Photovoltaics Glossary of Terms

Absorption Coefficient	Property of a material which defines the extent to which a material absorbs energy from sunlight
Accelerated lifetime testing	Placing photovoltaic modules in extreme weather conditions in a laboratory environment. This is designed to simulate the worst possible weather conditions possible when a solar panel is in the field. This is used to help determine module lifetimes
Alternating current (AC)	Electricity flowing in both directions at a specified (or determinable) frequency. For example in Australia our AC network is 50Hz or 50 cycles per second, which means that, 50 times each second the current flows one way and 50 times per second current flow in reverse
Amorphous silicon	The non-crystalline form of silicon. This form lacks the crystal structure of crystalline silicon, and is somewhat unstable (it degrades in sunlight for example).
Anisotropic etch	A chemical that etches (burns) away the surface of a semiconductor at different rates depending on the direction/plane. This way, by pouring the etching chemical on a material, some sides will burn off faster, leaving a particular shape (e.g. a pyramid)
Antireflection coating	Surface coating on the cells that prevents light reflecting off the surface of the cell. For maximum efficiency all light incident on the cell should be trapped inside it. Antireflective coatings minimise incident light reflection from the cell
Array	A number of photovoltaic modules linked together to form a system. The size of the array is determined by the load and amount of solar radiation at the site
Availability	Systems or applications that do not tolerate system downtime as a result of power failure are said to require high availability. It is critical for these systems to be powered all the time (e.g. medical freezers for human bodies or emergency telephones). It is the % of time (reliability) that the energy supply must function. 100% availability means the energy supply is needed continuously, without interruption.
Bandgap	The energy difference between the top of the valence band and the bottom of the conduction band
Batteries	Electrochemical devices that can store energy. There are many technologies available and have varying voltages, lifetime and charging requirements
Battery backup	A device which maintains a continuous supply of electric power to connected equipment by supplying power from a separate source when utility power is not available

Battery bank	A grouping of individual batteries such that they are electrically connected in series/parallel combinations to give the desired total output voltage and current. This group will have two outlet terminals with which to connect to a circuit, providing a single connection point to access all the batteries.
BIPV	Building Integrated Photovoltaic is the use of photovoltaic modules as a part of the building materials (such as wall, roof)
Black-outs	When generators that were supplying an electricity grid fail and cause loss of power to loads and buildings that require it
Boost charge	Partial charge of a storage battery, usually at a high current rate for a short period.
Breakdown voltage	Minimum reverse voltage to make the diode conduct in reverse
Bulk semiconductor material	Either the p-type or the n-type region of a solar cell - the thicker part. e.g. p-type semiconductor bulk material might be doped with an n-type dopant to form a thin n-type layer on one surface
Circuit elements	Elements such as resistors, inductors and capacitors which made up a circuit
Charge Controller	Device that manages the charge and discharge of batteries from a photovoltaic array. It ensures that batteries are not over charged or over discharged to make the batteries last longer
Chemical etch	The process of using chemicals such as acid and bases to dissolve away unwanted materials such as metals, grease
Circuit breakers	Automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit
Climate change	The variation in the Earth's global climate or regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the Earth, external forces (e.g. variations in sunlight intensity) or, more recently, human activities.
Compound	A material that combines multiple elements from the periodic table together in a single structure. Each element is chemically altered in this state, so the whole material exhibits different properties to a simple physical mixture of each element.
Conduction band	The energy level required by an electron (or hole) for it to be considered free to escape its atom’s valence shell and thus, conduct current.
Conductor	Material which readily allows electric current to pass when a voltage is applied

