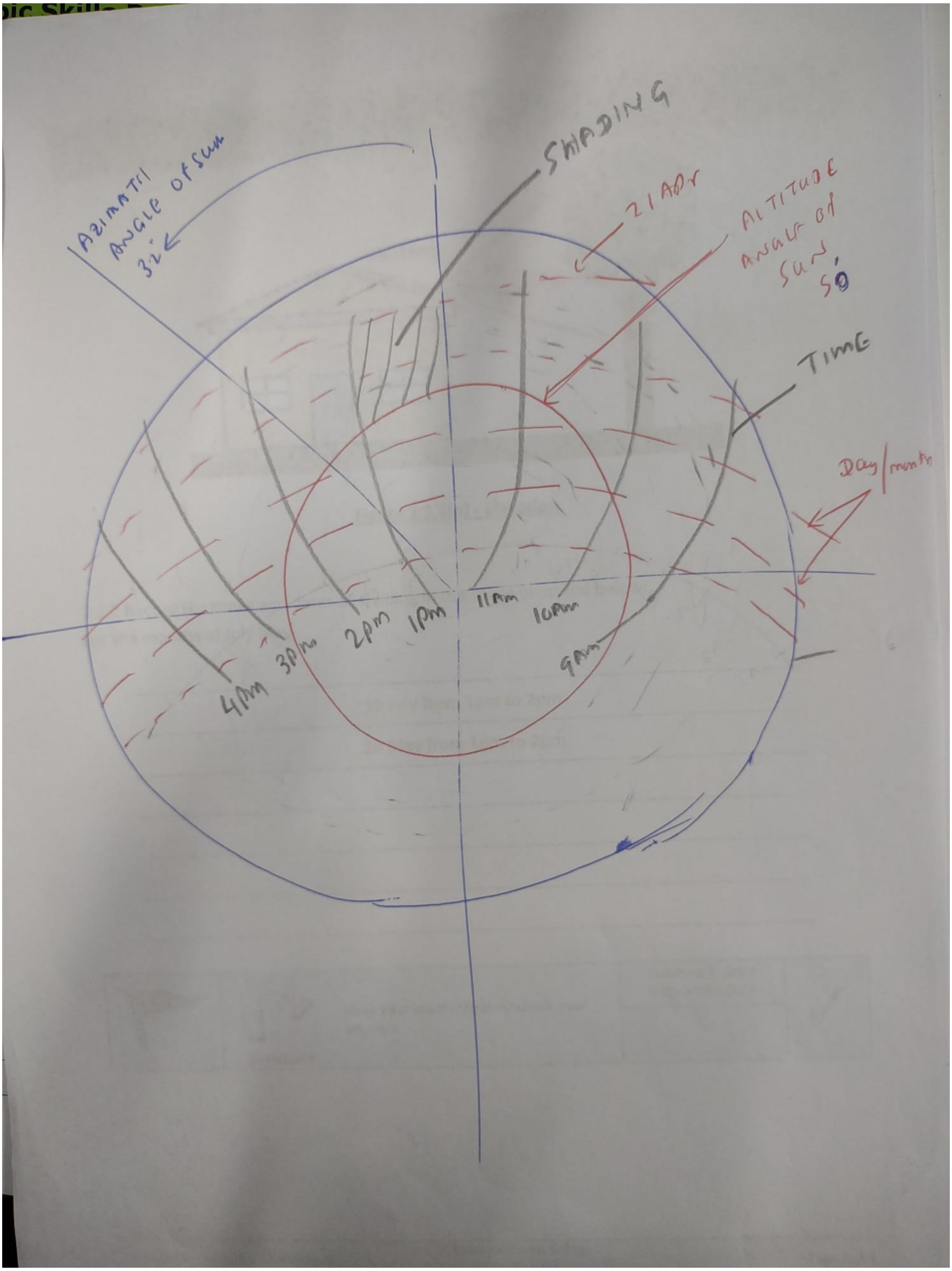
3.1 Skills Practice Review Questions

3.1.1 Return all equipment to the correct storage areas as directed by your teacher, and then complete the following questions.

1. Describe four factors that cause variations in the daily irradiation of a fixed PV array.

Topic 1.2

- **Season change**
- **Shading and soiling**
- **Cloud cover**
- **Time of day**


SHADING
AZIMATIL ANGLE OF SUN 32
21 Apr
ALTITUDE ANGLE OF SUN 50
TIME
Day/month
4pm
3pm
2pm
1pm
11am
10am
9am

Check out "ScanTheSun"

https://play.google.com/store/apps/details?id=com.scanthesun

solar irradiance app - Google Search

SOLAR RADIATION METER (ORJA)

https://www.google.com/search?q=solar+irradiance+app&oq=&gs_lcrp=EgZjaHJvbWUqCQgAECMYJxjqAjIJCAAQIxgnGOoCMgkIARAjGCcY6gIyCQgCECMYJxjqAjIJCAMQIxgnGOoCMgkIBBAjGCcY6gIyCQgFECMYJxjqAjIJCAYQIxgnGOoCMgkIBxAjGCcY6gIyCQgIECMYJxjqAjIJCAkQIxgnGOoCMgkIChAjGCcY6gIyCQgLECMYJxjqAjIJCAwQIxgnGOoCMgkIDRAjGCcY6gIyCQgOECMYJxjqAjIRCA8QABgDGEIYjwEYtAIY6gIyDwgQEC4YAxiPARi0AhjqAjIRCBEQABgDGEIYjwEYtAIY6gIyDwgSEC4YAxiPARi0AhjqAjIPCBMQLhgDGI8BGLQCGOoC0gEGLTFqMGo3qAIUsAIB&client=ms-android-vf-au-revc&sourceid=chrome-mobile&ie=UTF-8

Solar Panel Tilt Angle Calculator

https://footprinthero.com/solar-panel-tilt-angle-calculator

Metrology

http://www.bom.gov.au

Latitude

www.latlong.net

	Have your teacher/trainer check your answers ***Feedback***	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Design grid-connected photovoltaic power supply systems
Topic Title:	Grid-connected Photovoltaic (PV) Systems

Skill Practice Number:	2.1
Skill Practice Name:	Grid-Connected PV System Diagrams

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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August 2023

Topic Skills Practice 2.1

UEERE0054 Design grid-connected photovoltaic power supply systems

Topic 2. Grid-connected Photovoltaic (PV) Systems

Skills Practice 2.1: Grid-Connected PV System Diagrams

Task:

To draw a block and circuit diagrams of various grid-connected PV power system arrangements.

Objectives:

At the completion of this skills practice, you should be able to:

- Draw and label a block diagram of a grid-connected PV power system.
- Draw and label circuit diagrams of grid-connected PV power systems.

Topic Skills Practice 2.1

1. Planning the Skills Practice

1.1 Research Grid-Connected PV System Arrangements

1.1.1 Research grid-connected PV power systems using reference material, such as:

- Energy Space Content Page 2.1.
- AS/NZS 4777.1 Grid connection of energy systems via inverters – Installation requirements.

1.1.2 Once you feel you have sufficient knowledge of the subject matter, obtain the following materials to assist you with carrying out this skills practice:

- Pens/pencils
- Ruler

2. Carrying Out the Skills Practice

2.1 Grid-Connected PV System – Block Diagram

2.1.1 In the space provided on this page, draw and label a block diagram of a simple grid-connected PV power system. Include the following items in your diagram:

a) PV array.
b) GC inverter.
c) Disconnectors.
d) Main switchboard.
e) Metering.

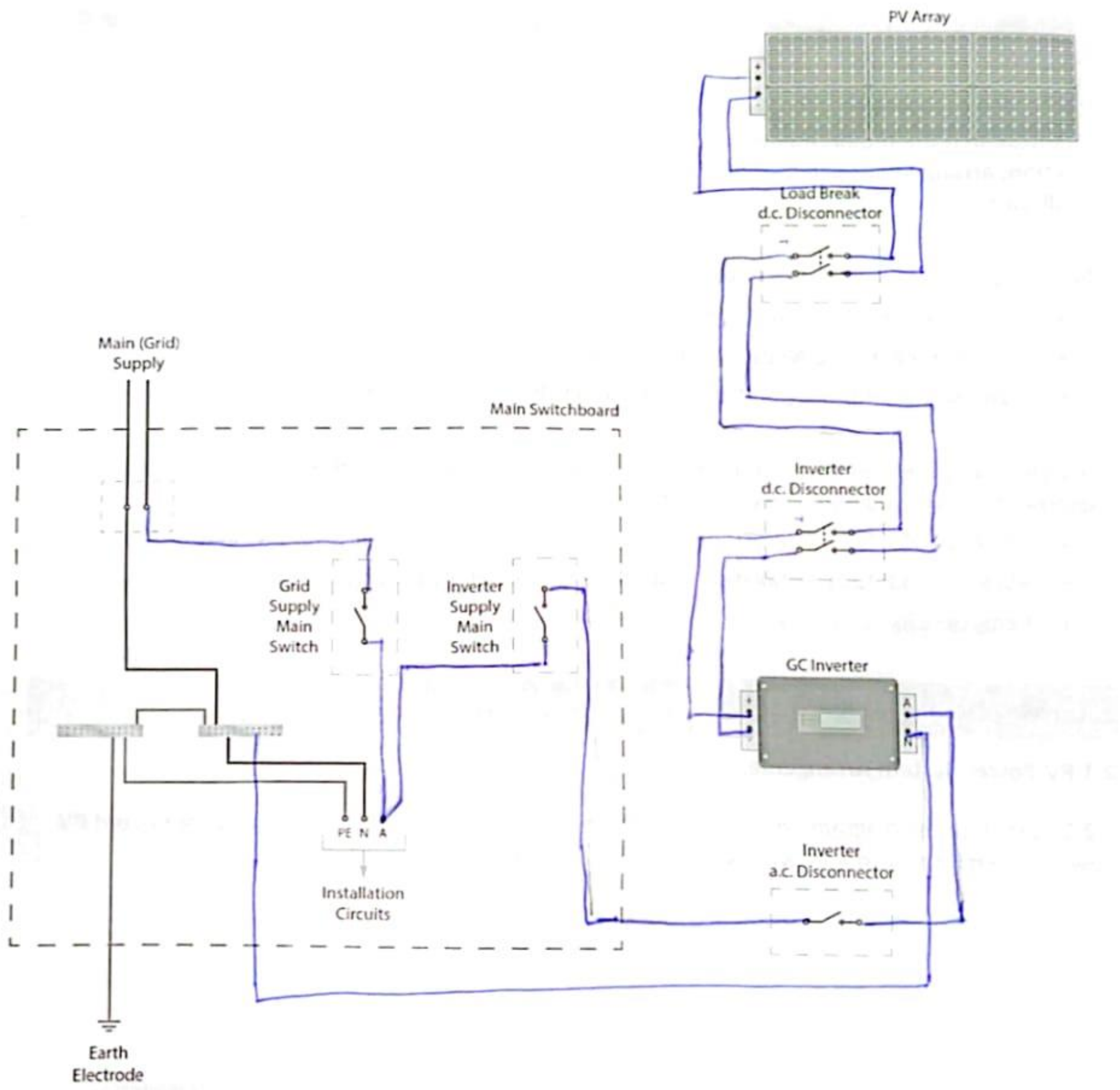
	 ***Feedback***	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 2.1

