Solar power is generated when energy from the sun (sunlight) is converted into electricity or used to heat air, water, or other fluids. There are two main types of solar energy technologies:

- **Solar thermal** is the conversion of solar radiation into thermal energy (heat). Thermal energy carried by air, water, or other fluid is commonly used directly, for space heating, or to generate electricity using steam and turbines. Solar thermal is commonly used for hot water systems. Solar thermal electricity, also known as concentrating solar power, is typically designed for large scale power generation.
- **Solar photovoltaic (PV)** converts sunlight directly into electricity using photovoltaic cells. PV systems can be installed on rooftops, integrated into building designs and vehicles, or scaled up to megawatt scale power plants. PV systems can also be used in conjunction with concentrating mirrors or lenses for large scale centralised power.

Solar thermal and PV technology can also be combined into a single system that generates both heat and electricity. Geoscience Australia 2013

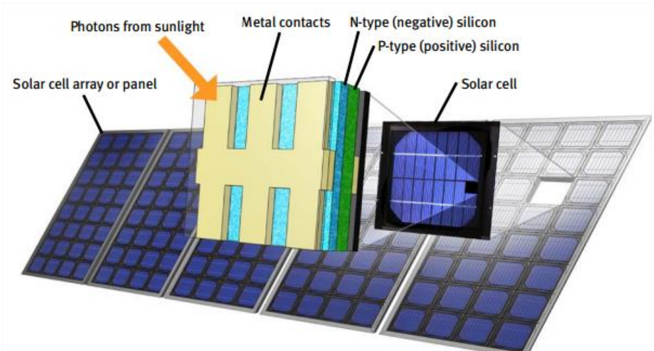
Solar Thermal

The sun's heat energy can be captured by a number of different collectors and turned into hot water. This type of power is called solar thermal.

Flat plate collectors are the most common form of solar thermal power used for instance in home hot water systems. These flat plate collectors are like greenhouses that trap and use the sun's heat to raise the temperature of water up to about 70 degrees Celsius.

Because dark colours absorb more heat than light colours, the collector surfaces are usually painted black to absorb as much heat from the sun as possible. This helps water circulating through the panel to reach a higher temperature. Some collectors have a special surface, which reduces the amount of heat re-radiated from the collector. These produce even hotter water.

Parabolic dishes are concave-shaped discs, which remain constantly focused on the sun with the aid of sun-tracking devices. The curve of each dish concentrates the sun's rays to a small central point, thus reducing heat losses and enabling water (or other fluid) passing through that point to be heated to a high temperature. If the temperature is high enough this water can be turned into steam to drive turbines to make electricity.



A Solar PV panel

Photovoltaic Systems

Solar photovoltaic (PV) refers to the panels that you may have seen installed on the rooftops of homes and businesses. The panels have several layers that work together to produce electricity. When the light from the sun hits the panels it causes electrons to flow between the P-type and N-type layers of silicon, creating a current that produces electricity.

Facts about solar photovoltaic power

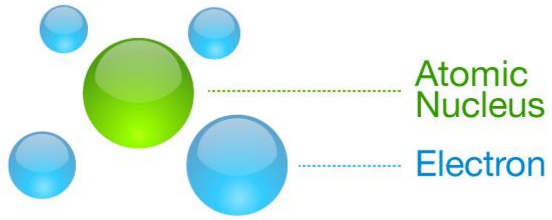
- Solar PV is like having a mini power station on your roof because it can supply power without being connected to an electricity grid. This makes it an excellent source of energy for remote areas.
- Have you ever seen a telephone box with solar panels on the roof? Many phone boxes in rural areas are powered like this.
- Need power at night? Solar PV panels can only generate electricity when the sun is shining, but excess power can be stored for use at night or on cloudy days.
- Solar PV is installed on over one million rooftops across Australia. (April 2013)
- Germany, Spain, Japan and the USA are the leaders in the solar PV industry, but Australia has the highest average solar radiation of any continent. This means we have the potential to overtake all these countries and lead the world in solar energy generation. Go Australia!

www.cleanenergycouncil.org.au/education

How Solar PV cells work

The Solar Cells

The most important part of solar panels are the silicon solar cells. Silicon is made of tiny atoms which have charged electrons. The most common design of solar panels today uses two different types of silicon. This is to create negative and positive charged atoms. To create a negative charge, the silicon is combined with Boron, and to create a positive charge, the silicon is combined with Phosphorus.
This combination of different solar cells creates more electrons in the positively charged silicon and less electrons in the negatively charged silicon. The positively charged silicon cells are sandwiched with the negatively charged silicon cells. This configuration enables a reaction that produces electricity when the silicon cells are exposed to sunlight.

