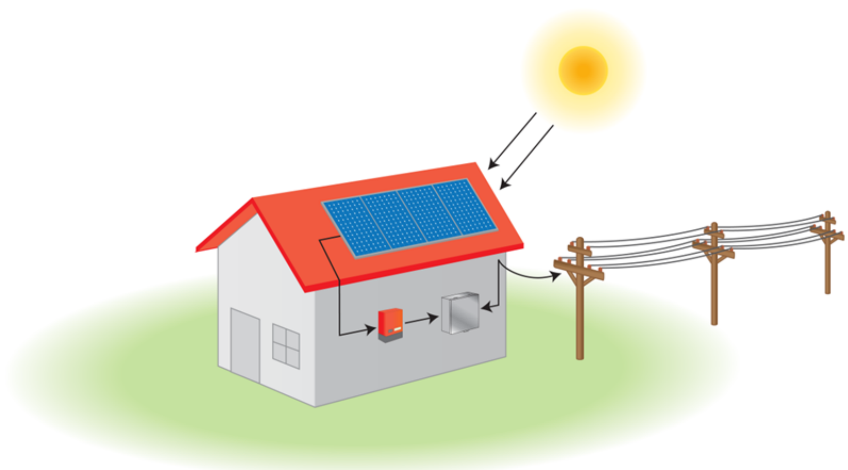
View

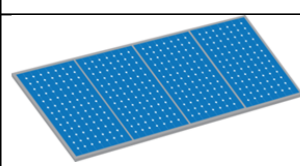
Introduction

In this topic you will learn about the arrangement and operational features of grid connected PV power systems, including functions such as synchronisation, safety and control features.



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.

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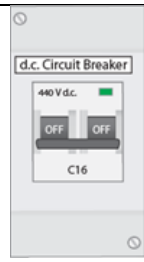
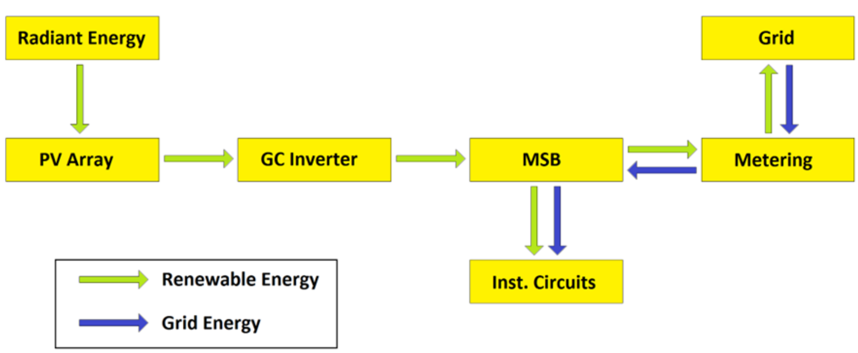
Inverter		Converts direct current into alternating current.
Metering		Measures the imported and exported electrical energy
d.c. Controls and Protection		Protects d.c. equipment against overcurrent and provides a point of isolation.
a.c. Controls and Protection		Protects a.c. equipment against overcurrent 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.



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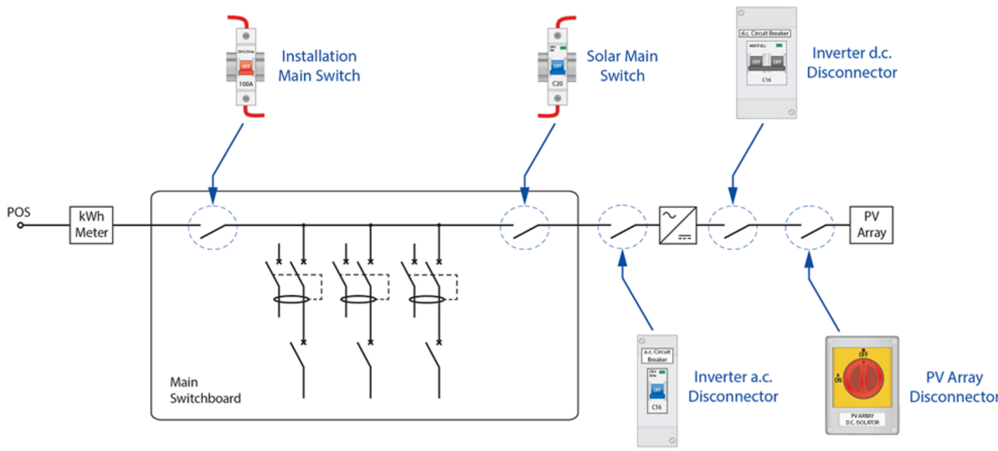
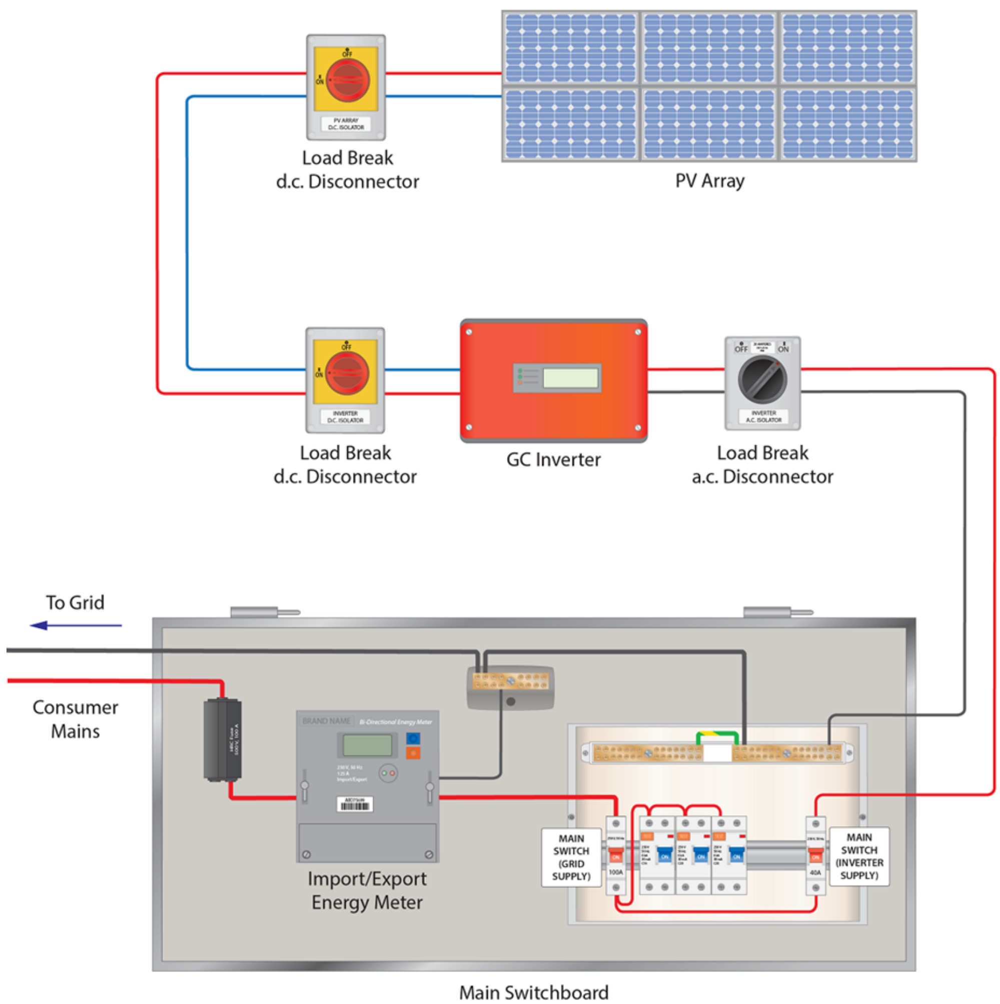
PV System Configuration

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.

RCD Protection

It should be noted that prior to the 2016 edition of AS/NZS 4777.1, it was not permitted to install an RCD between the consumer mains and a grid connected inverter, however this requirement was changed in AS/NZS 4777.1:2016.

It is now permissible to use an RCD to meet the mechanical cable protection requirements and isolation requirements of AS/NZS 3000:2018 for the cable between the grid-connected inverter and the connecting switchboard, provided the inverter is not a multimode inverter.

If an RCD is used, the RCD must:

- Operate in all active and neutral conductors.
- Be compatible with the inverter as per the manufacturer's instructions.

It remains prohibited to connect an RCD between a multimode grid-connected inverter and the connecting switchboard.

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This learning activity consists of 6 parts designed to develop your understanding of grid-connected PV system features.

Topic 1.1 Learning Activity

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

Topic 1.1 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the PV system configurations, operational features and diagrams.

Topic 1 Content Quiz

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Introduction

In this topic you will learn about the various terminology used in relation to the various types of photovoltaic modules and the operating principles of the photovoltaic modules.

Semiconductors

A semiconductor is a material that displays the properties of both a conductor and an insulator, depending on the circuit conditions. Examples of semiconductor devices include diodes, transistors and photovoltaic (PV) cells.

Silicon is the most widely used material in semiconductor devices. A pure silicon crystal has no free electrons, however:

- An n-type impurity, having an extra electron, can be added to silicon, resulting in an overall negative (n-type) charge.
- A p-type impurity, having one less electron, can be added to silicon, resulting in an overall positive (p-type) charge.

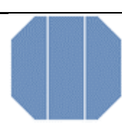
Adding impurities to silicon is known as 'doping'.

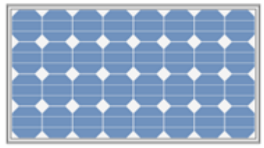
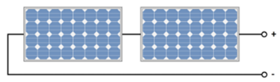
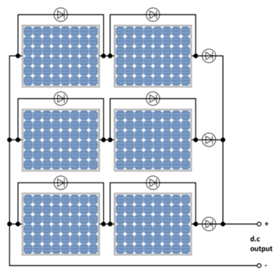
p-n Junction

When a p-type and n-type material are placed side by side, a 'p-n junction' is formed, which either conducts or insulates depending on some external factor. A PV cell is a photosensitive p-n junction, where photons striking the junction produce enough energy to free electrons. These free electrons can then flow through an externally connected circuit.

Photovoltaic Terms

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

Photovoltaic Terms		
Term	**Definition**	
Band gap energy	The band gap energy of a semiconductor material is the minimum energy required to free an electron.	
Cell		A cell is a single PV unit, typically producing a nominal output voltage of 0.5 V.

Module		A module is a number of PV cells (typically 30, 36, or 72) connected in a series 'string', and packed into a robust protective housing.
String		A string is two or more modules connected in series.
Array		An array is a number of interconnected modules. The nominal output voltage and current ratings of the array will depend on the series-parallel arrangement of the modules.

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

Load the Activity

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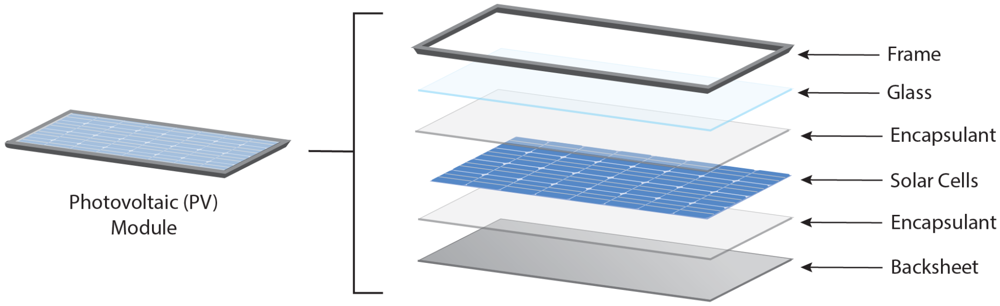
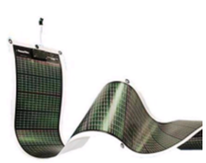
Types of PV Modules

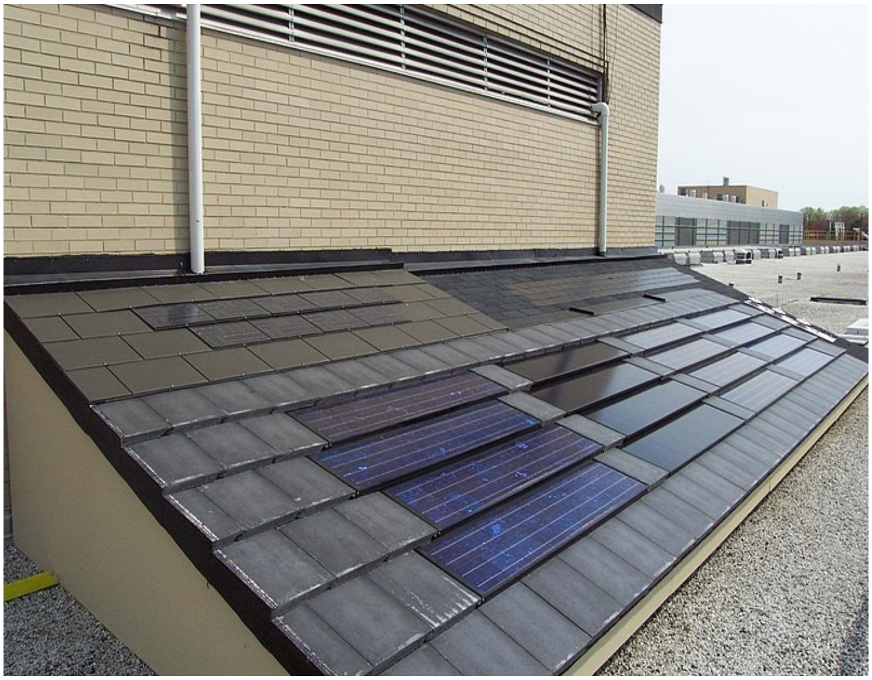
The following diagram shows the basic structure of a PV module:



There are three main types of PV cells and modules. Some basic features of the different types are compared in the following table.

PV Module Types		
Type	**Image**	**Characteristics**
Monocrystalline PV cells		• Typical efficiency of 15% to 22%. • Most sensitive to the red-end of the spectrum. • Made from a thin slice of a single large silicon crystal.
Polycrystalline PV cells		• Cheaper than monocrystalline cells. • Typical efficiency of 13% to 19%. • Most sensitive to the red-end of the spectrum. • Made from slices of cast silicon ingot that consists of many crystals, giving them their speckled appearance.
Amorphous PV cells		• Cheaper to produce than crystalline cells. • Typical efficiency of 7% to 10%. • Most sensitive to the blue-end of the spectrum. • Made by applying layers of doped non-crystalline silicon to a substrate. • Can be manufactured to be flexible. • Offer easy integration into building materials (e.g. windows).

The following photo shows an example of amorphous PV modules being used as roof tiles:



Emerging Technologies

PV technologies are currently being developed to include multiple p-n layers, each doped with slightly different materials to achieve a wider spectral response, thereby increasing cell efficiency.

Amorphous microcrystalline cells are also currently being developed, which incorporate both an amorphous and microcrystalline layer.

Operating Conditions

PV modules need to be capable of withstanding various conditions, including:

- Weather conditions such as:
  - High temperatures.
  - Rain and hail.
  - Strong winds.
- Accumulation of dirt and dust.
- Corrosion.
- Vandalism.

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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 photovoltaic (PV) terminology, module features and characteristics.

Topic 2.1 Learning Activity

Last modified: Tuesday, 5 September 2023, 10:44 AM

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Photovoltaic Cell Characteristics

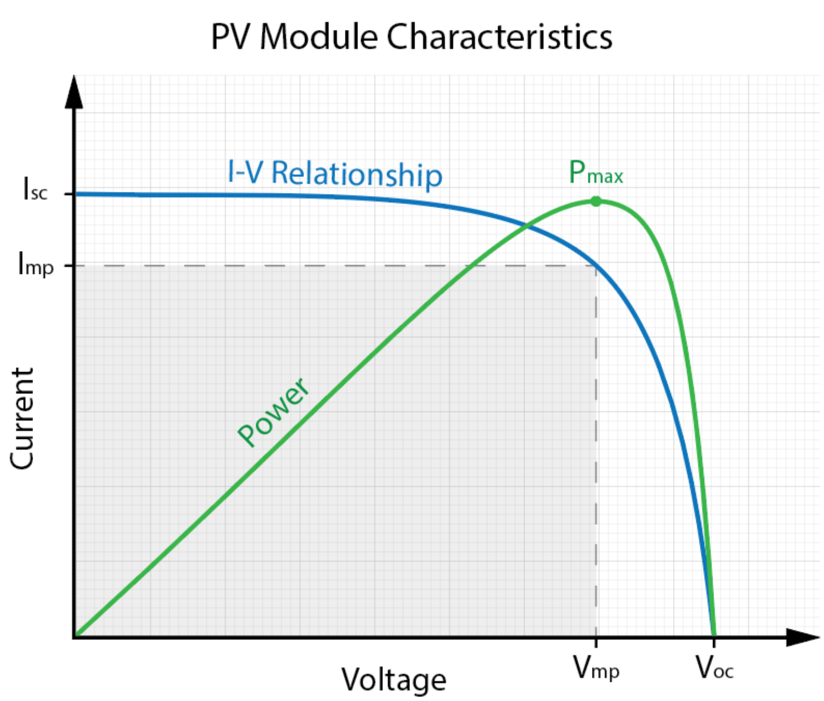
A photovoltaic (PV) cell is a constant current generator. This means that at a given irradiance the cell output current remains constant. The power output however depends on the load that is connected:

- As the load resistance decreases towards zero ohms (i.e. a short circuit), the cell output voltage also decreases towards zero. When the voltage reaches zero, the output power also becomes zero (remember that P = VI).
- On the other hand, as the load resistance increases towards infinite ohms (i.e. an open circuit), the cell output voltage will rise to a level at which current will conduct internally across cell. This causes the output current, and therefore also the output power, to drop to zero.

I-V Characteristic Curve

This relationship between cell output voltage and current can be represented by an "I-V curve". In order to understand the operation of a PV cell, we need to understand this I-V relationship.

Every PV module has a specific I-V characteristic curve that will be provided in the module specifications. The diagram below shows an example of an I-V curve and associated power curve plotted on a graph:



The 'maximum power point (P_{max})' (sometimes indicated as 'MPP') is the point on the I-V curve at which maximum output power is achieved.

The 'fill factor' for a given PV module is the ratio of the P_{max} to the product of the short-circuit current and open-circuit voltage, as indicated by the following equation:

$$FF = \frac{P_{max}}{V_{oc} \times I_{sc}}$$

Where:

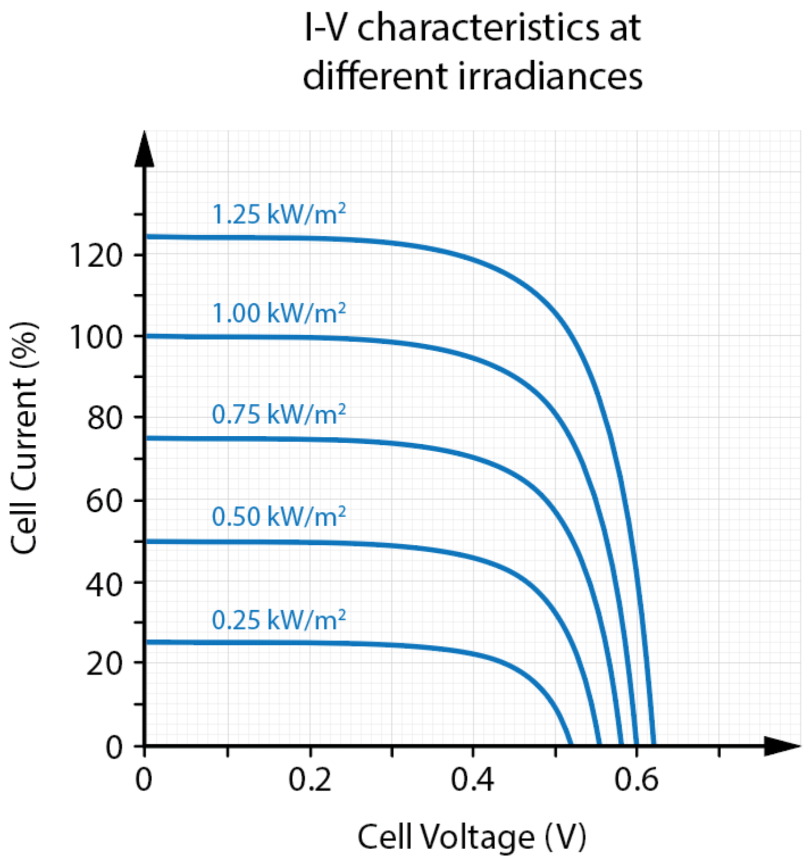
FF	=	Fill factor
P_{max}	=	Maximum power point in watts (W)
I_{sc}	=	Short-circuit current in amperes (A)
V_{oc}	=	Open-circuit voltage in volts (V)

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

Load the Activity

Effect of Irradiance

If the irradiance of a PV module decreases, then the output of the PV module also decreases, as shown by the following module I-V curves:



Effect of Temperature

As the temperature of a PV cell increases, the cell breakdown voltage decreases, resulting in reduced P_{max}.

During development, PV cells are tested to determine their performance under different operating conditions. The nominal operating cell temperature (NOCT) is the temperature reached by a PV cell under the following conditions:

- An irradiance of 800 W/m^2.
- An ambient temperature of 20^{0}C.
- A wind velocity of 1 m/s.
- Mounted such that air can circulate around the back side of the cell.

NOCT is used as a benchmark against which to compare the cells performance at other temperatures.

The following I-V curves show how temperature affects cell performance:

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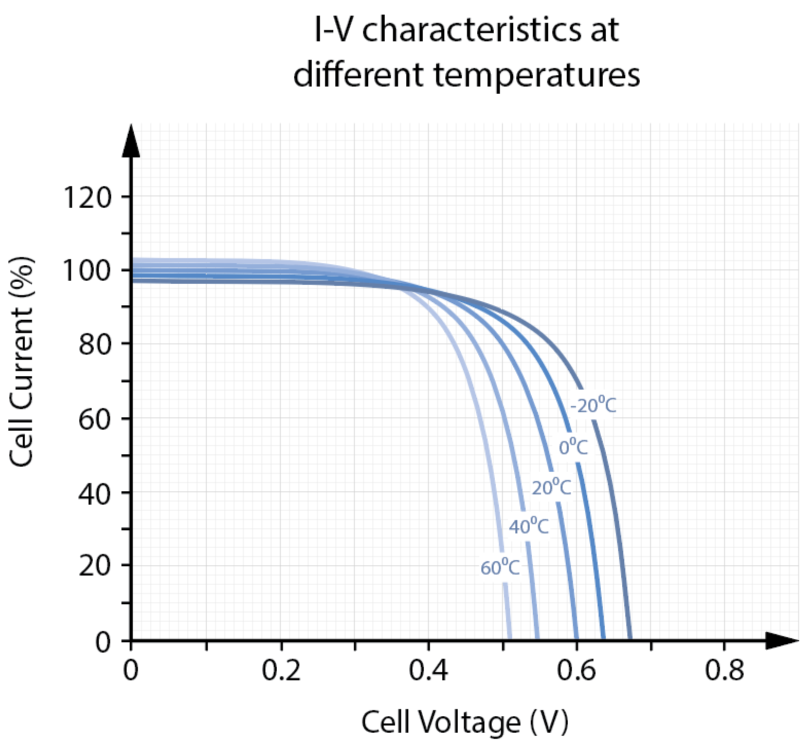

The NOCT can be used to determine the actual operating temperature of a PV module for given ambient temperature and irradiance conditions, as indicated by the equation:

$$T_{cell} = T_{amb} + \frac{G\,(NOCT - 20)}{800}$$

Where:

T_{cell}	=	Cell temperature in degrees Celsius (^{0}C)
T_{amb}	=	Ambient temperature in degrees Celsius (^{0}C)
G	=	Irradiance in watts per square metre (W/m^2)
NOCT	=	Nominal operating cell temperature in degrees Celsius (^{0}C)

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

Load the Activity

Temperature Coefficients

Temperature coefficients indicate how the various operating characteristics and parameters of a PV module will be affected by variations in cell temperature.

Temperature coefficients may be given for:

- Short-circuit current (I_{sc}).
- Maximum-power current (I_{mp}).
- Open-circuit voltage (V_{oc}).
- Maximum-power voltage (V_{mp}).
- Output power (P).
- Fill factor (FF).
- Efficiency (η).

PV Module Ratings

PV modules are rated to describe a range of operating parameters, which are provided by the manufacturer in the form of 'specifications' or 'data sheets'.

PV module ratings indicate the operating characteristics of the module under standard test conditions (STC) which are:

- An irradiance of 1 kW/m^2.
- An ambient temperature of 25^{0}C.
- An air mass of 1.5.

The following table describes some of the main ratings and details that will be of interest when comparing and selecting PV modules.

PV Module Ratings		
Rating	**Example**	**Description**
Rated Power (P_{max})	170 W	• Indicates the maximum power output of the module, i.e. optimal performance. • Helps you understand how much energy you can expect to generate.
Voltage at P_{max} (V_{mp})	34.8 V	• Indicates the module voltage at optimal performance. • Important for determining the system arrangement to achieve the desired operating voltage, and for selecting/ matching other parts of the system.
Current at P_{max} (I_{mp})	4.9 A	• Indicates the module current at optimal performance. • Important for determining the system arrangement to achieve the desired operating current, and for selecting/ matching other parts of the system.
Open Circuit Voltage (V_{oc})	43.5 V	• Indicates the module voltage under an open circuit condition (e.g. no load connected). • It's important that the other parts of the system are rated to withstand the total open circuit voltage of the array.
Short Circuit Current (I_{sc})	5.5 A	• Indicates the module current under a short circuit (i.e. zero ohms) condition. • It's important that the other parts of the system are rated to withstand the total short circuit current of the array.
Temperature Coefficient of P_{max}	-0.5%/^{0}C	• Indicates how the power output will be affected by changes in temperature. • The example indicates that for every degree Celsius increase above 25^{0}C (i.e. STC), the power output will be reduced by 0.5%.
Temperature Coefficient of V_{oc}	-165 mV/^{0}C	• Indicates how the module voltage will be affected by changes in temperature. • The example indicates that for every degree Celsius increase above 25^{0}C, the open circuit voltage will decrease by 165 mV.
Temperature Coefficient of I_{sc}	0.06%/^{0}C	• Indicates how the module current will be affected by changes in temperature. • The example indicates that for every degree Celsius increase above 25^{0}C, the short circuit current will increase by 0.06%.
Dimensions	1593 x 790 x 50 mm	• Indicates the physical size of the panel. • Important for determining the number of panels that will fit on a given roof space.

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Weight	15.4 kg	• Indicates the physical weight of the panel. • Important when planning how panels will be handled safely on the job.

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

Load the Activity

De-Rating Factors

PV modules should be de-rated to accommodate the following factors:

- Manufacturing tolerance.
- Soiling (dirt and dust).
- Operating temperature.

A manufacturing tolerance will be listed on the PV module data sheet, for example a tolerance of +/- 5% requires that a de-rating factor of 0.95 (5% reduction) is applied to the module.

To account for soiling of modules, the 'rule of thumb' is to apply a de-rating factor of 0.95, but further de-rating may be required for modules installed in dry, dusty locations, or in other areas that may be subject to heavy soiling.

The output power of a module should be de-rated based on its *operating temperature*, using the output power temperature coefficient of the module. Typical temperature coefficients are:

- Monocrystalline modules: - 0.45%/^{0}C
- Polycrystalline modules: - 0.5%/^{0}C
- Amorphous modules: - 0.2%/^{0}C

It should also be noted that PV modules deteriorate over time; the power output of bulk silicon cells is reduced by approximately 1% per year.

This learning activity consists of 8 parts designed to develop your understanding of PV module operating characteristics and ratings.

Topic 2.2 Learning Activity

In this skills practice, you are required to draw and label the equivalent circuit of a PV cell, and to draw and label the I-V curves for a PV module under various operating conditions.

Topic 2.2 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of PV technologies, including terminology, modules, operating characteristics and ratings.

Topic 2 Content Quiz

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View

Introduction

In this topic you will learn about the arrangement of PV arrays, including series and parallel module configurations, and the arrangement of blocking and bypass diodes. You will also learn about BIPV products, and the factors to consider when selecting PV modules for a given installation.

PV Array Configurations

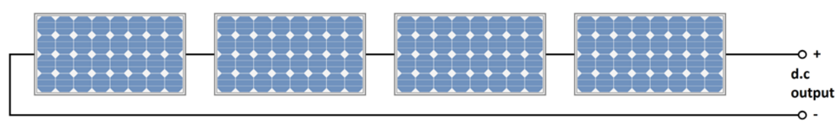
An array consists of a number of PV modules connected in series, parallel, or series-parallel.

- 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 total 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.