2.2 Grid-Connected PV System – Circuit Diagram

2.2.1 In the space provided on this page, draw and label a circuit diagram of a simple grid-connected PV power system. Include the following items in your diagram:

a) PV array.
b) GC inverter.
c) Main switchboard.
d) Disconnectors.
e) Main switches.
f) Metering.
g) Consumer mains.



	Feedback Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓

Topic Skills Practice 2.1

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Complete this section after successfully drawing and labelling the diagram in section 2.

1. Explain what is meant by the term 'islanding' in relation to grid-connected PV power systems.

In grid-connected PV systems, islanding refers to the situation where a portion of the electrical grid, including the PV system, continues to operate and supply power even after the main grid has disconnected due to a fault or outage. This isolated section, powered by the PV system, is essentially an "island" of electricity.

2. Explain the operation of active anti-islanding grid protection.

Active anti-islanding protection for grid-tied inverters involves proactively testing the grid connection to detect islanding conditions. Unlike passive methods that rely on monitoring grid parameters, active methods inject small, controlled disturbances into the system and analyze the response. If the grid is stable, these disturbances will be absorbed, but in an islanded state, they will cause detectable anomalies that trigger the inverter to disconnect, preventing unsafe operation.

	Feedback Have your teacher/trainer check your answers	**Teacher/Trainer Initials and Date**	✓

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August 2023

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Design grid-connected photovoltaic power supply systems
Topic Title:	Grid-connected Photovoltaic (PV) Systems

Skill Practice Number:	2.3
Skill Practice Name:	Grid-Connected PV System Comparison

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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August 2023

Topic Skills Practice 2.3

UEERE0054 Design grid-connected photovoltaic power supply systems

Topic 2. Grid-connected Photovoltaic (PV) Systems

Skills Practice 2.3: Grid-Connected PV System Comparison

Task:

To compare and contrast the benefits of two different grid-connected PV power system options.

Objectives:

At the completion of this skills practice, you should be able to:

- Identify different options for a grid-connected PV system for a given site.
- Document the key ratings and features of grid-connected PV systems.
- Compare and contrast key ratings and features of grid-connected PV systems.
- Explain the benefits and drawbacks of different grid-connected PV system options to customers.

1. Planning the Skills Practice

1.1 Research Grid-Connected PV Systems

1.1.1 Research two currently available grid-connected PV power systems, suitable for a proposed installation at a location indicated by your teacher/trainer. It may be helpful to use the following sources of reference material:

- The internet.
- Manufacturer catalogues.
- Retailer promotional materials.

1.1.2 Once you feel you have sufficient knowledge of the subject matter, obtain the following materials to assist you with carrying out this skills practice:

- Pens/pencils.

Topic Skills Practice 2.3

2. Carrying Out the Skills Practice

2.1 Grid-Connected PV System – Option 1

2.1.1 Identify the first grid-connect PV system and fill out the relevant product data in the spaces provided below.

PV System 1 – Details

Description: ______________________

____

____

Manufacturer: ______________________

Product No: ______________________

Cost: ______________________

Array Parameters

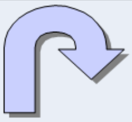
Module Type:		No. of Modules:	
MPP Power:		Efficiency:	
MPP Voltage:		O/C Voltage:	
MPP Current:		S/C Current:	

Inverter Parameters

Inverter Type:		No. of Inverters:	
Max d.c. Power:		Max d.c. Voltage:	
d.c. Window:		Max d.c. Current:	
Max a.c. Power:		Efficiency:	

– Proposed PV System Option 1			
System Size(kW):	5 KW	**No. of Panels:**	14

Panel Brand:	REC TWIN 6AK 2 MONO SERIES	**Panel ModelNo:**	REC 31S
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG 3k – D - NI	**Inverter Model No:**	SG 3k – D - NI
System Size (kW):	5 kw	**Battery Chemistry:**	Lithium Nickle
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES7 - 12

	 **Have your teacher/trainer check your work** ***Feedback***	**Teacher/Trainer Initials and Date**	✓

Module Specifications (STC)			
Output		**Characteristics**	
MPP power:	390 W	Max. efficiency:	25 %
Tolerance:	+ 5 % / 0 %	Temp. coefficient:	-0.29%/°C
MPP voltage:	39 V	Type of cells:	MONOCRYSTALLINE (MAXEON GEN 5)
MPP current:	10 A	No. of cells:	66
O/C voltage:	48V ± 3%	Dimensions:	1017/1835/40
S/C current:	10.8A ± 3%	Weight:	20 kg
Max. fuse (A):	20 A	IP rating:	IP68
Array Specifications (5 marks)			
Output		**Characteristics**	
MPP power:	7020 WATTS	No. of modules:	2 x 9 = 18
MPP voltage:	351 VOLTS	No. of strings:	2
MPP current:	10 A	Mounting system:	Tilt Frame
O/C voltage:	432 VOLTS	Bypass diodes:	☐ Yes ☐ No
S/C current:	10.8 AMPS	Blocking diodes:	☐ Yes ☐ No
Inverter Specifications (5 marks)			

d.c. Parameters		a.c. Parameters	
Max. power:	9100 W	Max power:	7000 W, VA
Max. voltage:	550 V	Nominal power:	230 V
Voltage range:	70-550 V	Voltage range:	160 V/300 V
Max. current:	2 x 12.5 A/12.5 A	Max. current:	33.5 A
Max. strings:	2/1	Frequency range:	50/60 Hz

Topic Skills Practice 2.3

2.2 Grid-Connected PV System – Option 2

2.2.1 Identify the second grid-connect PV system and fill out the relevant product data in the spaces provided below.

PV System 2 – Details

Description: ______________________________

____

____

Manufacturer: ______________________________

Product No: ______________________________

Cost: ______________________________

Array Parameters

Module Type:		No. of Modules:	
MPP Power:		Efficiency:	
MPP Voltage:		O/C Voltage:	
MPP Current:		S/C Current:	

Inverter Parameters

Inverter Type:		No. of Inverters:	
Max d.c. Power:		Max d.c. Voltage:	
d.c. Window:		Max d.c. Current:	
Max a.c. Power:		Efficiency:	

Feedback	Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓

Part 7 – Proposed PV System Option 2			
System Size (kW):	6 Kw	**No. of Panels:**	14
Panel Brand:	MKBEKA AGM	**Panel ModelNo:**	ES7 - 12
Inverter Size:	7.7 KW	**No. of Inverters:**	1
Inverter Brand:	SG 5k – D - NI	**Inverter Model No:**	SG 5k – D - NI
Output	**Characteristics**		
MPP power:	690 W	Max. efficiency:	22 %
Tolerance:	+ 5 % / 0 %	Temp. coefficient:	-0.29%/°C
MPP voltage:	39 V	Type of cells:	MONOCRYSTALLINE (MAXEON GEN 5)
MPP current:	10 A	No. of cells:	66
O/C voltage:	48V ± 3%	Dimensions:	1017/1835/40
S/C current:	10.8A ± 3%	Weight:	20 kg
Max. fuse (A):	20 A	IP rating:	IP68
Array Specifications (5 marks)			
Output	**Characteristics**		
MPP power:	8020 WATTS	No. of modules:	2 x 9 = 18
MPP voltage:	451 VOLTS	No. of strings:	2

MPP current:	15 A	Mounting system:	Tilt Frame	
O/C voltage:	432 VOLTS	Bypass diodes:	Yes	No
S/C current:	10.8 AMPS	Blocking diodes:	Yes	No
Inverter Specifications (5 marks)				
d.c. Parameters	**a.c. Parameters**			
Max. power:	10100 W	Max power:	9000 W, VA	
Max. voltage:	550 V	Nominal power:	230 V	
Voltage range:	70-550 V	Voltage range:	160 V/300 V	
Max. current:	2 x 12.5 A/12.5 A	Max. current:	33.5 A	
Max. strings:	4/1	Frequency range:	50/60 Hz	

Attachment B – Site Survey Checklist			
Inverter Size:	7.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG – 5K – D - NI	**Inverter Model No:**	SG –5K – D - NI
Part 9 – Proposed Battery System Option 2			
System Size (kW):	5.6 KW	**Battery Chemistry:**	Lithium Nickle
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES8 - 20
Inverter Size:	7.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG 5K – D NI	**Inverter Model No:**	SG 5K– D NI

Topic Skills Practice 2.3

2.3 Grid-Connected PV System Comparison

2.3.1 Answer the following questions to compare and contrast the features of the two PV system options.

1. Which of the two systems will produce more energy to the installation?

System 2

2. Which of the two systems has higher upfront costs?

System 2

3. Which of the two systems will have a shorter 'payback period'?

System 1

4. Describe three advantages of system 1 compared to system 2.

Cheaper

Allow to install more device

Higher efficiency

Topic Skills Practice 2.3

5. Describe three advantages of system 2 compared to system 1.

Higher power

Higher current

More strings

2.3.2 Now present the two systems to your teacher/trainer (or other person as directed by your teacher/trainer), explaining the features, benefits and drawbacks of each when compared with each another.

	Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Complete this section after you have successfully completed Section 2.

1. Explain how the effects of shading can be minimised in a PV array.

PV systems use bypass diodes, which protect the module and redirect the current through the shaded cell. This improves the overall performance of the module even if some of the shade loss is unavoidable. Other tools such as MLPEs can also increase the performance of shaded modules.

	Feedback	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Practices

Skill Practice Number:	6.2
Skill Practice Name:	Determine Solar Access

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 6.2

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 6. Site Survey Practices

Skills Practice 6.2: Determine Solar Access

Task:

To determine the solar access for a PV array installation site at your location, and to select an appropriate position, orientation and tilt angle for a PV array to be installed there.

Objectives:

At the completion of this skills practice, you should be able to:

- Determine the latitude of a given location.
- Interpret solar radiation maps.
- Measure solar irradiance using a solarimeter.
- Determine solar irradiance from sunshine hour data.
- Determine the dates and times that a PV array will become shaded.

1. Planning the Skills Practice

1.1 Equipment	1.2 Suggested Materials	1.3 Miscellaneous Items
• Solarimeter. • Sun path diagram. • Computer.	• GPS. • Solar configuration software.	• Pens/pencils. • Calculator. • Internet access.

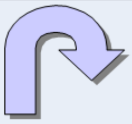
Topic Skills Practice 6.2

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below.
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B).
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L).
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision Level (D, G or B)	Risk Classification (H, M or L)	Control Measure/s
Material / equipment	D	M/L	House Keeping
UV rays	D	M/L	Sunscreen

		Teacher/Trainer Initials and Date	
	 Have your teacher/trainer check your risk assessment *Feedback*		✓

2. Carrying Out the Skills Practice

2.1 Solar Exposure Data

2.1.1 Use a GPS or internet site, such as http://www.ga.gov.au, to determine your current latitude and record your result below.

Location	Latitude

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Topic Skills Practice 6.2

9 Mavis Street, Revesby, Sydney	-33.936670/151.019140

2.1.2 Go the Bureau of Meteorology website at http://www.bom.gov.au to locate the latest solar exposure map (yesterday). Daily solar exposure maps can be located by clicking on the links:

- 'Climate and past weather', then
- 'Maps – history to now', and then
- 'Solar exposure'.

2.1.3 Interpret the map data to determine the daily solar exposure for your location in MJ/m^2. Then use this value to calculate the daily irradiation in kWh/m^2, showing your working and answers in the space provided below:

Remember: 1 Joule is equal to 1 watt for 1 second.

Solar Exposure

Working:

Working:

Highest Daily Exposure

Example 2/2/ 2021 is 21 MJ/m

21/3.6= 5.83 Kw/m

www.bom.gov.au

Climate & Past weather

Maps- History to now

Solar exposure / MAP – Solar exposure period – 1 day

11 September 2023 Record 18MJ/m^2

$$\text{Kw/m} = \frac{\text{MJ/m}^2}{3.6} = \frac{18}{3.6} = 5 \text{ Kw/m}$$

Date:	2/2/ 2021	**Solar Exposure:**	21 MJ/m	**Daily Irradiation:**	5 Kw/m

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Topic Skills Practice 6.2

	Feedback **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

2.2 Determine Solar Exposure

2.2.1 Use a solarimeter to measure the solar irradiance at your location. Record your results below:

Date	Time	Irradiance
18/09/2023	1:22PM	6.79 w/m^2 969 LUX

2.2.2 Return to the Bureau of Meteorology website to obtain the sunshine hour data for your location. Maps indicating average sunshine hours can be located by clicking on the links:

- ‘Home page’, then
- ‘Climate and past weather’, then
- ‘Maps – averages’, and then
- ‘Sunshine duration’.

2.2.3 Use the sunshine hour data to determine the yearly and monthly average irradiation at your location. Record your values in the table below:

Average Daily Irradiation			
Location	**Electrical Trade College**		
Yearly	**6-7 hours**		
January	**8**	**July**	**7**
February	**8**	**August**	**8**
March	**7**	**September**	**8**
April	**7**	**October**	**8**
May	**6**	**November**	**8**
June	**6**	**December**	**8**

	Feedback **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

2.3 Select Optimal Array Position

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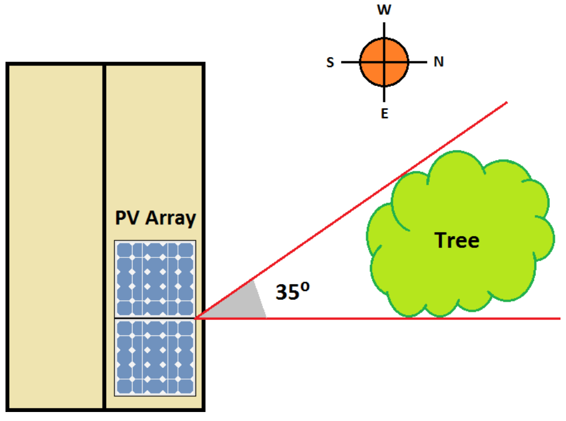
Topic Skills Practice 6.2

2.3.1 Draw a basic site plan of your location in the space provided on this page, and show where you could locate your PV array to attain optimal performance.

2.3.2 Indicate the optimal tilt angle and the orientation of your array in the table provided below.

Tilt Angle	Orientation
35 degree	North

2.3.2 Identify whether or not the array will become shaded at any point, and record the times and dates of shading in the space provided below:



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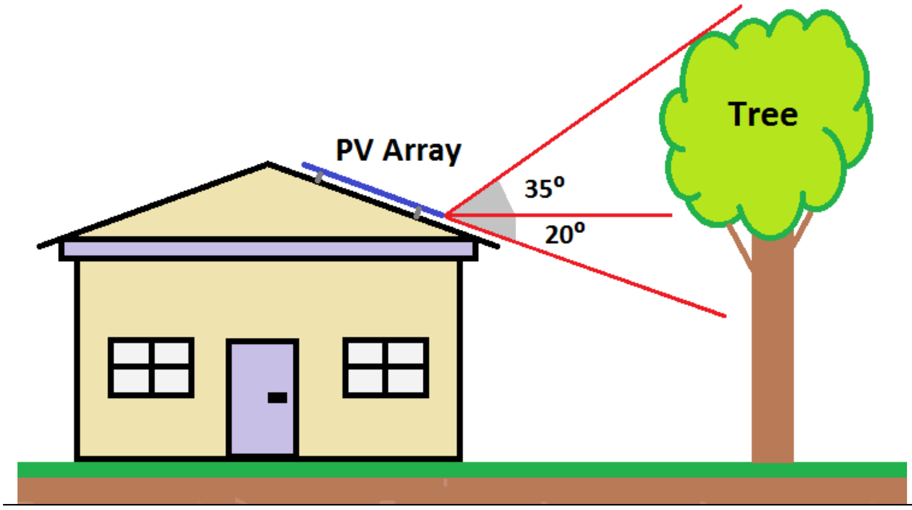
Topic Skills Practice 6.2



	Feedback Have your teacher/trainer check your answers	**Teacher/Trainer Initials and Date**	✓

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Return all equipment to the correct storage areas as directed by your teacher/trainer, and then complete the following question.

1. Describe four factors that cause variations in the daily irradiation of a fixed PV array.

- Season change
- Shading and soiling
- Cloud cover
- Time of day

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Topic Skills Practice 6.2

	Feedback **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Design grid-connected photovoltaic power supply systems
Topic Title:	Grid-connected Photovoltaic (PV) Systems

Skill Practice Number:	2.1
Skill Practice Name:	Grid-Connected PV System Diagrams

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

Topic Skills Practice 2.1

UEERE0054 Design grid-connected photovoltaic power supply systems

Topic 2. Grid-connected Photovoltaic (PV) Systems

Skills Practice 2.1: Grid-Connected PV System Diagrams

Task:

To draw a block and circuit diagrams of various grid-connected PV power system arrangements.

Objectives:

At the completion of this skills practice, you should be able to:

- Draw and label a block diagram of a grid-connected PV power system.
- Draw and label circuit diagrams of grid-connected PV power systems.

Topic Skills Practice 2.1

1. Planning the Skills Practice

1.1 Research Grid-Connected PV System Arrangements

1.1.1 Research grid-connected PV power systems using reference material, such as:

- Energy Space Content Page 2.1.
- AS/NZS 4777.1 Grid connection of energy systems via inverters – Installation requirements.

1.1.2 Once you feel you have sufficient knowledge of the subject matter, obtain the following materials to assist you with carrying out this skills practice:

- Pens/pencils
- Ruler

2. Carrying Out the Skills Practice

2.1 Grid-Connected PV System – Block Diagram

2.1.1 In the space provided on this page, draw and label a block diagram of a simple grid-connected PV power system. Include the following items in your diagram:

a) PV array.
b) GC inverter.
c) Disconnectors.
d) Main switchboard.
e) Metering.

