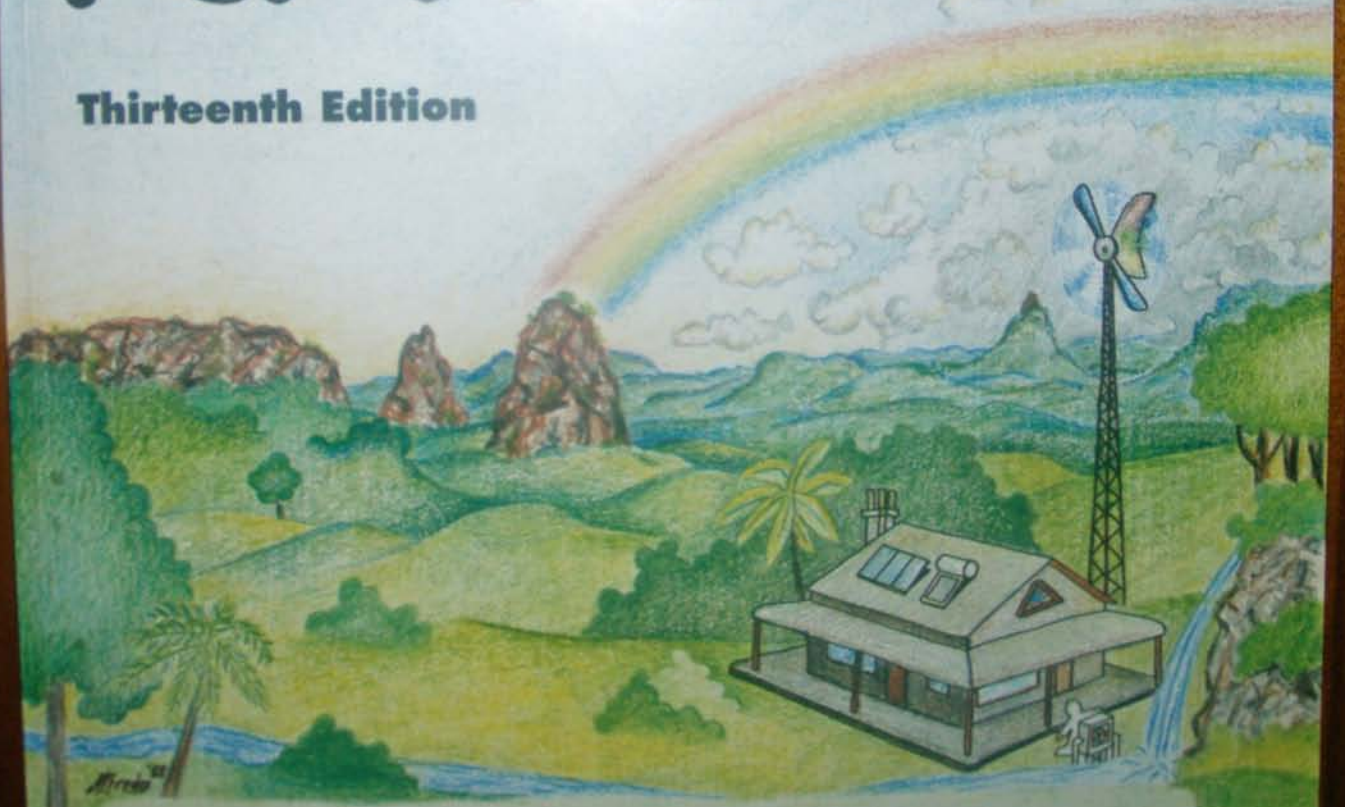
RAINBOW POWER COMPANY

NIMBIN - AUSTRALIA

ENERGY FROM NATURE

Thirteenth Edition



Renewable Energy Handbook

compiled by **Peter Pedals**

Harnessing the ENERGY FROM NATURE

13th Edition, Revision 1, September 2006

Introduction.

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RAINBOW POWER COMPANY
NIMBIN - AUSTRALIA

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Rainbow Power Company is a fully accredited member (# F543) of the Business Council for Sustainable Energy (BCSE). Energy from Nature Home Pty Ltd is an approved training provider for designers of Remote Area Power Supply Systems.

Rainbow Power Company Staff in front of company premises (from left): Hugh Murtagh, Maria Dave Lambert and Peter Pedals. Dave Christmas, Marie Pearson and Greg Clitheroe.

Below left: Billie Jackson playing table tennis.

Below right: Terry Thomas practising archery.

This book is written as a reference book, it is not expected to be read from cover to cover although some readers may wish to do so.

Pages 8 to 12 are to give the reader a basic working knowledge of electrical theory and pages 13 to 26 are to help to design and install your own system.

You may wish, for example to go straight on to page 137 for a list of products or to page 133 (near the back of the book) for a summary of much of the information in this book.

If you do not find the answer to a question in this book, please ask us.

100% recycled bleach-free paper

School tour of Rainbow Power Company premises.

Testing Rainbow Micro Hydro at the Catholic University in Lima Peru.

The Rainbow Power Company: Leading by Example

Some governments and industries are just now starting to take the threat of world-wide environmental pollution seriously or taken appropriate action in dealing with the problem. But so far it has been too little too late. Australia in particular has got a very poor standing and international reputation in this regard. We Australians now produce more greenhouse gases per head of population than any other nation. Australia and Iceland were the only two nations that were excused from applying to increase greenhouse gases above previous years at the Kyoto international convention and we are not able to meet the agreed to target.

The staff of the Rainbow Power Company are united in our endeavour to demonstrate that it is possible to live a reasonably comfortable lifestyle in an environmentally sustainable way. Rainbow Power Company may be the only company in Australia with an ongoing Carbon Credit as we continue to produce more electricity than we consume and have been actively involved in re-vegetation.

Demonstrations have often meant confrontations. The Rainbow Power Company is demonstrating for Environmental Harmony in a gentle, peaceful and encouraging manner. We are demonstrating by example!

Powered by Grid Interactive Inverter

These new premises receive nearly all the power requirements for day to day operations from the immediate environment in the form of sunshine and wind energy. With an array of 100 solar panels and a wind turbine enough power is produced to keep up with daily power requirements with any surplus power being exported to the grid via three 4.5 kW grid interactive inverters. If there is not sufficient wind or solar power the grid can supplement any shortfall.

The staff and executive of the Rainbow Power Company are also setting an example of how to avoid the pollution of waterways and beaches caused by standard sewerage disposal systems. With a dry composting toilet facility we are able to produce a rich organic humus to be returned to the soil. The dry composting toilet system does not require any water, which is periodically in short supply in Nimbin.

The Company does not create a large volume of liquid effluent that might otherwise cause blue-green algal blooms in our local waterways as we have seen in river systems all over Australia.

The Rainbow Power Company is also self-sufficient with its water requirements, collecting water from the roof of the premises. We manage our own sewerage, water and power. The Company does however depend on facilities and services from the outside world including telephone, roads and the financial banking system.

The philosophy of the Rainbow Power Company is summed up with the address of the premises located at 1 Alternative Way. We are demonstrating that there is an alternative way for both industry and home life that does not add to the world environmental crisis.

With our steadily growing export market managed on our behalf by RESHAPE Pty Ltd (a subsidiary company) we will be able to spread our message further and hopefully turn the tide in favour of more environmentally sustainable Energy Systems.

Energy from Nature has a Home

There is now a display and training facility set up in the mezzanine of the Rainbow Power Company. The display is set up as a 12 volt solar/wind/steam hybrid power system. Please feel welcome to drop in and see the display during business hours.

With thanks to all!

"Energy from Nature" owes its continuing growth and existence, to the staff of the Rainbow Power Company and the suppliers of many of the products found within these pages. I must express my thanks to all of you who helped to assemble the material that has now evolved into the eleventh edition of "Energy from Nature" and to everyone who has supported the Company and this publication over the past 13 years.

Peter Pedals

January 2001

Export of Rainbow Power Company Products and Services

Setting up outlets in developing countries

Over the years, Rainbow Power Company has developed a range of services and products to cater for all the special needs of our overseas clients.

Above: Children at a Lihir (Papua New Guinea) school get to watch television in their new solar powered school.

Left: a course held at Rainbow Power Company with students from Solomon Islands, Singapore and Australia.

- **Training**: Renewable energy systems are extremely reliable, however, training in this new technology is of critical importance in ensuring their success. It is important that people learn of not only the benefits, but also the limitations of renewable energy systems. It is also important that installations be carried out to a high standard to ensure their trouble free operation.

  The Company conducts a range of training programs, overseas and at our training centre in Nimbin for periods of between 1 day and 6 weeks. The Company has conducted courses for a number of people from several countries including Papua New Guinea, Solomon Islands and Fiji.

- **Consultancy**: The Company has carried out feasibility studies and site assessments for clients from Papua New Guinea to Ecuador.

- **Village Power Systems**: Rainbow Power Company specialises in small village systems for lighting, vaccine refrigeration, cottage industry and community centres. We provide complete wiring diagrams and user instruction sheets, as well as specialist installers and trainers for large systems.

Above: Dwelling being fitted out with solar power in Lihir, Papua New Guinea.

Left: Solar pumping installation in Papua New Guinea

- **UV Water Sterilization**: A system based on a 40W solar panel can sterilize several thousand litres of water a day to prevent water borne disease. Contact our office for further advice about the system for your water supply. We can provide a range of other products and services which are too numerous to list in this book.

Left: Peter Pedals with an early Rainbow Micro Hydro.

Below: Rainbow Power Company premises 1995

How did the Company start?

Peter: I have had a reputation for over a decade now for my involvement primarily in expanding upon the applications of pedal power as both an energy source and a way of keeping fit. Hence I acquired the nick-name of Peter Pedals. But I have been equally interested in other natural and appropriate energy sources and have several times been involved in displays along these lines.

I conceived of the Rainbow Power Company almost twenty years ago. I saw it as a good name and visualised a logo for it. Nothing much happened, other than talking about it, for a few years. Then a couple of mates, Dave and Jack, got together with me and we started to do the market stalls.

Dave: It started out just operating out of the back of someone's van. We used to go to the monthly markets in Nimbin and at The Channon. (It wasn't me, but the other Dave in the company who joined up with Peter in 1985.)

Peter: On 26 May, 1987 a lot of interested people got together and proceeded to set up the company structure.

Dave: In July 1987 we officially formed the Rainbow Power Company. We rented a little shop in Nimbin but we quickly outgrew that and managed to buy bigger premises down the road.

Green Economics & Ethical Business

We at the Rainbow Power Company are employed in an industry with a primary objective of turning the tide away from environmental destruction and towards environmental harmony. We frequently hear businesses claim that they hold environmental concerns above all else, but often this attitude is taken in order to increase sales and is only a public relations facade.

Social and Ecological Ethics

We are fortunate at the Rainbow Power Company, not just because we are employed, but because we are doing what we want to do and can feel good about. The Rainbow Power Company is motivated by a strong environmental and ecological ethic. This ethic is translated into action in the pursuit of the following objectives:

- To create **employment** for dedicated workers whilst maintaining equality in the workplace of pay, benefits and status.
- To **manufacture, wholesale, retail and demonstrate** by example all manner of devices powered by Renewable Energy sources.
- To consciously practise and review an internal **management structure** where decisions are based on worker participation and responsibility, interacting with the Board of Directors.
- To **research and develop** a wide range of reliable equipment to generate and use electrical and thermal power from sustainable sources.
- To **trade** in only high quality, user friendly, efficient, cost effective products, supported by reliable up-to-date advice and after sales service.
- To examine **alternative** possibilities of accomplishing a task, service or structure, and in accordance with its ethics, to choose the most appropriate method.
- To **educate** the general public in all aspects of using energy from renewable sources, and living and developing in a sustainable way.
- To **aid developing countries** of the world in improving their living standards by educating and trading with them in renewable energy products.
- To make enough **profit** to keep financially healthy, stay independent, maintain the philosophy, aims and objectives and pay workers and shareholders better than average.
- To work towards the **improvement of conditions** on the planet for the environment, and all that implies, and for human society.

'Energy from Nature Home' renewable energy display Grand Opening, 18th August 1994.
Inset: Peter Garrett giving the opening speech.

With the original staff of the Rainbow Power Company it was not the case of some employer providing us with the opportunity to become gainfully employed; it was in fact quite the reverse. We knew what we wanted to do. We had many of the products and ideas and we had the experience with setting up our own and neighbours' power systems. Collectively, we had many skills in the Nimbin area, including the ability to come up with an idea and carry it through to a prototype and eventually production line and sales.

Creating Ideal Employment Opportunities

It all started to fall into place in about April 1987 when we held a meeting of all interested individuals and we realised that we had all the skills available to put the idea into action. Our unanimous response was "Let's **create** the Company that will employ us" and "Let's make sure that we get the Company structure and the work environment such that we can feel that the job is the ideal job for all of us".

Everyone should have the right to be gainfully employed in an industry that has SOUND ENVIRONMENTAL AND SOCIAL OBJECTIVES ... and knowing that THE WORLD IS IN CRISIS one may need to be prepared to accept a lower wage level, at least until the industry can survive an increase in wages.

In the Rainbow Region (ie north-east NSW) a low wage is offset by other factors such as fresh air, friendly neighbours, salubrious climate, great views and a commonality of purpose in our local villages that are inaccessible at any price to workers in major cities. Most of the staff at the Rainbow Power Company also live on Multiple Occupancies with no power bills (we supply our own power, water and sewerage) and low rural rates. Operating out of a small village ensures comparatively low overheads for the Company.

A Co-operative Company

The Rainbow Power Company is very similar to a co-operative in respect to member participation. The Company encourages workers to become shareholders and will consider shareholders favourably in applying for work. In having workers who are shareholders and shareholders having to be active to have a vote, the company is assured of having the interests of the workers at heart and of the voters being 'in touch' and reasonably well informed of the issue. Likewise, the workers have the Company at heart.

Most of the above company structure and group attitude was established in July 1987 when the Company was officially set up. In the earlier days with fewer workers, we were all able to share knowledge of day-to-day events and decisions, and a common overview of the state of the business. Jobs were shared, multi-skilling being an essential ingredient, especially important due to the fact that most employees worked less than a five day week as a result of other personal commitments such as family, community and farm work. Everyone knew what everyone else was doing. 'Management' was a dirty word.

However, with the growth of business, and the inevitable growth in numbers of employees, tasks to be done and physical space in which to do them, has come the realisation that our internal management structures cannot remain static. The enormity of the collective job to be done necessitates specialisation; it becomes more difficult to maintain an overview. Nevertheless, we are so far managing to maintain a very high level of multi-skilling and shared jobs.

Our Common Commitment

Our saving grace (if indeed we have one) is a common commitment to worker integrity, a realisation that well-informed, self-reliant employees can and will do a better job. Being able to work together in one big beautiful building, sharing lunches in the staffroom alongside the courtyard and being conscientious about communicating all help the process of sharing the vision, the responsibility, and the honour of being Rainbow Power Company.

We would like to be able to offer a blueprint for surviving these changes to those other organisations with similar ideals, aspirations and problems. At least we hope that our shared commitment from our own members and employees as well as other 'new age' organisations worldwide will help see us through the maze, to remain an exciting, innovative, satisfying place to engage in Right Livelihood.

Why?

Why Appropriate Technology?

The Earth is one giant living entity, of which the human race is the equivalent of microbes on its skin. All life on Earth represents the biomass of the planet, the total mass of all living organisms combined. Without vegetation, Earth would have no free oxygen in its atmosphere - in that sense vegetation is just as important to our survival as our own lungs. If you think of this planet as one giant living entity, then any inappropriate action on our behalf is going to cause Earth as a living entity to be unwell, and in turn threaten our own well being. As a direct result of mankind's exploitation of Earth's resources, it's biomass is on a constant decline. Appropriate action is an action that meets our needs, and at the same time is an action that looks after the health of the planet as a whole.

Why Stand Alone Power Systems?

Why do we have these enormous man made energy grids criss-crossing the country, powered by energy sources that pollute with chemicals, smog, electro-magnetic radiation and radio-activity? The electro-magnetic radiation is then distributed all over the country via the power grid, putting stress on the health of those living near it or with it. Why do we put so many of Earth's limited resources into these gigantic metallic electrical conductor grids when everyone knows that the ENERGY FROM NATURE is all around us everywhere? If we can just harness the ENERGY FROM NATURE right here where we are, why even consider taking power from a distant polluting power plant via such an expensive and wasteful energy grid?

We need to seriously consider stand alone power systems as a viable option or to feed surplus solar, wind or micro-hydro power into the grid where the power lines are already established.

Why Renewable Energy Sources?

By using fossil fuels and nuclear reactors as energy sources, we are not only jeopardising our own health with chemical, atmospheric and radio-active pollution, but threatening the health of the living system of Earth as a whole. Fossil fuels are not renewable energy sources. They are finite resources, and they are going to be depleted. The resilience of the Earth; the capability of the atmosphere, the biosphere, and of all life on Earth to cope with man made pollutants, is also limited.

If we all can begin to harness the ENERGY FROM NATURE we are no longer threatening the delicate balance of life on Earth. We can regain the power of free will in society by taking responsibility over our own energy requirements and cease to be at the mercy of others' ill conceived and entirely profit motivated decisions.

The ENERGY FROM NATURE is renewable because the sun rises and sets every day. The radiant energy of the sun makes the plants grow so that we can eat and breathe. The sun also makes us feel warm; it causes water to evaporate from the Earth's surface, only to fall back on it as rain, hail and snow. This in turn causes the rivers and streams to flow. The air moves to give us wind as a result of the combination of convection currents caused by the heat of the sun and the Earth spinning on its axis.

So we have sun, wind and flowing water, all of which will be with us as sure as the sun rises every day. We do not have to generate power in a life threatening way if we have all this power, the ENERGY FROM NATURE, all around us every day, just waiting to be harnessed.

How!

AC/DC: How electric current flows

Current flows through a wire in two basic ways:

Direct current (DC): electrons flow in the same direction through a conductor (eg wire). We use 12 volt DC batteries to start our cars and DC at lower voltages in dry-cell batteries for torches, small transistor radios and cassette tape players.

Alternating current (AC): the flow of electrons oscillates rapidly backwards and forwards through the wire. In Australia, Britain and Europe the mains power is 240 volt AC which has a wave-like pulse of 50 cycles per second, measured as 50 Hertz (Hz). House-current in Canada and the United States is 110 volt AC with a frequency of 60 Hz.

Direct current electricity is used in most small-scale home energy systems, usually in low voltages, particularly 12 volt and 24 volt. A battery bank stores the electricity in a chemical form and reconverts the chemical energy back into an electrical form as the need arises. A battery or bank of batteries provides power when the sun isn't shining or the wind isn't blowing. The battery bank also serves to maintain a constant voltage.

In an independent power system you can have a mix of extra low voltage DC (eg 12 volt DC) and 240 volt AC appliances. You can use 12 volt DC economically for lights, radio and TV and use an inverter, which changes DC to AC, for standard AC household appliances.

High voltage AC has become the standard for supplying electricity through a grid system. High voltage because it can be easily transmitted over long distances and AC because it can be easily transformed to different voltages.

Extra low voltage DC does have some definite advantages for stand alone remote power systems where long distance transmission is not required. As far as storage is concerned, there is no such thing as an AC battery. High voltage is highly dangerous to deal with. The combination of both high voltage and AC is a particularly lethal mixture. The lower the voltage of the battery bank, the fewer cells are required, the cheaper the overall system and the less battery maintenance is required.

RENEWABLE ENERGY SYSTEMS

One of the advantages of a low voltage supply is that it is relatively cheap and easy to install, even in locations far removed from a grid type power supply. The battery bank can then be charged by a clean and renewable energy source such as sun, wind and water. Solar electricity is clean, noiseless and uses no fuel except sunlight. Solar energy is renewable in the sense that the sun will shine on another day to recharge your batteries.

Photovoltaic cells (solar panels) generate DC directly from sunlight at a voltage slightly higher than the battery voltage to which they are connected so as to be able to charge the battery bank.

Solar cells operate mainly on sunlight, or radiant energy and not on heat or thermal energy (used by solar collectors such as water heaters). Solar cells operate on the visible light spectrum as well as infrared and ultraviolet rays. They will continue to generate electricity, but at a lower level, on cloudy, overcast days.

Very simply, a solar cell converts sunlight directly into electricity.

This is called the photovoltaic effect, a word derived from the Latin word photo (light) and voltaic after Alessandro Volta, who invented the electric battery.

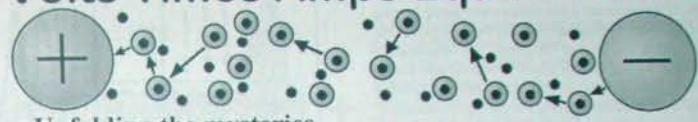
Starting with a small power system

Another advantage of the stand alone power system is that one can start with a very small system comprising of one solar panel, a distribution/meter box, a small battery bank, a few lights and a power outlet and add more solar panels, increase battery capacity, add lights etc. when you can afford to.

You don't need to have a complete and sophisticated power system at the outset. It is not only possible, but quite practical and reasonable to start with a minimum of basic components with the intention of it developing into a system that will provide enough power for it to run quite an extensive energy system.

There are a few applications for electrical power that you may find in a standard 240 volt household for which it would be very costly to generate that much power and you would be well advised to use another energy source other than electrical. Where you need to produce a lot of heat, such as for cooking, room heating, hot water you should consider options such as bottled gas, kerosene or a wood stove with a hot water jacket. This advice applies particularly to solar electricity. You can, however, use Solar Collectors (as opposed to photovoltaic solar cells) to make hot water (see page 60).

Volts Times Amps Equals Watts



Unfolding the mysteries of electricity

A great deal of our learning depends upon being able to observe and touch. In the early years of our life we do not get thoroughly acquainted with electricity the way we do with material objects because electricity cannot be inspected and dissected. In fact, for most of us it remains a total mystery. It actually seems quite magical or supernatural when it is demonstrated how it seems to be able to pass through a solid object such as lead or copper.

If we are living with our own Solar Electric system, we need to at least have a basic understanding of what the difference is between volts, amps and watts.

Yes, magical it is! And the marvellous wonders that can be performed with it just go on ad infinitum. But don't let any of this mystical stuff deter you from getting some kind of a working grasp of it. We are not going to attempt to unfold the mysteries of the universe in this chapter but just enable you to be able to deal with the basic principles associated with a Solar Electric system.

Sunshine into Electricity

If the sun shines on your Solar Panel and the Panel is properly connected to the Battery you should have a current flowing between the Panel and the Battery. This current is measured in amps. When the current is flowing between the charging source and the battery to increase the voltage of the battery, we refer to it as a charging current.

Electrons are an integral part of atoms and molecules. Each atom must always have the same number of electrons near it. Not all atoms and molecules are happy about letting go of one electron in exchange for another, only those atoms and molecules known as electric conductors will readily do so. A conductor is a material within which there are "free" electrons. These electrons will move when a force is exerted upon them. The movement of these free electrons in a conductor (eg copper wire) creates an electric current. Some materials are better conductors than others.

If a free electron from a source of energy is forced into an atom at one end of a conductor, it upsets the balance between electrons and protons of that atom. This forces another free electron from that atom to shift to an adjacent atom, thus upsetting its balance. This shifting or drifting of free electrons towards the other end of the conductor is called electric current flow.

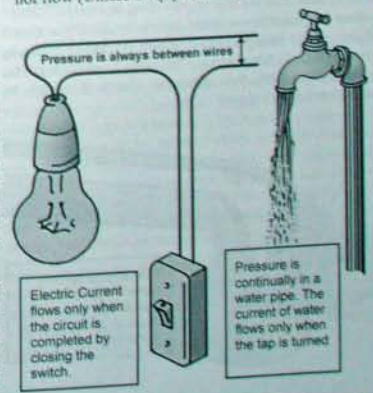
A Solar Electric Panel (Photovoltaic Panel) will exert a force upon these free electrons in an electric conductor, but only if light falls upon it and the electric circuit is completed. You could, for example connect a piece of copper wire directly between the positive and negative terminals on the Solar Panel.

As a result of the force exerted upon them each electron just jumps from the outer electron shell of one atom to the next, causing that atom to shed an electron which is then passed on to the next atom and so on. But the other end of the conductor must also be connected to the energy source that is causing the electrons to flow.

The end of the conductor passes its free electron back to the Solar Panel to fill the gap by the first electron which started the process. To put this electric current to some use, you could cut the wire at some point and connect an appliance or light bulb to the cut ends. The electric current would then pass through the appliance or light bulb as it is pushed around the circuit by the Solar Panel.

Comparing electricity to water

To help your understanding of these fundamentals it makes it easier if we compare the principles of electric current to those of flowing water. If you pump water into a pipe and place a secure plug in the other end of the pipe, the water will cease to flow. Regardless of the amount of pressure you build up, the water will not flow (Unless the pipe bursts).



However, if we construct a unit with a water pump forcing a current of water through a closed system of pipes that connects back to the inlet of the pump, we have made a path or circuit for the flow of water. We could now install and run an hydraulic motor somewhere in this circuit in the same way as we used the light bulb in the electrical circuit.

A Solar Panel or Electric Generator is like a pump. It creates pressure (voltage) which makes electrons move or flow in the wire. If a return path is not available to make a complete circuit (such as when a switch is off - ie not making contact) the flow is stopped. Regardless of the amount of pressure (voltage) generated, the electrons cannot flow (unless the voltage is high enough to arc across the gap).

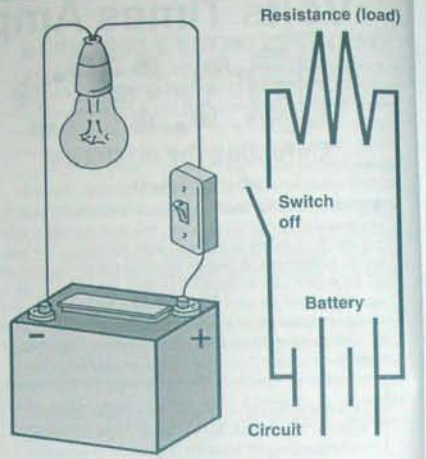
As you may have gathered by now, voltage is the term used for electrical pressure and may be compared with pressure under which water flows through a pipe. Current is the term used for the rate of flow of electricity in a conductor and corresponds to the rate of flow of water in a pipe.

Battery Storage

When a battery is connected into circuit with a Solar Panel it does not actually store the electricity (moving electrons) produced by the Solar Panel but undergoes a chemical change as a result of the electric current passing through it. This chemical change when the battery is connected to an energy source such as a Solar Panel is referred to as charging. This process can be reversed by connecting the same battery to an appliance or light. When the chemically stored energy in a battery is changed into an electric current to power an appliance or a light, this process is referred to as discharging.

At night when the Solar Panel is not receiving any sunlight to cause electron flow then the battery must be able to take over the role of providing an electric current when you want to use some electricity. So if you turn a light on, the battery starts discharging and in so doing pushes the electrons around the circuit and through the light bulb which then uses the electrical energy to manifest light energy.

A small pipe carrying water at high pressure can convey as much water as a large pipe at low pressure.



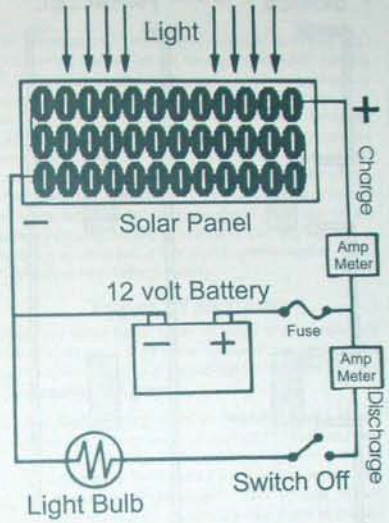
In the diagram you can see that when the light switch is turned off, the circuit is broken and hence the electrons cannot flow.

Voltage is pressure

A 12 volt Solar Panel will actually produce a voltage higher than 15 volts in order to charge a 12 volt battery. If the voltage of the Solar Panel was not greater than the voltage of the battery, the current would not flow and the battery would not charge. We need to have a difference in electrical pressure to induce a current to flow and the current will flow from the higher pressure to the lower pressure.

If you imagine a water tank on a hill with a water pipe coming out of it you may also visualise that the further down the hill you go with the hose, the more water pressure you will get. If you turned on a tap, without the use of pumps or any other way of artificially increasing the pressure, you will not get any water out of it if the tap is at the same level as the water in the tank. The further down the hill the tap is located the faster the water will flow out of it. In the same way you need a voltage higher than the battery voltage in order to charge a battery (so that the current can flow into it). The main difference between water and electricity in this analogy is that electricity flows just as easily uphill as downhill.

The average 12 volt Solar Panel has between 32 and 36 cells, each of which produces about 0.5 volts under direct sunlight. The number of cells connected in series determines the combined voltage potential of the cells and of the panel as a whole.



The size of the individual cells that make up the Solar Panel determines the amount of current flow that the panel can produce. The current would flow from the Solar Panel to the 12 volt battery and would flow at a rate that would be determined by the combination of the voltage difference between the Solar Panel and the battery and the size of the individual cells in the Solar Panel. If there is insufficient light to make all the cells in a Solar Panel produce a voltage greater than the battery voltage, the battery will not be getting any charge, regardless of the size of the individual cells.

The 12 volt lead-acid battery has 6 cells in series, each of which produces a voltage of about 2 volts. Actually, a fully charged cell of a lead acid battery not under charge will be about 2.1 volts and hence a 12 volt battery will have a voltage of 12.6 volts.

The sun shining on the Solar Panel may be equated to rain falling on the shed roof that fills the water tank where the rate at which the tank fills is dependent on how heavy the rain is, how big the shed roof is in comparison to the water tank, and how good the connections are between the shed roof and the water tank. Similarly, the connections between the Solar Panel and the battery and the size of the wire to carry the current are also important. Undersized wire and bad connections can impair the current flow or stop it entirely. A bad connection has the same effect as a resistance.

The flow rate, or amps, is largely determined by the size of the pipe (for water), or cable (for electricity), assuming that there are no other restrictions anywhere that are greater than the pipe or cable. If we go back to the example of the tap below the tank and we wish to determine how fast the water flows from the tap, we can do so by knowing two things.

Firstly we need to know the pressure, which is a function of the vertical distance between the tap and the tank (minus the resistance of the pipe).

Secondly we need to know the diameter of the outlet of the tap, assuming this is the main limiting factor for the flow rate. The rate at which the water flows is directly proportional to the pressure and is also directly proportional to the diameter of the outlet. If we call the pressure volts, the flow rate determined by the diameter of the outlet we call amps, and the rate at which you could fill a bucket we call watts; we can say now that watts equals volts times amps.

To make it easier to understand the significance of this, you can understand that there are two ways of filling a bucket faster, you can either increase the pressure (have a tap further downhill) or increase the size of the tap and the water-pipe. If you have no pressure, no matter how large the pipe and outlet is, there will be no flow.

Battery storage versus usage

If you fill a battery with a trickle charger charging at the rate of one amp for 100 hours, you can say that you have put 100 amp-hours into the battery. Similarly, if you charged the battery at a rate of 10 amps for 10 hours, you have again put 100 amp-hours into that battery. If you turn on a light that uses 2 amps and leave it on for 5 hours, you have taken 10 amp-hours out of the battery.

The overall state of charge of a battery is the amp-hours charge (including the initial charge in the battery) minus the amp-hours discharge. In this equation you must also take into account that the battery needs a little excess charge to maintain itself. The maximum amp-hour charge in a battery is limited to the amp-hour capacity rating of the battery which is to say that you cannot store more in a battery than it is capable of storing. All batteries have some degree of self discharge and transfer some electricity into other forms of energy other than electro-chemical (transferring electrical energy into chemical energy and vice-versa).

We have already determined that amps times volts equals watts. Watts is a rating of power. It stands to reason that amp-hours times volts would then equal watt-hours. Watt-hours is a rating of work. Battery capacity is usually given in amp-hours.

Pressure Times Flow Rate Equals Power

The formula: volts times amps equals watts (V x I = P) tells us that there is a direct relationship between pressure (volts), flow rate (amps) and power (watts).

The same relationship holds true with water. It is possible to mechanically transfer the power of water with a low pressure and high flow rate to a high pressure and low flow rate. There is some power lost in the mechanical transfer. The total power of the output can never be greater than the power of the input. It is equally possible to do the reverse of going from a high pressure and low flow rate to a low pressure and high flow rate.

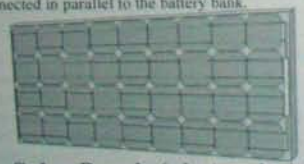
Series or Parallel?

The cells of a battery are connected in series in order to get the appropriate voltage. Each cell of a lead-acid battery for example has a nominal voltage of 2 volts. By connecting 6 cells in series you have a 12 volt battery. The positive terminal on each cell is connected to the negative terminal of the next cell and so on.

If on the other hand you connected the positive terminal of one cell to the positive terminal of the next cell and likewise connected the two negative terminals together the voltage of the two combined cells would still be 2 volts but the storage capacity (amp-hours) would be twice that of each individual cell. This is called parallel connection.

Parallel Connections

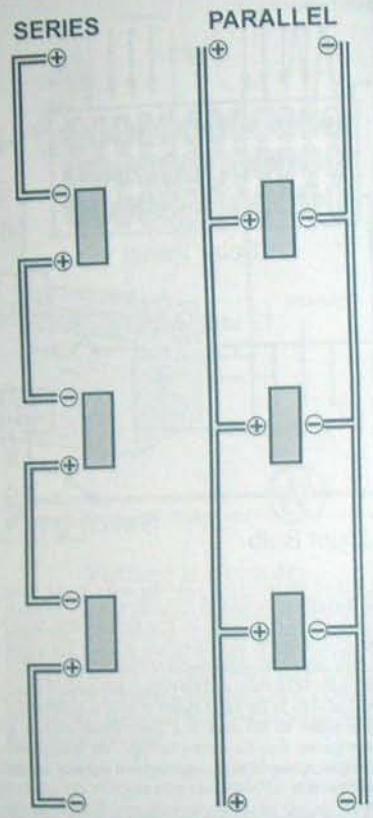
Appliances, lights, voltmeter, solar array, wind turbine, hydro-electric generator and battery charger are all connected in parallel to the battery bank.



Solar Panels (photovoltaic)

Individual cells of a solar panel produce about 0.5 volts per cell in direct sunlight and are connected in series to produce the desired voltage. Solar panels to charge a 12 volt battery usually have 36 cells in series.

Solar Panels are connected in series to charge battery banks in excess of 12 volts (eg 2 identical panels in series for a 24 volt battery bank). Solar panels are connected in parallel to increase the charging rate. Both series and parallel connection are combined for higher voltage and higher charging rate. The entire solar array is in parallel with the battery bank.



Battery Bank

Fully charged Lead-Acid batteries have an open circuit voltage (OCV) of 2.1 volts per cell. That voltage may be higher during charging and lower during discharging. Six cells are connected in series to produce a nominal 12 volts.

It is recommended to use larger capacity (more amp-hour storage) batteries rather than connecting battery banks in parallel. If one cell of a battery bank is faulty and loses its charge, a battery bank connected in parallel to it will then constantly discharge into that bank until voltages equalise at which point that battery bank may have no useable storage remaining.

Nickel Cadmium batteries have an OCV of 1.25 volts per cell and 10 cells are used to produce a nominal 12 volts.

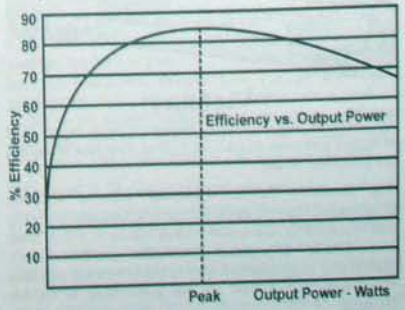
Remote Area Power Systems

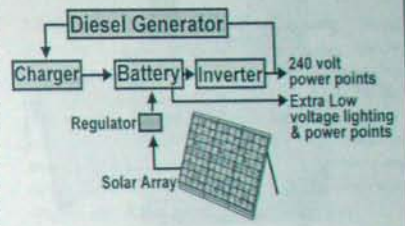
The conventional power grid supplies 240 volt AC (Alternating Current) to the average household. Around 12,000 homesteads in Australia do not have access to a centralised electricity grid. Even when connection is physically possible, costs of the order of $10,000 per kilometre are prohibitive. Many of these consumers are dependent on diesel or petrol generators with occasional battery storage and/or renewable energy systems added. Others may depend mostly on renewable energy systems with possibly a petrol, LPG or diesel generator with a battery charging facility as a backup. These systems may have a conventional AC type of supply and/or a DC (Direct Current) battery supply.

Types of Systems

There are three basic types of stand alone renewable power systems. All of these systems may incorporate any combination of solar, wind and hydro as the primary energy sources.

1. **DC Only System** used in vehicles, boats, sheds, caravans, cottages etc to power lighting and low voltage appliances. The power is usually stored in a battery bank (usually 12 volt) which is regularly or intermittently recharged. This system should incorporate meters to monitor and fuses to protect the system. It may or may not include a charge regulator.
2. **Combined DC and AC System** is as above except that it contains a DC to AC (eg 12 volt to 240 volt) inverter to enable the use of commonly available 240 volt appliances. The inverter should be carefully matched to the loads (see Inverter section).
3. **AC Only System** where all the loads are run on AC via an inverter. This type of system is inherently more costly, less efficient and more prone to failure (eg no lights if inverter fails) than the above systems.





If you are charging a low voltage battery bank to meet your power requirements, we do not recommend that you then run your house as a conventional 240 volt AC household through an inverter (an AC Only System) as this would necessitate a much larger and more costly installation as would otherwise be the case. It would dictate a substantial battery bank powering an appropriately sized inverter to cope with everything being on at the same time. It would also require a substantially larger charging source (eg solar panels) to put back into the battery what the inverter is taking out.

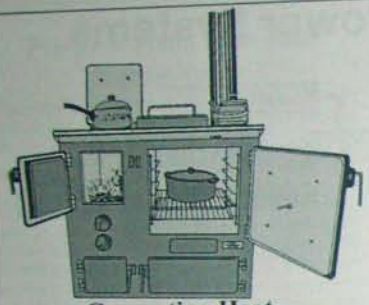
If you refer to the graph, we have presented a fairly typical performance curve of a very typical battery bank to 240 volt AC inverter. You will notice from this that at its peak you may expect 85% efficiency from a modern solid state inverter. The further the wattage rating of the appliance is from this peak, the more inefficiently the inverter will deliver that power.

If you look at the type of appliance that you may wish to have in your home you may find some electronic appliances dependant on getting their power supply via a transformer. The transformer uses the high voltage to generate a much lower voltage. We may be able to operate these directly by the low voltage DC power supply without needing the transformer or inverter.

One of the more annoying aspects of some inverters, particularly inverters which are either square wave or stepped wave, is that they can produce an annoying hum on your stereo equipment. With some effort this can be minimised or filtered out, but at the same time introducing another level of inefficiency. If you can run the sound system directly from a low voltage DC supply or from a sine wave inverter you shouldn't get any hum.

Low Voltage Motors

It is generally recognised that low voltage motors have more torque than a 240 volt motor of the same wattage rating (power consumption).



Generating Heat

For appliances that are designed to generate heat, such as a stove (be it for cooking or for room heating) and a hot water system, there are alternative ways to generate that heat. There may be a number of options to choose from including bottled gas, fire-wood, sunshine, bio-gas or producing the heat electrically if the electricity can be generated cheaply enough. With the present price of photovoltaic panels (solar electric panels) this option is not in the race.

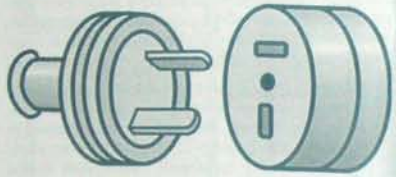
Refrigeration

In the average 240 volt household little attention is paid to how much power an appliance uses. With refrigerators, for example, the emphasis seems to be on space saving rather than efficiency, hence they have thinner walls but need more power to stay cool. Ideally, to maximise on efficiency, the refrigerator should be of the low voltage compressor motor type and preferably be top opening (so that the cold air doesn't fall out when you open it).

Alternatively, you could use a gas or kerosene powered fridge. An LPG refrigerator of 120 litres capacity should use about 500 grams of gas per day.

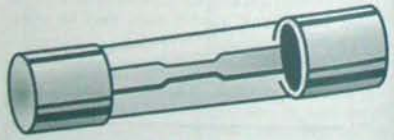
A 240 volt refrigerator running via an inverter from a battery bank is generally not recommendable. Considering the frequent starting and stopping of the compressor motor and the very high starting current of the motor it would be a costly practice in terms of the size of the battery charging system, battery bank and inverter that would be required. A standard 240 volt AC 220 litre fridge/freezer will consume 1.5 to 4 kWh of electricity per day. 12 or 24 volt compressor motor fridge/freezers do not have a high starting current and will operate with a power consumption of between 0.3 and 1.5kWh per day.

A 12 volt 220 litre fridge/freezer uses between 25 and 90 amp-hours per day. An equivalent 240 volt fridge connected to a 12 volt to 240 volt inverter would use between 150 and 400 amp-hours per day from the battery bank.



Safety

Another argument in favour of low voltage is the safety aspect. Extra low voltage DC is safer than AC. Anything less than 120 volts DC is not considered lethal, whereas with AC you need to come as low as 32 volts! There is still a fire hazard, however, with low voltage DC, and so you must protect the system with the appropriate fuses and/or circuit breakers.



Viability

To make a solar electric power system more cost effective you need to go a lot further than just imitating the suburban house.

The Rainbow Power Company puts a sizeable proportion of its revenue and expertise into investigating and researching renewable energy options. If you want some advice on a more sustainable alternative to a reasonably comfortable lifestyle, come and ask us about it (or write to us) - we are not just selling it, we are living it.

How to Reduce Generator Fuel Bills

Many homesteads, stations and rural communities around Australia are largely or solely dependent upon diesel or petrol as a fuel to generate electric power.

1st Step: A Battery Bank

Just by incorporating a battery bank, a 240 volt battery charger, and an inverter into the power system you can reduce your fuel bills by as much as 50% and in so doing recoup your capital outlay for the extra hardware within one year.

2nd Step. Further Fuel Savings

Method 1: Lighting. By a simple modification of removing the lighting circuit of the house from the 240 volt AC supply (especially if it is from the generator) and reconnecting the lights to the low voltage DC battery supply and changing all light bulbs over to low voltage ones you can have good quality lighting that is more reliable and uses considerably less power. Where long cable runs are supplying power to multiple lights, some rewiring may be required.

Fluorescent lights operating on low voltage DC need to be equipped with low voltage dedicated inverters which eliminate that stressful flicker so often associated with fluorescent lighting and so are much more relaxing and pleasant to live with. The PL type lights are very energy efficient and have a warmth and quality about them which is superior to most other lights.

PL type lights are a mixture of fluorescent, neon, sodium and mercury vapour light technology; are up to five times more efficient than the commonly used incandescent lights and last six times longer. By using the most efficient lights where the lights are needed the most you can make another significant reduction in your fuel bills.