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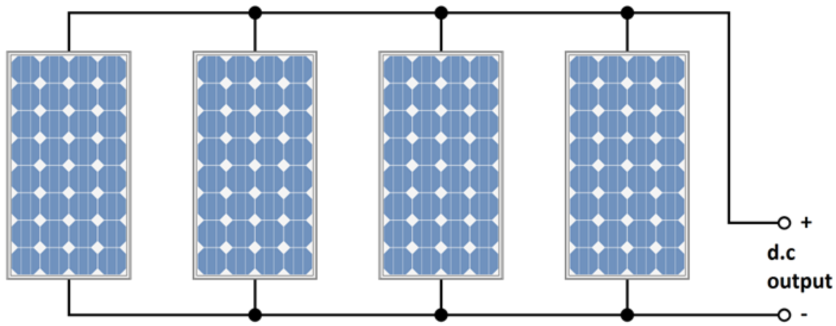
Worked Example 2 – Modules in Parallel

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.

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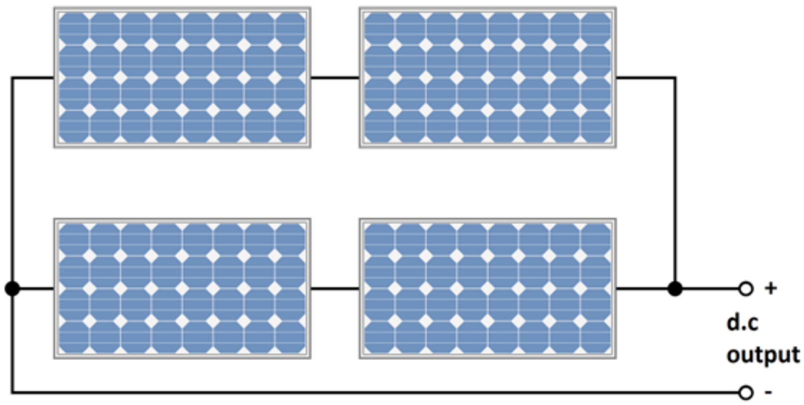
Worked Example 3 – Modules in Series-Parallel

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.

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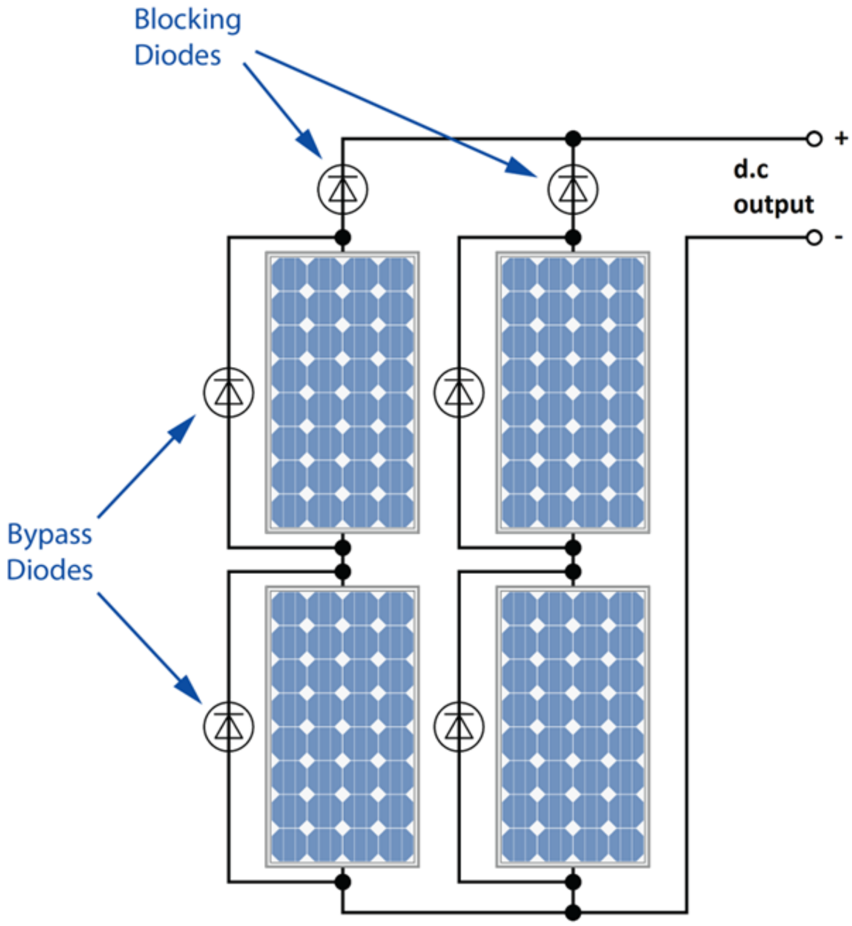
To prevent this, blocking diodes are connected in series with each string. The blocking diode allows current to leave the shaded string, but prevents current from back-feeding into it.

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):

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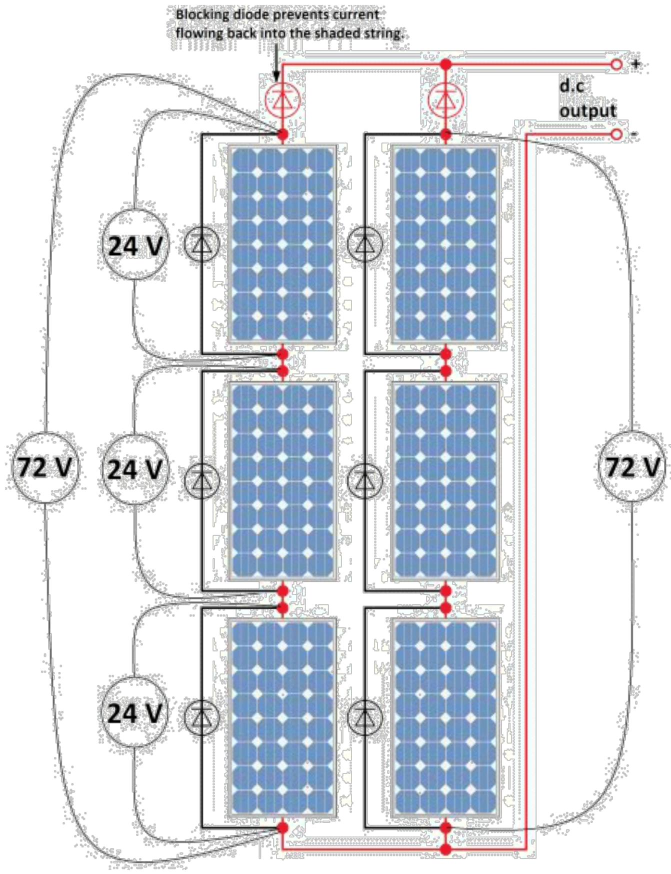

Notice how the bypass diode has effectively removed one of the modules from the circuit, thereby reducing the string voltage to 48 V, whilst the voltage of the other string remains at 72 V. The blocking diode in the shaded string prevents current flowing back into the shaded string.

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

Load the Activity

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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.

Australian Standards

Australian Standards containing requirements related to the installation of PV arrays include:

- AS/NZS 5033:2021 Installation and safety requirements for photovoltaic (PV) arrays.
- AS/NZS 4777.1:2016 Grid connection of energy systems via inverters – Installation requirements.
- AS/NZS 4777.2:2020 Grid connection of energy systems via inverters – Inverter requirements.
- AS/NZS 3000:2018 Wiring Rules.

PV Array Wiring

Low voltage PV system wiring must be installed in accordance with both AS/NZS 5033:2021 and the Wiring Rules (AS/NZS 3000:2018). PV arrays must be wired using flexible cables with a minimum cross-sectional area (c.s.a.) of 4 mm^2, and must **not** be primarily supported by plastic cable ties. Care must also 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 d.c. wiring must be segregated from a.c. wiring, and if installed within wall cavities, roof spaces, under a floor, or installed externally in an accessible location, it must be enclosed in metal or HDPVC conduit (or equivalent enclosure).

This learning activity consists of 7 parts designed to develop your understanding of PV array arrangements, wiring, and connection configurations.

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Topic 3.1 Learning Activity

In this skills practice, you are required to draw a PV array wiring diagram, indicating the connections between modules, bypass diodes and blocking diodes, and the polarity of the array output.

Topic 3.1 Skills Practice

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View

Factors to consider when selecting a suitable location for a PV array include:

- Solar window.
- Orientation.
- Required tilt.
- Shading.
- Air flow.
- Aesthetics.
- Ease of maintenance.

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.

Vegetation Control

Trees and the like can shade nearby PV arrays. In addition, leaves falling from trees and birds sitting in branches over arrays can result in soiling. Where vegetation exists near a PV array, periodic trimming may be required. This can be achieved from the ground using extendable saws or from elevated work platforms (EWPs) such as boom lifts.

Inverter Location

Factors to consider when selecting a suitable location for a grid-connected inverter include:

- Distance from the array.
- Ventilation.
- IP rating.
- Ease of maintenance.

The route length of the d.c. cabling run between a PV array and inverter or regulator should be kept as short and direct as possible to reduce:

- Power loss.
- Voltage drop.
- Required size of d.c. cabling.
- Cost.

Excessive voltage drop can result in automatic shut-down of an inverter – if the voltage drops below the inverter's minimum rated input value.

Balance of System

The term 'balance of system' (BOS) relates to all the components of a PV installation apart for the PV modules themselves. Depending on the type of installation, BOS may include:

- Grid-connected inverters.
- Regulators.
- Battery banks.
- Protective devices.
- Isolators (switch-disconnectors).
- Mounting and supports.
- Enclosures.
- Cabling.
- Earthing hardware.

This learning activity consists of 5 parts designed to develop your understanding of PV system layout and factors to consider when selecting equipment.

Topic 3.2 Learning Activity

In this skills practice, you are required to select suitable locations and arrangements for grid-connected PV system components in various installation scenarios.

Topic 3.2 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the configuration and positioning of PV arrays, including wiring and connection configurations.

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Topic 3 Content Quiz

Last modified: Thursday, 24 August 2023, 4:45 PM

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View

Introduction

In this topic you will learn about the types, features and ratings of inverters used in present day grid connected systems, and the differences between them. You will also learn how to connect a grid-connect inverter to measure the input and output parameters at various loads.

Inverters

An inverter is an electronic device that converts a d.c. input into an a.c. output. There are two main categories of inverters:

- Standalone (SPS) inverters.
- Grid-connect (GC) inverters.

An SPS inverter will typically be used to convert the d.c. supply from a battery bank to an a.c. supply of a standalone power system.

SPS inverters must not be connected to the electricity grid.

In order to connect a PV power system to the electricity grid, a suitably rated GC inverter must be used. The Australian Standard symbol for a low voltage inverter is shown below:

Grid-Connect (GC) Inverters

The following block diagram shows the relationships between components within a GC inverter:

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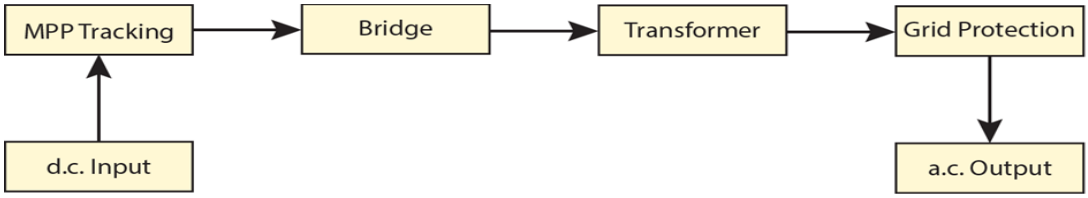

The basic purpose of each component is summarised below:

GC Inverter Components	
MPP Tracking	Maintains maximum module/string efficiency for the given operating conditions.
Inverter Bridge	Converts the d.c. waveform into an a.c. waveform using Pulse Width Modulation (PWM).
Transformer	Changes the voltage to 230 V and helps to smooth out the waveform.
Grid Protection	Matches the frequency of the inverter output with the grid, and disconnects the inverter from the grid in the event of abnormal grid parameters.

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

Load the Activity

Types of GC Inverters

There are three main types of GC inverter, as summarised in the following table.

Types of GC Inverters	
Central/String Inverter	A central inverter (or 'string inverter') is connected to the entire PV array, and is typically mounted near the installation metering/main switchboard.
Multimode Inverters	A multimode inverter is capable of operating in several operating 'modes'. Multimode inverters with 'standalone mode' are becoming more widespread as they can be arranged with a battery bank to provide greater independence from the grid – the batteries are charged by the PV array during the day, and the stored energy is utilised at night.

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Micro-inverters	A micro-inverter system consists of several small inverters, each connected to individual modules within the array. Micro-inverters are typically mounted directly onto the array assembly, which means that the wiring running from the array to the switchboard will be a.c. PV modules are also now commonly available with in-built micro-inverters, thereby reducing installation time.

Advantages and Disadvantages

Some advantages of micro-inverters compared to central inverters, include:

- Reduced d.c. cabling.
- Increased efficiency.
- Increased reliability.
- Reduced output due to partial shading or soiling is limited to the affected module.
- Module level MPPT and monitoring.

The main disadvantages of micro-inverters are:

- Higher initial cost.
- Increased maintenance due to multiple units.
- Difficulty of maintenance due to roof mounting.

This learning activity consists of 4 parts designed to develop your understanding of the basic types and function of an inverter.

Topic 4.1 Learning Activity

In this skills practice, you are required to draw diagrams of low voltage inverters typically used in grid-connected PV power systems.

Topic 4.1 Skills Practice

Last modified: Tuesday, 5 September 2023, 1:42 PM

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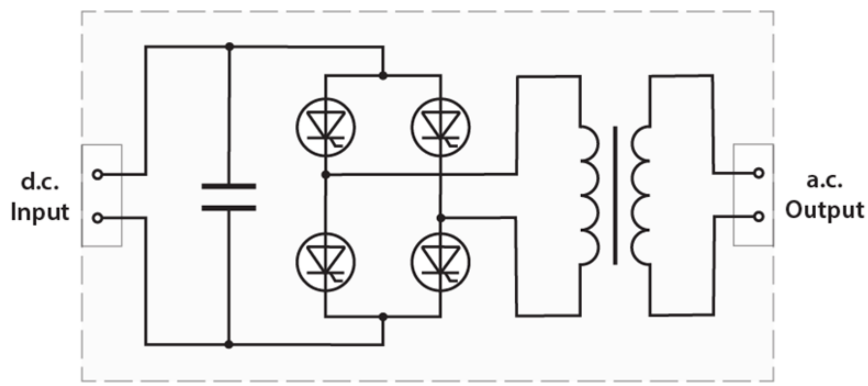
Principle of Inverter Operation

The principle of inverter operation is to rapidly switch a d.c. input, such that the direction of current flow is repeatedly reversed. Applying the switched supply to the primary winding of a transformer will result in an alternating magnetic flux, and a modified sine wave output on the secondary winding.

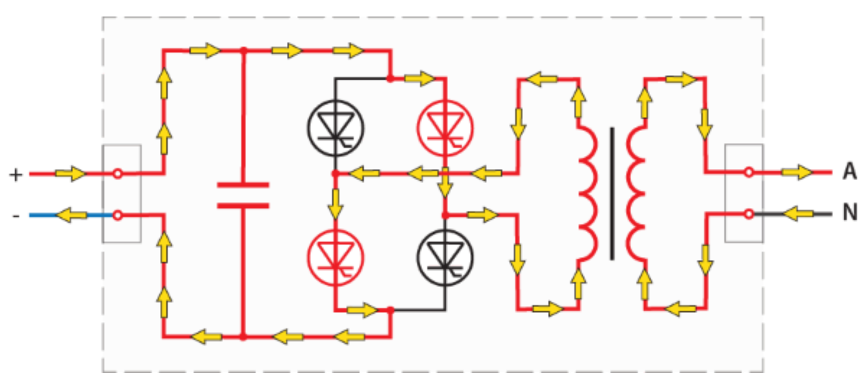
Inverter Bridge

An inverter bridge circuit consists of two pairs of silicon-controlled rectifiers (SCRs) that are switched alternately, producing a square wave.



Inverter Bridge Operation

The following diagrams show the basic operation of an inverter bridge – note how the switching of the two pairs of SCRs produces an alternating current output.



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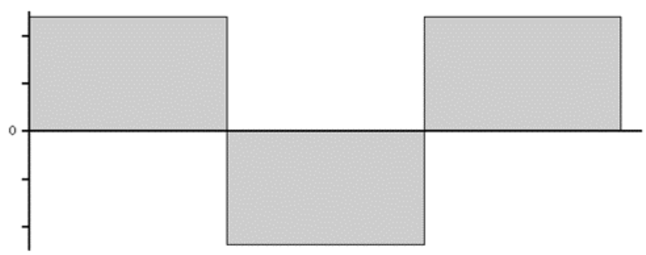
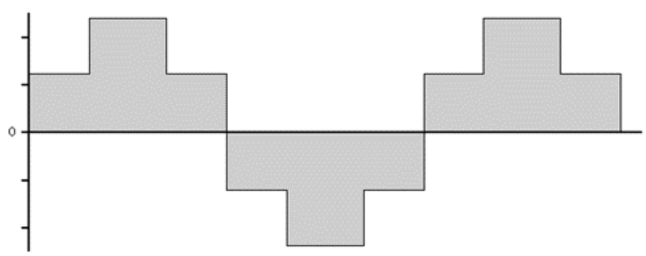
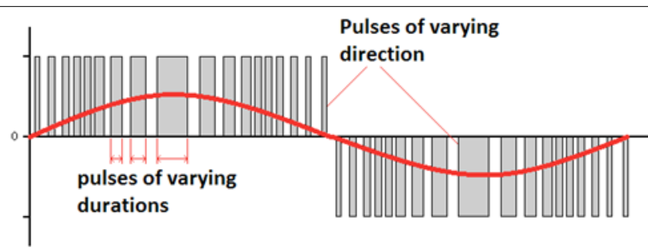
It can be seen that the d.c. positive and negative conductors are connected to the inverter input terminals (on the left) and the a.c. active and neutral conductors are connected to the inverter output terminals (on the right).

FET Inverter

A FET inverter operates the same way, but uses voltage controlled (field effect) transistors to switch the d.c. input.

Pulse Width Modulation (PWM)

Pulse Width Modulation (PWM) is a technique of rapidly switching the current in a series of pulses that each has the same magnitude but varies in duration (i.e. width). An accurate sine wave can be synthesised using this method. The following table shows the difference between square waves, modified sine/square waves and PWM synthesised waveforms. Note the current waveform resulting from the PWM technique, shown in red.

Type	Waveform
Square Wave	
Modified Sine/Square Wave	
Synthesised Sine Wave (PWM)	

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

Load the Activity

This learning activity consists of 3 parts designed to develop your understanding of inverter switching principles.

Topic 4.2 Learning Activity

Last modified: Tuesday, 5 September 2023, 1:55 PM

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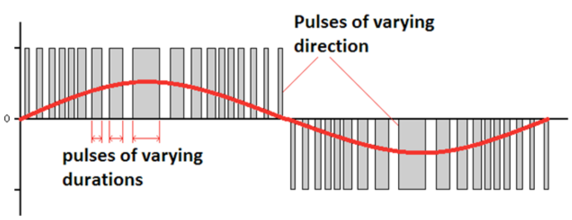
Grid-Connect Inverter Characteristics

Only specific types of inverters are suitable to be connected to the electricity supply grid. The features of grid-connect (GC) inverters that make them suitable for this purpose are highlighted in the following table.

GC Inverter Characteristics	
Feature	**Operation**
True Sine Wave PWM Output	True (synthesised) sine wave PWM output is required to ensure the quality of the grid is not compromised. 
Frequency Synchronisation	Frequency matching synchronises the inverter output with the frequency of the grid.
Passive Protection	Passive protection disconnects the inverter from the grid when abnormal grid voltage or frequency is sensed.
Active Protection	Active protection produces a frequency shift in the event that the grid goes off-line (e.g. due to maintenance or power outage), causing the inverter passive protection to trip.
Maximum Power Point Tracking (MPPT)	An MPPT device adjusts the load resistance placed on a PV array, to maintain maximum efficiency for a given irradiation and operating temperature.

Inverter Regions

There are three 'regions' in Australia that will affect some of the particular operating parameters required for a grid-connected inverter. Each region is based on the type of grid to which the inverter will be connected. The reason for this is that a given inverter system has the potential to have a more significant effect on a smaller grid, than a larger grid.

Region	**Grid Connection**

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Australia A	Connected to large interconnected power grid
Australia B	Connected to small interconnected power grid
Australia C	Connected to isolated/remote power grid

Most installations will fall into the 'Australia A' category. Several requirements in AS/NZS 4777.2:2020 require slightly different operating parameters depending on the particular region.

Grid Protection

Grid-connected inverter systems are required to incorporate a grid protection device that disconnects the inverter system from the grid in the event that the supply is disrupted, or operates outside of pre-determined voltage or frequency limits. Grid protection is typically incorporated within the grid-connected inverter, and consists of:

- Passive anti-islanding protection.
- Active anti-islanding protection.

Passive Anti-islanding Protection

Passive protection disconnects the inverter from the grid when an abnormal grid voltage or frequency is sensed. The voltage limits for passive protection are the same for all regions:

- A voltage of ≤70 V must be disconnected within 2 seconds.
- A voltage of ≤180 V must be disconnected within 11 seconds.
- A voltage of ≥265 V must be disconnected within 2 seconds.
- A voltage of ≥275 V must be disconnected within 0.2 seconds.

The passive protection frequency limits vary slightly by region, as described in the following table.

Region	**Passive Protection Frequency Limits**
Australia A and Australia B	• A frequency of ≤47 Hz must be disconnected within 2 seconds. • A frequency of ≥52 Hz must be disconnected within 0.2 seconds.
Australia C	• A frequency of ≤45 Hz must be disconnected within 6 seconds. • A frequency of ≥55 Hz must be disconnected within 0.2 seconds.

GC Inverter Ratings

Any inverter used for grid-connected applications in Australia must comply with AS/NZS 4777.2:2020. When selecting an inverter, the inverter ratings must be carefully matched to the installation requirements. The following table shows some of the primary ratings to be considered.

GC Inverter Ratings	
Continuous rating	The maximum power at which the inverter can operate continuously without overheating.

Half hour rating	The maximum power at which the inverter can operate over a half hour period without overheating.
Surge rating	The maximum inrush current the inverter can withstand without damage.
d.c. voltage range (operating window)	The upper and lower d.c. input voltage limits.
a.c. voltage range	The upper and lower a.c. output voltage limits.
Peak efficiency	The maximum efficiency the inverter can achieve.
IP rating	The ability of the inverter to withstand the ingress of water and dust.

Inverter Operating Window

GC inverters will only operate within a specific range of d.c. input voltage – this is referred to as the "operating window" of the inverter. If the input voltage goes outside this range, then the inverter will cease to operate. This is of particular importance when selecting locations and cable routes between arrays and inverters, as excessive voltage drop in the connecting cable would result in the inverter output dropping to zero. The battery bank input port of a multimode inverter will also have a specified operating window.

Temperature Coefficient of Voltage

PV module temperature coefficient of voltage indicates the change in voltage that will occur for changes in ambient temperature. It is important to coordinate this rating with the inverter operating window, to ensure that the system will operate within the expected range of ambient temperatures.

Temperature coefficients are typically given in %/^{0}C, indicating the percentage change in voltage for a given change in temperature.

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Worked Example – Temperature Coefficient of Voltage

Consider a PV array that consists of 6 modules connected as a single string. Each module has the following STC voltage characteristics:

- Nominal Voltage (V_{MPP}): 36 V
- Open Circuit Voltage (V_{oc}): 45 V
- Voltage Temperature Coefficient: -0.35%/^{o}C

Determine the minimum and maximum nominal array voltages for an ambient temperature range of 0^{o}C to 50^{o}C.

(a) Array voltage at STC (25^{o}C)

36 x 6 = 216 V

(b) Array voltage @ 0^{o}C

-0.35 x (0 – 25) = 8.75%

216 x 1.0875 = 234.9 V

(c) Array voltage @ 50^{o}C

-0.35 x (50 – 25) = -8.75%

216 x 0.9125 = 197.1 V

If the expected temperature range for the installation was 0^{o}C to 50^{o}C, then the operating window of the inverter would need to be (at least) 197 V to 235 V.

Manufacturer's Data

A basic example of a manufacturer's datasheet for a GC inverter is pictured below:

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Input Parameters	
Max. d.c. power	3760 W
Max. d.c. voltage	500 V
d.c. voltage range	210 V – 410 V
Max. input current	22 A
MPP trackers	1
Max. number of strings	3
Output Parameters	
Nominal a.c. power	3250 W
Max. a.c. power	3640 W
Nominal a.c. voltage range	220 V – 240 V
Max. a.c. current	17 A
a.c. frequency / tol.	50 Hz / ±4 Hz
Power factor	1
Connection	Single phase
Efficiency	
Max Efficiency	95.7 %
Consumption: No Load / Standby	12 W / < 3.5 W
General	
International protection	IP66
Operating temperature range	-25 °C ... +60 °C
Dimensions (W x H x D)	400 x 600 x 240 mm
Weight	39 kg

This learning activity consists of 8 parts designed to develop your understanding of inverter waveforms, ratings and specifications.

Topic 4.3 Learning Activity

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In this skills practice, you are required to connect a grid-connect inverter into a circuit and observe the operating characteristics. You will need access to your RTO's practice facilities to complete this skills practice so ask your teacher/trainer about how to proceed.

Topic 4.3 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the different types, operation and features of inverters used in grid-connect systems.

Topic 4 Content Quiz

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View

Introduction

In this topic you will learn the various factors, standards and safety practices associated with the installation of grid connected PV power systems, including working on roofs, and installation labelling and identification requirements.

Workplace Health & Safety

The health and safety considerations for working on roofs are outlined in the following table:

Hazards	Risks	Control Measures
Working at heights.	Falls from heights, dropping tools/equipment.	Safety harness, non-slip footwear.
Manual handling.	Strains, sprains, cuts, abrasions.	Gloves, safe lifting methods, mechanical handling equipment.
UV radiation.	Sunburn, heat stroke, skin cancer.	Sun-cream, UV protected clothing, polarised safety glasses.

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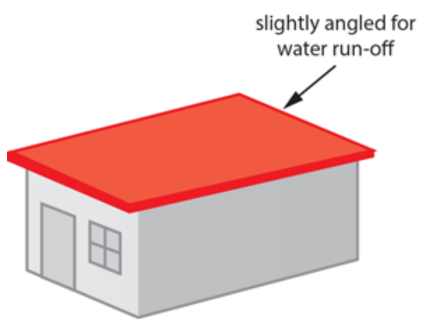
Energised parts (e.g. overhead services, consumer's mains and other LV cables).	Electric shock.	Exclusion zones around energised parts.
Asbestos.	Inhalation of asbestos fibres.	Removal of asbestos by an accredited contractor.

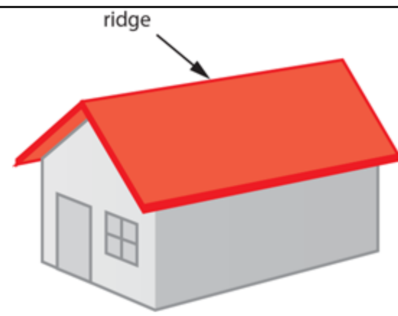
Roof Structures

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

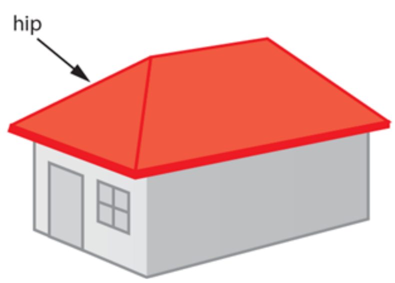
Basic Roof Structures



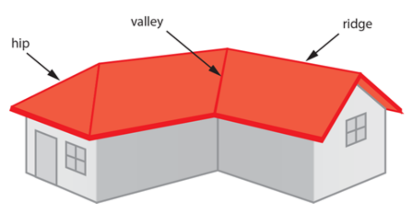
Flat Roof (slab or frame)



Gable Roof (frame)

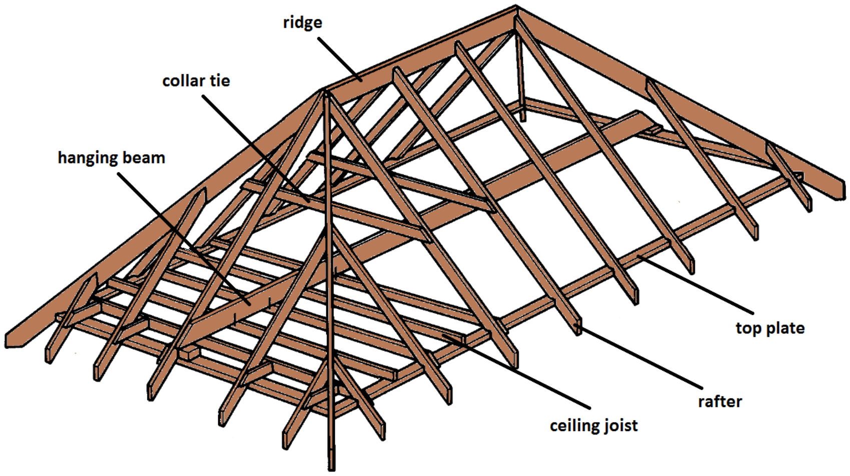


Hip Roof (frame)



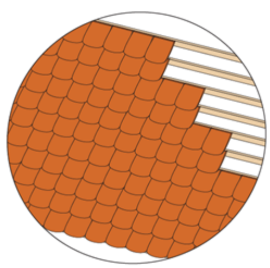
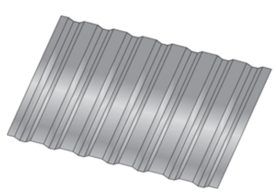
Hip and Valley Roof (frame)

Roof structures can be quite complex. The following diagram shows the basic arrangement of beams in a hip roof.