Contacts	Metal (usually silver or aluminium) that is deposited on a solar cell to collect the generated carriers (electrons) from the cell and deliver them to a load circuit. There is a top contact (the grid you see on top of a cell) and a rear contact (usually covers the entire back of the cell). The two contacts are electrically separated by the silicon and connect to the circuit to allow current to flow.
Control Circuitry/ Controller	Electric circuit used to monitor and distribute the photovoltaic array output. This usually includes a MPPT, charge controller and regulator and sometimes other more complicated components such as an inverter
Conventional current	Flow of positive charge (externally from positive to negative terminal of a generating source). In metal wires, this is opposite in direction to actual physical current that is caused by electrons
Conversion efficiencies	The ratio between output to input, maybe presented as decimals or percentage
Corrosion	The degradation of a metal's structural strength and colour due to contact and chemical reaction with water. It is commonly associated with rusting of iron
Covalent Bond	A bond between atoms where each contribute one electron to the bond, so each atom can be considered as having both the electrons as part of its total collection. There are usually 2 electrons in each covalent bond for silicon.
Crystals	A solid in which the constituent atoms, molecules, or ions are packed in a regularly and strictly ordered repeating pattern extending in all three spatial dimensions. The material is quite rigid and the structure is usually highly stable
Crystallisation	The process by which a liquid substance forms a very neatly structured solid crystal when it is cooled sufficiently slowly. Only some substances form such crystals.
Crystallinity	The extent to which a material exhibits the properties of a crystal. If an entire silicon ingot is made of just one crystal, this is the highest level of crystallinity possible. If we observe scattered atoms that show no order that you would find in crystals, then we say the material has very low crystallinity.
Current	The amount of electric charge flowing through a surface over time (amount of charge per second)
Dielectric materials	A substance that is highly resistant to the flow of an electric current
Direct current (DC)	Electricity flowing in only one direction (generally around a circuit)
Depletion region	An insulating region within a conductive, doped semiconductor material where the charge carriers have been swept away through recombination. It is also the region at the very centre of a p-n junction where there is no net charge.

Diffusion	The natural tendency for an impurity or element to spread evenly through another material, driven by vibrations associated with kinetic energy due to temperatures (i.e. Brownian motion). At room temperature, we see food colourings diffusing in water (spreading itself out evenly) or smell perfumes diffusing throughout a room. At high temperature this process occurs much faster. It is a natural tendency for a material in high concentration to spread out in the medium it is in.
Diode	Electrical element (component) that allows electricity to flow in only one direction. A photovoltaic cell is a large area diode that can absorb the sun's energy
Direct Bandgap	In a direct bandgap semiconductor, electrons at the conduction-band minimum can combine directly with holes at the valence band maximum, while conserving momentum
Doping	The process of intentionally introducing impurities into an extremely pure semiconductor in order to change its electrical properties. It is done by introducing a dopant (e.g. other elements) into the semiconductor in order to alter the conduction properties. It allows conductivity to be controlled by creating an excess of positive or negative charge carriers
Efficiency	In regards to solar cells, it describes the amount of electrical energy produced as a fraction of the light energy received by the cell as a percentage. This is the key measure of cell performance
Electrical distribution system	System of delivery of electricity to the end user. The most common form of distribution is the 'electricity grid' – a network of transmission lines (wires) connecting generators to loads.
Electric field	A conceptual region where electrical charges experience a force due to other electrical charges nearby. The field is shown in lines, where closely-spaced lines indicate stronger forces experienced. The arrows on the lines indicate the direction a positive charge would flow if placed in that location in the field.
Electrochemical	Refers to chemical reactions where electricity is either consumed or released in the process. Chemical reactions are ones where chemical bonds are broken and reformed
Electrons	Fundamental subatomic particles that carry a negative electric charge
Encapsulation	The protection placed around the cells when modules are made. Encapsulation has been designed to last for over 20 years and therefore protect the cells for that period to ensure proper operation of the module
Energy/Energise	To supply or transfer enough energy to an object (e.g. an electron) to allow it to do work. If something has energy, it means it is capable of doing work or transferring that energy to another object which could use that energy to do work. Energy is measured in Joules (SI unit)