Method 2. Selected Appliances. By introducing a few low voltage power points and a selection of low voltage appliances you can reduce generator run time and use less power overall. Low voltage appliances, particularly radio, electric fence, pumps etc connected direct to the battery supply are more energy efficient than their 240 volt equivalents. A low voltage pump uses much less power than its 240 volt counterpart.

Method 3: Refrigeration. By changing over to a low voltage compressor motor type refrigerator you may be able to significantly reduce your fuel bill still further. A low voltage compressor motor type refrigerator or freezer on average uses significantly less power than its 240 volt counterpart. Run the generator only for peak loads and get most benefit from the battery bank 24 hours per day.

Method 4: Other fuels for heating. Using electricity for heating is very inefficient. Use gas or firewood or some other readily available fuel for heating instead. You may have a slow combustion stove going continuously in the winter months with a water jacket for your hot water needs. A solar hot water system could take care of your hot water needs for most of the year and a gas cooker may be used when the stove isn't on. You may also consider a gas fridge instead of an electric fridge.

Method 5: A smaller generator. Generator based power systems are often geared to being able to power everything being turned on at once, ie maximum loading. By transferring a significant portion of this load either to the battery based inverter or directly to the battery bank there can be a considerable downscaling of the size of generator needed.

Any petrol or diesel generator needs to have a minimum loading when it is running. This means that if you just want to watch TV which is connected to the generator you would have to turn on a whole lot of other things, lights, appliances, heaters etc in order to provide this minimum load. Just to watch TV can cost you a small fortune in fuel. A smaller generator has a smaller minimum loading and uses less fuel per kWH for the smaller loads.

Having a large battery charger permanently connected to the generator would provide a loading which is storing the power for future use instead of just wasting it.

Method 6: Solar, wind or hydro. If you have already employed one or a combination of the previous methods to reduce your fuel bills you could start using your savings to invest in long term measures to reduce your fuel bills even further. Every solar panel, wind turbine and hydro unit will mean a further reduction in fuel bills. You could keep adding to the system and gradually get to the situation where your dependence on fuel for the generator is very minimal or none at all. A combination of energy sources is always the best option - when the sun doesn't shine either there is plenty of wind or its raining. Hydro power, unfortunately is not applicable to many outback areas as a fast flowing stream and/or a vertical head of water (to give pressure) are essential.

Follow these recommendations and you can have minimal fuel bills without sacrificing lifestyle.

Estimating Your Needs

You need to have a good idea of how much electricity is required before you can decide on the appropriate size of your solar array, and the size of cables and battery bank.

There are three simple steps to determine the average daily load:

1. Select which lights and appliances will be used.
2. Find out how many amps or watts each consumes.
3. Work out how many hours each day (on average) each appliance will be used.

Since the size of your battery bank is rated in terms of amp-hours and the meter on your distribution/meter box measures the power coming in from your charging system in amps, it makes sense to convert watts to amps. I will give you some examples:

1. You have a 12 volt portable stereo that has a label on the back that says 12 volts, 0.2 amps. You don't need to calculate anything for this as the current draw is already given in amps at 12 volts.
2. You want to use a 12 volt 20 watt light bulb. To work out the amps you just divide 20 watts by 12 volts and you get 1.67 amps.
3. You have a 240 volt juice extractor rated at 300 watts. If you have a solid state inverter rated at 400 watts you can expect 85% efficiency. So to work out the amps at 12 volts you divide 300 watts by 12 volts and you get 25 amps; on top of that you have the inverter efficiency to add to that figure. Divide 25 by 0.85 (85%) and you get about 30 amps.
4. You have a 240 volt colour TV that doesn't have a watts rating but does give an amps rating. The figures it gives are 240 volts, 50 hertz, 0.3 amps. This amps usage figure is the power consumption at 240 volts. Since amps times volts equals watts, this works out at 72 watts (240 times 0.3). Now to work out the amps at 12 volts you divide 72 watts by 12 volts and you get 6 amps. If you run this off the same 400 watt inverter you can only expect 70% efficiency (refer to inverter data supplied by your dealer). Divide 6 amps by 0.7 (70%) and you get 8.5 amps.

Now to give you an example of working out the daily power consumption:

1. You listen to either the radio or cassette player for 6 hours each day. The 12 volt system you have is rated at 0.2 amps at 12 volts. Multiply the amps by the hours and you get the result of 1.2 amp-hours per day.
2. You use three 20 watt 12 volt lights for about four hours each night. The power consumption for each light we worked out earlier to be 1.67 amps. So for three lights we calculate a current draw of 5 amps. So to calculate the power consumption we multiply 5 amps by 4 hours to get the result of 20 amp-hours per day.
3. You use a juice extractor for 10 minutes each day. We have already calculated that the inverter draws 30 amps when the juice extractor is running. Divide 30 by 6 (because you use the juicer for 1/6th of an hour) and you get a result of about 5 amp-hours per day.
4. You watch the colour TV for about 2 hours each night. We estimated before that the inverter draws about 8.5 amps when the colour TV is on. Multiply 8.5 by 2 and you get 17 amp-hours per day.

Here are those figures in tabulated form:

Appliance	Amps	Hours used	Amp-hours / day
12 volt Stereo	0.2	6.0	1.2
3 Lights	5.0	4.0	20.0
Juicer	30.0	0.2	5.0
Colour TV	8.5	2.0	17.0
		Total	43.2

See section on solar panels, wind generators, hydro-electric systems, batteries etc. (as appropriate for your system) for further information on designing your overall system.

We can design your system for you, using a computer based Power System designing software. We will require detailed information on your envisaged power usage including power ratings and hours per day usage of lights, appliances etc. Contact Rainbow Power Company staff for a "Power System Sizing" form and further details.

Typical Appliance Ratings

POWER CONSUMPTION GUIDE (240V)

	Start	Watts
Adding Machine		6
Air Conditioner		1200 →2500
(evaporative - mobile)		275 →1000
Alarm/security system		6
Blanket (under)		60 →120
Blanket (over)		150 →350
Can Opener		100
Cassette Deck		30
CB (receiving)		10
Cellular phone (on standby)		20
Circular Saw (small)		1350
Clothes Drier		2400
Coffee Grinder		75
Coffee Percolator		540
Compact Disc Player		30
Computer (Laptop or Notebook)		15 →25
Computer (Desktop with Hi-Res Colour Screen)		250
Computer Printer (see Printer below)		80
Disposal Unit		650
Drill		250 →500
Dishwasher		1000 →3000
Domestic Water Pump	2000	500
Electric Toothbrush (charging stand)		6
Exhaust Fan		40 →75
Fan		20 →100
Fax (standby)		10
Fax (printing)		120
Food Mixer & Whis		500
Floor Polisher		350
Freezer	2500	500
Frypan		1400
Hair Drier		150 →600
Health Lamp		150 →600
Heater		500 →2000
Hotwater Service		2500 →5000
Infra-red Grill		2000
Iron		1250
Juicer/Blender		350
Kettle or Jug		1600 →3000
Microwave oven		600 →1000
Printer (Ink Jet)		15 →40
Printer (Dot Matrix)		80 →200
Printer (Laser)		1200
Radio		15 →60
Radiator		1000 →2500
Record Player		75
Refrigerator	1500	300
Sewing Machine		80
Space Heater		2000
Stove		5000 →10000
Television		60 →200
Toaster		500 →1500
Tumble Drier		2500
Typewriter		35
Vacuum Cleaner		700 →1200
Video Recorder		17 →50
Washing Machine	2580	400
Welder - 240A		4800

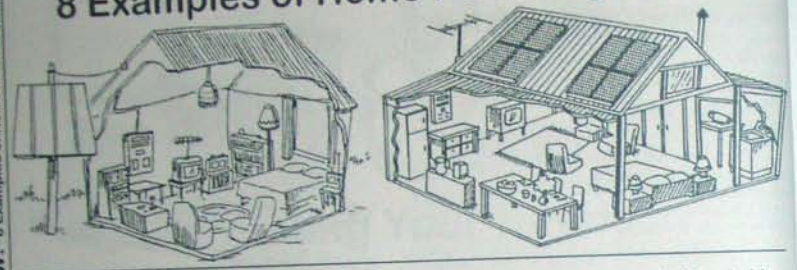
NOTE: These figures are a guide only and the wattage ratings may vary greatly from one appliance to another.

Electric Motors - Starting Current

	Watts	type of motor: induction capacitor	split-phase
¼ hp	275	600	850	2050
½ hp	400	880	1050	2400
¾ hp	450	975	1350	2700
1 hp	600	1300	1800	3600
1½ hp	900	1900	2600	
2 hp	1120	1900	2600	

NOTE: Brush type motors without a load do not require a significantly higher starting current than their continuous current rating.

8 Examples of Home Power Systems



System 1. 12 volt Basic Cabin

- 1 × 50 watt solar panel with mounting frame
- 1 × 117 amp-hour deep cycle battery
- 1 × battery box with battery manager (Sundaya)

Output is about 180 watt hours per day or about 15 amp-hours per day*. This will run a few 12 volt lights, a 12 volt LCD colour TV, 12 volt stereo, radio and other small appliances.

System 2. 12 volt Intermediate Cabin

- 2 × 85 watt solar panels
- 1 × solar panel mounting frame
- 2 × 250 amp hour, 6 volt batteries
- 1 × distribution box
- 1 × 15A regulator
- 1 × 200 watt inverter

Output is about 600 watt hours per day or about 50 amp-hours per day*. This is a good system for typical cabin use. It gives three times the power of the previous one and means more time to run appliances or more storage to cope with prolonged overcast periods. The 200 watt inverter is large enough for a small TV, video and laptop.

System 3. 12 volt / 240 volt Deluxe Cabin

- 4 × 85 watt solar panels
- 1 × solar panel mounting frame
- 2 × 350 amp-hour, 6 volt batteries
- 1 × distribution box
- 1 × 20A regulator with LCD display
- 1 × 700 watt sine wave inverter

Output is about 1200 watt hours per day or about 100 amp-hours per day*. This is an ideal starting system for remote home owners. The inverter option lets you use small AC appliances up to 700 watts continuous such as TV, video, stereo, blender and drill. A sine wave inverter is ideal for sound systems and variable speed equipment.

System 4. 12 or 24 volt / 240 volt Household

- 4 × 125 watt solar panels
- 1 × solar panel mounting frames
- 1 × distribution box
- 1 × 40A regulator with LCD display (12V)
  OR
- 1 × 20A regulator with LCD display (24V)
- 1 × 1400W/3600W sine wave inverter (12V)
  OR
- 1 × 1700W/4500W sine wave inverter (24V)
- 3 × 1050 amp-hour, 4 volt batteries (12V)
  OR
- 4 × 600 amp-hour, 6 volt batteries (24V)

Output is about 1765 watt hours per day, or about 147 amp-hours per day with the batteries and solar array in a 12 volt configuration or 73.5 amp-hours per day* if set up as a 24 volt system. Will provide power for enough capacity to run an efficient fridge, microwave, a number of lights, vacuum cleaner, washing machine, pumps and various other appliances, including power tools.

System 5. 24 volt / 240 volt Household

- 8 × 80 watt solar panels
- 2 × solar panel mounting frames
- 6 × 1050 amp-hour deep cycle, 4V batteries
- 1 × distribution box
- 1 × 20A regulator with LCD display
- 1 × 1700W/4500W sine wave inverter

This system will supply loads up to 2.8 kWh per day which may include all standard household appliances with a maximum continuous loading of 2.2 kW and a maximum surge loading of 6.5 kW.

With all the above systems you may run **extra low voltage** (ie 12V or 24V) **or 240 volt** equipment where a suitable inverter is installed. Refer to the typical appliance ratings on the previous page to get an idea of what can be run on an inverter of a given power rating.

* Based on solar radiation figures for Northern NSW and Southern Qld.

System 6. 24 volt / 240 volt Household

- 8 × 120 watt solar panels
- 2 × solar panel mounting frames
- 6 × 1380 amp-hour deep cycle, 4V batteries
- 1 × distribution box
- 1 × 40A regulator with LCD display
- 1 × 2400W/7000W sine wave inverter

This system will supply loads up to 4.22kWh per day which may include all standard household appliances with a maximum continuous loading of 2.2kW and a maximum surge loading of 6.5kW.

System 7. 48 volt / 240 volt Homestead

- 16 × 80 watt solar panels
- 4 × solar panel mounting frame
- 8 × 339 amp-hour, 6 volt batteries
- 1 × distribution box
- 1 × 40A digital display regulator
- 1 × 3300W/8000W sine wave interactive inverter /charger

This system will supply loads up to 5.63kWh per day which may include all household appliances and workshop tools. The interactive inverter/charger option allows the inverter to start up an electric start generator to give the batteries an extra charge or to operate in phase with the inverter to power large AC loads. The inverter can also work in phase with the mains to either export surplus power or operate as a back-up.

System 8. 110 volt / 240 volt Homestead

- 27 × 80 watt solar panels
- 7 × solar panel mounting frames
- 18 × 339Ah, 6 volt batteries
- 1 × distribution box
- 1 × 15A 110V regulator
- 1 × 10000W sine wave inverter/charger

This system will supply loads up to 9.49kWh per day which may include all household appliances and workshop tools with a maximum continuous loading of 10kW.

Systems 7 and 8 may not be suitable to run **extra low voltage** equipment as 48V and 110V DC lights and appliances are not generally available. Refer to the typical appliance ratings on page 17 to get an idea of what can be run on an inverter of a given power rating.

* **Based on solar radiation figures for Northern NSW and Southern Qld.**

Backup Power

In periods of continuously overcast weather you may need another energy source as a backup or take measures to considerably reduce your power consumption. Such backup may incorporate a petrol, diesel or steam power generator with a 240 volt power outlet and/or battery charging facility.

Power System Sizing

Contact the Rainbow Power Company for a personalised power assessment and a costing. Ask for a Power System Sizing Form to be mailed or faxed to you, fill in the form and return it to Rainbow Power Company. You will then be supplied with a costing of the components you will need to meet your requirements. You may also receive some suggestions on ways of reducing your power requirements with little or no affect on your lifestyle but often drastically reducing the cost of the power system. There is a small charge for this service which will be refunded on the purchase of $1000 or more components from the Rainbow Power Company.

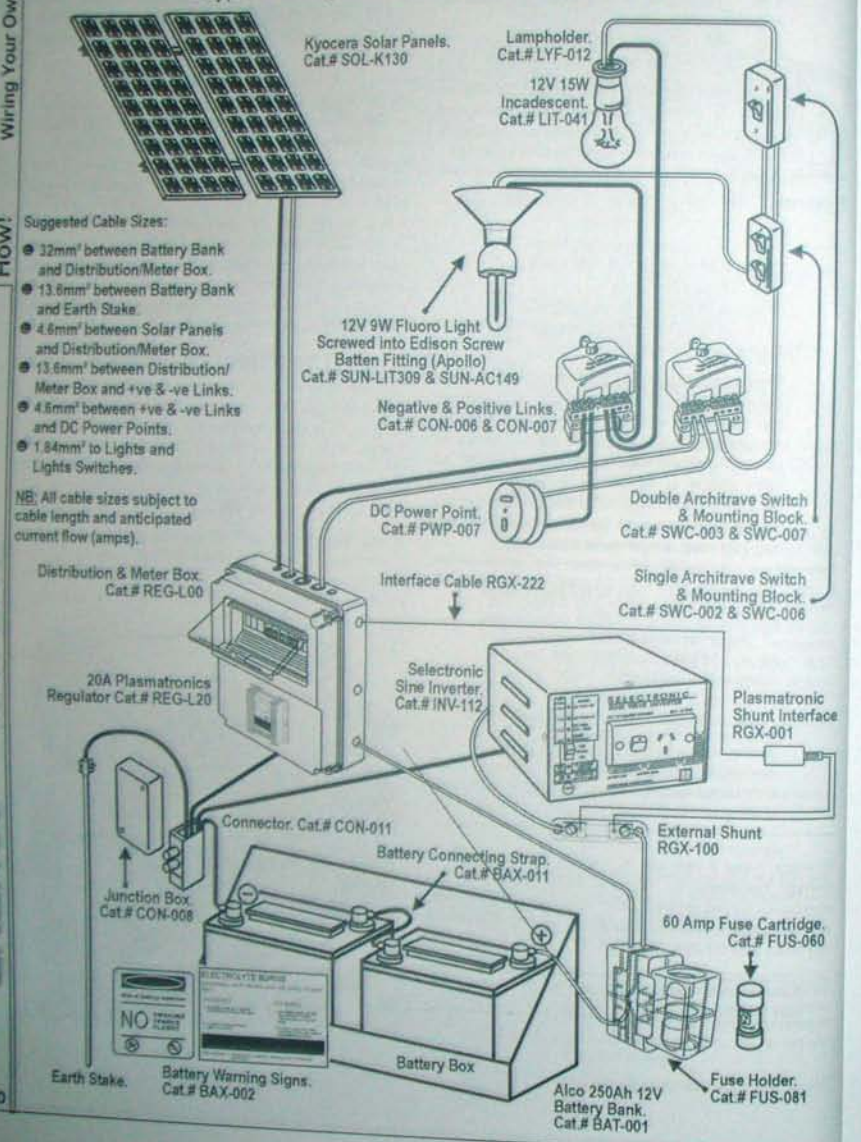
The Effect of Shading

Shading can make all the difference on whether a solar power system works effectively or not. Even partial shading of a solar module will dramatically reduce its output. Your choices include either getting rid of the offending object which causes the shading, move the solar array to a better location or spend more money on solar, wind, hydro or generator backup to cope with the shading.

If you can supply us with months and times that the shading would affect your solar array then we can account for it in your system design. If the distance isn't too great, Rainbow Power Company staff can do a shading analysis consultation at your site.

Wiring Your Own Home

A typical example of a solar power system layout.



Wiring Your Own Home

The Basics of Extra Low Voltage Wiring

Many people living in rural areas will have discovered the high cost of connecting to the power grid. The only affordable option for you may be to have your own stand-alone power supply. Petrol and diesel generators may be seen as an immediate solution. But, per kilowatt hour of power, they are a more expensive way to meet your power requirements than being connected to the power grid.

In this kind of situation a Solar Electric power system becomes quite price competitive. The major costs of such a power system are primarily the capital expenses (ie purchase price of solar panels, batteries, wire, fittings etc.). One advantage with low voltage systems such as a 12 volt or 24 volt system is that it is considered not to be dangerous and hence a licensed electrician is not required.

If the walls of your house are not already lined, it makes good sense to design and install your electrical wiring before the walls are finished to avoid problems later on and unsightly wires being visible. Make sure the walls are vermin proof and cables are protected inside conduit as rats chewing through insulation can cause serious problems. Attempt to plan for future expansion of your electrical system by using a larger size of wire where necessary and allowing for extra connections in accessible areas.

Choose Correct Cable Size

On the previous page we have a very basic circuit diagram for a typical small home. We must stress the importance of using significantly larger wire than would be used in an equivalent 240 volt situation. With 12 volt wiring, the voltage drop resulting from resistance losses is comparatively twenty times higher than with 240 volt wiring. The voltage drop is much the same regardless of voltage, but a 2 volt drop at the appliance end of a 240 volt lead is quite insignificant (0.83%), whereas a 2 volt drop in a 12 volt situation is quite significant (16.67%).

The size of the wire should be increased when either the distance or the amps is increased. It is also important to make good solid connections everywhere and to guard against corrosion. The corroded surface on a strand of wire has an electrical resistance which could cause havoc in a low voltage installation.

Cable Connections

In an extra low voltage installation (eg 12V or 24V) it can save you against future corrosion problems by smearing some petroleum jelly on multi-stranded wire whenever the insulation is stripped back and slipping a snugly fitting cable end terminal (see page 45) over it before inserting it into a screw connection. You may now fasten the wire into screw connectors (in active and neutral links*, switches, power points etc.). Tighten the screw down, and be assured that you have adequate protection against corrosion.

Soldering

Where cables do not go into screw connections (eg into cable lugs) they can be soldered. Tarnished metal cannot be soldered. All metal surfaces must be absolutely clean, shiny and untarnished before any soldering is attempted.

Cable lugs can be soldered effectively with the stripped cable inserted by holding it over a gas flame and running the solder into it once its hot enough to melt solder. When a soldering iron is required, it is a good idea to use a soldering iron that can be heated over a clean gas flame and a fairly large tip to retain the heat. The tip must be 'tinned' over an area which is at least equivalent to the cross sectional area of the wire you intend to solder. 'Tinning' is the process of melting solder onto a metal surface so that the two metals bond to each other (ie the solder and the copper). If the tip looks black, flaky or generally dirty it may need to be cleaned up with a file so that a shiny metallic surface is exposed. Once the iron has built up enough heat over a clean flame, the solder should flow onto the tip very easily.

The solder that is normally used for electrical work is resin core solder, which means that it carries a special soldering flux mixture in the centre of the usually wire-like solder. For most of the work that we are going to describe we would recommend 1mm diameter resin core solder, although for some of the larger cables a larger diameter solder may be desirable.

The insulation should be stripped away from the cable cleanly without damaging the wire strands underneath and the wires twisted a little with your fingers. The hot soldering iron is placed against the exposed wire whilst carefully melting the end of the solder against the iron in such a way as to transfer some of the molten solder and the heat of the iron onto the wire. The wire should then acquire enough heat to melt the solder directly. The solder should cover the exposed wire completely so that the separate copper strands are bonded together and the exposed copper surface no longer visible. The solder should flow into the multi-stranded wire so that all the strands are bound together.

If there is any corrosion on the copper, the solder will not take. You may then have to dip the end of the wire into hydrochloric acid in order to clean it so the solder will take. A flat copper surface can be cleaned with a file or sandpaper, but this approach cannot be used with multi-stranded cable. Ideally, the solder should have flowed back into the insulation without having heated it to the point that the insulation has expanded. You may need to put in a lot of practice before you do it well.

Battery Connections

There needs to be protection in the way of fusing, at the battery bank. This fuse protection may be implemented in one of two ways:

1. The **negative** of each parallel battery terminal be **earthed to a common ground** and the **positive** of each parallel battery terminal be **fused**.
2. The **negative** of each parallel battery terminal be **fused** and the **positive** of each parallel battery terminal **also** be **fused**.

This fuse (or these fuses) should be in the form of fully enclosed cartridge type fuses large enough to carry the loads powered by it and yet small enough to protect the size of cable being connected to it .

Cable Size	Maximum Fuse Size
49 mm²	150 amps
32 mm²	110 amps
21 mm²	90 amps
13.6 mm²	70 amps
7.9 mm²	45 amps
4.6 mm²	25 amps
2.9 mm²	20 amps
1.84 mm²	15 amps

The wire and connectors at the battery terminal and the battery itself, should be lightly coated with petroleum jelly (vaseline) for extra protection against the corrosive properties of battery acid. Do not connect onto both battery terminals until all other wires connected to the battery are safely secured and not likely to short (positive touching negative).

Distribution/Meter Box

The distribution/meter box should be fairly close to the battery using wire to connect the two of at least 5mm² for a system requiring only a single load circuit and 15mm² or bigger for multiple load circuits. Once connected, the distribution /meter box now becomes the hub of the system, with all the wiring from here on connected back to the distribution/meter box and not to the battery.

We must point out that a 12 volt power supply has as much potential to cause a fire as does a 240 volt supply. The fuse(s) or circuit breaker(s) are there to protect each separate circuit from the distribution /meter box against such risk. While you are wiring up the house, leave the fuse out of the fuse holder or leave the circuit breaker off until you have finished the job on that particular circuit.

The distribution/meter box should be connected before the cable is bolted onto the battery terminals. Whether you are putting in 12 volt lights or 12 volt power points, you will usually find it easier if you start at the light fitting or power point and carefully lay and securely fix the wire until you get back to the distribution/meter box or to the active and neutral links.

You may want to install a whole lot of lights and power points in one area at a fair distance from the distribution/meter box. What you can do here is to run a heavy duty twin cable (positive and negative) of say 15 mm² from the distribution/meter box to another set of active and neutral links near where you want to do this extra wiring. Once connected, these links now become a distribution point for further expansion.

As you are running the wire from the light fitting back to the active and neutral links, you should take the wire past the point where you want the light switch. Cut through the positive wire only and the two exposed ends of this cut can now be stripped of insulation, slip cable end terminals over the exposed ends and connect into the switch. If the switch happens to be further away from the power source than the light, you can start wiring from the switch and take the wire past where you want the light to be and connect the light to the two exposed ends of the positive wire in the same way as we did the switch in the previous example. But if you do this, you must remember that the wire coming back from the switch to the light fitting is now negative (in case you are connecting a polarity conscious light fitting).

Incandescent lights are not polarity conscious, that is to say, it doesn't matter which way it is connected to the power source. Fluorescent lights designed for 12 volt systems are usually polarity conscious and won't work if you connect them the wrong way round. Fluorescent lights are usually protected against reverse polarity so as not to be damaged by it, but the same is usually not true for TV's, radios, tape decks etc, so take care and check everything several times before plugging appliances in.

When wiring up switches and to avoid making mistakes, it makes it easier if you only cut through the positive wire coming past the switch and to leave the negative wire intact. The recommended wire to your lights should be 2 mm² to individual lights and 5 mm² for high wattage lights and long cable runs.

You may want some 240 volt power points around the house, powered either by an inverter or by a petrol /diesel generator. It must be stressed that **240 volts** can be **lethal** and it is required in Australia that **all 240 volt wiring be done by a licensed electrician**.

* Because active and neutral links were designed and rated for 240 volts AC, they are called active and neutral links, but in a low voltage DC application you can substitute the word "positive" for "active" and "negative" for "neutral".

Refer to Australian Standards: AS 4509 (Stand-Alone Power Systems) AS 1768 (Lightning protection), AS 2401.1 (Battery Chargers), AS 2676.1 & AS 3011.1 (Battery Installation), AS 3000 (Wiring Rules), AS 3010 (Internal Combustion Engine Electricity Supply).

Refer to battery section for information on battery safety and risk of explosion!

Refer to fuse section for information on risk of electrical fire!

Areas of Neglect and Failure

1. **Shading or Partial Shading on Photo-voltaic Solar Panels.** Even if only one single cell of the Solar Panel is shaded, the output from the entire panel will be either significantly reduced or stopped. You can see this for yourself by either connecting the panel to an ampmeter or light-globe without a battery or placing an ampmeter between the panel and the battery. Now put your hand over only a section of the panel and see what happens. It is a good idea to have an amp-meter permanently connected between the panel and the battery to verify that a charge is occurring.

   It is not uncommon for a system to fail because of poor orientation of the panel. The panel may have been well sited when erected, but the change in seasons means that it is permanently shaded by a nearby tree. A panel not bolted down is likely to be blown over in the wind.

   Contact Rainbow Power Company for a shading analysis consultation.

2. **Using a 240 & 12 Volt Generator.** It is often assumed that with a Generator having both a 240 volt and 12 volt outlet that the 12 volt outlet can be used for charging a 12 volt battery. This may not be the case!

   The 12 volt outlet may NOT produce a high enough voltage to ever fully charge your battery, even if it is capable of producing a lot of amps.

   Unless it is specified that it is designed for charging a 12 volt battery, the 12 volt outlet on your Generator Set may be designed to produce the equivalent voltage of a 12 volt battery but **NOT** to charge it. The voltage would most likely be between 12 and 12.6 volts, and a 12 volt lead-acid battery needs more than this in order for a current to flow (to charge it).

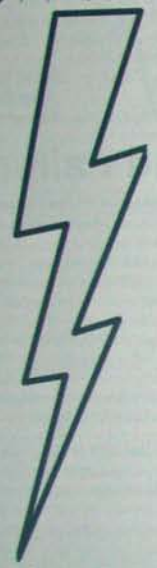
3. **Poor contact or corrosion in contacts.** Check tightness of all bolted and screwed connections. If join moves easily it needs tightening. DO NOT OVERTIGHTEN! Although copper, steel and aluminium make good conductors of electricity, they cease to conduct when corrosion gets between the contacts. If either positive or negative wires are exposed to moisture (eg in the soil, on the floor or an ants nest in the junction box), electrolytic action can corrode the wire and connectors very rapidly. Some metals, aluminium for example, cannot be soldered. Copper is the best conductor for its price.

4. **Corroded battery terminals.** Batteries should be regularly cleaned, particularly the top surface and around the battery terminals. Undo the connectors on the battery, clean all signs of corrosion (eg with a file) from both the terminal and connector. Smear grease or petroleum jelly (vaseline) over the terminal and reassemble. Wipe the dirt off the top of the battery, making sure that none of it gets into the vent holes.

5. **Lack of charge in battery.** If your average daily discharge is constantly greater than the average daily charge, you will find a gradual deterioration of your power supply until it reaches the point where lights are dim, the picture on the TV screen shrinks and appliances will cease to work properly. The remedy for this is to either cease to use the power for a week or so whilst connected to your usual charging system to give your battery bank a chance to recuperate, or to somehow boost charge your battery with an appropriately sized battery charger. Check the battery section of this book for more details.

6. **Electrolyte level in batteries too low.** Part of a regular monthly maintenance schedule is to check the electrolyte level in each cell of your battery bank. Only use distilled or demineralised water to top up the battery. Check the battery section of this book for more details.

LIGHTNING PROTECTION



Lightning does not have to strike directly in order to cause damage and havoc with any electrical system or apparatus. Most damage in fact is not caused by direct strikes but by the high voltages induced in the environment at fair distances from the actual strike. In order to avoid such damage it is recommended that your power supply system be grounded.

Grounding

Grounding means to connect part of your electrical system or wiring electrically to earth. The air normally carries an electrical charge in relation to the earth. During lightning storms, this static electrical charge has built up and ideal circumstances allow this to be neutralised with an opposite electrical charge which has accumulated on objects on or near the ground. If the potential difference (voltage) between sky and the object, or between the object and the earth is great enough, a spark will jump between the two. High objects, especially those with a sharp point are most prone to lightning strikes. Grounding of electrical systems prevents a potential difference with the earth from developing.

Grounding can be achieved in a number of ways:

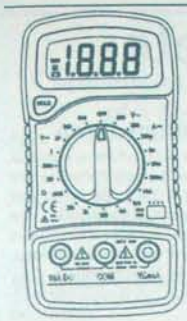
1. Drive a ground rod (usually 2.5 metres long) into the earth.
2. Where ground is dry and/or sandy, more rods should be installed, at least 3 metres apart. Connect all ground rods together via min. 15 mm² bare copper wire, buried.
3. Metal cold water pipes that are buried are good to ground to - NOT hot water or gas pipes.
4. Iron well casings are super ground rods, but you may need to drill and tap a hole to get a good bolted connection.
5. If your site is rocky and you cannot drive ground rods deeply, bury at least 50 metres (the more the better) of bare copper wire. Several pieces radiating outwards is best. Try to bury them in areas that tend to be moist. If you are in a lightning prone area, bury a hundred metres if you can, over the broadest area feasible.
6. If your solar array or wind generator is at a distance from your house, drive ground rods at both ends and bury a bare earth wire in the trench with the power lines between the two. You may also bury the power lines between the two points in metal conduit and connect the conduit to the ground rods.

NOTE: Use only the proper clamps to connect wire to earth rods. Do not solder ground wire connections. You can use metal earth clamps to connect to pipes.

What to Connect to Ground

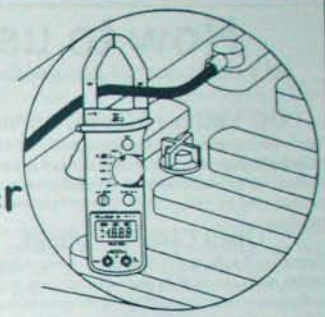
- The metal framework of your solar panel array.
- Wind generator and antenna masts.
- Generator frame.
- AC neutral wires and conduit in the manner conventional for all AC systems.
- Battery Bank Negative. First test the battery bank for leakage to ground with a multimeter. Set the multimeter to the highest milli-amp scale. Place the negative probe on the battery negative terminal and the positive probe on your ground system. No reading? Good! Now switch it down to the lowest milli- or micro-amp reading scale and try again. If you get only a few micro-amps, or zero, then ground your battery negative. If you did read a leakage to ground, check your system for something on the positive line that may be contacting earth somehow. If you read a few micro-amps to ground, it is probably your meter detecting radio signals.
- For Inverters, refer to information supplied with the inverter or contact the retailer or manufacturer as to how it should be grounded.

NOTE: Earthing both the battery negative and neutral wires from some older inverters can sometimes defeat the "AUTOSTART" function. The solution is to only earth one or the other.



Using a Multimeter or Clampmeter

on a Stand-Alone Power System



A multimeter is a very valuable diagnostic tool which, because of its mobility and multi-function capability can provide information that a stationary distribution /meter box cannot. A clampmeter is even more versatile. A multimeter or clampmeter is ideal for:

- Measuring Voltage of Individual Battery Cells
- Measuring Voltage Drop in Cable and Connectors
- Measuring Charge Rate of Individual Solar Panels
- Measuring Power Consumption of Individual Lights and Appliances
- Checking Calibration of Meters on the Control Board
- Checking Light Bulbs and Diodes

In the following few pages we will discuss how to measure volts and amps and calculate watts and amp-hours. We will also discuss how to test if a circuit is complete or not (continuity test).

Buying a Hand-held Meter

It would be advisable to get a multimeter with either a 10 amp range or a 20 amp range. A DC clamp meter that can register several hundred amps would be particularly useful for measuring power consumption of inverters and the output of solar arrays and large battery chargers. The voltage range of the multimeter would preferably be 0-15 volts for a 12 volt battery bank or 0-30 volts for a 24 volt battery bank. It would also be good to have a 0-3 volt range for testing individual cells of a lead-acid battery or a 0-2 volt range for testing individual cells of a nicad battery. For our purposes the ohms scale isn't so important other than for testing continuity.

It is also recommended to purchase yourself a set of insulated slip-on Alligator Clips.

If what you are attempting to measure is constantly fluctuating an analog meter (which has a needle pointing to a scale of numbers) is easier to read than a digital meter. For measuring the voltage of a battery bank and DC currents and voltages generally, a digital meter (which has an LCD display similar to the display of a calculator) is preferred.

HINTS

1. When using the meter, pay particular attention to polarities and check positive and negative points. The red lead connects to positive and the black lead to negative.
2. It is generally good practice to position one probe first (usually the negative probe), and get it secured with an alligator clip or by finger tightening a screw onto the probe before testing or probing with the other probe. This makes it easier to concentrate on only one probe.
3. If you are checking unknown currents and voltage, use highest range first, then next lower range, and so on until readings can be obtained.
4. For most accurate readings, keep the meter lying flat on a non-metallic surface. Also, use a range setting that results in a reading in the upper third of the meter scale.
5. With an analog meter, for exact readings, look at the scale from the point where the pointer and its reflection on the mirror behind the pointer come together; otherwise a reading error may result due to parallax.

WARNINGS

1. Do not apply voltage to probes while the range switch is in current (amps) or ohms position. When using the clamp on a digital clampmeter, this is not a concern.
2. Testing AC wiring circuits can be dangerous. Never clamp on to a 'hot' wire (usually red or brown) since if you did so and then touched the other probe, you could receive an electric shock. For your own safety leave the AC diagnostics to a qualified electrician and just concentrate on the DC circuitry.

How to use a Multimeter

It is recommended to read the instruction manual of your multimeter before reading the following:

DC Voltage Measurement

Select the required DC voltage range (if in doubt start from the highest range and work your way down until a reading can be obtained) with the probes connected in parallel (+ve to +ve, -ve to -ve) to the points to be measured.

Open Circuit Voltage

Open Circuit voltage (OCV) is the terminal voltage of a battery while at rest. This means that there is no charge or discharge of that battery. OCV is the most meaningful voltage of a battery as this can indicate state of charge. Each cell of a fully charged lead-acid battery should have an OCV of around 2.1 volts. At 50% discharge the OCV will be about 2.0 volts per cell. At around 1.8 volts per cell or less the battery is considered discharged.

It is good practice to occasionally compare the OCV of the component cells of a battery bank (if the intercell connectors are accessible). This will allow you to identify the sluggish cells. The sluggish cells should be given an identifying mark and used to regularly monitor the battery bank. The sluggish cells can then be used to identify when next to apply a boost charge to the battery bank. You never want a variation between the best and the worst cell of more than 0.05 volts.

A NiCad battery has an OCV of about 1.25 volts per cell and its variation between charged and discharged is difficult to measure as the voltage varies so little.

Charging Voltage

The voltage of a battery being charged can give you an indication of when that battery has reached full charge. This is NOT an OCV.

Whilst charging the voltage of a battery may not vary much for most of the charge and then rise quite dramatically once the battery is full. A Lead Acid battery voltage will rise to between 2.3 and 2.4 volts per cell when fully charged. If a Lead Acid battery has been left in a state of partial or total discharge for a long period of time (months) it may be sulphated (definition on page 136) and have a very high internal resistance in which case the charging voltage may behave as if the battery is full when in fact it's not. Taking a specific gravity reading with a hydrometer will then tell you that in fact the battery is not fully charged (see battery section of "Energy from Nature").

Whilst a NiCad battery is being charged the voltage may rise to 1.62 volts per cell. A NiCad battery never suffers from sulphation and the charging voltage can be used very reliably to determine that it is fully charged. The multimeter is not a reliable indicator of the state of charge up until charging is completed.

Measuring Voltage Drop

A voltage drop will only occur whilst there is a current flowing. Voltage drop is directly proportional to the amount of current flowing and the cable length. By comparing the voltage reading at one end of a cable to the reading taken at the other end you can obtain the voltage drop (subtract the lower reading from the higher reading).

To reduce the voltage drop you may need to increase the cable size and improve the connections.

DC Current Measurement

Select the required DC current range (if in doubt start from the highest range and work your way down until a reading can be obtained) with the test leads connected to the points to be measured. Amps are usually measured by breaking the continuity of the positive line and connecting an amp meter between these two points (ie in series), whereas with a DC clampmeter you need to isolate a single conductor (either positive or negative), open the clamp jaws so as to place that single conductor inside the jaws before closing them and reading the display.

An amp-meter on a distribution/meter box to measure discharge rate needs to able to read the power consumption of the maximum number of things that may be turned on at once. Such a meter would hardly register and hence would be almost useless in measuring the consumption if it is very low. A 12 volt electric fence energiser and a battery powered radio are two examples of appliances that are usually on for long periods of time whose power consumption is quite low. If an appliance is on continuously for a long period of time even a small power consumption will accumulate to be quite significant and from that point of view it is good to be able to measure it.

Testing the Current Consumption of a Light or Appliance

Make sure that the appliance or whatever that you are about to measure is turned off. If you have all your positive connections made at one common link it may be easiest to break the continuity at this point. Links often have numbers stamped into the brass to identify the wire locations. Simply undo the screws that hold the wire in question. Finger tighten the screws back onto your positive probe, fix an alligator clip onto the negative probe to hold onto the end of the wire that just came out of the link. Once all your connections are secure you can turn the appliance on and check its current consumption.

Checking the Charging Rate of a Solar Panel

Again you need to break the continuity of the positive line. This time you don't need to turn anything off first. This time the positive probe connects to a point that connects back to the panel and the negative probe connects to a point that goes on to the battery bank. You can isolate and measure individual solar panels by measuring on the solar panels directly or you can measure the output of all the solar panels combined by removing the solar fuse on the distribution/meter box and using the fuse contacts as your test points.

Power (Watts) versus Current (Amps)

To calculate the power consumption of an appliance or the power output of a solar panel, simply multiply the measured current by the measured voltage.

Power Loss (Watts)

The power loss of cable and connectors is calculated by multiplying the measured voltage drop by the measured current flow (see 'Measuring Voltage Drop' and 'Testing the Current Consumption of a Light or Appliance' - above).

Amp-Hours and Watt-Hours

Amp-hours is calculated by multiplying the current (amps) by the number of hours that that current has been flowing for. To calculate watt-hours, multiply amp-hours by measured volts.

Testing for Continuity

In order to measure continuity you need to have a voltage source.

If there is a poor connection or a break in the house wiring it can often be located by tracing the wires from the battery bank outwards and using the battery bank as your voltage source.

With the meter on the appropriate voltage scale start by measuring the voltage at the battery. Now move to the next location where you can connect your probes as you head towards the possible location of the fault.

If at any point you measure no voltage then there is a break in the wiring between the previous test point and this one.

If you measure a drastic voltage drop (particularly with a small load turned on) this may indicate a poor connection such as a wire that is almost broken, corrosion in a connector or a wire, or it may be due to undersized wiring.

Testing if a light bulb is OK

This test can only be applied to incandescent type light bulbs. Fluorescent lights will not respond to this test.

It would be easier in this case to use one of the ohms scales on the meter or to use the continuity function if it has one. To make these functions work the multimeter should have an internal battery.

Some multimeters have a built-in continuity function which often sounds a buzzer. Test this by selecting continuity on the range switch and touching the two probes together. If it buzzes try holding the probes onto the two contacts of the light bulb and see if it buzzes - if it does the light bulb is OK.

Using Ohms (Ω) for Continuity

If you do not have a continuity function on your multimeter you can use one of the ohms scales.

If you select an ohms scale and touch the probes together you should see the needle of an analog meter move right across the scale and a digital meter should change from reading maximum resistance to zero. Most digital meters will show a high number which flashes (over range) when the circuit is broken (no continuity). If you get the appropriate response from your meter, hold the two probes onto the light bulb contacts. If the needle of the analog meter moves across the scale or if the digital meter reads zero or a low number then there is continuity and the light bulb is OK.

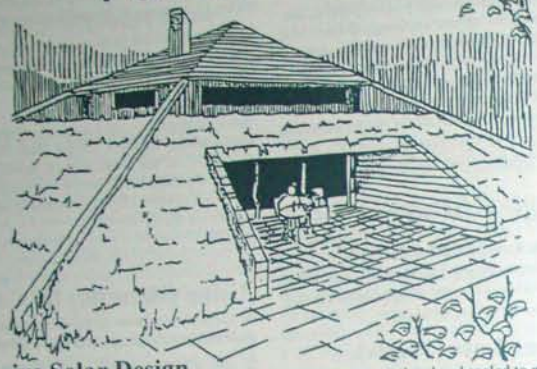
Testing if a diode is OK

A diode is like a one-way valve. It should allow the current to only flow in one direction and prevent the current from flowing in the other direction. A good diode should show continuity in one direction and no continuity (or over range) in the other.

Do not test the diode whilst there is an external voltage (eg solar panel) connected as this will effect the outcome and possibly damage the meter.

Connect the probes to the device you want to check and note the meter reading. Reverse the probes and note the second reading. If the one reading shows some value and the other is overrange, the device is good. If both readings are overrange, the device is faulty (open circuit). If both readings are very small or zero, the device is also faulty (short circuit).

Passive Solar



Passive Solar Design

Passive Solar Design is about maximising the available radiant heat from the sun in winter or when it's cold and maximising on the cooling effects of night or shading in the summer or when it's hot. This idea is used to regulate the indoor temperature and thus minimise the need for other energy sources for both heating and cooling.