Roofing Materials

The type of roofing material will influence the method of mounting for a given PV array. Types of roofing materials that may be encountered in Australia are outlined in the following table.

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

PV Array Mounting Systems

PV array mounting systems can be classified into three main types:

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- Top-down rail systems.

- Racking systems.
- Pole mounting systems (top-of-pole/side-of-pole).

Top-Down Rail Systems

The following table outlines the features, advantages and disadvantages of top-down rail systems.

<table>
<tr><th>Top-Down Rail System</th><th>Features</th></tr>
<tr><td></td><td>

- Roof mounting system.
- Feet are fixed to the rafters.
- Aluminium rails fasten to the feet.
- Clamps with stainless steel bolts fasten the PV array to the rails.

</td></tr>
<tr><th>Advantages</th><th>Disadvantages</th></tr>
<tr><td>

- Flexible configuration.
- Fast and easy installation.
- The array being parallel with the roof is typically more aesthetically pleasing.

</td><td>

- No tilt angle adjustment – roof tilt determines the tilt angle of the array.
- Limited air circulation due to low roof clearance.

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

Racking Systems

The following table outlines the features, advantages and disadvantages of racking systems.

<table>
<tr><th>Racking System</th><th>Features</th></tr>
<tr><td></td><td>

- Roof mount, awning and free-standing types available.
- Post type mounting feet are fixed to ground or roof surface.
- Rails fasten to the array and posts.
- Stainless steel bolts are used to fasten components in position.

</td></tr>
<tr><th>Advantages</th><th>Disadvantages</th></tr>
<tr><td>

- Rear posts offer tilt angle adjustment, clearance, and room for air circulation.
- Generally, provide easy access to the rear of the panels.

</td><td>

- Less flexible mounting configuration – feet may need to be mounted at specific intervals.
- Can result in poor aesthetics.

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

Pole Mounting Systems

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The following table outlines the features, advantages and disadvantages of pole mounting systems.

Pole Mounting System	**Features**
	• Free standing type. • Steel pole is mounted into the ground. • Array cross-brace assembly is fastened to the top of the pole with a mounting sleeve or to the side of the pole with a mounting bracket. • Stainless steel bolts are used to fasten components in position.
Advantages	**Disadvantages**
• Mounting sleeve offers tilt angle adjustment. • Maximum air circulation. • Easy access to the rear of the panels.	• More space required. • Generally, not aesthetically pleasing. • Excavation required for pole and cable trench.

Waterproofing

It is important to ensure the integrity of waterproofing is maintained when installing PV arrays on roofs. All mounting points should be effectively sealed with a waterproof sealant. Where cables enter the roof space through a penetration in the roof structure, a suitable gland/device designed for that purpose should be used to ensure a proper seal. Note that the use of silicon sealant as the main method of sealing penetrations is not generally considered to be appropriate.

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:

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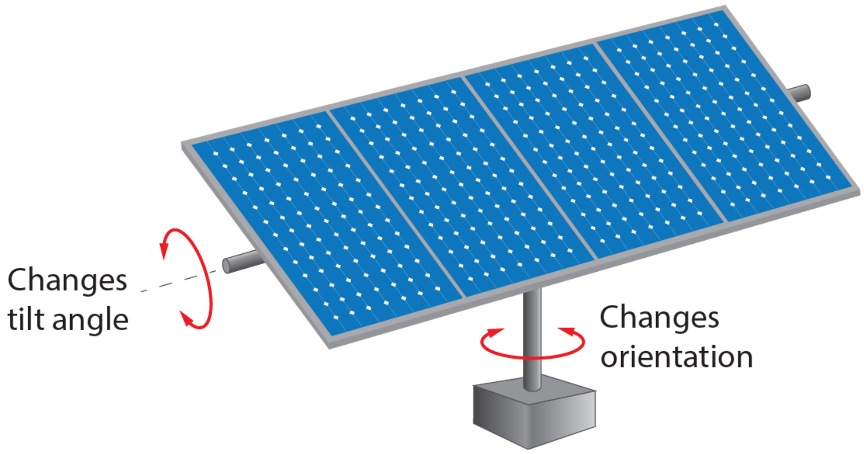

The effect of solar tracking is to optimise irradiation of the array throughout the day, thereby increasing total energy production. However, there are also some downsides to solar tracking, such as:

- 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 PV array installation practices, considerations and safety requirements.


Topic 5.1 Learning Activity

In this skills practice, you are required to identify a suitable roof mounting system for a given PV installation and undertake a risk assessment for the installation of a PV array on the roof of a building. You will also develop a Safe Work Method Statement (SWMS) for the job.


Topic 5.1 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 4777.1:2016 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. (note that the 2016 edition of AS/NZS 4777.1 still limits the maximum d.c. voltage to 600 V for domestic installations). 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 40^0C 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. There are several requirements for PV system signage and labelling of various components that will be explored further on Content Page 5.3.

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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 4777.1:2016 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 4777.1:2016	
Installation Factors	**Summary of Requirements**
Equipment Selection	The inverter used in the installation must comply with the requirements of AS/NZS 4777.2. Inverter wiring must be selected in accordance with AS/NZS 3000, AS/NZS 3008.1.1 and AS/NZS 5033 as applicable.
Installation Requirements	Inverter system wiring and equipment must be installed in accordance with the requirements of AS/NZS 4777.1 and the requirements of AS/NZS 3000 (except where varied by AS/NZS 4777.1). Inverters must be installed: • In accordance with the manufacturer's instructions. • In a well-ventilated and readily available location. • 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.
Control and Protection	Control and isolation devices must be provided to allow safe operation, maintenance, testing, fault finding and repairs. A main switch for the inverter supply must be provided on the connecting switchboard that: • Operates in all active conductors. • Is capable of being secured in the OFF position. • Is rated to break the rated current of the inverter system. Protection devices must be provided to protect inverter system wiring against overloads, short-circuits and excessive earth leakage.

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Inverter Wiring and Connection	The inverter system must be connected to a dedicated circuit on the connecting switchboard, using flexible cables and approved connectors/couplings that have been designed for that purpose. The a.c. and d.c. circuits must be kept segregated from one another. Within an enclosure, this must be by an insulating barrier (e.g. PVC conduit). Outside of enclosures, this can be by either: • A minimum 50 mm separation. • An insulating barrier.
Wiring Systems	The inverter system 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
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 7.

Battery Banks

It is becoming increasingly cost effective for consumers to include battery storage into their PV power systems. Battery technology is a large and quickly evolving field within the renewable sector, which is explored in depth in the other units of competency, including:

- UEERE0060 – Design grid-connected battery storage systems.
- UEERE0077 – Install battery storage equipment power conversion equipment to grid.
- UEERE0078 – Install battery storage to power conversion equipment.

This learning activity consists of 6 parts designed to develop your understanding of the installation requirements and standards that apply to grid-connected PV power systems.

Topic 5.2 Learning Activity

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PV System Identification

Where an electrical installation includes a low voltage grid-connected PV power system, a variety of signage and labels must be provided to ensure the safety of personnel who may need to isolate and/or work on the installation.

Section 6 of AS/NZS 4777.1:2016 sets out the minimum standards for these signs and labels. Appendix A provides further guidance and examples of compliant signs. The following items are required to be clearly identified:

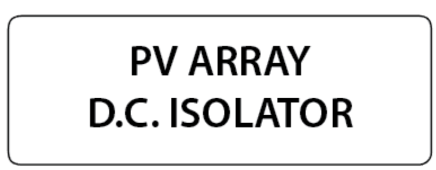
- The wiring between the PV array and the inverter.
- The inverter.
- The connecting switchboard.
- The inverter system main switch.
- The normal supply main switch (in the connecting switchboard).
- All intermediate switchboards between the connecting switchboard and the main switchboard.

Identification of Wiring

Wiring between the energy source and the inverter must be labelled at least every 2 m to indicate the type of energy source (e.g. 'SOLAR' or 'BATTERY'). An example of a compliant labelling, designed to be attached with cable ties, is shown below:

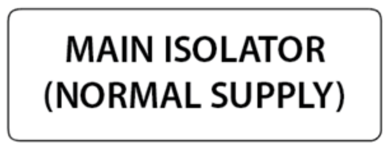
Inverter Signage

The a.c. and d.c. isolators installed adjacent to an inverter must be clearly identified. The following images show typical examples of these signs/labels:



Switchboard Signage

There are several items that must be identified at the switchboard to which the inverter directly connects (i.e. the connecting switchboard), as shown in the following table.

Connecting Switchboard Signage Requirements	
Signage Requirements	**Example**
A warning sign must be provided indicating that there are multiple supplies.	
The main switch for the inverter system must be clearly labelled.	
The main isolator/switch for the normal supply must also be labelled.	 (where the connecting switchboard is the main switchboard)  (where the connecting switchboard is a distribution board)
If the inverter is not installed next to the switchboard, then its location must be indicated.	

In the case that the connecting switchboard is a distribution board, then a warning sign must be provided at the main switchboard, and at each intermediate switchboard. The sign must indicate where to isolate the inverter supply. An example is shown below:

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In larger installations, it may be necessary to indicate the locations of inverters on a building layout drawing, provided at the main switchboard and/or fire panel.

Shutdown Procedure Signage

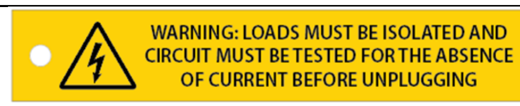
Signage indicating the shutdown procedure for the inverter system must be provided adjacent to the relevant switchgear to be operated.

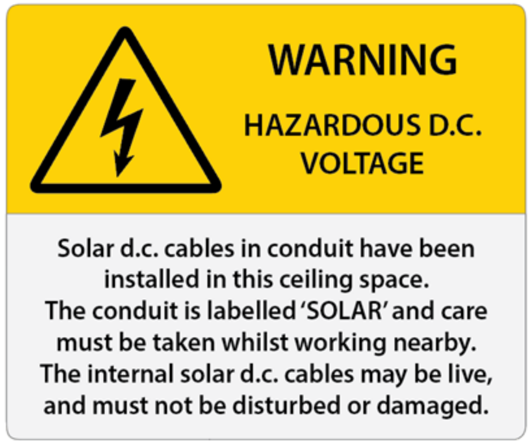
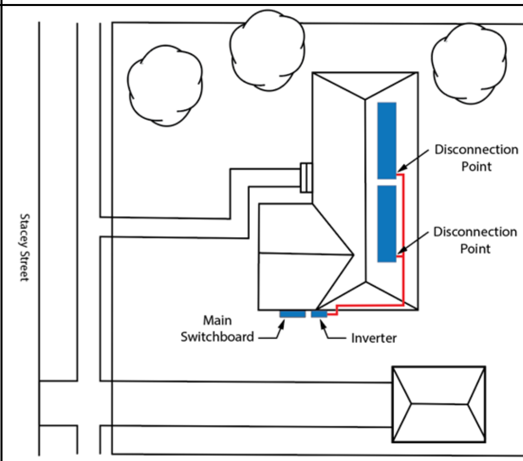
Consideration also needs to be given to the risks posed to emergency services workers. If the building has a fire panel, a warning sign must be provided that indicates the location of the shutdown procedure signage and switchgear.

Other Signage

Further AS/NZS 4777.1 signage requirements apply to installations containing multiple inverter supplies and energy sources, and for multimode inverters. See Section 6 for further details in these instances.

AS/NZS 5033:2021 also sets out several labelling and signage requirements for grid-connected PV systems, as summarised in the following table.

Additional PV System Signage Requirements (AS/NZS 5033:2021)	
Signage Requirements	**Example**
Disconnection points are required to be clearly labelled to ensure they are readily identifiable and will not be disconnected under load conditions.	 Sign for disconnection point
	 Sign for PV string disconnection point
	 Sign for system with multiple isolation/disconnection points, required adjacent to the PCE
PV d.c. wiring system junction boxes must be identified with a warning label.	

<table>
<tr>
<td>Entries to ceiling spaces or accessible floor spaces containing PV d.c. wiring systems must be identified with a warning label explaining the presence of the d.c. wiring system.</td>
<td>
</td>
</tr>
<tr>
<td>A green circular sign must be placed on the main switchboard to warn emergency services that a PV supply exists. The sign must indicate the isolation arrangement:
• DP – disconnection point
• SW – load-break disconnector
• AC – microinverters</td>
<td>
</td>
</tr>
<tr>
<td>The layout of the solar system must be identified on a plan that shows the locations of the array and PCE, to be located either at the main switchboard, meter box or fire panel.</td>
<td>
</td>
</tr>
</table>

Multimode Inverters – Additional Requirements

Additional risks are posed by grid-connected PV systems incorporating a multimode inverter that is capable of operating as a stand-alone power supply. The following additional requirements apply to multimode inverters:

- A main switch shall be provided for the stand-alone port of the inverter.
- The stand-alone port main switch shall be labelled "MAIN SWITCH (STAND-ALONE SUPPLY)".
- The inverter must provide an earth referenced a.c. supply when operating in stand-alone mode.
- The main switchboard shall be provided with a warning sign stating that neutral and earthing conductors may be live when the installation is operating in stand-alone mode.
- All final subcircuits supplied by the inverter must be RCD protected in accordance with AS/NZS 3000:2018.
- It is not permitted to protect the inverter grid-interactive port submain with an RCD.

There are also some additional requirements for multimode inverters stated in *AS/NZS 4777.2:2020 Grid connection of energy systems via inver* *Inverter requirements.* When the multimode inverter is operating as a standalone 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 standalone supply must not exceed 5%, and no individual harmonic may exceed 5%.

This learning activity consists of 6 parts designed to develop your understanding of the standards and requirements for identification and labelling of grid-connected PV power systems.

Topic 5.3 Learning Activity

In this skills practice, you are required to install and connect the various components of a grid-connected PV power system. You will need access to your RTO's practical facilities for this task, so ask your teacher/trainer for guidance.

Topic 5.3 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of the standards and safety practices for installing grid connected PV power systems.

Topic 5 Content Quiz

Last modified: Tuesday, 29 August 2023, 11:28 AM

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Introduction

In this topic you will learn about the commissioning procedures required to confirm compliance and functionality of grid connected PV power systems, including shut-down and start-up procedures, inspection, testing, fault finding and rectification. You will also practice inspecting and testing a PV power system, and locating and repairing faults.

PV System Hazards

The hazards and risks associated with carrying out work on PV arrays are summarised in the following table:

PV System Hazards		
Hazards	**Risks**	**Control Measures**
d.c. voltages. Exposed terminals. d.c. arcing.	Electric shock. Electrical burns.	PV blankets. Safe isolation. Gloves. Exclusion zones.
UV radiation.	Sunburn. Sunstroke.	Sun-cream. UV protected clothing. Polarised safety glasses.
Working at heights.	Falling.	Safety harness. Non-slip footwear.

Shut-Down and Isolation

The most effective control measure against the risk of electric shock whilst working on electrical equipment is the use of safe Lock Out and Tag Out (LOTO) procedures. LOTO involves applying physical locks and tags to isolation points that will prevent downstream equipment and circuit conductors from becoming energised. Note that there may be multiple isolation points for a grid-connected PV system that will need to be switched off, locked out and tagged.

Prior to isolating, it is necessary to shut-down the PV system so that isolation can occur under 'no-load' conditions. Suddenly isolating a PV system under load conditions can result in voltage rise and arcing.

Care must also be taken to ensure that any shut down or isolation procedures do not initiate automatic changeover equipment that might bring other supplies online. The arrangement of alternative supplies with automatic changeover systems can be complex, so it may be necessary to seek guidance from the person in charge of the installation.

Isolation Procedures

The particular steps required for safely shutting down and isolating a particular PV system will be specific to the arrangement of that particular installation. The specific procedure for a given installation is required to be documented and provided adjacent to the relevant switchgear to be operated.

The fundamental steps in a safe isolation procedure are laid out in the following table:

General Isolation Procedure	
1	Identify and locate **all** isolation points.
2	Notify relevant personnel of your intent to isolate.
3	Isolate, lock and tag **all**applicable isolation devices.
4	**Test the test equipment on a known live source to verify functionality.**
5	Test for voltage to verify de-energised.
6	**Test the test equipment on a known live source to verify functionality.**

The Australian Standard *AS/NZS 4836 Safe working on or near low-voltage and extra-low voltage electrical installations and equipment* specifies the approved procedures and techniques for safe electrical isolation.

The images below are examples of the tags used to identify isolations and the responsible personnel. It is important to understand that there are two types of tags, as described below.

<table>
<tr><th colspan="2">Electrical Safety Tags</th></tr>
<tr><th>Front and Back</th><th>Application</th></tr>
<tr><td>


Personal Danger Tag
</td><td>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.</td></tr>
</table>

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 **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 has 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.

Filling in Tags

It's important to provide the following information on electrical safety tags:

- Your name.
- A contact phone number.
- The company you are from.
- Date and time of the isolation.

The strength of the lock-out tag-out process comes from the expectation that the person who puts the locks in place, fills out and attaches the tag is the person who removes it when it is safe to re-energise the circuit.

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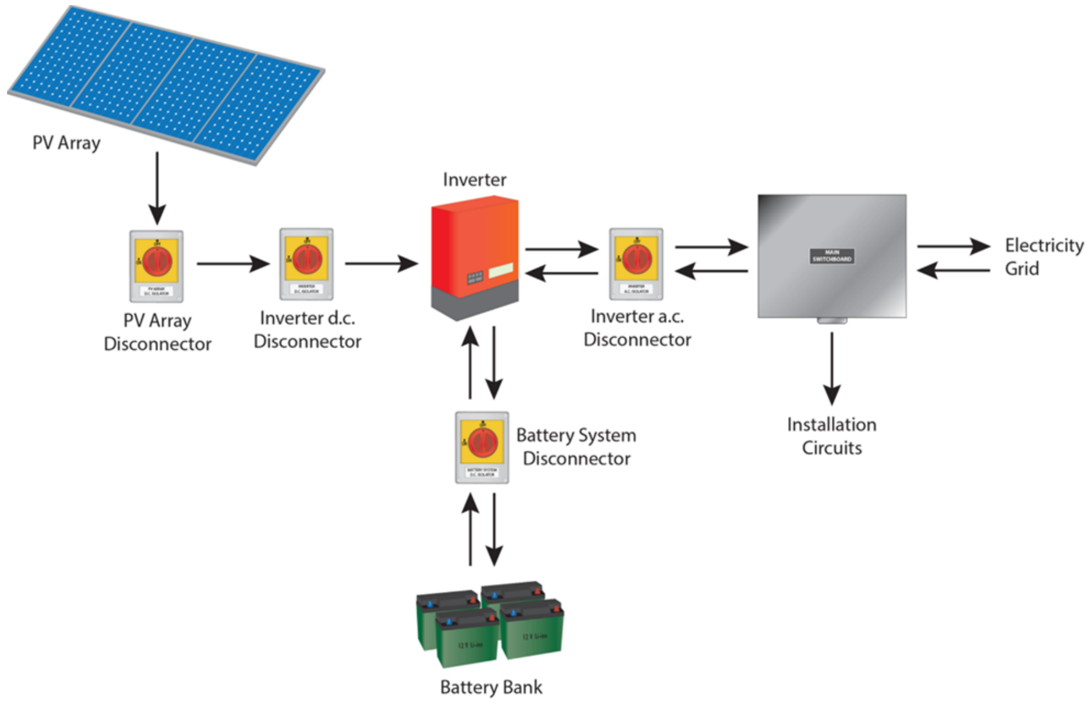
Check your understanding of the content by clicking the link below then undertaking the activity.

Load the Activity

Isolating PV Systems – Examples

The following diagram shows a basic grid-connected PV supply system arrangement:



For the installation pictured above, the disconnectors (isolators) that would need to be locked out and tagged would depend on the scope of work that was to be carried out. Some examples are provided in the following table.

Isolating PV System Equipment	
Scope of Work	**Required Isolations**
Undertake routine maintenance on the battery system.	As a minimum, isolate lock-out and tag: • Battery system disconnector. *Note: that the batteries themselves are a source of energy and so the battery terminals will still be live!*
Undertake routine maintenance on the PV array.	As a minimum, isolate lock-out and tag: • PV array disconnector. Note: it may also be necessary to cover the modules with a suitable PV blanket to prevent d.c. generation.
Undertake routine maintenance on the inverter.	As a minimum, isolate lock-out and tag: • Battery system disconnector. • Inverter a.c. disconnector. • Inverter d.c. disconnector.
Shut-down and isolate the entire alternative supply system from the installation.	As a minimum, isolate lock-out and tag: • Battery system disconnector. • Inverter a.c. disconnector. • Inverter d.c. disconnector. • PV array disconnector.

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Remember:

Always test for voltage to verify isolation and test your tester on a known live source to confirm it is operating correctly

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

Load the Activity

Restarting PV Systems

As with isolation procedures, the particular steps required for safely restarting a particular grid-connected PV system will be specific to the installation. Procedures for safely reinstating the system should be documented and provided in the installation. The general steps in the procedure are listed below:

Restarting PV System Procedure	
1	Notify relevant personnel of your intent to restart the alternative supply system.

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2	Where applicable, initiate any start-up procedures under no-load conditions (e.g. remove blankets from PV array).
3	Remove isolator lock-out devices and danger tags, and switch on the isolators (generally in reverse order to the shut-down procedure).
4	Use a voltage tester to measure and verify the supply voltage at the equipment terminals is correct.

This learning activity consists of 5 parts designed to develop your understanding of PV power system supply shut-down, isolation and restarting procedures.

Topic 6.1 Learning Activity

In this skills practice, you are required to safely shut-down and isolate a PV supply system and then safely reinstate the system. You will need access to your RTO's practical facilities for this task, so ask your teacher/trainer for guidance.

Topic 6.1 Skills Practice

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PV Power System Commissioning

PV power system commissioning is a systematic process of inspection and testing, under de-energised and energised conditions, to:

- Verify system wiring and components are correctly connected.
- Verify system wiring and components operate normally.
- Ensure connection to the grid will not result in danger or damage.
- Document initial system performance.

Prior to commencing commissioning procedures, it is essential to familiarise yourself with the applicable safe work methods and perform a Job Safety/ Hazard Analysis (JSA/JHA). Procedures consist of both de-energised and energised testing, so hazards and risks associated with energised low voltage equipment must be taken into careful consideration. It may be necessary to restrict access to equipment and areas under test.

Commissioning Procedures

The following diagram outlines the general procedures for commissioning electrical systems.

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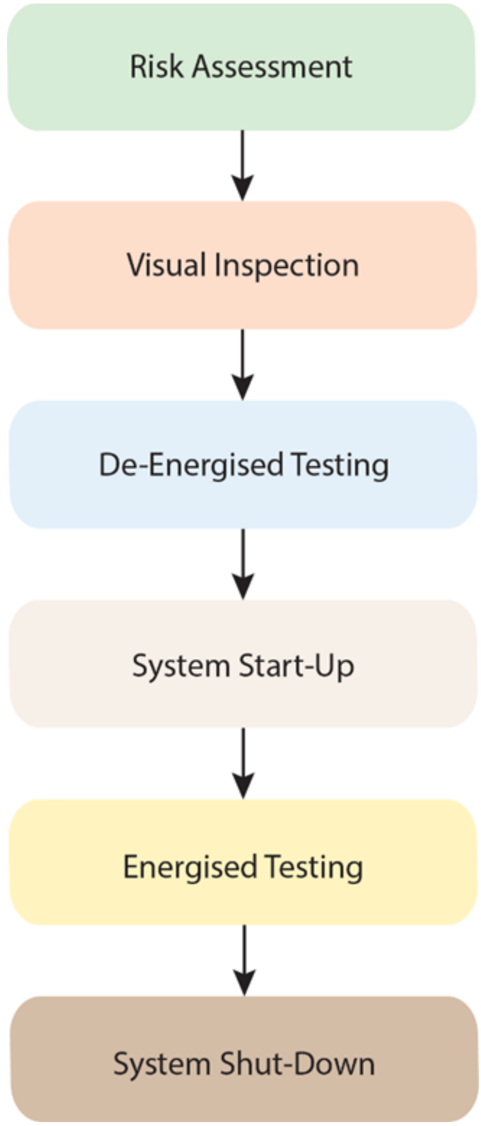
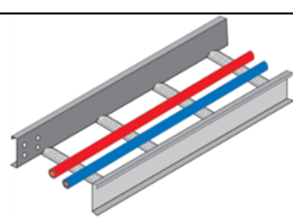


Inspection and Tests

A number of checks and tests are required to verify the compliance and functionality of grid-connected PV power systems, as summarised in the following table. Note that more details canbe found in AS/NZS 5033:2021 Clause 6.3.

PV Power System Commissioning		
Component	**Illustration**	**Checks**
System Wiring		• Support/protection methods. • Continuity. • Insulation resistance. • Polarity.

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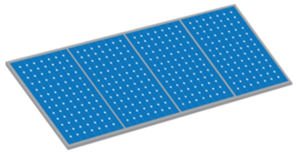
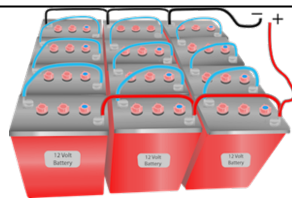
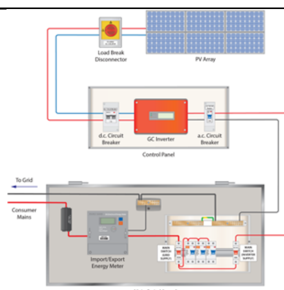
PV Array		• Correct wiring connections. • Open-circuit voltage of each string. • Open-circuit voltage of array. • Short-circuit current of each string. • Short-circuit current of array.
Inverter		• Identification/labelling. • Input and output voltages. • Input and output currents. • Output frequency. • Output waveform shape. • Operation of over/undervoltage disconnection and alarm circuits.
Regulators		• Identification/labelling. • Input and output voltages. • Input and output currents. • Operation of over/undervoltage disconnection and alarm circuits.
Batteries		• Identification/labelling. • Terminal voltages. • Specific gravity. • Electrolyte levels. • Ah performance.
Overall System		• Documentation. • Functionality. • Voltage drop.

System Manual

At the completion of PV system installation and commissioning, a manual must be provided to the system owner. The following list summarises the details required to be provided in the system manual – see AS/NZS 5033:2021 Clause 6.2 for comprehensive details:

- System ratings and commissioning date.
- Lists of equipment (modules, inverters etc.) and associated manufacturer's manuals.
- Procedures in the event of an earth fault alarm.
- Shutdown and isolation procedures.
- System diagram(s).
- Disconnection device's locations and cable routing.
- System performance estimate.
- Maintenance checklist and schedule.
- Commissioning records.
- Warranty information.

This learning activity consists of 6 parts designed to develop your understanding of PV system testing and commissioning procedures.

Topic 6.2 Learning Activity

In this skills practice, you are required to commission a PV power system in accordance with relevant Australian Standards and CEC guidelines. You will need access to your RTO's practical facilities for this task, so ask your teacher/trainer for guidance.

Topic 6.2 Skills Practice

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In order to locate faults in a PV power system, each possible location must be investigated, including:

- PV array.
- Inverter.
- d.c. and a.c. wiring.

The following table describes the typical problems that can occur in PV systems.

Typical Problems in PV Power Systems		
Location	**Fault**	**Possible Causes**
Faults in PV arrays	Decreased power output	• Shading. • Soiling. • Damage.
	Open or partially open circuits	• Cell failure. • Blocking/bypass diode failure. • Corrosion. • Hot joints.
	Short or partially short circuits	• Cell failure. • Blocking/bypass diode failure. • Insulation failure.
Faults in GC inverters	Component failure	• Failed capacitors. • Failed electronic components.
	Overheating	• Blocked vents. • Failed fan motor.
Faults in PV system wiring	Open or partially open-circuits	• Corroded terminals. • Loose terminations. • Mechanical damage.
	Short or partially short-circuits	• Damaged insulation. • Ingress of water into enclosures.
	Incorrect wiring connections	• Installer error.

Fault Finding Techniques

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A visual inspection should be carried out first. Things to check for include:

- Presence/absence of voltage.
- Tripped circuit protection.
- Incorrect control settings.
- Loose terminations.
- Incorrect wiring connections.
- Mechanical or water damage.

After the equipment has been inspected, various tests can be used to identify problems and check assumptions. It should be remembered to test on both the line and load sides of equipment as necessary. Tests that can be used to fault find PV systems are summarised in the following table.

Fault Finding Testing Techniques	
Tests	**Details**
Voltage Testing	• Can be used to identify: • Open or partial open-circuits. • Short or partial short-circuits. • Safe isolation. • Carried out with the supply energised (apart from proving de-energised).
Current Testing	• Can be used to check the load current. • Carried out with the supply energised.
Resistance / Continuity Testing	• Used to identify: • Open or partial open-circuits. • Short or partial short-circuits. • Must only be carried out on isolated equipment. • It may be necessary to disconnect components prior to testing for resistance/continuity.
Insulation Resistance Testing	• Used to check the condition of insulation. • Must only be carried out on isolated equipment. • Care must be taken not to apply the test voltage across sensitive electronic components.