Energy level	This refers to the amount of energy that an electron may actually possess. There are ranges of energy levels that electrons in semiconductors may have, and we call these ranges, “bands”
Enhanced greenhouse effect	The enhancement of Earth’s natural greenhouse gases due to man made emissions of greenhouse gases, mostly carbon dioxide
Equilibrium	In p-n junction formation, this is the natural state where backward & forward current flows are equal. We see no net movement of charge once equilibrium is reached
Fault currents	An abnormal flow of current in an electric circuit due to a fault (usually a short circuit or abnormally low impedance path).
Fossil fuel	Refers to hydrocarbon fuels, primarily coal, petroleum (fuel oil) and natural gas. It is formed from the remains of dead plants and animals over millions years under pressure under rock, and in an absence of oxygen (thus preserving them from microbes)
Frequency (electrical)	The number of wavelength cycles a photon or an oscillating AC signal passes through in one second. It is given in the SI units, Hertz (Hz). Most electricity grids operate on 50Hz (Global) or 60Hz (US and Japan).
Fuses	Electrical protection devices that break the electrical circuit if too much current is present. Fuses are particularly important for circuits with batteries, where very large currents can be drawn in the event of a fault or short circuit (over 200 amps depending on the battery type and size). This may damage sensitive electrical devices like microprocessors.
Germanium	A type of semiconductor material. Has a smaller bandgap than other semiconducting materials
Grain boundaries	Interfaces where crystals of different orientations meet.
Grid-connected system	A photovoltaic system that is connected to the electricity grid network via an inverter. Because PV outputs DC electricity and grids are AC, this type of system must have an inverter between the PV and the grid to convert and feed AC power into the grid
Greenhouse gases	Gaseous components of the atmosphere that contribute to greenhouse effect
Greenhouse effect	The radiative process by which an atmosphere warms a planet by trapping the sun’s heat.
Electricity grid	Often just called, “the grid.” This refers to the network of cables & high-power electrical devices used to deliver power from the generators to the loads (residential, industrial etc.)
Ground fault	A difference in the currents in the hot and neutral wire which may cause electric shock
Global Warming	The increase in the average temperature of the Earth’s surface, atmosphere and oceans which is mainly linked to the increase of greenhouse gases (GHGs) in the atmosphere

Harmonics	A wave of signal can be transmitted with waves of multiple frequencies overlayed on the main one. These are the harmonics and their allowable frequencies are always an integer multiple of the fundamental frequency
Holes	A vacant position in a crystal lattice left by the absence of an electron, especially a position in a semiconductor (like a solar cell) that acts as a carrier of positive electric charge.
Hybrid system	Combination of two or more types of energy to supply a load (for example, solar and wind, or solar and diesel)
Indirect Bandgap	Semiconductors that have an indirect bandgap are inefficient at emitting light. Electrons require both a photon and a momentum change to move from the valence band to the conduction band
Ingot	Molten and subsequently solidified silicon cubes or cylinders, ready for cutting into wafers.
Insulator	Material that does not allow electric current to pass through easily
Integrated circuit	A miniaturized electronic circuit (consisting mainly of semiconductor devices, as well as passive components) that has been manufactured in the surface of a thin substrate of semiconductor material.
Interconnection	With regard to PV modules, this refers to the connection of the individual cells that make up the module. The bottom of one cell is connected by metal wires to the top of the next cell
Inverter	Electrical device that converts DC electricity into AC electricity
Ion	An atom that has lost or gained electrons to give unequal number of electrons and protons. This altered 'atom' now carries a net charge
Islanding	Any situation where the grid electricity is off-line and one or more inverters from a grid-connected PV system maintain a supply of electricity to that section of the grid or to a consumer's installation An island situation may cause an electrical shock hazard to service personnel operating on the island network section while they think it has been shut down.
IV curve	A graph of the current-voltage characteristics of a solar cell under illumination
Kerf losses	Silicon 'sawdust' that is generated and lost when you saw an ingot to cut individual wafers out of it.
kWh	A unit of energy. 1kW of power continuously consumed (or produced) for one hour draws (or generates) a total of 1kWh (kilowatt-hour) of energy. In SI units, 1 kilowatt-hour is equal to 2.6MJ (megajoules or "million joules") of energy