Solar Collectors are expensive, so before you consider using solar heating and cooling, you should design the building to make passive use of available solar radiation by carefully and strategically placing windows with eaves to shade both walls and windows in summer. Such low-energy design would also usually incorporate efficient insulation and inbuilt heat storage, such as a rock/concrete floor or wall receiving direct sunlight. Sawdust, sand and cement, a wall made of bottles filled with water or a mud-brick wall may also be used in this way.

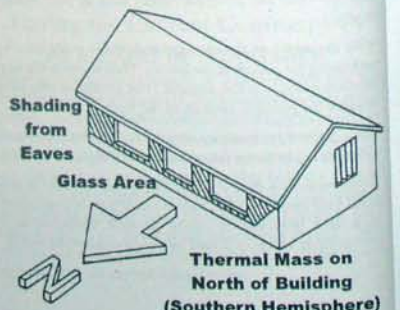
The wall facing the sun (the north wall in the southern hemisphere) should contain a large area of glass to permit the entry of winter sun. It is also recommended to build the house on an east-west orientation (ie the broadest sides of the house facing north and south).

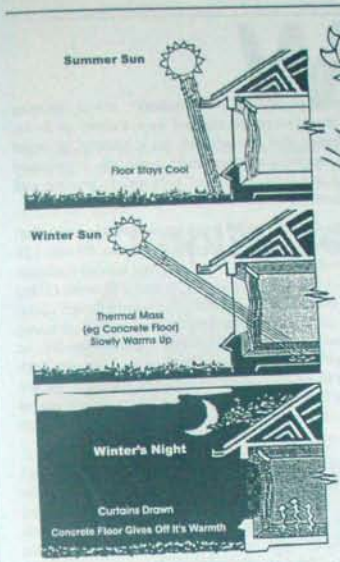
All external doors and windows should be weather stripped to minimise drafts. Deciduous trees and vines can be planted along or near the walls which face north to let the sun in in winter and provide more shading in summer. Eaves on walls facing north should be designed so that windows are protected from summer sun.

Insulation usually involves the use of a material which is not a good conductor of heat and sometimes in combination with a reflective surface to reflect the heat back.

Air that is encapsulated and sealed to prevent air flow has the properties desired of a good insulating material. Be careful with house design not to create easily accessible spaces for vermin such as rats, mice and cockroaches.

If your walls, ceiling and suspended floors are well insulated then windows may still be one of the weak spots of the energy efficiency of your home. This can be improved with the use of closely woven and close fitting drapes or blinds. A top enclosure such as boxed pelmets or coverings touching or hanging from the ceiling and a snug fit at the sides will stop air circulating from the windows into the room. Reflective linings are of extra benefit in summer as they reflect some of the heat back outside. The use of double insulated glazing, insulated shutters and/or low emissivity glass can improve the control of heat transfer through the windows even further.



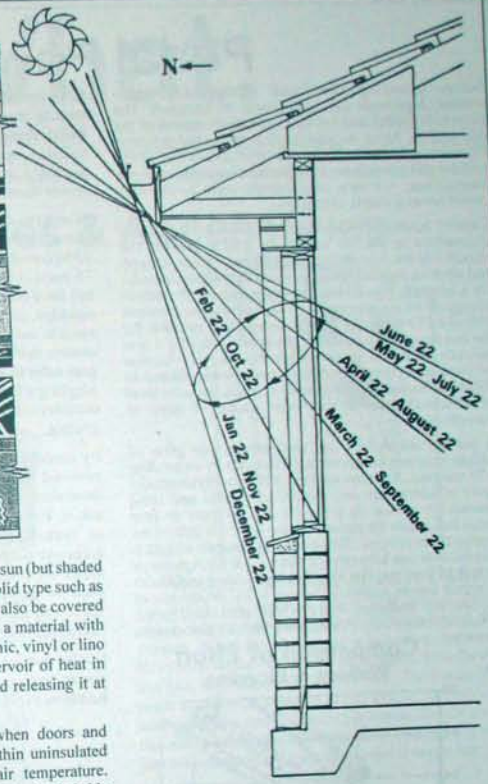


Walls and floors that are exposed to winter sun (but shaded from summer sun) should be of a heavy, solid type such as concrete slab. These floors and walls may also be covered with a dark coloured covering made from a material with a low resistance to heat flow such as ceramic, vinyl or lino tiles. Such walls and floors act as a reservoir of heat in winter, absorbing heat during the day and releasing it at night.

On hot days you may still find that when doors and windows are closed, air temperature within uninsulated buildings can rise above the shade air temperature. Particularly when a breeze is coming from the shaded side of the house or if cool air from beneath the house can be coaxed into the house and escape on the down-wind side of the house it may be an advantage to have more ventilation. To help keep the cooking area cool in summer it helps to have a vented hood above the stove to exhaust the hot air.

Air vents at the apex of the house and at ground level on the cooler side of the house will encourage convection currents. In cooler weather, ventilation should be kept to a minimum and air vents closed.

The eaves on the sunny side of a house should keep the midday sun out of the windows between October 22 and February 22 (for southern hemisphere). If we measure from the base of the window up to a point level with the eaves we can use this measurement to determine the size of the eaves. Here are two alternative ways to calculate the size of your eaves:



1. If you have a calculator with the TANGENT function. Subtract 11° from the latitude of where you live. Take the TAN of this number and multiply the answer by the distance between the eaves and the bottom of the window. The final result represents the overhang of the eaves.

OR

2. Multiply the distance between the eaves and the bottom of the window by the overhang index in the column next to the latitude on the table below.

Latitude	Overhang Index
25°	0.25
30°	0.33
35°	0.41
40°	0.49
45°	0.56

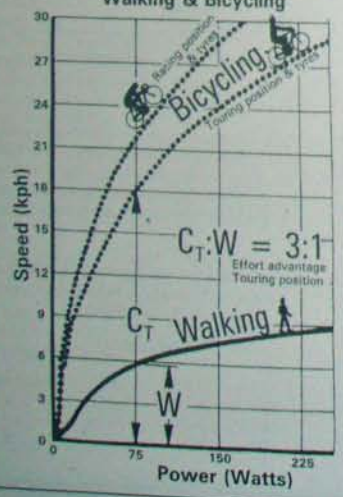
Pedal Power

Before technology developed mechanically driven wheels, legs were our main form of transport. The bicycle preceded and led up to the development of the automobile. Since its introduction, the petrol powered automobile has had a disastrous effect on our way of life and the global environment. But when we talk of viable alternatives, we very conveniently seem to overlook ourselves as a viable alternative.

Careful, scientific work enables us to look with a better perspective at the use of human muscle power. The muscles of the legs and of the heart have more strength and stamina than any other muscles on the human body. On a leisurely bicycle ride we expend about 75 watts of energy. If we are reasonably fit we can produce between 190 and 250 watts for several hours. It is possible for the human body to produce 750 watts (1 hp) for a few seconds. Whereas most motors have a very narrow performance curve in terms of peak power related to RPM, the human body is capable of much the same level of efficiency over a very wide range of rates of movement.

A person, unaided by any tool, carries one gram of weight over one kilometre in 10 minutes by expending 0.75 calories. A person walking is thermo-dynamically more efficient than any motorised vehicle and most animals. A person on a bicycle can go three or four times faster than the pedestrian, but uses one fifth of the energy in the process. One gram of a person's weight is carried over one kilometre of flat road at an expense of only 0.15 calories. The bicycle is the perfect transducer to match human metabolic energy to the impedance of locomotion. Equipped with this tool, man outstrips the efficiency of not only all machines, but all other animals as well.

Comparison of Effort
Walking & Bicycling



Efficient applications of metabolic power (human muscle power) can be adapted to a variety of tasks. Pedal Power can be adapted to a variety of tasks utilising mechanical impedance matching. Impedance matching involves the use of appropriate gearing and power transfers to suit the task at hand.

In order to design a pedal machine we need to know that a comfortable pedalling speed is between 60 and 120 RPM (revolutions per minute) and that we can maintain 75 watts (1/10th hp) continuously and 250 watts (1/3rd hp) for a considerable period. To operate a high speed machine, such as is normally powered by a high speed electric motor, such as a juice extractor, blender, or electric drill by pedal power we need to use a very high gear ratio to get the required terminal speed. If we are adapting a hand powered tool to pedal power we would consider a direct drive instead, without any intermediate gearing.

By modifying an exercise bike, you could have a pedal powered chuck which could be used for drilling, or the drive shaft of a whole range of gadgets could be inserted into it. For example, a few kitchen type appliances such as centrifugal juice extractor and a blender with burnt-out motors can be modified. By removing all the motor windings from the shaft and inserting the exposed shaft into the vertically mounted pedal powered chuck. These can then be put to good use to make a healthful and well earned cool drink!

Further information and sketch plans of a few Pedal Power machines can be obtained by sending $5 to the Rainbow Power Company.

What:

The products which appear on these pages are only a selection of the range of products that are available. There are also other models of many of the products which are listed.

An alphabetic listing of RPC products can be found on page 139 near the back of the book.

Appliances & Accessories

12 Volt Motion Detector

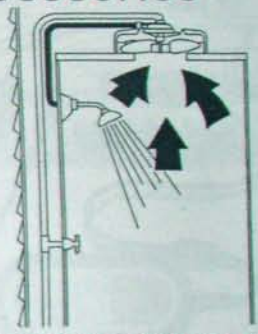
Will switch a light on when you approach and off again when it no longer senses movement.

12V:– Cat.# SWC-013 24V:– Cat.# SWC-014

12 Volt Digital Timer

Can be programmed to switch appliances ON and OFF up to six times each day or any selection of days per week. It has a built-in rechargeable battery if you wish to plug it into a different location. Can switch loads up to 10 amps.

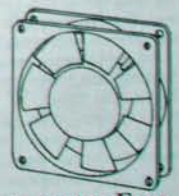
Cat.# SWC-033
24 volt version also available.
Cat.# SWC-034



Water Driven Exhaust Fan

The Enviro Fan needs no power, it is a water driven ceiling exhaust fan which is ideal for the bathroom and ensuites. When the shower tap is turned on, the water flows from the tap, through the fan turbine to drive the fan, and then out through the shower rose. The Enviro Fan needs a minimum pressure of 208 kPa or 21 metres of head and a flow rate of 12 litres per minute. The fan looks like and operates very much like an electric fan and will turn off automatically when the shower is turned off.

Cat.# AIR-003



Extractor Fans

12V 120mm

power use = ⅛ amp (AIR-002), ½ amp (AIR-C12)
Uses a quiet DC brushless motor (50dBA) and will move 2 to 3 cubic metres of air each minute.
12V: Cat.# AIR-002&C12 24V: Cat.# AIR-005&C24

DC to DC Voltage Adaptors

12V or 24V 2A Switchmode Power Adaptor to 1.5, 3, 4.5, 6, 7.5, 9 and 12V Fully Regulated
Will accept a 11V-30V input so it's suitable for use in cars or trucks or in 12V and 24V home power systems. The converter plugs into a cigarette lighter socket and will bring any voltage in the 11 -30V DC range. 6 DC plugs supplied.

Cat.# APX-012

High Power 12V Laptop Supply

DC power adapter to suit most brands of laptop computers which require a DC input from 15V to 24V. The polarity and voltage are selectable and output is fuse protected. 6 amp output to 15, 16, 18, 19 and 20 volts. 5 amp output to 22 and 24 volts. To suit all major laptop brands including Apple, Dell, Compaq, IBM, Toshiba, Gateway, Sharp and Acer. Requires battery voltage of between 11V and 14V.

Cat.# APX-011

Refrigeration

The following suggestions will help you to get the most out of your refrigerator and reduce your power consumption:

1. Open fridge door only as often as absolutely necessary, by having the contents organised in an orderly fashion will help.
2. The temperature of a fridge should be about 4°C to 5°C. You can check this by placing a thermometer in the top of the fresh food section. For every 1° colder you will need 5% more energy. Do not change this setting frequently once established. You may need to check this setting when the seasons change.
3. Allow all food and drink to cool to room temperature before placing it in the fridge.
4. Shut the door or lid tightly. If the seal of the door does not hold a sheet of paper firmly between the mating surfaces of the door it may mean that you need to adjust the hinge, clean the mating surfaces or replace the seal.
5. Allow the air to flow freely around the condenser and compressor unit. Make sure that there is no obstacle to impair this air flow and clean the condenser and compressor unit regularly to allow no dust build up.

The same rules should apply to a freezer. You should plan to open your freezer no more than twice per day by moving the foods that you intend to use that day into the fridge.

Electric versus LPG

It feels good to think that all of your power requirements are supplied by sunshine, but there are several factors to consider in favour of the LP gas refrigeration option:

- The cost of extra solar panels and battery storage may be more than 15 years supply of LPG. With a good hydro or wind site this comparison would be more favourable towards an electric fridge.
- The common electric fridges use ozone destroying CFC's whereas LPG fridges use a more environmentally friendly refrigerant (ammonia).
- An electric fridge operates on and off, continually day after day. It doesn't take long to considerably reduce battery storage when there is little solar input (eg when there is little sunshine due to cloud cover).

If you are able to cope with the increased up front cost and can meet the power requirements of the fridge under less favourable conditions you may also wish to consider these points:

- Solar panels have a design life of greater than 20 years.
- LPG is non-renewable and contributes to greenhouse gases.
- LPG will probably increase in price faster than inflation rate.
- CFC's in current fridges can be recycled.

LP Gas Refrigeration

All units are equipped with a ⅜" SAE imperial flared gas connection. "Consul" 220 litre fridge/freezer has 30 litre freezer with separate hinged door. Door hinges are reversible. Uses about 45 kg of LPG in 3 months (1.58 MJ/hr). Has interior light powered by two 'D' size batteries for which rechargeable batteries may be used.

DC Fridges & Freezers

Standard domestic cabinets fitted with 12V or 24V DC compressor motors.

Advantages over 240V Fridge

- Uses about ⅓ of the power of an equivalent 240V fridge (including inverter losses).
- Doesn't require an inverter.

Note:

- A small 12V or 24V DC fridge still uses at least 220 watt-hours per day.

Cat.#	Capacity Litres	Description	Energy Consumption	Dimensions (cm) H	W	D	Kg	Hinges L or R
APL-001	200+31=231	*LPG 2 door Fridge & Freezer	38 MJ/day	145	59½	73	78	L or R
APL-UB110	110	1 door Fridge & Freezer	540 Wh/day	86½	50½	49½	26	L/R
APL-UB120	120	1 door Fridge & Freezer	564 Wh/day	84½	54½	57	40½	L/R
APL-UB171	159+11=170	1 door Fridge & Freezer	600 Wh/day	100	50	55	45	L/R
APL-W220	168+46=214	2 door Fridge & Freezer	1080 Wh/day	139½	54	56½	44	L/R
APL-UR140	130	Fridge only	600 Wh/day	84¼	54½	57	36¼	L/R
APL-UR250	240	Fridge only	816 Wh/day	140	54½	57	51	L/R
APL-W002	49	Chest Fridge/Freezer	290 Wh/day	475	355	63	17¼	Top
APL-073	73	Eutectic Chest Fridge or Freezer	220/440 Wh/day	51	48	84	35	Top
APL-CB150	90/55	Chest Fridge/Freezer	444 Wh/day	92	56	66	46	Top
APL-CB210	150/55	Chest Fridge/Freezer	540 Wh/day	92	72	66	53	Top
APL-CB315	260/55	Chest Fridge/Freezer	600 Wh/day	91¼	100	66	60	Top
APL-CF150	150	Chest Freezer	660 Wh/day	92	56	66	42	Top
APL-CF210	210	Chest Freezer	720 Wh/day	92	72	66	49	Top
APL-W210	210	Chest Freezer	1080 Wh/day	92	72	66	60	Top

Note: all Energy Consumption figures assume ambient temperature between 28°C and 35°C
* APL-001: 220L LPG Fridge uses 180Kg of LPG per year
Legend: W=12,24,240V C=Chest, U=Upright, R= Refrigerator Only, F=Freezer, B=Both, E=Either Fridge or Freezer Only

World Health Organization Vaccine Refrigerators also available.

Batteries

Lead Acid

WARNING - FIRE HAZARD

A low voltage power supply is just as likely to cause a fire if a short circuit occurs as with any other voltage. Please use suitable fuses or circuit breakers near the battery and between the battery and any other power sources. Also ensure that electrical conductors such as metal objects cannot accidentally fall across the battery terminals.

Exploding Battery: Batteries generate explosive gases during operation and when charging. Flames, sparks, burning cigarettes or other ignition sources must be kept away at all times. Ensure that there are no loose metal objects around the batteries that can be blown down by a strong wind or knocked onto the battery terminals. Similarly sparks can be generated at the battery due to a poor connection.

Always shield eyes when working near batteries. Battery charging should be carried out in a well ventilated area - never in a closed room. Always turn battery charger off before disconnecting a battery.

BATTERY SAFETY

Battery acid can cause burns. Use extreme care when handling acid. If electrolyte is spilled or splashed onto clothing or the body, wash with water and neutralise with a solution of baking soda and water. Electrolyte splashed into the eyes is extremely dangerous. If this occurs, force eyes open and wash with clean cool water for five minutes and call a doctor. A solution of 1 tablespoon of bicarbonate of soda to ½ litre of water should be kept readily available and in view near the battery bank. This solution will neutralise the acid and hence be a more effective eye-wash in the event of such an accident.

BATTERY ACID

Otherwise referred to as electrolyte. The water used for diluting acid and for topping up must be free of mineral impurities. Distilled water, demineralised water, or rain water collected in glass or plastic may be used. Never use tap water as the effect of impurities is cumulative and detrimental to the battery.

NOTE: Do **NOT** add battery acid to the battery unless under the specific directions of a battery technician.

Placement of Batteries

Place batteries on a firm, solid and level support. Weight of batteries should be equally distributed over the base area. Batteries should not be in direct contact with a cold surface such as concrete. If the base of the battery stays cold, the acid will not mix readily and will tend to stratify (most concentrated acid at the bottom and least concentrated at the top). It is recommended that you use an insulating material such as rubber or vinyl under the batteries that will not be affected by the corrosive properties of battery acid.

Battery Connections

Make as few connections directly to the battery as possible. It is desirable to have a fully fused Distribution/Meter Box from which all other connections can be made.

Before making your connection to the battery, first smear petroleum jelly (eg Vaseline) over the terminal post to prevent or reduce the likelihood of battery acid creeping up the terminal post and rapidly corroding your connector.

Make sure that the connector is fixed very firmly and that it is making good contact with the terminal post to reduce voltage drop.

Do not increase your battery capacity by connecting several small batteries in parallel. The more parallel connections there are, the more prone the system is to uneven charging due to lazy cells and unequal cell characteristics. This will cause an overall reduction in expected battery life and increase maintenance requirements.

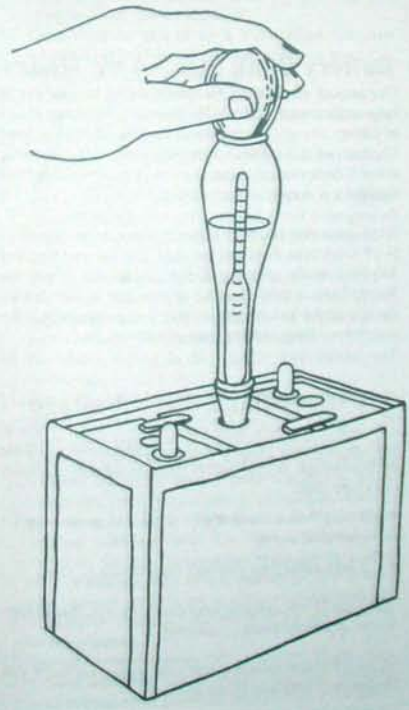
DO NOT LIFT BATTERY BY TERMINAL POSTS

Cycling of Batteries

The life of a battery is related to how many times and how deeply it can be cycled (charged and discharged). A cycle is defined as one charge, to fully charged, and one discharge, to almost fully discharged. An 80% discharge is regarded as 'deep'. However, for maximum life, lead-acid batteries should be discharged as little as possible. We recommend that your average cycle should be no deeper than about 20%, and never beyond 50%.

A standard car battery can only take about twenty deep discharges before it becomes completely useless.

If you have an all year round hydro potential then you may get away with only a very small battery bank (equal to your daily usage) because the battery bank is getting charged 24 hours per day. If you only have an intermittent flow, then a hydro system may be an excellent back-up for a solar power system.



Testing Specific Gravity of a Battery

Care of Battery

1. Visual inspection: Check electrolyte level at least once a month. If the batteries are fully charged and still charging, water loss may increase. It is advisable that a suitable charging regulator be installed to prevent overcharging of the battery. Overcharging is indicated if the battery is bubbling vigorously.
2. Hydrometer Test: Check the electrolyte level, to ensure that it is above the plates in all cells.

   If it is below the plates, the test cannot be carried out until water is added and the battery charged to mix the water and residual acid in the battery. It is important to ensure that the plates do not remain exposed to air and allowed to dry and oxidise (see notes on page 37).

   The state of charge of each cell can be measured with a hydrometer to determine the specific gravity of the electrolyte (specific gravity is its weight compared to water).

Using Hydrometer

Draw the acid into the hydrometer, so that the float is lifted free and not touching the top or the bottom. The barrel must be held vertically and the eye level with the surface of the liquid. Disregard the curvature of the liquid against the glass.

Cell temperature corrections should be applied if accurate readings are required. 0.004 points should be added or subtracted for each 5°C +/- variation from 25°C.

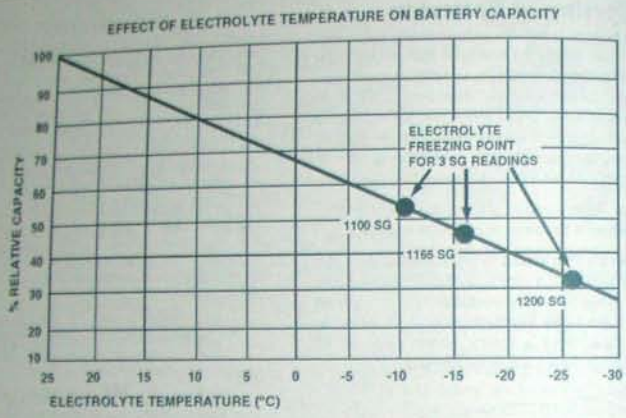
3. Voltage Test: Voltage readings should be taken whilst the batteries are neither charging nor discharging (nothing connected and turned on). Immediately after either charging or discharging the battery voltage may not have stabilised. The voltage will settle down in about 30 minutes after charge or discharge are discontinued.

The Rainbow Power Company can supply you with battery connectors, distribution box, fuses, suitable electric cable, charging systems etc. Do not hesitate to contact us for more advice, information, service etc.

State of Charge	Apex		Suncycle		PVStor	
(Approximate)	SG*	OCV †	SG*	OCV †	SG*	OCV †
100%	1.277	2.12	1.24	2.086	1.225	2.095
90%	1.258	2.1	1.23	2.077	1.216	2.0775
80%	1.236	2.08	1.22	2.067	1.207	2.06
75%	1.227	2.07	1.215	2.062	1.203	2.0513
70%	1.217	2.06	1.21	2.058	1.198	2.0425
60%	1.195	2.04	1.2	2.048	1.189	2.025
50%	1.172	2.02	1.19	2.04	1.179	2.0075
40%	1.146	2	1.18	2.031	1.171	1.99
30%	1.124	1.98	1.17	2.022	1.163	1.9725
25%	1.111	1.96	1.165	2.018	1.158	1.9638
20%	1.098	1.95	1.16	2.013	1.153	1.955
10%	1.073	1.93	1.15	2.005	1.145	1.9375
0%	1.048	1.91	1.14	1.996	1.135	1.92

SG * — Specific Gravity @ 25°C
OCV † — Open Circuit Voltage per 2 Volt Cell

What: Batteries – Lead Acid
ENERGY FROM NATURE



What Type and Size of Battery?

For power and lighting purposes (eg in a home situation) it is recommended that an appropriately sized Deep Cycle Battery Bank be used. Vehicular batteries (other than traction batteries) are usually not Deep Cycle Batteries and are not appropriate for a house power supply system.

The size of the battery bank may be determined by the size and expected usage patterns of the overall electrical installation. Both the size of the battery bank and the limitations to the user of the power supply must in turn be determined by the size of the charging system and the frequency of charging.

It is not advisable to increase the battery bank by putting several batteries in parallel. A 12 volt battery does however consist of six 2 volt cells in series to make the required 12 volts. What we are saying here is to avoid adding several smaller 12 volt banks to each other to make up a larger one, it makes for a much more complex monitoring system and could mean that you do a lot of damage to the entire battery bank if just one 2 volt cell breaks down. More storage should be attained by acquiring a larger battery bank, and not by adding small ones in parallel.

Above 200 Amp-Hours you will find that the bank will consist of either two 6 volt units connected in series or six 2 volt units connected in series. With the individual 2 volt cells, if there is a problem with one cell it is only a matter of replacing it without having to replace an entire battery. By not having one battery bank connected in parallel to another battery bank, you will not have damaged one battery bank by discharging it into a dead cell of the other bank.

Battery Bank Size - Amp Hours

The amount of potential electricity stored in a battery is measured in Amp-Hours (AH). For every 100 Amp- Hours of battery storage you will need the equivalent of at least 60 watts of Solar Panel. For photovoltaic installations, about 5 days storage capacity to reach a 50% discharged condition is usually recommended.

We suggest that you have a battery storage capacity of 10 to 15 times your daily use for solar or wind charging and 5 to 10 times for generator charging. The size of both the battery bank and the charging system may be dictated by the size of the inverter you wish to run, particularly if the inverter is a large one (eg over 600 watts).

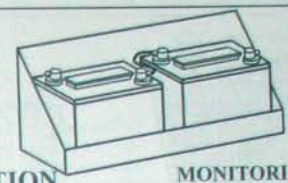
Battery Bank Size - Voltage

The most commonly used voltage is 12 volts. There is quite an extensive range of lights and appliances available for this voltage. Higher battery voltages (usually multiples of 12) are used:

- If only 240 volts is required via a large inverter (ie over 1200 watts)
- If long cable runs and high currents are required

Although 32 volt systems were once common, this voltage is now gradually being phased out.

To plan a power system to suit your budget we invite you to discuss it with one of our staff.



INSTALLATION

The following points must be heeded when installing your battery bank:

1. Lead Acid Batteries should be installed in a cool well ventilated area, well away from any source of heat and from windows admitting direct sunlight.
2. Open stands should allow access from both sides for maintenance and cleaning.
3. Always keep cells upright to avoid damage or displacement of plate assemblies.
4. Never lift cells by the terminal lugs; large cells may be lifted by their handles (if fitted) or by means of a sling made of plastic sheeting.
5. Cells must be placed on a flat surface for even weight distribution, and should never be rested on the edges of packing cases etc.
6. Levers of any kind must not be used to position cells, instead a cell must be lifted bodily and lowered gently into position.
7. Never slide a battery across a floor; this particularly applies to those with acrylic cases.
8. When batteries are installed in cabinets, adequate ventilation must be provided to avoid a dangerous concentration of hydrogen. Cabinet doors should be open during gas charging.
9. Stands should provide support for at least 50% of the base area. It is recommended that timber supporting rails should be covered on top and sides with rubber or PVC at least 1/16" thick.
10. No metal should be in contact with plastic cell containers.
11. Battery connection links should be kept as short as practical, terminals should be cleaned and the connecting lugs firmly tightened using stainless steel bolts - do not over tighten. Grease-impregnated felt washers should be placed under the lugs to arrest corrosion. The interconnecting lug faces on Telecom type batteries must be cleaned, and if necessary squared with a coarse file. The lugs are bolted together, the lug, bolt and nut being lightly coated with petroleum jelly before assembly. The correct size spanner must be used; pliers or grips must not be used or damage may result. Nuts must not be over-tightened.
12. During normal battery life, positive plates may expand and increase in length by 5%. Intercell connections must therefore be soft lead or flexible. Heavy bus bars or charging leads must be able to accommodate some movement.

MONITORING AND MAINTENANCE

A battery bank will need to be monitored and will need a certain amount of attention from time to time. First of all, a battery bank must be charged and remain as fully charged as possible. It is advisable, in a home power situation that you have an amp-meter to show the rate of charge and a volt-meter to give some idea of the state of the batteries. Both of these meters should be mounted in such a position that they are noticed frequently. This strategy will make you more familiar with what to expect and make you aware of a problem when it arises, such as no amps showing when the batteries are supposed to be charging.

You will need to take note of the rate of water loss of the battery bank and make sure it is topped up before the level drops to less than one centimetre above the plates or to the lower level marked on some batteries. Bring it to the bottom of the filler wells or to the upper (high) level specified by the manufacturers. Only top the battery up with distilled water or clean rain water collected in plastic or glass. Do not over-fill. It is advisable to take specific gravity (S) measurements of all the cells of the battery bank once in a while with a hydrometer (see page 38).

CHARGING THE BATTERY

The word "gas" here refers to a gas given off by the acid due to electrolysis of the water. If continued at a high rate this gassing can be quite a violent boiling action and will result in loss of water and plate damage.

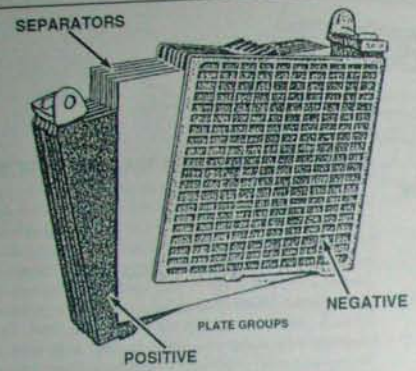
These points must be born in mind:

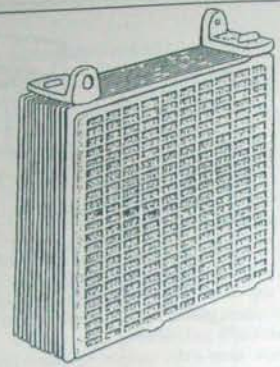
1. If a battery is left in a partially discharged state for an extended period, sulphation of the plates will occur, which if allowed to proceed, results in irreversible loss of capacity.
2. If a cell is maintained at a constant voltage without any cycling, "stratification" of the electrolyte into layers of differing densities will occur. This can be minimised by occasionally charging the battery to a gassing voltage (ie some bubbling occurs).

CHARGE LEVEL OF BATTERY

The charged or discharged condition of a lead-acid battery is indicated by the colour of the positive plate*, the voltage, and the strength (specific gravity) of the electrolyte.

* see page 136 for definitions




ASSEMBLED ELEMENT

Electrolyte Level

Many batteries have markings on the cases to show the maximum and minimum advisable levels of the electrolyte. The lead plates in the battery must be submerged completely by the electrolyte, but there must also be a certain amount of headroom to allow the battery to gas without causing the electrolyte to spill out of the battery case.

Visual Inspection

In a fully charged battery, the positive plate is a dark chocolate brown colour (caused by the presence of lead peroxide) and the negative plate is light grey (the original lead colour).

After having ascertained the approximate state of charge of the battery you can get a rough idea of how it is behaving under charge by observing whether it is gassing and how much it is gassing. The word gassing refers to the little bubbles that constantly come to the surface during charge. If it is a very vigorous action, like a pot of boiling water, then the battery is either charging too fast or no longer needs a charge. Lots of very tiny bubbles (the size of pin pricks) is desirable.

If you have a clear-cased battery you can also inspect the amount of sediment that has accumulated in the sediment space at the bottom of the battery. If there is a lot of sediment in the sediment space it would indicate that the battery has lost its active material from the plates and consequently lost some of its amp-hour capacity*.

Voltage

The voltage of a fully charged lead-acid battery can be as high as 13.2 volts (disconnected) after charging. During charging it may be much higher (see pages 39 and 40). This falls rapidly when the battery is first discharged and will remain steady at around 12.6 volts, very slowly reducing down to 12 volts as the discharge continues. When the battery is more than 50% discharged the voltage will reduce more and more rapidly until at about 11 volts, the battery is considered discharged.

Open Circuit Voltage

The most meaningful voltage reading of a battery is referred to as the Open Circuit Voltage (OCV). The OCV is defined as the terminal voltage (the voltage at the battery terminals) of a battery while at rest or not under load and with no charge going in. After being disconnected from the charging circuit, the higher battery terminal voltage gradually decays over a period of several hours to reach the stabilised OCV.

Under load or discharge conditions, the terminal voltage is less than the OCV, due to the internal resistance of the battery and the speed of the electrolytic (the liquid in the battery) reaction. When the battery is disconnected from the load, the OCV will gradually recover and rise to a level only slightly less than it was prior to the discharge.

If a battery is fully charged, the OCV will be around 12.6 volts. At 50% discharge the OCV will be around 12 volts. For maximum battery life it is recommended that the daily discharge depth should not exceed 10% (OCV = 12.5 volts) of the battery's amp-hour capacity and at the worst operating condition should not go beyond 50% (OCV = 12.0 volts) of its amp-hour capacity. This can occur with a photovoltaic system during a prolonged rainy period.

Specific Gravity

The hydrometer measures the Specific Gravity (SG) of a battery. You will find that the electrolyte in the hydrometer tends to curve up at the edges against the glass. This curvature is referred to as a meniscus. The SG reading should be taken from the bottom of the meniscus.

The SG is a measure of the concentration of the acid in a battery. Due to chemical action caused by charging and discharging, the proportion of sulphuric acid (SG = 1.8) to water (SG = 1) in the electrolyte and therefore, the SG of the electrolyte, gradually increases during charge and decreases during discharge.

The complete working range of SG lies between the limits of 1.1 and 1.3. If below 1.1, damage may be caused by the plates becoming hydrated, while if above 1.3 the plates and grids are liable to be corroded.

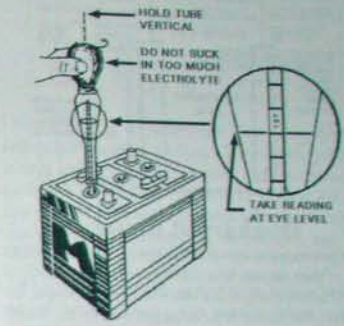
The SG of the electrolyte of a fully charged battery is between 1.215 and 1.28, depending on the battery type. When the SG falls to about 1.175 the battery is considered to be discharged and needs charging.

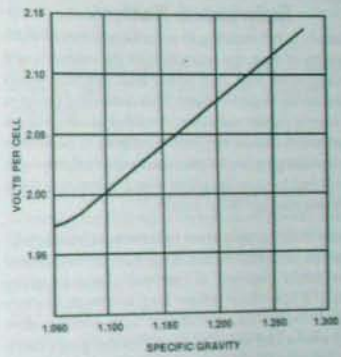
The SG is often multiplied by 1000 and the hydrometer scale marked accordingly. SG readings should be referred to a temperature of 25°C. A temperature that is significantly at variance with this temperature will cause a change of density of the electrolyte and needs to be taken into account when the SG is measured. Refer to the SG versus temperature graph (page 35). A significantly lower temperature will also cause a sluggishness of the battery.

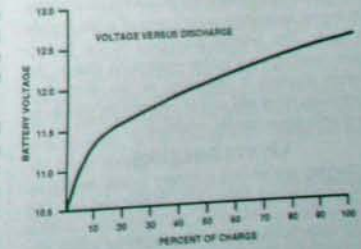
Owing to the time required for the diffusion of the electrolyte, the change in SG lags behind the charge or discharge by an amount which depends on the characteristics and dimensions of individual cells and the rate of charge or discharge. Consequently, the SG will continue to rise for a short period after the charge has been terminated and similarly may continue to fall after a discharge has been terminated, although, if the end of the discharge is at a low rate the lag may not be noticeable.

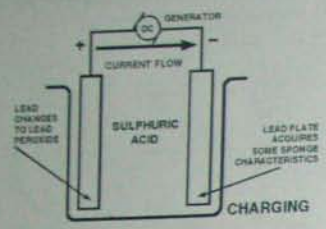
Only add distilled water to the electrolyte. Do not add acid, unless under the instruction and supervision of a Rainbow Power Company Battery Technician. Do not add water with impurities as these impurities will be accumulative over time and will cause problems. Do not take a SG reading just after topping up with water.

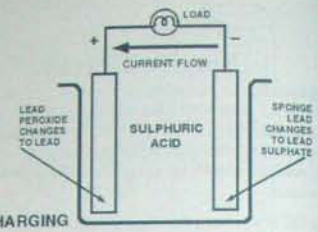
How to use a hydrometer to check the specific gravity of a battery











Discharged Battery

Most batteries should not be charged at a rate exceeding 10% of their ampere hour capacity (eg a 200 Ah battery should not be charged at a rate exceeding 20 amps). Do not leave the battery in a discharged state for any length of time.

Sulphated Battery

If a battery is left standing in a discharged condition for any length of time, the sulphate from the sulphuric acid combines with lead and forms lead sulphate which hardens on the negative plates. This compound becomes increasingly harder and more crystalline in composition and becomes increasingly more difficult to be broken down by charging. In the process the lead sulphate also expands and buckles the plates which in turn can cause irreparable damage to the battery.

Batteries in this condition are referred to as "sulphated". If they are neglected for too long, they are useless and can be safely disposed of (preferably at a recycling depot). If it hasn't been left too long, a sulphated battery can be brought back into service by a constant slow charge over a long period of time. Fast charging a badly sulphated battery will probably ruin it.

Some tell tale signs of a sulphated battery are a gradual darkening of the negative plate accompanied by a white deposit on its surface whereas the positive plate changes to light brown sometimes under cover of a black scale which peels. The internal resistance of the battery increases resulting in a higher voltage on charge. As sulphation involves a reduction of the electrolyte concentration, never add acid to improve the density as this will only aggravate the condition.

Overcharging

Overcharging and boiling a battery is also damaging. Severe overcharging causes a lot of heat and gas. This may cause the plates to buckle, the separators to weaken and the water to evaporate. The bubbling action also causes active material to be shed from the plates, thereby decreasing the amp-hour capacity. The evaporation of the water can cause the plates to be exposed to the air and deteriorate due to oxidation.

During normal charging, the liberation of gas occurs to a very slight extent when the battery rises to about 13.8 volts, while normal gassing occurs when the voltage has risen to about 14.2 volts. While the initial release of gas from the plates is determined by cell voltage, the volume of gas is a function of the rate of charge. A violent bubbling action and a gradual temperature increase are warning signs that your battery is being overcharged.

Voltage Regulation

It is advisable to install some kind of regulating device to prevent batteries from overcharging. The voltage at which the batteries may need to be regulated depends on several factors. These factors include whether you have a constant or periodic charging source. Solar panels, wind generators and petrol generators can all be considered as periodic charging sources, they may only be charging for a few hours each day or a few days in the week.

Under any regulated charge the electrolyte will, however, tend to stratify so that a boost charge should be applied at between one and six week intervals.

Boost charging serves to both stir up the electrolyte to overcome stratification, and to equalise the voltages between the cells. The highest and lowest cell voltages should not differ by more than 0.05 volts. A boost or gas charge will normally rectify any voltage variations.

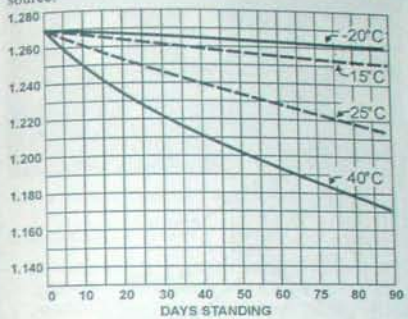
The Rainbow Power Company sells a range of regulators. We invite you to contact our staff to discuss with you and design a suitable power system to meet your requirements and then to advise you on the operation and maintenance of that system.

Cycling

Cycling is the process of partially discharging a battery and then charging it back up to full or nearly full charge. This may be a manual process or it may be carried out by a charger which automatically cuts in and out at predetermined cell voltages. It may be "shallow" or "deep".

It is preferable to cycle a lead-acid battery bank as "shallow" as possible. Even though you are using a Deep Cycle Battery its life expectancy increases as a result of not cycling it too deeply. You should never discharge your battery by more than 50% in the worst instance and stay within 10% to 20% during average daily operating conditions.

A lead-acid battery will self discharge over a period of time if left standing and not connected to any charging source.



BATTERY CARE CHECK LIST

1. Keep battery clean and dry - dampness lets electric current leak away.
2. Keep vent plugs in place to stop dirt falling into cells.
3. A thin coating of petroleum jelly helps prevent corrosion of terminals and connections.
4. For topping up the cells, use either distilled water or clean rainwater preferably collected in glass or plastic. Never top up the battery with anything other than distilled water or rainwater. Do not top up battery with acid, unless on the advice of a Rainbow Power Company Technician.
5. Make sure that the positive and negative plates inside the battery are covered with electrolyte at all times. Do not overfill.
6. Avoid adding water to a battery just prior to taking a SG reading, as the reading will be misleading. If water has to be added, the battery should be charged for a while to mix it with the electrolyte thoroughly before the reading is taken.

Maintenance Schedule:

(i) Check SG of electrolyte	1 month
(ii) Check level of electrolyte: top up if necessary	1 month
(iii) After boost charge, check cell voltages These should correspond to each other to within 0.05 volts	1 - 6 months
(iv) Check tightness of terminals and remove corrosion if necessary	6 months

DO NOT: top up battery cell with water when the battery is in a state of discharge. If the electrolyte level is very low, top up only to make sure the plates are covered and no more. The fluid level rises with the charge level, so if water is added when the battery is discharged, it may overflow on charging and lose electrolyte.

DO NOT: "tap" into part of your battery bank to obtain lower voltages for running lower voltage appliances. You will damage the battery bank by discharging some cells in relation to the rest of the battery bank.

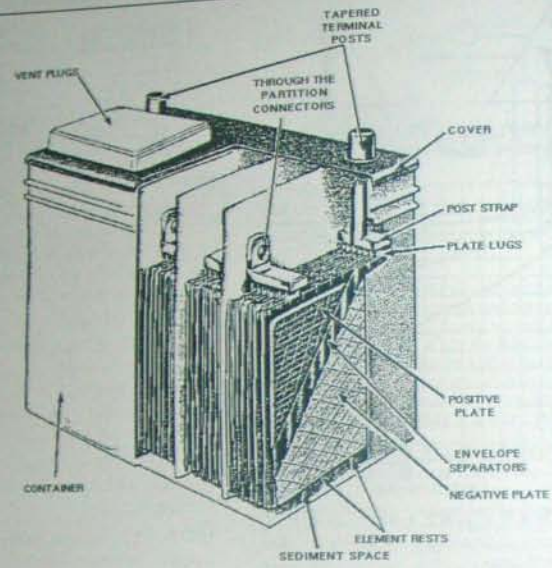
DO NOT: lift batteries by the lugs or terminals. Batteries need to be adequately supported from underneath.

DO NOT: go near the batteries with an open flame or cigarette. You may cause the batteries to explode.

DO NOT: overcharge your battery bank to the point of heating the cells up. This will cause internal damage. It is acceptable to charge to the point of the electrolyte bubbling. You may need to add water if the electrolyte level goes down.