This learning activity consists of 6 parts designed to develop your understanding of PV system testing and commissioning procedures.

Topic 6.3 Learning Activity

In this skills practice, you are required to identify, locate and rectify faults in grid-connected PV arrays, inverters and associated wiring. You will need access to your RTO's practical facilities for this task, so ask your teacher/trainer for guidance.

Topic 6.3 Skills Practice

Undertaking this topic quiz will help you to confirm your understanding of PV power system general commissioning procedures, including inspection, testing, fault finding and rectification. **?**

Topic 6 Content Quiz

Last modified: Wednesday, 30 August 2023, 10:30 AM

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Mark as done

Cluster Introduction

This unit cluster consists of 6 topics, exploring the installation of grid-connected photovoltaic (PV) power systems, including components, arrangements and configurations, standards and requirements, and associated safe working practices.

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 hand skills you'll need on the job, such as installing and connecting PV system components. 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 clustered unit tests. The Clustered Knowledge Test (CKT) is designed to determine your understanding of the unit concepts, whilst the Clustered Skills Test (CST) 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:

UEERE0080 Install photovoltaic power conversion equipment to grid

and

UEERE0081 Install photovoltaic systems to power conversion equipment

Unit Learning Plan

The Cluster Learning Plan (CLP) 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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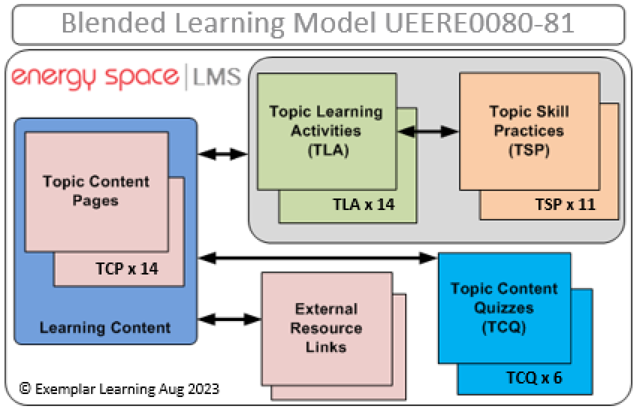

Topic Content Pages present the topic technical content using simple explanations, diagrams and interactive objects. These pages also provide links to external resources, learning activities, skills practices and quizzes, positioned like 'checkpoints' throughout the learning journey.

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: Thursday, 14 November 2024, 7:49 AM

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View

Click ***Attempt Quiz Now*** to commence the activity.

Attempts: 25

Summary of your previous attempts

Attempt	State	Grade / 27.00	Review
Preview	Finished Submitted Saturday, 15 February 2025, 1:40 AM	0.00	Review

Highest grade: 0.00 / 27.00.

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Click ***Attempt Quiz Now*** to commence the activity.

Attempts: 8

Summary of your previous attempts

Attempt	State	Grade / 16.00	Review
Preview	Finished Submitted Saturday, 15 February 2025, 1:41 AM	0.00	Review

Highest grade: 0.00 / 16.00.

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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:	

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

		Teacher/Trainer Initials and Date	
	Feedback 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

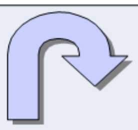
Install Solar Radiation Meter (ORJA) APP Google Store, Play

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.

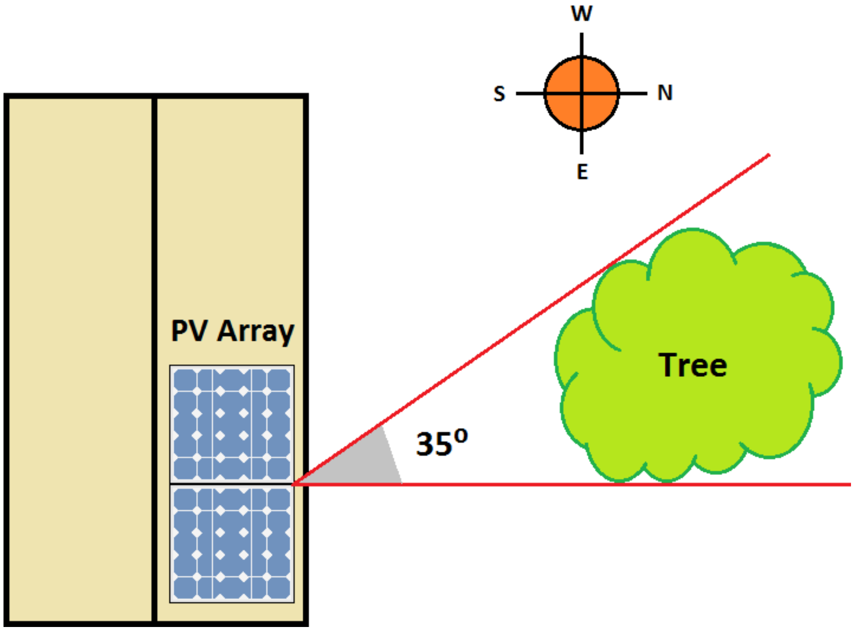


Figure 2.3.1(a) - Overview

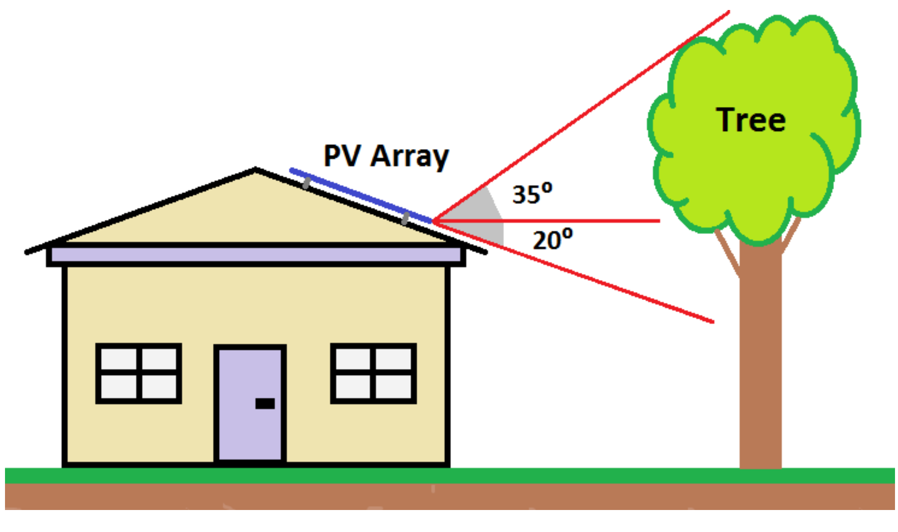


Figure 2.3.1(b) - Elevation

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	
	Feedback Have your teacher/trainer check your answers		✓

3. Completing the Skills Practice

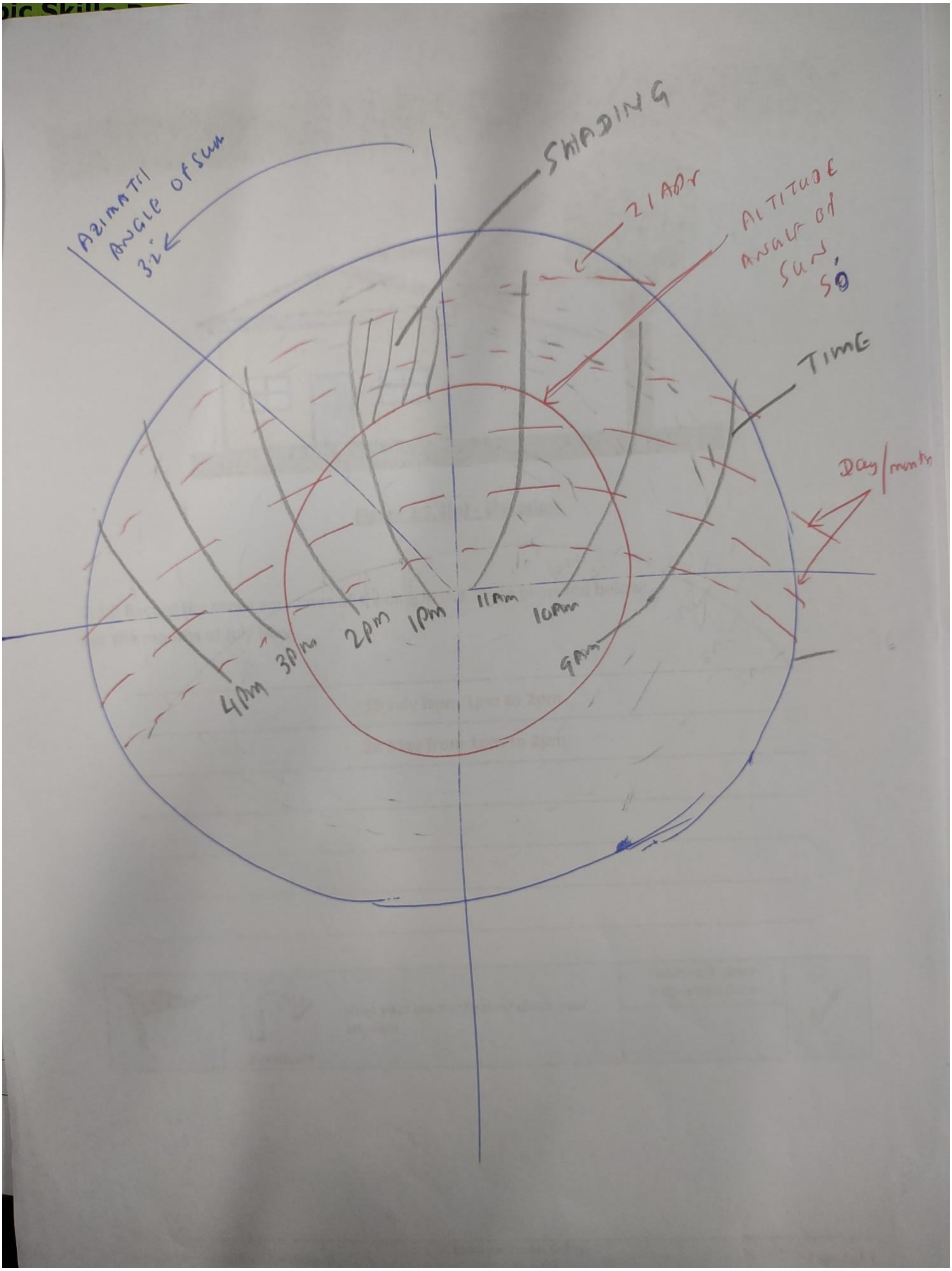
3.1 Skills Practice Review Questions

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
21 Apr
ALTITUDE ANGLE OF SUN, 50
AZIMATI ANGLE OF SUN 32
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**	✓

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:	

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.

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.

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**	✓

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

____

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

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:	

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.

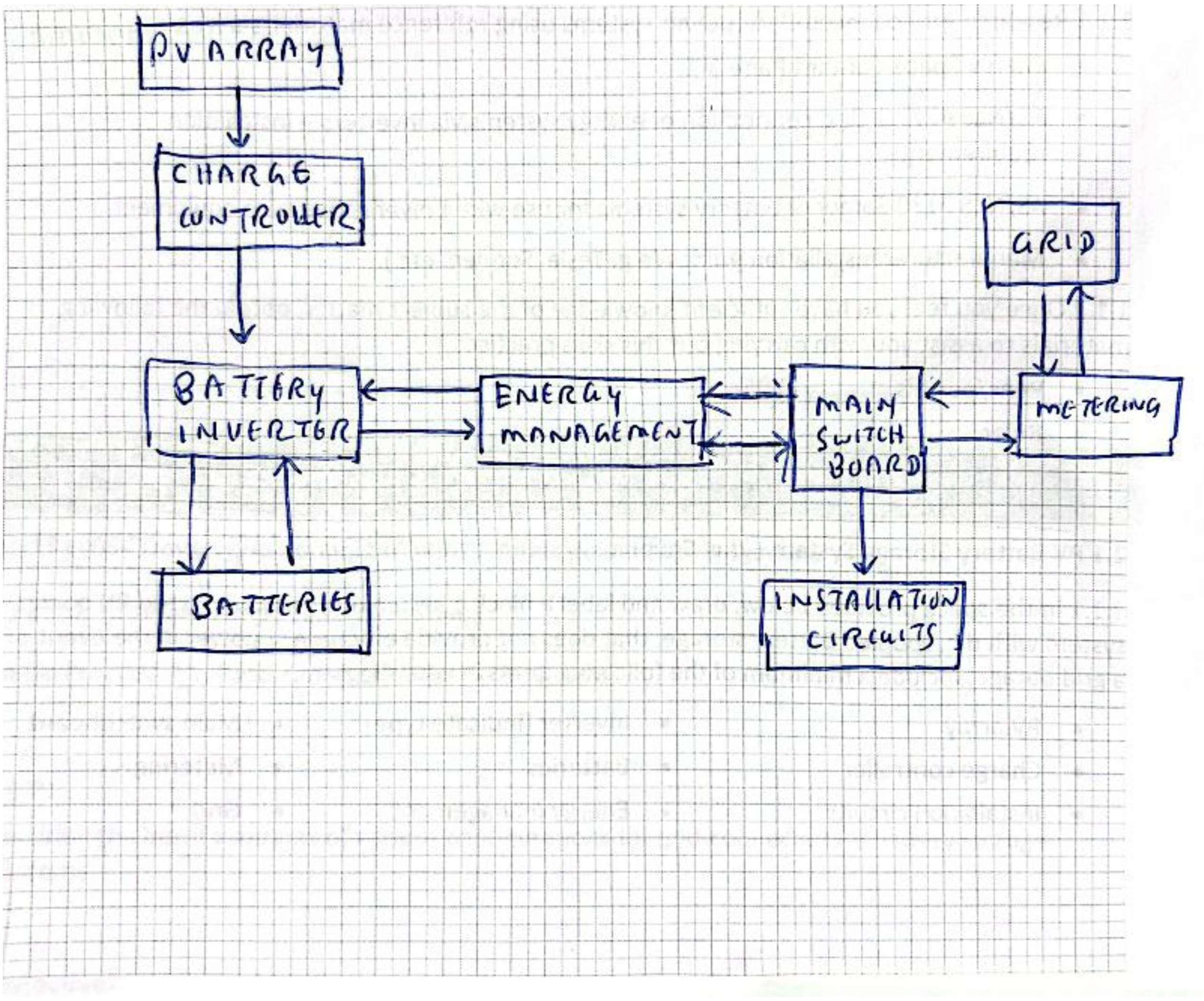
2. Carrying Out the Skills Practice

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



Feedback

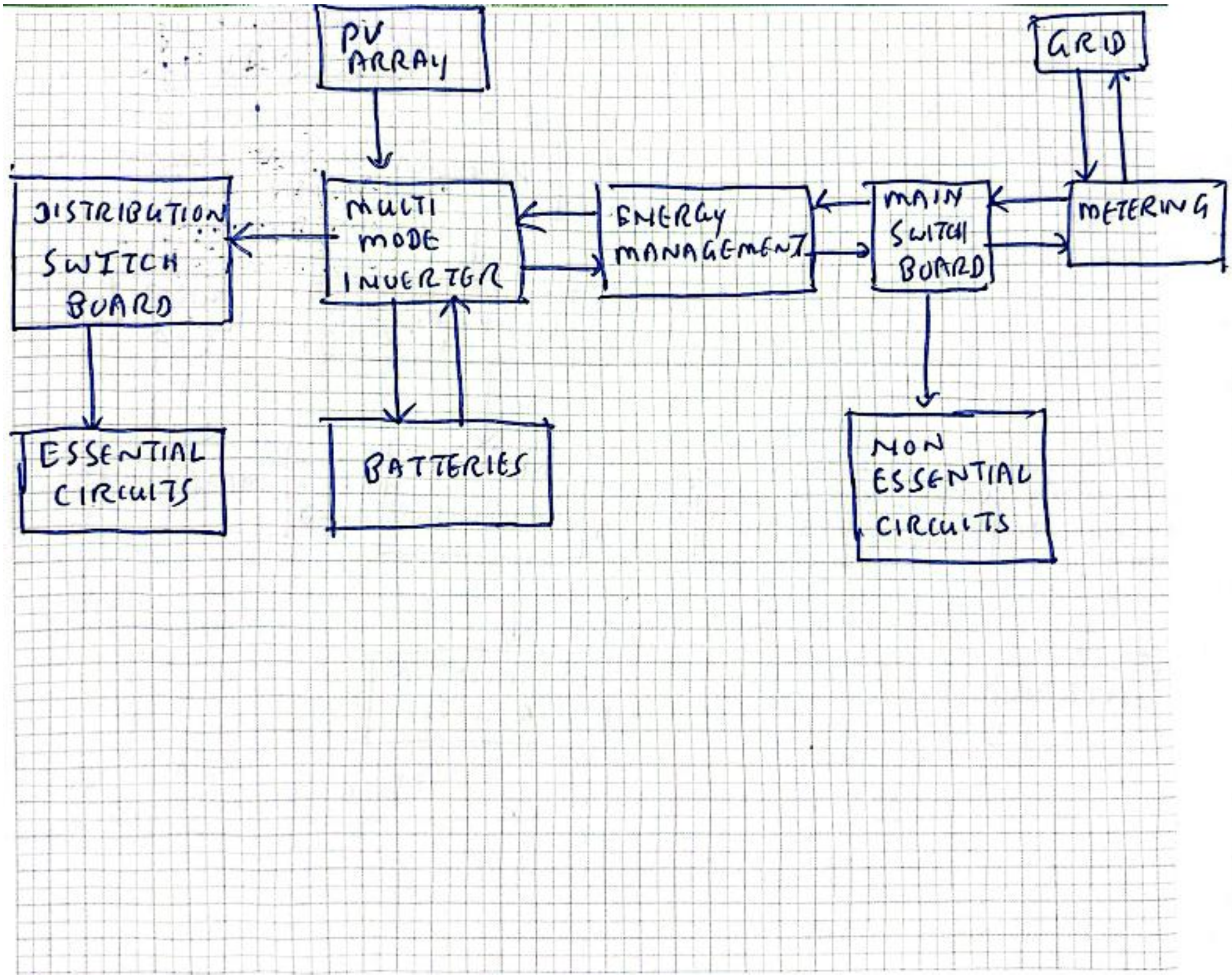
Have your teacher/trainer check your work

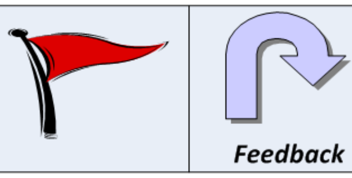
Teacher/Trainer Initials and Date	✓

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





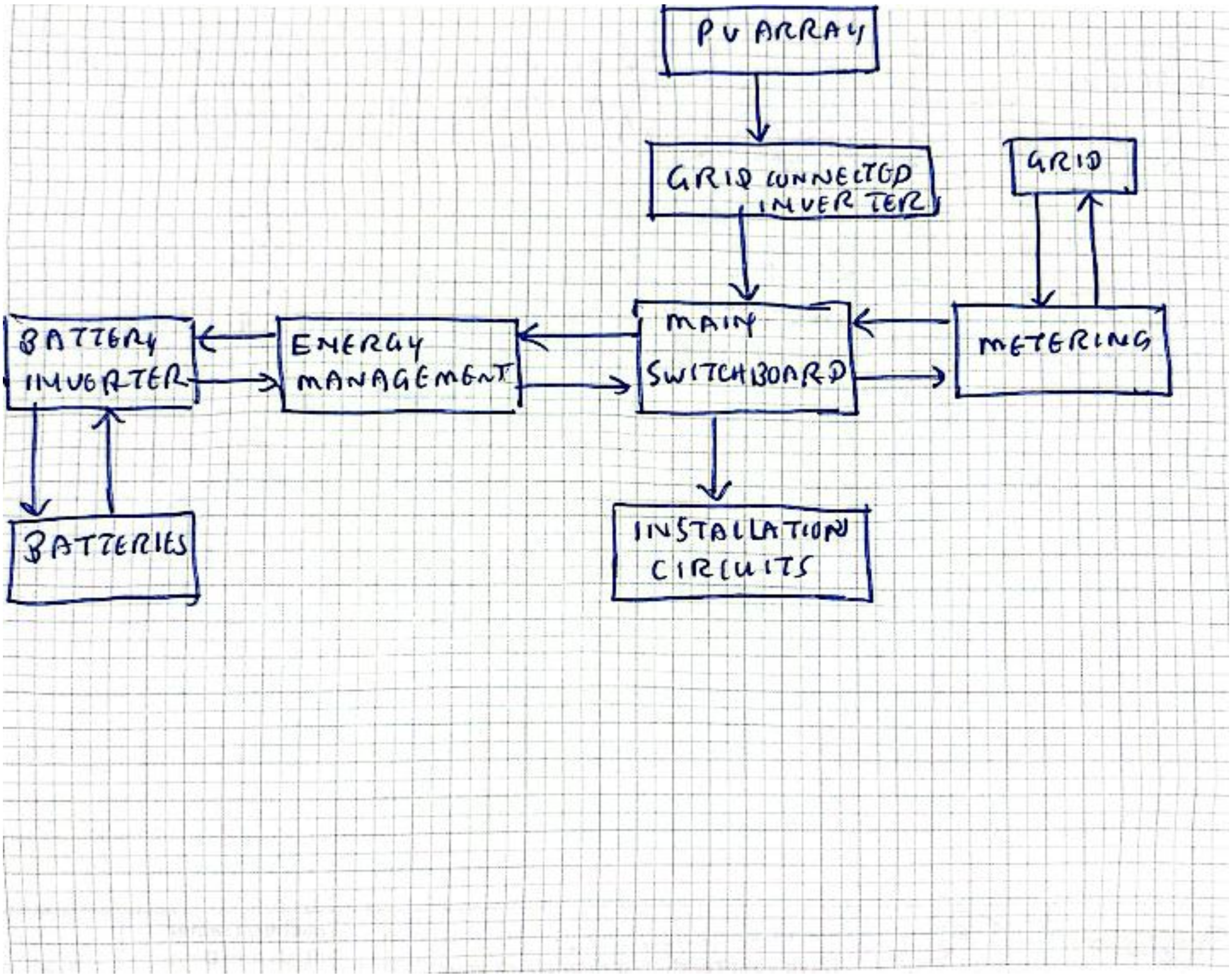
			Teacher/Trainer Initials and Date	✓
	Feedback	Have your teacher/trainer check your work		

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

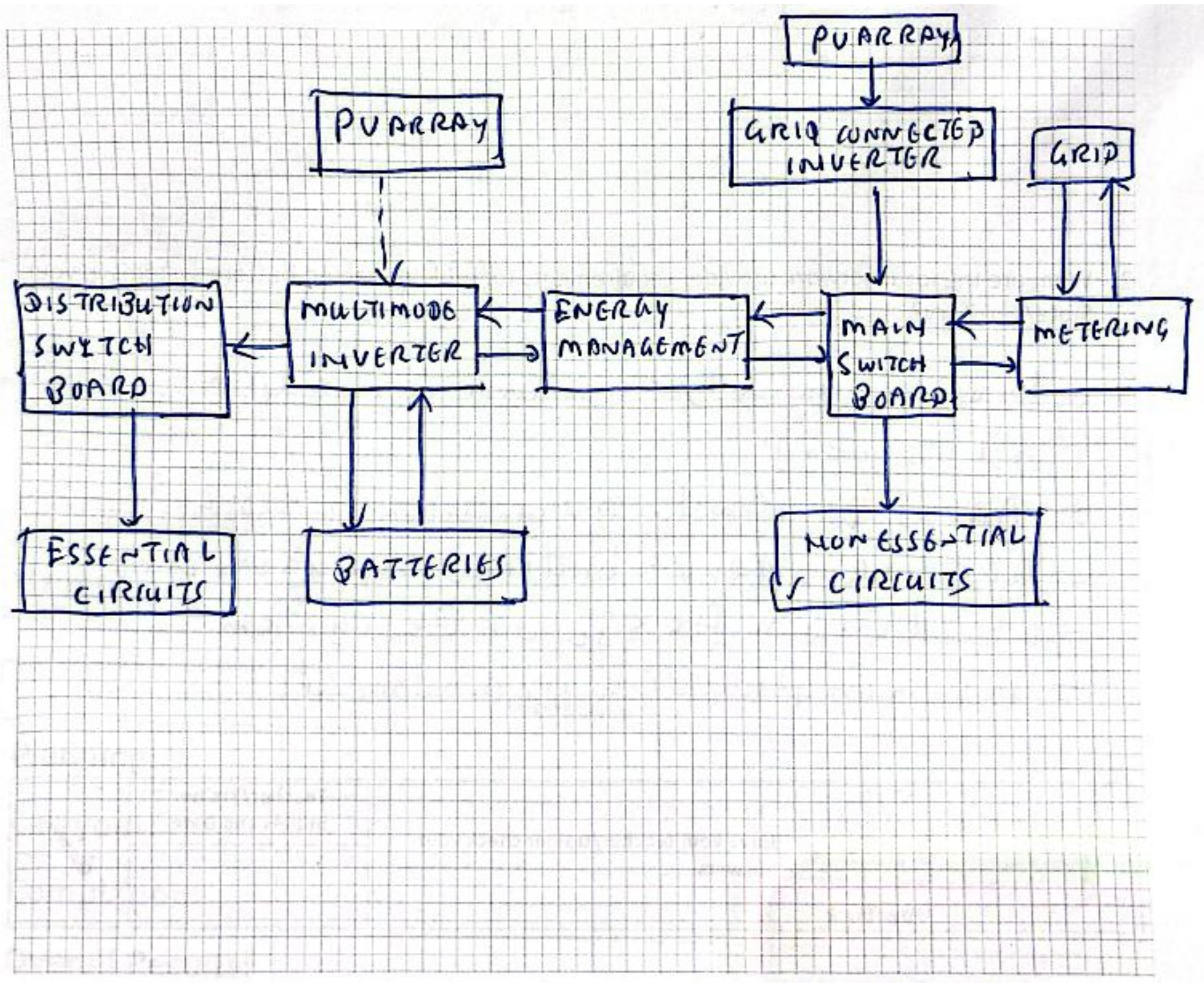


			Teacher/Trainer Initials and Date	
	Feedback	Have your teacher/trainer check your work		✓

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		✓

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

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

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**	✓

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:	

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.

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

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

Topic Skills Practice 4.4

3. Completing the Skills Practice

3.1 Hazard Assessment Checklist

□ Hazard assessment has been approved by works manager.

□ Hazard assessment has been communicated to relevant personnel.

□ Required work permits identified.

□ 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**	✓

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:	

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.

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

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

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?	☑	☐	

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?	☑	☐	

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.

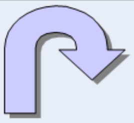
Laptops are mostly used in the system.

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

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: ____________________

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 $15.36 \times \frac{28}{100}$ = 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**	✓

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:	

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.

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

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

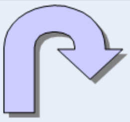
Topic Skills Practice 6.1

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.

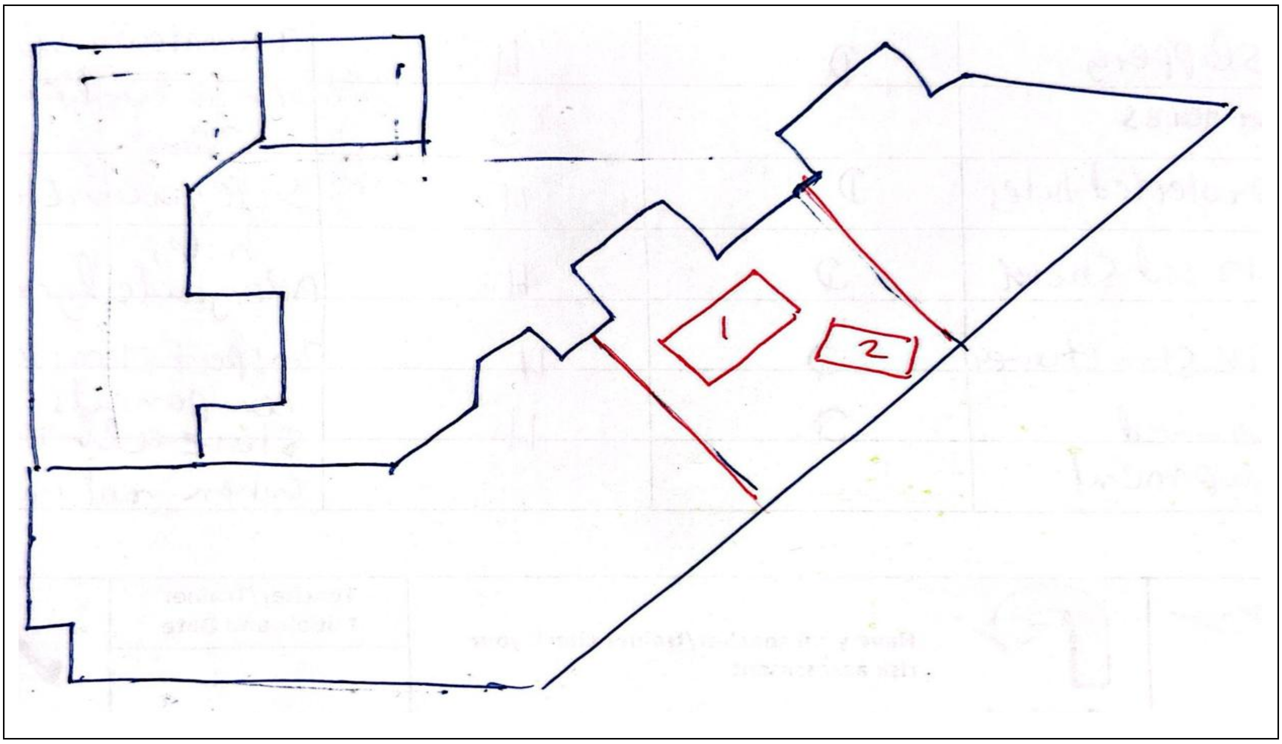
Safety Harness correctly fitted?	☑ Yes	☐ No
Lanyard correctly attached?	☑ Yes	☐ No

	 **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

Topic Skills Practice 6.1

necessary.