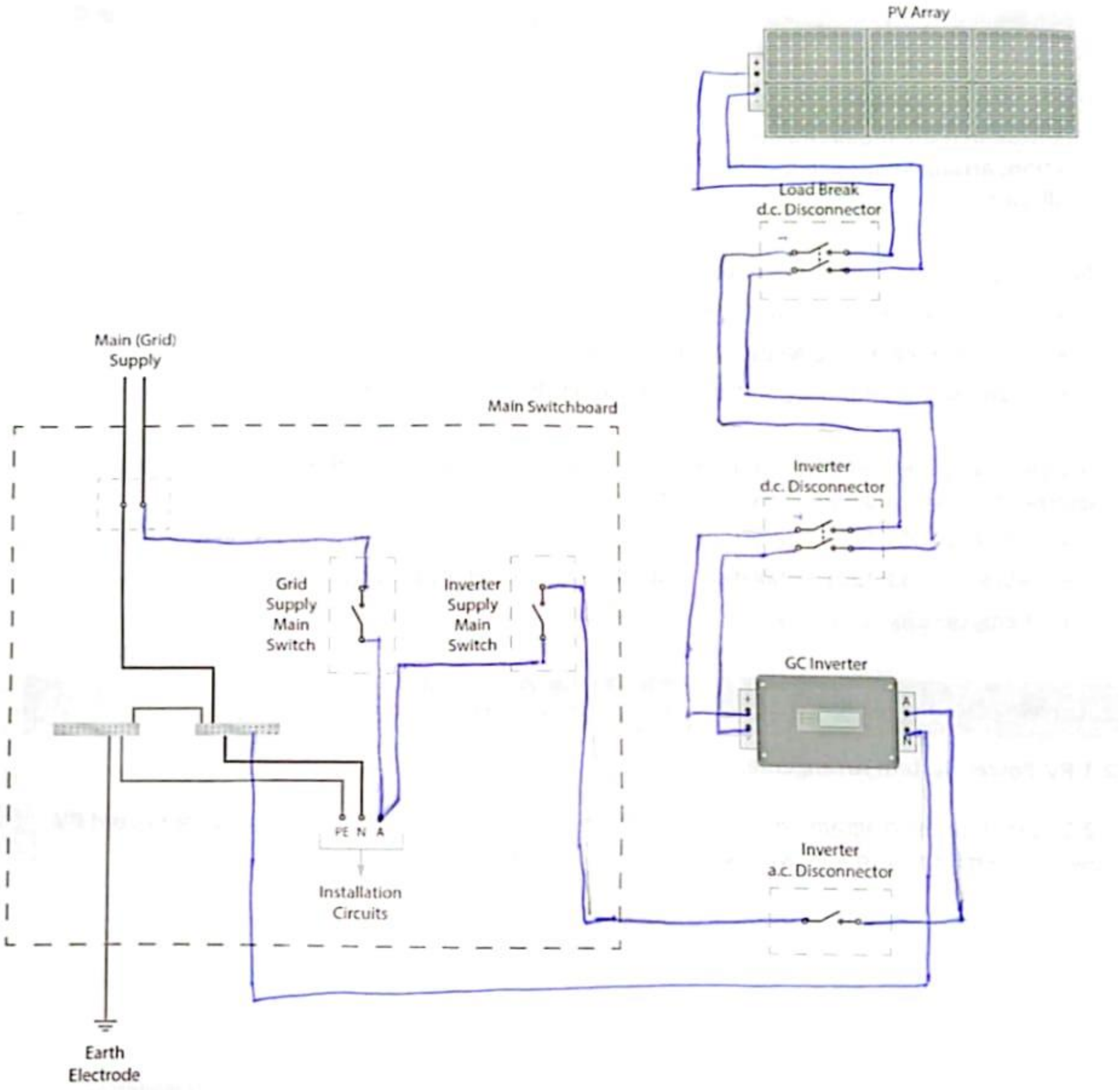
Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 2.1

2.2 Grid-Connected PV System – Circuit Diagram

2.2.1 In the space provided on this page, draw and label a circuit diagram of a simple grid-connected PV power system. Include the following items in your diagram:

a) PV array.
b) GC inverter.
c) Main switchboard.
d) Disconnectors.
e) Main switches.
f) Metering.
g) Consumer mains.



	Feedback **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 2.1

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Complete this section after successfully drawing and labelling the diagram in section 2.

1. Explain what is meant by the term 'islanding' in relation to grid-connected PV power systems.

In grid-connected PV systems, islanding refers to the situation where a portion of the electrical grid, including the PV system, continues to operate and supply power even after the main grid has disconnected due to a fault or outage. This isolated section, powered by the PV system, is essentially an "island" of electricity.

2. Explain the operation of active anti-islanding grid protection.

Active anti-islanding protection for grid-tied inverters involves proactively testing the grid connection to detect islanding conditions. Unlike passive methods that rely on monitoring grid parameters, active methods inject small, controlled disturbances into the system and analyze the response. If the grid is stable, these disturbances will be absorbed, but in an islanded state, they will cause detectable anomalies that trigger the inverter to disconnect, preventing unsafe operation.

	*Feedback* Have your teacher/trainer check your answers	Teacher/Trainer Initials and Date	✓

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Design grid-connected photovoltaic power supply systems
Topic Title:	Grid-connected Photovoltaic (PV) Systems

Skill Practice Number:	2.3
Skill Practice Name:	Grid-Connected PV System Comparison

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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August 2023

Topic Skills Practice 2.3

UEERE0054 Design grid-connected photovoltaic power supply systems

Topic 2. Grid-connected Photovoltaic (PV) Systems

Skills Practice 2.3: Grid-Connected PV System Comparison

Task:

To compare and contrast the benefits of two different grid-connected PV power system options.

Objectives:

At the completion of this skills practice, you should be able to:

- Identify different options for a grid-connected PV system for a given site.
- Document the key ratings and features of grid-connected PV systems.
- Compare and contrast key ratings and features of grid-connected PV systems.
- Explain the benefits and drawbacks of different grid-connected PV system options to customers.

1. Planning the Skills Practice

1.1 Research Grid-Connected PV Systems

1.1.1 Research two currently available grid-connected PV power systems, suitable for a proposed installation at a location indicated by your teacher/trainer. It may be helpful to use the following sources of reference material:

- The internet.
- Manufacturer catalogues.
- Retailer promotional materials.

1.1.2 Once you feel you have sufficient knowledge of the subject matter, obtain the following materials to assist you with carrying out this skills practice:

- Pens/pencils.

Topic Skills Practice 2.3

2. Carrying Out the Skills Practice

2.1 Grid-Connected PV System – Option 1

2.1.1 Identify the first grid-connect PV system and fill out the relevant product data in the spaces provided below.

PV System 1 – Details

Description: ____________________

____

____

Manufacturer: ____________________

Product No: ____________________

Cost: ____________________

Array Parameters

Module Type:		No. of Modules:	
MPP Power:		Efficiency:	
MPP Voltage:		O/C Voltage:	
MPP Current:		S/C Current:	

Inverter Parameters

Inverter Type:		No. of Inverters:	
Max d.c. Power:		Max d.c. Voltage:	
d.c. Window:		Max d.c. Current:	
Max a.c. Power:		Efficiency:	

– Proposed PV System Option 1			
System Size(kW):	5 KW	**No. of Panels:**	14

Panel Brand:	REC TWIN 6AK 2 MONO SERIES	**Panel ModelNo:**	REC 31S
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG 3k – D - NI	**Inverter Model No:**	SG 3k – D - NI
System Size (kW):	5 kw	**Battery Chemistry:**	Lithium Nickle
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES7 - 12

	Have your teacher/trainer check your work ***Feedback***	**Teacher/Trainer Initials and Date**	✓

Module Specifications (STC)				
Output		**Characteristics**		
MPP power:	390 W	Max. efficiency:	25 %	
Tolerance:	+ 5 % / 0 %	Temp. coefficient:	-0.29%/°C	
MPP voltage:	39 V	Type of cells:	MONOCRYSTALLINE (MAXEON GEN 5)	
MPP current:	10 A	No. of cells:	66	
O/C voltage:	48V ± 3%	Dimensions:	1017/1835/40	
S/C current:	10.8A ± 3%	Weight:	20 kg	
Max. fuse (A):	20 A	IP rating:	IP68	
Array Specifications (5 marks)				
Output		**Characteristics**		
MPP power:	7020 WATTS	No. of modules:	2 x 9 = 18	
MPP voltage:	351 VOLTS	No. of strings:	2	
MPP current:	10 A	Mounting system:	Tilt Frame	
O/C voltage:	432 VOLTS	Bypass diodes:	☐ Yes	☐ No
S/C current:	10.8 AMPS	Blocking diodes:	☐ Yes	☐ No
Inverter Specifications (5 marks)				

d.c. Parameters		a.c. Parameters	
Max. power:	9100 W	Max power:	7000 W, VA
Max. voltage:	550 V	Nominal power:	230 V
Voltage range:	70-550 V	Voltage range:	160 V/300 V
Max. current:	2 x 12.5 A/12.5 A	Max. current:	33.5 A
Max. strings:	2/1	Frequency range:	50/60 Hz

Topic Skills Practice 2.3

2.2 Grid-Connected PV System – Option 2

2.2.1 Identify the second grid-connect PV system and fill out the relevant product data in the spaces provided below.

PV System 2 – Details

Description: ______________________

____

____

Manufacturer: ______________________

Product No: ______________________

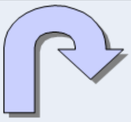
Cost: ______________________

Array Parameters

Module Type:	________	No. of Modules:	________
MPP Power:	________	Efficiency:	________
MPP Voltage:	________	O/C Voltage:	________
MPP Current:	________	S/C Current:	________