DO NOT: install batteries in parallel if it can be avoided. To increase battery capacity you should endeavour to get a single bank of the required amp-hour capacity rather than smaller batteries hooked up in parallel. For example, six 2 volt cells connected in series to provide 500 amp-hours of capacity is preferable to two 12 volt, 250 amphour batteries connected in parallel. Batteries in parallel should either be protected or electrically isolated through the use of diodes or fuses. This will ensure that if one battery fails due to a shorted cell, the current rushing from the good battery to the defective battery does not overheat the conductor risking a fire. It will also save the charge and perhaps the life of the sound battery.

DO NOT: use alligator clips or other sprung jaw methods as sparking often occurs when they are removed or attached. Hydrogen gas is generated by batteries under charge which is very explosive in the presence of air. Sparking can ignite it. The resulting explosion will not only destroy the battery but also injure the person holding the alligator clips with flying debris and battery acid.



BATTERY FAILURE

The capacity of a battery indicates the ability of the battery to deliver an electric current at a given rate for a specified time. If the battery appears to have lost capacity it may be because it hasn't been recharged thoroughly, or it may be sulphated or else the battery may be approaching the end of its useful life.

A battery will lose active material from the plates due to frequent cycling, movement and vibration. This material will settle in the sediment chamber and thus ceases to play an active part in the battery's function. This results in a gradual loss of capacity throughout the battery's useful life.

A battery may stop functioning very suddenly if an internal short circuit is caused. Such a short circuit may be the result of the sediment in the sediment chamber coming into contact with both positive and negative plates. Otherwise it may be that the plates have come into contact with each other as a result of buckling of the plates or "treeing" between the plates. "Treeing" is the result of a very slow recharge rate (500 hours or more) when the spongy lead deposits on the negative plates in a "tree" like formation. This may eventually bridge the gap between the positive and negative plates.

Another possible cause of failure of a lead-acid battery is when the contacts between plates, straps, terminals and/or intercell connectors are broken.

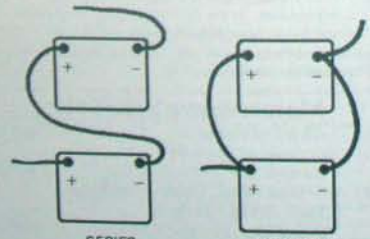
Battery Replacement

If there are any signs that the battery bank is not performing well, first check whether the batteries are fully charged or not.

The battery probably needs replacement if:

1. one cell voltage is far below the others.
2. the battery fails to charge.
3. the battery fails to hold its charge or voltage.

An investigation by a Rainbow Power Company Battery Technician can determine whether the batteries need replacing. The battery age and usage pattern may give some clue as to the outcome of such investigation.



Trojan Deep Cycle Batteries

One of the most successful traction batteries available.

Made in USA.

1. The successful development of a corrosion resistant grid alloy and a cohesive lead oxide compound has resulted in long lasting positive and negative plates operated under deep cycle conditions.

2. The plates are insulated with micro-porous rubber separators and fibreglass retainer mats. The rubber separators are noted for their pore size and high resistance to the destructive effects of battery acid. Other separators with large pore size accumulate lead oxide in their pores which lowers battery efficiency and often leads to premature break-down. The electrical resistance of the rubber separators is extremely low.

3. The battery elements stand on ample support ribs moulded into the bottom of the container where discharged material is safely held during the life of the battery.

4. Unlike most plastic batteries, the lids on Trojan units are not heat sealed. The lids are made to fit down onto the containers to a depth of 11 mm and are sealed with Epoxy Resin. The seal is very effective and adds strength to the assembly.

5. The vent openings in the lid are sealed with a one-piece flame retardant gang vent plug. The single push-in unit simplifies inspection of the acid levels and is a big time saver.

6. Rugged stud type terminals allow for quick and simple battery connections. Angle type lead terminals are available if considered essential to an application.

RPC Cat.#	Unit Volts	Amp-hour 20hr	Amp-hour 100hr	Life Cycles† to 80% discharge	Dimensions L	Dimensions W	Dimensions H	Weight Kg
BAT-026	12	105	117	115	324	171	248	24
BAT-001	6	225	250	754	264	181	284	28
BAT-029	6	305	339	625	295	178	365	41
BAT-002	6	395	438	625	295	178	424	55

† Actual performance may vary, based upon operating conditions, application requirements, battery care and charging conditions.

RAYLITE M-Solar Batteries

Positive Plate: The tubular plate construction incorporates lead alloy spines in complete contact with active material, which is retained by an outer gauntlet. This enables the electrolyte to penetrate freely, ensuring a high power output per unit volume.

Top up Level Indicator: Two ribs on the separator guard serve both as level indicators, and to strengthen the guard.

Negative plate: The negative plate is of a highly porous paste on a lead alloy grid. This complements the positive plate construction, providing a balanced performance and superior life.

Separators: Separators are manufactured from microporous polyethylene and have a generous overlap to reduce the risk of short circuit. They are impervious to acid attack.

Mud Trap: Prevents possible shorting between plates due to active material shedding during the life of the cell.

Container and Lid: The lid is heat-sealed to the container ensuring an excellent bond. This is vital to mechanical strength and safety.

Cycle Life:
- @10% DOD = 10,000 cycles
- @20% DOD = 4,500 cycles
- @50% DOD = 2,000 cycles
- @80% DOD = 1,200 cycles

Perfect Seals Bolt-On Connector

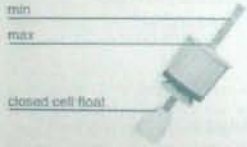
Injection moulded connector head: The bolt-on connector facilitates easy cell replacement. Acid resistant, totally enclosed terminal post, maximum safety. Orifice for voltage readings.

Stainless steel bolt: Corrosion resistant.

Threaded brass insert: Maximises terminal connector conductivity.

Perfect Seal: A polypropylene pressure bushing seated on a rubber "O" ring, locked in place by a polycarbonate ring. The cell lid is welded to the container, and polypropylene is injection moulded into the post to lid cavity. This design eliminates acid leaks through the post assembly.

Santoprene Connectors:
- Made of thermoplastic rubber
- Acid resistant
- Abrasion resistant
- Fatigue resistant
- Built in "O" rings
- Easy and simple to connect
- Access for easy voltage checking
- More flexible than PVC cable
- Exceptional moulding bond eliminates contamination



Cat.#	Cell Type	Unit Volts	Capacity (Amp Hours) C∞	Capacity (Amp Hours) C100	Dimensions (mm) Length	Dimensions (mm) Width	Dimensions (mm) Height	Weight Kg
BAT-R600	MIL 17S	6V	419	600	585	198	460	91
BAT-R750	MIL 21S	6V	524	750	585	230	460	116
BAT-R900	MIL 25S	6V	629	900	585	262	460	133
BAT-	MTL 25S	4V	759	1050	411	262	530	97
BAT-	MTE 21S	4V	996	1380	415	230	740	127
BAT-	MTE 25S	4V	1200	1660	415	262	740	145

Battery & Cable Accessories

Battery Trays

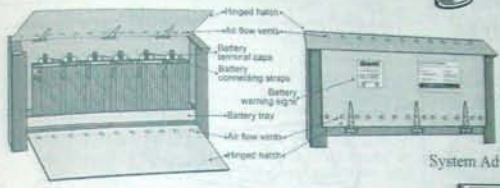
A Battery tray needs to be large enough to take the entire electrolyte contents of one cell of your battery bank, in case it splits open or springs a leak.

700mm × 380mm × 60mm Cat.# BAX-030
1155mm × 350mm × 55mm Cat.# BAX-036

Battery Terminal Cap

Positive and Negative terminal cover (clear), prevents accidental short circuiting of battery terminals. Provided with a hole for a meter probe.

Cat.# BAX-003



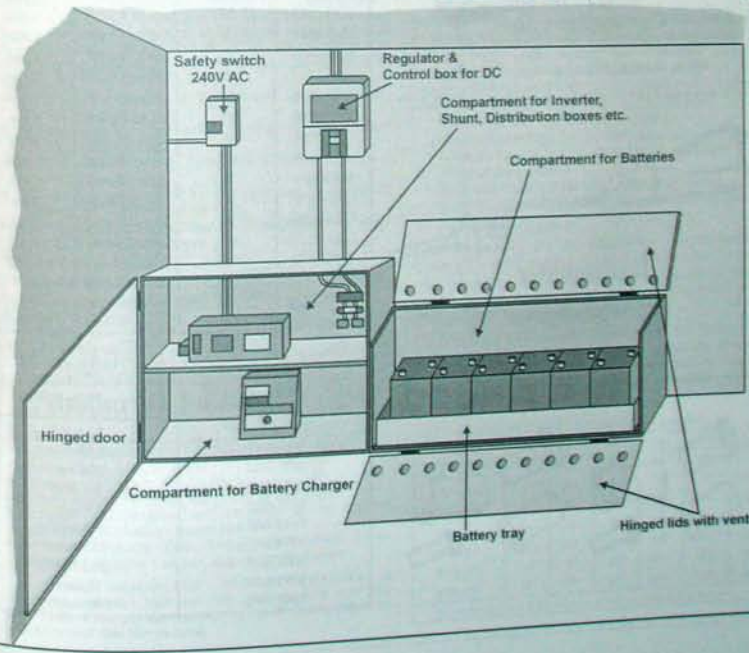
Safety Signs

No Smoking Sparks Flames (red & black on white), Electrolyte Burns (green on white).

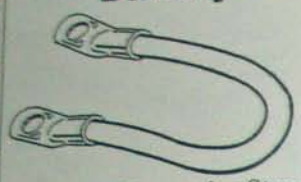
Battery Warning Signs: Cat.# BAX-002
System Advisory Signs: Cat.# BAX-001

Battery Boxes

Batteries need to be separated from other electrical components and kept away from children and animals. You may be able to make your own battery box out of plywood. Contact Rainbow Power Company for design information and dimensions.



Battery & Cable Accessories



Battery Connecting Strap

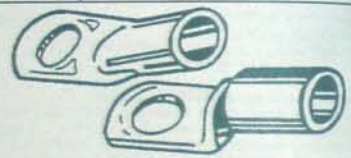
16mm² cable, 250mm long, 10mm lug — Cat.# BAX-304
35mm² cable, 350mm long, 10mm lug — Cat.# BAX-311
Other sizes available on request

Cable Clips

Cat. #	to suit
WRX-001	2 mm² twinflex
WRX-002	1.84 mm² double insulated or 2.9 mm² double insulated
WRX-003	4.6 mm² double insulated or 2 × 7.9 mm²
WRX-004	2 × 4.6 mm² double insulated or 2 × 13.6 mm²

Crocodile Clips

50A, sheathed pair — Cat.# BAX-012
400A, sheathed pair — Cat.# BAX-016



Cable Lugs

Cat.#	Amps	Cable Size	Stud
LUG-0405	20	up to 4 mm²	5 mm
LUG-0406	20	up to 4 mm²	6 mm
LUG-0408	20	up to 4 mm²	8 mm
LUG-0410	20	up to 4 mm²	10 mm
LUG-0605	25	up to 6 mm²	5 mm
LUG-0606	25	up to 6 mm²	6 mm
LUG-1006	45	up to 10 mm²	6 mm
LUG-1606	70	up to 16 mm²	6 mm
LUG1608	70	up to 16 mm²	8 mm
LUG-1610	70	up to 16 mm²	10 mm
LUG-2508	90	up to 25 mm²	8 mm
LUG-2510	90	up to 25 mm²	10 mm
LUG-3506	110	up to 35 mm²	6 mm
LUG-3508	110	up to 35 mm²	8 mm
LUG-3510	110	up to 35 mm²	10 mm
LUG-5010	150	up to 50 mm²	10 mm

Hydrometer

Cat.# BAX-008
GEFO: Cat.# BAX-009

Cable Joiners: Cat.# WRX-J07 / J14 / J25 / J32 / J50
(number represents mm² of cable)

Cable End Terminals

Cat.#	to suit
WRX-B75	0.75 mm²
WRX-B02	1.84 mm²
WRX-B03	2.9 mm²
WRX-B05	4.6 mm²
WRX-B07	7.9 mm²
WRX-B15	13.6 mm²
WRX-B25	25.7 mm²
WRX-B36	32 mm²
WRX-B50	49 mm²

Battery Chargers

Switch Mode Power Supply / Charger

Cat.# BCH-021

The Switch Mode DC Power Supply provides a high power output for such a small and lightweight unit. It is suitable for a variety of uses, including battery charging, direct DC operated equipment from an AC outlet and providing variable voltages of 3V to 15V and at up to 40A continuous operation.

Features

1. Lightweight and Small Size: The switch mode power supply has the advantages of lightweight and small size.
2. High Efficiency: The unit operates with an efficiency of over 80% under ideal conditions as compared to inefficient transformer based power supplies and battery chargers.
3. Variable Voltage Output: The variable range of output voltages from 3V to 15V enables precise voltage control to suit the load and can be used to limit the current output when used as a battery charger as well as preventing excess battery voltage during the charging process.
4. Overload Protection: Current fold-back circuitry is adopted to limit the output and thereby limit a potential overload. The overload indicator will light up when the unit is overloaded.
5. Over Temperature Protection: The over temperature circuitry functions when the unit exceeds the rated temperature limit. The output voltage and current will then drop down to a safe value and the overload indicator will light up.
6. Over Voltage Protection: The over voltage circuitry protects the unit and connected equipment from high output voltage.
7. High RFI Stability: Incorporates circuitry to prevent an unacceptable level of RFI (Radio Frequency Interference).

SPECIFICATIONS

Output Voltage: (Selectable)	3-15 V DC Adjustable **OR** fixed at 13.8V DC
Output current:	40 A
Ripple and noise:	10 V_{pp}
Line regulation:	80 mV (±10%)
Load regulation:	230 mV (0-100% Load)
Power-source:	240 V AC @ 50Hz
Meter type:	Digital LED
Dimension (W × H × D):	220 x 110 x 300 (mm)

Woods Dialomatic Battery Chargers

Save up to 50% of your fuel bill by charging a battery bank. The **WOODS** charger will supply a constant load for the generator and the battery bank will supply power for lights etc when the generator is not running. **WOODS** Dialomatic features:

- Heavy-duty components ensure a trouble free, durable long life.
- Input circuit breaker and Output fuse ensure electrical protection.
- Large, accurate, easy to read meters can be seen at a glance.
- Current is controlled by the operator by means of the dial on the front of the unit.
- No need to select voltage. Will automatically adapt to a range of voltages.
- Compact & portable for easy use.

Unregulated Models:

- Maximise charger output
- Maximise generator efficiency
- Cut down on fuel consumption (battery bank will need monitoring to avoid overcharging).

Regulated Models:
Regulated models are available if you wish to avoid monitoring the battery (eg let the generator run whilst going shopping or visiting)

- Output will progressively decrease as the state of charge of the battery improves.
- Prevents battery from being overcharged. These models use more fuel per amp-hour of charge.

The **WOODS DIALOMATIC BATTERY CHARGER** is manually operated and has full control with just one dial. These chargers are simplicity itself. Just connect to a Battery and dial the current.

Operation

Both the voltage and current on **WOODS DIALOMATIC BATTERY CHARGERS** are controlled simultaneously with a single dial, making the selection infinite between the minimum and maximum range of the charger. Make sure the charger is switched off before connecting to or disconnecting from the battery.

Main switch to off. Turn dial to zero.
Connect **RED** lead to **POSITIVE** terminal.
Connect **BLACK** lead to **NEGATIVE** terminal.
Main switch to **ON**.
Turn dial **CLOCKWISE** until **AMMETER** moves.
THE CHARGER HAS FOUND THE BATTERY VOLTAGE AUTOMATICALLY.

Continue turning the dial **CLOCKWISE** to obtain the desired charging current. Voltmeter indicates Battery state of charge and maximum voltage indicated must not be exceeded. To obtain voltage reading press and hold the dual meter switch button.

To overcome any excessive gassing of the battery if the charger is to be left overnight, a maximum setting of 5 Amps should not be exceeded unless heavy batteries are being charged which require more current.

DIALOMATIC unregulated models

Cat.#	Volts	Amps	Width	Depth	Height	Kg
BCH-032	12	30	260	290	320	11
BCH-036	12	60	260	290	320	15
BCH-033	24	15	260	290	320	11
BCH-034	24	30	260	290	320	17
BCH-280	24	60	460	290	320	28
BCH-420	48	15	260	290	320	17
BCH-440	48	30	460	290	320	28

Note: BCH-280 and BCH-440 require 15A, 240V socket to plug into.

Small Lead-Acid Batteries

- have the handling ease of dry batteries.
- sealed construction allows trouble-free, safe operation in any position.
- batteries are sealed and maintenance free, so therefore never need the addition of water.
- well suited for small portable power supplies for lap-top computers, lanterns etc.

Recharging

These batteries can be recharged with a battery charger designed for recharging small 6 volt and 12 volt batteries (such as the RPC 6 volt battery charger). A 12 volt battery cannot be charged directly from a 12 volt power source such as a 12 volt home lighting system. A 6 volt battery, however, can be charged from a 12 volt source with the appropriate battery charger.

Care of your battery

To ensure a long life for your battery, do not let your battery stand in a flat or partially charged condition for long periods before recharging. Keep your battery clean and dry at all times. Avoid exposing your battery to extremes of temperature (hot or cold).

As with all lead-acid batteries, the life of these batteries is severely shortened by frequent deep discharges. It is not recommended to continually discharge the battery beyond 50%. When the OCV or static voltage (no charge or discharge) is less than 12 volts for a 12 volt battery or less than 6 volts for a 6 volt battery the usage should be discontinued and the battery recharged. Deep discharges will shorten the life expectancy of the battery and may cause difficulty in recharging the battery.

SPS Cat.#	Volts	Amp-Hours over 20 Hours	Dimensions (mm) L	W	H	Weight Kg
BAT-004	6	4	70	48	102	0.8
BAT-005	12	4	90	72	110	1.8
BAT-021	12	7	151	65	94	2.5
BAT-009	12	18	180	74	166	6.0

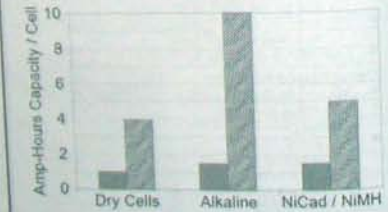
NiCad/NiMH Batteries

Kick the habit! Stop using those costly and polluting disposable batteries. Wherever small batteries are required, replace them with Nicad or NiMH rechargeable batteries. Ideally, you should buy two sets, so that when the batteries get weak, just swap them over and recharge the batteries you took out.

Battery	type	Amp-hour	Cat.#
UM-4	'AAA' NiMH	0.9	BAT-022
UM-3	'AA' NiMH	2.3	BAT-021

Storage Capacity

comparison



Rechargeable versus Disposable

In the chart (above), general purpose (normal disposable) and alkaline battery capacities are average figures and are not based on any single brand. It must also be noted that general purpose and alkaline batteries have a voltage 1.5V whereas NiCads have a voltage of 1.25V per cell.

10 × 'AA' or 'AAA' NiCad & NiMH Battery Charger

for charging 1 to 10 × 'AA' or 'AAA' NiCads or NiMH from 12V or 240V (DC lead not included)

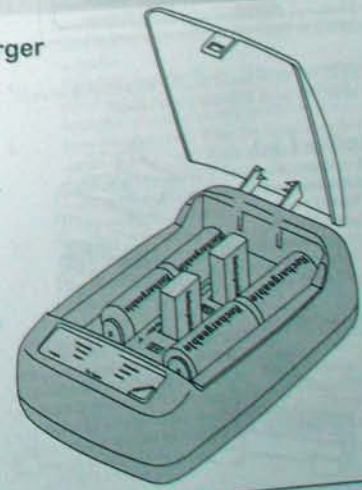
- Maximum charging timer for overcharge protection
- Coloured LEDs indicate discharging, charging and ready for use

Cat.# BCH-005

12V/240V/USB NiCad / NiMH Charger

Charge 2 or 4 batteries at a time.
Can be powered from a 12 volt source, any AC source or USB port.
Automatically switches from fast charge to trickle charge when charging process is completed.
Will charge AA batteries at 800mA and AAA batteries at 300mA in the fast charge mode and switch to one tenth of thus current in trickle charge mode.

Cat.# BCH-003



12V/240V NiCad / NiMH Chargers

for charging 2 or 4 'AAA', 'AA', 'C' or 'D' cells from 12V or 240V (DC lead not included) discharge mode operated by pressing switch switches to trickle charge when charging is finished

Cat.# BCH-023

Connectors, Links and Fuses

Connectors make multiple connections of wires easy.

Active and neutral links are solid brass bars with a series of holes, with a set of screws to hold the wire in each hole. There are red active links for all positive connections and black neutral links for all negative connections.

Fuses - the safety connection

A fuse or a circuit breaker is an essential part of any electrical circuit. With a low voltage power supply, the risk of fire as a result of a short circuit is just as real as it is with 240 mains power. It is recommended that a fuse or circuit breaker be placed as close to the battery bank as is practicable. All connections to the rest of the electrical system should be done in such a way that it is all protected by at least one fuse or circuit breaker.

Battery Fuse

It is recommended to have a cartridge fuse on the positive terminal of each parallel battery where the negative is earthed and to have a fuse on each positive and negative terminal where no earthing is used.

The rating of the fuse should be less than the maximum current carrying capacity (ampacity) of the cable to protect it.

Ampacity of DC Cables

Cross Sectional Area	Current (Amps)
1.84 mm²	15 amps
2.9 mm²	20 amps
4.6 mm²	25 amps
7.9 mm²	45 amps
13.6 mm²	70 amps
32 mm²	110 amps
49 mm²	150 amps

NOTE: A fuse or circuit breaker is wired up in series in the same way as an amp-meter or a switch.

Active Link

with red base and cover
7 interconnected holes
3 holes for 15mm²
Cat.# CON-007
10 interconnected holes
3 holes for 36mm²
Cat.# CON-012

Neutral Link

with black base and cover
7 interconnected holes
3 holes for 15mm²
Cat.# CON-006
10 interconnected holes
3 holes for 36mm²
Cat.# CON-013

Connectors

Cat.#	Number of Connectors	to suit
CON-002	strip of 12	2 x 1.8 mm²
CON-003	strip of 12	2 x 2.9 mm²
CON-005	strip of 12	2 x 4.6 mm²
CON-004	strip of 12	2 x 7.9 mm²
CON-009	single	2 x 7.9 mm²
CON-010	single	2 x 13.6 mm²
CON-011	single	2 x 32 mm²

Junction boxes

small: 3 connectors and cover will take up to 15 mm²

Cat.# CON-001

large: 4 small connectors and cover box is large enough to fit any of the above connectors

Cat.# CON-008

Glass fuses

3AG fuses, will fit in-line fuse holder please indicate value required,

Cat.# FUS-003

In-line fuse holder

good quality product, suitable for 3AG fuses

Cat.# FUS-006

Stackable Blade fuse holder

Cat.# FUS-007

fuses to suit:

3A to 30A — Cat.# FUS-005

Cartridge fuse

Fuse holder Cat.# FUS-081
63 amp Cat.# FUS-063
80 amp Cat.# FUS-080
100 amp Cat.# FUS-100

Triple HRC fuse holder

Wire in up to three separate fuses that can be engaged or disengaged at the same time in one single knife-switch action.

Cat.# FUS-300

Fuses to suit:
40A – Cat.# FUS-340
63A – Cat.# FUS-363
80A – Cat.# FUS-380
100A – Cat.# FUS-3100
125A – Cat.# FUS-3125

Diodes

A diode functions in electrical terms in much the same way as a one-way valve functions with water.

Diodes are generally used to stop a backward flow of electricity such as preventing a battery discharging through a solar panel at night. A diode used in this way is referred to as a blocking diode. Monocrystalline solar panels, such as the BP 10W to 83W range do not need blocking diodes as the amount of reverse current at night is negligible and the power loss through the diode is greater.

When a diode is used to shunt an electric current past a circuit presenting a high electrical resistance it is referred to as a bypass diode.

Bypass Diodes

Bypass diodes are fitted to solar panels where required. Bypass diodes external to solar panels are not required for 12V and 24V configurations.

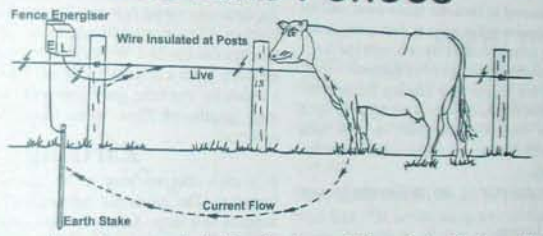
Installing a Blocking Diode

Make sure that the current (amp) rating of the diode is at least equal to the current expected to flow through it. Diodes larger than 6 amp need a heat sink to prevent themselves from overheating.

Blocking diodes are usually installed in the connecting box on the solar panel, but may be connected anywhere in the positive line between the solar array (or whatever is your normal charging source) and the battery bank. The negative line need not be altered. If there is no indication of current flowing from your normal charging source, you may have put the diode in back to front - reverse the diode and check again.

The voltage before the diode will be 0.6 volts higher than after the diode. This may mean that a small adjustment on the regulator is needed.

Electric Fences



Remote areas are now able to be economically fenced using solar electric fencing systems. High power output fence energisers are available, drawing their power from 12 volt DC batteries, whose charge is maintained by solar modules.

Advantages of Electric Fencing

1. **Low Cost:** The costs of constructing electric fences are much less than conventional types because they require a lot less materials and labour by comparison.
2. **Easy to Build:** Lower wire tension strains and generally lighter material requirements make them quicker and easier to construct, especially in difficult terrain. Ideal permanent electric fencing should have strainers and angle posts construction so that no movement will take place under strain of the wire erected.
3. **Extended Life:** Electric fences are not subjected to the same physical pressures from animals, and can therefore be expected to have a greatly extended service life. The life of existing old fences can be considerably extended using electric fencing, by the use of outriggers or offset wires which must be insulated.
4. **Universal Application:** Electric fencing will contain all types of animals, and is a positive deterrent to wild animals, predatory or domestic animals.
5. **Simplicity and Flexibility:** There is no quicker or easier way to effectively subdivide a paddock for controlled grazing than with an electric fence.
6. **Low Maintenance:** After the fence is properly installed and the stock are trained, the maintenance of electric fencing is less than for non-electric fences because stock pressures do not happen when the fence is powered or pulsed.
7. **Less Stock Damage:** The shock from the electric fence causes no physical damage. If stock are forced through the fence by fright of any kind (eg bush fires, or dogs) they are at less risk than with a non electric fence.

Design Varies with Local Conditions

Electric fencing requirements vary depending on terrain, local conditions of soil type, rainfall, and vegetation, so therefore it is not possible to specify one design of fence which will work in all situations. The following pages will give you some insight into the most appropriate electric fence design for your situation.

Time and Space

All animals need time under conditions of no stress to discover that their perimeters are hostile (ie wires which are electrically pulsed). To achieve a no stress situation the initial or introductory paddock should be as large as possible to allow space for the animals to run freely if "spooked". Adequate feed and water should also be available and the environment within the fence should be non-hostile. This situation is a good basis to make animals aware that the fence actually produces pain, when contact is made.

Don't Turn Power Off

Once the fence is installed keep it energised, or pulsed:

(a) The energiser uses a small amount of power. The smaller electric fences typically draw about 10 mA whereas some of the larger units use about 150 mA.

(b) Animals should not be allowed to find out that the fence wire does not hurt. It will effectively hold back stock when it's on.

The energiser is connected to both the fence wires and the earth. It puts out a regular pulse of very low current and high volts. When an animal makes contact with the fence wire, it also remains earthed and therefore becomes part of an electrical circuit, the pulses thus passing through the animal. The strength of the shock it receives depends upon the energy available from the energiser, and the total resistance of the circuit. Ground conditions influence this situation considerably.

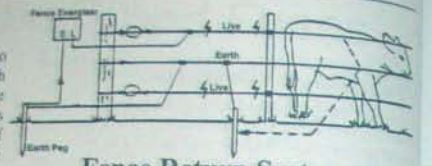
There are two basic systems in use in Electric Fences. They are:

1. Earth Return System.
2. Fence Return System.

Earth Return System

The Earth Return System uses one or more fence wires to deliver the pulse from the energiser. To complete the circuit, current must flow through the animal when it touches the wire and back to the energiser by way of the ground. This system therefore relies on the animal making good electrically conductive contact with the ground, and the earth being sufficiently moist to provide a low resistance circuit back to the energiser terminal earthing system. These conditions usually apply in high-rainfall coastal areas, and on irrigated pastures.

Earth Return Systems are very effective, because there is less chance of leakage and the fence is harder to short out.



Fence Return Systems

Fence Return Systems are widely used in many areas of Australia with low rainfall. To overcome the problems associated with dry land and low conductivity soils, a Fence Return Earthing System may be used.

This system uses both Pulsed and Earthed Wires on the fence, therefore requiring two or more wires. To complete the circuit, current must flow through the animal from the Pulsed Wire to the Earthed Wire and back to the Energiser earthing system. If the ground is sufficiently moist for the Earth Return to work, then the animal will receive a shock by touching only the Pulsed Wire. If the Earth Return is not working, then the animal will receive a shock when it pushes far enough through the fence to contact two parallel wires, one Pulsed, one Earthed. The animal will not receive a shock if it only touches the Earthed Wire. A combination of the two methods gives a system by which the stock can receive a shock by touching only one wire, or both wires, on long lengths of fence when there is very little soil moisture.

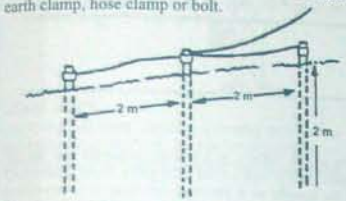
Earthing

It is clear that earthing in an electric fence is most important. The successful operation of an electric fence depends to a large degree on how well the energiser is earthed. Poor earthing is a common cause of failure. Different soil types and moisture contents require different approaches. The following ideas are given as guidelines to help with the construction of the most effective earth for a particular location.

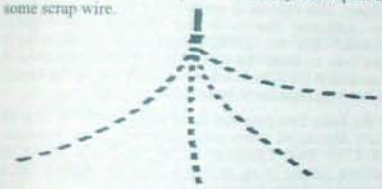
1. Where possible choose a damp site even if it means locating the earth system up to several hundred metres from the energiser.
2. Check to determine that it is not going to be closer than 2 metres from a mains neutral, town water main or telephone earth.
3. For safety reasons use an insulated wire from the energiser earthing terminal to where the wire leaves the building that the energiser is housed in. This will ensure that no contact is made with another earth system.
4. Construct and protect the earth system in such a way that animals or vehicles are not likely to damage it.
5. Many earth systems have failed through corrosion at electrical joints. Solder joints where possible and where this cannot be done use screw connectors well covered with silicon sealer and/or insulating tape.
6. Multi strand tinned copper wire is best for earth leads but where this is not available galvanised should be used.

Here are some earthing suggestions:

System 1. **Earth Ground Rods.** Using three lengths of 18 mm (3/4") galvanised pipe or rods driven into the ground to a depth of at least two metres and spaced at least two metres apart. Some installations require more than three rods to achieve satisfactory earthing. All rods must be connected together. Before joining the connecting wire, make sure both rod and wire are clean by polishing with sandpaper. Connection onto the rods can be made by an earth clamp, hose clamp or bolt.



System 2. **Buried Wire.** In some locations excellent earthing can be achieved by burying (mole plowing) lengths of wire and joining them at a common point. Plain copper wire is best but expensive unless you can pick up some scrap wire.



System 3. **Buried Metal Object.** Good grounding (earthing) can be achieved by burying a metallic object in damp ground (eg an old radiator, sheet of metal). Naturally within reason the bigger the object the better. Wherever possible solder the earth wire directly on but if this cannot be done make sure it is securely clamped against bare metal and that the joint is given a liberal coating of sealing compound. Make sure that you compact the earth when filling the hole.

System 4. **Earth Wire Combined with Ground Earthing.** When soil conductivity is generally poor (eg very dry soil) you can combine a fence return and an earth return system. At regular intervals around the fence place earth stakes with the earth wire connected to it. You could use metal posts with insulators for the live wire(s) and attach the earth wire(s) directly to the metal.

Leakage

Current can be lost from the pulsed wire to earth by way of vegetation touching the wire, through faulty insulators, broken wires, slack wires touching posts, etc. They can become very significant, when not rectified, to the point that the fence no longer produces an electric shock. A "SHORT-CIRCUIT" through broken wires or wires touching Earth or Earth Wires will also render an electric fence inoperative.

DO:

1. Use efficient earth stakes. They should be galvanised steel, copper, BUT NOT black steel posts or rusty pipe.
2. Position earth stakes at least 3 metres away from domestic power earth stakes.
3. Ensure good electrical connection between earth stakes.
4. Use an earth return wire system with additional stakes, preferably in a damp situation, every one kilometre or so in long lengths of fence where less than perfect soil moisture conditions remain all year round.

DO NOT:

1. Connect energiser earth to a domestic power earth peg. In most countries this is illegal and considered a very dangerous electrical practice.
2. Connect the energiser earth to any water reticulation system, domestic or stock. This is also considered a very dangerous electrical practice.

SAFETY

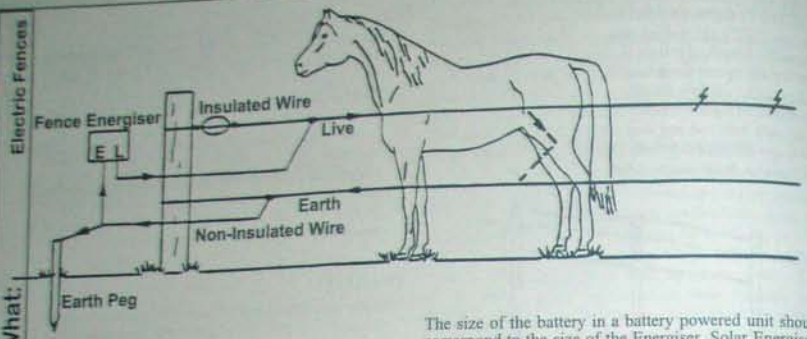
PEOPLE should always treat an Electric Fence with respect. An Electric Fence Energiser can deliver a powerful shock which may be frightening under some conditions. Care should be exercised near swimming pools, dams etc, where people are likely to be on wet ground with bare feet.

WARNING SIGNS should be placed at intervals of not more than 100 metres along any section of Electric Fence where "members of the public might reasonably be expected to touch it."

HORSES respond more sensitively to shock than most other animals, yet suffer no ill effects from contact with Electric Fencing. You should take particular care when training horses that they have plenty of room to run when they first experience shock from an Electric Fence.

LIGHTNING STRIKES during thunderstorms are common. There may be miles of carefully insulated fence wires on the property, which will conduct the lightning straight back into the Energiser. Apart from the obvious fire risk, this will almost certainly damage or destroy the Energiser. Disconnect the Energiser from the fence and from the power source for protection during electrical storms or install lightning diverters into the fencing system.

PHONE LINES, ANTENNAS must be well clear of the pulsed wire. When building the system, take care that there is no chance for the pulsed wire to contact phone lines, radio or TV aerial, or any other part of a building, even if the pulsed wire falls down. Do not run Electric Fence lines parallel to telephone lines if it can be avoided as this induces interference.



It is better to do the job correctly rather than have it fail, and have to do it again.
Read the available literature or ask for advice.

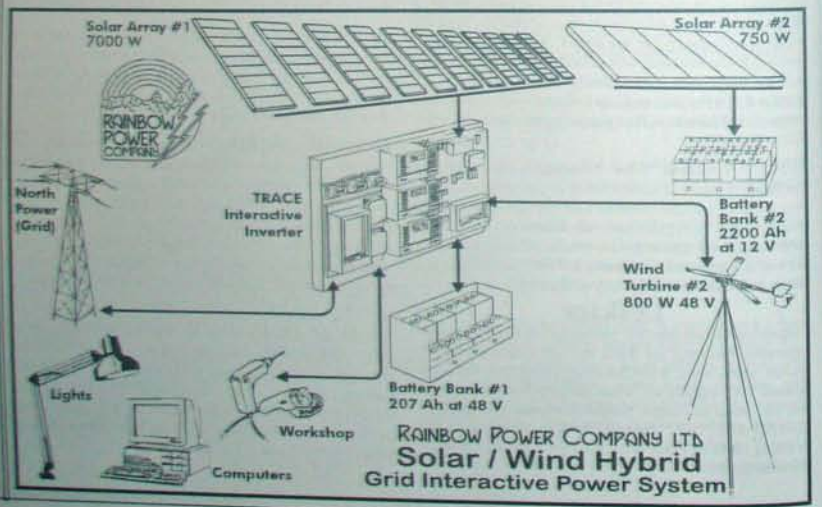
Types of Energisers

Electric Fence Energisers vary in their source of power, and their power output. Their power output is rated in JOULES. The higher the joules figure, the more fence wire may be electrified, provided the energiser is earthed suitably under all weather conditions, either wet or dry.

Energisers fall into two groups, being BATTERY powered or MAINS powered. SOLAR powered Energisers are used with a BATTERY.

The size of the battery in a battery powered unit should correspond to the size of the Energiser. Solar Energisers should be bought as a package, because it is necessary to balance the power available from the Solar Panel with the power required to operate the Energiser. The solar panel must also be well matched with the battery, so that the battery can be easily recharged after a period of little or no charge, without fear of seriously overcharging the battery. This balance is needed to ensure that the fence has sufficient reserve to last through bad weather periods, while not wasting excess panel output. Always take care to align the Solar Panel in accordance with instructions (or refer to Solar Panel section of this book), so ensuring maximum output from the panel.

If the Solar Energiser has an internal battery, it may be fairly discharged when received. After initial purchase, leave the Solar Energiser in the sun for a day or so without turning it on to ensure that the battery has a reasonable charge before you start using it.



12V & 24V Hi Powered Battery Charger

- A small light weight (13 kg) portable petrol powered battery charger that really works!
- Quickly charges vehicle battery. Much safer than jump-starting.
- Fast and fuel efficient.
- 24 volt model also available.
- 12 volt model produces up to 50 Amps.
  24 volt model produces up to 45 amps.
- One tankful of fuel (1.2 litres)
  can produce 45 amps @ 12 volts for 1 hour or
  20 amps @ 12 volts for 3 hours.

Ideal uses:

For farms, camping, boating, yachting, emergency services, 12 volt lighting, mobile mechanics, earthmoving contractors or anyone working outback.

Australian Made

Can supply enough charge for a flat battery in approximately 5 minutes to start the car or tractor. The unit can charge flat batteries at 50 amps maximum. The unit can be used as reliable emergency lighting power or charger back-up for solar power.

Features include:

- Regulated charge or supercharge, by the flick of a switch.
- Short circuit and over voltage protected.
- Safe from electrocution (12 or 24 volt DC only).
- Super bright LED amp display for charging indication.
- Lightweight.

Nominal Charging Voltage	12 Volt DC	24 Volt DC
Engine Details		
Catalog Number	BCH-502	BCH-503
Max. Engine Power	4 kW / 5.5 hp	4 kW / 5.5 hp
Revs @ Max. Engine Power	3600 rpm	3600 rpm
Engine Model	Honda GX160	Honda GX160
Engine Type	air-cooled OHV 4 stroke	air-cooled OHV 4 stroke
Engine Displacement		
Starting System	Recoil	Recoil
Fuel Tank Capacity	3.6 Litres	3.6 Litres
Fuel Type	Unleaded Petrol	Unleaded Petrol
Fuel Consumption	¾ Litre per Hour	¾ Litre per Hour
Oil Capacity	0.6 Litres	0.6 Litres
Alternator Details		
Alternator Model	Bosch 12V 120 Amp	Bosch 24V 45 Amp
Max. Voltage (Low)	14.2 V DC (regulated)	28 V DC (regulated)
Max. Voltage (High)	15 V DC (regulated)	29 V DC (regulated)
Max. Voltage (Cut-out)	18 V DC	36 V DC
Max. Amps (Continuous)	100 Amps	40 Amps
Amp Meter Display Type	Digital LED	Digital LED
Other Details		
Display Detail	4 Digit Display – 1 digit after the decimal point	
Leads	3 metres Long with Alligator Clamps	
Dimensions (L x W x H) mm	466 x 362 x 352	466 x 362 x 352
Weight	22 kg	22 kg

Solar Hot Water Systems

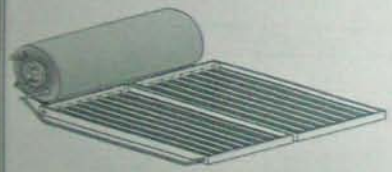
180 litre 1-2 people

305 litre 2-5 people

440 litre 5-8 people

600 litre 8-10 people (Small Commercial)

Many people use Solar Collectors for their hot water requirements. On an independent power system, solar heating, fuel stoves and bottled gas are usually the primary sources of heating.



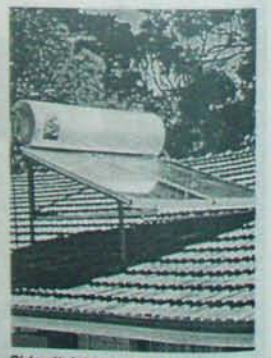
Solar Edwards Hot Water Systems are our choice for the following reasons:

1. Ideally suited for connection to harsh water areas and external heating sources (such as wood fired room heaters or stoves). Wood fired heaters and stoves may be connected to the system for auxiliary boosting.

2. Stainless steel storage cylinder does not require a sacrificial anode and is designed to minimise the surface area thereby reducing heat loss.

Standard with pitch installation.

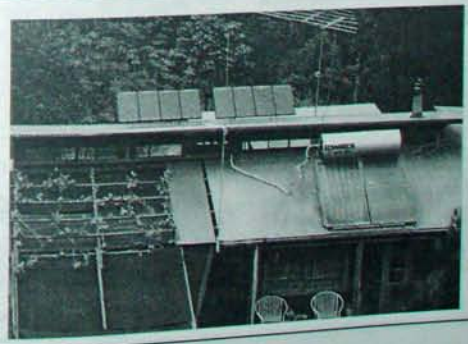
Reverse pitch installation using brackets.



Side pitch installation using brackets.