	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 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

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

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:	

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).

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**	✓

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

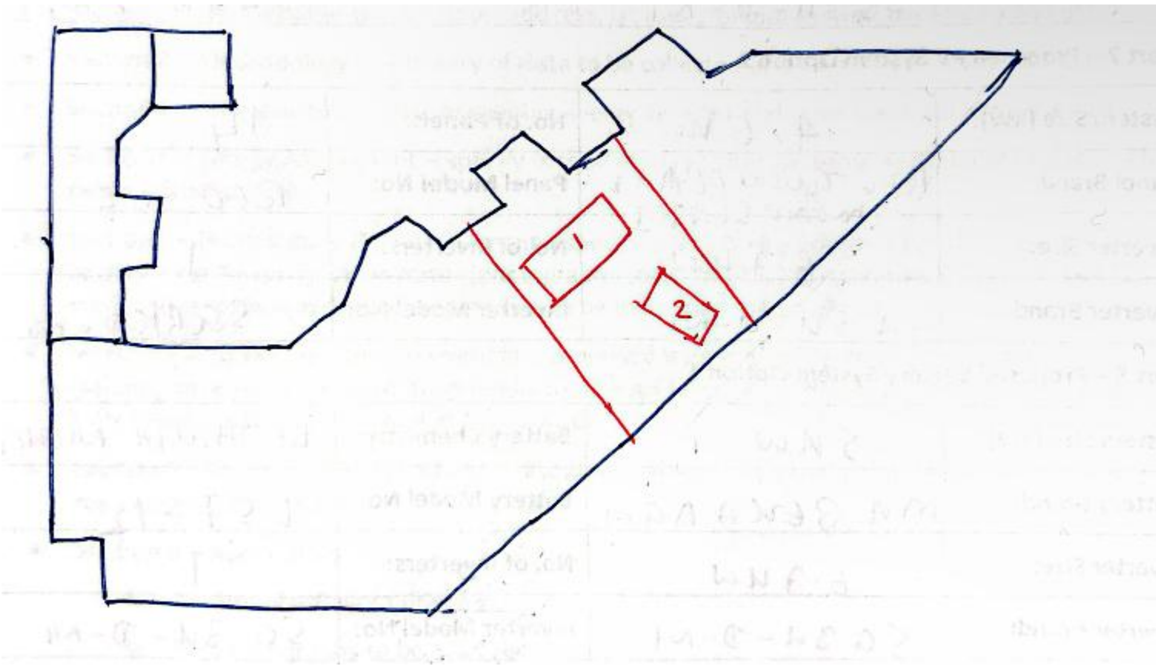
Install timer to switch off the light

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

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)*

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

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

Topic Skills Practice 6.3

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

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

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

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

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

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

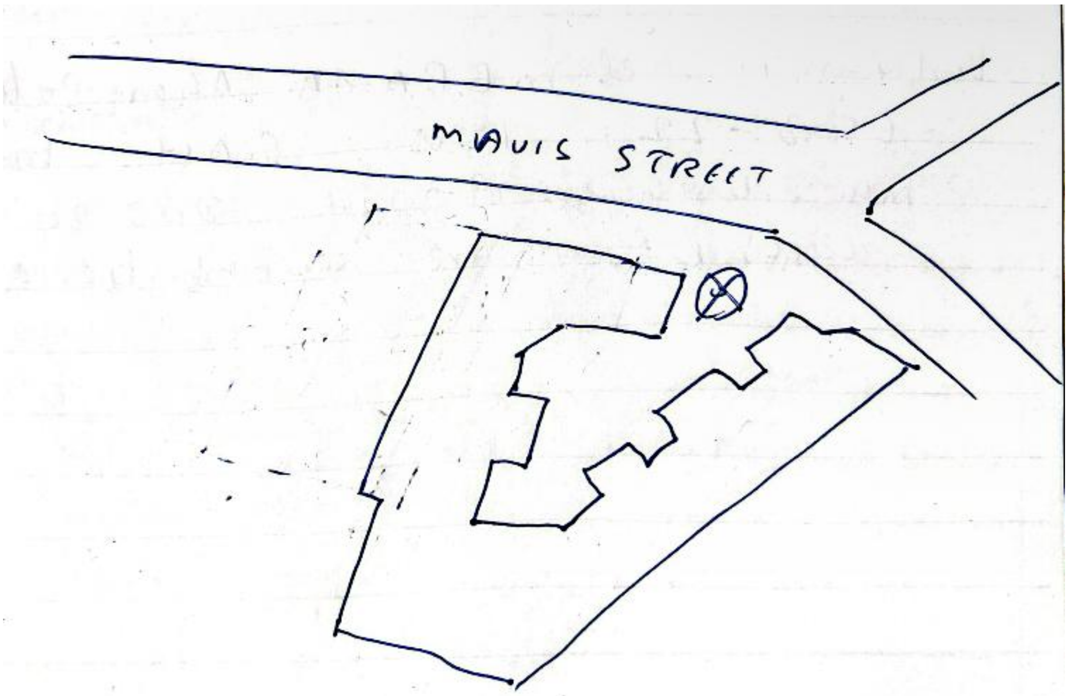
Network provider requirements: Minimum quality standard for output voltage and frequency access to remote monitoring, acceptable type of battery/inverter /Limitation on size of system

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)*



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

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

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

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

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:	

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	1.2 Suggested Materials	1.3 Miscellaneous Items
• Solarimeter • Sun path diagram • Computer	• GPS • Solar configuration software	• 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/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

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

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

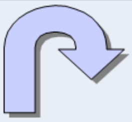
Install Solar Radiation Meter (ORJA) APP Google Store, Play

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.

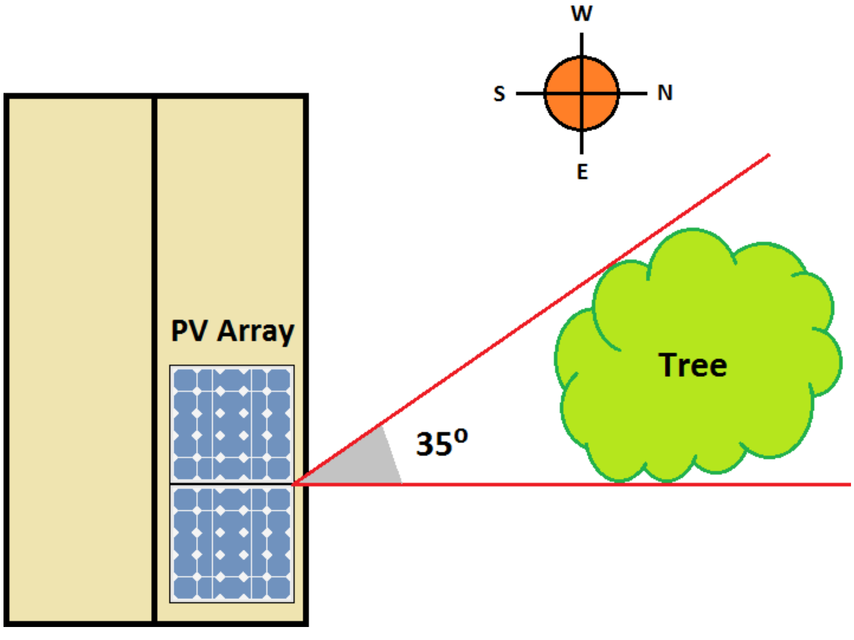


Figure 2.3.1(a) - Overview

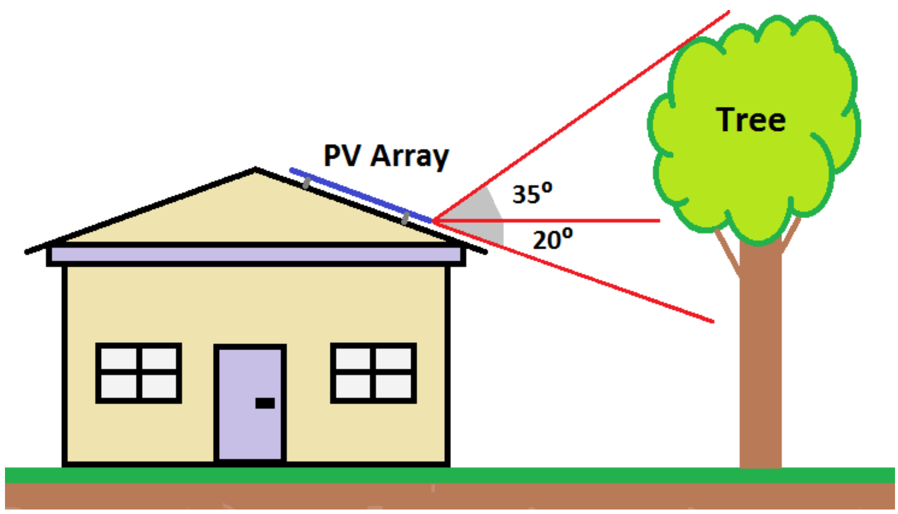


Figure 2.3.1(b) - Elevation

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	
	Feedback Have your teacher/trainer check your answers		✓

3. Completing the Skills Practice

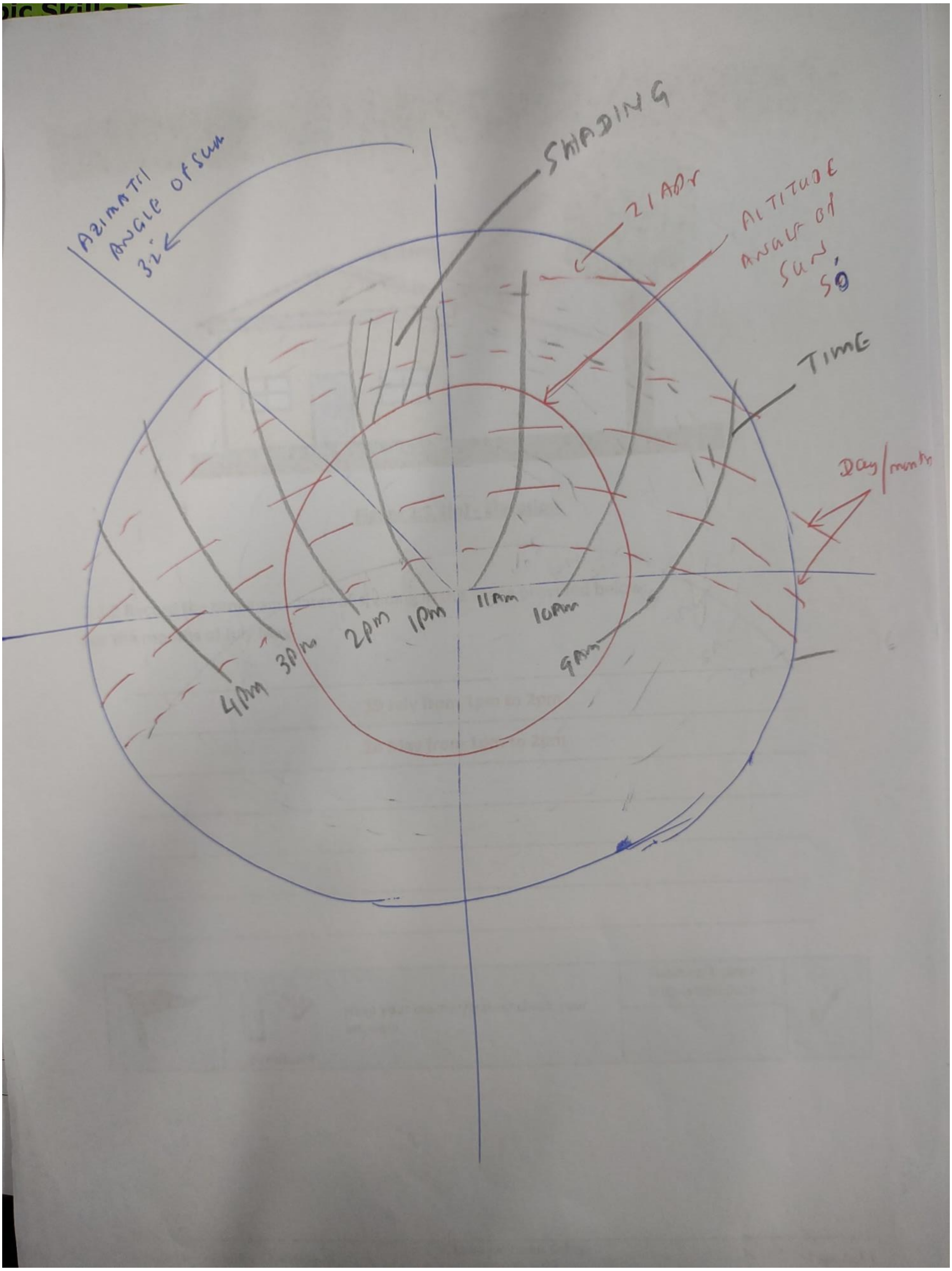
3.1 Skills Practice Review Questions

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

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

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.

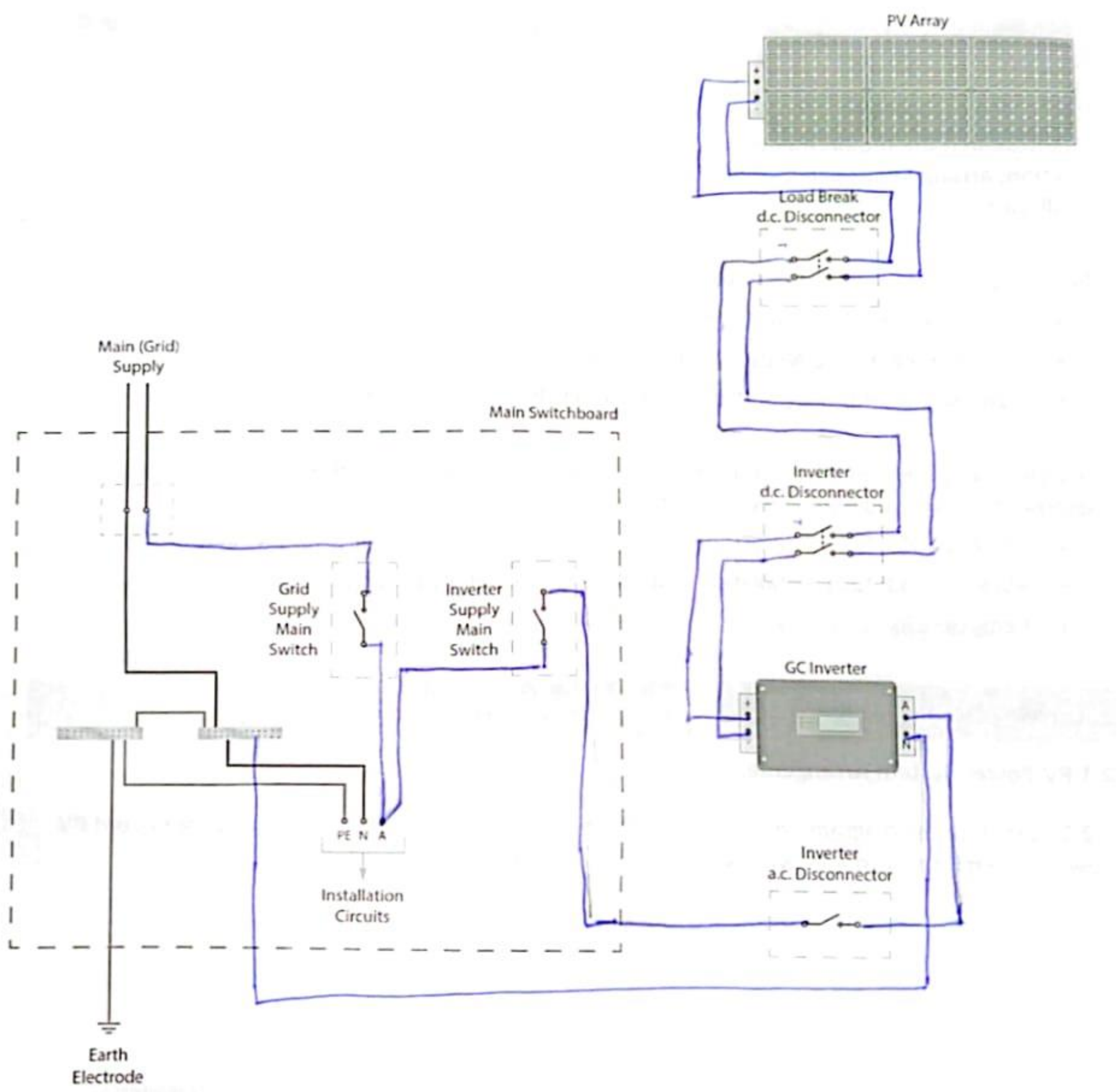
	Feedback	**Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

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:	

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

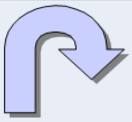
Module Type:		No. of Modules:	
MPP Power:		Efficiency:	
MPP Voltage:		O/C Voltage:	
MPP Current:		S/C Current:	

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

	 ***Feedback*** **Have your teacher/trainer check your work**	**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:	

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**	✓

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:	

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.

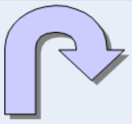
Topic Skills Practice 6.2

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	
	 Feedback	Have your teacher/trainer check your risk assessment		✓

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

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

Topic Skills Practice 6.2

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

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

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

2.3 Select Optimal Array Position

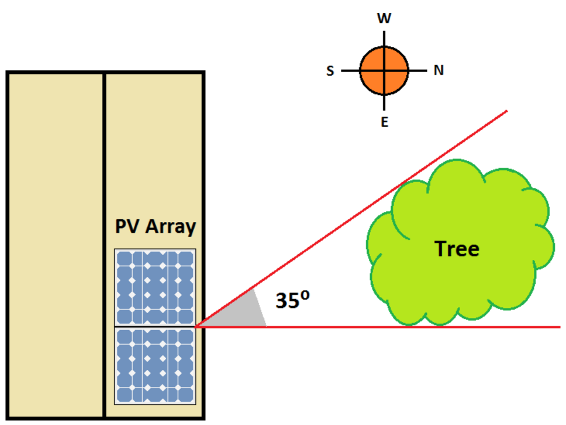
Topic Skills Practice 6.2

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.

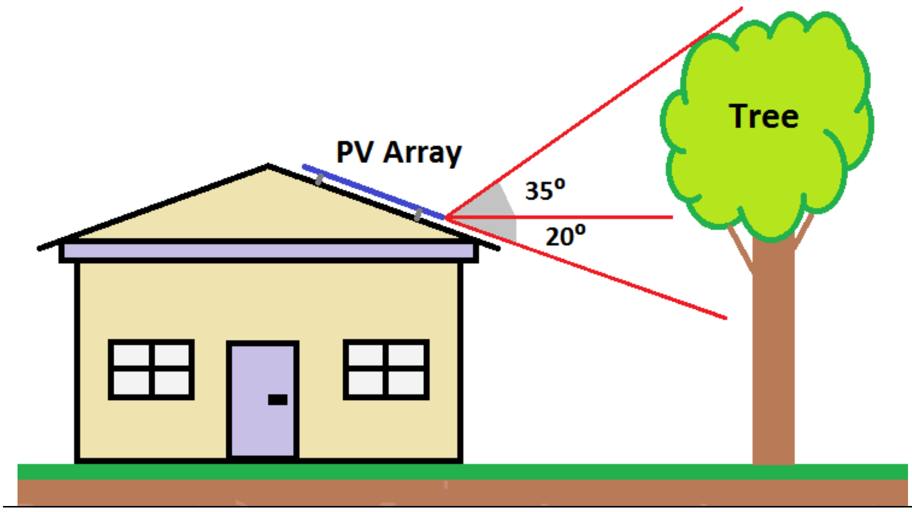
2.3.2 Indicate the optimal tilt angle and the orientation of your array in the table provided below.

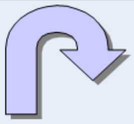
Tilt Angle	Orientation
35 degree	North

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:



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

Topic Skills Practice 6.2

	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:	

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.

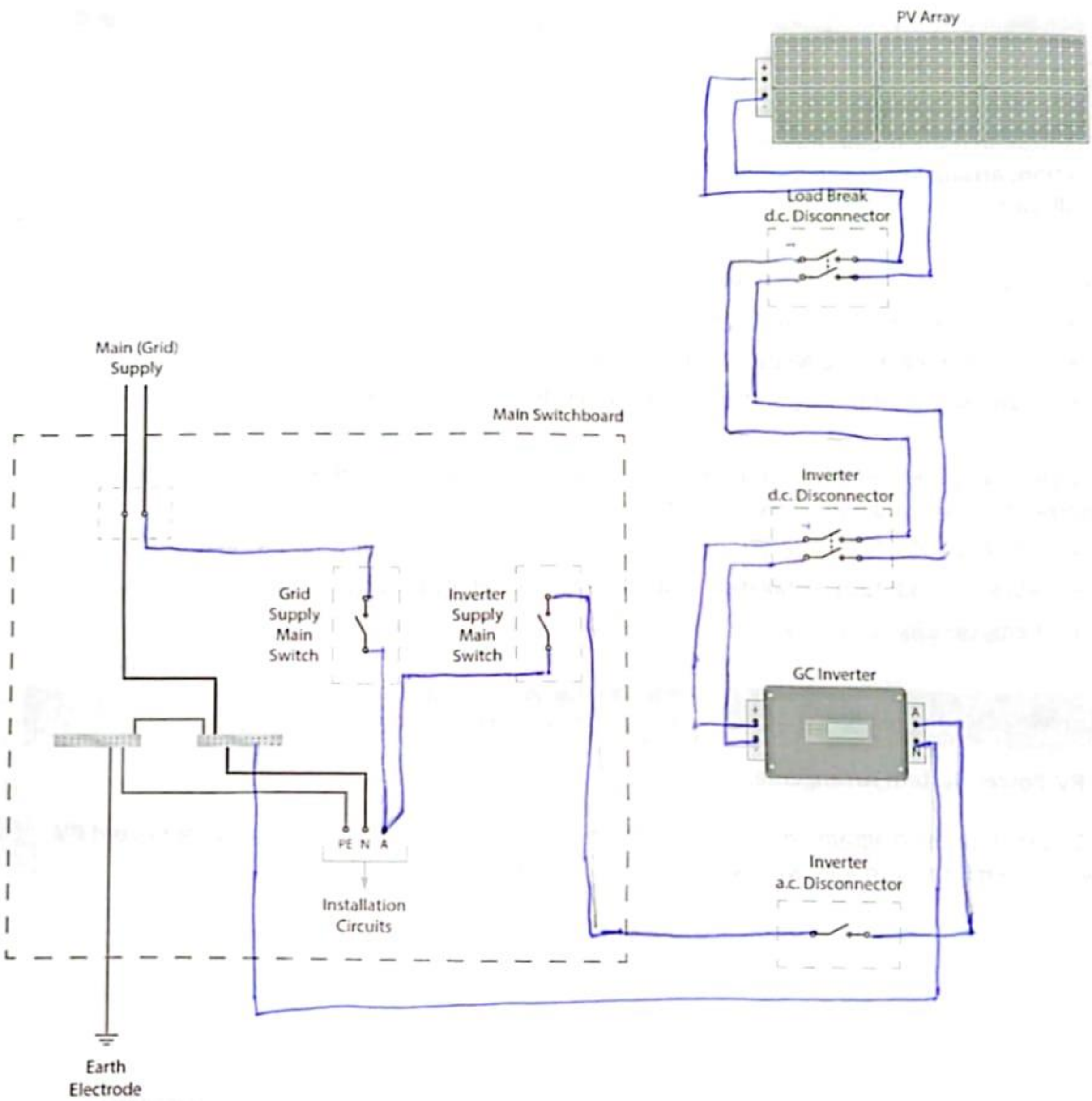
	 ***Feedback*** **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

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:	

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

	Feedback Have your teacher/trainer check your work	**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.

<u>PV System 2 – Details</u>

Description: ______________________________

____

____

Manufacturer: ______________________________

Product No: ______________________________

Cost: ______________________________

<u>Array Parameters</u>

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

<u>Inverter Parameters</u>

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

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	✓

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:	

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.

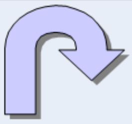
Topic Skills Practice 6.2

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

	 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

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

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

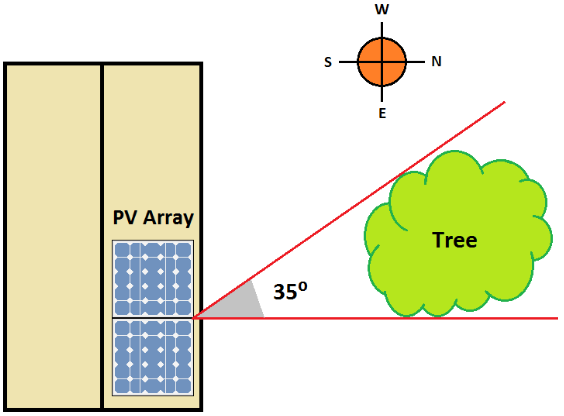
Topic Skills Practice 6.2

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.

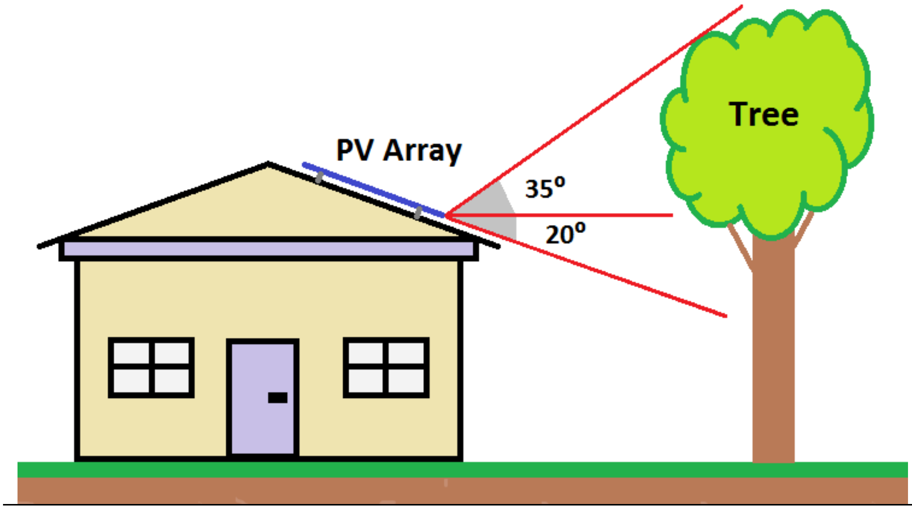
2.3.2 Indicate the optimal tilt angle and the orientation of your array in the table provided below.

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:



Topic Skills Practice 6.2



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

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

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 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:	

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.

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.

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**	✓

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**	✓

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:	

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.

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

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

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?	☑	☐	

Topic Skills Practice 5.2

Part 5 – Climate Control Systems					
Avg. Temperatures:	Summer (^oC): 25			Winter (^oC): 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)	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?	☑	☐	

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

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.

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

Energy Consumption: ______________

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**	✓

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:	

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).