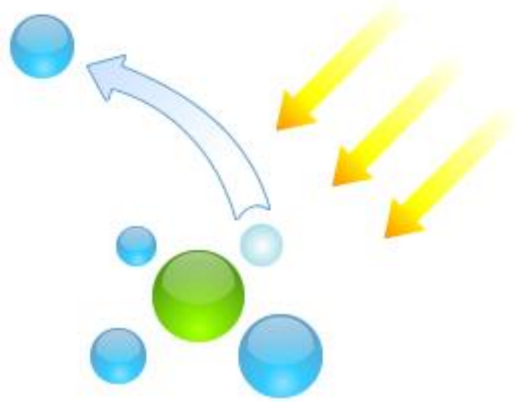


Silicon Atom found in Solar Cells

Generating Electricity

The particles of light which travel from the sun to Earth every day are called photons. Photons take approximately 7 seconds to get from the sun to your roof. When the sun shines on solar panels, the photons cause a reaction and the magic of solar power generation begins.

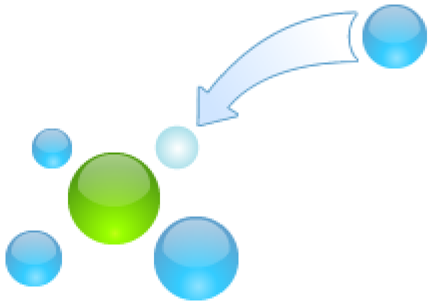
1 The photons from the sun hit the solar cells; they loosen some of the electrons which surround the atoms in the silicon solar cells. The negative charged electrons separate from their atoms in the silicon cells.



1) Electron leaving a Silicon atom, creating a gap

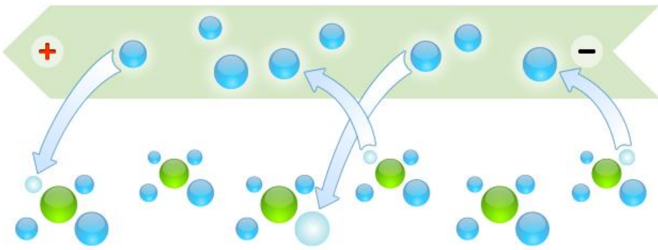
http://www.australiansolarquotes.com.au

2 Loose electrons now migrate through the electrical current to an available electron gap in the silicon cells. This reaction happens as long the sun hits the solar panels.

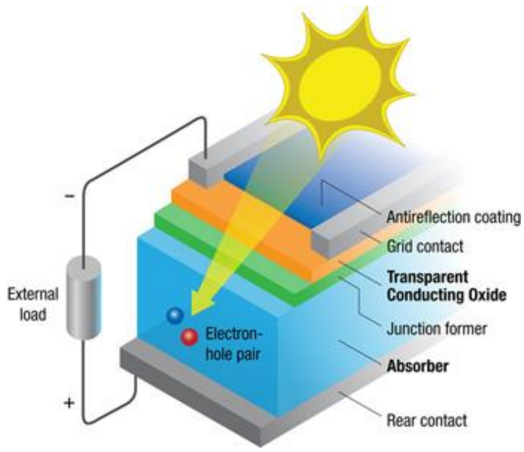


2) Electron closing the gap in left in the Silicon atom

3 Throughout the day, this process is repeated and the electrons flow in one direction constantly leaving atoms and filling the gaps with different atoms. This flow of electrons creates an electrical current, or how we like to call it, **Solar Power**.



3) Electron cycle in silicon solar cells creating solar power



http://www.nrel.gov

Pros

Abundant

The potential of solar energy is beyond imagination. The surface of the earth receives 120,000 terawatts of solar radiation (sunlight) – 20,000 times more power than what is needed to supply the entire world

Renewable

Solar energy is a renewable energy source. This means that we cannot run out of solar energy, as opposed to non-renewable energy sources (e.g. fossil fuels, coal and nuclear).

We will have access to solar energy for as long as the sun is alive – another 6.5 billion years. We have worse things to worry about; in fact, scientists have estimated that the sun itself will swallow Earth 5 billion years from now.

