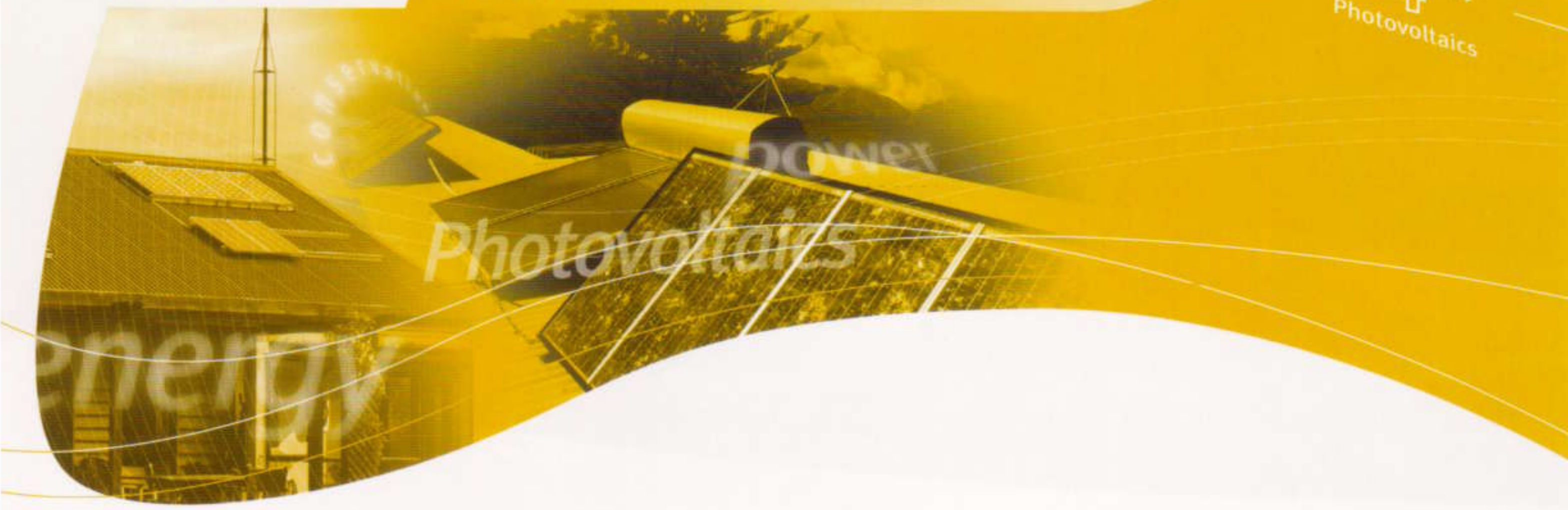
Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

RENEWABLE ENERGY

Fact Sheet 4 Photovoltaics



Photovoltaics can generate electricity for your home or business, either as part of a stand-alone power system, or for buildings already connected to the local electricity network.

The term 'photovoltaic' means 'light – electricity'. A photovoltaic system (often just called a PV or solar electric system) converts radiant energy from the sun directly into electricity.

The benefits of photovoltaic systems

PV systems use the most abundant energy source on the planet, solar radiation, to generate electricity. They are silent, consume no fuel and generate no pollution. They also contribute to the reduction of greenhouse gas emissions; a 2kW PV system on a house will prevent the emission of about 40 tonnes of CO_2 during its projected 30-year lifetime. Furthermore, the use of PV will reduce your electricity bills and exposure to fluctuating and steadily rising electricity prices.

A PV system can be installed in stages; it can start small and be expanded as energy use or financial resources grow. It also requires very little maintenance over its lifespan .