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**	✓

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

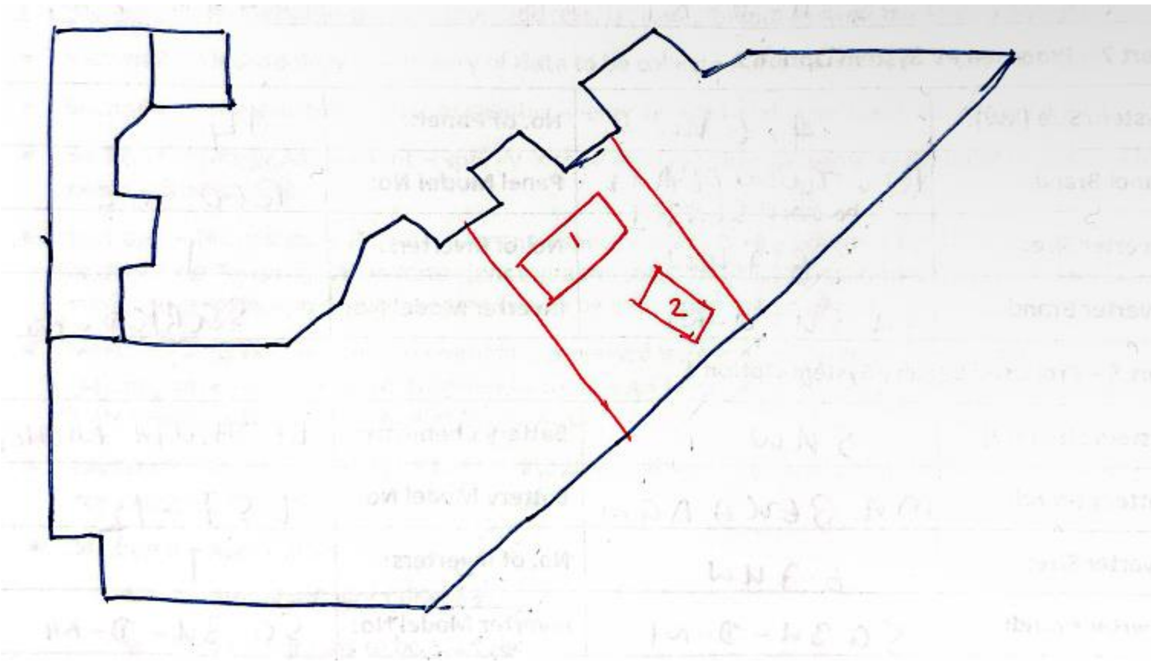
Install timer to switch off the light

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

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)*

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

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

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

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

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

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

Topic Skills Practice 6.3

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

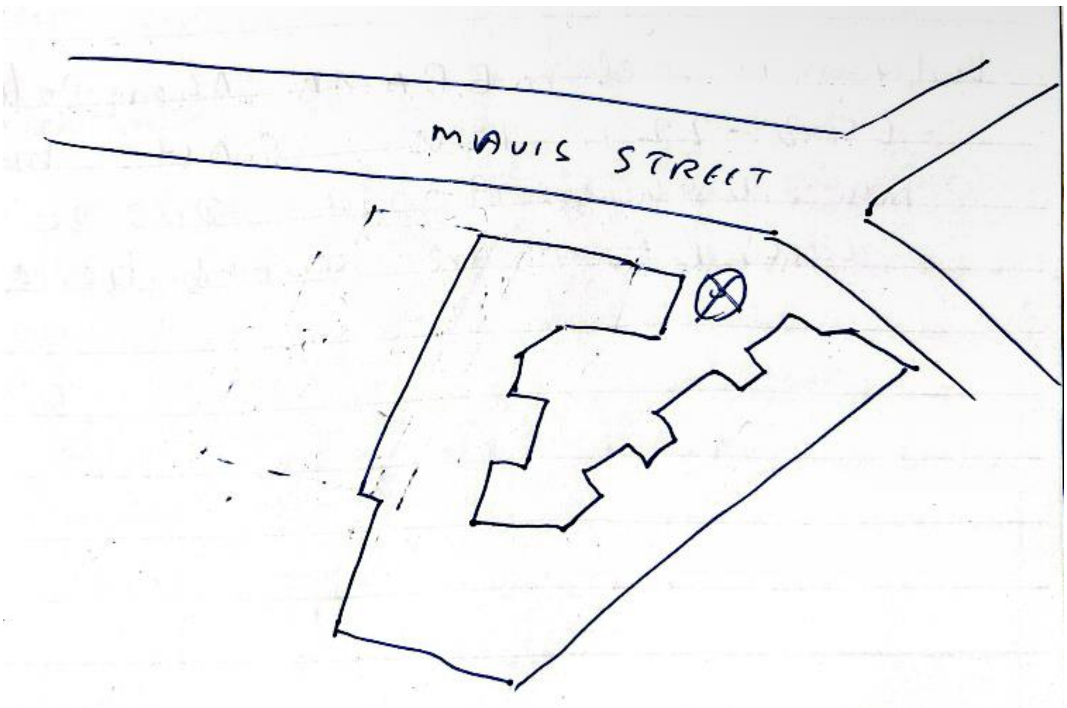
Applicable regulations: ACCREDITED SOLAR INSTALLER

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.

☑ Proposed location for inverter photograph attached. ☑ Proposed location for batteries photograph attached.

		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 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

Topic Skills Practice 6.3

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

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	Grid Connected PV Systems

Skill Practice Number:	1.1
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 1.1

UEERE0080 Install photovoltaic power conversion equipment to grid

UEERE0081 Install photovoltaic systems to power conversion equipment

Topic 1. Grid Connected PV Systems

Skills Practice 1.1: 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.

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 1.1.

Topic Skills Practice 1.1

- 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:

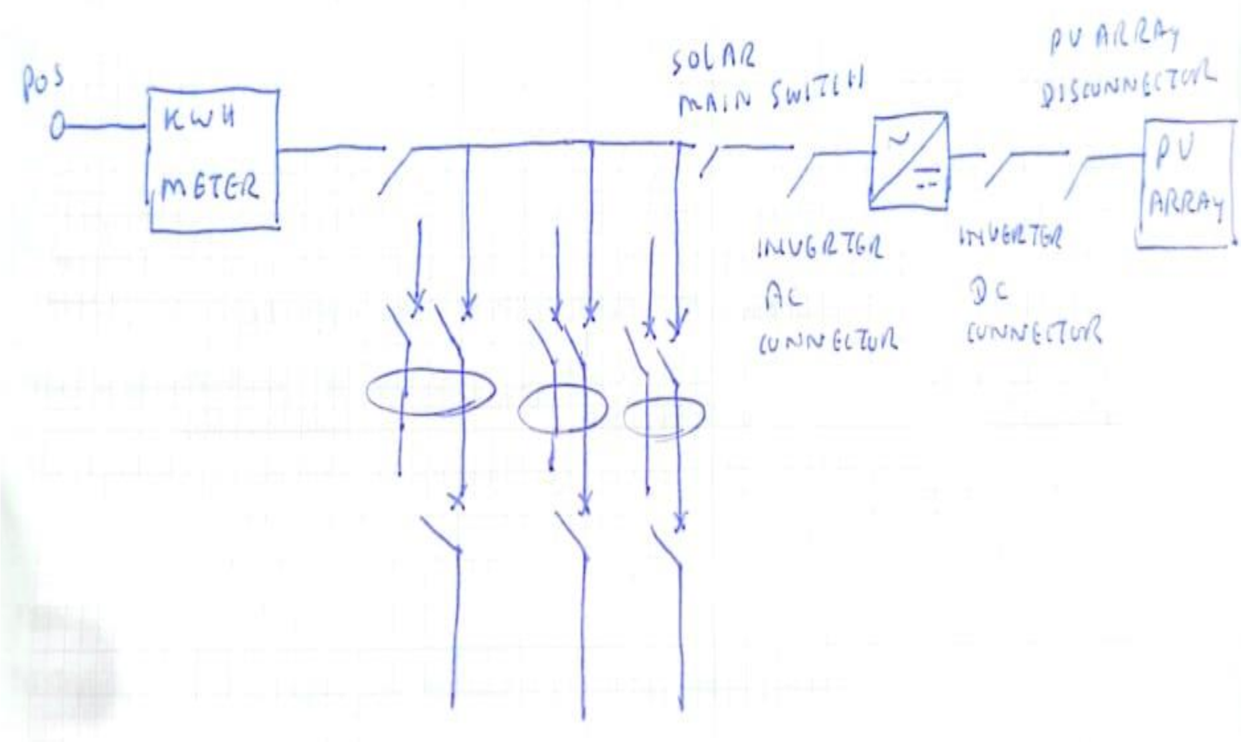
- Pens/pencils
- Ruler

2. Carrying Out the Skills Practice

2.1 Grid-Connected PV System – Block Diagram 1

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.



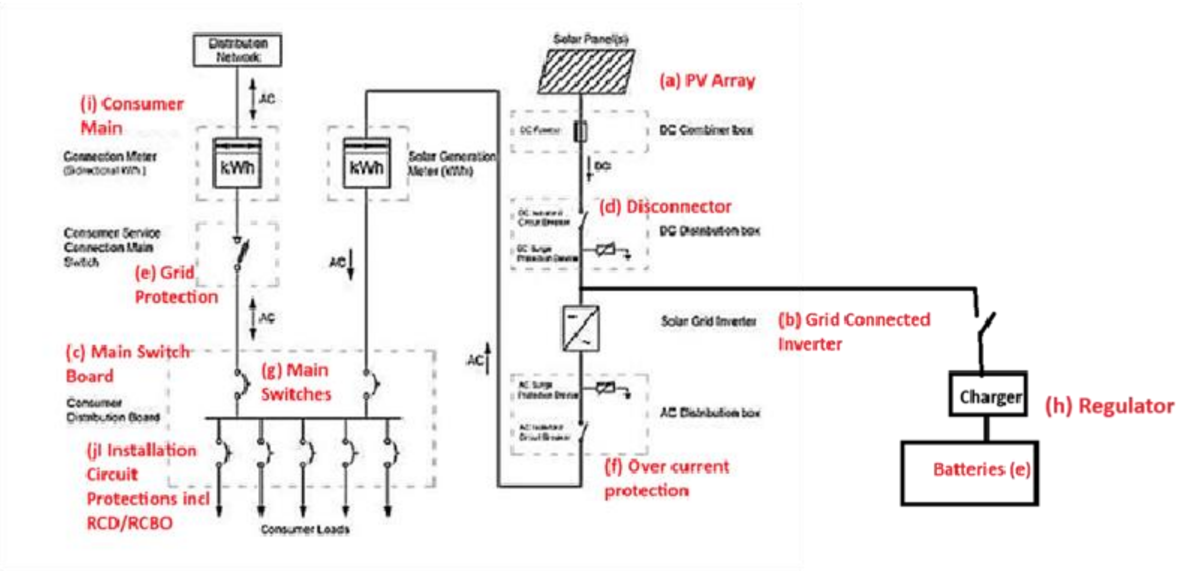
	Have your teacher/trainer check your work ***Feedback***	**Teacher/Trainer Initials and Date**	✓

Topic Skills Practice 1.1

2.2 Grid-Connected PV System – Block Diagram 2

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

a) PV array.
b) GC inverter.
c) Disconnectors.
d) Protection devices.
e) Main switchboard.
f) Metering.
g) Battery bank.
h) Regulator.



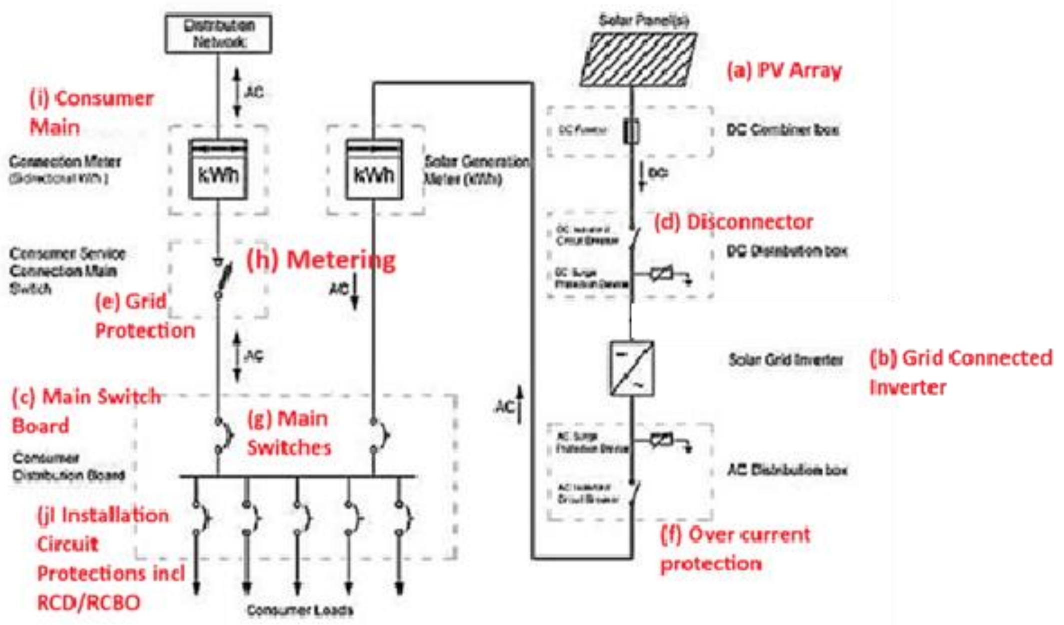
Topic Skills Practice 1.1

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

2.3 Grid-Connected PV System – Circuit Diagram 1

2.3.1 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) Grid protection.
f) Overcurrent protection.
g) Main switches.
h) Metering.
i) Consumer mains.
j) Installation circuit protection (incl. RCDs).



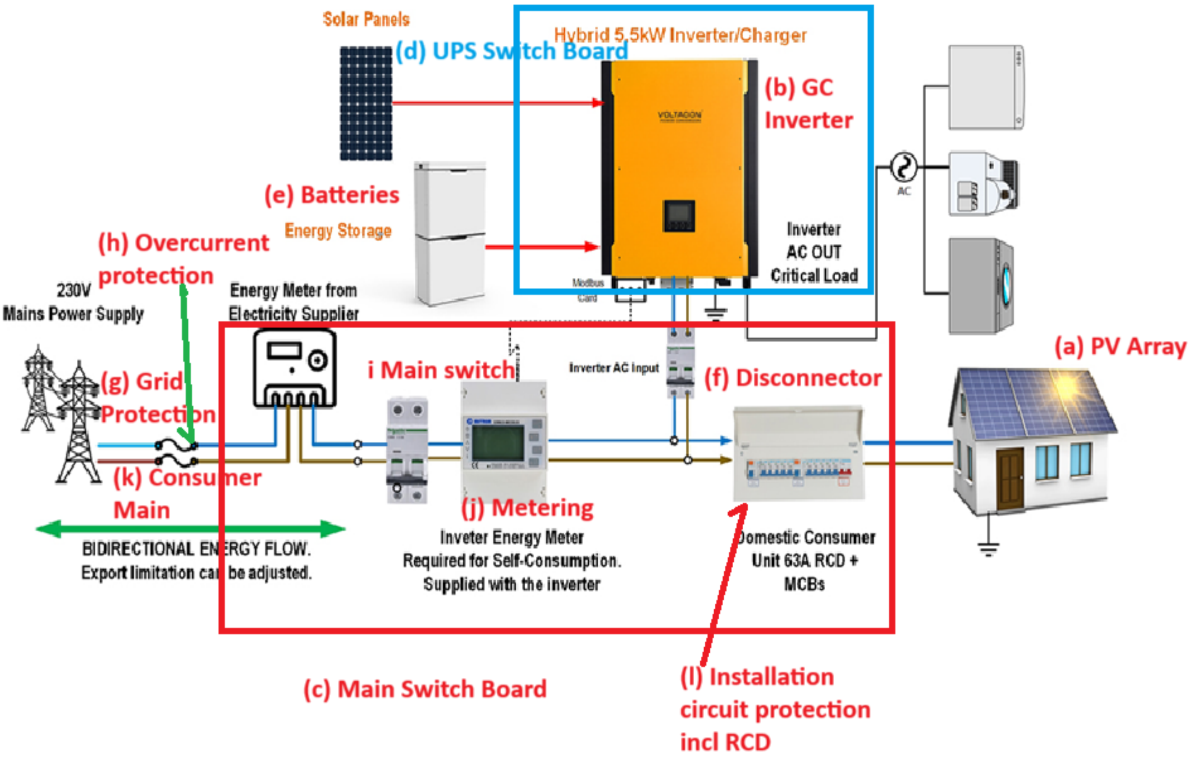
Topic Skills Practice 1.1

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

2.4 Grid-Connected PV System – Circuit Diagram 2

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

a) PV array.
b) GC inverter.
c) Main switchboard.
d) UPS switchboard.
e) Batteries.
f) Disconnectors.
g) Grid protection.
h) Overcurrent protection.
i) Main switches.
j) Metering.
k) Consumer mains.
l) Installation circuit protection (incl. RCDs).



Topic Skills Practice 1.1

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 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.

Islanding is the electrical phenomenon in a section of a power network disconnected from the main supply, where the loads in that disconnected section are entirely powered by PV-systems and where the voltage and frequency are maintained around nominal values.

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

Active anti-islanding protection in grid-connected solar power systems involves actively monitoring the grid for disturbances and quickly disconnecting the solar inverter if a grid failure (islanding) is detected. This is crucial for safety, preventing the inverter from continuing to feed power into a disconnected section of the grid, which could be dangerous for utility workers or cause damage.

3. What are the AS/NZS 4777.1 requirements for the main isolating switch of the switchboard to which a grid-connected PV power system is connected?

AS/NZS 4777.1 requires that any switchboard connected to a grid-connected PV power system must have a clearly marked main isolating switch that disconnects all final sub-circuits and sub-mains originating from that switchboard. For systems with multiple inverters, isolation switches for the inverter supply must be grouped, and if there are more than two inverters, a single main switch (inverter supply) is required for isolation.

4. How should a grid-connected PV power system be connected to an installation with respect to the installation RCDs?

Grid-connected photovoltaic (PV) systems should be connected to an installation in a way that complements the existing RCDs (Residual Current Devices) without causing nuisance tripping. This typically involves careful consideration of the inverter type and its potential to introduce DC leakage currents that could affect the RCDs. Specific regulations and standards, like AS/NZS 5033 and AS/NZS 4777.2, guide the installation process.

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

U Kyaw Naing

Strong

VIEW MY IDENTITY

My devices

See all

moto g 50 plus

Explore myID

How to use it

ID strength...

Where to use it

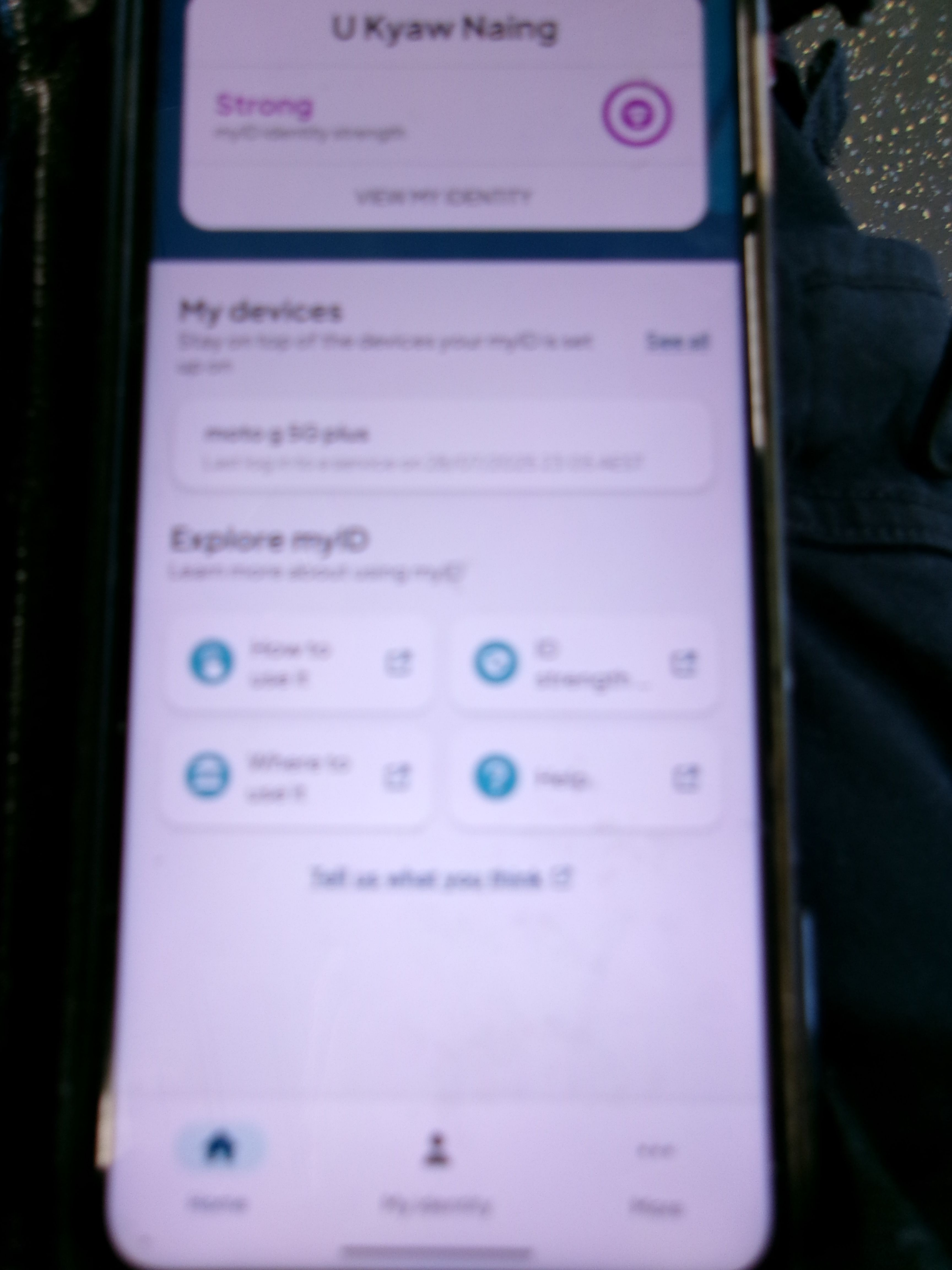
Help

Tell us what you think

Home

My identity

More


U Kyaw Naing
Strong
My devices
See all
Explore myID

U Kyaw Naing

Strong

myID identity strength

VIEW MY IDENTITY

My devices

See all

moto g 50 plus

Explore myID

How to use it

ID strength...

Where to use it

Help

Tell us what you think

Home

My identity

More

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0061 Design grid-connected photovoltaic power supply systems UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	Grid Connected PV Systems

Skill Practice Number:	1.3
Skill Practice Name:	Determine Solar Access

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

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

Topic Skills Practice 1.3

UEERE0061 Design grid-connected photovoltaic power supply systems

UEERE0080 Install photovoltaic power conversion equipment to grid

UEERE0081 Install photovoltaic systems to power conversion equipment

Topic 1 -Grid Connected PV Systems

Skills Practice 1.3 - 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. Finally, you will estimate the expected solar energy yield for the installation.

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 1.3

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

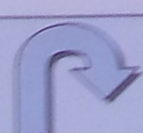
- Pens/pencils.
- Calculator.
- Internet access.

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	✓

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
41 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/m² $Kw/m = \frac{MJ/m^2}{3.6} = \frac{18}{3.6} = 5\ Kw/m$

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

	Have your teacher/trainer check your answers *Feedback*	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

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
30	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:

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	✓

2.4 Estimate Solar Energy Yield

2.4.1 Finally, estimate the average monthly energy yield for the array specifications provided by your teacher/trainer, taking into account the PSH, array location and any shading as applicable. Indicate your answer in the table below, and show any working in the remaining space on this page.

Average Monthly Energy Yield
120 KWH/m^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, and then complete the following questions.

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

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

REFERENCE & PRACTICAL

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

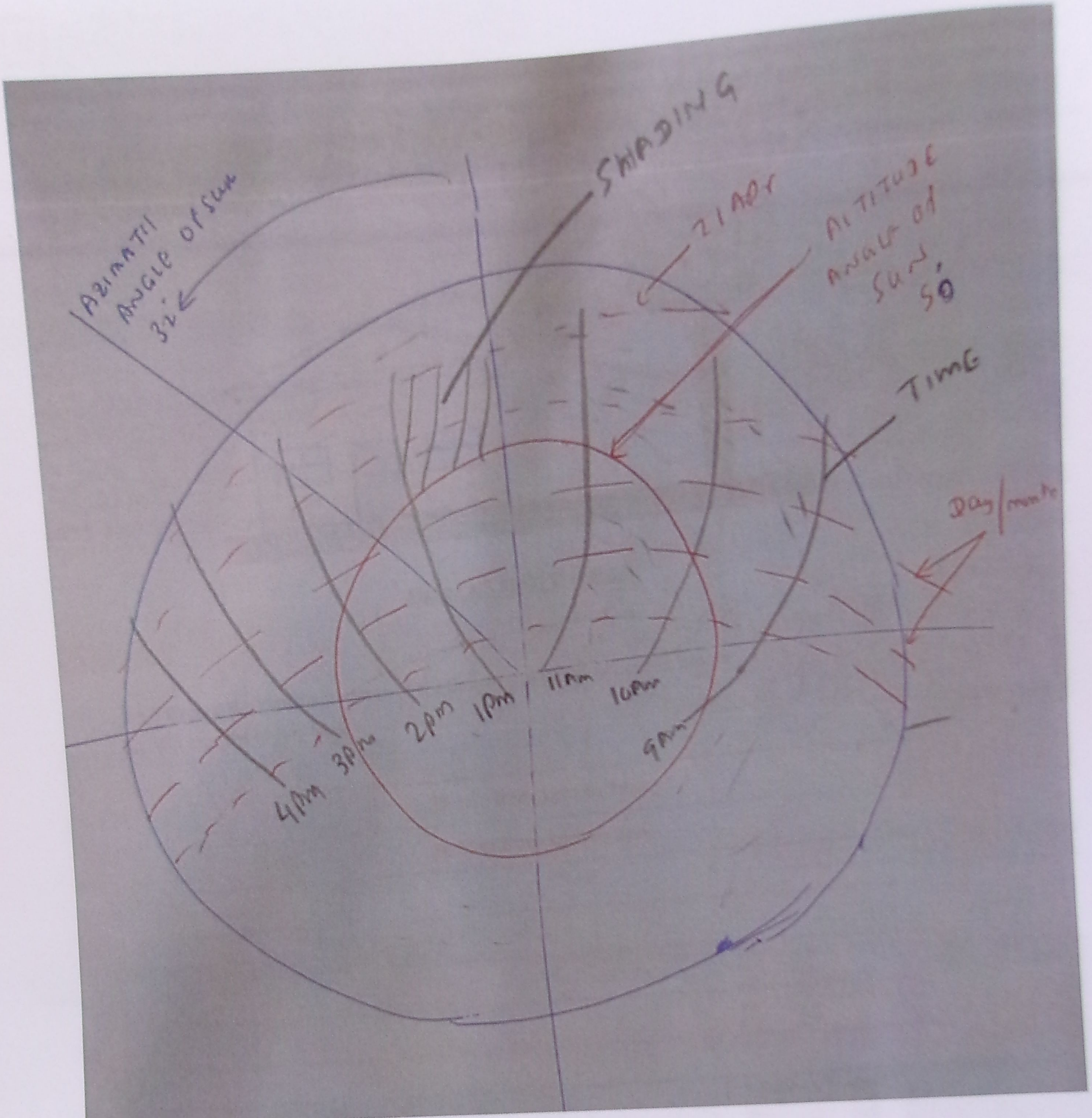
https://footprinthero.com/solar-panel-tilt-angle-calculator

Metrology

http://www.bom.gov.au

Latitude

www.latlong.net



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

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0061 Design grid-connected photovoltaic power supply systems UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	PV Arrays

Skill Practice Number:	3.1
Skill Practice Name:	PV Array Configurations

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

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

Topic Skills Practice 3.1

UEERE0061 Design grid-connected photovoltaic power supply systems

UEERE0080 Install photovoltaic power conversion equipment to grid

UEERE0081 Install photovoltaic systems to power conversion equipment

Topic 3. PV Arrays

Skills Practice 3.1: PV Array Configurations

Task:

To draw a PV array wiring diagram, indicating the connections between modules, bypass diodes and blocking diodes, and the polarity of the array output.

Objectives:

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

- Draw in the wiring connections necessary to correctly connect PV modules into an array.
- Draw in the wiring connections necessary to correctly connect bypass diodes into an array.
- Draw in the wiring connections necessary to correctly connect blocking diodes into an array.

1. Planning the Skills Practice

1.1 Research PV Array Configuration

1.1.1 Research reference material to identify the wiring arrangements used to connect PV arrays. The following references will include some useful information:

- Energy Space Content Page 3.1.
- Photovoltaic Power Systems – Resource Book, Commonwealth of Australia and Brisbane Institute of TAFE.

