Turning Sunlight into Electricity

NZPVA Info Sheet # 3

Photovoltaics for Homeowners

July 2003

Previous information sheets in this series provide background information on photovoltaics that is of interest to homeowners:

Info Sheet #1 – An Introduction to Photovoltaics

Info Sheet #2 – Everything You Wanted to Know About Photovoltaic Technology

Contact the NZPVA for copies of these and other publications.

New Zealand Photovoltaic Association Inc.

Promoting the use of our sun as a sustainable energy source for the production of electricity

Positioning photovoltaic arrays on a home

Photovoltaics describes the process of converting radiant energy from the sun (solar energy) directly into electricity. Note that photovoltaic systems are not the same as solar water heating systems that use heat absorbing panels to heat water directly.

Photovoltaic (PV) arrays can be placed on just about any surface of a home that catches sunshine for most of the day. The roof is an obvious choice, but arrays can be placed on other surfaces such as sunshades, the roof of a conservatory or carport, or as cladding on the sides of a building. The simplest way of mounting an array is to place the modules in a solid frame on top of the existing roof. However, the array may be integrated into the roof and special PV roofing modules are available for such purposes.

Of course, the more light an array receives, the more electricity it will generate. The following issues will affect how much light the array will receive:

Orientation: The array should be orientated as close to due north as possible.

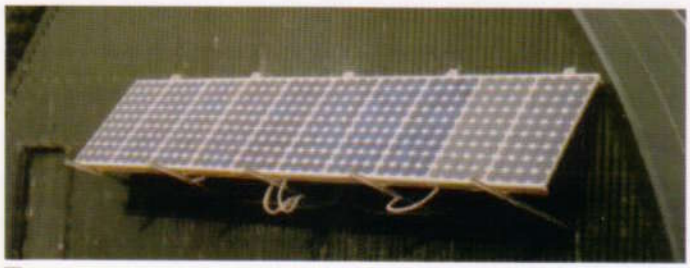
Tilt: A minimum tilt of 15° from horizontal is important to allow rain to wash dust from the array. In practice, any tilt between vertical and 15° could be used, but the optimal angle is latitude minus 10° for grid-connected systems and latitude plus 15° for stand alone systems. The tilt should be somewhat lower to maximise performance in summer and higher to maximise performance in winter.

Shadowing: Even minor shading can result in a considerable loss of performance of the array. Thus, shadows from trees and adjacent buildings should be avoided as much as possible.

Tracking: For maximum output, the array would rotate to follow the sun on a daily basis and the tilt would be adjusted seasonally. However, mobile systems of this kind are expensive and in practice the orientation and tilt of an array are often fixed.

Area required for a photovoltaic system

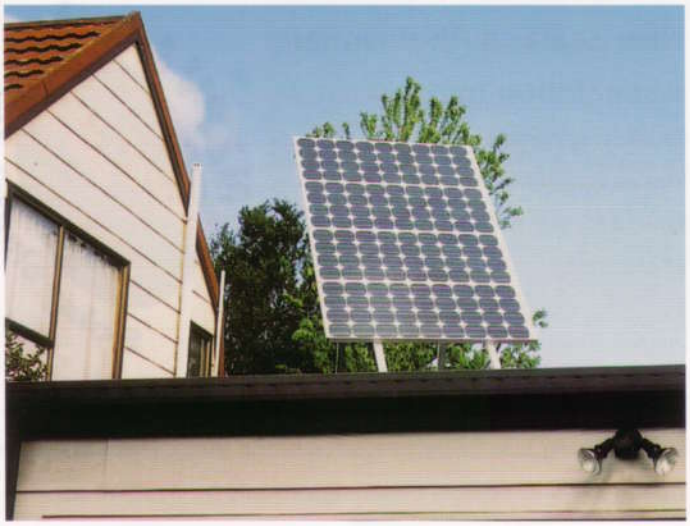
The area of the system depends on the power output required and the type of module used. An area of about 8m^2 will be required to mount an array with a rated power output of 1kWp (the "p" stands for "peak" and designates the maximum amount of power produced under standard conditions) if monocrystalline silicon modules are used. This will vary somewhat if polycrystalline or amorphous modules are used. These areas can be scaled up or down depending on the power required.