Inverter Parameters

Inverter Type:	________	No. of Inverters:	________
Max d.c. Power:	________	Max d.c. Voltage:	________
d.c. Window:	________	Max d.c. Current:	________
Max a.c. Power:	________	Efficiency:	________



Feedback

	Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓

Part 7 – Proposed PV System Option 2			
System Size (kW):	6 Kw	**No. of Panels:**	14
Panel Brand:	MKBEKA AGM	**Panel ModelNo:**	ES7 - 12
Inverter Size:	7.7 KW	**No. of Inverters:**	1
Inverter Brand:	SG 5k – D - NI	**Inverter Model No:**	SG 5k – D - NI
Output	**Characteristics**		
MPP power:	690 W	Max. efficiency:	22 %
Tolerance:	+ 5 % / 0 %	Temp. coefficient:	-0.29%/°C
MPP voltage:	39 V	Type of cells:	MONOCRYSTALLINE (MAXEON GEN 5)
MPP current:	10 A	No. of cells:	66
O/C voltage:	48V ± 3%	Dimensions:	1017/1835/40
S/C current:	10.8A ± 3%	Weight:	20 kg
Max. fuse (A):	20 A	IP rating:	IP68
Array Specifications (5 marks)			
Output	**Characteristics**		
MPP power:	8020 WATTS	No. of modules:	2 x 9 = 18
MPP voltage:	451 VOLTS	No. of strings:	2

MPP current:	15 A	Mounting system:	Tilt Frame	
O/C voltage:	432 VOLTS	Bypass diodes:	Yes	No
S/C current:	10.8 AMPS	Blocking diodes:	Yes	No
Inverter Specifications (5 marks)				
d.c. Parameters	**a.c. Parameters**			
Max. power:	10100 W	Max power:	9000 W, VA	
Max. voltage:	550 V	Nominal power:	230 V	
Voltage range:	70-550 V	Voltage range:	160 V/300 V	
Max. current:	2 x 12.5 A/12.5 A	Max. current:	33.5 A	
Max. strings:	4/1	Frequency range:	50/60 Hz	

Attachment B – Site Survey Checklist			
Inverter Size:	7.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG – 5K – D - NI	**Inverter Model No:**	SG –5K – D - NI
Part 9 – Proposed Battery System Option 2			
System Size (kW):	5.6 KW	**Battery Chemistry:**	Lithium Nickle
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES8 - 20
Inverter Size:	7.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG 5K – D NI	**Inverter Model No:**	SG 5K– D NI

Topic Skills Practice 2.3

2.3 Grid-Connected PV System Comparison

2.3.1 Answer the following questions to compare and contrast the features of the two PV system options.

1. Which of the two systems will produce more energy to the installation?

System 2

2. Which of the two systems has higher upfront costs?

System 2

3. Which of the two systems will have a shorter 'payback period'?

System 1

4. Describe three advantages of system 1 compared to system 2.

Cheaper

Allow to install more device

Higher efficiency

Topic Skills Practice 2.3

5. Describe three advantages of system 2 compared to system 1.

Higher power

Higher current

More strings

2.3.2 Now present the two systems to your teacher/trainer (or other person as directed by your teacher/trainer), explaining the features, benefits and drawbacks of each when compared with each another.

	Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Complete this section after you have successfully completed Section 2.

1. Explain how the effects of shading can be minimised in a PV array.

PV systems use bypass diodes, which protect the module and redirect the current through the shaded cell. This improves the overall performance of the module even if some of the shade loss is unavoidable. Other tools such as MLPEs can also increase the performance of shaded modules.

	Feedback	**Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Practices

Skill Practice Number:	6.2
Skill Practice Name:	Determine Solar Access

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 6.2

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 6. Site Survey Practices

Skills Practice 6.2: Determine Solar Access

Task:

To determine the solar access for a PV array installation site at your location, and to select an appropriate position, orientation and tilt angle for a PV array to be installed there.

Objectives:

At the completion of this skills practice, you should be able to:

- Determine the latitude of a given location.
- Interpret solar radiation maps.
- Measure solar irradiance using a solarimeter.
- Determine solar irradiance from sunshine hour data.
- Determine the dates and times that a PV array will become shaded.

1. Planning the Skills Practice

1.1 Equipment	1.2 Suggested Materials	1.3 Miscellaneous Items
• Solarimeter. • Sun path diagram. • Computer.	• GPS. • Solar configuration software.	• Pens/pencils. • Calculator. • Internet access.

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Topic Skills Practice 6.2

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below.
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B).
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L).
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision Level (D, G or B)	Risk Classification (H, M or L)	Control Measure/s
Material / equipment	D	M/L	House Keeping
UV rays	D	M/L	Sunscreen

	 **Feedback** Have your teacher/trainer check your risk assessment	**Teacher/Trainer Initials and Date**	✓

2. Carrying Out the Skills Practice

2.1 Solar Exposure Data

2.1.1 Use a GPS or internet site, such as http://www.ga.gov.au, to determine your current latitude and record your result below.

Location	Latitude

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Topic Skills Practice 6.2

9 Mavis Street, Revesby, Sydney	-33.936670/151.019140

2.1.2 Go the Bureau of Meteorology website at http://www.bom.gov.au to locate the latest solar exposure map (yesterday). Daily solar exposure maps can be located by clicking on the links:

- 'Climate and past weather', then
- 'Maps – history to now', and then
- 'Solar exposure'.

2.1.3 Interpret the map data to determine the daily solar exposure for your location in MJ/m^2. Then use this value to calculate the daily irradiation in kWh/m^2, showing your working and answers in the space provided below:

Remember: 1 Joule is equal to 1 watt for 1 second.

Solar Exposure					
Working: *Working:* Highest Daily Exposure Example 2/2/ 2021 is 21 MJ/m 21/3.6= 5.83 Kw/m www.bom.gov.au Climate & Past weather Maps- History to now Solar exposure / MAP – Solar exposure period – 1 day 11 September 2023 Record 18MJ/m^2 Kw/m = $\frac{MJ/m^2}{3.6} = \frac{18}{3.6}$ = 5 Kw/m					
Date:	2/2/ 2021	**Solar Exposure:**	21 MJ/m	**Daily Irradiation:**	5 Kw/m

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Topic Skills Practice 6.2

	Feedback — **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

2.2 Determine Solar Exposure

2.2.1 Use a solarimeter to measure the solar irradiance at your location. Record your results below:

Date	Time	Irradiance
18/09/2023	1:22PM	6.79 w/m^2 969 LUX

2.2.2 Return to the Bureau of Meteorology website to obtain the sunshine hour data for your location. Maps indicating average sunshine hours can be located by clicking on the links:

- 'Home page', then
- 'Climate and past weather', then
- 'Maps – averages', and then
- 'Sunshine duration'.

2.2.3 Use the sunshine hour data to determine the yearly and monthly average irradiation at your location. Record your values in the table below:

Average Daily Irradiation			
Location	**Electrical Trade College**		
Yearly	**6-7 hours**		
January	**8**	**July**	**7**
February	**8**	**August**	**8**
March	**7**	**September**	**8**
April	**7**	**October**	**8**
May	**6**	**November**	**8**
June	**6**	**December**	**8**

	Feedback — **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

2.3 Select Optimal Array Position

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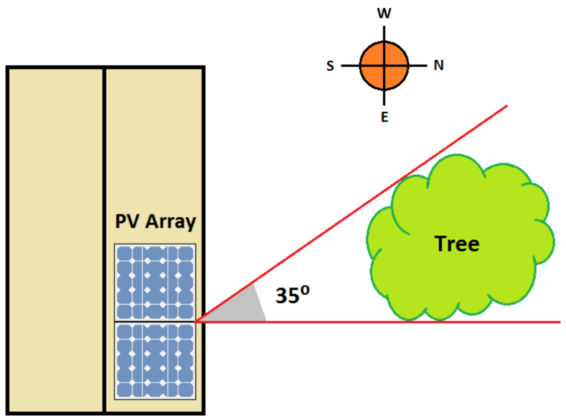
Topic Skills Practice 6.2

2.3.1 Draw a basic site plan of your location in the space provided on this page, and show where you could locate your PV array to attain optimal performance.

2.3.2 Indicate the optimal tilt angle and the orientation of your array in the table provided below.

Tilt Angle	Orientation
35 degree	North

2.3.2 Identify whether or not the array will become shaded at any point, and record the times and dates of shading in the space provided below:



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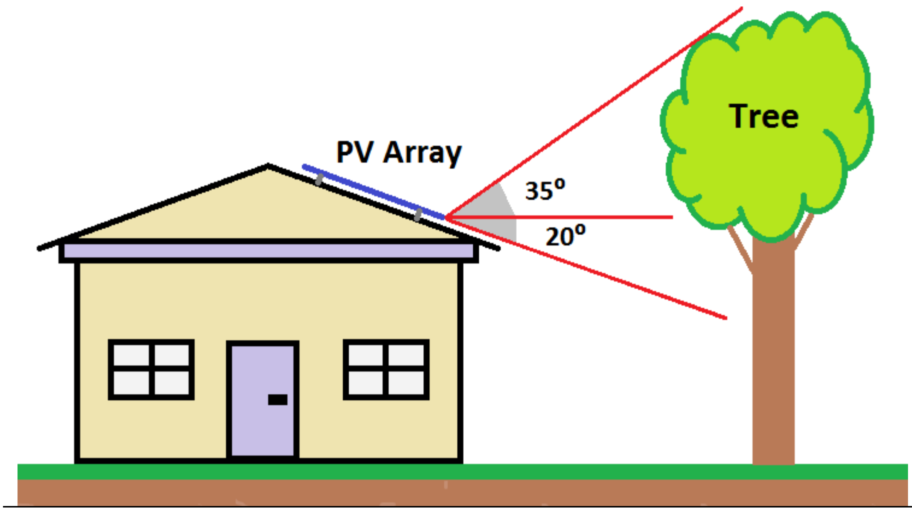
Topic Skills Practice 6.2



	Feedback — **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Return all equipment to the correct storage areas as directed by your teacher/trainer, and then complete the following question.