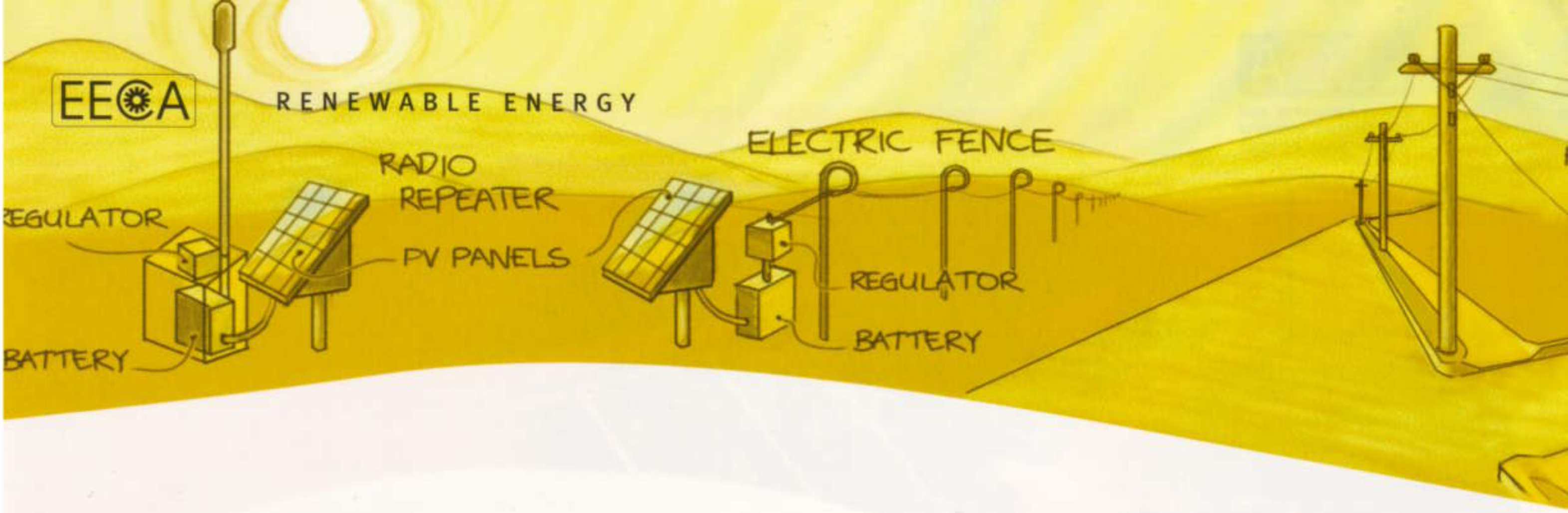
Where are PVs used?

In New Zealand PV systems are used extensively to power a range of equipment such as communications equipment, water pumps, lights on navigational buoys, electric fences on farms, and some of the calculators and wrist watches that we use every day. Larger systems have been used for some time on homes, farms, public buildings, petrol stations and lighthouses in remote areas.

Innovative applications for PV are being developed all the time. For example, ferry vessels can now be powered by PV, and a PV-powered plane set an altitude record of 29,524 metres in 2001. In Australia there is a popular race for cars powered by nothing but the sun's energy.

PV systems are often part of a stand-alone power system (SAPS) that is not connected to the electrical distribution network. In these systems, the electricity generated by the PV system is stored in batteries where it can be used when the PV cells are not producing electricity.

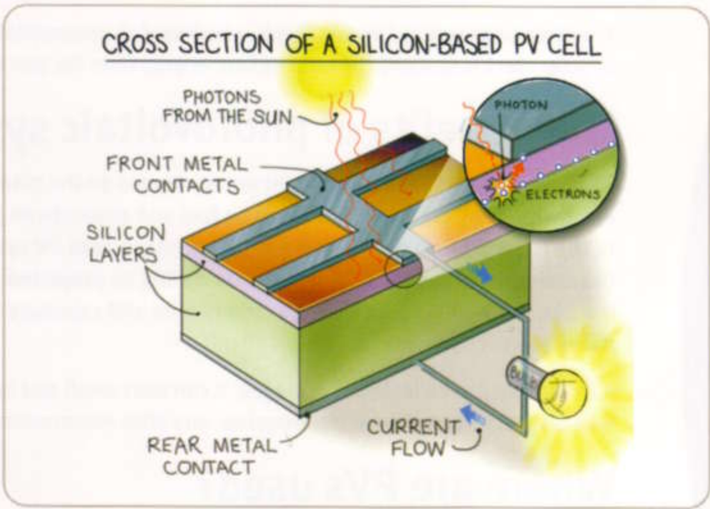
A stand-alone PV system avoids the cost of connecting a property to the local lines network, which can be between $18,000 and $24,000 per kilometre. Given this investment, it becomes cost effective to consider SAPS solutions using PV panels for homes, communications stations, and farms or lodges in remote areas.



Network-connected systems

On a property that already has a mains power connection, additional equipment can be used to link a PV system to the local lines network. This allows electricity to be drawn from the lines network if there is a shortfall, or electricity to be supplied to the network if the PV system is generating excess power. Effectively, the network acts as the back-up system, instead of a generator and batteries.

When your PV system generates excess electricity you may be paid for electricity exported to the network. As a consumer you pay for electricity imported from the network. No changes in the household wiring are necessary, but the system must meet the technical and safety requirements of the local network company, and the Electricity Regulations 1997. You will also need an agreement with your retailer if you are to sell electricity. The requirements vary between network companies and electricity retailers. Your retailer will be able to advise you of their requirements and which network company you need to contact.