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 PV Array Wiring Diagram 1

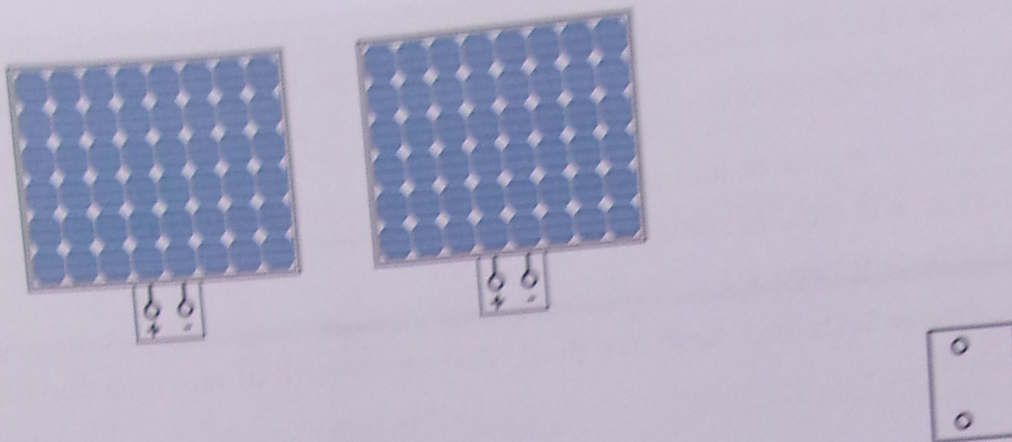
2.1.1 On the following page, draw in all the necessary bypass diodes, blocking diodes and wiring connections, to create a PV array with the following *approximate* output parameters (neglect derating):

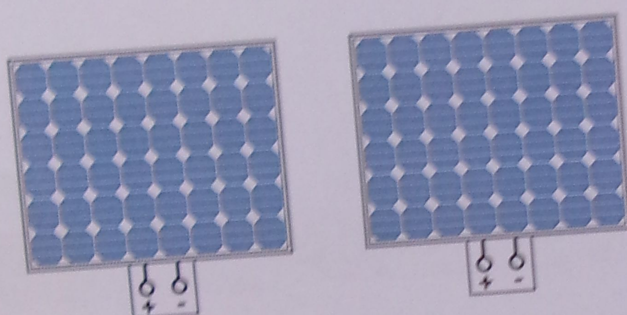
- Output Power (max): 0.8 kW.
- Output Voltage (max): 48 V.
- Output Current (max): 16.7 A.

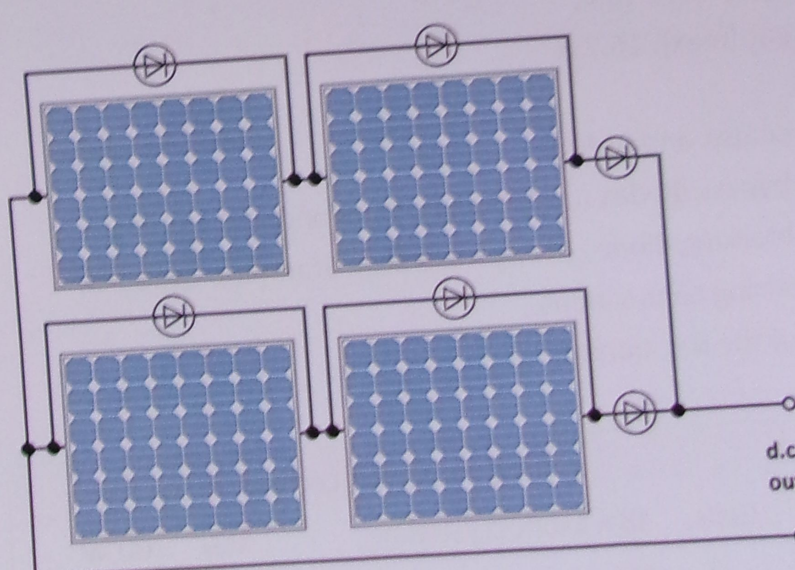
Draw your diagram neatly, and include:

- All required bypass diodes (using Australian Standard symbols).
- All required blocking diodes (using Australian Standard symbols).
- All required wiring connections.
- The polarity of the d.c. output.

Module Specifications			
Cells:	48 x Monocrystalline	P_{MP}	200 W
V_{OC}	29.1 V	I_{SC}	9.0 A
V_{MP}	23.8 V	I_{MP}	8.3 A





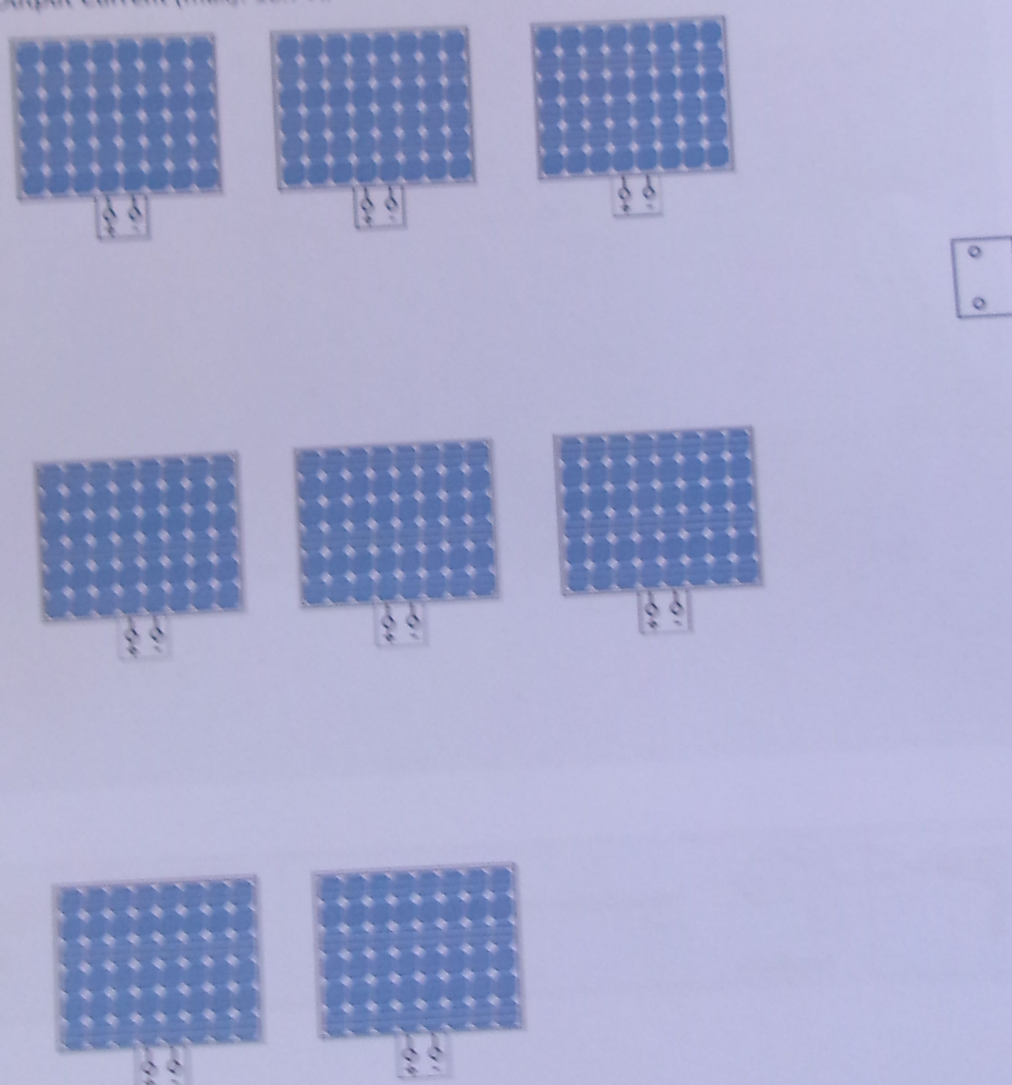


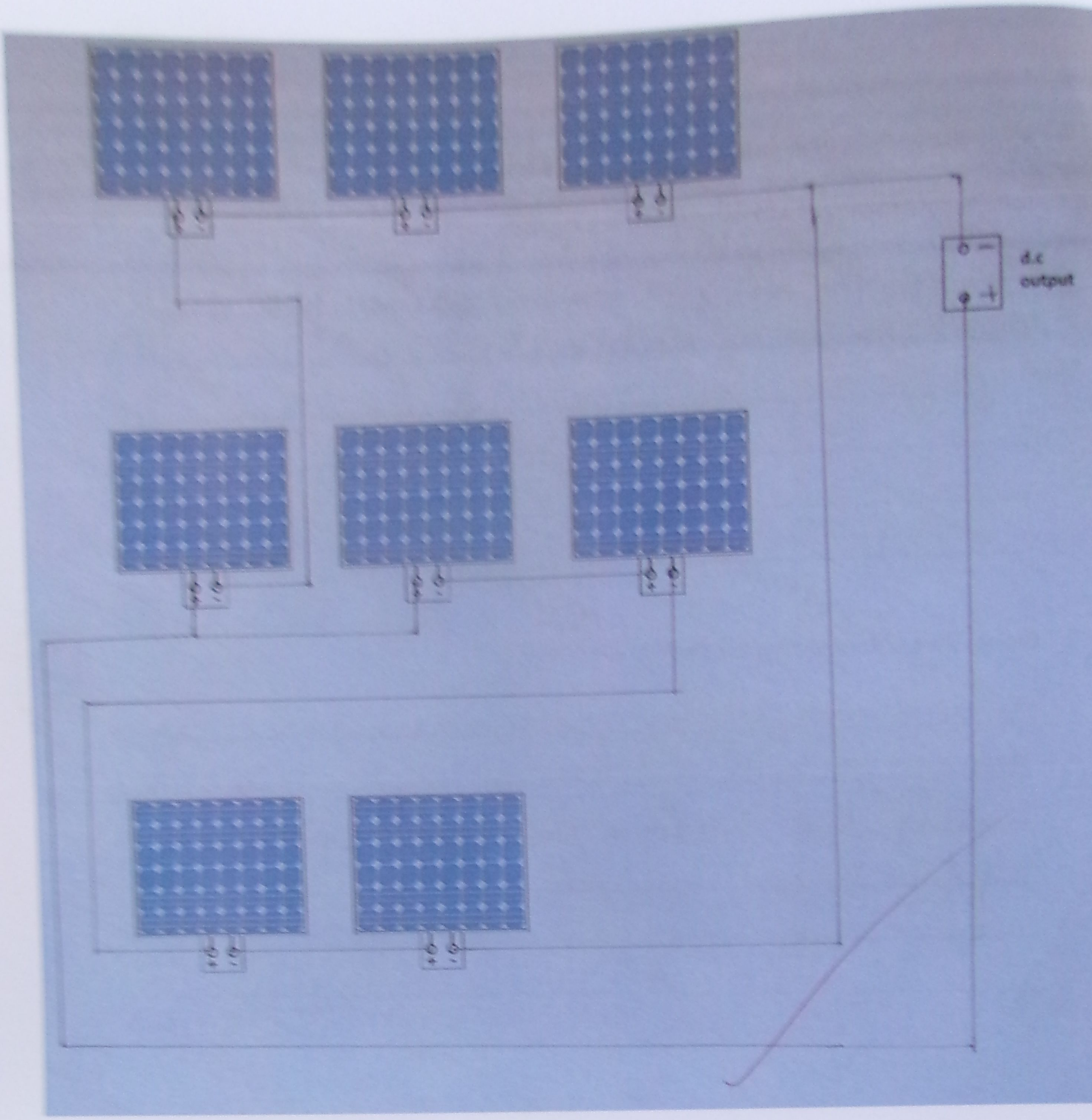
Have your teacher/trainer check your	Teacher/Trainer Initials and Date	✓

2.2 PV Array Wiring Diagram 2

2.2.1 On the following page, draw in all the necessary bypass diodes, blocking diodes and wiring connections, to create a PV array using the same PV modules, with the following *approximate* output parameters (neglect derating):

- Output Power (max): 1.6 kW.
- Output Voltage (max): 95 V.
- Output Current (max): 16.7 A.





	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 completing your diagrams in section 2.

1. Explain the purpose of a blocking diode in a PV array.

To prevent reverse flow of current into the any number of modules

2. Explain the purpose of a bypass diode in a PV array.

To eliminate the hot spot phenomena which can damage PV cells and even cause fire if the light hitting the surface of the PV cells in a module which is not uniformed.

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

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0061 Design grid-connected photovoltaic power supply systems UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	PV System Installations

Skill Practice Number:	7.3
Skill Practice Name:	Install a Grid-connected PV Power System

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

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

UEERE0061 Design grid-connected photovoltaic power supply systems

UEERE0080 Install photovoltaic power conversion equipment to grid

UEERE0081 Install photovoltaic systems to power conversion equipment

Topic 7. PV System Installations

Skills Practice 7.3: Install a Grid-connected PV Power System

Task:

To install and connect the various components of a grid-connected PV power system.

Objectives:

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

- Install and connect PV arrays.
- Install and connect GC inverters.
- Install and connect PV system wiring.
- Install and connect PV system isolators and protection devices.

Note: it is recommended that this skills practice is conducted in conjunction with skills practice *TSP08.2 Commission Grid-connected PV Systems.*

1. Planning the Skills Practice

1.1 Equipment

- PV modules.
- Array mounting system.
- Grid-connected inverter.
- Electrical installation.
- Suitable d.c. cabling.
- Suitable a.c. cabling.
- HD PVC conduit.
- Suitable fixings/fasteners.

1.2 Suggested Materials

- Power drill.
- Insulation resistance tester.
- Multimeter.
- Clamp meter.
- AS/NZS 3000.
- AS/NZS 5033.
- AS 4777.
- AS/NZS 3008.1.1.

1.3 Miscellaneous Items

- PPE.
- Hand tools.
- Battery drill.
- Socket set.
- Pens/pencils.
- Calculator.

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	Use fall protection gears
PV Panel/Wirig short circuited	D	H	Test insulation resistance
Output circuit electrical shock	D	H	Test insulation resistance
Injury caused by battery acid	D	H	Use glove and eye protection
Exposed terminals	D	H	Enclose the terminals
Live electrical terminals	D	H	Testing/Locking and Tagging

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

1.5.1 Record the details of the PV system components you wi...

Module Specifications			
Output		**Characteristics**	
Maximum power:	180W	Maximum efficiency:	86.8%
Tolerance:		Temp coefficient (P_{max}):	-0.3 %/C⁰
MPP voltage:	23.7V	Type of cells:	Mono crystalline
MPP current:	7.6A	No. of cells:	48
Open-circuit voltage:	30V	Dimensions (L x W x H):	1318x994x46 mm
Short-circuit current:	8.23A	Weight:	16.0KG
Reverse current:		IP rating:	IP 67

Array Specifications			
Output		**Characteristics**	
Max power:	7020W	No. of modules:	2x9=18
MPP voltage:	351 V	No. of strings:	2
MPP current:	10 A	Mounting system:	Tilt frame
Open-circuit voltage:	432 V		
Short-circuit current:	10.8A		

Grid-Connect Inverter Specifications			
d.c. Input		**a.c. Output**	
Max input power:	4000 W	Nominal output power:	230V AC
Max input voltage:	90V to 960V	Max output power:	900W
d.c. voltage range:	600 V	a.c. voltage range:	180 to 276V
Max input current:	25 A	Max output current:	13.7A
Max number of strings:	1	Frequency range:	45 to 56 HZ
Characteristics			
Maximum efficiency:	98.4%	Power factor:	99
Temperature range:	-25 to 60 °C	THD:	63%

PV System Isolation and Protection				
Device	**Location**	**Voltage**	**Current**	**IP**
Circuit Breaker	Main circuit board	218V	32 A	IP66
ISGO	20A			

PV System Cabling			
d.c. Cabling		**a.c. Cabling**	
Type:	XLPE	Type:	PVC V90
Stranding:	4 mm² thin copper	Stranding:	2.5 mm² Solid Copper
Temperature rating:	-40 ⁰C to 90 ⁰C	Temperature rating:	79 ⁰C
Voltage rating:	1000	Voltage rating:	230V
CCC:	38 A	CCC:	29 A
Route length:	13m	Route length:	2m
Voltage drop:	0.5%	Voltage drop:	0.1%

Comments/Notes

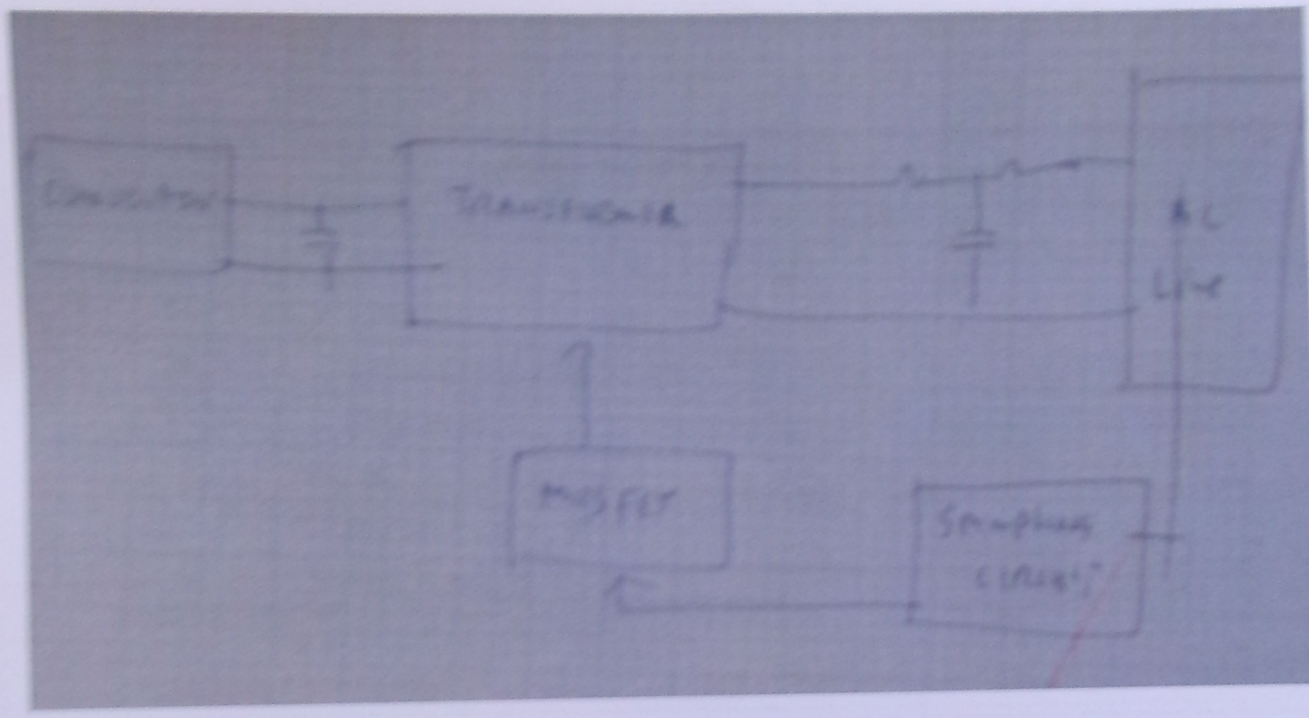
1.6 Installation Diagrams

1.6.1 Use the space provided on this page to draw a basic site plan for the installation, indicating the locations of all major components.

Site Plan

1.6.2 Use the space provided on this page to draw a basic circuit (schematic) diagram of the installation, indicating the PV system generation, isolation, protection and grid-connection points.

Circuit (Schematic) Diagram



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

permission from your teacher, install and connect each of the PV system components, using approved safe working practices.

Ensure effective isolation of the installation supply prior to commencing installation work

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

2.1.2 Record details of component fixings and fasteners used in the following table:

Components	Base Material	Fixings/Fasteners
PV Array/Mounting System	Rail fixed to roof	Mechanical installation
GC Inverter	Bracket	Wall mounted bolt/ nut
d.c. Cabling	XLPE Copper cable	PVC Conduit/Wiring Enclosure
a.c. Cabling	PVC V90	PVC Conduit/Wiring Enclosure
d.c. Isolation Device(s)	PV Disconnector	Mounted between inverter and panel
a.c. Isolation Device(s)	MCB RCBO	Mounted in switch board

	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 Clean your work area, return all equipment to the correct storage areas as directed by your teacher, and then complete the following review questions.

1. What tests should be carried out on PV system d.c. and a.c. cabling prior to connection to an energy source?

   Polarity test

   Continuity Test

   Insulation resistance test

   Earth leakage test

2. What are the requirements for identification of the PV system main switch?

   Labelling on PV System Main Switch

3. What is the minimum IP rating for grid-connected PV system components installed outdoors?

   IP 55

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

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0061 Design grid-connected photovoltaic power supply systems UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	PV System Verification

Skill Practice Number:	8.2
Skill Practice Name:	Commission Grid-connected PV Systems

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

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

Topic 8. PV System Verification

Skills Practice 8.2: Commission Grid-connected PV Systems

Task:

To perform commissioning work on a PV power system in accordance with relevant Australian Standards and CEC guidelines.

Objectives:

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

- Inspect PV system wiring and components.
- Test PV system wiring for continuity.
- Test PV system wiring for insulation resistance.
- Test PV system wiring for correct polarity.
- Test PV strings for continuity.
- Test PV array earthing conductors for continuity/resistance.
- Test PV array insulation resistance.
- Measure PV string open-circuit voltages.
- Measure PV array open-circuit voltages.
- Measure array operating voltages and currents.
- Measure GC inverter input and output voltages.
- Verify the operation of GC inverter passive protection.
- Document commissioning activities including compliance and non-compliance issues.

Topic Skills Practice 6.2

1. Planning the Skills Practice

1.1 Equipment

- PV power system.
- Ohmmeter/continuity tester.
- Insulation resistance tester.
- d.c. voltmeter.
- d.c. clamp meter.
- a.c. voltmeter.
- a.c. clamp meter.

1.2 Suggested Materials

- AS/NZS 3000.
- AS/NZS 5033.
- AS/NZS 4509.1.

1.3 Miscellaneous Items

- PPE.
- Hand tools.
- 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	Use fall protection gears
PV Panel/Wirig short circuited	D	H	Test insulation resistance
Output circuit electrical shock	D	H	Test insulation resistance
Injury caused by battery acid	D	H	Use glove and eye protection
Exposed terminals	D	H	Enclose the terminals
Live electrical terminals	D	H	Testing/Locking and Tagging

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

2. Carrying Out the Skills Practice

2.1 Inspect PV System Wiring & Equipment

2.1.1 Use the following checklists to carry out a visual inspection of the PV system equipment.

PV Array				
Array Type:	Mon pere cells	Mounting System:	Clamp hold down screw	
Max Power:	330W	No. of Strings:	2	
MPP Voltage:	1000V	O/C Voltage:	40.8V	
MPP Current:	29A	S/C Current:	10.19A	
Item	**Compliance**		**Comments/Details**	
Mounting system structurally sound	Yes ☐	No ☐		
Array tilt is suitable	Yes ☐	No ☐	Angle: 33 degree	
Array orientation is suitable	Yes ☐	No ☐	Angle: North	
No contact between dissimilar metals	Yes ☐	No ☐		
Integrity of waterproofing maintained	Yes ☐	No ☐		
Suitable signage at array junction boxes	Yes ☐	No ☐		

Inverter				
Inverter Type:	Growatt 7000	Max Input Power:	1800 W	
Location:	Wall	Max Output Power:	1650 W	
Mounting:	Saddle	d.c. Voltage Range:	120-450 V	
IP Rating:	IP66	a.c. Voltage Range:	200- 250 V	
Item	**Compliance**		**Comments/Details**	
Inverter has been correctly selected	Yes ☐	No ☐		
Sufficient space at inverter location	Yes ☐	No ☐		
Inverter is adequately ventilated	Yes ☐	No ☐		
Inverter is adequately supported	Yes ☐	No ☐		
Inverter is adequately protected	Yes ☐	No ☐		

Topic Skills Practice 6.2

System Wiring			
d.c. Conductors:	PV Array to Inverter	a.c. Conductors:	Inverter to load
Insulation Type:	XLPE	Insulation Type:	PVC V90
Route Length:	13 m	Route Length:	1-2m

Item	Compliance		Comments/Details
Protected against UV radiation	Yes ☐	No ☐	
Protected against mechanical damage	Yes ☐	No ☐	
Protected against overcurrent	Yes ☐	No ☐	
d.c. wiring/enclosures correctly labelled	Yes ☐	No ☐	
Losses not greater than 5%	Yes ☐	No ☐	

System Control & Isolation			
Item	**Compliance**		**Comments/Details**
Isolator provided adjacent to PV array	Yes ☐	No ☐	Ratings: 1000V 32 A IP66
d.c. isolator provided adjacent to inverter	Yes ☐	No ☐	Ratings:1000V 32 A IP66
a.c. isolator provided adjacent to inverter	Yes ☐	No ☐	Ratings: 240V 20A IP66
Solar main switch provided at MSB / DB	Yes ☐	No ☐	Ratings: 240V 20A IP66
Isolation devices correctly labelled	Yes ☐	No ☐	
IP rating of isolation devices is suitable	Yes ☐	No ☐	

Main Switchboard/Distribution Boards			
Item	Compliance		Comments/Details
Correct warning signage provided at MSB	Yes ☐	No ☐	
Correct warning signage provided at DBs	Yes ☐	No ☐	
Shut-down procedure signage provided	Yes ☐	No ☐	
Fire emergency signage provided	Yes ☐	No ☐	

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

2.2 Verify PV System Wiring

2.2.1 Use the following schedule to carry out testing of the PV system wiring, starting from the inverter side of the no-load (PV Array) isolator, and ending at the kWh meter/service neutral link. Record all test results in the schedule provided below.

Continuity of d.c. Wiring				
Test Device:	Multimeter		**Range:**	Ohm
Conductor	**Test Results**	**Compliance**		**Comments**
Positive (+)	0	Yes ☐	No ☐	
Negative (-)	0	Yes ☐	No ☐	
Bonding (E)	0	Yes ☐	No ☐	
Continuity of a.c. Wiring				
Test Device:	Multimeter		**Range:**	Ohm
Conductor	**Test Results**	**Compliance**		**Comments**
Active (A)	0	Yes ☐	No ☐	
Neutral (N)	0	Yes ☐	No ☐	
Earth (PE)	0	Yes ☐	No ☐	

Topic Skills Practice 6.2

Insulation Resistance of d.c. Wiring				
Test Device:	IR Tester		Range:	500 V DC
Test	Test Results	Compliance		Comments
(+) to E	Infinity	Yes ☐	No ☐	
(-) to E	Infinity	Yes ☐	No ☐	
(+) to (-)	Infinity	Yes ☐	No ☐	

Insulation Resistance of a.c. Wiring				
Test Device:	IR Tester		Range:	500 V DC
Test	Test Results	Compliance		Comments
A – E	Infinity	Yes ☐	No ☐	
N – E	Infinity	Yes ☐	No ☐	
A – N	Infinity	Yes ☐	No ☐	

Polarity of d.c. Wiring					
Test Device:	Multimeter			Range:	Ohm
Conductor	Switched		Compliance		Comments
Positive (+)	Yes ☐	No ☐	Yes ☐	No ☐	
Negative (-)	Yes ☐	No ☐	Yes ☐	No ☐	

Polarity of a.c. Wiring					
Test Device:	Multimeter			Range:	Ohm
Conductor	Switched		Compliance		Comments
Active (A)	Yes ☐	No ☐	Yes ☐	No ☐	
Neutral (N)	Yes ☐	No ☐	Yes ☐	No ☐	

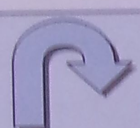
Feedback	Have your teacher/trainer check your work	Teacher/Trainer initials and Date:	✓

Topic Skills Practice 6.2

2.3 Verify PV Array Connections

2.3.1 Use the following checklist to carry out testing of PV strings, PV array, array interconnection wiring. Refer to AS/NZS 5033 for guidance, and record all test results in the spaces provided.

Verify PV String isolation				
Test Device:	IR Tester		**Range:**	500 V DC
Test	**Test Results**	**Isolation Confirmed**		**Comments**
(+) to E	Infinity	Yes ☐	No ☐	
(-) to E	Infinity	Yes ☐	No ☐	
(+) to (-)	Infinity	Yes ☐	No ☐	
Test	**Test Results**	**Operation Confirmed**		**Comments**
Live Source	240V	Yes ☐	No ☐	

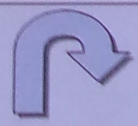
	 *Feedback* — **Have your teacher/trainer check your work**	**Teacher/Trainer Initials and Date**	✓

String Continuity				
Test Device:	Multimeter		**Range:**	Ohm
Conductor	**Test Results**	**Compliance**		**Comments**
String 1 (+)	0	Yes ☐	No ☐	
String 1 (-)	0	Yes ☐	No ☐	
String 2 (+)	0	Yes ☐	No ☐	
String 2 (-)	0	Yes ☐	No ☐	
String 3 (+)		Yes ☐	No ☐	
String 3 (-)		Yes ☐	No ☐	
String 4 (+)		Yes ☐	No ☐	
String 4 (-)		Yes ☐	No ☐	

Topic Skills Practice 6.2

Continuity of Bonding Conductors				
Test Device:	Multimeter		Range:	Ohm
Conductor	Test Results	Compliance		Comments
Positive (+)	0	Yes □	No □	
Negative (-)	0	Yes □	No □	
		Yes □	No □	
		Yes □	No □	

Continuity of Array to Isolator Wiring				
Test Device:	Multimeter		Range:	Ohm
Conductor	Test Results	Compliance		Comments
Positive (+)	0	Yes □	No □	
Negative (-)	0	Yes □	No □	

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

Topic Skills Practice 6.2

2.3.2 When you are directed by your teacher, use safe working procedures to re-energise each string and then complete the following tests, recording your results in the schedules provided.