Specifications:

	Details / Units	Model L180	Model L305H	Model L305	Model L440	Model L600
Cylinder — Cased						
Capacity	Litres	180	300	300	440	600
Dimensions — Length x Diameter	millimetres	1220 x 560	1900 x 560	1990 x 560	2735 x 560	3785 x 560
Weight — Dry	kilograms	40	58	58	88	120
Weight — Full of Water	kilograms	220	358	358	528	720
Material	Stainless Steel	Marine Grade 316				
Material Thickness	millimetres	1.6				
Polyurethane Insulation Thickness	millimetres (bottom / top)	25 / 65				
Casing Material	Colorbond	Colour optional				
Casing Thickness	millimetres	0.4				
Test Pressure	kilopascals	2070				
Maximum Supply Pressure	kilopascals	450				
Cold Water Relief	kilopascals	600				
Hot Water Relief	kilopascals	700				
Electric Booster Element	Volts / kW	As required				
Collectors		one	one	two	three	four
Capacity	Litres	2	2	4	6	8
Dimensions (depth = 80 mm)	millimetres (length x width)	1000 x 1980	2000 x 1000	2000 x 1980	3000 x 1980	4000 x 1980
Area (Nominal)	metres ^{2}	2	2	4	6	8
Weight — Dry	kilgrams	31	31	62	93	124
Weight — Full of Water	kilograms	33	33	66	99	132
Aluminium Plate Thickness	millimetres	0.8				
Copper Header Pipe Diam./ Wall Size	millimetres	25.4 / 0.91				
Copper Riser Pipe Diam./ Wall Size	millimetres	12.7 / 0.91				
Glass Cover Thickness — Standard	millimetres	3				
Glass Cover Thickness — Tempered	millimetres	3				
Colorbond Casing Thickness	millimetres	0.4				
Fibreglass Insulation Thickness	millimetres	50				
Total System						
Dimensions — Area on Roof	millimetres	1220 x 2500	1230 x 1500	2030 x 2500	3060 x 2500	4090 x 2500
Weight — Dry	kilograms	71	89	120	181	244
Weight — Full of Water	kilograms	253	391	424	627	852
Warranty — Labour	Years	1				
Warranty — Cylinder	Years	7				
Warranty — Collectors	Years	7				
Warranty — Electrical	Years	1				
Warranty — Valves	Years	1				



Hydro Power

Hydro-Electric Systems

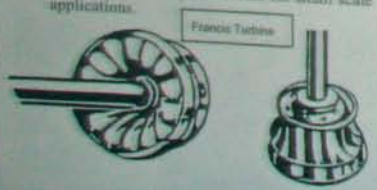
If you have a good hydro-power site it will be more cost effective in terms of dollars per watt than either solar or wind power. The average hydro-electric generator costs only ONE TENTH as much as a solar (photovoltaic) system of equivalent power. Hydro power has a major advantage in terms of continuity of supply. Solar only generates power when the sun is shining; hydro generates power 24 hours a day.

With only occasional rains, the water is stored, over the long term, in the water catchment areas. This water is released slowly to keep creeks and streams flowing continuously over quite a long period. This continuity means that a large battery bank (for storage) may not be necessary because the hydro power can provide a constant charge to the battery bank 24 hours per day.

Hydro-electric power systems fall into two main areas, impulse and reaction turbines. An Impulse turbine spins in air with a high pressure water jet causing it to spin. A reaction turbine is totally submerged in water and spins as a result of the water flowing past it. Hydro power systems can be further subdivided into four categories:

1. **High head:** Using a high head allows the extraction of a greater potential energy from the same quantity of water. This is dependent on a fall in excess of 20 metres but it needs a relatively small flow rate. The water is piped down to the hydro plant to create the necessary head (pressure). The Turgo and the Pelton wheel are high head turbines.

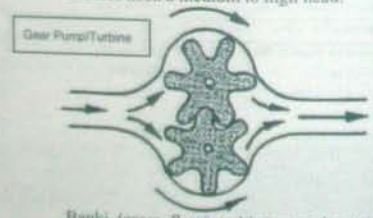
2. **Medium head:** With a lower head, a greater volume is required to produce the same power. The Francis (reaction) turbine is a medium head turbine which is a good turbine for small scale applications.



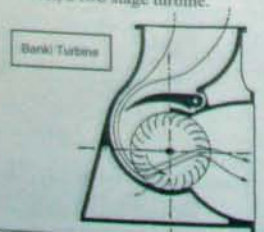
3. **Low head:** A low head turbine requires a relatively large volume of water in order to extract a useful amount of power. It is also much more limited, due to difficulties in finding an appropriate site for the turbine which invariably needs to be located in or at the edge of a creek or stream. A Kaplan (propeller) turbine is an example of a low head turbine.

4. **Flow of the stream turbine:** Where there is a fast flowing stream but virtually no head a floating propeller driven turbine may be used. See page 69 for more details.

A gear pump can also be used as a turbine. Gear pumps have high frictional and leakage losses, but are otherwise suitable for small scale hydro power applications. Gear pumps used as turbines need a medium to high head.



Banki (cross flow) turbines can be used for heads as low as 1 metre, up to heads as high as 200 metres. They can be manufactured in the back-yard workshop and are good for small scale hydro power applications. A Banki is, in effect, a two stage turbine.



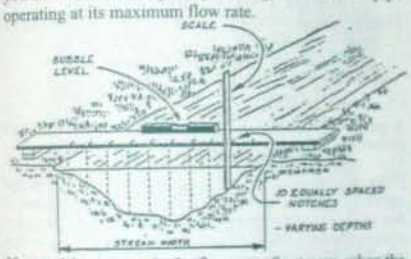
To determine the power potential of water flowing in a river or stream it is necessary to determine both the flow rate of the water and the head through which the water can be made to fall.

Flow Rate

The flow rate is the quantity of water flowing past a point in a given time. This is usually measured in litres per second.

How to Measure Flow Rate

An easy method for measuring flow rate is with a common 10 litre bucket and a stop watch. The litres per second flow rate would then 10 litres divided by the number of seconds it took to fill the bucket. This method can be employed if you have a narrow opening through a weir or a pipe operating at its maximum flow rate.



If you wish to ascertain the flow rate of a stream, when the 10 litre bucket method cannot be employed, you can get a rough idea by measuring the size (cross section) and average flow rate of the stream. For this method the speed of the mid-stream surface water is measured by timing a float. Choose a part of the stream where the cross section is regular. Measure the cross section by finding the average depth as shown, and the width. Time the float over a short distance to obtain the speed. The average speed of the whole stream can then be calculated by multiplying the measured speed by:

0.8 for a concrete channel
0.7 for an earth channel
0.5 for a rough hill stream

For streams less than 150 mm average depth, the factor becomes unpredictable and can be as low as 0.25. The flow rate is then equal to the distance that the float travelled multiplied by the correction factor and multiplied by the average depth and width of the stream and then divided by the number of seconds for the float to cover that distance. If the measurements are taken in metres and the float is timed in seconds, then the result multiplied by 1000 will give you the litres per second flow rate. Overall accuracy of this method is about 80%.

The water flow will always vary widely with the seasons and in some cases by a factor of several hundred. It is therefore essential to obtain as clear a picture as possible of the flow pattern and in particular the lowest flows experienced in the dry season.

What is Head of Water?

The head is the vertical height in metres from the turbine up to the point where the water enters the intake pipe (which may be at a creek, stream, dam or weir).

The horizontal distance or the length of the pipe-line does not create an increase in pressure. It is the vertical distance which determines the maximum pressure that can be created in a length of pipe. This vertical distance or difference in altitude is called 'head'. Because hydro-electric systems depend on water pressure to generate electricity, it is important to be able to work out either the existing or potential water pressure.

Remember that the more pressure you have, the less flow you need to create the same amount of power.

How To Measure Head

You can measure or gauge your head by one of several means:

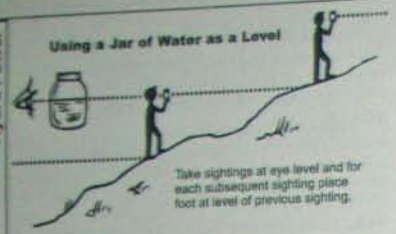
1. **Pressure Gauge:** If you already have a pipeline installed with water flowing, it is just a matter of connecting a water pressure gauge (available from the Rainbow Power Company) to measure the pressure. The head in your situation can be worked out from the pressure that is measured. This pressure must be measured with the pipe completely filled with water (from the water source down) without any air pockets in the pipe and no water flowing in the pipe. If you have water flowing in the pipe due to taps turned on, leaks etc you will be measuring the pressure drop due to the friction in the pipe rather than your potential water pressure.

2. **Contour Map:** Locate the water source and the potential site for your hydro on a reasonably accurate contour map.

3. **Using a Level:** Another method of measuring head is to use a dumpy level or a transparent water container (eg a glass jar). With a glass jar you can get a rough idea of level and make use of this to measure head.

Here is how:

a. starting at the lowest point (eg where the hydro may be situated)
b. viewing a point at eye level (horizontal) on the ground ahead by viewing through the glass over the level surface of the water to a point that you can walk up to
c. walking up to that point (and count the number of times you walk up to the next point)
d. placing your feet on that point
e. repeating b., c. and d. until your eyes are level with the water source (where the pipeline would begin)
f. Multiply the distance between your feet and your eyes by the number of times you walked up to the next point (including the final sighting)



You can improve on this way of measuring head by viewing across the level surface of a spirit level or using a long clear plastic tube filled (bar a few inches) with water. With both of these techniques you follow the same procedure as above except that you need a second person to either hold the spirit level or the other end of the plastic tube. With the plastic tube technique you can place your thumb over the end of the tube when you need to move. You may still need to carry extra water to refill the tube to counteract inevitable spillage.

Monitoring of Water Pressure

Once you have laid down a water line it is worth while to get an accurate pressure reading by installing a water-pressure meter so that you can get a reading both when there is water flowing and when there is not. This will also give you an idea if there is a problem with the water line (eg low pressure due to blockage, air pockets or loss of siphon).

The friction of the wall of the water-pipe will cause a reduction of water pressure when there is water flowing. The amount of pressure reduction will depend on the diameter of the pipe and the flow rate (and very slightly by roughness of the inside wall of the pipe). The larger the pipe and/or the less the flow rate, the less the pressure loss you will encounter.

Pipe Size to Match the Power

It is inevitable that some head is lost due to pipe friction. Maximum power from a hydro is often limited only by the pipe size. By increasing pipe diameter by a small amount, the maximum potential power output can be increased significantly, bearing in mind the maximum capability of the turbine used. It depends of course on whether you are intending to get maximum efficiency out of your turbine or maximum cost effectiveness. To obtain maximum efficiency for the turbine may be prohibitively expensive on water pipe. The maximum power that can be obtained from any particular size of pipe is when a nozzle is used that will cause a 25% friction loss (ie 25% of the total static head is absorbed by friction). Refer to page 65 and 66.

The Power of Water

The formula for calculating the power of flowing water is:

Power = 9.8 x Q x H

(power measured in watts)

where Q = Flow rate (Litres per second)

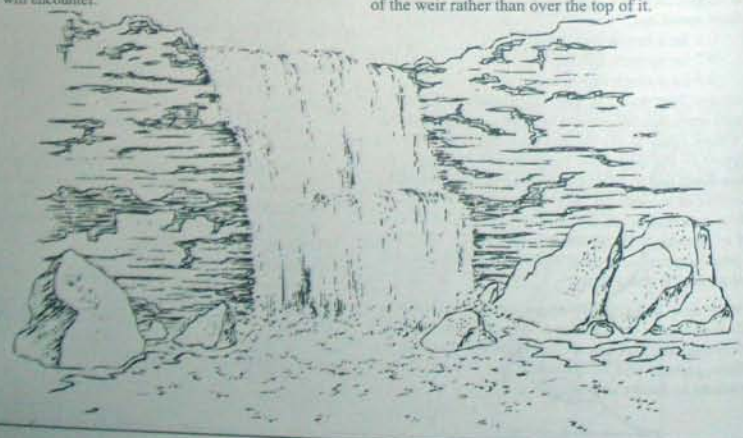
H = Height the water falls in metres

A good installation will convert about 30% of this into electricity.

Losing the Siphon

If the level of the pipe-line is higher at any point than the top of the water at the water source it will be a problem if any air ever enters the pipe. You would need to fill the pipe completely with water before submerging the top of the pipe into the water source. This exercise is referred to as regaining the siphon. The siphon is created by the weight of the water column below the water level pulling the water over the high point. Because air is highly elastic a relatively small amount of air can cause a significant problem.

You can minimise potential problems and ensure a constant flow of water from a dam or weir by raising the level of the wall to a level higher than the highest level of the pipe-line. The pipe-line would then be coming out through the wall of the weir rather than over the top of it.



Rainbow Micro Hydro

Electric Generator

12 or 24 volt 300 watt

Practical and Economical

The Rainbow Micro Hydro represents a revolution in the production of electricity from small streams. Designed by the Rainbow Power Company after 2 decades of experience in the field, the unit incorporates state of the art design and materials throughout, resulting in low maintenance equipment with an exceptional service life.

Rainbow Micro Hydro Generator Unit

Power Output

The Rainbow Micro Hydro will produce useful amounts of power from as little as 0.2 litres per second or as low as 7 metres head. This range is exceptional for a micro hydro unit.

It will produce 20 amps (in 12 volt model) with a head (pressure) of 18 metres and 5 litres per second flow rate. With an increased head, less flow would be required for the same performance (see graph next page).

Power Transmission over Distance

Power transmission over hundreds of metres is possible because the generator produces higher voltage before being transformed to a battery voltage by the controller / regulator / battery charger.

This allows the turbine to be sited for the best pipe location and the controller located close to the battery where its performance can be easily monitored.

Easy to Install

Installation requires no special skills. The Micro Hydro is easily integrated into any battery centred electrical system. A comprehensive installation manual is supplied with the unit.

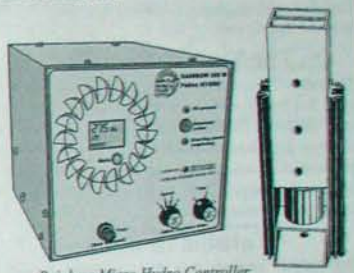
Adjusting to your Site

Flow rate is controlled by a choice of nozzle sizes. These nozzles can be changed in less than a minute without tools. Head and power is adjusted by two dials on the controller/regulator/battery charger. By varying the size of the nozzle(s), and the two dial settings, the Rainbow Micro Hydro can be optimised to suit the parameters of the site.

Long Life and Reliability

There is only one moving part on two standard bearings (6204) which are easily replaceable. There are no brushes or any wearing components in the generator unit. The plumbing is of corrosion resistant brass and aluminium.

The Rainbow Micro Hydro requires minimum maintenance and will provide years of trouble free service with no further cost.



Rainbow Micro Hydro Controller Unit & Load Dump

Electronic Controller

You don't need to buy a separate **regulator**; the controller fulfills the functions of **adjustable exciter**, **battery charger**, multi-source **charge regulator** with **digital display** and **data logger**.

The **exciter** controls the generator, allowing its speed to match the optimum turbine speed for the specific installation. The left control knob, 'speed', has 4 positions, corresponding to heads of less than fifteen metres up to more than forty metres. The right control knob, 'trim', has 3 positions. It acts as an exciter for the correct power level.

The **LCD display** can monitor and show battery voltage, charge current, accumulated amp-hours, daily maximum and minimum volts as well as give you these details for the last 32 days. The digital display allows you to find the position of both control knobs to achieve maximum power.

The **battery charger** converts the high voltage produced by the generator into a suitable form to charge either a 12 or 24 volt battery. This charger has several special features. The design is fundamentally efficient, featuring the use of high efficiency mosfet transistors.

The hydro controller can receive and control additional energy sources, such as a solar array, wind-turbine and petrol or diesel genset, including automatic starting and stopping of the genset.

The battery charger converts the high voltage produced by the generator into a suitable form to charge either a 12 or 24 volt battery. This charger has several special features. The design is fundamentally efficient, featuring the use of high efficiency mosfet transistors.

Special Maintenance Free Generator

The heart of the machine is a highly efficient three phase induction generator. Having no slip-rings or carbon brushes, this device is completely maintenance free for the life of the two ball-bearing races supporting the rotor, its only moving part. The generator is totally enclosed in a finned aluminium casing. Cooling is provided by a fan mounted directly onto the shaft.

The Turbine/Impeller

The turbine operates over a large range of heads and flow rates. It is constructed of a modern high-strength epoxy resin composite chosen for its rigidity and resistance to abrasion. It is mounted directly onto the shaft. Water is prevented from leaking along the shaft to the bearings by the use of a slinger. There are no seals to wear out or contribute to friction losses.

Turbine Housing

The turbine housing case and mounting frame is constructed of recyclable low density polyethylene. This makes the turbine corrosion and impact resistant and light enough to be carried by one person.

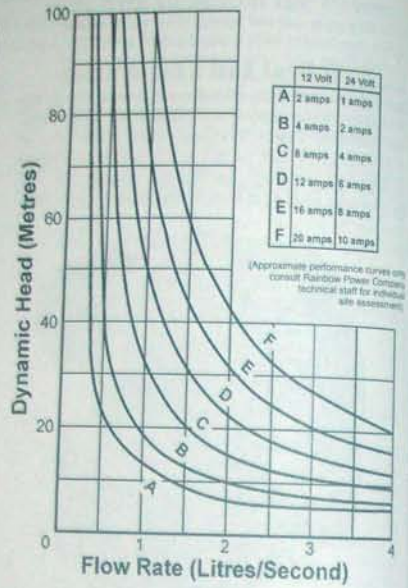
The RPC Pelton Wheel Manual

This manual is a goldmine of information covering such topics as: How to set up a hydro system - water filtration, size of water-pipe, how to connect up the plumbing and the electricals, how to maintain it; fault finding etc. It was written specifically for the RPC Pelton Wheel and the cost of the manual will be deducted from the purchase of a RPC Pelton Wheel if you purchased a manual beforehand. The manual is also normally provided with the Micro Hydro Generator.

Rainbow Micro Hydro Performance Characteristics

The graph shows the performance of both the 12 and 24 volt model of the Micro Hydro.

The head (Dynamic Head) is measured at the turbine and may be considerably less than the geographical height (Static Head) if too small a pipe is used.



	12 Volt	24 Volt
A	2 amps	1 amps
B	4 amps	2 amps
C	8 amps	4 amps
D	12 amps	6 amps
E	16 amps	8 amps
F	20 amps	10 amps

(Approximate performance curves only consult Rainbow Power Company technical staff for individual site assessment)

Hydro Consultancy

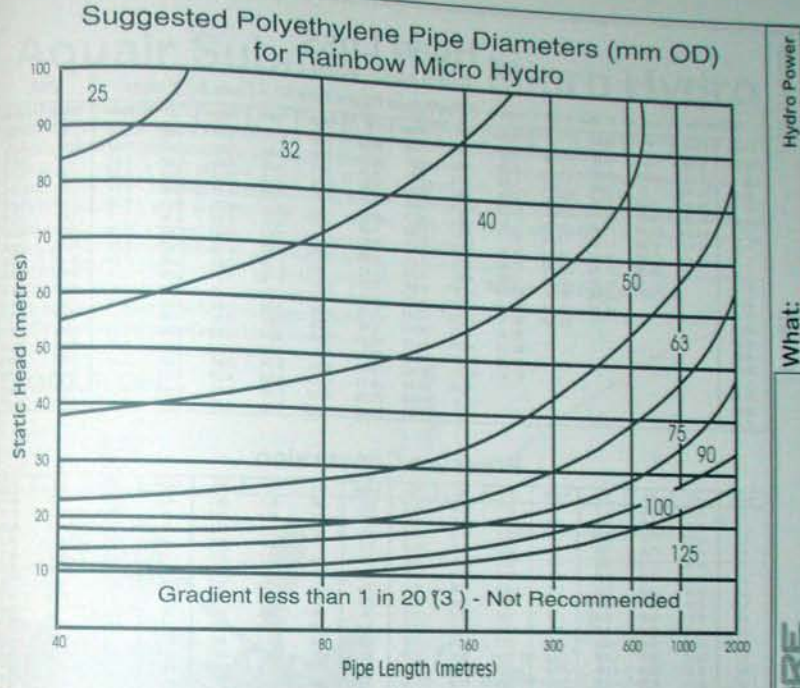
The Rainbow Power Company has a computer model which will give you optimum pipe size, power output and flow rate. All we need from you is the head, the pipe diameter and an indication of the variation of the flow rate.

Specifications

Models available: 12V&24V - Cat.# HYD-200

Turbine Impeller Type:	132mm diameter pelton wheel
Impeller Material:	Cast epoxy resin composite
Flow Control:	Changeable nozzles
Maximum Head:	150 metres
Minimum Useable Head:	7 metres
Maximum Flow:	4 litres per second
Minimum Flow:	0.2 litres per second
Generator Type:	Capacitively excited 3 phase 4 pole induction converter
Generator Voltage:	<=370 volts AC
Maximum Power:	300 watt
Charger/Converter Type:	High frequency switch mode variable ratio
Regulated Output Voltage Range:	(See Plasmatronics Manual)
Input-Output Electrical isolation:	>2500 volts
Regulation:	Programmable shunt
Regulator Load:	Air cooled element

Speed Control feature avoids the need for site customised, specially wound generators which are often used on small hydro systems.



Note

All the above pipe diameters are in millimetres (outside diameter) class 'B' polyethylene. The sizes are to give between 90% and 100% of the maximum 300 W performance.

Where near maximum performance from the hydro generator would never be required, a pipe diameter of one size smaller may be selected. Never select a pipe diameter of two sizes smaller as this may render the pelton wheel virtually useless.

One size bigger in pipe diameter is more effective than two pipes operating in tandem. A section of smaller diameter pipe can undo most of the benefit of the larger pipe before and after it.

Between 7 metres and 14 metres head 300 watts is not achievable regardless of nozzle size and pipe size. Despite not being able to operate at close to maximum power the hydro would still be a valuable asset at these low heads.

Pipe sold in metric units is usually measured in outside diameter (OD) whereas pipe sold in imperial units is measured by inside diameter (ID).

Internal Diameter

Obviously it is the inside diameter (ID) of a pipe which affects its friction to the water. Pipe measurement has been utterly confusing because of conflicting conventions between ID and OD measurements and "soft" and "hard" metric conversions. Many botched installations have resulted from this confusion. We recommend you actually measure the ID of the pipe to be used, and any fittings which the water must traverse.

A factor often forgotten is that many plants and animals can cling to the walls inside the pipe. These make it thinner and rougher and can easily halve the output of the machine. To get an indication of this effect look at stones in the creek bed. If there is a crust then this thickness must be subtracted from the pipe diameter.

Pipe friction is very counter-intuitive. The effect of diameter is fifth power, which means too small a pipe is much worse than you think. Also it means that a short section of thinner pipe or fittings with narrow ID will cost you more than you think in head.

Head Loss

metres per 100 metres

Nominal Pipe Diameter (OD for Metric and ID for Imperial) - Polyethylene Pipe – Type 50 – Class 6 ('B' class)													PVC	
l/sec	25mm	1"	32mm	1¼"	40mm	1½"	50mm	2"	63mm	2½"	75mm	3"	90mm	100mm	125mm
0.2	2.05	1.01	0.60	0.39	0.20	0.14	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00
0.4	7.39	3.64	2.15	1.41	0.70	0.50	0.23	0.12	0.07	0.04	0.03	0.02	0.01	0.01	0.00
0.6	15.66	7.72	4.56	3.00	1.49	1.06	0.49	0.26	0.15	0.08	0.06	0.03	0.03	0.02	0.01
0.8	26.88	13.15	7.76	5.10	2.54	1.81	0.83	0.44	0.26	0.14	0.11	0.06	0.04	0.03	0.01
1.0	40.33	19.88	11.74	7.72	3.85	2.74	1.26	0.67	0.40	0.22	0.17	0.08	0.07	0.04	0.01
1.2	56.54	27.87	16.45	10.82	5.39	3.84	1.77	0.93	0.56	0.31	0.23	0.12	0.09	0.06	0.02
1.4	75.22	37.08	21.89	14.39	7.17	5.11	2.35	1.24	0.74	0.41	0.31	0.16	0.12	0.07	0.02
1.6	96.33	47.48	28.04	18.43	9.19	6.55	3.01	1.59	0.95	0.52	0.40	0.20	0.16	0.09	0.03
1.8		59.06	34.87	22.93	11.43	8.15	3.74	1.98	1.18	0.65	0.49	0.25	0.20	0.12	0.04
2.0		71.79	42.39	27.87	13.89	9.90	4.55	2.41	1.43	0.79	0.60	0.30	0.24	0.14	0.05
2.5			64.09	42.13	21.00	14.97	6.88	3.64	2.17	1.19	0.91	0.46	0.36	0.22	0.07
3.0			89.84	59.06	29.44	20.99	9.65	5.10	3.04	1.67	1.27	0.64	0.51	0.30	0.10
3.5				78.58	39.17	27.93	12.83	6.78	4.04	2.22	1.69	0.85	0.68	0.40	0.13
4.0					50.16	35.76	16.44	8.69	5.18	2.85	2.16	1.09	0.87	0.51	0.17
4.5					62.39	44.48	20.44	10.81	6.44	3.54	2.69	1.36	1.08	0.64	0.21
5.0					75.80	54.07	24.85	13.14	7.82	4.30	3.27	1.65	1.32	0.76	0.25
5.5					87.91	64.51	29.65	15.67	9.34	5.14	3.90	1.97	1.57	0.93	0.30
6.0						75.80	34.84	18.41	10.97	6.03	4.59	2.31	1.84	1.09	0.36
6.5						87.91	40.40	21.36	12.72	7.00	5.32	2.68	2.14	1.26	0.41
7.0							46.35	24.50	14.59	8.03	6.10	3.08	2.45	1.45	0.47

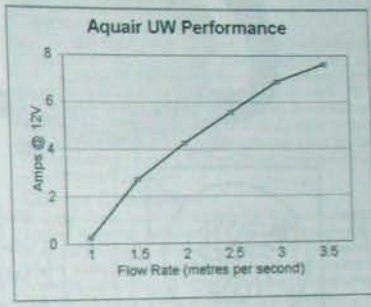
Pressure Conversion

metres	kPa	feet	PSI	metres	kPa	feet	PSI	metres	kPa	feet	PSI	metres	kPa	feet	PSI
5	49.03	16.42	7.11	10	98.1	32.84	14.22	20	196	65.7	28.4	45	441	147.8	64.0
5.1	46.96	16.75	7.25	10.2	100.0	33.50	14.51	20.5	201	67.3	29.2	46	451	151.1	65.4
5.2	46.86	17.08	7.40	10.4	102.0	34.15	14.79	21	206	69.0	29.9	47	461	154.4	66.8
5.3	47.76	17.41	7.54	10.6	104.0	34.81	15.08	21.5	211	70.6	30.6	48	471	157.8	68.3
5.4	48.66	17.73	7.68	10.8	105.9	35.47	15.36	22	216	72.3	31.3	49	481	160.9	69.7
5.5	49.56	18.06	7.82	11	107.9	36.12	15.65	22.5	221	73.9	32.0	50	490	164.2	71.1
5.6	50.46	18.39	7.96	11.2	109.8	36.78	15.93	23	226	75.5	32.7	51	500	167.5	72.5
5.7	51.37	18.72	8.11	11.4	111.8	37.44	16.21	23.5	230	77.2	33.4	52	510	170.8	74.0
5.8	52.27	19.05	8.25	11.6	113.8	38.10	16.50	24	235	78.8	34.1	53	520	174.1	75.4
5.9	53.17	19.38	8.39	11.8	115.7	38.75	16.78	24.5	240	80.5	34.8	54	530	177.3	76.8
6	54.07	19.70	8.53	12	117.7	39.41	17.07	25	245	82.1	35.6	55	539	180.6	78.2
6.1	54.97	20.03	8.68	12.2	119.6	40.07	17.35	25.5	250	83.7	36.3	56	549	183.9	79.6
6.2	55.87	20.36	8.82	12.4	121.6	40.72	17.64	26	255	85.4	37.0	57	559	187.2	81.1
6.3	56.77	20.69	8.96	12.6	123.6	41.38	17.92	26.5	260	87.0	37.7	58	569	190.5	82.5
6.4	57.67	21.02	9.10	12.8	125.5	42.04	18.21	27	265	88.7	38.4	59	579	193.8	83.9
6.5	58.57	21.35	9.24	13	127.5	42.69	18.49	27.5	270	90.3	39.1	60	588	197.0	85.3
6.6	59.48	21.67	9.39	13.2	129.5	43.35	18.77	28	275	92.0	39.8	61	598	200.3	86.8
6.7	60.38	22.00	9.53	13.4	131.4	44.01	19.06	28.5	279	93.6	40.5	62	608	203.6	88.2
6.8	61.28	22.33	9.67	13.6	133.4	44.66	19.34	29	284	95.2	41.2	63	618	206.9	89.6
6.9	62.18	22.66	9.81	13.8	135.3	45.32	19.63	29.5	289	96.9	42.0	64	628	210.2	91.0
7	63.08	22.98	9.96	14	137.3	45.98	19.91	30	294	98.5	42.7	65	637	213.5	92.4
7.1	63.98	23.32	10.10	14.2	139.3	46.63	20.20	30.5	299	100.2	43.4	66	647	216.7	93.9
7.2	64.88	23.65	10.24	14.4	141.2	47.29	20.48	31	304	101.8	44.1	67	657	220.0	95.3
7.3	65.78	23.97	10.38	14.6	143.2	47.95	20.77	31.5	309	103.4	44.8	68	667	223.3	96.7
7.4	66.68	24.30	10.53	14.8	145.1	48.60	21.05	32	314	105.1	45.5	69	677	226.6	98.1
7.5	67.59	24.63	10.67	15	147.1	49.26	21.33	32.5	319	106.7	46.2	70	686	229.9	99.6
7.6	68.49	24.96	10.81	15.2	149.1	49.92	21.62	33	324	108.4	46.9	71	696	233.2	101.0
7.7	69.39	25.29	10.95	15.4	151.0	50.57	21.90	33.5	329	110.0	47.6	72	706	236.5	102.4
7.8	70.29	25.62	11.09	15.6	153.0	51.23	22.19	34	333	111.7	48.4	73	716	239.7	103.8
7.9	71.19	25.94	11.24	15.8	154.9	51.89	22.47	34.5	338	113.3	49.1	74	726	243.0	105.3
8	72.09	26.27	11.38	16	156.9	52.55	22.76	35	343	114.9	49.8	75	736	246.3	106.7
8.1	72.99	26.60	11.52	16.2	158.9	53.20	23.04	35.5	348	116.6	50.5	76	745	249.6	108.1
8.2	73.89	26.93	11.66	16.4	160.8	53.86	23.33	36	353	118.2	51.2	77	755	252.9	109.5
8.3	74.80	27.26	11.81	16.6	162.8	54.52	23.61	36.5	358	119.9	51.9	78	765	256.2	110.9
8.4	75.70	27.59	11.95	16.8	164.8	55.17	23.89	37	363	121.5	52.6	79	775	259.4	112.4
8.5	76.60	27.91	12.09	17	166.7	55.83	24.18	37.5	368	123.2	53.3	80	785	262.7	113.8
8.6	77.50	28.24	12.23	17.2	168.7	56.48	24.46	38	373	124.8	54.0	81	794	266.0	115.2
8.7	78.40	28.57	12.37	17.4	170.6	57.14	24.75	38.5	378	126.4	54.8	82	804	269.3	116.6
8.8	79.30	28.90	12.52	17.6	172.6	57.80	25.03	39	382	128.1	55.5	83	814	272.6	118.1
8.9	80.20	29.23	12.66	17.8	174.6	58.46	25.32	39.5	387	129.7	56.2	84	824	275.9	119.5
9	81.10	29.56	12.80	18	176.5	59.11	25.60	40	392	131.4	56.9	85	834	279.1	120.9
9.1	82.00	29.89	12.94	18.2	178.5	59.77	25.89	40.5	397	133.0	57.6	86	843	282.4	122.3
9.2	82.91	30.21	13.09	18.4	180.4	60.43	26.17	41	402	134.6	58.3	87	853	285.7	123.7
9.3	83.81	30.54	13.23	18.6	182.4	61.08	26.45	41.5	407	136.3	59.0	88	863	289.0	125.2
9.4	84.71	30.87	13.37	18.8	184.4	61.74	26.74	42	412	137.9	59.7	89	873	292.3	126.6
9.5	85.61	31.20	13.51	19	186.3	62.40	27.02	42.5	417	139.6	60.4	90	883	295.6	128.0
9.6	86.51	31.53	13.65	19.2	188.3	63.05	27.31	43	422	141.2	61.2	92	902	302.1	130.9
9.7	87.41	31.86	13.80	19.4	190.3	63.71	27.59	43.5	427	142.9	61.9	94	922	308.7	133.7
9.8	88.31	32.18	13.94	19.6	192.2	64.37	27.88	44	431	144.5	62.6	96	941	315.3	136.5
9.9	89.21	32.51	14.08	19.8	194.2	65.02	28.16	44.5	436	146.1	63.3	98	961	321.8	139.4

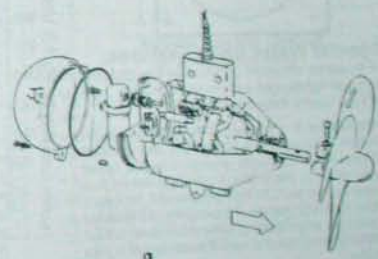
Aquair Submersible Micro Hydro

A submersible propeller type hydro generator which will produce power (up to 2.4 kWh/day) in a fast flowing stream of water. When mounted in a stream that flows at 15kph (4.2 m/s), it will produce 8 amps at 12 volt continuously. Even a stream flowing at 10kph (2.8 m/s) it will produce 1.5 kWh/day. The water speed can be increased by using a venturi funnel. Operates just below the water surface and is driven by an on-shaft propeller. It is available in 12 or 24 volts. If you have a choice of voltage, you should be aware that the power cable for the 12V model will need to be four times larger than that for the 24V model. The propeller is 312mm diameter, so the water depth needs to be at least 400mm.

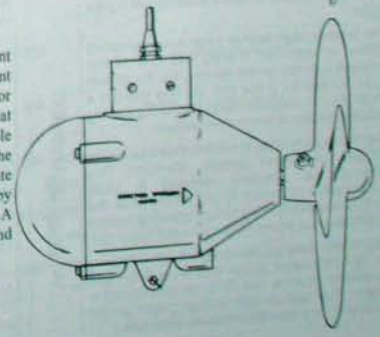
If you are measuring the speed of your stream, you should do so at the proposed location of the hydro. If you are timing a floating object being swept along by the current you should use something that is mostly submerged (like a block of wood) rather than something that only skims the surface of the water, such as styrofoam.



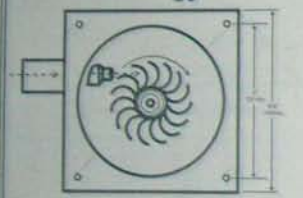
AQUAIR UW



The forward facing 3 bladed propeller drives a permanent magnet alternator producing up to 8 Amps output current for a 12 volt system. The shaft rotates in double seals for optimum protection, backed by twin '0' ring static seals at the rear of the casing. The cable exit is similarly double sealed by an internal moulding and external gland. The alternator body is filled with hydraulic fluid to eliminate corrosion and to equalise pressure changes caused by variation in immersion depth and ambient temperature. A reservoir in the end casing allows expansion and contraction of this fluid.



The Water Baby Micro Hydro Turbine



Special Water Baby Features:

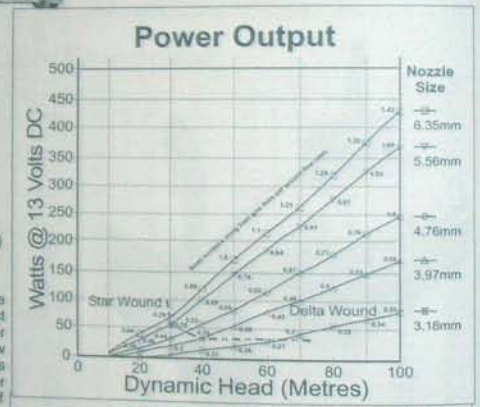
- Operates efficiently on ultra low flow (0.2 l/s)
- Super lightweight and compact design
- High quality turbine at a low price

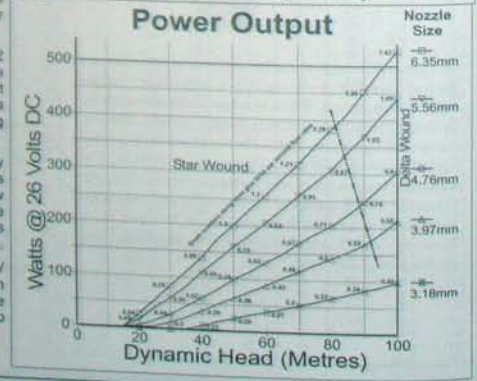
This turbine is a smaller ('baby') version of the Stream Engine. It is a lightweight and compact device which converts energy in water under pressure into electricity. It can operate on flow rates as low as 0.2 litres per second, on heads from 15 to 150 metres. To compare, 0.2 litres per second is only slightly greater than the amount of water flowing out of a typical water faucet in your home.

The Water Baby's bronze turgo runner is only 2 inches in diameter, making this one of the smallest turbines on the market. It is the perfect hydro turbine for a site with low flow rate but a large 'drop' in elevation, such as a spring coming out of a hillside or a mountain stream.

The Water Baby uses a maintenance free, highly efficient permanent magnet alternator. This alternator is specially designed to allow adjustments in output to be made while the turbine is spinning. This feature greatly simplifies optimization of power output for each hydro site.

The Water Baby comes standard with 12V, 24V or 48V DC output. It can also be outfitted with additional nozzles (up to 4) to accommodate higher flow rate. A high voltage option is also available for longer transmission distances.





Stream Engine Micro Hydro

The Stream Engine employs a brushless, permanent magnet alternator which is adjustable, enabling the user to match turbine performance with available water supply or turbine output to daily electrical load demand. The Stream Engine is capable of continuous outputs of over 1kW (more than 24 kWh/day - depending on loads, timing of usage and available battery storage), while requiring virtually no maintenance.

The Stream Engine is designed for use in battery-based power systems, with electricity generated at a steady rate, and stored in batteries for use at higher rates than is generated. During times of low demand, power is stored. An inverter is used when residential AC power is desired.

Power Output and Site Assessment

To determine the power available at a site, head and flow measurements must be taken. Flow is the rate at which water moves, measured in litres per second (l/s). This can be measured by channelling all the water into a container of a known volume, noting the time it takes to do so. A weir can be used to measure flows in larger streams. Head can be measured by using a transit, by siting along a level, or by using a pressure gauge at the end of the pipeline. An altimeter can also be used, so long as it is accurate, and sufficiently sensitive and the readings are taken within a reasonably short time frame under the same atmospheric conditions (ie no weather change). It is important to keep in mind that output can only be accurately determined if head and flow measurements are made correctly, so care should be taken during this process.

Water from a stream is channelled into a pipeline to gain enough head (the vertical distance the water falls) to power the system. The Stream engine operates at heads of about 2m and upward. The water passes through a narrow nozzle causing it to accelerate before striking the bronze turgo wheel. The turgo wheel then turns the generator shaft.

Up to 4 universal nozzles can be installed on one Machine. Nozzles are adaptable in sizing from 3mm to 25mm. Stream Engine is available for 12, 24, or 48 volts.

"Balance of System" & Other Components

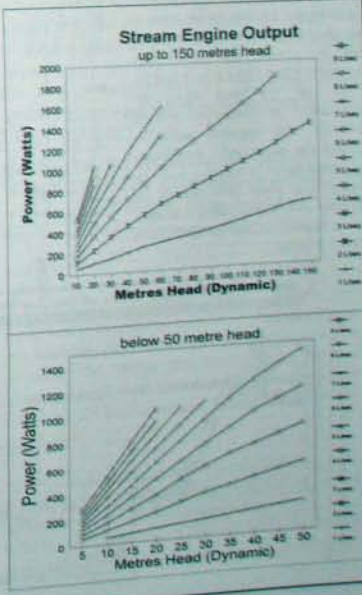
Rainbow Power Company offers system design services. Also available are "balance of system" components including batteries, inverters, and charge controllers. Batteries are an integral part of the self-sufficient energy system. Lead-acid, deep-cycle batteries are usually used in conjunction with solar, small wind, micro hydro and hybrid (incorporating multiple energy sources) systems. Deep-cycle batteries are designed to withstand repeated charge and discharge cycles typical in renewable energy systems.

Inverters

Batteries can supply only DC (direct current) whilst most appliances use high voltage AC (alternating current). In certain cases where DC lights and appliances are available they may be preferable to their 240V AC equivalents. Refrigeration is one example. Inverters are used to convert DC into AC so that stored battery power may be used, as needed, by appliances and other loads. Contact Rainbow Power Company for our wide selection of inverters and batteries.

Charge Controllers

A charge controller is not included in the basic Stream Engine. When the batteries are charged to capacity, the power is diverted to a secondary, "diversion" load, such as hot water heaters. The diversion of the generated power is accomplished by using a charge controller. Many types are available to perform this function.



Tamar Hydro-Electric Turbines

Tamar manufacture all metal construction Pelton, Turgo, Francis, Kaplan and Axial Flow turbines. Power outputs are from below 1kW to over 1MW. These units include battery charging units (12V, 24V, 48V or 110V DC) with no governor required and 240VAC and 415V 3 phase units with governor.

240V & 415V Turbines

Optional Equipment:

Flow Control. Automatic or manual flow control enables the generator output to vary according to load and water available. This feature is standard on some control systems and is particularly useful in drier months when water may be in short supply.

Governors. The governor controls the frequency to either 50Hz or 60Hz and can supply heating for hot water or space heating. Electric governors can also be used to control turbine power output by controlling the water flow through the turbine.

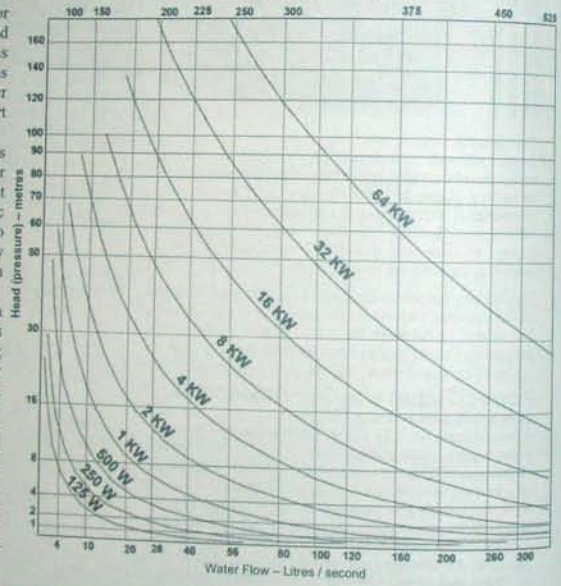
Auto-start-on-demand. This system is designed for sites where water is in short supply, particularly during the dry season. The turbine only operates when a load is switched on. Start up and shut down are automatic. A head pond acts as storage and supplies sufficient power for peak loads. An electric governor helps to conserve water by controlling water flow through the turbine. Any excess power is shunted away to produce heat for hot water or space heating.

How Much Power is Available?

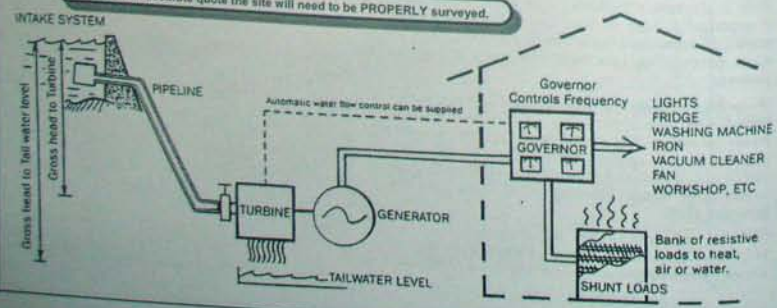
Power from water depends on the pressure and amount of water going through the turbine. Use the following graph as a guide to how much power you could expect from a generator for various site conditions. Notice that less water is required for the same power if the nett head can be increased.