Environmentally Friendly

Harnessing solar energy does generally not cause pollution. Solar panels make energy, but they take energy to make, too. And, until about 2010 or so, the solar panel industry used more electricity than it produced, according to a new analysis. Now, the industry is set to "pay back" the energy it used by 2020. It is clear that solar energy reduces our dependence on non-renewable energy sources.

Sustainable

An abundant and renewable energy source is also sustainable. Sustainable energy sources meet the needs of the present without compromising the ability of future generations to meet their needs. In other words, solar energy is sustainable because there is no way we can over-consume.
Solar energy is available all over the world. Not only the countries that are closest to the Equator can put solar energy to use – Germany, for example, has by far the highest capacity of solar power in the world.

Cons

Expensive

One of the main disadvantages is the initial cost of the equipment used to harness the suns energy. Solar energy technologies still remain a costly alternative to the use of readily available fossil fuel technologies. As the price of solar panels decreases, we are likely to see an increase in the use of solar cells to generate electricity.

Intermittent

Solar energy is an intermittent energy source. Access to sunlight is limited at certain times (e.g. morning and night). Predicting overcast days can be difficult. This is why solar power is not our first choice when it comes to meeting the base load energy demand. However, solar power has fewer problems than wind power when it comes to intermittence.

Energy Storage is Expensive

Energy storage systems such as batteries will help smoothen out demand and load, making solar power more stable, but these technologies are also expensive.

Luckily, there`s a good correspondence between our access to solar energy and human energy demand. Our electricity demand peaks in the middle of the day, which also happens to be the same time there`s a lot of sunlight!.

Pollution in manufacturing

While solar power certainly is less polluting than fossil fuels, some problems do exist. Some manufacturing processes are associated with greenhouse gas emissions. Nitrogen trifluroide and sulfur hexafluoride has been traced back to the production of solar panels. These are some of the most potent greenhouse gases and have many thousand times the impact on global warming compared to carbon dioxide. Transportation and installation of solar power systems can also indirectly cause pollution.

Pros	Cons
Reduces Electricity Costs With the introduction of net metering and feed-in tariff (FIT) schemes, homeowners can now “sell” excess electricity, or receive bill credits, during times when they produce more electricity than what they actually consume.	**Exotic Non-Renewable Materials** Certain solar cells require materials that are expensive and rare in nature. This is especially true for thin-film solar cells that are based on either cadmium telluride (CdTe) or copper indium gallium selenide (CIGS).
Technology is Improving Technological advancements are constantly being made in the solar power industry. Innovation in nanotechnology and quantum physics has the potential to triple the electrical output of solar panels by 2030.	**Requires Space and suitable location** Power density, or watt per square meter (W/m^2), is essential when looking at how much power can be derived from a certain area of real estate of an energy source. Low power density indicates that too much real estate is required to provide the power we demand at reasonable prices. The global mean power density for solar radiation is 170 W/m^2. This is more than any other renewable energy source, but not comparable to oil, gas and nuclear power.

Concentrated Solar involves the use of arrays of mirrors to concentrate the solar energy (Heat and Light radiation) onto a receiver. Concentrated solar is currently divided into 2 separate technologies: Concentrator Solar Photovoltaic (CSV) and Concentrated Solar Power (CSP).

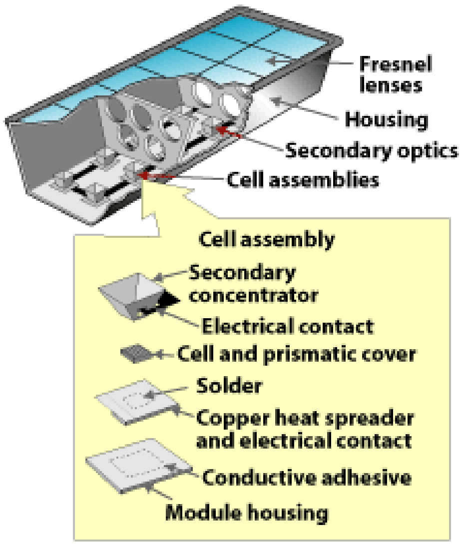
Concentrator Photovoltaic Systems (CSV)

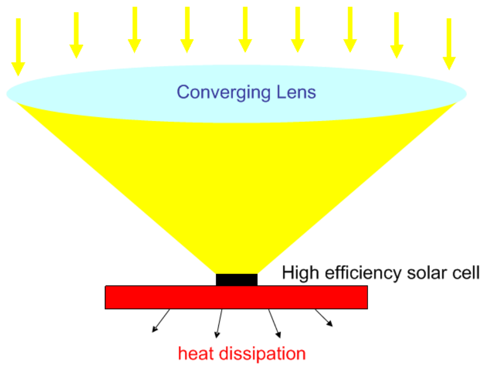
Concentrator Photovoltaic Systems (CSV) systems use less solar cell material than other PV systems. PV cells are the most expensive components of a PV system, on a per-area basis. A concentrator makes use of relatively inexpensive materials such as plastic lenses and metal housings to capture the solar energy shining on a fairly large area and focus that energy onto a smaller area—the solar cell. One measure of the effectiveness of this approach is the concentration ratio—in other words, how much concentration the cell is receiving.