Warning: hazardous voltages and high currents may be present

Open-Circuit String Voltage				
Test Device:	Voltmeter		**Range:**	0- 250V Dc
String	**Test Results**	**Compliance**		**Comments**
String 1	40.8V	Yes ☐	No ☐	
String 2	40.8V	Yes ☐	No ☐	
String 3		Yes ☐	No ☐	
String 4		Yes ☐	No ☐	

String Polarity				
Test Device:	Multimeter		**Range:**	Ohm
String	**Test Results**	**Compliance**		**Comments**
String 1	0	Yes ☐	No ☐	
String 2	0	Yes ☐	No ☐	
String 3		Yes ☐	No ☐	
String 4		Yes ☐	No ☐	

Topic Skills Practice 6.2

Open-Circuit Array Voltage				
Test Device:	Voltmeter		**Range:**	250V
Test	**Test Results**	**Compliance**		**Comments**
PV Array	240V	Yes ☐	No ☐	

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

2.3.3 When your teacher has demonstrated the correct testing methods, carry out an insulation resistance test on the PV array wiring, and record your results in the schedule provided.

Insulation Resistance of Array Wiring				
Test Device:	IR Tester		**Range:**	500V Dc
Test	**Test Results**	**Compliance**		**Comments**
(+) to E	Infinity	Yes ☐	No ☐	
(-) to E	Infinity	Yes ☐	No ☐	

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

2.4 System Start-Up & Shut-Down

2.4.1 Use the following schedules to verify and document the operating parameters of the PV system. Refer to AS/NZS 5033 and AS/NZS 4509.1 for guidance.

2.4.2 After obtaining permission from your teacher, start-up the PV power system by energising isolation points in accordance with safe working procedures and manufacturer's specifications.

PV System Start-Up		
Did the inverter synchronise with the grid supply on start-up?	Yes ☐	No ☐

Operating Voltage - Inverter Input

Test Device:	Voltmeter		Range:	0 to 250V
Test	**Test Results**	**Compliance**		**Comments**
(+) to (-)	121.7V	Yes ☐	No ☐	

Operating Voltage - Inverter Output

Test Device:	Voltmeter		Range:	0 to 250V
Test	**Test Results**	**Compliance**		**Comments**
A – N	12V	Yes ☐	No ☐	
A – E	12V	Yes ☐	No ☐	
N – E	0V	Yes ☐	No ☐	

Operating Current – PV Strings/Array

Test Device:	Ammeter		Range:	0 to 20 A
Test	**Test Results**	**Compliance**		**Comments**
String 1	10A	Yes ☐	No ☐	
String 2	10A	Yes ☐	No ☐	
String 3		Yes ☐	No ☐	
String 4		Yes ☐	No ☐	
Array	20A	Yes ☐	No ☐	

PV System Shut-Down		
Did the passive protection operate when the grid supply was disconnected?	Yes ☐	No ☐

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

Topic Skills Practice 6.2

3. Completing the Skills Practice

3.1 Skills Practice Review Questions

3.1.1 Verify that the PV system has been left in a safe condition.

3.1.2 Clean your work area, return all equipment to the correct storage areas as directed by your teacher, and then complete the following review questions.

1. Explain the purpose of commissioning PV power systems.

-Confirm that PV system will meet its performance goals

-Demonstrate how the system performs

2. List the tests that must be carried out on a PV power system before the PV supply is connected to the installation.

DC Circuit

Polarity test , Insulation resistance test, Continuity test, Voltage test, Current test

AC Circuit

Polarity test , Insulation resistance test, Continuity test, Voltage test, Current test

RCD Test

Earth leakage test

Topic Skills Practice 6.2

3. Did you identify any non-compliance issues in the PV installation?

   If yes, provide details below, along with probable causes and suitable solutions.

NO

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

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0061 Design grid-connected photovoltaic power supply systems UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	PV System Verification

Skill Practice Number:	8.3
Skill Practice Name:	Locate and rectify faults in PV power systems

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

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

Topic Skills Practice 8.3

UEERE0061 Design grid-connected photovoltaic power supply systems

UEERE0080 Install photovoltaic power conversion equipment to grid

UEERE0081 Install photovoltaic systems to power conversion equipment

Topic 8. PV System Verification

Skills Practice 8.3: Locate and rectify faults in PV power systems

Task:

To identify, locate and rectify faults in grid-connected PV arrays, GC inverters and associated wiring.

Objectives:

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

- Identify common faults in lighting circuits and controls by their symptoms.
- Locate faults in lighting circuits and controls.
- Rectify faults in lighting circuits and controls.

Topic Skills Practice 8.3

1. Planning the Skills Practice

1.1 Equipment

- Simulated grid-connected PV system with fault switches.
- a.c. and d.c. voltmeters.
- a.c. and d.c. clamp meters.
- Insulation resistance tester.
- Cathode ray oscilloscope.

1.2 Suggested Materials

- AS/NZS 3000.
- AS/NZS 5033.
- AS 4777 Series.
- AS/NZS 4509 Series.

1.3 Miscellaneous Items

- PPE.
- Hand tools.
- 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	Use fall protection gears
PV Panel/Wirig short circuited	D	H	Test insulation resistance
Output circuit electrical shock	D	H	Test insulation resistance
Injury caused by battery acid	D	H	Use glove and eye protection
Exposed terminals	D	H	Enclose the terminals
Live electrical terminals	D	H	Testing/Locking and Tagging

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

ying Out the Skills Practice

oubleshoot Grid-Connected PV Systems

Your teacher will provide you with a number of grid-connected PV power system scenarios, containing one or more faults. Using safe working practices and troubleshooting principles, fy each fault, documenting your procedures and test results as you go.

ample circuit problem is provided below to give an indication of how to complete each ise:

Grid-Connected PV System – Faulty Scenario Example

PV System Details/Ratings:	2.9 kW, 200 V array, 3.3 kW single phase GC inverter
PV System Control:	No-load isolator, d.c. inverter isolator, a.c. inverter isolator, PV main switch
System Fault Symptoms:	No power delivered from PV system

	Steps/Procedure	Test Equipment	Observations/Results
1	Test for voltage at a.c. isolator	a.c. voltmeter	0 V
2	Test for voltage at d.c. isolator	d.c. voltmeter	80 V
3	Inspect array	Visual inspection	Heavy soiling, some shading, and two damaged modules

Circuit Fault(s)	Location(s)	Required Repairs
Soiling, shading, mechanical damage	Array - rooftop	Replace damaged modules, clean array, control vegetation

Topic Skills Practice 8.3

Grid Connected PV System – Faulty Scenario 1

PV System Details/Ratings:	29 KW
PV System Control:	No load isolator
System Fault Symptoms:	Earth leakage Circuit Breaker does not operate

	Steps/Procedure	Test Equipment	Observations/Results
1	Test earth resistance of Earthing conductor	Multimeter	Between circuit Board and Mounting system
2			
3			
4			
5			
6			

Circuit Fault(s)	Location(s)	Required Repairs
High resistance earth	Between circuit Board and Mounting system	Reinstall earth wire

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

Grid-Connected PV System – Faulty Scenario 2

PV System Details/Ratings: 29 KW

PV System Control: No load isolator

System Fault Symptoms: Poor value of dc out put voltage by solar arrays

	Steps/Procedure	Test Equipment	Observations/Results
1	All terminals are to be	Ohmmeter	High resistance
	inspected		Loose connection
2	Connections are to be sure that		
	No copper strand missing		
3	Determine that all connections		
	Aare tight		
4	Terminate the neutral cable		
	Making sure that connections	Ohmmeter	High resistance
5	are tight and no copper strand missing		Loose connection
6			

Circuit Fault(s)	Location(s)	Required Repairs
Loose connection	At terminal	Secure the connection and
		terminations

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

Topic Skills Practice 8.3

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 review questions.

1. List three types of faults that can occur in PV system wiring.

   Cable loose connection

   Short circuit terminals

   Insulation cracking due to heat

2. Describe six safe working procedures that should be followed whilst troubleshooting grid-connected PV power systems.

   Switching off and Tagging procedure

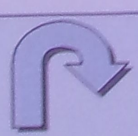
   Fall protection

   Ladder safety

   UV Protection

   Slip/ trip and fall protection

   Back injury can be caused by lifting of heavy solar modules

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

Topic Skills Practice Cover Sheet

Unit Name:	UEERE0061 Design grid-connected photovoltaic power supply systems UEERE0080 Install photovoltaic power conversion equipment to grid UEERE0081 Install photovoltaic systems to power conversion equipment
Topic Title:	Grid Connected PV Systems

Skill Practice Number:	1.1
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 1.1

UEERE0080 Install photovoltaic power conversion equipment to grid

UEERE0081 Install photovoltaic systems to power conversion equipment

Topic 1. Grid Connected PV Systems

Skills Practice 1.1: 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.*

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 1.1.*
- *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*

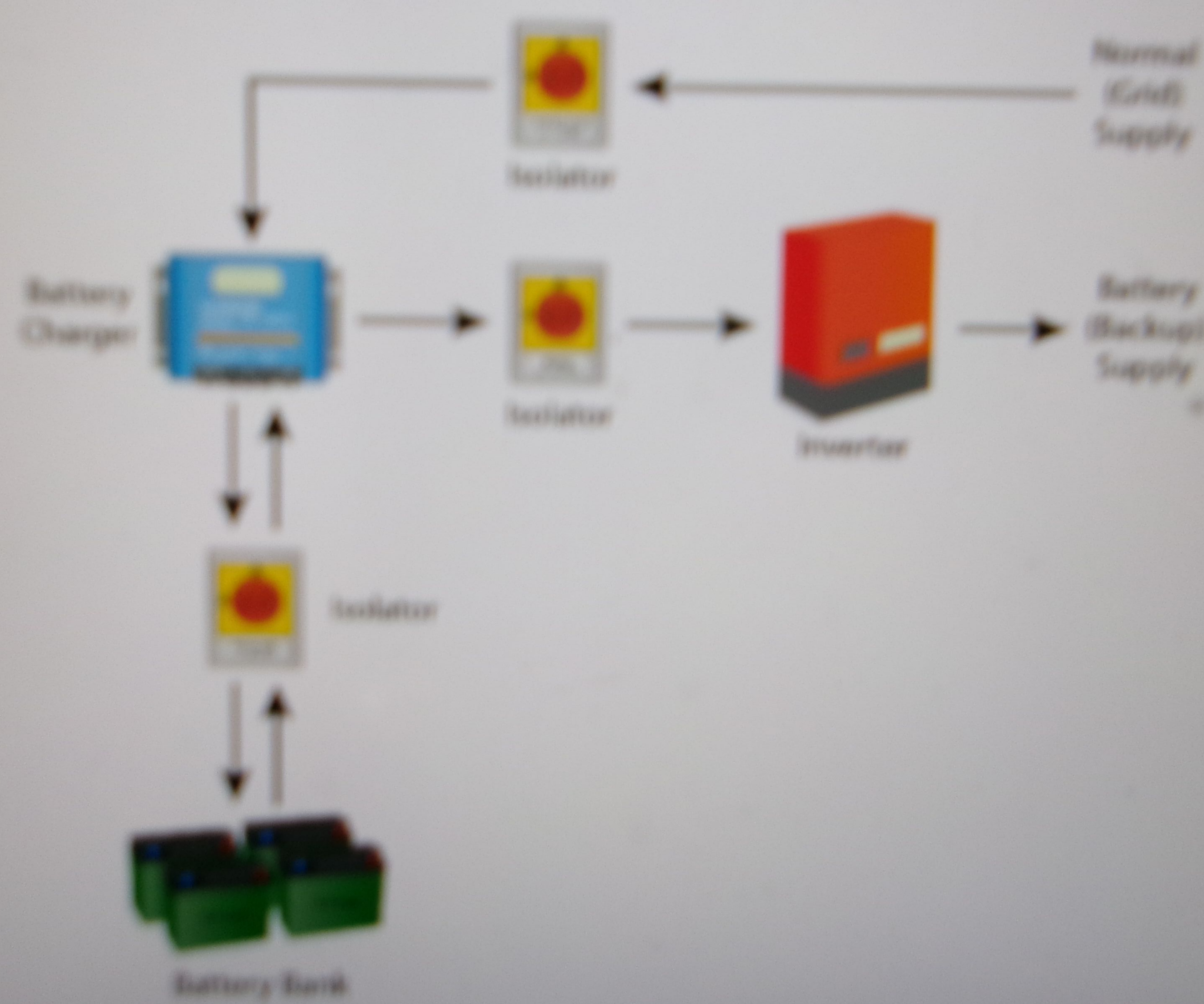
2. Carrying Out the Skills Practice

2.1 Grid-Connected PV System – Block Diagram 1

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.

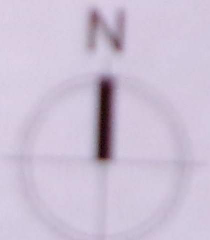
	Feedback	Have your teacher/trainer check your work	Teacher/Trainer Initials and Date	✓



Normal
(Grid)
Supply
Isolator
Battery
Charger
Isolator
Inverter
Battery
(Backup)
Supply
Isolator
Battery Bank

2.3 Select Optimal Array Position

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.



Together we can make a difference.

<u>Sharp 1500 1.5kW Solar System Panel Specifications</u>

Your Sharp 1500 system will be supplied with one of the following sets of panels:

Manufacturer	Mono Or Poly	Size (Watts)	Panels Required To Achieve Minimum 1500 Watts
Sharp	Mono	188	8
Sharp	Poly	215	7
Sharp	Poly	220	7

Please note all solar panels supplied are CEC accredited and compliant with IEC/EN61730 and IEC/EN61215 or IEC/EN61646.

The choice of panels will be at the **sole discretion** of our installer subject to such matters as stock availability.

Please see the following specification sheet for further details and panel specifications.

188 WATT

BIG POWER, SMALL FOOTPRINT

SINGLE CRYSTAL SILICON PHOTOVOLTAIC MODULE WITH 188W MAXIMUM POWER

This single crystal 188Watt module features 15.99% encapsulated cell efficiency and 14.24% module efficiency. Using breakthrough technology perfected in Sharp's space cell program, the **NU-A188EY** module allows for maximum usable power per square metre of solar array.

A safe, clean, reliable source of energy, Sharp's NU-A188EY photovoltaic module is designed for large electrical power requirements. Based on the technology of crystal silicon solar cells developed for 50 years, this module has superb durability to withstand rigorous operating conditions and is suitable for grid connected systems.

Common applications for the Sharp NU-A188EY include residences, office buildings, solar power stations and solar suburbs. As the world's leading manufacturer of photovoltaic modules, Sharp produces an extensive line of high power modules for every electrical power requirement.

FEATURES

- High-power module (188W) using 156.5mm square single crystal silicon solar cells with 14.24% module conversion efficiency
- Photovoltaic module with bypass diode minimises the power drop caused by shade
- Textured cell surface to reduce the reflection of sunlight and BSF (Back Surface Field) structure to improve cell conversion efficiency: 15.99%
- White tempered glass, EVA resin and a weatherproof film, plus aluminum frame for extended outdoor use
- Output terminal: Lead wire with waterproof connector
- Certifications: IEC 61215 and IEC 61730
- SHARP modules are manufactured in ISO 9001 certified factories

SHARP

NU-A188EY – MAXIMUM POWER

ELECTRICAL CHARACTERISTICS

Cell	48 Monocrystalline (156.5mm)^2 Sharp silicon solar cells
No. of Cells and Connections	48 in series
Open Circuit Voltage (Voc)	29.6V
Maximum Power Voltage (Vpm)	24V
Short Circuit Current (Isc)	8.60A
Maximum Power Current (Ipm)	7.84A
Maximum Power (Pm)[1]	Min. 179W Typical 188W
Encapsulated Solar Cell Efficiency (ηc)	15.99%
Module Efficiency (ηm)	14.24%
Maximum System Voltage	DC 800V
Series Fuse Rating	15A
Type of Output Terminal	Lead Wire with MC Connector

Specifications are subject to change without notice
[1] (STC) Standard Test Conditions: 25°C, 1 kW/m², AM 1.5

MECHANICAL CHARACTERISTICS

Dimensions	1328 x 994 x 57.5mm
Weight	16.5kg

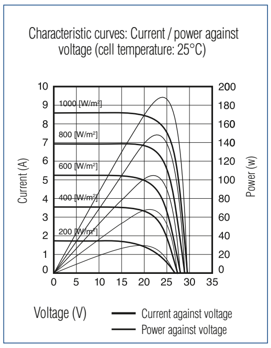
TEMPERATURE COEFFICIENT

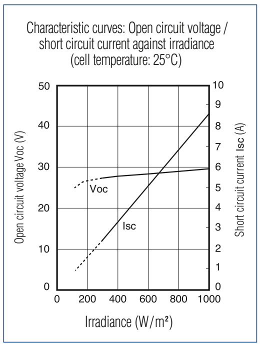
Temp. Coefficient of Pmax	-0.485	% / °C
Temp. Coefficient of Voc	-0.104	V / °C
Temp. Coefficient of Isc	0.053	% / °C

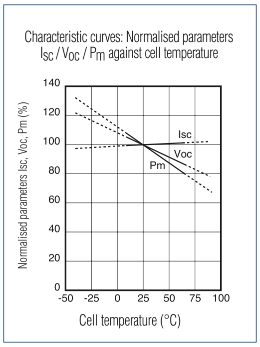
ABSOLUTE MAXIMUM RATINGS

Parameters	Rating	Unit
Operating Temperature	-40 to +90	°C
Storage Temperature	-40 to +90	°C
Dielectric Voltage Withstood	5,200 max.	V-DC

IV CURVES







Specifications are subject to change without notice

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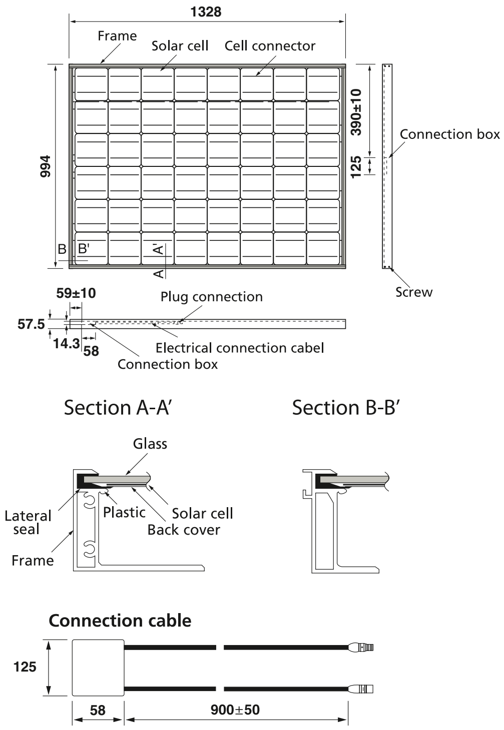

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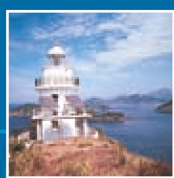

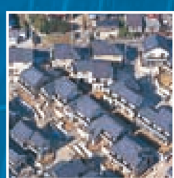

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SHARP

Sharp Corporation of Australia
1 Huntingwood Drive, Huntingwood, NSW 2148.
Phone: (02) 9830 4600 E-mail: sales@sharp.net.au
www.sharp.net.au

SHARP Solar

215WATT

BIG POWER, SMALL FOOTPRINT

MULTI CRYSTAL SILICON PHOTOVOLTAIC MODULE WITH 215W MAXIMUM POWER

This multi crystal 215watt module features 14.6% encapsulated cell efficiency and 13.1% module efficiency. Using breakthrough technology perfected in Sharp's space cell program, the **ND-F215A1** module allows for maximum usable power per square metre of solar array.

A safe, clean, reliable source of energy, Sharp's ND-F215A1 photovoltaic module is designed for large electrical power requirements. Based on the technology of crystal silicon solar cells developed over 45 years, this module has superb durability to withstand rigorous operating conditions and is suitable for grid connected systems.

Common applications for the Sharp ND-F215A1 include residences, office buildings, solar power stations and solar suburbs. As the world's leading manufacturer of photovoltaic modules, Sharp produces an extensive line of high power modules for every electrical power requirement.

FEATURES

- High-power module (215W) using 156.5mm square multi crystal silicon solar cells with 13.1% module conversion efficiency
- Photovoltaic module with bypass diode minimises the power drop caused by shade
- Textured cell surface to reduce the reflection of sunlight and BSF (Back Surface Field) structure to improve cell conversion efficiency: 14.6%
- White tempered glass, EVA resin and a weatherproof film, plus aluminum frame for extended outdoor use
- Output terminal: Lead wire with waterproof connector
- Certifications: IEC 61215 & IEC 61730
- SHARP modules are manufactured in ISO 9001 certified factories

ND-F215A1 – MAXIMUM POWER

ELECTRICAL CHARACTERISTICS

Cell	156.5mm Square Polycrystalline silicon
No. of Cells and Connections	60 in series
Open Circuit Voltage (Voc)	36.7V
Maximum Power Voltage (Vpm)	30.2V
Short Circuit Current (Isc)	7.82A
Maximum Power Current (Ipm)	7.13A
Maximum Power (Pm)[1]	Typical 215W
Encapsulated Solar Cell Efficiency (ηc)	14.6%
Module Efficiency (ηm)	13.1%
Maximum System Voltage	DC 1000V
Series Fuse Rating	15A
Type of Output Terminal	Lead Wire with MC3 Connector

Specifications are subject to change without notice
[1] (STC) Standard Test Conditions: 25°C, 1 kW/m², AM 1.5

MECHANICAL CHARACTERISTICS

Dimensions	994 x 1652 x 46mm
Weight	21.0kg

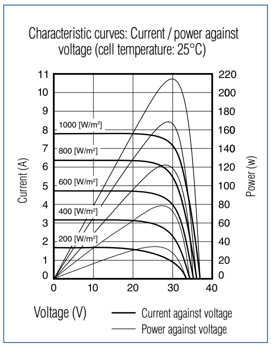
TEMPERATURE COEFFICIENT

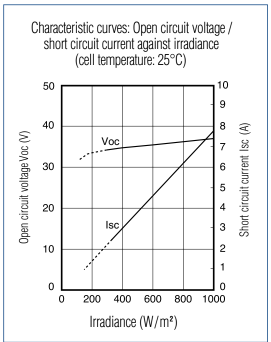
Temp. Coefficient of Pmax	-0.485	% / °C
Temp. Coefficient of Voc	-0.13	V / °C
Temp. Coefficient of Isc	0.053	% / °C

ABSOLUTE MAXIMUM RATINGS

Parameters	Rating	Unit
Operating Temperature	-40 to +90	°C
Storage Temperature	-40 to +90	°C
Dielectric Voltage Withstood	3000 max.	V-DC

IV CURVES





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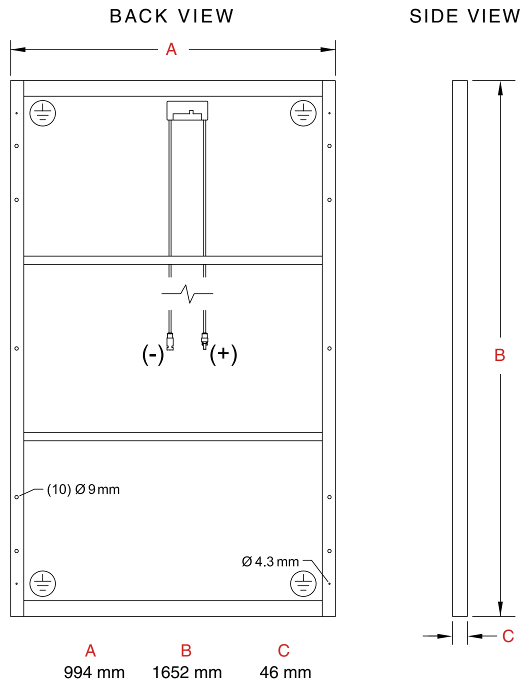

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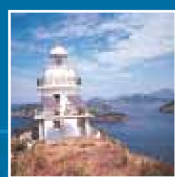
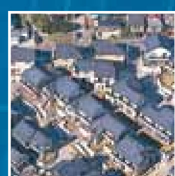
- Design and specifications are subject to change without prior notice.
- Colour variations to products may occur due to printing.
- All information and technical details are correct as at product release date.





SHARP

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SHARP Solar

220 WATT

BIG POWER, SMALL FOOTPRINT

MULTI CRYSTAL SILICON PHOTOVOLTAIC MODULE WITH 220W MAXIMUM POWER

This multi crystal 220watt module features 15% encapsulated cell efficiency and 13.4% module efficiency. Using breakthrough technology perfected in Sharp's space cell program, the **ND-220E1F** module allows for maximum usable power per square metre of solar array.

A safe, clean, reliable source of energy, Sharp's ND-220E1F photovoltaic module is designed for large electrical power requirements. Based on the technology of crystal silicon solar cells developed over 45 years, this module has superb durability to withstand rigorous operating conditions and is suitable for grid connected systems.

Common applications for the Sharp ND-220E1F include residences, office buildings, solar power stations and solar suburbs. As the world's leading manufacturer of photovoltaic modules, Sharp produces an extensive line of high power modules for every electrical power requirement.

FEATURES

- High-power module (220W) using 156.5mm square multi crystal silicon solar cells with 13.4% module conversion efficiency
- Photovoltaic module with bypass diode minimises the power drop caused by shade
- Textured cell surface to reduce the reflection of sunlight and BSF (Back Surface Field) structure to improve cell conversion efficiency: 15%
- White tempered glass, EVA resin and a weatherproof film, plus aluminum frame for extended outdoor use
- Output terminal: Lead wire with waterproof connector
- Certifications: IEC 61215 & IEC 61730
- SHARP modules are manufactured in ISO 9001 certified factories

SHARP

ND-220E1F – MAXIMUM POWER

ELECTRICAL CHARACTERISTICS

Cell	156.5mm Square Polycrystalline silicon
No. of Cells and Connections	60 in series
Open Circuit Voltage (Voc)	36.5V
Maximum Power Voltage (Vpm)	29.2V
Short Circuit Current (Isc)	8.20A
Maximum Power Current (Ipm)	7.54A
Maximum Power (Pm)[1]	Typical 220W
Encapsulated Solar Cell Efficiency (ηc)	15%
Module Efficiency (ηm)	13.4%
Maximum System Voltage	DC 1000V
Series Fuse Rating	15A
Type of Output Terminal	Lead Wire with MC3 Connector

Specifications are subject to change without notice

[1] (STC) Standard Test Conditions: 25°C, 1 kW/m², AM 1.5

MECHANICAL CHARACTERISTICS

Dimensions	994 x 1652 x 46mm
Weight	21.0kg

TEMPERATURE COEFFICIENT

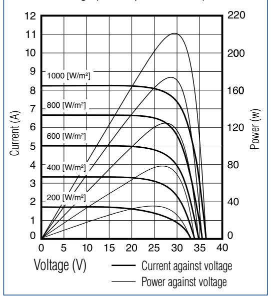
Temp. Coefficient of Pmax	-0.485	% / °C
Temp. Coefficient of Voc	-0.13	V / °C
Temp. Coefficient of Isc	0.053	% / °C

ABSOLUTE MAXIMUM RATINGS

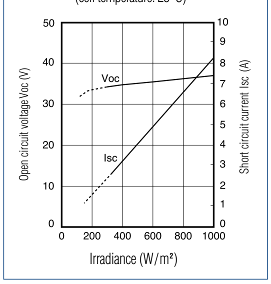
Parameters	Rating	Unit
Operating Temperature	-40 to +90	°C
Storage Temperature	-40 to +90	°C
Dielectric Voltage Withstood	3000 max.	V-DC

IV CURVES

Characteristic curves: Current / power against voltage (cell temperature: 25°C)

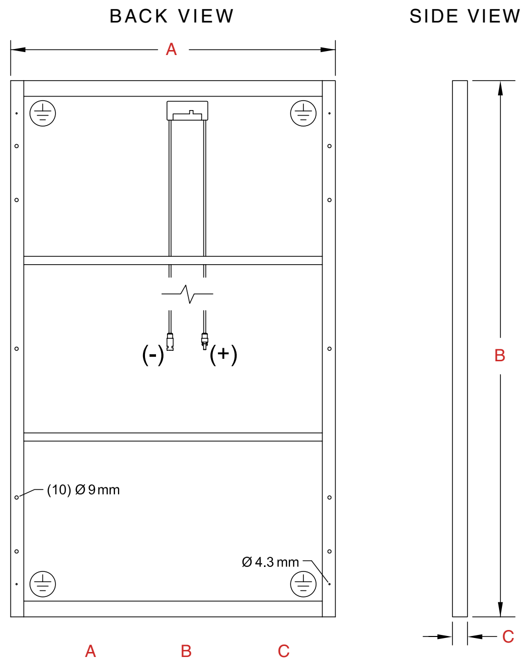


Characteristic curves: Open circuit voltage / short circuit current against irradiance (cell temperature: 25°C)



Specifications are subject to change without notice

DIMENSIONS

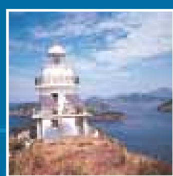


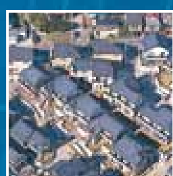
A	B	C
994 mm	1652 mm	46 mm

Specifications are subject to change without notice

In the absence of confirmation by device specifications sheets, Sharp takes no responsibility for any defects that may occur in equipment using any Sharp devices shown in catalogues, data books, etc. Contact Sharp in order to obtain the latest device specification sheets before using any Sharp device.

- Design and specifications are subject to change without prior notice.
- Colour variations to products may occur due to printing.
- All information and technical details are correct as at product release date.





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