Power Output

Suggested Pipe Diameter (mm)



Note: For an accurate quote the site will need to be PROPERLY surveyed.



Inverters

12/24 Volt to 240 Volt Inverters

An inverter is a complex device which is used to run 240 volt appliances from a battery bank. It will run most appliances reasonably efficiently.

Usually, if the appliance or an equivalent can be run by direct current and low voltage from a battery bank, the power consumption will be less. Some appliances may not like the wave form from a particular inverter. Or you may find that the inverter causes a hum on sound (stereo, TV etc) equipment. It is a fairly costly item that may need the occasional service or repair. For all of these reasons it makes sense to have as much as you can powered directly by the battery bank and only use the appropriately sized inverter for those appliances that you could not find an adequate low voltage version of.

It must also be pointed out that in some cases, an inverter rated at the same wattage (or VA - volt-amps) as the rating of the appliance may not be able to run that appliance. This is very much the case with induction motors (such as you will find in many washing machines). What the problem is here is that the inverter cannot match the starting load or torque of the motor. Once the motor is running it may only use the rated power but it may require between 3 and 10 times as much power to get the motor started. So you may find, with a typical washing machine, that even though the motor is rated at 200 watts, the inverter may need to be able to intermittently supply up to 2000 watts in order to get the motor started. We have found that a 1kVA (1000 watt) inverter seems to handle most washing machines.

Inverters have both a continuous rating and a transient or peak rating. If the inverter is rated at 1000 VA, it will usually be able to supply up to twice that (2000 VA or 2kVA) without damage to enable you to start motors. This varies with different makes of inverter, so check the manufacturers specifications before buying to ensure that it will handle the transient rating of your motor.

Unless an inverter in excess of 1200 watts is required, we would recommend that you stay with the 12 volt system because of its simplicity and versatility. There is a lot more available in the way of 12 volt appliances than there is for higher DC voltages.

Connect the inverter directly to the battery bank rather than to the distribution/meter box. It is important that the inverter is connected directly and solidly to the battery bank to minimise on wire and faulty connections between the two. Loose connections can cause dangerous sparking. Do not lengthen the leads from the inverter to the battery without advice from the Rainbow Power Company or the manufacturer. If you require this 240 volt power at a distance from the inverter, you should do so with an appropriate 240 volt extension lead or have a licensed electrician wire up some power points to it.

Some useful hints

Use peak power AC appliances like washing- machines, vacuum cleaners and circular saws on days when you can expect a good recharge from the sun or wind. Use only one such appliance at a time, so that the inverter is not overloaded. Spread the peak power demand over the week. You could for example make Monday your washing day, vacuum on Tuesday or Wednesday, use power tools on Thursday or Friday and leave the weekend clear for entertainment.

When operating a computer system, other appliances running from the same power supply may cause the computer to crash when turned on. If you need to turn on a printer it is best to save your files on a disk or tape, turn off your computer and then turn on the printer followed by the computer. You can now reload your files and continue.

Producing heat (eg for cooking, hot water and room heating) with 240 volts is very expensive and uses a lot of power with an inverter, though a microwave oven may be used for a brief time.

WARNING

Equipment to be operated from an inverter must be in a safe condition, since the voltages produced are at mains potential. This means that frayed cords, exposed unearthed metal parts (unless double insulated), and broken or wet insulators must be repaired before the item is used.

Note:

- Contact with both output lines could be fatal!
- Some thought should be given to the location of the inverter as many inverters make a noise.
- As inverters larger than 200W can draw considerable currents, they should be placed fairly close to the battery bank.

Phantom Loads

Just because a switch says "OFF" doesn't mean a device is off. Many modern appliances are never really OFF. They contain clocks, memories, remote controls, microprocessors, and instant ON features that consume electricity when plugged in. That's 24 hours a day, 7 days a week.

Although the power drain will often be quite small, it will still be draining your battery bank non-stop all year round. If the small load is via a 12 volt to 240 volt (or 24 to 240) inverter the inefficiency of the inverter would make the power consumption quite considerable, particularly over a 24 hour period.

1. The first group of appliances to consider are those supplied with a 240 volt power pack. The appliance is essentially an extra low voltage device with a power pack that usually is in the form of a black (or sometimes white, grey or beige) cube that plugs straight into your 240 volt power point. You may turn off the appliance, but the transformer inside the power pack is still consuming power. Sometimes the same applies to equipment supplied with a standard 240 volt lead (without a power pack) but with a transformer inside the equipment which is not turned off by the on/off switch that turns the rest of it off. In more technical terms you would say that the primary is still alive.

2. More and more appliances are becoming available that either have an inbuilt electronic clock or some other form of electronic memory that is kept intact with a constant but small electric current. In this case the on/off switch is placed in the circuit so that everything but the clock or memory is switched off by it.

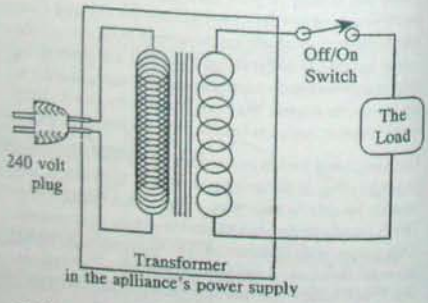
3. Most if not all equipment designed to process digital information will be supplied with a power filter designed to give it a certain degree of protection against spikes and surges in the power supply. Irregularities in the power supply may corrupt the information being processed and sometimes corrupt the program that is processing the information. Very frequently the on/off switch will be located after the power filter which will continue using a small amount of power after the equipment is turned off.

Ghost-Busting

How to Detect a Phantom

You can find those phantom loads by watching for signs of current flow where there should be none. If your 240 volt power supply is by way of an autostart load sensing inverter the most obvious sign to watch out for is that your inverter is still running when everything is supposedly turned off. You could then simply unplug all the appliances and plug them back in one by one and find which one will cause the inverter to turn itself back on. You may need to unplug this appliance and plug the others back in, one by one, and see if the inverter will turn itself on with any of the other appliances. Any appliance that will trigger a load sensing inverter to turn itself on whilst the appliance appears to be turned off would be a phantom load.

You may find that it takes several appliances that are supposedly turned "OFF" to trigger the load sensing function of the inverter. This may be because one appliance on its own does not constitute a sufficient load to trigger the load sensing function.



Another way of detecting phantom loads is with a multimeter with an amp scale. It is recommended you find a friendly 240 volt technician to measure each of your appliances as you will need to expose the wires at the back of a power point and you are dealing with lethal voltages.

How to Deal with Phantoms

If your phantom load turns out to be an electronic clock or a constant memory you may first need to ask yourself whether you need or can afford to keep it running constantly. If it is an internal battery charger for a non-volatile memory (memory that stays intact when equipment is turned off) it may be enough to just have it plugged in occasionally.

It is quite important to deal with these small loads in some way because they are forcing the inverter to operate in its least efficient mode for extended periods of time. The inverter is then drawing considerably more power from the battery bank than the device is drawing from the inverter. Very often a 240 volt power pack will be supplying extra low voltage DC to the appliance. If the 240 volt power pack can be bypassed and the appliance plugged directly into the battery bank or by using a DC to DC voltage adaptor, at least you have decreased the power consumption.

Sometimes it may also be possible to supply low voltage DC to the appliance where an external power pack is not used.

If you are not sure leave it unplugged when it is not in use.

Switch it at the Power Point

Rather than needing to pull the plug out in order to disconnect any device you could provide a switching power point and get into the habit of always switching it **ON or OFF** at the power point.

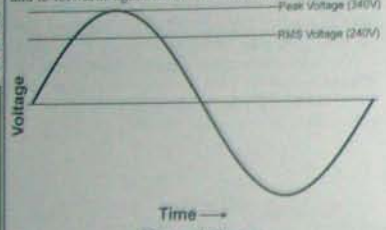
Part of the solution for dealing with phantom loads is **being aware of what to look out for** and **carefully selecting your appliances** before you purchase them. You may need to **enlist** the **help** of someone who knows, such as your local appliance repair person. Selecting **energy efficient appliances** that do not behave as phantom loads can avoid a lot of cost and hassle whether you supply your own power or are connected to the grid.

Photo of Rainbow Power Company in the mid 1990s.

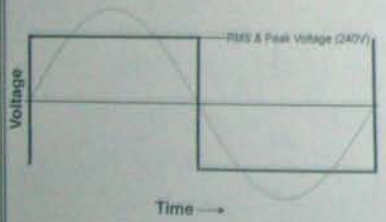
Sine Wave and Square Wave Electricity

The power drawn from the battery bank is DC (Direct Current). The 240 volt mains power supplied by the electricity grid is AC (Alternating Current).

The power created by many inverters is 240 volt AC, but will not be exactly the same as the electricity available via an electricity authority. AC electricity as supplied in Australia reverses in direction fifty times per second and does so with a constantly varying force, surging forwards, slowing to a stop, surging in reverse, slowing to a stop and surging forwards again. This steady increase and decrease in force as the current changes from forwards to reverse and to forwards again is referred to as "sine wave".

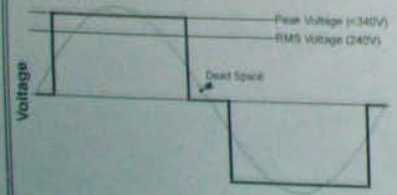


Sine Wave



Square Wave

Some (particularly the older style) solid state inverters produce "square wave", "modified square wave" or "stepped wave" electricity. "Square wave" is the term used when the electricity has a constant force, such as it has with DC but switches direction more or less instantly at the same kind of frequency as the normal grid supply (at 50 times per second).



Modified Square Wave

"Modified square wave" or "stepped wave" is where the force of the electricity is varied by having an intermediate step in between changing direction. This wave form approximates more closely to a sine wave than does the "square wave".

"Digitally synthesized sine wave" inverters are steadily becoming more common place and replacing the more problematic 'square' and 'modified square' wave inverters. 'Quasi sine wave' or 'modified sine wave' are often used to describe the output wave form of an inverter. Such terminology is very misleading in its reference to 'sine wave' when the output is purely a 'modified square wave'.

Different appliances will be affected to greater and lesser degrees by the different forms of AC. Resistive and universal motor loads will be unaffected. Resistive loads are found in incandescent light bulbs and heat producing appliances such as kettles, jugs, irons, radiators and stoves. Universal motors with brushes and commutators are found in most hand tools and many kitchen appliances such as food processors, blenders and centrifugal type juice extractors.

Inductive loads may run with a little more noise and get warmer. Inductive loads are found in voltage transformers and motors like those often found in refrigerators, freezers and washing machines. Induction motors also need a comparatively high surge current to start up. For a 'modified square wave' inverter to handle an inductive load well, it not only needs to have a good surge capacity, but it also needs to have a feature referred to as 'dead-space clamp'.

Some appliances will run noticeably less well on square and stepped wave AC than on pure sine wave. Those affected include:

- Some of the latest sewing machines
- Some programmable timers
- Microwave ovens (which operate more slowly)
- Some battery chargers
- Some cordless appliances
- Some dimmer switches
- Some digital clocks
- Some variable speed devices such as fans
- Some hi-fi and other sound equipment
- Some TVs and video equipment
- Some Fax's and Laser Printers
- Iron ballasted fluorescent lights (see lighting section - page 82)

Certain equipment may be damaged by wave forms other than sine wave. Some devices will operate better with the installation of a line conditioner (choke or transformer) on the inverter, although some square wave inverters may destroy line conditioners. There may also be less costly and more effective ways of running certain appliances than by using an inverter.

If you do find that you are having a problem with certain appliances - we recommend that you consult us.

Note: Many inverters make a noise, so some thought should be given to its location (and your battery bank).

Portable Economy Inverters: 150 to 300W

modified square wave

Xpower 150

12 Volt 150W continuous, 300W surge

The Xpower 150W inverter will operate from a 12 volt battery and operate 240 volt loads up to 150W continuous. Comes equipped with an ON/OFF switch, a power LED indicator and plugs into a standard cigarette lighter socket. It is recommended that the cable supplying the cigarette lighter socket be 2mm² or larger (depending on cable length). Plug it into your car or use it at home!

Features:

- Low voltage protection: the shutdown occurs when the battery discharges to 10 V DC. An alarm sounds when the voltage gets down to 10.7 volts.
- Over load protection: shutdown occurs when the load consumption exceeds 300 watts.
- Over power protection: shutdown occurs when the appliance peak power exceeds the inverter peak power.
- Short circuit protection: shutdown occurs when the out put has a short circuit.
- Temperature protection: shutdown occurs when the temperature exceeds the 60°C.

Applications:

Laptop or notebook computers, VCR, fax, video games, operation of rechargeable products that need 240V to charge such as video cameras and cellular phones etc.

Warranty:

Two year warranty is provided for any defect in materials and workmanship from the date of purchase and we will repair or replace the defective inverter after diagnosing the problem. This warranty will be null and void if this unit is damaged as a result of negligence or improper use, such as working under circumstances outside of specifications or incorrect installation.

Specifications:

Cat.#	INV-014
Input voltage:	12 Vdc (10 – 15V dc)
Input current:	15 amps
Output voltage:	230 Vac
Output frequency:	50hz
Output waveform:	modified square wave
Constant power:	150 watts
Peak power:	300 watts
Height:	82mm
Length:	156mm
Width:	103mm
Weight:	650g

Xpower 300

12 Volt 300W continuous, 600W surge

The Xpower 150W inverter will operate from a 12 volt battery and operate 240 volt loads up to 300W continuous. Comes equipped with an inbuilt cooling fan, an ON/OFF switch, a power LED indicator and crocodile clips to be connected directly to a battery. If the cable is extended, it is recommended that 7.9 mm² cable be used and that the cable length be less than 5 metres.

It is suitable for operating everything that the micro-inverter can do and more, including a small TV and VCR together, Fax, any brush-motor driven appliance rated at less than 300W (eg Juicer Blender, small Power Tools etc).

Specifications:

Cat.#	INV-015
Input voltage:	12 Vdc (10 – 15V dc)
Input current:	30 amps
Output voltage:	230 Vac
Output frequency:	50hz
Output waveform:	modified square wave
Constant power:	300 watts
Peak power:	600 watts
Height:	82mm
Length:	200mm
Width:	103mm
Weight:	780g

Prowatt 250

24 Volt 225W continuous, 500W surge

The Prowatt 250W inverter will operate from a 24 volt battery and operate 240 volt loads up to 225W continuous. Comes equipped with a power LED indicator and plugs into a standard cigarette lighter socket. It is recommended that the cable supplying the cigarette lighter socket be 2mm² or larger (depending on cable length). Plug it into your 24V vehicle or use it at home! Applications similar to Xpower 300.

Specifications:

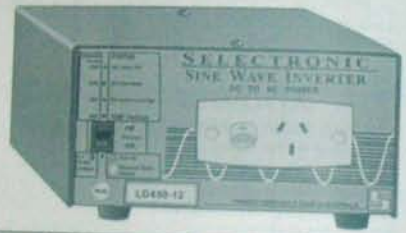
Cat.#	INV-016
Input voltage:	24 Vdc (10 – 15V dc)
Input current:	13 amps
Output voltage:	230 Vac
Output frequency:	50hz
Output waveform:	modified square wave
Constant power:	225 watts
Peak power:	500 watts
Height:	40mm
Length:	150mm
Width:	115mm
Weight:	580g

SELECTRONIC Sine Wave INVERTER

LD series – 12V models

200W to 600W Continuous 600W to 1500W Surge

The low cost Selectronic's "LD" range of inverters will provide true sine wave mains style power for the smaller type of applications. The LD 200-12 can be either shelf or wall mounted, whereas the larger LD 600-12 is for shelf mounting only.



Reliable and Safe

The "LD" range is manufactured to meet Australian Standards AS3100 and AS3108 (for electrical equipment and isolating transformers) and also conforms to the requirements of the Electromagnetic Compatibility framework (C tick) providing low radio interference.

Modular Construction allows for quick and easy on-site servicing by an authorised person. Inconvenient down time is thus minimised.

PARAMETER	LD 200-12	LD 600-12	CONDITION
Output Power @ 25°C Ambient	200 Watts 250 Watts 600 Watts	600 Watts 800 Watts 1500 Watts	Max.Continuous ½ Hour Rating Max.Surge
Voltage Input Range	10 – 17V DC		Voltage Range
Input Current	No Standby 0.3 A DC 20 A DC 57 A DC	0.06 A DC 0.54 A DC 60 A DC 147 A DC	Stand-By Inverter On No Load Max.Continuous Max.Surge
Demand Start Sensitivity	No Demand Start		User Adjustable
Response Time			Response
Low Voltage Shutdown	11 V DC †		User Adjustable
High Voltage Shutdown	17 V DC		Fixed
Output Voltage	240 V AC ± 4%		@ Nominal DC Input
Output Current	0.83 A AC 2 A AC	2.4 A AC 5.4 A AC	Max.Continuous Max.Surge
Peak Efficiency	91%	90%	
Output Wave	True Sine Wave		
Output Frequency	50Hz ± 0.01%		
Total Harmonic Distortion	< 4%		
Protection	Overload, Over-temperature, Over/Under voltage, Reverse		
Input/Output Isolation	3,750 V AC		
Memory Retention	Permanent		
Operating Temperature	-10°C to 50°C		
DC Isolation	Single Pole Circuit Breaker		Range

Mechanical Specifications

Size	215 × 88 × 190	210 × 170 × 260	(W) x (H) x (D) mm
Weight	4 kg	7.6 kg	
Weight Packed	4.5 kg	8.3 kg	
Input Lead Length	1 metre	1.5 metres	
Output Socket	Single unswitched GPO	Dual switched GPO Hardwire J Box	
Chassis	Powder coated zinc steel (Wedgewood Blue)		
Warranty	2 year parts and labour (conditions apply)		

SELECTRONIC Sine Wave INVERTER

LD series – 24V models

250W to 700W Continuous 600W to 2000W Surge

The low cost Selectronic's "LD" range of inverters will provide true sine wave mains style power for the smaller type of applications. The LD 250-24 can be either shelf or wall mounted, whereas the larger LD 700-24 is for shelf mounting only.

Reliable and Safe

The "LD" range is manufactured to meet Australian Standards AS3100 and AS3108 (for electrical equipment and isolating transformers) and also conforms to the requirements of the Electromagnetic Compatibility framework (C tick) providing low radio interference.

Modular Construction allows for quick and easy on-site servicing by an authorised person. Inconvenient down time is thus minimised.

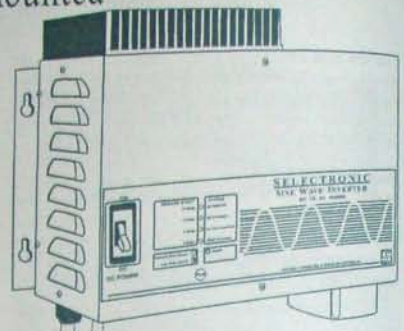
PARAMETER	LD 250-24	LD 700-24	CONDITION
Output Power @ 25°C Ambient	250 Watts 320 Watts 750 Watts	700 Watts 900 Watts 2000 Watts	Max.Continuous ½ Hour Rating Max.Surge
Voltage Input Range	20 – 34V DC		Voltage Range
Input Current	No Standby 0.2 A DC 12 A DC 34 A DC	0.03 A DC 0.25 A DC 32 A DC 87 A DC	Stand-By Inverter On No Load Max.Continuous Max.Surge
Demand Start Sensitivity	No Demand Start		User Adjustable
Response Time			Response
Low Voltage Shutdown	22 V DC †		User Adjustable
High Voltage Shutdown	34 V DC		Fixed
Output Voltage	240 V AC ± 4%		@ Nominal DC Input
Output Current	1.04 A AC 2.8 A AC	2.8 A AC 6.9 A AC	Max.Continuous Max.Surge
Peak Efficiency	93%	92%	
Output Wave	True Sine Wave		
Output Frequency	50Hz ± 0.01%		
Total Harmonic Distortion	< 4%		
Protection	Overload, Over-temperature, Over/Under voltage, Reverse		
Input/Output Isolation	3,750 V AC		
Memory Retention	Permanent		
Operating Temperature	-10°C to 50°C		
DC Isolation	Single Pole Circuit Breaker		Range

Mechanical Specifications

Size	215 × 88 × 190	210 × 170 × 260	mm
Weight	4 kg	7.6 kg	
Weight Packed	4.5 kg	8.3 kg	
Input Lead Length	1 metre	1.5 metres	
Output Socket	Single unswitched GPO	Dual Switched GPO Hardwire J Box	
Chassis	Powder coated zinc steel (Wedgewood Blue)		
Warranty	2 year parts and labour (conditions apply)		

SELECTRONIC Sine Wave INVERTER

Wall Mounted



The Selectronic's "WM" range of inverters can be either wall mounted or bench mounted. The "WM" series all have hard wire facility, main DC breaker and a five year warranty. They also come equipped with built-in Serial Port Expansion Interface allowing the addition of options such as permanent remote Key Pad access, adjustment of inverter settings by either installer or owner via a temporary remote key pad application or access to remote energy management and future expansion.

Reliable and Safe

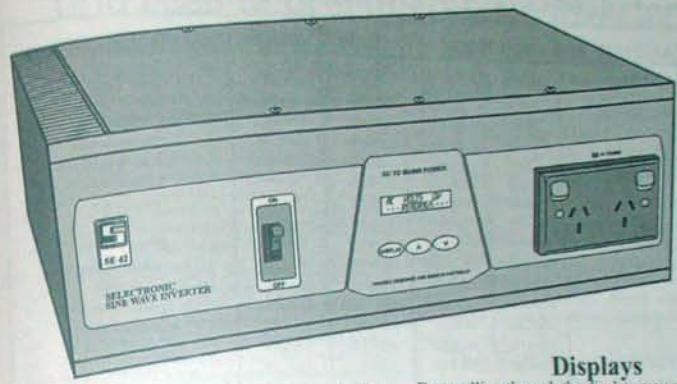
The "WM" range is manufactured to meet Australian Standards AS3100 and AS3108 (for electrical equipment and isolating transformers) and also conforms to the requirements of the Electromagnetic Compatibility framework (C tick) providing low radio interference.

Modular Construction allows for quick and easy on-site servicing by an authorised person. Inconvenient down time is thus minimised.

All three models in the "WM" range have standard features such as adjustable demand start, low volts adjust, AC overload and over-temperature protection as well as status and alarm indicators.

PARAMETER	WM 1400-12	WM 1700-24	CONDITION
Output Power @ 25°C Ambient Watts	1,400 1,800 3,600	1,700 2,250 4,500	Max.Continuous ½ Hour Rating Max.Surge
Output Power @ 40°C Ambient Watts	1,200 1,600 3,600	1,500 2,000 4,500	Max.Continuous ½ Hour Rating Max.Surge
Voltage Input Range	10 – 17V DC	20 – 34V DC	Voltage Range
Input Current Amps DC @ 25°C	0.05 0.7 136 349	0.05 0.6 80 212	Stand-By Inverter On No Load Max.Continuous Max.Surge
Demand Start Sensitivity Response Time Factory Setting	4 – 16 Watts 1 Second Max. 4 W	4 – 16 Watts 1 Second Max. 4 W	User Adjustable Response Demand Start Sensitivity
Low Voltage Shutdown Factory Setting High Voltage Shutdown Output Voltage Output Current	10 – 11.5 V DC 11 V DC 17 V DC 240 V AC ± 4 % 5 A AC 15A AC	20 – 23 V DC 22 V DC 34 V DC 240 V AC ± 4% 6.25 A AC 18.75 A AC	User Adjustable Low Voltage Shutdown Fixed @ Nominal DC Input Max.Continuous Max.Surge
Output Wave Output Frequency Total Harmonic Distortion Power Factor Limitation Input/Output Isolation Memory Retention Operating Temperature DC Isolation	True Sine Wave 50Hz ± 0.01% < 4% Nil 1,875 V AC Permanent -10°C – 50°C Single Pole Circuit Breaker		Range
Mechanical Specifications			
Size			mm
Weight Weight Packed	14 kg 17 kg	14 kg 17 kg	
Input Lead Length Output Wiring Chassis Warranty	1.5 metres Three Terminal Junction Box with Conduit knock outs Powder coated zinc steel (Wedgewood Blue) 5 year parts and labour (conditions apply)		

SELECTRONIC Sine Wave INVERTER



The Selectronic Sine Wave Inverters are digitally synthesized true sine wave inverters designed and manufactured in Australia for Australian Conditions.

The Selectronic Sine Wave Inverters provide a clean, quiet sine wave output with a degree of power and flexibility previously unavailable from sine wave inverters. From the moment the Liquid Crystal Display bursts into life, you will unleash the power of the most sophisticated and innovative sine wave inverters to be manufactured in Australia. The sine wave output gives you confidence that your Selectronic Sine Wave Inverter will run appliances easily and efficiently. You will soon forget you are not connected to the mains.

Compatibility

The Selectronic Sine Wave Inverters (except for the SE10 and SE12) feature a display panel allowing you to adjust the important parameters of the inverter whilst providing information about your system. This makes these inverters compatible with any remote power system.

Display Feature

All important parameters of the Selectronic Sine Wave SE series Inverters (except for the SE10 and SE12) are adjustable via either the front panel or the optional remote keypad. The display will actively show you inverter status, time & day, AC volts, AC amps, battery volts and monitor all charge and discharge currents (with optional current shunt). The SE series of Selectronic Sine Wave Inverters can also be configured to control external circuits (eg to pump to a header tank once a week, control security lights or start a generator) with the optional output interface.

Displays

By scrolling through the displays you are able to read the DC battery volts, AC current and Inverter status. The display will also alert you to the cause of any inverter shut down due to high or low DC volts, AC overload and temperature overload. A set of diagnostic readings can also be accessed to assist in remote troubleshooting.

Power

The Selectronic Sine Wave Inverters have high surge power, a generous 30 minute rating, and enough continuous power to run most energy efficient remote power systems 24 hours a day.

Demand Start

In standby mode the Selectronic Sine Wave Inverters will turn on and off with any type of load. Should you need a different sensitivity setting, simply program the on board microprocessor via the front panel to start the smallest load or overcome a phantom load. This feature can be overridden if necessary and will save you valuable battery power.

SE22: Dual Voltage

The SE22 can be used on either 12 or 24V battery banks.

High & Low DC Voltage Cut Out

The Selectronic Sine Wave Inverters have fully adjustable low voltage cut out and cut in, and high voltage cut out. Also a low voltage disconnect option can be selected to fully protect your batteries.

Safety

Totally protected against thermal overload, current overload and AC short circuit. Input and output are electrically isolated for your safety and MEN compatibility.

Modular Construction

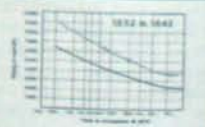
Each section of the Selectronic Sine Wave Inverters are constructed as a removable module which can be quickly replaced minimising 'down time'.

Electrical Specifications

PARAMETER	SE22		SE32	SE42	CONDITION
Input Voltage	12V DC	24V DC	24V DC	48V DC	Nominal Voltage
Output Power @ 25°C Ambient	1360W	1600W	2400W	3600W	Maximum continuous
	1800W	2160W	3500W	5500W	½ hour rating
	4000W	5000W	7000W	10000W	Maximum surge
Output Power @ 40°C Ambient	1200W	1500W	2200W	3300W	Maximum continuous
	1700W	2000W	3350W	5200W	½ hour rating
	4000W	5000W	7000W	10000W	Maximum surge
Voltage Input Range	10~17V	20~34V	20~34V DC	40~68V DC	Range
Low Voltage Shutdown	9.5~10.5V	19~21V DC	19~21V DC	38~46V DC	Default, non-adjustable
High Voltage Shutdown	16~17V DC	30~34V DC	30~34V DC	60~68V DC	User-adjustable maximum
Input Current	60mA DC	50mA DC	100mA DC	50mA DC	Stand by
	750mA DC	625mA DC	700mA DC	400mA DC	Inverter on - no load
	130A DC	80A DC	120A DC	78A DC	Maximum continuous
	190A DC	105A DC	185A DC	138A DC	½ hour rating
	400A DC	250A DC	350A DC	216A DC	Maximum surge
Output Current	5.4A AC	6.7A AC	10A AC	15A AC	Maximum continuous
	16A AC	20A AC	26A AC	41A AC	Maximum surge
Demand Start Sensitivity	3W ~ 30W				User adjustable
Demand Start Response Time	1 second maximum				User adjustable
Output Voltage Range	220 ~ 240V AC ±4%				(1) Nominal DC Input. No load to full load
Output Frequency	50Hz ±0.01%				
Output Wave Shape	True sine wave				
Total Harmonic Distortion	<4%				
Power Factor Correction	Nil				
Input/Output Isolation	1875 V AC				
Operating Temperature Range	-10°C to 50°C				
Memory Retention Time	Permanent				

Mechanical Specifications

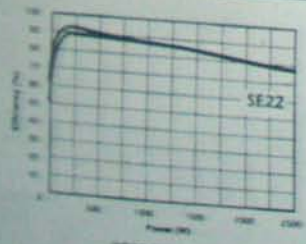
Size	500mm wide x 160mm high x 370mm deep	
Weight / Weight Packed	20kg / 23kg	22kg / 25kg 25kg / 32kg
Input Lead Length	1.5 metres with 10mm stunning lug	
Outputs Wiring Method	Base: 3 terminal junction box with conduit knock outs	
Output Socket	Dual switched 5 pin GPO with neon indicators	
DC Isolation	Single pole circuit breaker	
Warranty	5 Years (conditional)	



Parts and Labour

12 Volt Input

24 Volt Input



SE22 Efficiency

SE22 Power Ratings

Grid Feed & Grid Interactive Inverters

Renewable Power in the City

As time goes on, more and more urban dwellings and commercial premises will opt to have a renewable energy source, such as a PV solar array to generate some or all of their power requirements. There are two options to choose from:

Grid Feed: With a grid feed inverter you can send the power from PV solar panels direct to the grid. Your incoming power would be coming directly from the grid. A grid feed system does not incorporate a battery bank and therefore does not give you any continuity of power in the event that the grid fails.

Grid Interactive: With a grid interactive setup all the power is directed through and monitored by the inverter(s) which will allow you to sell power to the grid when you have a surplus of power, buy power from the grid when you don't produce enough power to meet your own needs and charge the battery bank from the grid if and when required (automatically). A grid interactive system will allow you to continue having power even when your neighbourhood is having a power blackout. You may not even have realised that there was a blackout until you realise that all the lights in your area have gone out except for your own.

DC to AC

Photovoltaic solar panels generate a DC current and the electricity grid distributes AC current at 50Hz (cycles per second) at generally higher voltages. In order to successfully interface between the two you will need either a grid feed or a grid interactive inverter. Either inverter will need to constantly monitor the AC from the grid and stay perfectly in phase. A grid interactive inverter would be able continue working during a blackout without a hiccup and instantly adjust phase when the grid comes back on. As well as the phase control, the inverter also needs to monitor the state and quality of the grid power and shut out the grid if it falls outside of specified parameters. This requires sophisticated electronics that meets the strictest guidelines of the power utilities.

New Inverter Technology

It is the new inverter technology that makes the grid interactive systems work. The new breed of inverters are digitally synthesized sine wave inverters based largely on computer technology which allows them to be programmable and have an incredible range of abilities, programmable functions and data logging capabilities.

The programmable functions usually include current sensitivity for standby mode, allowable voltage parameters of grid connection and may include grid boosting of battery bank and starting and stopping of a generator as a back-up. The grid interactive inverters usually double as battery chargers and can record current, voltage, accumulated amphours etc on a daily weekly or monthly basis.

The Future of Renewables

In the next decade we will see the coming of age of solar power as it starts being taken seriously by urban dwellers. With environmental pollution being taken ever more seriously, the cost of conventionally generated power increasing and the cost of solar power decreasing, solar power is becoming more and more attractive, even in direct competition with other power sources. This should mean a considerable expansion of the solar industry and probably in the electricity utility sector as opposed to the struggling solar industry who have been involved with the technology since year dot and would receive an industry expansion with open arms.

Come and see our system

We invite you to check out the three phase (4.5kW per phase) grid interactive power system at the Rainbow Power Company. We have a solar generating capacity to 7kW peak plus a 800 watt wind turbine and manage to sell more power than we buy.

Grid Feed Inverters

FRONIUS Grid Feed inverters are available in closely graduated power categories.

Fronius Model:	IG 15	IG 20	IG 30
Input Data			
MPP Voltage Range	150 – 400 V		
Max. Input Voltage	500 V (@ 1kW/m², -10°C)		
PV System Output (W_p)	1300 – 2000	1800 – 2700	2500 – 3600
Max. Input Current (Amps)	10.8	14.3	19
Output Data			
Nominal Output	1300W	1800W	2500W
Max. Power Output	1500W	2000W	2650W
Max. Efficiency	94.2%	94.3%	
Mains Voltage / Frequency	230 V / 50 Hz		
Distortion Factor	< 3.5%		
Power Factor	1		
Power Consumption at Night	0 W		
General Data			
Size (L × W × H)	366 × 344 × 220 mm		
Weight	9 kg (12 kg packed)		
Cooling	controlled forced-air cooling		
Housing Variations	designer internal housing, optional		
Ambient Temperature Range	– 20°C to 50°C		
Permissible Humidity	0 to 95%		
Protective Devises			
DC Insulation Measurement	warning when R_{iso} < 500kΩ		
Polarity Reversal Protection	built-in		
Behaviour on DC Overload	displacement of operating point		

Selectronic Interactive & Grid Feed Inverters

- 4 line back lit LCD, easy to read
- New menu structure makes programming faster
- Improved electronics for greater reliability
- "State of Charge" reading replaces "discharge Ah" for simpler understanding
- New software makes generator synchronising much faster and reliable
- Selectable Generator type or custom settings improves generator stability
- Auto control of generator further enhanced with "time of day" control
- Auto control of generator will provide emergency power if inverter is out of service
- No power disturbances during starting and stopping of generator
- View up to 32 daily events directly on the LCD without modem or PC
- Enhanced user adjustability
- Individual display of internal and external shunt current & net battery current
- Sums generator and inverter outputs together if required for peak load
- Improved LED layout allows quick glance status check
- Programmable Load Search & reduced low load losses
- Improved documentation
- Simpler installation and easier field PCB replacement
- Physically smaller than previous RAPS unit

Model #	Cont.Power	Bat.Voltage	Max.Charge	Max.Genset	Min.Genset	Unit / Packed Weight (kg)	HxWxD (mm)
Single Phase, Generator Interactive Inverter Charger							
PSI RAPS 5/24	5 kW	24 V	200 A	15 kVA	6.25 kVA	72 / 79	585x400x420
PSI RAPS 6/48	6 kW	48 V	120 A	15 kVA	7.5 kVA	73 / 80	585x400x420
PSI RAPS 10/48	10 kW	48 V	200 A	30 kVA	12.5 kVA	87 / 94	585x400x420
PSI RAPS 12/120	12 kW	120 V	70 A	30 kVA	15 kVA	93 / 100	585x400x420
RAP-15-108-1 RAP-15-120-1	15 kW	108 V 120 V	100 A	20 kVA	20 kVA	280	1130x550x530
Three Phase, Generator Interactive Inverter Charger							
RAP-20-108-3 RAP-20-120-3	20 kW	108 V 120 V	150 A	30 kVA	25 kVA	310	1400x900x600
RAP-30-108-3 RAP-30-120-3	30 kW	108 V 120 V	250 A	External	40 kVA	350	1400x900x600
RAP-40-108-3 RAP-40-120-3	40 kW	108 V 120 V	300 A	External	50 kVA	390	1400x900x600
Single Phase, Grid Feed							
SGI 10	10 kW	N/A	80 A	N/A	N/A	260	1130x550x530
Single Phase, Grid Interactive (with Battery Backup)							
SGB 10/120	10 kW	120 V	80 A	N/A	N/A	260	1130x550x530

Note: Wherever a generator is stipulated, a remote start Diesel Generator is Required

Selectronic PS1 Range	PS1 5/24	PS1 6/48	PS1 10/48	PS1 11/108	PS1 12/120
Inverter Mode					
Battery voltage Nominal	24V DC	48V DC	48V DC	108V DC	120V DC
Battery voltage default range	22-34V DC	44-68V DC	44-68V DC	88-150V DC	98-170V DC
Continuous output power @ 25°C	5kW	6kW	10kW	11kW	12kW
Continuous output power @ 30°C	4.5kW	5.5kW	9kW	10kW	11kW
Continuous output power @ 40°C	4kW	5kW	8kW	9kW	10kW
Continuous output power @ 50°C	3.2kW	4kW	6.4kW	7.2kW	8kW
Continuous output power @ 60°C	2kW	2.5kW	4kW	5kW	5.5kW
Max output power 5 minutes (initial power <1kw)	6.5kW	8kW	13kW	13kW	16kW
Max overload 5-5 seconds	8kW	10kW	16kW	20kW	22kW
Max continuous output-interactive mode	5kW + gen output	6kW + gen output	10kw + gen output	11kW+ gen output	12kW + gen output
Max continuous AC output current	21A + gen output	25A + gen output	42A + gen output	46A + gen output	50A + gen output
Max continuous DC input/output current	250A DC	150A DC	250A DC	120A DC	120A DC
DC input, load search, no AC load	0.6A/15W	0.3A/15W	0.3A/15W	0.12A/15W	0.12A/15W
Load search sensitivity range	5-40W				
Output voltage/frequency- invert mode zero to max load, max ex cont	240v AC +1% /-4%, 50Hz +/- 01% @ <4% THD				
Interactive Mode					
Changeover time, invert to generator	Zero				
Maximum supported generator capacity	10kVA	15kVA	20kVA	30kVA	30kVA
Load auto switched to generator in fault mode	Yes				
Max adjustable charge rate	0-200A	0-120A	0-200A	0-100A	0-100A
No of charge stages	4 stages, plus equalise and recovery				
Charger type	Unity PF; 4 state constant I, constant V with current & power limit				
Charger settings	Adjustable to suit all battery types, default: sealed				
Generator Start Parameters					
	4 x time of day, 3 x state of charge				
	2 x adjustable power limits, 4 x back up times				
	Battery voltage, inverter shutdown				
	Inverter temperature				
Generator start method	2 or 3 wire, pulsed or run signal (adj)				
General					
Unit weight / packed weight	72kg / 76kg	73kg / 80kg	87kg / 94kg	93kg / 100kg	93kg / 100kg
Dimensions	585mm High x 400mm Wide (430mm incl mounting flanges) x 420mm Deep				
Communications serial interface	RS232 x 2400bps				
Memory retention of settings and logged data	Permanent via on board battery backed RAM & EEPROM				
No. of Shunts	1 x 100A internal, 1 x optional external shunt				
Circuit breaker for generator input	63A 63A 125A 125A 125A				
Circuit breaker for AC output	63A	63A	125A	125A	125A
Circuit breaker for DC battery input, with electronic trip	250A*	125A	250A	125A	125A
Standards	C tick, AS3100				
Efficiency - Peak	91%	93%	96%	96%	96%
@ 10% & 30% nominal load	87% - 91%	89% - 93%	91% - 96%	90% - 95%	90% - 95%
@ 50% & 100% nominal load	91% - 90%	90% - 92%	96% - 93%	96% - 94%	96% - 94.5%
Safety isolation	AC output to chassis & battery 5kV, battery to chassis 1kV				
Power factor charging	Unity				
Power factor inverting	0-1				
Enclosure rating	IP40				
Cooling method	2 x thermostatically controlled fans				
Protection	Circuit breakers on all external power connections, plus electronic trip of DC breaker* & reverse battery on all units except 5/24				
On board log	Records over 200 events, alarms and data which can be accessed remotely via serial port/modem. Up to 32 current day events on LCD				
Four line alphanumeric backlit LCD displays	Configuration parameters, Batt Volts, Nett Batt Amps, AC Load kW, Gen kW/Volts/Freq, Av daily kWh, Shunt 1&2 Amps, Event log, Charge Amps, State of Charge				
Warranty	1 year, or 2 years when installed by a Selectronic accredited installer				

Light Bulbs, Tubes and Fittings

Lighting is usually the first consideration when people decide on obtaining an electricity supply. Moreover, people seldom get an electricity supply and not use it for lighting.

It is not only the convenience of a light switch that determines this choice but also the efficiency of electric lighting and that it is easy to arrange electric lighting in such a way that the light falls where it is most needed. Kerosene lamps, oil lamps, gas lamps and candles throw their light mostly upwards and sideways but little light is thrown downwards. There are no unpleasant vapours or odours given off by electric lighting such as there is with kerosene, oil etc.

LOW VOLTAGE LIGHTING

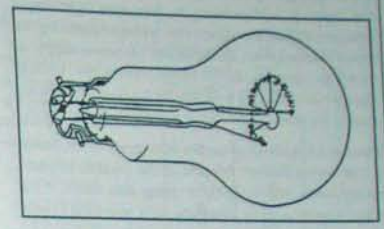
Low voltage lighting is considered to be more efficient than the equivalent 240V lights. For the same number of watts (measure of power) you can produce more lumens or candle-power (measure of brightness) from a low voltage incandescent light. The same is true for fluorescent lights, but for a different reason. The reasons for this are given, please read on.

We generally use fluorescent or hybrid fluoro lights of between 5 and 20 watts as general room lighting where the lights are used for many hours each night and quartz halogen or standard incandescent lights of between 5 and 20 watts for localised lighting or for lights that get switched on and off more frequently.

It really pays to have the most efficient lights, since you are buying your own energy source and things like solar panels are quite expensive. Fluorescent lights are the most efficient, a 7 watt hybrid fluoro light gives 400 lumens of light. A 20 watt halogen bulb without reflector gives about 350 lumens of light, whereas a 20 watt incandescent bulb will give about 260 lumens.

Incandescent Lights

The light is produced by a thin filament which, with the current flowing through it, glows because of the temperature reached by the filament. The length of the filament is determined by its resistance and the voltage which is expected to flow through it. The higher the voltage the longer and thinner the filament needs to be in order to produce enough resistance (to generate the heat in the filament). Consequently low voltage light bulbs are more robust and can be run at a higher temperature because they are not as fragile.



If you look closely at a 240 volt incandescent light bulb you will see how the filament is spun into a coil of a very small diameter which is then spun into a larger coil. This coil is held by a series of special little suspenders in a horse shoe shape - all this to create sufficient length.

Quartz-Halogen bulbs

A Quartz-Halogen (QH) bulb is designed with the use of special materials to be able to be run at a higher temperature than the standard incandescent bulb. These QH bulbs operate at white-hot temperatures whereas the standard incandescent bulb hovers somewhere between red and yellow hot.

If you consider the price of photovoltaic panels you can see that spending a little extra on more efficient lighting can help you save in the overall size of the solar array and battery bank. You also gain the benefit of having a superior quality of light (a spectrum similar to daylight).