1. Describe four factors that cause variations in the daily irradiation of a fixed PV array.

- **Season change**
- **Shading and soiling**
- **Cloud cover**
- **Time of day**

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Topic Skills Practice 6.2

	Feedback — **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Principles

Skill Practice Number:	1.2
Skill Practice Name:	Prepare for Site Survey

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 1.2

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 1. Site Survey Principles

Skills Practice 1.2: Prepare for Site Survey

Task:

To identify stakeholders and personnel involved in a proposed grid-connect installation, and to communicate with a client (as a role play) in preparation for undertaking a site survey associated with the work.

Objectives:

At the completion of this skills practice, you should be able to:

- Identify stakeholders and qualified personnel relevant to proposed grid-connect work.
- Communicate effectively with clients regarding the site survey process and the general benefits of grid-connected alternative energy systems.

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Topic Skills Practice 1.2

1. Planning the Skills Practice

1.1 Site Scenario

You have been contracted to undertake a site survey to determine viability of grid-connect photovoltaic (PV) and battery storage energy systems at a particular site.

Your teacher/trainer will specify the particular location and nature of the site (e.g. this could be your own home, at the RTO campus, or some other suitable location).

Note that the person playing the role of the client will need to have answers ready relating to the personnel/contractors proposed for the design, installation and ongoing maintenance of the grid-connect project.

2. Carrying Out the Skills Practice

2.1 Client Consultation

2.1.1 In this section, you are required to carry out a roleplay consultation with another person playing the role of the client. This could be your teacher/trainer, a classmate, or other suitable person – as specified by your teacher/trainer.

In the first part of the consultation, you must identify the different stakeholders and personnel relevant to the project.

In the second part of the consultation, you are required to discuss the site survey process with the client to ensure the survey can run smoothly. Items to discuss include:

- Need for and arrangements for access to the various areas of the site.
- The types of information that need to be collected and evaluated.
- Relevant standards, regulators and regulations.
- Roles and responsibilities of the client and the surveyor.
- Potential benefits of installing a photovoltaic (PV) array at the site.
- Potential benefits of installing battery storage at the site.
- What the client can expect to receive upon completion of the survey.
- The general benefits and advantages of adding PV and battery storage to an installation.

Take notes throughout the consultation to document the outcomes in the spaces provided on the following page.

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Topic Skills Practice 1.2

Client Initial Consultation			
Surveyor:	STUDENT 1	**Client:**	STUDENT 2
Type of Site:	Workshop	**Date:**	
Location:	9 Mauisst, Revesby 2212		

Part 1 – Stakeholders and Personnel

Proposed designer(s) – PV: Student name

Proposed designer(s) – batteries: Student name

Proposed installer(s) – PV: Student name

Proposed installer(s) – batteries: Student name

Proposed maintenance contractor: Student name

Part 2 – Site Survey Process

Notes:

Gather the information on

- Current energy usage patterns
- Current and future energy need of installation
- The Nature of structure building materials and methods etc.
- The existing building structure and electrical installation
- The available solar resources at the site
- Potential location for grid connection equipment PV array inventor batteries

Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice 1.2

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

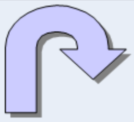
3.1.1 Now discuss your consultation with the person who was playing the role of the client, and answer the following questions.

1. Ask the client how well they feel that you explained the site survey process, on a scale of 1 to 10, with 1 being very poorly and 10 being outstanding.

Students will indicate how well they explained on a scale between 1 to 10

2. Ask the client if there were any improvements you could make in the way you communicated with them. Note down any feedback below.

- Think before you speak
- Get to the point
- Seek confirmation
- Listen carefully
- Ask questions
- Confirm your unclear standing

	 **Feedback** — **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Energy Assessment

Skill Practice Number:	5.2
Skill Practice Name:	Evaluate Energy Usage

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 5.2

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 5. Energy Assessment

Skills Practice 5.2: Evaluate Energy Usage

Task:

To identify the electrical infrastructure at a site, undertake a basic energy efficiency audit at a given site, and make recommendations for reducing energy consumption.

Objectives:

At the completion of this skills practice, you should be able to:

- Interpret site drawings to identify electrical infrastructure.
- Document the energy services and key infrastructure at a site.
- Identify areas of excessive energy consumption.
- Identify methods of reducing energy consumption.
- Develop practical strategies for improving energy efficiency.

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Topic Skills Practice 5.2

1. Planning the Skills Practice

1.1 Equipment

- Building/premises.

1.2 Suggested Materials

- Light meter.
- Thermometer.

1.3 Miscellaneous Items

- Relevant PPE.
- Pens/pencils.

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B)
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L)
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision (D, G or B)	Risk Class (H, M or L)	Control Measure/s
Electrical potential live cable	D	H	Isolation
Material on the floor	D	L	Housekeeping
Potential sharp objects tools cable	D	L	PPE gloves

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Topic Skills Practice 5.2

		Teacher/Trainer Initials and Date	
	Feedback — Have your teacher/trainer check your risk assessment		✓

2. Carrying Out the Skills Practice

2.1 Conduct an Energy Assessment

2.1.1 Your task is to undertake an energy assessment at a given site, including identification of key electrical infrastructure, evaluation of energy usage and determining techniques to reduce energy usage. This should be done by:

- Consultation with the occupiers of the site.
- Review of site drawings and documentation (e.g. site plans, electricity bills/usage logs).
- A 'walk through' visual inspection of the site.

2.1.2 Use the following checklist to carry out an energy evaluation of the premises/building, as directed by your teacher/trainer.

Part 1 – Building/Premises Details			
Auditor:	Student name	**Date:**	9 am → 5 pm
Type of Premises:	Workshop	**Operating Hours:**	
Location:	9 Mavis St, Revesby 2212		
Part 2 – Electrical Supply (Consumer Mains)			
No. of Phases:	3	**Voltage:**	240V
Cable Route:	13m to 15 m	**Cable Size:**	35 mm^2
Max Demand:	100 A	**Metering Type:**	Smart meter

Part 3 – Energy Usage				
Average Daily Energy Usage:	**Summer**	**Autumn**	**Winter**	**Spring**
	20.04 kWh	18.66 kWh	23.34 kWh	20.03 kWh

Notes: Heat source operated in winter drawing more power

Summer and spring, aircon are operated . Autumn energy usage is less

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Topic Skills Practice 5.2

Part 4 – Lighting Systems				
Types of Lighting (*tick*):	☑ Incandescent	☐ Gas Discharge	☐ LED	☑ *Other*:
No. of Lamps:	4			12

Part 4 – Items		**Yes**	**No**	**Comments/Improvement Strategies**
4.1	Can existing lamps be replaced with more energy efficient types?	☑	☐	
4.2	Could sensors or timers be used to reduce energy wastage?	☑	☐	
4.3	Could windows/skylights be utilised and/or installed to reduce the need for artificial lighting?	☑	☐	
4.4	Do inhabitants regularly turn off lighting when not in use?	☑	☐	
4.5	Do inhabitants regularly utilise existing natural lighting instead of artificial lighting where possible?	☑	☐	
4.6	Is any external lighting on during daylight hours?	☑	☐	
4.7	Do any luminaires, windows or skylights require cleaning?	☑	☐	

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Topic Skills Practice 5.2

Part 5 – Climate Control Systems					
Avg. Temperatures:	Summer (^{o}C): 25			Winter (^{o}C): 20	
Types of Climate Control (*tick*):	☐ Radiant Heating	☐ Ducted		☑ Reverse Cycle	☐ *Other*:
No. of Units:	4				

Part 5 – Items		**Yes**	**No**	**Comments/Improvement Strategies**
5.1	Does the natural climate require the use of heating/cooling?	☑	☐	
5.2	Could appropriate clothing or other methods be used to reduce the need for heating/cooling?	☐	☑	
5.3	Can existing heating/cooling appliances be replaced with more energy efficient types?	☑	☐	
5.4	Could thermostats or other controls be adjusted to reduce energy wastage?	☑	☐	
5.5	Is thermal insulation installed in walls, ceilings and under floors?	☑	☐	
5.6	Are external doors and windows effectively sealed to reduce heat transfer?	☑	☐	
5.7	Could screens/shades be utilised to reduce the effects of direct sunlight?	☑	☐	
5.8	Are doors and windows kept closed when heating/cooling appliances are operating?	☑	☐	
5.8	Is any heating/cooling equipment in need of maintenance?	☐	☑	
5.9	Could natural air flow be utilised to reduce the need for climate control?	☑	☐	

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Topic Skills Practice 5.2

Part 6 – Electrical Appliances	
Types of Electrical Appliances: (Indicate Energy Star Rating if applicable)	Sumsuang fridge Samsaung tv 5 stars

Part 6 – Items		**Yes**	**No**	**Comments/Improvement Strategies**
6.1	Are any appliances regularly left ON or in standby mode when not in use?	☐	☑	
6.2	Could timers be utilised to reduce energy wastage?	☑	☐	
6.3	Can any existing appliances be replaced with more energy efficient types?	☐	☑	
6.4	Do inhabitants know how to use energy saving features and/or switch off appliances?	☑	☐	
6.5	Are refrigerator thermostats set at 3 to 4^{o}C and freezer thermostats set at -15 to -18^{o}C?	☑	☐	
6.6	Is there scope for replacing conventional water heating with solar water heating?	☑	☐	
6.7	Are refrigerators and freezers defrosted regularly?	☑	☐	
6.8	Are any appliances in need of maintenance?	☑	☐	

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Topic Skills Practice 5.2

Part 7 – Other Practices and Awareness		**Yes**	**No**	**Comments/Improvement Strategies**
7.1	Are tasks done manually instead of using energy consuming devices wherever possible?	☐	☑	
7.2	Is hot water usage kept to a minimum?	☑	☐	
7.3	Are there posters/signage to remind inhabitants of energy efficient practices?	☑	☐	

Part 8 – Final Comments and Summary of Recommendations

General purpose lighting, features of special purpose lightings are good.