Light	Electromagnetic radiation from the sun. Most of the spectrum is ultraviolet, visible light and infra red. Photovoltaic cells can use most of this radiation and convert it to electricity
Loads	Any device or appliance that is using or consuming power
Maximum power point	A single operating point for a photovoltaic cell where the values of the current (I) and voltage (V) of the cell result in a maximum power output
Maximum power point tracker (MPPT)	Integrated into the charge controller/regulator and operates the solar panels at their maximum power point. This ensures that in all light conditions, the maximum allowable power is being extracted for a photovoltaic array
Metals	A shiny material that conducts heat and electricity very well. Flexible metals can be used as electricity conducting wires
Micron	Also known as a micrometer. It is a unit of length equal to one thousandth of a millimetre, or one millionth of a meter.
Mismatch	Mismatch losses are caused by the interconnection of solar cells or modules which do not have identical properties or which experience different conditions from one another.
Modified square wave	This waveform is a compromise between the sine wave and the square wave. The positive and negative pulses of the square wave are thinned, separated and made taller, so the peak voltage is much closer to that of a sine wave, and the overall shape of the wave more closely resembles that of a sine wave.
Module/Panel	A number of photovoltaic cells linked together into a convenient unit. 36 cells are commonly linked together because this provides the voltage required to charge a 12-volt battery and are usually a convenient size for installation
Motor	In this text, a motor refers to a device that converts electrical energy or stored energy in fuel, into rotational energy in a spinning shaft. The spinning shaft can be connected to other devices to cause them to turn as well.
Multicrystalline silicon	A type of crystalline silicon which typically has a simpler technique for production, and hence, is cheaper. The silicon is made up of many smaller crystals, all at different orientations
Multijunction cell	The use of multiple layers of silicon, doped with alternating p and n layers to create multiple p-n junctions. Each layer of silicon is optimized to absorb a different part of the solar spectrum, thereby increasing the overall collection efficiency of the PV device.
N-type Silicon	This is silicon that has been doped with a material with more electrons in its outer atomic structure than silicon. The most common example is silicon doped with phosphorous

Open-circuit	This is when a circuit is cut. Think of an electric cable that has been cut by scissors. This is an open circuit. Voltages in circuits are sometimes measured across an open circuit (use multimeter leads to reconnect cut cable)
Open circuit voltage	The maximum voltage available from a solar cell, and this occurs at zero current
Oxidise	For a material to combine chemically with oxygen (often the oxygen already present in air), to produce a new substance with different properties
Packing density	The area of the module that is covered with solar cells compared to that which is blank. The packing density affects the output power of the module as well as its operating temperature. The packing density depends on the shape of the solar cells used.
Parallel	The voltages across components in parallel with each other are the same in magnitude and they also have identical polarities.
Partial shading	A condition where light to part of solar module or cell is blocked by external features such as tree or building
Passivation	The process of incorporating materials in the solar cell to make open bonds chemically inactive. That is, they will not interact with impurities that may be present in the semiconductor material and this therefore prevents electrical performance degradation
Periodic Table	A table of all known elements in the universe that exist as atoms. Each listing shows the weight of one mole (6.02×10^{23} atoms) of the element, the number of protons (and neutrons), and the element's chemical symbol.
P-N junction	Interface between p-type and n-type silicon. Due to the charge differences between the doped materials, an electric field is set up. Also know as a diode and forms the basis of a solar cell and allows electrons to be collected from within the cell to flow as current
P-type silicon	This is silicon that has been doped with a material with fewer electrons in its outer atomic structure than silicon. The most common example is silicon doped with boron or aluminium
Photoelectric effect	The emission of electrons from most surfaces that occurs when light (photons) hits them
Photons	A state of light in which light is viewed as consisting of packets or particles of energy
Photovoltaic effect	A process or effect that generates voltage in a solar cell
Photovoltaics	Field research related to solar cell. A general term used to mean the conversion of sunlight directly into DC electricity using semiconductor devices
Photovoltaic cell	Semiconductor device that converts solar energy (mostly ultraviolet, visible light and infra red radiation) directly into DC electricity