PV system components

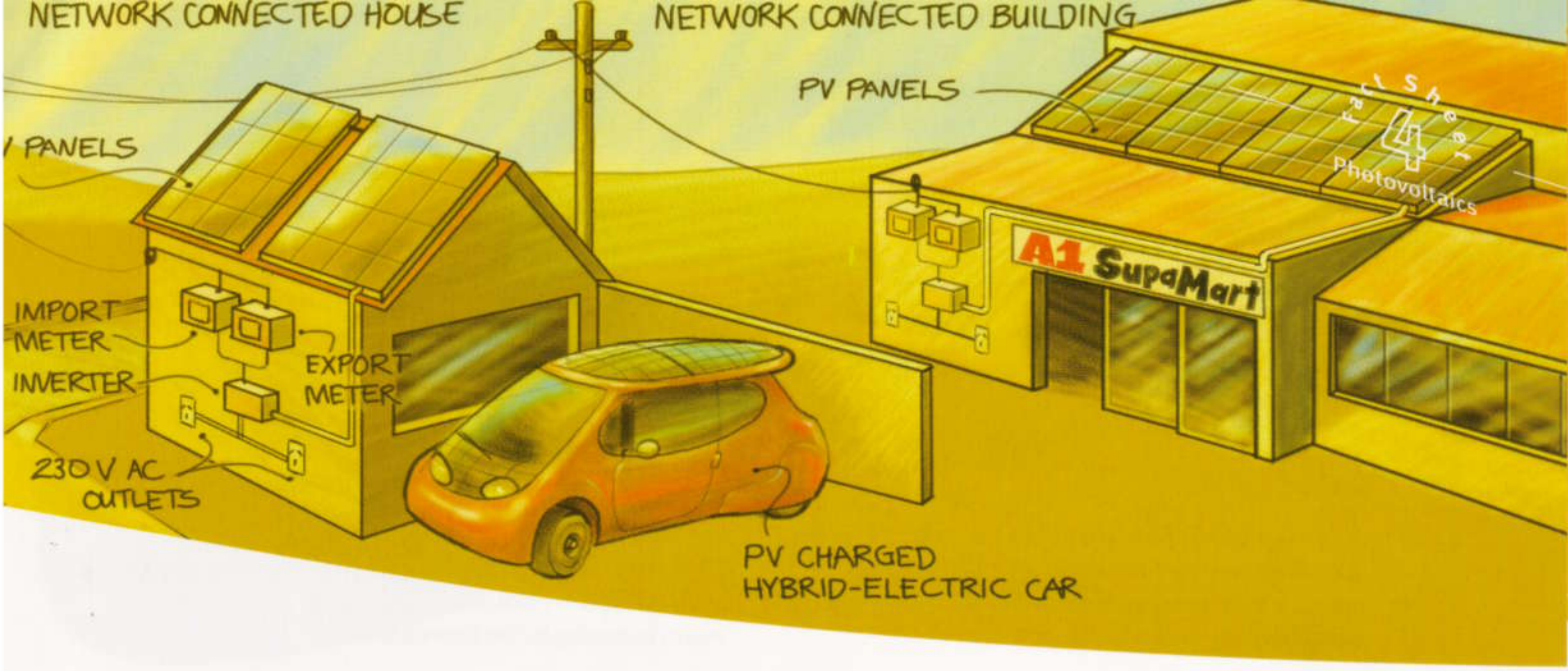
PV panels: The panels are the collector of the system and are made up of individual PV cells wired together. Each panel has a rating specifying its maximum (or 'peak') electrical output under standard conditions. For example, a panel with a 75W peak rating (75Wp) will have a power output of 75W at a sun intensity of 1000W per square metre (about what you would get at noon on a fine summer day) and an outside temperature of 25°C.

The main advantage of solar panels is that they are robust, virtually maintenance free, and fairly unobtrusive. They are designed to withstand arctic cold, desert heat, tropical humidity, winds in excess of 200kph, and 25mm diameter hail stones. The panels require sturdy mounting hardware to protect them from wind and snow loads.

Batteries: PV panels do not generate power continuously, so in a stand-alone system the output can be stored using batteries. If you have a network-connected installation you will not require batteries. At present, banks of 12V to 48V lead-acid batteries are commonly used. Sealed batteries cost more and require less maintenance, but a well-maintained lead-acid battery will usually last longer than a sealed battery. For optimum life, deep-cycle batteries should be used. Electronic devices called 'charge controllers' are used to control the battery charging and extend their life. The batteries will typically need replacing in 4 to 10 years, depending on quality, sizing and how they are used.

Inverter: PV panels generate direct current (DC). Since most household appliances run on alternating current (AC), an inverter is usually required. In a network-connected installation the inverter will convert DC to 230V AC before it gets exported or used in the house. In a stand-alone system the inverter converts power stored in the batteries to 230V AC. A range of DC household appliances does exist, but the choice of products is limited at present.

Protective devices such as diodes, DC fuses or circuit breakers, safety switches, grounds and properly gauged wiring are required to meet electrical code safety standards.



How do photovoltaic systems turn sunlight into electricity?