Climate control is provided by reverse cycle aircon system.

Laptops are mostly used in the system.

The arrays are installed at north facing position.

There is no obstructions or potential source of shading.

The access to equipment for safe and ongoing maintenance is available

The energy metering at the site needs not to be upgraded

Feedback	Have your teacher/trainer check your work	**Teacher/Trainer Initials and Date**	✓

3. Completing the Skills Practice

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Topic Skills Practice 5.2

3.1 Skills Practice Review Questions

3.1.1 Clean your work area and return all equipment to the correct storage areas as directed by your teacher/trainer.

3.1.2 Ensure that your documentation is complete, and then answer the following skills practice review questions.

1. What types of energy services were provided to the residential installation you evaluated?

Electricity

2. Determine the energy consumed if four 60 W lamps are left on for a period of 12 hours. Provide your answer and show all working in the space provided below.

$$\text{kwH} = \frac{60 \times 12 \times 4}{1000} = 2.88\ kwH$$

Energy Consumption: ____________________

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Topic Skills Practice 5.2

3. Determine the average daily energy consumption and cost of operating a 4.8 kW water heater if it operates for an average of 3.2 hours each day, and the service provider charges 28 c/kWh. Provide your answer and show all working in the space provided below.

Energy = 4.8 x 3.2 = 15.36 kwH

Cost 15.36 x $\frac{28}{100}$ = 4$ 30$ = 4.3$

Average Daily Energy Consumption: 15.36 KWH

Average Daily Cost: $4.30

4.

		Teacher/Trainer Initials and Date	
	Have your teacher/trainer check your answers ***Feedback***		✓

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Topic Skills Practice Cover Sheet

Unit Name:	UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems
Topic Title:	Site Survey Practices

Skill Practice Number:	6.3
Skill Practice Name:	Undertake a Site Survey

Student Name:	
Student ID:	
College/Campus:	
Group:	

Results	
Planning:	
Carryout:	
Completion:	
Overall Results:	
Comments:	

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Topic Skills Practice 6.3

UEERE0054 Conduct site survey for grid-connected photovoltaic and battery storage systems

Topic 6. Site Survey Practices

Skills Practice 6.3: Undertake a Site Survey

Task:

To undertake a survey of a given site to determine suitability for a grid-connect PV array battery storage system.

Objectives:

At the completion of this skills practice, you should be able to:

- Undertake initial consultation with client.
- Evaluate the existing electrical infrastructure at a site.
- Evaluate the energy needs and usage at a site.
- Evaluate site and structures.
- Determine suitability of the site for grid-connect PV and battery storage.
- Determine solar access.
- Identify local regulatory requirements related to grid-connect PV and battery storage.
- Specify grid-connect PV and battery storage options.
- Produce a final site survey report and present details to client (teacher/trainer).

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Topic Skills Practice 6.3

1. Planning the Skills Practice

1.1 Equipment	1.2 Suggested Materials	1.3 Miscellaneous Items
• Building/premises. • Internet access	• Light meter. • Thermometer.	• Relevant PPE. • Pens/pencils.

1.4 Risk Assessment

Risk assessment procedure:

- Identify any hazards that may exist with this skills practice below
- List the supervision level you will be working under - Direct (D), General (G) or Broad (B)
- List the risk classification – High Risk (H), Medium Risk (M) or Low Risk (L)
- List the control measures required for each identified hazard that you need to implement.

Hazard/s Identified	Supervision (D, G or B)	Risk Class (H, M or L)	Control Measure/s
Falling from height	D	H	Provide adequate training
Slippery Surfaces	D	H	Maintain slip free walking space
Unprotected hole	D	H	Safeguard all holes
Electrical shock	D	H	Adequately maintain
Weak structure	D	H	Inspect structure components
Unsecured equipment	D	H	Store all tools when not in use

Feedback	**Have your teacher/trainer check your risk assessment**	**Teacher/Trainer Initials and Date**	✓

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Topic Skills Practice 6.3

2. Carrying Out the Skills Practice

2.1 Conduct a Site Survey

2.1.1 Your task is to undertake a site survey, using the following checklist, to determine grid-connect solar PV and battery storage system options at a particular site. The location of the site will be indicated by your teacher/trainer.

The site survey must include:

- Consultation with the occupiers of the site.
- Review of site drawings and documentation (e.g. site plans, electricity bills/usage logs).
- A 'walk through' visual inspection of the site.
- Evaluation of the solar resource.

Part 1 – Building/Premises Details				
Surveyor:	Student name		**Date:**	
Type of Premises:	Workshop		**Coordinates:**	– 33.936070/– 151.019140
Address:	Mavis street Revesby NSW 2212			
Part 2 – Energy Usage				
Network Provider:	Ausgrid Energy		**Power Bills:**	$ 500 /qtr
Average Daily Energy Usage:	**Summer**	**Autumn**	**Winter**	**Spring**
	20.04 kWh	18.66 kWh	23.34 kWh	20.03 kWh

Recommendations for Reducing Energy Use:

To use natural lighting providing light penetrated roof.

To p[provide natural ventilation

Install timer to switch off the light

At non business hours (or) no occupant in the building, Use energy efficiency light and equipment.

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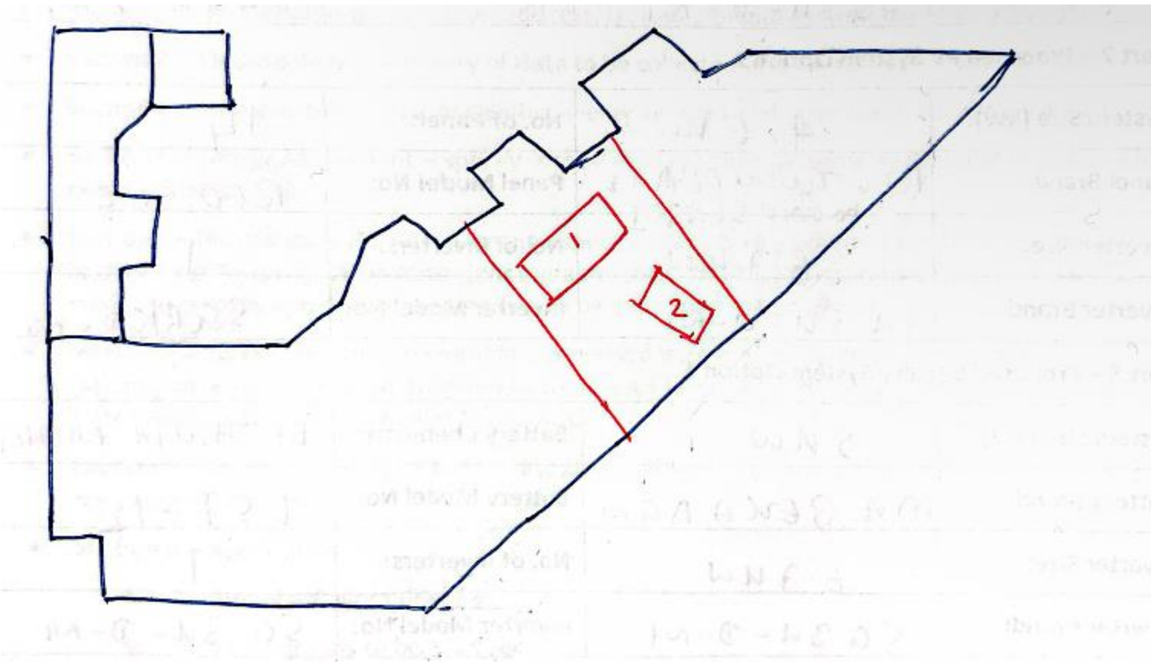
Topic Skills Practice 6.3

Part 3 – Premises			
Construction Type:	Concrete wall	**Levels/Storeys:**	2
Roofing Material:	Tin	**Roof Orientation:**	North
Obstructions/Shading:	Non	**Roof Pitch:**	22.5 to 30

Roof Layout Drawing:



Part 4 – Existing Electrical Services				
Metering Type:	Smart meter	**Upgrade Required?**	☐ Yes	☑ No
Incoming Mains Phases:	3	**Cable Route:**	☐ UG	☑ OH
Incoming Mains Size:	35 mm^2	**Inc. Mains Length:**	10 m	
Submains Size:	16 mm^2	**Submains Length:**	25 m	
Switchboard Locations:	Ground floor *(note: photos to be taken)*			
Other Energy Services:	N/A			

Part 5 – Proposed Locations for System Equipment	
PV Array Location:	*Roof top (note: photos to be taken)*
Inverter Locations:	*PV Workshop (note: photos to be taken)*

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Topic Skills Practice 6.3

Battery Locations:	*In workshop (PV) (note: photos to be taken)*		
Part 6 – Proposed PV System Option 1			
System Size (kW):	5 KW	**No. of Panels:**	14
Panel Brand:	REC TWIN PEAK 2 mono series	**Panel Model No:**	REC 315
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG3k – D -NI	**Inverter Model No:**	SG3k – D - NI
Part 7 – Proposed PV System Option 2			
System Size (kW):	4.6 kw	**No. of Panels:**	14
Panel Brand:	REC TWIN PEAK 2 mono series	**Panel Model No:**	REC 305
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	SG 5k -D - NI	**Inverter Model No:**	SG 5K -D - NI
Part 8 – Proposed Battery System Option 1			
System Size (kW):	5 kw	**Battery Chemistry:**	LITHIUM NICKEL
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES7 - 12
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	5G 3 K – D - NI	**Inverter Model No:**	SG 3K – D -NI
Part 9 – Proposed Battery System Option 2			
System Size (kW):	4.6 KW	**Battery Chemistry:**	LITHIUM NICKEL
Battery Brand:	MK BEKA AGM	**Battery Model No:**	ES 7 - 20
Inverter Size:	6.7 kw	**No. of Inverters:**	1
Inverter Brand:	5G 5K – D - NI	**Inverter Model No:**	Sa 5K – D NI

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Topic Skills Practice 6.3

	Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

2.2 Produce a Final Site Survey Report

2.2.1 Use your findings from the previous section to produce a final site survey report either using the template provided below, an alternate template provided by your teacher/trainer, or your own documentation.