NOTE: Halogen bulbs are designed to run at an optimum temperature. They do have a degree of tolerance, but their expected lifespan is shortened by operating them on excessively high and excessively low voltages. Please make sure that your batteries are in a charged condition and that your wiring is adequate (see WIRING YOUR OWN HOME and WIRE section).

Fluorescent Lights

Even with fluorescent lights there is an argument against running them from a large central inverter. The fluorescent tube works on a completely different principle to the incandescent bulb. It doesn't have a filament but causes a special mixture of gases to glow by passing an electric spark through it. In order to overcome the inherent electrical resistance of these gases the voltage needs to be in excess of 100 volts. Increasing the voltage above this level does not make the fluorescent light any brighter.

By providing a special dedicated inverter to power the tube it is possible to design this inverter to supply the optimum amperage, voltage and frequency to give the best light. It is interesting to note that light output increases as frequency increases without increasing the power consumption. The standard AC power supply in Australia operates at 50 hertz (cycles per second) whereas the dedicated inverters for the fluorescent lights usually are made to operate at several thousand hertz.

There is a new development in fluorescent tubes known as the hybrid fluoro - because of the cocktail of gases incorporated into it. Without going into detail, these tubes display a more complete light spectrum (better colour rendition). These tubes are commonly bent into a U shape rather than the more familiar straight tube.

There is another reason for running the fluorescent tube from its own little dedicated inverter rather than from a larger inverter. The standard household inverter is designed to produce 240 volts at 50 cycles per second (hertz). At this rate, the fluoro tube produces a flicker which is too fast to easily notice but slow enough to have an irritating effect on the nervous system. The little inverters dedicated to running these fluoro tubes produce an AC wave-form at several thousand cycles per second, which is too fast for the retina to perceive or to irritate the nervous system. Some new 240V compact fluoro lights are now provided with high frequency electronics.

One problem with the dedicated inverters that drive the fluorescent lights is that they cause some radio interference on 'AM' radio (but not on 'FM' or TV).

NOTE: Please make sure that your batteries are in a charged condition and that your wiring is adequate (see WIRING YOUR OWN HOME and WIRE sections) before operating fluorescent lights with dedicated inverters. A low voltage will cause starting problems and may also considerably shorten the lifespan of the tube. If the light does not switch on you may have your connections reversed. The dedicated inverters are protected against REVERSE POLARITY and all you need to do is reverse the connection and try again.

Lights and Inverters

Fluorescent lights using iron ballasts are often a problem causing fluctuations in the light and/or noises emanating from the inverter and light fixture. Iron ballasts, as compared to electronic ballasts (commonly used with compact fluoro's), are quite weighty and are usually associated with ceiling or wall mounted fluoro fittings and desk-top fluorescent lamps with weighted base.

Lighting Hints

Although you might like the appearance of timber, stone or mud, try to keep your walls and ceilings as light (in colour) as possible to reduce lighting demands and improve your overall lighting efficiency. Lampshades should preferably enhance the light and if you want a 'mood' light then choose a light of lower power consumption rather than shading a brighter light. Place lights where you need them most, such as having a suitable light in your favourite reading place rather than attempting to light up the whole room with one single light. Place work lights so that you are not working in your own shadow.

Turning lights off saves energy, but frequent switching on and off shortens the bulb's life. Make it a practice to turn off incandescent lights if you are leaving the room for three minutes or more, and turn off fluorescent lights if you leave for more than 15 minutes. With the new improved ballasts on some fluorescent lamps, manufacturers recommend turning them off if leaving for five minutes.

If the house is large and has many lights, quite large cables may be required to overcome voltage drop over the distance. If the required battery bank also needs to be greater than 12 volts, it may be wiser to have 240 volt lighting operating from one inverter.

ENERGY SAVING 240V LIGHTING

The Hybrid or Compact Fluoro is a relatively recent innovation in electric lighting and not only can it save on the cost of a stand alone solar electric installation, it can also reduce the production of Greenhouse Gases if used in grid supply households. If the majority of 240 volt incandescent lights were replaced by Hybrid Fluoro lights there would be less demand on coal burning Power Stations.

A single 18 watt compact fluoro produces as much light as a 75 watt incandescent bulb and lasts about 13 times longer. Over its lifetime it will avoid emissions from a coal burning power plant of more than 1 ton of carbon dioxide, about 20 pounds of sulphur dioxide, and various other nasty things. The same light bulb will save the cost of buying a dozen light bulbs and the cost of generating 570 kWh of electricity.

Fuel Saving for Petrol/Diesel Generator

During its lifetime the compact fluorescent light bulb can save up to 900 litres of fuel if powered by a petrol or diesel generator. To maximise fuel savings it is recommended to charge a battery whilst the generator is running and operate the compact fluorescent lights with an inverter or several dedicated inverters. This practice will allow reduced running time of the generator during off peak and the battery is charged.

Lighting Chart

The following table gives a comparison between various forms of lighting. Figures include power consumption (watts), brightness (lumens) and efficiency rating (lumens/watt).

Lighting Comparisons

The mostly horizontal light distribution from candles and kerosene lights, the inconvenience of lighting them and vapours and smoke given off by them should be considered in comparing them to electric lights.

A direct comparison between the efficiencies of the various forms of electric light is quite meaningful as the best selection and distribution of lights may dramatically reduce the overall cost (solar panels & battery bank) and running cost (in fuel for back-up power) of a stand-alone power system. Contact RPC staff for advice and assistance in designing your lighting requirements.

The 35 watt sodium vapour lamp (low pressure sodium) is available as a 12 volt light but due to its orange colour it reduces all colours to monochrome shades. This light is ideal for visibility in foggy conditions (ie as a street light) but is not considered suitable as an indoor light.

RPC Cat.#	Light Type	Nominal Watts	Lumens	Lumens per Watt
	Cloudless summer midday		90,000	
	Summer midday on balcony		3,000	
	Full Moon		0.5	
	Minimum for Reading		25	
	Candle	(7.2g/hour)	16	0.22
	Kero Hurricane Lamp	(50 ml/hour)	100	0.20
	Kero Pressure Lamp	(80 ml/hour)	445	1.60
	LPG Pressure Lamp	(34 g/hour)	1000	2.35
	Incandescent Auto Globe	5	45	9
	Incandescent Auto Globe	20	264	13.2
LIT-007	Quartz Halogen	5	60	12
LIT-008	Quartz Halogen	10	140	14
LIT-009	Quartz Halogen	20	350	17.5
LIT-031	Quartz Halogen	50	900	18
SUN-LT303	Sundaya Ultex 12V 3W (warm) fluoro	3	>120	48
SUN-LT406	Sundaya Ultex 12V 6W (warm) fluoro	6	>240	46.5
SUN-LT409	Sundaya Ultex 12V 9W (warm) fluoro	9	>360	47
SUN-LT412	Sundaya Ultex 12V 12W (cool) fluoro	12	>510	49.4
SUN-LT418	Sundaya Ultex 12V 18W (cool) fluoro	18	>800	51.7
LIT-019	Strip Fluoro	18	900	60
	Strip Fluoro	36	2835	78.8
	Sodium Vapour	35	5250	150
	Mercury Vapour	80	3700	46
	Metal Hallide	70	5500	78

Information derived from lighting manufacturers, World Bank, Appropriate Technology and CIA World Fact Book.

When comparing candles, kerosene and LPG lighting with electric lighting it would seem more meaningful to compare the cost of operating these lights and their inconvenience than to compare their efficiencies. LED lights have an efficiency of about 15 lumens per watt.

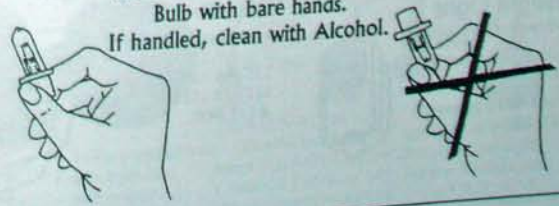
Note: Fluorescent tubes will lose 20% to 25% of brightness over 5000 to 8000 hours of usage. Gradual blackening at the ends of the tube and increased difficulty in starting indicate that a tube replacement may be due.

Type	Design Life (hours)
Incandescent	1000
Quartz-Halogen	2000
Compact Fluoro	3000
LED	20000

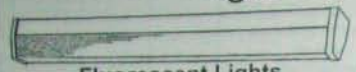
Comparison between Compact Fluoro and 240V Incandescent

IMPORTANT

Never handle Quartz Halogen Bulb with bare hands.
If handled, clean with Alcohol.



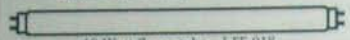
Light Bulbs and Tubes



Fluorescent Lights

including tube, without diffuser:
8 Watt 12 Volt – Cat.# LYF-008
18 Watt 12 Volt – Cat.# LYF-019
18 Watt 24 Volt – Cat.# LYF-064

Diffuser for 18 Watt – Cat.# LYF-020



18 Watt fluoro tube – LIT-018

Cold Cathode Light

Edison Screw, with reflector:
12V 7W – LIT-CE107R
24V 7W – LIT-CE207R
Edison Screw, without reflector:
12V 7W – LIT-CE107
24V 7W – LIT-CE207

Halogen Bulbs (2 pin)

12V 5W — Cat.# LIT-007
10W — Cat.# LIT-008
20W — Cat.# LIT-009
50W — Cat.# LIT-031
24V 10W — Cat.# LIT-010
20W — Cat.# LIT-028
50W — Cat.# LIT-042

Sealed Dichroic Halogen

12V 20W – Cat.# LIT-025
24V 20W – Cat.# LIT-029
24V 50W – Cat.# LIT-250

Plugs into: LYF-070 & LYF-071

Jar Light

Frosted — Cat.# LYF-041
(to fit standard bayonet lampholder)

Recommended halogen bulbs:
LIT-007, LIT-008, LIT-009 & LIT-028

Night Light

Fits into standard bayonet lamp holder.

12V night light uses only 0.02 amps
Cat.# LED-005

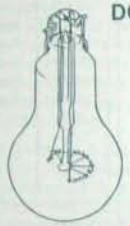
24V night light uses only 0.01 amps
Cat.# LED-006

12V & 24V Compact Fluoros

E17 Edison Screw:
12V 3W (warm) – Cat.# SUN-LT303
12V 6W (warm) – Cat.# SUN-LT406W
12V 9W(warm) – Cat.# SUN-LT409W
12V 12W (cool) – Cat.# SUN-LT412C
12V 18W (cool) – Cat.# SUN-LT418C

Bayonet Cap:
24V 23W – Cat.# LIT-FB223
24V 30W – Cat.# LIT-FB230

Standard Edison Screw:
24V 15W – Cat.# LIT-FE215



DC Incandescent Lamps

12V:
15W: Cat.# LIT-041
25W: Cat.# LIT-043
40W: Cat.# LIT-044

24V:
15W: Cat.# LIT-046
25W: Cat.# LIT-047

2D 16W Square Light

12V: Cat.# LYF-136
24V: Cat.# LYF-236

Adjustable Spot Light

White – Cat.# LYF-073
Black – Cat.# LYF-074
to suit: LIT-025, LIT-029 & LIT-250

Outdoor Flood Light

Cat.# LYF-075

to suit 2 pin halogen bulbs
LIT-007, LIT-008,
LIT-009, LIT-025,
LIT-028, LIT-031
& LIT-042

Light Fittings

Standard Pendant Lampholder
will take all BC bulbs and adapters
Cat.# LYF-013

Economy Pendant Lampholder
will take all BC bulbs and adapters
Cat.# LYF-009

Standard Batten Lampholder
will take all BC bulbs and adapters
Cat.# LYF-012

BC Adapter
Cat.# LYF-004

BC Adapter for halogen
Cat.# LYF-002
(does not include lamp)

Economy Edison Screw Lampholders

Plastic with screw terminals: Cat.# LYF-003
Plastic with lampshade retainer: Cat.# LYF-011

Batten Fitting including built-in
pull-cord switch Cat.# LYF-300

Standard Edison Screw Lampholders

Ideal for polarity defined dedicated DC lamps.

Edison Screw Pendant
Lampholder
Cat.# LYF-011

Edison Screw Batten
Lampholder
Cat. # LYF-010

E17 Edison Screw Fittings

Apollo Batten
can be combined
with extenders
Cat.# SUN-AC149

Tablo weighted base
can be combined
with pointer
Cat.# SUN-AC144

Pointer
Bendible
Lampholder
for Tablo

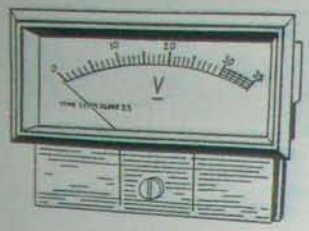
Cat.# SUN-AC146
Flexible extenders
60cm Cat.# SUN-AC138
120cm Cat.# SUN-AC140
180cm Cat.# SUN-AC139

Pullite
with built-in switch
(just pull on the light)
requires Sundaya cable
Cat.# SUN-AC141

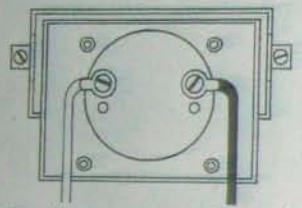
Ceramic Halogen Lampholder

Cat.# LYF-014

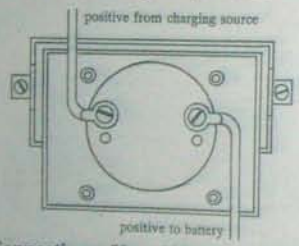
Meters



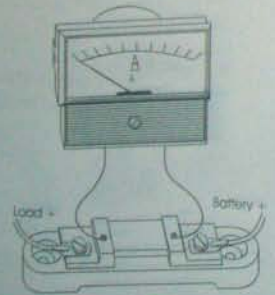
Connecting Volt Meter



Connecting Amp Meter



Connecting a 50 or 100 Amp Meter



CONNECTING METERS

There is a fundamental difference between how a volt-meter and an amp-meter is connected into a circuit

VOLT-METERS

A volt-meter is connected up in parallel to the battery in much the same way as a light or an appliance is connected.

On the back of the volt-meter you will find either two screw on connectors or two solder lugs, one marked "+" and the other marked "-". The one marked "+" connects straight back to the positive terminal from the battery and the one marked "-" connects straight back to the negative terminal from the battery.

AMP-METERS

You may find the same markings on the back of the amp-meter, but the fundamental difference between an amp-meter and a volt-meter is that the amp-meter connects up in series like a switch.

The amp-meter may be connected on the positive wire or on the negative wire but not on both. If, for instance, you want to connect an amp-meter to the wires coming from the solar panel to measure the rate of charge, you cut through one of the two wires (usually the positive) coming from the solar panel and leave the other one intact. Both ends of the cut wire now connect to each of the connectors on the back of the amp-meter. If it is the positive wire you are using then the end coming from the solar panel connects to the connector marked "+" and the end going to the battery connects to the connector marked "-".

If either your volt-meter or your amp-meter needle deflects backwards off the scale then you have most likely connected the meter up backwards. If this occurs you need to reverse the polarity (eg by swapping the two leads over).

Meter	Cat.#
Centre zero 10 amp	MET-007
Centre zero 20 amp	MET-008
10 amp	MET-002
20 amp	MET-003
30 amp	MET-006
50 amp with shunt	MET-001
100 amp with shunt	MET-009
15 volt	MET-004
30 volt	MET-005

Rainbow Sundaya Solar Lantern Kits

The Solar Lantern Kit is a complete small solar power system which incorporates the following components:

Solar Panel 14Wp Cat.# SUN-PV14

This small amorphous silicon PV- panel with Moulded frame is especially suitable for small Economy type of lighting or TV systems. Sundaya provides mounting structures to mount either 1, 2 or 3 panels on 1 pole on a rooftop. One panel in combination with Sundaya Apple S4 storage system generates an average of 60 watt-hours per day (based on 4-5kwh/m² insolation). The panel is manufactured by Free Energy Europe in France. It is rated at 14W and comes with a 10 year performance warranty.

Battery Pack Cat.# SUN-BP20/BP40/BP55

These battery packs incorporate a 20Ah, 40Ah and 55Ah battery storage to suit the various kits. These battery packs are a plug and play wall mountable sealed lead acid storage system of 240 Wh 480 Wh and 660Wh consecutively. The battery packs come complete with built-in microprocessor based energy management system and have a clear LCD display that displays battery state of charge and charge/discharge or rest mode. These units are also equipped with an alarm to warn user when battery is one hour to forced disconnect due to a low battery state-of-charge.

Items in these battery packs also include:

- Hub1 cable assembly
- Mounting bracket
- Installation material

Multilight Cat.# SUN-LT06W / LT12W / LT18W

The Multilight 1 is a sturdy waterproof (submersible to 25 metres) lamp armature with polycarbonate lamp cover. 6W, 12W and 18W versions are available. The Multilight has a preheat start inverter and is equipped with a replaceable Ulux tube. The lamp has a lifetime of over 100,000 On/Off cycles and over 10,000 burning hours. These lights are ideal for camping, boats and caravans. One or two multi-lights are included in these Kits.

S Con "Plug & Play switch connector. Cat.# SUN-AC002
T Con "Plug & Play cable joiner. Cat.SUN-AC001

Kit Models

Cat. #	Model	PV	Battery Ah	Lights	Cable
SLK-060B	Starter Kit	1 x 14W	20Ah S4 pack	2 x 6W Fluoro	28 metres
SLK-200P	Standard Kit	1 x 50W	45Ah S4 pack	2 x 10W A Light, 1 x 12W Multilight	32 metres
SLK-200D	Deluxe Kit	1 x 50W	45Ah S4 pack	3 x 10W A Light, 3 x 9W Ulux, 4 x Lumi Light	68 metres
SLK-400A	Premium Kit	2 x 50W	117Ah S3 pack	3 x 10W A Light, 3 x 9W Ulux, 4 x Lumi Light	68 metres
SLK-400K	Premium Extra	1 x 130W	117Ah S3 pack	3 x 10W A Light, 2 x 18W Ulux, 1 x 18W Multilight, 2 x Lumi Light	62 metres

All except Starter and Standard Kit come with 4 way DC socket to plug in desklamp, stereo etc.
A single 16W module tilted at 15° to the north will operate a single 9W Multilight for 4½ hours per day throughout PNG and 5 hours in Milne Bay Province and Solomon Islands.

Rainbow Sundaya Moale Mini Solar Kit

Cat.# SLK-200A

This Mini Kit is made up of the following components:

1. PVS200 Solar Panel

Cat.# SLK-200-P01

The kit is a convenient package complete with all installation materials to install the panel on your roof including the seal to prevent leaks.

With an insolation of 4-5kWh/m²/day this set in combination with one of Sundaya Storage Systems provides 200Wh/day; sufficient for 33 hours of 6W light, or 5.5 hours 14" Sundaya colour TV, or any other 12VDC appliance. The Solar Panel is rated at 50W and is manufactured by General Electric.

2. S4.660 Power Pack

Cat.# SLK-200-P02

The S4.660 is a plug and play wall mountable sealed lead acid storage system of 660 Wh capacity with a state of the art microprocessor based smart energy management system. The unit has a clear LCD display that displays battery state of charge and charge/discharge or rest mode. The unit is also equipped with an alarm to warn the user when battery is one hour to forced disconnect.

Items in this set:

- Hub1 cable assembly
- Mounting bracket
- Installation material

3. 10L400 Standard Plus Lightkit

Cat.# SLK-200-P03

A complete set of lights and accessories, containing the 3 Ulite9, 2 Lumi White, 1 Lumi Red, 1 Lumi Purple, 3 A-lights, 3 Apollo, 1 socket outlets, and 3 Broco switches. The wide selection of lights allows you to light up several rooms, and to economise on power usage by allowing you to only select the amount of lighting, which you require for a specific task. For example, you might install two lights in your kitchen - over the workbench and over the kitchen table. Use one light when preparing your food and then the second light while eating. This saves power by only lighting up the area that you require.

Ulite 9 (Cool Daylight) Light

The Ulite is a 12VDC instant start Compact Fluorescent Lamp with E17 Fitting. The Lamp is rated at 9W and has a lifetime of over 5,000 On/Off cycles and over 8,000 burning hours. Three lights with batten mount lampholders are supplied in the Mini Kit.

Lumi Light

The Lumi has two incandescent light bulbs of 0.5 and 2 Watt. The Lumi has two switches; one switch for On/Off and one switch for switching between 0.5 and 2 Watt light bulbs. The Lumi is most suitable in a bedroom or as a cosy light in your living room. Four Lumi lights are provided in the Mini Lighting Kit.

A-Lights

The A-light is the best performance ratio lamp in the industry. The A-light uses an economical Phillips 10W fluorescent tube and is equipped with the highest grade electronic components to ensure a long lifetime. The uniquely shaped UV-stabilised reflector takes care of a good diffusion of the light. Three of these lights are included in the Mini Lighting Kit. The A-light conforms to World Bank Specifications. Over 500,000 units have already been installed world-wide.

Energy Usage

This kit will operate 3 of the fluorescent lights for 5 hours per day and 2 Lumi Lights for two hours per day with the 50W solar panel tilted at 15° facing north throughout Papua New Guinea and the Solomon Islands.

Sundaya DCS Cabling System

The Sundaya DCS cabling system allows you to position lights and switches to suit the layout of your home. You can make these connections yourself without employing an electrician! High quality sealed connections are made to ensure lasting performance in humid tropical climates. For more details (Flash Media required for best viewing).

Plugs, Power Points and Sockets

DC POWER-POINTS

It is important for safety reasons to use low voltage power points that are distinctly different from 240 volt power points. If it is possible to plug a low voltage appliance into 240 volts the result could be lethal.

For DC power points we usually use 5 mm² wire, but this is dictated by what you would expect to plug into it. For a 12 volt colour TV you would certainly need 5mm². For a portable radio or cassette player you would only need a very light gauge of wire, but it would still be a good idea to use 2mm² so that a portable 12 volt light may be plugged in as well.

Double Cigarette Lighter Socket
Cat.# SKT-004

Single Cigarette Lighter Socket
Cat.# SKT-013

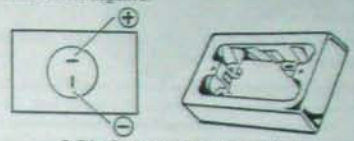
Cigarette Lighter Plug
w/- fuse
Cat.# PLG-004

DC Line Jacks
2.1mm Cat.# PLG-021
2.5mm Cat.# PLG-025

Check appliance to determine polarity

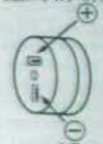
Sundaya DC plugs
"D" plug Cat.# SUN-AC114
"D" plug with 1.5m of 2.5mm² cable
Cat.# SUN-AC105

The two pin power points and sockets are usually mounted so that the horizontal slot is at the top and the vertical slot is directly below it. The standard polarity is then such that the horizontal slot is positive and the vertical slot is negative.



2 Pin Polarised Unswitched
Cat.# PWP-008

mounting block to suit
Cat.# PWP-011



Wall-mounted Power Point
Cat.# PWP-007

Cord-extension Socket
Cat.# SKT-008

2 Pin Polarised Plug
Cat.# PLG-003

Sundaya DC Powerboards
4 way "D" socket with 1.5m cable and "D" plug
Cat.# SUN-AC003
4 way "D" socket with 3m 2.5mm² cable and "T" connector Cat.# SUN-AC004

Pumps

Many people have a rain water tank below the level of the plumbing in the house. Even if the tank is above this level it may not be high enough to supply water under sufficient pressure for household requirements. You may also need to have an on demand watering system for drinking troughs for animals or for irrigation.

There are four ways to supply water under increased pressure:

1. Solar array (one or more photovoltaic panels) connected direct to a low voltage pump to fill a header tank. This way there are no switches or batteries needed although an optimizer (Maximizer see page 105) is required. The pump only works when there is sufficient sunlight falling on the solar array to provide enough electricity.
2. Pump connected to the battery bank with a manual switch. If you already have a battery bank with charging system to hook into, this is the cheapest alternative. If your water outlet is above the water level in the tank you don't even need a tap. All you need is an open pipe with a switch near it.
3. Pump to a header tank with battery power. You can use a manual switch, a switch with a timer incorporated, a float switch which switches the pump on when the water in the header tank is low, or by using a pressure pump (option 4) and a float valve on the header tank so that the water is replaced in the header tank as it is used.
4. A pump to supply constant pressure with the use of a pressure tank and pressure switch. As soon as any tap is turned on the pressure tank releases some of its pressure to start the water flowing. At the reduced pressure the pressure sensitive switch then switches to turn on the pump. The pump then supplies the water and re-pressurises the pressure tank.

Shower = 15 litres per minute
Fill Bath = 130 litres
Flush Toilet = 4.5 to 14 litres
Lawn Sprinkler = 800 litres/hour

IMPORTANT:

1. You need to ensure that the pump never runs dry.
2. It is recommended to use an accumulator tank on all pumps with a built-in pressure switch (unless the manufacturers advise otherwise).
3. Avoid damage due to grit and dirt by using an appropriate filter.
4. Pumps make noise; take this into consideration when locating your pump.

½" Tap = 45 l/m at 140 kPa
¾" Tap = 75 l/m at 140 kPa
Cattle = 45 to 90 litres/day
Milking Cows = 135 to 180 l/day
Sheep & Pigs = 4.5 to 9 l/day

Pipe Friction Table: Polyethylene and PVC Pipe — metres of frictional loss per 100 metres of pipe
Allowance has been made for the normal number of pipe fittings

Gallons (Imperial) per Minute	Litres per Minute	Poly-pipe Imperial Size (Inside Diameter) ½"	¾"	1"	1¼"	1½"	2"	PVC Pipe Class B Imperial Size (Inside Diameter) 1½"	2"	2½"	3"
		Poly-pipe Metric Size (Outside Diameter) 16	25	32	40	50	63				
2.5	11	25	3	1				0.4			
5	23	90	12	3	1	0.5		1.2	0.5		
10	45		40	10	4	1.5	0.3	2.1	0.6	0.2	
15	68		80	20	8	3	0.7	3.2	1.0	0.4	0.2
20	90			30	13	5	1.3	4.2	1.6	0.6	0.3
25	114			50	20	8	2	6	2.1	0.8	0.4
30	135			60	25	10	3	8	2.8	1.0	0.5
35	159				30	14	4	10	3.8	1.2	0.7
40	182				40	18	5	20	5.2	1.7	1.0
50	227				60	27	7	22	7.4	2.5	1.3
60	273					38	9	25	9.5	3.3	1.7
70	318					50	12	31	13	4.2	2.0
80	364						16	40	20	5.1	2.2
90	409						20	48	22	6.4	3.0
100	455						24	62	26	8.4	3.9
120	546						34	81	33	12	5.1
140	636						46		40	15	7
160	727								50	25	9
180	818								60	27	10
200	910										

SHURflo Extreme: — Variable Speed Constant Pressure Pump

TYPICAL APPLICATION

Multi-fixture potable water installations. Other uses may include 12 VDC pressurized water systems. Also available in 24VDC (24 to 36V). This pump may be used for water transfer.

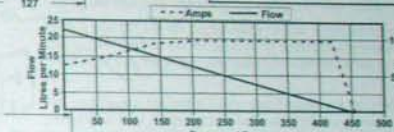
PUMP

Type:	5 Chamber Diaphragm
Ports:	Quick Connect
Liquid Temp.:	54°C Max
Prime:	2.7 metres
Inlet PSI:	207 kPa (30 PSI) Max
Run Dry	Yes
Fittings	¼" NASPT Dual O-ring included ½", ¾" Barb available (straight & elbow)

12V: Cat.# PMP-SX12 24-36V: Cat.# PMP-

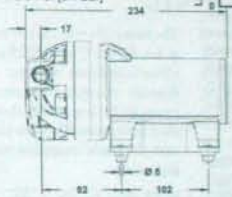
ELECTRICAL

Motor 12V:	Permanent Magnet, Intermittent Duty
Protection:	Thermal Overload, Automatic Restart
Leads:	2mm² 400 mm Red +, 330 mm Black -
Fuse:	15 Amp Recommended
Control:	Microprocessor PWM Pressure Transducer
Shut-Off:	Voltage Variant, Factory Set at 448 kPa (65PSI) [4.4 Bar] @ 12 VDC ± 5 PSI [0.4 Bar]



MATERIALS

Housing:	Nylon
Valves:	EPDM
Diaphragm:	Santoprene
Hardware:	Stainless Steel



DIMENSIONS

Given in mm on diagrams
Net Weight: (Boxed) 4 Kg

LIMITED WARRANTY

3 Year Limited Warranty

Shurflo Economy Pump

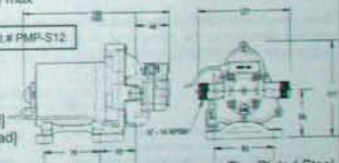
Suitable for pressurized water systems and for general water transfer.

12 Volt Type: 3 Chamber Diaphragm Ports: ½"-14 NPSM-male Run Dry: Yes Liquid: 54°C max
Prime: 2.7 metres Inlet Pressure: 207kPa (21 metres head) max

ELECTRICAL

Motor:	12VDC Permanent Magnet, Intermittent Duty
Protection:	Thermal Overload, Automatic Restart
Leads:	1.37mm² 40 cm Red [+], 33 cm Black [–]
Fuse:	10 Amp Slow Blow Recommended
Control:	Adjustable Switch with Check Valve
Shut-Off:	310 kPa [32 m head] ± 34.5 kPa [3.5 metres head]
Restart:	172 kPa [17.5 m head] ± 34.5 kPa [3.5 metres head]

Cat.# PMP-S12



MATERIALS

Housing: Polypropylene Valves: EPDM Diaphragm: Santoprene Hardware: Zinc Plated Steel

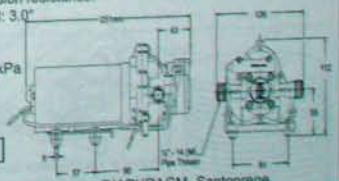
WARRANTY: 1 Year Limited Warranty **SHIPPING:** Weight (Boxed): 2.3 kg

24 Volt TYPE: Positive Displacement 3 Chamber Diaphragm Pump

Note: Pump is coated with a plastic compound for improved corrosion resistance.

CHECK VALVE: (1-Way Operation) Prevents Reverse Flow CAM: 3.0°
MOTOR: Permanent Magnet, Thermally Protected
VOLTAGE: 24 VDC Nominal
PRESSURE SWITCH: Splash-Proof, Adjustable from 200 to 350 kPa
Factory Set @ 310 kPa Shut-Off, Turn On 170 kPa ± 35 kPa
LIQUID TEMPERATURE: 54° C Max.
PRIME: Self-Priming up to 2.75m Vertical
Max. Inlet Pressure 210 kPa
PORTS: ½"-14 Male Parallel Thread

Cat.# PMP-S24

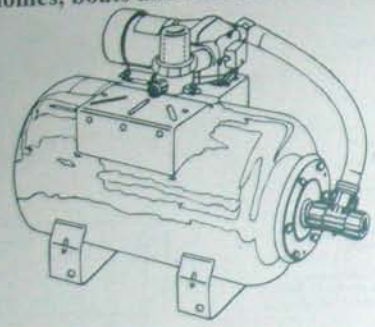


MATERIALS:

PLASTICS- Polypropylene VALVES- Santoprene DIAPHRAGM- Santoprene
FASTENERS- Stainless Steel NET WEIGHT: 2.9 Kg DUTY CYCLE: Continuous until case reaches 138°C

Water Pressure Systems

for homes, boats and recreational vehicles



Water Pressure Systems are required when you have a water tank at or below tap level (eg underground tank) or when you have a gravity fed system that doesn't supply sufficient pressure. You may create sufficient pressure by either pumping up to a header tank or using a pump with an automatic pressure switch and a pressure tank.

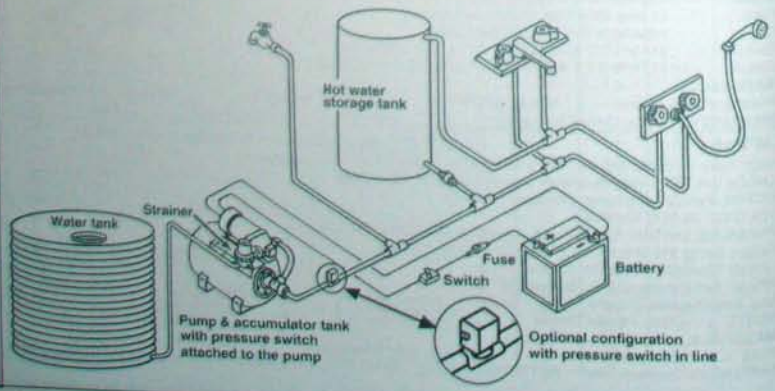
It is recommended to have at least a 10 litre accumulator (pressure) tank to provide a more even and constant pressure and to reduce wear of the integrated automatic pressure switch in the pump. The accumulator tank enables the pump to cope with a slow flow rate, such as when a tap is on partially and with a float valve when it is close to turning off. Without an accumulator tank the pump would switch on and off very rapidly.

It is also recommended to use a strainer or filter to prevent damage to the pump and to use 25mm (¾") water pipe or larger to guarantee a good delivery rate.

The pump chosen for the following pressure systems kit is the Flojet 'Quad' 4325 pump. The 'Quad' pump was chosen because of their 4 chambers which allow a smooth pumping action and quiet operation. The pressure system kits include all the required nuts, bolts, pipe fittings and flexible hose. The pump (with strainer) and 25 litre pressure tank need to be purchased separately.

- Refer to page 94 for the Cat.# and pump specifications.
- Please note that the pump is available in 12 volt or 24 volt.

25 Litre Pressure Tank
Cat.# PMP-012



Solar Pumps

Maximum Power Utilised

Water pumping is exceptionally well suited to a solar power source. The more sun you get, the more water is pumped. This natural match between supply and demand is the answer to many farmer's water supply needs. Using other energy sources usually involve greater installation costs, running costs and/or maintenance:

1. Windmills, which historically have been the popular pumping method in rural Australia, are subject to "wind droughts", often during hot summer periods when the demand for water is at its peak.
2. Diesel or petrol driven pumps require constant maintenance and fuel.

Other advantages of solar pumping systems include:

- Ease of installation
- Moderate total system cost
- Long Life
- Low Maintenance
- Wide range of heads and flows
- High reliability
- Can be designed for easy relocation (if necessary).

Solar panels are maintenance free with a life expectancy of over 25 years. Occasional rain usually provides adequate cleaning of dust from the panels.

The solar modules do not need full sun to pump water. Modern electronics maximises the use of the available energy throughout the day and maintains pumping under reduced sun conditions. The electronic Maximizer installed between the solar array and the motor increases water pumping output by at least 40% and up to 100% where high starting torques are often encountered. The voltage and current of the solar array are transformed by the Maximizer to the current level demanded by the motor. The available power (watts) remains virtually the same as that produced by the panels, but the combination of voltage and amperage are adjusted to suit the motor. The amperage can be increased by reducing the voltage or vice versa.

With a Maximizer the pump starts earlier in the morning and works later in the afternoon. If a cloud temporarily blocks the sun the pump may only slow down rather than stop.

By combining the solar array and Maximizer with the pump that best suits the requirements of the particular pumping situation, the efficiency is further improved. For example:

Positive displacement pumps driven by low voltage DC permanent magnet motors are well suited to use the available power efficiently, and their efficiency increases with static head since more of the power is utilised to "lift" the water and less to supply the motor/pump losses. Piston pumps, diaphragm pumps and helical rotor pumps are examples of positive displacement pumps.

Solar Bore Pumps

SHURflo 9325 solar powered submersible pumps are rugged, durable and ideal for remote homes and cabins, irrigation, livestock watering and ponds.

The SHURflo 9325 DC pump design features:

- Works from solar modules without battery storage via a Pumping Maximizer **(Cat.# REG-111)**.
- Fits in 4" or larger well casing.
- Lightweight (2.7 kg) strong construction.
- Corrosion proof housing with stainless steel fasteners.
- Dry running capability without pump damage.
- Internal bypass feature for pump protection.
- Hard wearing 'santoprene' diaphragms.
- Heavy duty motor.
- Easy to service.

Stainless Steel Drop Cable is available at cut lengths. Delivery pipe and power cable not included.

Pump Specifications:

RPC Cat.#	PMP-004
Model #	9325-043-101
Pump Design	Positive Displacement 3 chamber diaphragm pump
Cam	3°
Motor	Permanent Magnet Thermally Protected
Voltage	24V DC Nominal
Amps	4 Amps Maximum
Internal Bypass	105 – 110 PSI Max.
Maximum Lift	70 metres
Max. Submersion	30 metres
Outlet Port	¼" barbed fitting for ½" ID tubing
Inlet	50 mesh stainless steel screen
Materials	high strength engineered plastics, s/s fasteners
Weight (Net)	2.7 kgs

Recommended Solar Number & Size	Recommended Optimum Vertical Lift	
	Lift in Metres	Litres per Hour
2 × 40W	18	400
2 × 50W	10	500
2 × 50W	30	360
2 × 50W	60	180
2 × 80W	10	630
2 × 80W	25	500
2 × 80W	50	400
2 × 80W	70	300

continued from previous page

System #	870015	870025	870034	870044	870055	870065	870075	870084	870094	870105	870115	870124
Pump Model	SD12-30	SD12-30	SD6-35	SD3-70	SD12-30	SD12-30	SD12-30	SD3-70	SD6-35	SD12-30	SD12-30	SD3-70
Total Delivery Head	1xKC60H	1xKC60	1xKC80H	1xKC80H	2xKC60H	2xUS64	2xKC80	2xKC60H	2xKC80H	3xKC60H	3xKC80	3xKC60H
5	2640	2940	1440	1050	4860	4860	4860	1840	2520	6480	6480	2450
10	2460	2760	1320	1020	4650	4650	4650	1770	2460	6200	6200	2360
15	2160	2520	1260	960	4440	4440	4440	1740	2340	5920	5920	2320
20		2280	1200	900	4200	4200	4200	1680	2310	5600	5600	2240
25		2100	1080	870	3900	3960	3980	1620	2220	5200	5280	2160
30			1000	840	2760	3120	3780	1560	2100	3680	5040	2080
35				800				1470	2040			1960
40				780				1440				1920
50								1380				1840
60	Performance Data in Litres per Day							1290				1720
70	Based on 6 Peak Sun Hours Insolation							1200				1650

Note: The number in superscript at the end of the System # denotes the bore diameter. All the System #s followed by [9] require a 5 inch diameter bore.

In most areas the output will be about 20% higher than indicated in summer and less in winter.

Lorentz PS200 Mini

"The World's Most Economical Solar Pump"

A Revolution in Solar Pumping

We call it "Mini" though it gives water for... 150 cattle, 200 camels, 650 pigs, 1,000 sheep or 32,000 chickens.

That's what you can do with 6,000 litres of water on a summer day. Far away from the utility grid, PS200 Mini brings up more water for your live stock, irrigation, or your remote residence than any other pump of comparable size.

Thanks to its superior and reliable technology, the efficiency of PS200 Mini is higher than that of any other solar pump in the market. Compare yourself! The Mini Workhorse delivers 6,000 litres 15 m high with a 150 Wp array. With just 120 Wp PS200 Mini transports 2,200 litres of water from a depths of 30 m.

(*Figures based on 5.5 Peak Sun hours per day, array losses due to high temp. & dirt as well as cable losses included in our table)

You only want to install 80 Wp? PS200 Mini manages to push over 2,000 litres over 20 m vertical lift and through a 3 km long 1" pipeline!

Our helical rotor pump is known as a very simple and reliable pump. It just consists of a rotor and a stator. The motor is as simple as a conventional AC motor, water filled and without any brushes!

Lift from as deep as 50 m (165 ft)

Maximum 10 m per day (3,785 US-Gal.)

Mini eliminates the costs of fuel, delivery, engine maintenance, and pollution.

In many cases it is LESS COSTLY than a conventional pump and generator installation.

Great reliability and life expectancy.

Helical Rotor wet end, brushless motor (maintenance free).

High resistance to sand and corrosion.

Fits 4" and larger well casings.

Wide voltage range for 24 to 48 V systems (2-4 solar modules in series). Only one controller for solar direct or battery systems.

DIRECT REPLACEMENT for SOLAR DIAPHRAGM PUMPS

Mini can replace less reliable diaphragm pumps, to eliminate frequent repairs, and to increase the water production, too. In most cases, you can use the existing solar array. Refer to the performance table, and compare the solar (minimum PV watts) requirement with the existing equipment.

HIGH EFFICIENCY = LOWER COST

Mini pumps more water per watt than other solar pumps and KEEPS IT UP year after year.

RELIABLE AND MAINTENANCE-FREE

Mini eliminates the weakest links in solar pumping by using a helical rotor (progressing cavity) pump and a brushless, water-filled motor - No failure-prone diaphragms, no flooded-motor failures.

Mini INCLUDES:

- Pump
- Pump controller
- Submersible cable splice kit
- Low-water probe
- Complete illustrated instruction manual

Pump: 3-phase brushless DC-motor on bottom, helical-rotor pump head and check valve on top.

Typical model shown.

Controller: Maximum power tracking, 3-phase variable speed controller in sealed plastic housing.

NO ONGOING HASSLES:

NO annual diaphragm replacement
NO motor brush replacement
NO delicate plugs that fail
NO pistons, cams, flapper valves
NO plastic parts
NO electronics in the wells

DEEP WELL APPLICATIONS

Mini can be submersed as deep as necessary. Submersion depth does not affect the performance or place additional stress on the pump or motor.

SURFACE WATER APPLICATIONS

Mini can be installed in a stream, pond, tank or shallow well, in any position.

DRY RUN PROTECTION

A low water probe (included) turns pump off to prevent dry-run damage. Reset is automatic after 20 minutes. The PS200 Controller has an RPM limit adjustment to reduce the maximum flow rate to about 50 %, to help match a limited water source.

SAND AND SILT TOLERANCE

Mini has high resistance to wear from sand, clay, etc. that may occur in a properly constructed water well. However, a concentration of solids greater than 2% (by volume) may cause blockage in the pump or the drop pipe, especially at low flow rates. Do not use Mini to clean out a dirty well.

CONTROLLER DISPLAY

Lights indicate: system on, pump on, tank full, water source low, overload, and battery low.

STORAGE REQUIREMENT

A storage tank (not included) should be sized to supply a minimum of 5- 10 days' water supply, depending on climate and application. Water storage is generally more economical than energy storage in batteries.

Lorentz PS200 onthued

BATTERY SYSTEMS

LOW-VOLTAGE DISCONNECT prevents battery damage from over-discharge. This feature is included in the controller. Disconnect - Reconnect 22V-26V and 44V-48V.

DROP PIPE

Pump has G1¼" (optionally 1" NPT) outlet. If water is dirty, consider a smaller size drop pipe to increase the flow velocity. This helps exhaust solid particles and prevent accumulation in the pipe. When considering reduced pipe size, consult a pipe sizing (friction loss) chart. Pipe can be of any standard material, rigid or flexible. A torque arrestor is NOT required.