PV cells convert sunlight into electricity by a simple energy conversion process. When sunlight (in the form of photons) hits the PV cells, the photons excite electrons in the atoms of a semi-conducting material used to make the cells. The energised electrons result in an electrical voltage being generated, and when an electrical circuit is closed, electrons flow producing an electric current (see diagram).

The most commonly used semi-conductor is silicon. Two layers of silicon with slightly different properties – one with an excess of electrons and one with a deficit of electrons – are sandwiched together. When sunlight energises the electrons they flow from the layer with excess electrons to the other layer with a deficit of electrons.

The electrical output from a single silicon PV cell is small. But when many cells are joined together to form a 'panel', useful amounts of electricity are produced. These panels can also be arranged in an 'array', so that even more electricity can be produced. A single panel may have an output of 12 volts, the same as the voltage of many car batteries.

Installing a system

To install a system, you will need to talk to an expert who can help you accurately calculate your energy needs and the size of system you require. The designing and installing of a system should be carried out by skilled personnel to ensure a safe and energy efficient outcome. To avoid damage or risk of fire, appropriate New Zealand Standards need to be observed, such as those relating to the installation of batteries, and wiring regulations.

Properly designed and installed PV systems are covered by most insurance policies in the same way as any other electrical equipment, but the policy provider should be consulted to determine the limits of coverage.

Energy efficiency and other options

The cost of a PV system is largely determined by the peak load – the maximum amount of electricity likely to be demanded at any one time. There are various energy efficiency strategies you can adopt to reduce the peak load and therefore the cost of your system. These range from not operating energy intensive appliances (such as electric heaters, ovens, clothes dryers and electric hot water cylinders) at the same time, to investing in energy efficient appliances and lights.

Cost of photovoltaic systems

The cost of installing a PV system also depends on whether the system is being installed on a new building, which is often less expensive than on an existing building, and whether it needs a backup system. The cost needs to be balanced against all benefits associated with installing a system. Remember, the total economic rate of return should be calculated on the basis of life-cycle costs, including environmental benefits and the cost of the electricity produced over the lifetime of the system.

At this time, the total cost, including batteries, of a 1kW stand-alone PV system comprising quality components will range from about $26,000 to $33,000. This includes installation by a professional installer and appropriate warranties and backup service. The total cost of a 2kW network-connected PV system comprising quality components, including installation by a professional, will range from about $37,000 to $47,000. These are representative prices and are subject to variation.

The cost of supplying and installing a small PV system for a communication station, such as a radio repeater, is approximately $2,000. This would include a 60W panel and support pole, three 100 Amp-hour 12V batteries and a charge controller. It will cost more to install in extremely remote areas.

Case study

A family of four in Auckland decided to install PV panels. The family also wanted to be largely self-sufficient in energy, and be able to integrate their PV system into the local electricity network.

Therefore, they had to have two meters – one which measured the electricity they consumed, and one which measured the electricity they exported. Under a 'net-billing' arrangement with their electricity retailer, they only pay the net amount of these two meters.

They first invested in energy efficient appliances and a solar water heater. These cost more than standard appliances and water heating systems, but reduced their daily electricity demand to just 4kWh. By comparison, many houses require 35kWh or more per day. Reducing their demand enabled them to have a PV system to meet all of their electricity needs.

The costs of the PV system were:

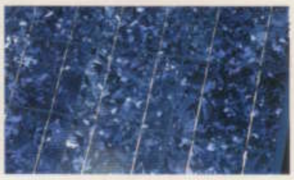
1.95kW PV array	$29,850
Installation, including labour, cabling, mountings and sealants	$3,250
Inverter	$4,000
Additional meter	$200
Electrician's certification	$150
Total costs	$37,450

The cost of the system is comparable to the purchase of a 4x4 car. However, the PV system will not depreciate and the owners know exactly how much they pay per year for electricity, which makes budgeting for the future easier.

Benefits and savings

Because the family's home is connected to the local network, they didn't need to purchase any batteries – the network is the battery bank.

In a year, they pay just $180 ($15 a month) for the line connection to their house. For about 9 months of the year the PV panels generate more than their daily electricity needs. In their case, the excess electricity generated is bought by their electricity retailer at about 1/3 the retail price (about 5c/kWh). The PV system generates on average 7.25kWh a day, which is 3.25kWh more than their energy efficient home requires. For the other months, they consume more than they generate and purchase electricity from their retailer at standard retail prices.



This fact sheet was produced by the Energy Efficiency and Conservation Authority (EECA). EECA is a Crown entity implementing the National Energy Efficiency and Conservation Strategy through improving energy choices.

For more information on energy efficient homes, photovoltaics, or other renewable sources of energy visit:
www.eeca.govt.nz
www.energywise.org.nz
www.photovoltaics.org.nz

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