Details to be included in the final report are:

- Section 1 – Overview – specify site survey scope, objectives, purpose and goals.
- Section 2 – Site Details – specify street address, latitude, longitude, size, ownership and use.
- Section 3 – Methodology – summary of data to be collected and associated survey methods.
- Section 4 – Infrastructure – specify existing energy services and main electrical infrastructure.
- Section 5 – Energy Assessment – specify current energy usage patterns and recommendations for reducing energy use.
- Section 6 – Photovoltaic (PV) Assessment – specify solar access, potential for shading, proposed locations for PV array and inverter (photographs to be included in Appendix B), at least two (2) actual PV system options (references/link to be included in Appendix C).
- Section 7 – Battery Storage Assessment – proposed locations for batteries and inverter (photographs to be included in Appendix B), at least two (2) actual battery storage system options (references/link to be included in Appendix C).
- Section 8 – Regulatory Requirements – list details of required permits/approvals and applicable regulations and standards.
- Section 9 – Appendices:
    - A – Site plan/layout drawings
    - B – Photographs to be attached:
        - Proposed location for PV array.
        - Proposed location for inverter.
        - Proposed location for batteries.
    - C – References/links to proposed PV and battery storage products

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Topic Skills Practice 6.3

Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

Section 1 – Overview
1.1 Scope:
Installing solar panel, installing inverter DC wiring, AC wiring, switch board, Battery system and wiring safety protection.
1.2 Objectives:
Grid connected PV power system with dc coupled battery storage that does not provide emergency power

Section 2 – Site Details
2.1 Address:
Mavis street, Revesby, NSW 2212
2.2 Latitude and longitude: – 33.936670/ 151.019140
2.3 Site size: Building size 2317 m^2 , Land Size 3902m^2
2.4 Site ownership: ETC
2.5 Land use: Industrial

Section 3 – Methodology
3.1 Data to be collected:
- Solar irradiance, longitude, GPS data
- Temperature, Availlable space, obstruction
- Determine number of panel needed and can be installed. Structural materials, location for Inverter and battery access to equipment
- Local requirement

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Topic Skills Practice 6.3

3.2 Survey methods:

- Consult with the client/site occupants
- Review site drawing, diagram, documentation
- Walk through the site to confirm and identify arrangement

Section 4 – Infrastructure

4.1 Existing energy services:

- Ausgrid energy, Sydney water
- Origin Gas

4.2 Electrical infrastructure:

(AC) 5 Kw, 240V 50Hz 23A, 2.5mm^2 (AC) PVC Cable

(DC) 6.7 kw 10.19A 40.8V, XLPE 38A cable

C.B SAAA – 181240 – LA, PV Switch BYH 32

C.B ISA GO, PV Disconnector 15A, 450V

4 sqmm EARTH

Section 5 – Energy Assessment

5.1 Current energy usage patterns:

Summer 20.09 kwh. Autumn 18.66kwh

Winter 23.34 kwh ,Spring 20.03 kwh

5.2 Energy usage recommendations

Off peak system should be utilized as the classes are conducted beyond office hours.

Time switches should be provided for switching off unnecessary lights when the site is not used

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Topic Skills Practice 6.3

Section 6 – Photovoltaic (PV) Assessment

6.1 Irradiance/sunshine hours: Yearly average 6-7 hours

6.2 Optimal tilt/orientation: 29.5 degree from horizontal

6.3 Potential shading: Non

6.4 Proposed array location: Roof top, North orientation

6.5 Proposed inverter location: PV Workshop

6.6 PV system option 1 – details:

- REC Twin Peakx2 PV Arrays are to be installed XLPE Dc wiring, 4620 watt, 14 modules, output dc voltage 40.8v, Nominal current 9.02A
- AC inverter 6700w, max dc voltage 600v, MPPT voltage 90-500v, No of string 1
- Outputs 50 Hz, 180-276V Current = 21.7A
- AC power 5000 VA
- Inverter Type SG 5K – D – NI

6.7 PV system option 2 – details:

Rec Twine PEAK x PV Arrays are to be installed. XLPE DC wiring, 4620w, 14 module, 9.62A 40.2V

- AC inverter 0700w, max dc voltage 600v MPPTvoltage 90-560v, No of string = 1
- Output 50 Hz 180-276V current 21-7A AC power 5000 VA

Inverter Rype SG5K -D-NI

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Topic Skills Practice 6.3

Section 7 – Battery Storage Assessment

7.1 Proposed battery unit location:

7.2 Proposed inverter location:

7.3 Battery storage option 1 – details:

Details in Part 8

7.4 Battery storage option 2 – details:

Details in Part 9

Section 8 – Regulatory Requirements

Local council area: BANKTOWN COUNCIL

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Required permits/approvals: Working at height, Council

By ACCREDITED SOLAR INSTALLER

Network provider: Ausgrid Energy

Network provider requirements: Minimum quality standard for output voltage and frequency access to remote monitoring, acceptable type of battery/inverter /Limitation on size of system

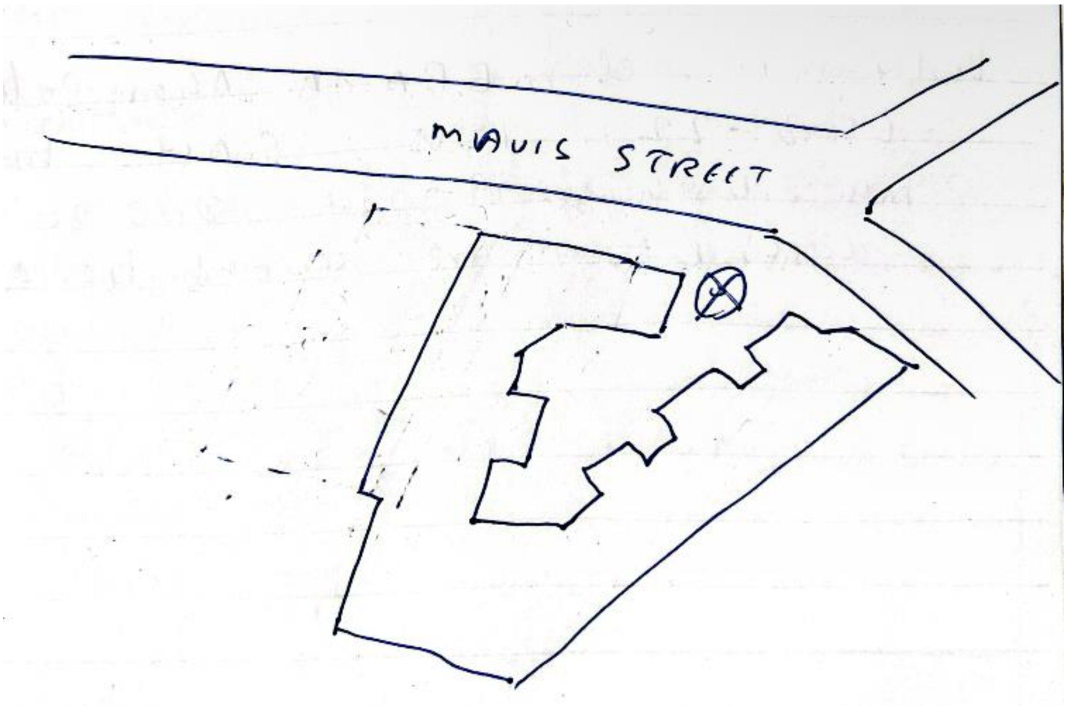
Applicable regulations: ACCREDITED SOLAR INSTALLER

Applicable standards: AS/NZS 4777:1.2016, AS/NZS SO33:2012

AS 3000:2018, AS/NZS S033:2021 ,Minimum protective requirement

Section 9 – Appendices

Appendix A – Site plan/layout drawing (*include dimensions, key electrical infrastructure and proposed installation locations)*



Appendix B – Site Photographs

☑ Proposed location for PV array photograph attached.

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☑ Proposed location for inverter photograph attached. ☑ Proposed location for batteries photograph attached.

	Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Submit your completed site survey report to your teacher/trainer and present/explain your findings.

3.1.2 Answer the following skills practice review questions.

1. List any potential site hazards that may impact the installation of proposed PV and/or battery storage equipment below.

   - Falling hazard
   - Electrical shock
   - Battery Acid Burn
   - Heavy solar panel fall

2. List any potential issues or problems that may impact the installation of proposed PV and/or battery storage equipment, and proposed solutions, below.

   - Weather situation - Provide Strong installation and structure
   - String wind
   - Debris impact - Provide appropriate access
   - Potential shading - Assess shade
   - Ambient temperature - Design the system to meet temperature variation

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Topic Skills Practice 6.3

	Feedback **Have your teacher/trainer check your answers**	**Teacher/Trainer Initials and Date**	✓