An array of ten monocrystalline solar modules.

Durability of photovoltaic modules

Modules are solidly constructed and are very robust. Good quality modules carry a 25-year warranty and will probably last quite a bit longer than that. They are designed to withstand all the rigours of the environment including arctic cold, desert heat, tropical humidity, and winds in excess of 200kph and 25mm diameter hail at terminal velocity.



An array of four 75W monocrystalline modules mounted on a roof top.

Can photovoltaics be used for domestic hot water or swimming pools?

Although it is technically feasible to use electricity produced by a PV array to heat water, it does not make economic sense. Hot water or pool heating can be done much more economically with a solar water heating system that uses heat-absorbing panels, very different to PV panels. Ideally, a PV system should be used in tandem with a solar water heating system.

The total system – what else is needed besides the modules?

PV systems in homes are required to supply power whenever it is needed. Therefore the system must include a mechanism for either storing the energy produced or for drawing power from the grid (i.e. using the grid as a "battery") when the modules are not producing electricity or enough electricity. If the home is connected to the grid, no battery storage system is required. The PV system will simply draw power from the grid when it is required. If the home is not connected to the grid, the PV system will require deep cycle batteries to store the energy generated by the PV array. These systems also need electronic devices called "charge controllers" to control the battery charging process and limit the discharging of the batteries.

Because PV systems produce direct current (DC), most systems usually include another device called an "inverter" to supply alternating current (AC) power in standard voltages and frequencies. This enables the use of standard appliances in the system. Special DC appliances can be used but most people prefer to use their standard 230V appliances.

In addition, 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. In general PV systems will also require sturdy mounting hardware to support the PV array.

Whole-building design and photovoltaics

Ideally, when you add PV to your home or are installing PV into a new home, you should take a "whole-building" energy perspective. Whole-building design combines PV with passive solar design (e.g. orientation to the sun and storing solar heat), energy efficiency measures (e.g. adequate insulation, double glazed windows and energy efficient appliances) and a solar water heating system. This approach will significantly reduce your home's energy consumption, allowing you to install a smaller PV system.

Regulations

Photovoltaic systems are generally subject to the same electrical, building and safety codes that govern the installation of electrical wiring and equipment in residential, commercial and industrial buildings. It is important to use components with appropriate safety approvals to international standards. Properly designed and installed PV systems are covered by most insurance policies in the same way as any other electrical equipment installed on the insured property, but the individual policy should be consulted to determine the limits of coverage. All connections to the 230 Volt AC output from an inverter will require electrical compliance to the appropriate standards.

How cost-effective are photovoltaic systems?

This depends on the situation. Where there is no grid electricity available (rural houses, remote cabins, baches), PV can be used for most electrical needs (although it is not generally economical to use it for space heating, stove cooking or hot water heating) and is very competitive on a straight cost comparison basis with conventional methods of producing electricity in such situations (i.e., diesel or petrol-powered generators).

Where homeowners are within reach of the grid, but have to pay to have a power line laid to their site, PV is also very cost competitive. As a rough guide, anyone in New Zealand building a structure more than 0.5 km from an existing power line will find that it pays to install a renewable energy system such as PV. The introduction of high local network charges (often an annual minimum of $500 for holiday homes) has made the "own-your-own" option even more attractive, even for dwellings which are already on the grid.

Generally speaking, for primary dwellings already connected to the grid, converting to a PV system will not be immediately competitive in terms of a straight comparison of the cost of electricity from the grid with the cost of electricity produced by PV. However, this does not take into consideration the overall benefits of PV, nor the hidden costs of producing electricity from fossil fuels and other means, in terms of subsidies for these forms of generation and the environmental costs of such generation. Furthermore, the cost of PV panels is falling, which will make the technology more and more competitive in the near future. This trend will be reinforced by rising power prices and by any dry-year shortages or other supply interruptions that will make "own your own generation" more and more attractive in urban and suburban situations.

Net Metering

Another significant trend for the individual homeowner in the urban or suburban setting is the availability of "net metering" for grid-connected PV systems. Net metered systems have a sufficiently large solar array to over-produce electricity during the day, causing the home's power meter to spin backwards. Under these circumstances, the homeowner is effectively selling electricity back to the retailer. On average, the normal 24-hour consumption of the household will be in balance with the PV output.