Photovoltaic system	The array combined with the control circuitry
Power	Amount of energy per unit of time. The unit for power is watt
Power draw	The power drawn by a particular circuit element in a circuit
Power supply	Device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies
Pulse width modulation	The modulation of signal's or power source's duty cycle, to either convey information over a communications channel or control the amount of power sent to a load
Recombination	The process by which electrons already in the conduction band fall back to a lower energy position in the valence band
Regulator	Similar to a charge controller but usually has additional capabilities to control systems components other than batteries (e.g. a diesel generator or PV array).
Reverse Leakage Current	Current flowing from that semiconductor device when the device is reverse biased (connecting the p-type silicon to negative terminal, and n-type silicon to the positive terminal)
Platinum	A metal which is resistant to corrosion and is widely used for electrical contacts
Radiation	Energy in the form of waves or moving subatomic particles.
Rated power or power rating	The amount of power a resistive circuit element or electrical device can withstand flowing through it. It is also the power that a device may generate if it's a power source. Manufacturers provide power ratings for devices they produce, and they are likely to fail if this rating is exceeded.
Remote area power supply	A system that provides electricity in remote locations, without requiring connection to an electricity distribution system.
Reverse saturation current	Small leakage current that flows when a diode (or p-n junction) is operated in reverse bias or reverse polarity
Ribbon silicon	A type of crystalline silicon which is fabricated by a variety of solidification (crystallization) methods that withdraw thin silicon sheets from pools of relatively pure molten silicon.
Screen-printing	A method of forming metal grid lines on the top surface of a solar cell. This method uses a paste containing the metal and squeezes it through a stencil outline that only allows the metal to be laid in the required pattern on the cell.
Selenium	An element in the periodic table which has photovoltaic and photoconductive properties

Semiconductor	A material that has properties somewhere between insulators and conductors. They can provide insulation at low energy levels (very low temperature and no sunlight) and conduct at higher energy levels (ambient temperatures and sunlight present). Doping of these materials changes their conductive properties and makes photovoltaics possible
Series	The current that enters a series circuit has to flow through every element in the circuit. Therefore, all elements in a series connection have equal currents.
Series resistance	Resistance which is caused by the movement of current through the emitter and base of the solar cell; the contact resistance between the metal contact and the silicon; and finally the resistance of the top and rear metal contacts.
Short circuit	An accidental low-resistance connection between two terminals of a power source that are meant to be at different voltages. A short-circuit is where a power source is connected (at its outlet terminals) by wires without any resistors connected in-between to consume the power. What happens is that very high currents (lots of electrons) flow from the power source directly back into itself. These high currents cause overheating in the power source itself (e.g. in a PV module, the high currents can cause melting of interconnects, or even explosions in a battery because of the chemicals inside). Short circuits also cause fires because sparks, and arcs form and burn combustibles
Short circuit current	The current through the solar cell when the voltage across the solar cell is zero (i.e., when the solar cell is short circuited)
Short wavelength light	Light with higher frequency in the electromagnetic spectrum. Wavelength is the inverse of frequency. The wavelength is the distance of the full-length of the wave in question.
Shunt	A device which allows electrical current to pass around another point in the circuit.
Shunt resistance	Resistance which causes power loss, and typically caused by manufacturing defects. Shunts provide a conduction path that bypasses the p-n junction in a solar cell.
Silicon	A semiconductor material. Most commonly used in the photovoltaic industry due to its abundance
Single crystal silicon	A type of crystalline silicon which typically has better material parameters but is also more expensive
SI Units	The internationally accepted system of units that are assigned to the various types of quantities encountered in the universe. The common formulas hold true to themselves and between one another when the units of the quantities are specified in SI Units. Note that some individuals & some nations do not comply with the SI system of units

