Title	**Demonstrate knowledge of photovoltaic technology**		
Level	**4**	**Credits**	**10**

Purpose	People credited with this unit standard are able to describe fundamental principles and operation of photovoltaic arrays. People credited with this unit standard are able to demonstrate knowledge of: – the photovoltaic effect; – PV cell technologies; – PV characterisation; – methods of determining the irradiation falling on the plane of a collector in a PV array; and – how the operating point, power and daily energy output of a PV array is determined under a given set of operating and environmental conditions.

Classification	Renewable Energy Systems > Renewable Energy Systems - Installation and Maintenance

Available grade	Achieved

Guidance information

1 References
All Australian Standards (AS) may be found at https://www.standards.org.au/;
All Australian/New Zealand standards (AS/NZS) may be accessed at http://www.standards.co.nz/;
AS 4777.1:2005, *Grid connection of energy systems via inverters – Part 1: Installation requirements*;
AS 4777.2:2005, *Grid connection of energy systems via inverters – Part 2: Inverter requirements*;
AS 4777.3:2005, *Grid connection of energy systems via inverters – Part 3: Grid protections requirements*;
AS/NZS 3000:2007, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*;
AS/NZS 4509.1:2009, *Stand-alone power systems - Part 1: Safety and installation*;
AS/NZS 4509.2:2010, *Stand-alone power systems - Part 2: System design*;
and all subsequent amendments and replacements.

2 Definitions
CIGS – copper indium gallium selenide.
Current regulations and standards – in this unit standard this term is used to refer to the requirements of the above references.
Enterprise policies and procedures – those practices and procedures that have been

promulgated by the company or enterprise for use by their employees.
I-V curves – a current-voltage (I-V) curve shows the possible combinations of current and voltage output of a photovoltaic (PV) device.
MPP – maximum power point.
MPPT – maximum power point tracker.
NOCT – nominal operating cell temperature.
PV – photovoltaic.

3 Range
- a All measurements are to be expressed in Système Internationale (SI) units, and where required, converted from Imperial units into SI units.
- b Candidates shall be supplied by the assessor with formulae involving more than three quantities.
- c Use of a calculator during assessment is permitted.
- d All activities must comply with any policies, procedures, and requirements of the organisations involved.
- e All activities and evidence presented for all outcomes and performance criteria in this unit standard must be in accordance with legislation, enterprise policies and procedures, ethical code, current regulations and standards, industry practice; and where appropriate, manufacturer's instructions, specifications, and data sheets.

4 It is recommended that candidates have been assessed against Unit 27433, *Demonstrate knowledge of renewable energy concepts and technologies* prior to assessment to this unit standard.

Outcomes and performance criteria

Outcome 1

Demonstrate knowledge of the photovoltaic effect.

Performance criteria

1.1 Define the term 'photovoltaic effect'.

1.2 Explain the application of the photovoltaic effect in practical devices.

Outcome 2

Demonstrate knowledge of PV cell technologies.

Performance criteria

2.1 Compare the suitability of commercially available PV cell technologies for different applications.

Range mono-crystalline silicon, multi-crystalline silicon, amorphous silicon, CIGS, single junction, multi-junction.

2.2 Describe manufacturing technologies of commercially available PV cell technologies.

Outcome 3

Demonstrate knowledge of PV characterisation.

Performance criteria

3.1 Describe the parameters that characterise PV cell and module properties.

3.2 Define common energy output terms from PV arrays.

Range I-V curve, fill factor, operating point, MPP, MPPT, cell temperature co-efficient, NOCT, current, voltage and power output coefficients.

3.3 Calculate the output of a PV module for a given temperature using NOCT.

3.4 Compare the main cell technologies in terms of spectral response, temperature response, efficiency, cost and embodied energy.

3.5 Discuss the implications of efficiency of PV modules.

Range physical dimensions, relationship to manufacturing cost.

Outcome 4

Demonstrate knowledge of methods of determining the irradiation falling on the plane of a collector in a PV array.

Performance criteria

4.1 Define common solar irradiation terms.

Range declination angle, orientation, reflectance, sunshine hours, extraterrestrial irradiation latitude, direct and diffuse radiation, azimuth and altitude angles, radiance, solar window, tilt angle, solstice, equinox latitude, solar path, near shading, albedo.

4.2 Describe units of measurement and schematic symbols for irradiation and irradiance.

4.3 Interpret samples of solar irradiation data tables and contour maps.

Range may include but is not limited to – units of measurement, adjustments for shading, seasonal variation.

4.4 Measure solar irradiance with a solarimeter.

Range may include but is not limited to – adjustments for shading, seasonal variation, tilt angle determination.

4.5 Describe the variation of irradiation on the surface of a collector throughout the year.

Range fixed collector, single-axis tracking collector, double-axis tracking collector.

4.6 Describe the use of field measurements and a sun path diagram to determine the times and dates when a PV array will be shaded by obstacles at a particular site.

4.7 Describe methods of calculating daily average irradiation on a horizontal plane.

Range may include but is not limited to use of – extraterrestrial irradiation, location constants, sunshine hour data.

4.8 Describe methods of calculating monthly mean daily irradiation falling on a PV array for each month of the year after adjustment for the effects of shading.

Range may include but is not limited to use of –irradiation data tables, computer software, sun path diagrams

4.9 Describe how tilt angles are selected for fixed and seasonally-adjustable PV arrays at a given latitude.

4.10 Describe how tilt angles are selected to optimise for stand-alone or for grid-connected systems.

Range optimise for worst month production, optimise for total annual production.

Outcome 5

Demonstrate knowledge of how the operating point, power and daily energy output of a PV array is determined under a given set of operating and environmental conditions.

Performance criteria

5.1 Describe the configuration of a PV cell with reference to the elements and terminal polarities.

5.2 Describe the effects of variations in irradiance and cell temperature on PV modules.

Range major points, operating point, power, daily energy output.

5.3 Determine major ratings of a PV module from manufacturers' information or nameplate data.

5.4 Determine the operating point of a PV module with a resistive load, a constant voltage source, or any other load with known I-V characteristics, using the load line method.

5.5 Describe the configuration of a typical PV array, including the function, placement, and ratings of blocking and bypass diodes.

5.6 Describe the effect of partial shading of a PV module or array.

5.7 Describe the impact of bypass diodes and the significance of their configuration on output current in typical operating conditions.

5.8 Calculate the power at MPP, and the power under typical battery charging conditions of a PV module at given irradiance and ambient air temperature.

5.9 Calculate daily energy output of a PV array in accordance with AS/NZS 4509.2, and by using “rule of thumb” de-rating factors.

5.10 Outline advantages of MPPT in water pumping applications and in battery charging applications.

Range three advantages.

5.11 Outline disadvantages of MPPT in water pumping applications and in battery charging applications.

Range three disadvantages.

5.12 Describe the use of an industry approved outdoor test method to determine electrical characteristics of a PV module according to relevant Australian/New Zealand or international standards.

Planned review date	31 December 2024

Status information and last date for assessment for superseded versions

Process	Version	Date	Last Date for Assessment
Registration	1	21 July 2011	31 December 2015
Review	2	17 July 2014	31 December 2020
Review	3	24 October 2019	N/A

Consent and Moderation Requirements (CMR) reference	0003

This CMR can be accessed at http://www.nzqa.govt.nz/framework/search/index.do.

Comments on this unit standard

Please contact The Skills Organisation at reviewcomments@skills.org.nz if you wish to suggest changes to the content of this unit standard.