CSV systems have several advantages over flat-plate systems.

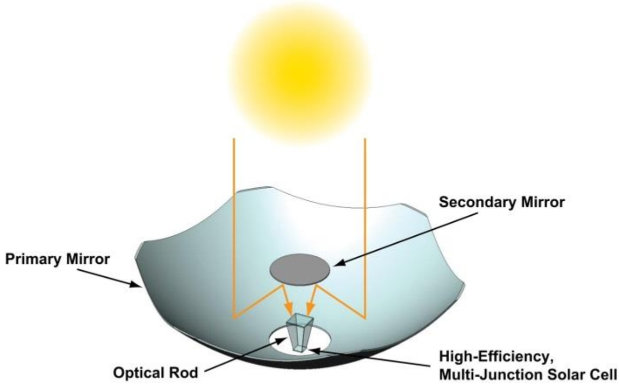
- concentrator systems reduce the size or number of cells needed and allow certain designs to use more expensive semiconductor materials which would otherwise be cost prohibitive.
- a solar cell's efficiency increases under concentrated light. How much that efficiency increases depends largely on the design of the solar cell and the material used to make it.
- a concentrator can be made of small individual cells. This is an advantage because it is harder to produce large-area, high-efficiency solar cells than it is to produce small-area cells.

However, challenges exist for concentrators. The required concentrating optics are significantly more expensive than the simple covers needed for flat-plate solar systems, and most concentrators must track the sun throughout the day and year to be effective. Thus, achieving higher concentration ratios means using not only expensive tracking mechanisms but also more precise controls. Both reflectors and lenses have been used to concentrate light for PV systems.





A typical concentrator unit consists of a lens to focus the light, a cell assembly, a housing element, a secondary concentrator to reflect off-centre light rays onto the cell, a mechanism to dissipate excess heat produced by concentrated sunlight, and various contacts and adhesives.



Mirror-based CSV systems

Concentrating solar power (CSP)

Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine that drives a generator.

Concentrating solar power offers a utility-scale, firm, dispatchable renewable energy option that can help meet our nation's demand for electricity. CSP plants produce power by first using mirrors to focus sunlight to heat a working fluid. Ultimately, this high-temperature fluid is used to spin a turbine or power an engine that drives a generator. The final product is electricity.

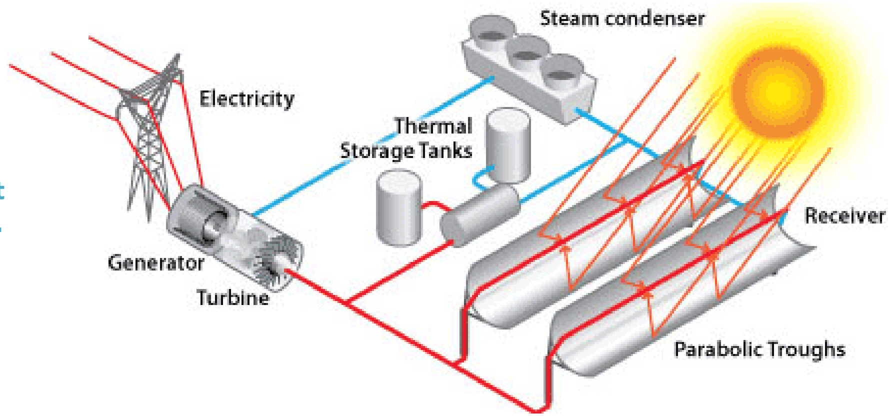
Smaller CSP systems can be located directly where power is needed. For example, single dish/engine systems can produce 3 to 25 kilowatts of power and are well suited for distributed applications.