The monthly bill for such grid-connected systems will show no (or virtually no) power charges. The residual lines charges will vary from location to location. You will need to contact your lines company and retailer to connect to the grid.

Cost of photovoltaic systems

The cost of installing a PV system depends on a number of factors. For instance, if the system is being installed on a new building, rather than as a retro-fit to an existing building, some cost savings are likely. Cost savings can also be expected if the installer is able to install PV systems on a group of houses at the same time.

As a cost guideline, for a grid-connected system, the cost of the PV modules will be about 1/2 of the total cost of the system. In New Zealand at present, the cost of the modules works out to about NZ$7-8/Wp. Thus, the cost of the modules for a typical 2kWp system will be about NZ$14-16,000 and the total cost of the complete system about NZ$34-38,000. The cost of stand-alone systems will be higher because a battery bank will be required to store the electricity produced.

It is the view of the New Zealand Photovoltaic Association that PV technology will become increasingly economical for widespread usage throughout New Zealand over roughly the next ten years, but at different rates in different locations. Furthermore the life of the system may be close to half of the life of a building. This means that anyone building now or carrying out extensive alterations can make an economic investment by planning for PV on a modular basis, and by installing at least part of the system now rather than face the additional expense of retrofitting and rewiring at a later stage. Remember, the total economic rate of return should be calculated on the basis of life cycle costs and benefits, including environmental benefits. Furthermore, for grid-connected systems, the cost of the electricity produced over the lifetime of the system is saved.

Incentives for photovoltaics

Many countries around the world, both developed and developing, including USA, Germany, Japan, UK, India, Indonesia and Mexico provide incentives to install PV systems. These incentives capture the environmental and economic benefits of PV, including stimulating the local growth of the industry, thereby driving down costs and creating employment opportunities in the PV sector.

For example, in Britain, 50% of the cost of purchasing and installing a PV system on a home can be claimed back under the UK Photovoltaic Demonstration Programme. A range of incentives are available in the USA under the umbrella of their one million solar roofs programme, including tax credits, state grants, and low-interest financing packages. No such incentives are provided by the New Zealand Government at this time.

Buying photovoltaic modules

An informed buyer should consider a number of factors when purchasing a PV module, these include:

- Check to see what external agencies have tested, qualified, or approved the module and ask the supplier if the manufacturer regularly tests production units to international standards.
- Ensure that mono- or polycrystalline modules have a solid feel and do not twist within their frames. Amorphous panels are designed to be flexible however.
- Ensure that the junction box is solidly attached and can accommodate standard electrical fittings. The junction box should be able to take heavy gauge wire and connections between modules should be able to be made easily.
- Ensure that the connections between individual cells in the module are open and well isolated and not folded behind the cells where they can cause electrical shorts or deterioration.
- Ensure that the warranty is for a specified time and not a "pro rata" warranty for a portion of that time.
- Determine how long the manufacturer has been in the PV manufacturing business and whether it is likely to be around in 20 or 25 years time. Check the reputation of their modules after many years of operation.

Maintaining the system

PV systems are very easy to use and require little if any maintenance. However, in those cases where PV systems are connected to deep-cycle storage batteries, the batteries will require some cleaning and topping-up, similar to that required by a standard battery.

Benefits of a photovoltaic system on your home

- Your own personal power source – you have the choice over how the electricity you use is produced.
- Silent energy production.
- Clean energy production – PV systems consume no fuel, generate no pollution and contribute to the reduction of greenhouse gas emissions; a typical PV system on a house will prevent over 34 tonnes of greenhouse gas emissions during its lifetime.
- Reduce your electricity bills and exposure to fluctuating and steadily rising electricity prices and interruptions.
- Mitigate the need to build new power plants in New Zealand.
- Increase the value of your property.
- Extremely low maintenance over a lifespan of 30 years or more.
- Increase self-awareness of electricity use contributing to more energy efficient behaviour.
- Modularity – can start small and expand the system as energy use and financial resources grow.

How to obtain and install a photovoltaic system

Check the New Zealand Photovoltaic Association's website for a list of suppliers and installers of PV systems in New Zealand.

Roof-integrated photovoltaic modules on the Vardon School in Hamilton.

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