Solar field/park	An area of land (field or park) which is specifically designed for the generation of solar power, which is usually connected directly to the grid
Solar spectrum	The full range of wavelengths of electromagnetic radiation supplied by the sun. This includes visible light, as well as infrared and ultraviolet wavelengths that are invisible to human eyes.
Solar thermal	General term used to describe the use of the sun's energy as heat. Generally, no electricity is produced using solar thermal energy (but there are some systems that do). An example of this is a solar hot water system on the roof tops of many houses.
Square wave inverter	A type of electrical inverter that produces a square wave output; it consists of a DC source, four switches, and the load
Stand alone system	These are systems that are self-sufficient. They consist of a photovoltaic array, control circuits and batteries so that power can be supplied at any time (even at night – from the batteries). There is no connection to the grid. An example might be a calculator or a house that has not got a connection to the electrical grid
State of charge	State of charge (SOC) is used to indicate the amount of charge left in a battery
Substrate	The material forming the base of the cell beneath the junction or superstrate (the material on the top of the junction). In most wafer cells, the substrate is quite thick and provides physical support
Superstrate	Solar cell configuration where the glass substrate is not only used as supporting structure but also as window for the illumination and as part of the encapsulation
Supersubstrate	Commonly used in thin-film cells, where the thick glass layer acts as the substrate, but it actually covers the front surface of the cell where the sunlight should come in. So, when manufacturing, we lay down the glass first, then the front layer, and then the rest of the cell. Then we flip it over when ready to use.
Sustainable	The ability to continue a defined behaviour indefinitely
Switches	A device for changing the course (or flow) of a circuit
String	Occurs when two or more modules or cells are connected in series
Tedlar	The fairly rigid back material on a PV module, used to provide structural support for the cells.
Texturing	Formation of pyramids in the surface of silicon to decrease the reflectivity of a surface
Thermalisation	The situation where an electron has been given more energy by a photon than required to jump the energy bandgap, and subsequently the electron loses this surplus energy by 'bumping' into other nearby atoms (converting the kinetic energy to heat)

Thin film	Thin films are material layers of about 1 µm thickness or less
Transformer	A device that transfers electrical energy from one circuit to another by magnetic coupling without requiring relative motion between its parts. It usually comprises two or more coupled windings, and, in most cases, a core to concentrate magnetic flux.
Transistor	A type of semiconductor device, commonly used as an amplifier. It is used widely in a variety of digital and analog functions, including amplification, switching, voltage regulation, signal modulation, and oscillators.
Transparency	We describe a material as being transparent if it lets through most of the light that falls on it (e.g. window glass is transparent to short wavelength radiation but not long wavelength radiation). This means the wavelengths of light that pass through can be absorbed by materials/things behind the transparent one.
Transparent conducting oxide	A transparent top surface electrode or contact. It is a material that lets sunlight through but also conducts electricity so the electrons can escape the cell from the top surface. Usually, tin oxide (or SnO_2) is used as a TCO
True sine wave	This is the shape of an ideal AC waveform (sinusoidal). It's the most desirable output of an inverter, producing no damage to appliances that utilise the AC electricity
Unencapsulated	Solar cells that have not been integrated into a module that would protect them from natural elements such as water, oxygen, dust
Uninterruptible power supply	A device which maintains a continuous supply of electric power to connected equipment by supplying power from a separate source when utility power is not available.
Valence band	Describes electrons in the outer orbit of their atoms and are tied to the atom and not free to move or conduct current. They possess less energy than is required to free themselves and conduct current.
Voltage	The difference in electrical potential between two points of an electrical or electronic circuit, expressed in volts. It measures the potential energy of an electric field to cause an electric current in an electrical conductor
Wafer	A thin slice sawn out of a solid silicon ingot that is turned on its flat side and used to manufacture a solar cell. These wafers are typically between 200-300µm thick.

Further definitions may be found at the following websites:

- Denis Lenardic (2006), *Photovoltaic Glossary* [online], Available: http://www.pvresources.com/en/glossary.php (Accessed 24th August, 2006)

- Fitzgerald, M. (2003), *Glossary of Energy Terms* [online], Available: http://www.pvpower.com/glossary.html (Accessed 24th August, 2006), Science Communications Inc.
- Sandia National Laboratories (2002), *Photovoltaic Systems Research and Development* [online], Available: http://www.sandia.gov/pv/docs/glossary.htm http://www.pvpower.com/glossary.html(Accessed 24th August, 2006)