There are several varieties of CSP systems:

Linear Concentrator Systems for Concentrating Solar Power

Linear concentrating solar power (CSP) collectors capture the sun's energy with large mirrors that reflect and focus the sunlight onto a linear receiver tube. The receiver contains a fluid that is heated by the sunlight and then used to create superheated steam that spins a turbine that drives a generator to produce electricity. Alternatively, steam can be generated directly in the solar field, which eliminates the need for costly heat exchangers.

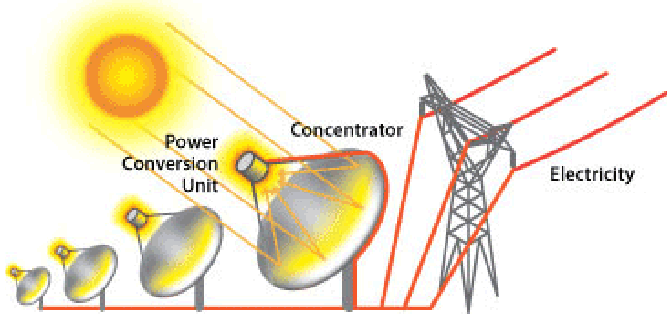
Linear concentrating collector fields consist of a large number of collectors in parallel rows that are typically aligned in a north-south orientation to maximize annual and summer energy collection. With a single-axis sun-tracking system, this configuration enables the mirrors to track the sun from east to west during the day, which ensures that the sun reflects continuously onto the receiver tubes.



A linear concentrator power plant using parabolic trough collectors.

Dish/Engine Systems for Concentrating Solar Power

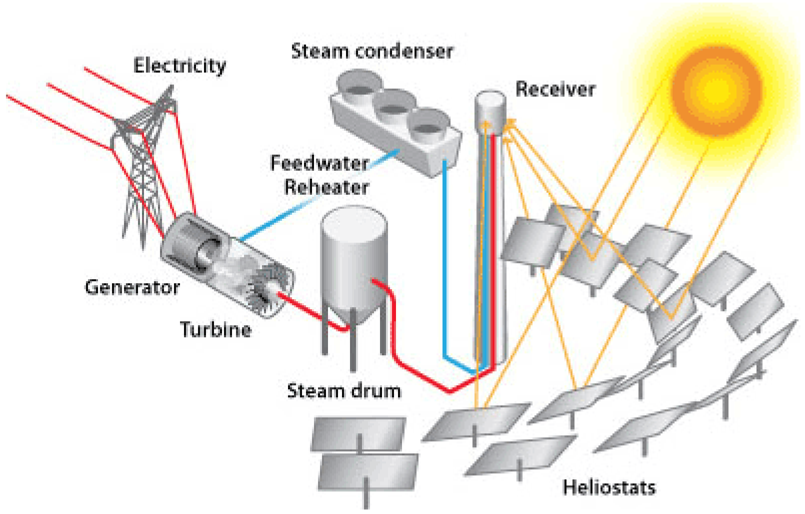
The dish/engine system is a concentrating solar power (CSP) technology that produces relatively small amounts of electricity compared to other CSP technologies—typically in the range of 3 to 25 kilowatts. Dish/engine systems use a parabolic dish of mirrors to direct and concentrate sunlight onto a central engine that produces electricity. The two major parts of the system are the solar concentrator and the power conversion unit.



A dish/engine power plant.

Power Tower Systems for Concentrating Solar Power

In power tower concentrating solar power systems, numerous large, flat, sun-tracking mirrors, known as *heliostats*, focus sunlight onto a receiver at the top of a tall tower. A heat-transfer fluid heated in the receiver is used to generate steam, which, in turn, is used in a conventional turbine generator to produce electricity. Some power towers use water/steam as the heat-transfer fluid. Other advanced designs are experimenting with molten nitrate salt because of its superior heat-transfer and energy-storage capabilities. Individual commercial plants can be sized to produce up to 200 megawatts of electricity.



A power tower power plant.

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Thermal Storage Systems for Concentrating Solar Power

One challenge facing the widespread use of solar energy is reduced or curtailed energy production when the sun sets or is blocked by clouds. Thermal energy storage provides a workable solution to this challenge.

In a concentrating solar power (CSP) system, the sun's rays are reflected onto a receiver, which creates heat that is used to generate electricity. If the receiver contains oil or molten salt as the heat-transfer medium, then the thermal energy can be stored for later use. This enables CSP systems to be cost-competitive options for providing clean, renewable energy.

Several thermal energy storage technologies have been tested and implemented including the two-tank direct system, two-tank indirect system, and single-tank thermocline system.