PUMP CABLE and SPLICE

The pump requires standard submersible cable, 3-wire + ground (total 4 wires). Connection to the pump is made using industry-standard splicing methods. A splice kit is included.

DIMENSIONS & WEIGHTS

PUMP & MOTOR

Diameter: 96 mm (3.78")
Height: 500-800 mm (20" - 32") depending on model
Weight: 11.5 kg (25 lbs) or less, depending on model

CONTROLLER

Controller: 260 x 175 x 100 mm (10" x 7" x 4")
3 conduit holes: ½", ¾", and 1¼" nominal pipe
Weight: 1.5 kg (3.6 lbs)
Enclosure: gasket-sealed, weatherproof

WETTED MATERIALS

316 stainless steel, chromium, NBR rubber, natural rubber, POM, polyurethane (cable).

TEMPERATURE LIMITS

Pump: water temp. 130° C to 28° C (55° F to 82° F)
Other ranges are available, please indicate.
Controller: Ambient -30° C to 55° C (-22° F to 131°)

NEED MORE WATER or GREATER LIFT?

Consider the standard System PS600 or PS1200 the instead of the PS200 Mini system. These systems use more power, to pump as high as 230m (750 ft) or to produce a maximum of 120 m³ per day (34,000 US gallons). They are also appropriate for pressurizing applications. Request separate specification sheets.

DOUBLE SYSTEM

Two pump systems can be installed in the same water source if the well casing is not less than 6" inside diameter. This doubles the daily water volume.

INSTALLATION

Install the pump by the same methods and materials used for conventional submersible pumps. The solar array requires nuts-and-bolts assembly and standard wiring practice. The PS200 Mini instruction manual is clearly illustrated. No special product training is required.

WARRANTY

TWO YEAR manufacturer's warranty against defects in materials and workmanship.

PS200 for 24V Battery

Total Lift (m)	Model #	Flow (L/minute)	Power (Watts)	Cable Size (mm²)
5	HR-04	5.5	24	2.5
	HR-07	7.5	37	2.5
	HR14	17.5	40	2.5
10	HR-04	5.2	29	2.5
	HR-07	7.5	42	2.5
	HR-14	16.6	55	2.5
15	HR-04	4.8	34	2.5
	HR-07	7	50	2.5
	HR-14	15.2	74	2.5
20	HR-04	4.5	38	2.5
	HR-07	6.5	60	2.5
	HR-14	12.5	91	2.5
30	HR-04	4.2	48	4
40	HR-04	3.8	58	4
50	HR-04	3.3	65	4

PS200 for 48V Battery

Total Lift (m)	Model #	Flow (L/minute)	Power (Watts)	Cable Size (mm²)
5	HR-04	11	55	2.5
	HR-07	17	90	2.5
	HR14	38.4	130	2.5
10	HR-04	10.3	70	2.5
	HR-07	16.5	100	2.5
	HR-14	36.1	165	2.5
15	HR-04	10.1	80	2.5
	HR-07	15.8	115	2.5
	HR-14	35	195	2.5
20	HR-04	9.8	90	2.5
	HR-07	15.5	135	2.5
30	HR-04	9.3	105	4
	HR-07	14.2	160	4
40	HR-04	8.7	125	4
	HR-07	13.5	190	4
50	HR-04	7.8	140	4
60	HR-04	7.2	160	4

PS200 for 24V Solar Direct @ 5 PSH

Total Lift (m)	Model #	Peak Flow (L/minute)	PV (Watts) 80 L/day	120 L/day	150 L/day	Cable Size (mm²)
5	HR-04	7.2	2850	3150	3400	2.5
	HR-07	13	3000	4750	5850	2.5
10	HR-04	6.5	2650	2950	3300	2.5
	HR-07	13	2800	4100	4800	2.5
15	HR-04	6	2350	2750	3200	2.5
	HR-07	12	2500	3900	4550	2.5
20	HR-04	5.8	1950	2450	3050	2.5
	HR-07	12	1750	3150	4300	2.5
25	HR-04	5.7	1650	2250	2850	4
30	HR-04	5.5	1350	2000	2550	4
40	HR-04	5.1	N/A	1500	2150	4

Note: For roughly double the daily flow and up to 50m lift consider 48V Solar Direct. Contact Rainbow Power Company for more details.

Lorentz PS600 & PS1200

"Lorentz: The World's Most Economical Solar Pump"

RELIABLE AND MAINTENANCE-FREE

PS600 eliminates the weakest links in solar pumping by using helical rotor (progressing cavity) and centrifugal pump ends and a brushless and water-filled motor.
No failure-prone diaphragms, no flooded-motor failures and no electronics in the well!

- Lift from as deep as 230 m (750 ft)
- Max. 100 m³ per day for PS600 and 135 m³ for PS1200
- Eliminates the costs of fuel and engine maintenance.
- Eliminates engine noise and pollution
- In many cases it is LESS COSTLY than a conventional pump and generator installation
- Great reliability and life expectancy
- High resistance to sand and corrosion
- Fits 4" and larger well casings
- Wide voltage range for:
  PS600: 48V to 72V systems (4-6 solar modules in series)
  PS1200: 72V to 96V (6-8 solar modules in series)
- Only one controller for solar direct or battery systems

DEEP WELL APPLICATIONS

The pump can be submersed as deep as necessary. Submersion depth does not affect the performance or place additional stress on the pump or motor.

SURFACE WATER APPLICATIONS

The pump can be installed in a stream, pond, tank or shallow well, in any position.

DRY RUN PROTECTION

A low water probe turns pump off to prevent dry-run damage. Reset is automatic after 20 minutes. The PS600 Controller has an RPM limit adjustment to reduce the maximum flow rate to about 50%, to help match a limited water source.

SAND AND SILT TOLERANCE

The pump has high resistance to wear from sand, clay, etc. that may occur in a properly constructed water well. However, a concentration of solids greater than 2% (by volume) may cause blockage in the pump or the drop pipe, especially at low flow rates. Do not use the pump to clean out a dirty well.

CONTROLLER

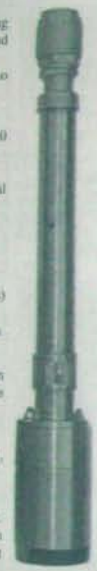
MPPT, well probe and float-/remote switch terminals. Lights indicate: system on, pump on, pump speed, tank full, water source low, overload, and battery low. Protected against reverse polarity, overload and high temperature.

BATTERY SYSTEMS

LOW-VOLTAGE DISCONNECT prevents battery damage from overdischarge. This feature is included in the controller.
Disconnect - Reconnect 44V-52V for PS600
Disconnect - Reconnect 88V - 104V for PS1200

STORAGE REQUIREMENT

A storage tank (not included) should be sized to supply a minimum of 5-10 days' water supply, depending on climate and application. Water storage is generally more economical than energy storage in batteries.



DROP PIPE

G 1¼" (optimally 1" NPT) pump outlet. If water is dirty, consider a smaller size drop pipe to increase the flow velocity. This helps exhaust solid particles and prevent accumulation in the pipe. When considering reduced pipe size, consult a pipe sizing (friction loss) chart. Pipe can be of any standard material, rigid or flexible. A torque arrestor is NOT required.

PUMP CABLE and SPLICE

Standard submersible cable, 3-wire + ground (total 4 wires). Connection to the pump is made using industry-standard splicing methods.

NEED MORE WATER?

Consider the PS1200 system. This system uses more power than the PS600, to pump as high as 230m and as much as 135m³ per day.

DOUBLE SYSTEM

Two pump systems can be installed in the same water source if the well casing is not less than 6" inside diameter. This doubles the daily water volume.

INSTALLATION

Install the pump by the same methods and materials used for conventional submersible pumps. The instruction manual is clearly illustrated. No special product training is required.

DIMENSIONS & WEIGHTS

PUMP & MOTOR
Diameter: 96 mm (3.78")
Height: 500-800 mm depending on model
Weight: 11.5 kg or less, depending on model

CONTROLLER
Controller: 425 x 175 x 150 mm
3 conduit holes: ½",¾", and ¼"nominal pipe
Weight: 4.8 kg
Enclosure: gasket-sealed, weatherproof

WETTED MATERIALS

316 stainless steel, chromium, NBR rubber, natural rubber, POM, polyurethane (cable)

TEMPERATURE LIMITS

Pump: water temp. up to 40° C
Specify temperature range on order
Controller: Ambient -30° C to 55° C

WARRANTY

TWO YEAR manufacturer's warranty against defects in materials and workmanship.

Lorentz PS600 Daily Flow Chart for solar direct operated pumps

Calculated on 6 kWh/m²/day

System Voltage: 48 - 72V nominal, eg 4 to 6 standard 12V modules wired in series.
C-xx = Centrifugal pump end HR-xx = Helical Rotor pump end

How to select the right pump system:
Find the LIFT you require, and read the column below.
Find the DAILY VOLUME you require. For more water look further down the column, ...or to the right side for tracked systems.
Use the PEAK FLOW RATE for pipe sizing.

PEAK FLOW RATE for pipe sizing

Type	m³/h	Type	m³/day
HR-03H	0.5	HR-14	2.7
HR-04/H	.08	HR-20	3.6
HR-07	1.2	C-BF-04	7.3
HR-10	1.9	C-DF-03	10.2

Pump Output to 5 metres

Watt	Pump Type	m³/day
240	C-BF-04	28
300	C-BF-04	35
350	C-BF-04	42
480	C-BF-04	50
600	C-BF-04	64
720	C-BF-04	70

Pump Output to 10 metres

Watt	Pump Type	m³/day
240	HR-14	17
300	HR-14	19
350	HR-14	22
480	HR-20	30
600	C-BF-04	42
720	C-BF-04	50

Pump Output to 15 metres

Watt	Pump Type	m³/day
240	HR-14	16
300	HR-14	19
350	HR-14	22.5
480	HR-20	27
600	HR-20	30
720	C-BF-04	36

Pump Output to 20 metres

Watt	Pump Type	m³/day
240	HR-14	12.6
300	HR-14	15
350	HR-14	18
480	HR-14	22
600	HR-20	25
720	HR-20	29

Pump Output to 30 metres

Watt	Pump Type	m³/day
240	HR-04	6.7
300	HR-04	7.5
350	HR-14	14
480	HR-14	18
600	HR-14	22
720	HR-20	25

Pump Output to 40 metres

Watt	Pump Type	m³/day
240	HR-04	5.5
300	HR-04	6.2
350	HR-04	6.9
480	HR-14	14
600	HR-14	17
720	HR-14	20

Pump Output to 50 metres

Watt	Pump Type	m³/day
240	HR-04	5
300	HR-04	5.5
350	HR-04	6
480	HR-14	11
600	HR-14	14
720	HR-14	17.8

Pump Output to 60 metres

Watt	Pump Type	m³/day
240	HR-04	3.9
300	HR-04	4.7
350	HR-04	5.8
480	HR-07	8.6
600	HR-07	9.5
720	HR-07	11

Pump Output to 70 metres

Watt	Pump Type	m³/day
350	HR-04	4.7
480	HR-04	6
600	HR-07	9.4
720	HR-07	10.2

Pump Output to 80 metres

Watt	Pump Type	m³/day
350	HR-03	3.8
480	HR-04H	5.7
600	HR-07	8.4
720	HR-07	9.4

Pump Output to 90 metres

Watt	Pump Type	m³/day
350	HR-03	3.5
480	HR-04H	4.8
600	HR-07	7.2
720	HR-07	8.7

Pump Output to 110 metres

Watt	Pump Type	m³/day
350	HR-03	3.1
480	HR-04H	5
600	HR-04H	5.7
720	HR-04H	6

Calculations are based on Uni-Solar panels. Flow rates may vary ±10%. All systems are selected for optimum performance. Each system can handle an additional 15% in case of unexpected draw-down in bore.
Use ET4/Track solar trackers to reduce your system cost or increase daily flow.
For battery-powered pumping systems:
48V systems use PS600 and 24 to 48V use the PS200 system
For other lifts and voltages consider PS1200 or PS200 system

48V Battery Performance

Total Lift (m)	Pump Model	Litres/Minute	Watts	Cable Size (mm²)
5	C-BF-04	110	480	6 mm² - 80m
5	HR04	40	140	2.5 mm² - 50m
5	HR-14	90	320	4 mm² - 80m
5	HR-14	100	350	4 mm² - 80m
10	C-BF-04	100	480	2.5 mm² - 35m
10	HR04	40	140	2.5 mm² - 50m
10	HR-14	90	320	4 mm² - 50m
10	HR-14	100	350	4 mm² - 50m
15	C-BF-04	90	480	4 mm² - 50m
15	HR04	40	140	2.5 mm² - 50m
15	HR-14	80	280	4 mm² - 50m
15	HR-14	90	320	4 mm² - 50m
20	HR-14	80	280	4 mm² - 50m
20	HR-14	90	320	4 mm² - 50m
25	HR-14	70	250	4 mm² - 50m
25	HR-14	80	280	4 mm² - 50m
30	HR-14	70	250	4 mm² - 50m
30	HR-14	80	280	4 mm² - 50m
40	HR-14	60	210	4 mm² - 50m
40	HR-14	70	250	4 mm² - 50m
50	HR-14	60	210	4 mm² - 50m
50	HR-14	70	250	4 mm² - 50m
60	HR-14	50	180	10 mm² - 100m
60	HR-14	60	210	10 mm² - 100m
70	HR-14	50	180	10 mm² - 100m
70	HR-14	60	210	10 mm² - 100m
80	HR-14	50	180	10 mm² - 100m
80	HR-14	60	210	10 mm² - 100m
90	HR-14	50	180	10 mm² - 100m
90	HR-14	60	210	10 mm² - 100m
100	HR-14	50	180	10 mm² - 100m
100	HR-14	60	210	10 mm² - 100m
110	HR-14	50	180	10 mm² - 100m
110	HR-14	60	210	10 mm² - 100m
120	HR-14	50	180	10 mm² - 100m
120	HR-14	60	210	10 mm² - 100m
130	HR-14	50	180	10 mm² - 100m
130	HR-14	60	210	10 mm² - 100m
140	HR-14	50	180	10 mm² - 100m

Lorentz PS1200 Daily Flow Chart for solar direct operated pumps

Calculated on 6 kWh/m²/day

System Voltage: 72 - 96V nominal, eg 6 to 8 standard 12V modules wired in series.
C-xx = Centrifugal pump end
HR-xx = Helical Rotor pump end

How to select the right pump system:
Find the **LIFT** you require, and read the column below.
Find the **DAILY VOLUME** you require. For more water look further down the column, ...or to the right side for tracked systems.
Use the **PEAK FLOW RATE** for pipe sizing.

PEAK FLOW RATE for pipe sizing

Type	m³/h	Type	m³/day
HR-03H	0.5	HR-14	2.7
HR-04/H	.08	HR-20	3.6
HR-07	1.2	C-BF-04	7.3
HR-10	1.9	C-DF-03	10.2

Pump Output to 5 metres

Watt	Pump Type	m³/day
350	C-BF-04	42
480	C-BF-04	52
720	C-BF-04	70
840	C-BF-03	77
1000	C-BF-03	85
1200	C-BF-03	95

Pump Output to 10 metres

Watt	Pump Type	m³/day
350	HR-14	22
480	HR-20	30
720	C-BF-04	50
840	C-BF-04	55
1000	C-BF-03	72
1200	C-BF-03	80

Pump Output to 15 metres

Watt	Pump Type	m³/day
350	HR-14	22.5
480	HR-20	27
720	C-BF-04	36
840	C-BF-04	41
1000	C-BF-04	48
1200	C-BF-04	53

Pump Output to 20 metres

Watt	Pump Type	m³/day
350	HR-14	18
480	HR-14	22
720	HR-20	29
840	HR-20	32
1000	C-BF-04	42
1200	C-BF-04	47

Pump Output to 30 metres

Watt	Pump Type	m³/day
350	HR-14	14
480	HR-14	18
720	HR-20	25
840	HR-20	27
1000	HR-20	31
1200	HR-20	33

Pump Output to 40 metres

Watt	Pump Type	m³/day
350	HR-04	6.9
480	HR-14	14
720	HR-14	20
840	HR-14	22.5
1000	HR-20	25
1200	HR-20	27

Pump Output to 50 metres

Watt	Pump Type	m³/day
350	HR-04	6
480	HR-07	11
720	HR-14	17.8
840	HR-20	19
1000	HR-20	21
1200	HR-20	22

Pump Output to 60 metres

Watt	Pump Type	m³/day
350	HR-04	5.6
480	HR-07	8.6
720	HR-07	11
840	HR-10	14
1000	HR-14	17
1200	HR-14	18

Pump Output to 70 metres

Watt	Pump Type	m³/day
350	HR-04	4.7
480	HR-07	6
720	HR-07	10.2
840	HR-07	10.5
1000	HR-10	14
1200	HR-10	15
1500	HR-14	17

Pump Output to 80 metres

Watt	Pump Type	m³/day
350	HR-03	3.8
480	HR-04H	5.7
720	HR-07	9.4
840	HR-07	10
1000	HR-10	13
1200	HR-10	14
1500	HR-10	16

Pump Output to 90 metres

Watt	Pump Type	m³/day
350	HR-03	3.5
480	HR-04H	5.5
720	HR-07	8.7
840	HR-07	9.4
1000	HR-07	10
1200	HR-07	11

Pump Output to 120 metres

Watt	Pump Type	m³/day
350	HR-03	3
480	HR-04H	4.5
720	HR-04H	5.7
840	HR-07	7.2
1000	HR-07	8.5
1200	HR-07	9.5

Pump Output to 140 metres

Watt	Pump Type	m³/day
350	HR-03	2.7
480	HR-03	3.3
720	HR-04H	5.3
840	HR-04H	6
1000	HR-04H	6.5
1200	HR-04H	7

Pump Output to 160 metres

Watt	Pump Type	m³/day
480	HR-03H	2.8
720	HR-03H	4

Pump Output to 180 metres

Watt	Pump Type	m³/day
480	HR-03H	2.3
720	HR-03H	3.5

Pump Output to 200 metres

Watt	Pump Type	m³/day
480	HR-03H	1.9
720	HR-03H	3.2

Pump Output to 230 metres

Watt	Pump Type	m³/day
480	HR-03H	1.6
720	HR-03H	3

Glockemann

Water Powered Pump

Revolutionary technology which, for the first time allows pumping of water using very low supply heads - 0.6 metre supply drop can deliver 3,000 litres per day to a head of 25 metres.

This Australian designed and manufactured product uses the energy of water falling only a short distance to power a diaphragm piston pump. The **Glockemann Water Pump** is highly efficient, runs silently and is simple to operate and maintain, even for non technical users. Manufactured from heavy guage galvanised steel and stainless steel. The pump incorporates a shut off mechanism which prevents damage by severe flooding and also prevents the pumping of heavily silted water.

Parts

All nuts, bolts and springs are of stainless steel. The diaphragm rubber is the exact consistency of tractor or truck inner tube and can easily be replaced by cutting one from a used truck or tractor tube. The leather piston cups are stock sizes and are obtainable from any irrigation supplier. Both diaphragm rubbers and piston cups are available from the Rainbow Power Company.

- **Water Powered:** needs no fuel or electricity, just a creek or stream.
- **Low Supply Head**: as low as 0.6 metre.
- **High Delivery Head**: up to 200 metres or more.
- **Quiet**: no mechanical noises, no metal to metal action.
- **Runs Reliably**: 24 hours per day, 7 days per week with no attention.
- **Built to Withstand Heavy Flooding**.
- **Easy Installation**: needs no concrete mounting, uses PVC drive tubes.
- **Requires Minimal Maintenance**.
- **Versatile**: no need for straight drive tubes, use 45°, 90° or 30° elbows to suit your site.
- **Automatic Flood Shut Off**: prevents polluted water being pumped to the tank, restart with the flick of a switch.
- **Adjustable Throttle**: in dry times just turn it down, as low as 25% capacity.
- **Low Flow Rate**: as little as 1 litre per second.

Length of Drive Pipe:
The drive pipe must not be less than 4 times the drive head.
Note: For more detail regarding head, flow, drive pipe diameter/length and supply pipe diameter/length refer to Installation Guide or contact Rainbow Power Company.

Glockemann Model	Supply Rate Litres/sec	Drop in Metres	Drive Pipe Size	Delivery Height (metres) - Output (Litres per day) 5m	10m	20m	30m	50m	75m	100m	150m	200m
Oasis 120 Cat # PMP-120	8	1.8m	150mm									
	5.5	1.8m	100mm									
	5	1.6m	100mm									
	7.5	1.4m	150mm									
	5	1.4m	100mm									
	7	1.2m	150mm									
	4.5	1.2m	100mm									
	7	1.0m	150mm									
	4.5	1.0m	100mm									
	8	0.8m	150mm									
	4	0.8m	100mm									
	5.5	0.6m	150mm									
	4	0.6m	100mm									
	5	0.4m	150mm									
	3.5	0.4m	100mm									
	4.5	0.3m	150mm									
Water Dragon 160 Cat # PMP-160	1	3.0m	Refer to Installation Guide for Details									
	1.3	2.5m										
	1.2	2.0m										
	1.4	1.5m										
	1.7	1.2m										
	1.0	1.0m										
	1.4	0.8m										
	1.4	0.6m										
	1.4	0.4m										

Not Recommended

Litres per day / 24 hours

Bore Diameters Oasis: d=75mm, e=86mm, f=98mm, g=124mm

Bore Diameters Both Models: p=75mm, q=48mm, r=60mm

Rainbow Fountain Kit

Cat.# PMP-001

Quality Kit:
incorporates all high quality components:

- 22W Photowatt solar module
- 10 year warranty on module
- solar module design life exceeds 25 years
- pump maximiser ensures optimum pumping efficiency
- brushless pump motor with magnetic drive
- 2 year warranty on pump
- pump design life of 15,000 hours (5 to 6 years at 7 hours/day)
- pump delivers 13 litres/minute at 1 metre head or 5 litres/minute at 1.5 metre head in full sun
- consumes 1.3 amps at 12 volts

Note: This pump is not a submersible pump, nor is it self priming.

Connecting the pump:
The blue wire from the pump connects to M+ on the optimiser and the black wire from the pump connects to M – on the optimiser. The S+ on the optimiser connects to the positive output on the solar module and S– on the optimiser connects to the negative output of the solar module.

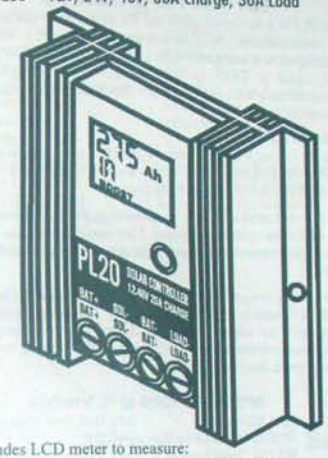
The kit does not include:

- the cable that goes between the solar module to the optimiser. Let us know what length of cable you need and we can supply it. The connectors will take up to 3 mm² cable. Keep the pump and optimiser within 10 metres of solar module if using 2.9mm² and 6 metres if using 1.84mm².
- a basin. Basins and Flow Forms are available from Hardware Shops and Landscaping Suppliers.
- spray nozzle or jet and plumbing to recycle the water. Hoses for the pump are available from Auto Parts outlets and are standard heater hose size. Other plumbing supplies are available from Hardware Shops.

Regulators and Control Boards

PLASMATRONICS PL Series Battery Charge Controllers

PL20 – 12V, 24V, 48V, 20A Charge, 20A Load
PL40 – 12V, 24V, 48V, 40A Charge, 7A Load
PL60 – 12V, 24V, 48V, 60A Charge, 30A Load



Includes LCD meter to measure:

- Battery voltage
- Charge current
- Load current
- Charge amp-hours
- Load amp-hours
- Battery temperature
- Daily maximum and minimum battery volts
- Data is kept for last 32 days.

The PL Series Regulators control the charging of batteries from photovoltaic solar panels. These regulators are primarily designed to protect the battery bank from overcharging but will also either protect or warn against over discharge depending on how the regulator is installed.

The PL controller can be used with other energy sources such as wind, micro-hydro and fuel driven generators by choosing the appropriate regulation method. The PL can support a variety of regulation methods including slow speed switching and fixed frequency pulse width modulation (PWM) in series and shunt modes.

The PL regulator allows thorough monitoring of your power system with all the necessary metering and data logging capabilities provided. The PL regulator has a very low current drain. With the addition of an optional serial interface adaptor and a modem, the system performance can be checked from a distant location and all settings adjusted remotely.

All settings on the PL regulator are adjustable via the front panel or a personal computer connection. The PL regulator can even be used to turn lights, pumps, sprinklers, back-up generator or even a micro-hydro on and off. The PL can dissipate surplus energy by turning a load on (eg a pump) when the battery is full, start up a back-up generator when the battery is low, avoid turning a generator on between specified times or turn security lights or sprinklers on and off at predetermined times.

Advantages of PL Series Regulators:

Versatility – One unit, thousands of applications.
Upgradeable – The same unit will do 12V, 24V and 48V.
Timing Function – Can be used like a domestic electric time switch.
Battery Gauge – Battery state of charge estimator.
Generator Control – Can turn a generator on and off according to battery voltage, estimated state of charge and time.
Low Battery Voltage Load Disconnect – Can be used to help prevent excessive discharge of battery bank.
Computer Interface Option – Can communicate with a computer or modem via an optional serial interface adaptor.
Inverter Metering – Optional external load shunt can be added to measure inverter power draw.

Features:

- Manually select 12V, 24V or 48V system voltage.
- Short circuit and reverse flow protection without fuses or blocking diodes.
- Reverse battery polarity protection.
- External temperature sensor can be attached.
- Full rate current at 55°C – tropics & outback friendly.
- Terminals accept 25mm² cable.
- Input sense for transmission loss correction.
- System performance data kept for last 32 days is not lost if the power is disconnected.

Plasmatronics Regulator Interfaces

PLS

Shunt Adapter for PL Regulators

The Plasmatronics PL regulators are able to log all incoming and outgoing currents to and from your battery bank. If you have large DC loads or inverters you will need a PLS shunt interface and an external shunt in order for the regulator to monitor them. The shunt interface and shunt is also recommended if you sometimes charge your battery with a generator.

Loads & Battery Gauge

The PLS is a shunt adapter that interfaces with the PL regulator so that the regulator can monitor everything going in and out of the battery bank and give you a complete picture of your power system including amp-hours drawn out of the battery bank each day and the state of charge of the battery bank. You don't have to do any calculations to figure out how much power you have used and how full your batteries are – you just consult the regulator.

Without the PLS the PL20 can only monitor 20 amps of DC load from the load terminal and the PL40 and PL60 can only monitor 7 amps and 30 amps respectively. This means that if you have DC loads or inverter loads that draw more than this on the DC side you cannot connect them to the load terminal and the regulator isn't able to monitor them unless they are measured by an appropriate shunt connected to the shunt interface.

The shunts are available in 100 amp and 200 amp versions, depending on how large a load you have. You can connect two shunts to one shunt interface or have two shunt interfaces each monitoring separate shunts. You can have one shunt dedicated to an inverter and another shunt monitoring another incoming source such as a battery charger powered by a generator. Contact the staff at Rainbow Power Company for more details.

PLI

RS232 Computer Interface for PL Regulators

The PLI is a device to allow the PL series solar controllers to communicate with a computer. The PLI can be connected to a computer with a standard IBM serial cable and using a DOS or a Win 95/98/NT program to communicate with the PL controller. You can also connect a modem to the PLI.

Description

The PLI is an RS232 interface for PL series regulators. It allows data communication between a computer and the regulator (via a modem if necessary).

To prevent problems due to ground potential differences, the PLI uses optical coupling. This means that there is no electrical connection between the computer side and the PL side.

The energy to operate the PL side is drawn from the battery bank connection of the PL controller The energy required to operate the computer side is drawn from the computer serial port connection. A small amount of power will be drawn from the computer.

SPECIFICATIONS of PL Interface

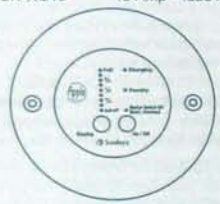
Line Speeds:	300, 1200, 2400, 9600 Baud
RS232 Input Levels:	>+/- 5V
RS232 Drive Levels:	>+/- 5V
Min Load Impedance:	3K
Output impedance TX:	300 ohm
DC Isolation:	500V
Temperature range:	-20°C to +70°C
Supply Current:	10mA (from PL supply) 1.5mA on RS232 side
Supply Voltage:	10V to 100V

Sundaya Apple Charge Controllers

The Apple is a PWM charge discharger regulator with a unique battery forced health improvement feature (FHI©). The Apple is equipped with an alarm to warn the user when battery is close to forced disconnect. The Apple uses latest technology ultra efficient switching components, which results in an extremely low voltage drop and almost no heat generation.

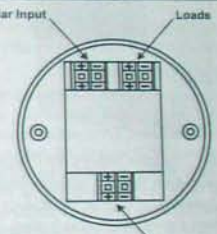
Load Current	15A
Current Consumption	4mA
Display	12 LED's
Maximum Cable	7mm²
Polarity Protection	Yes
Operating Temperature	0 - 40°C
Humidity	10 - 95%
Dimensions	120mm diam. × 40mm
Weight	0.5 kg

Cat.# SUN-RG05	5 Amp with 1.5m battery leads
Cat.# SUN-RG10	10 Amp – lead not supplied
Cat.# SUN-RG15	15 Amp – lead not supplied



Front

Side



Rear

Maximizer

The Maximizer is an electronic device that connects between any Solar Power source and the DC load or battery bank to automatically maximise the electrical power delivered from the panels to the load.

Maximise Solar Efficiency and Reduce Cable Cost when a Long Cable Run cannot be avoided

As the distance between the solar panels and battery bank increases, and the size of the solar array (the number of solar panels and overall wattage) increases, the cost of the connecting cable can become prohibitively expensive. The Maximizer can dramatically reduce the cost of connecting cable between solar panels and battery bank. By placing your solar panels in series to obtain a higher voltage you can reduce your percentage voltage drop over a distance. The Maximizer will then adjust the voltage at the battery bank to the charge level float voltage to which it has been preset.

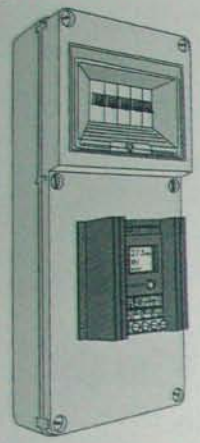
The Maximizer is in effect an electronic gear-box, matching the varying output of the solar array to suit the DC electrical pump or the battery bank.

A pump Maximizer is distinctly different to a battery Maximizer.

For battery charging, the Maximizer will increase the overall average system operating efficiency by up to 15% on the 36 cell solar panels. This is achieved by adjusting the output voltage from the panels to a constant voltage to continue charging at an optimum rate for as long as there is a sufficient solar panel wattage available (eg sufficient sunshine). As blocking diodes are not required with a Maximizer, the gain is further improved by eliminating the diode loss (voltage drop).

All battery charging Maximizers can be used to charge a wide range of battery voltages and feature fully controlled user adjustable float-charge regulation, auto-equalisation / anti-sulphation charging profile, combined with automatic ambient temperature float voltage level compensation. With the use of a Maximizer a solar battery regulator will not be required which is a further saving in system cost.

Rainbow DC Distribution Box



Cat. # REG-L00 (shown with PL-40 Regulator)

The Rainbow Distribution Box is a purpose designed DC power distribution box that is flexible to user requirements, caters for up to 24mm² battery cable and appropriately sized load cables with sufficient space inside of the box for ease of installation and upgrade.

Regulator/Controller Extra

The Distribution Box has sufficient space on the front panel to mount either the Plasmatronic PL Charge Controller (shown in illustration). An appropriate charge controller needs to be selected and purchased separately to complete the full functionality of a renewable (solar, wind and/or micro-hydro) power distribution centre. Because the new range of charge controllers incorporate a display meter there is no need to incorporate meters into the distribution box.

The new range of charge controllers offer a charge input of 12, 20, 30 or 40 amps and all incorporate a LCD display to show battery voltage, charge current as well as battery state of charge or accumulated amp-hours. Refer to pages 104 and 105 for more information.

Please note that a system producing AC as well as DC will require a separate 240V circuit and AC distribution box.

Features:

- Each circuit is protected by a circuit breaker. Three circuits are equipped with multi-hole links. More circuits may be added.
- Spacious, attractive housing designed to incorporate an optional charge controller.
- May be either surface mounted or flush mounted.
- Multiple conduit ports.
- Hinged, lockable door.
- Prewired and labelled for your convenience.
- Meets new Stand-Alone Power System Standard.

Protection

In order to meet safety standards and the Stand-Alone Power System Standard, either the system designer or the installer will need to calculate the appropriate cable sizes to be used for each circuit. The maximum allowable voltage drop for each circuit is as follows:

Solar, wind or hydro to distribution box = 10%
Battery to distribution box = 2%
Distribution box to load = 5%

Cable Size (mm²) = 3.5 × L × I ÷ V ÷ (2 or 5)
where: 2 or 5 refers to allowable voltage drop
L = Route Length (m), I = Current (Amps) and
V = Nominal System Volts (eg 12, 24 or 48)

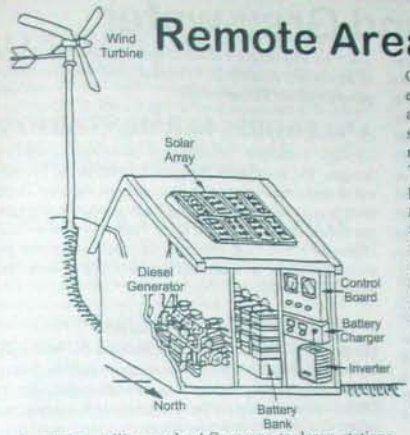
The battery cable needs to be protected with appropriate cartridge type fuse and fuse holder(s) on each active terminal of the battery bank. Considering that the danger of short circuits and resulting fires with battery based power systems originates at the battery, the battery fuse holder(s) need to be mounted on the outside of the battery compartment, below vent level, before the positive and negative battery cables come close to one another or a common electrical conductor.

The purpose of any fuse or circuit breaker in a power distribution system is to protect the cable against electrical overload or short circuit. The circuit breakers provided in the standard Distribution Box are: Solar = 25A, Circuits 1&2 = 20A, Circuits 3&Aux= 10A. In order to either choose the right cable size and fuse or circuit breaker, you can use the following table to make your choice. The value of the chosen fuse or circuit breaker must not be greater than the maximum ampacity of the cable.

Ampacity of DC Cables

Cross Sectional Area	Current (Amps)
1.84mm²	15 amps
2.9mm²	20 amps
4.6mm²	25 amps
7.9mm²	45 amps
13.6mm²	70 amps
32mm²	110 amps
49mm²	150 amps

Remote Area Power Supply



Supplying utility-grade AC power to large stations, remote villages, resorts or commercial enterprises can pose a number of difficulties. Diesel generators have a high running cost as opposed to the high capital cost of installing a large solar array with battery backup. The convention has been to use diesel generators but these usually do not incorporate a battery storage so the generator must be running to have any power. Stations with refrigeration usually run their generator for 10 to 24 hours per day. Those without refrigeration would run it for several hours per night to provide for lighting and television. The problem with such a system is that it wastes fuel.

The system must be sized to cope with heavy demands put on it by a user (eg welding). This load is called the peak load. As well as the peak load, it must also be able to handle the very short term, but very high surge loads caused when an electric motor (such as a freezer, washing machine or pump) starts up. These short term surge loads are often five times higher than the actual power used in normal operation. For most of the time the actual power being used is much less than the peak load that the system was designed to handle.

Diesel Generators

A diesel generator, as the main or back-up power supply, invariably has to be able to handle such peak loads. If, on the other hand, a diesel generator is too lightly loaded it can cause damage to the diesel engine and cause expensive repairs. In some cases a dummy load is turned on (any appliance or equipment to use power) to protect the diesel engine. This load increases fuel consumption for little or no benefit to the consumer. Both oversizing and under-utilisation cause fuel wastage.

Generators also require routine maintenance by ensuring regular oil, air and fuel filter changes, as well as routine service and operation to manufacturers' specifications. The engine must be run with a minimum load of 30%, but ideally with a load of 70-80%. Running of the engine on a low load for long periods will result in carbonisation, cylinder bore glazing and poor fuel economy. Engine life will be severely shortened. Well loaded, the engine may achieve 20% - 30% conversion of fuel to shaft power, the remainder is lost as engine heat, exhaust heat, unburnt fuel and noise. Engine protection circuits are included in most diesel-generator systems to ensure the unit will not run in a faulty condition.

The design life of a generator is limited. A diesel generator has a life expectancy of some 10,000 hours before a major engine overhaul is required (typically costing about 50% of the initial cost).

Petrol Generators

Petrol engines in comparison are more light weight, less robust and high revving. The spark ignition system makes for a more portable power supply. However, the system is inherently unsuitable for a continuous stationary power supply. Petrol engines have an expected service life of some 1,000 hours. The engine limitations mean that the generator sets are usually small (0.5 to 8 kVA). Many petrol generators can be converted to run off LP gas which should increase the engine service life and reduce pollution level.

A Hybrid System

The use of a hybrid system, using a generator, solar panels (or wind and hydro) together with a battery bank can give you 'the best of both worlds'.

Generator and Battery Power

The generator lowers the capital cost of the system. The use of a large battery charger powered by the generator to charge batteries can load the generator to make it more efficient and the stored power in the batteries will cut down on generator use. The use of a battery bank can cut fuel costs by 65% to 70%. The use of solar panels to also charge the batteries can further cut down on operating costs.

An inverter connected to the battery bank provides 240 volt power 24 hours per day or while the generator is switched off. Australian made inverters are available in many sizes from 0.2 to 25 kVA.

Designed to your Specifications

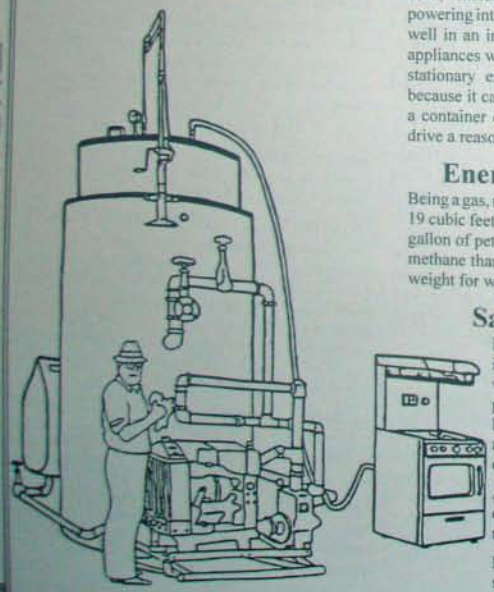
Our staff can design such a system to meet your requirements. In such a system we would normally recommend a generator run on diesel or LP gas.

Sewerage and Grey-water

You may live in a bush setting or have some other reason for needing to dispose of sewerage, grey-water and other waste materials rather than having it done for you by some bureaucracy. Although you may find it generally offensive, much of our waste matter should be considered a valuable resource. Animal wastes are usually left out in the open to decompose, creating nuisance and health hazards, or washed into water courses to pollute them. If treated properly, organic sewerage based fertiliser can help to restore or improve the fertility of the soil without any harmful side-effects.

Urine and grey-water from baths, sinks etc may be applied to gardens and orchards. Care must be taken to ensure that the grey-water is not contaminated with toxic substances or non biodegradable detergents etc. Urine should only be applied to the garden in a very diluted form, otherwise it may damage or kill the vegetation to which it is applied. In a diluted form it can provide many very valuable nutrients to the vegetation.

Faeces must be decomposed before being applied to orchards. Human faeces may contain human pathogens (disease causing organisms) some of which may remain active for many years. In a composting bed mixed with vegetable scraps and grass clippings the temperature may be raised to over 55°C which is sufficient to kill pathogens.



There are two methods of sewerage treatment that should be considered: Anaerobic (without air) and Aerobic (in the presence of air) Fermentation.

ANAEROBIC FERMENTATION

Through anaerobic fermentation sewerage produces bio-gas. The installation designed for producing bio-gas out of waste matter is known as a methane digester. Each adult human will produce enough gas to operate a single gas burner (for cooking) for up to 4 hours per week. It is important that no anti-biotics or chemical pollutants go into the digester as these substances could destroy the anaerobic bacteria.

What is Bio-Gas?

Bio-gas contains about two-thirds methane and one third carbon dioxide, with a trace of hydrogen sulphide. Town gas, by comparison, contains 9% carbon-monoxide that is lethal to inhale. When methane is combusted it produces carbon dioxide. It is better for the environment to release carbon dioxide into the atmosphere than releasing methane.

Uses of Bio-Gas

This gas may be used wherever town gas or LP gas may be used, including cooking, heating, refrigeration and powering internal-combustion engines. Methane gas burns well in an installation designed for coal gas but LP gas appliances would need to be modified. Bio-gas is fine for stationary engines but is not so feasible for vehicles because it cannot be liquefied and as a gas would require a container of very large volume in order to be able to drive a reasonable distance.

Energy Content of Bio Gas

Being a gas, methane requires a far greater storage volume, 19 cubic feet of methane will yield the same energy as one gallon of petrol when combusted. The octane is higher in methane than in petrol. Its calorific value is 17% greater, weight for weight, than petrol.

Safety Considerations

It is a fuel, and when mixed with air and ignited will explode just the same as petrol vapour and air. For this reason air must be purged from the digester and storage areas by letting the gas flow through for several days after the digester or storage tank has been opened to the atmosphere.

A methane digester produces a gas similar in composition to town gas and can be used to run a range of gas appliances.

Further information can be obtained by sending $10 to the Rainbow Power Company.

AEROBIC FERMENTATION

Aerobic Fermentation requires a smaller and simpler installation but still requires a certain degree of maintenance to keep it operating at maximum efficiency. It provides a good compost, it is cheaper to install than a digester and is simple to operate. Unlike anaerobic fermentation it has no other by-products.

Water - a Valuable Resource

Between 30% and 50% of domestic water usage gets flushed down the toilet. Often this most valuable resource ends up polluting waterways, underground water supplies or gets pumped out to sea. It can pollute large areas by soiling beaches, disrupting plant and animal life in streams, and finding its way into underground water supplies.

There are other losses in these types of sewage systems including organic material and major plant nutrients because quite large amounts of nitrogen, phosphorus and potassium are flushed away every day.

The problem with water carriage sewerage is that it enlarges a small problem into a big one. Most public authorities concerned with public health insist that a septic tank for a domestic installation is to be preferred to a composting toilet. This insistence is despite the fact that the concentration in the effluent from a septic tank:-

- **exceed** what is allowable for activities where one could easily come into contact with the water (eg wading and boating) **by a factor of about 10,000**;
- are perhaps **five to twenty times** what comes out of a properly operating secondary sewage treatment plant;
- are perhaps **1,000 times** the concentration of effluent from a tertiary treatment plant;
- are of the order of a **million times** the concentration of what comes out of a composting toilet.

The effluent from a septic tank can be worse than what comes into it. The blackwater from a water closet enters the septic tank and mixes with the sullage from other household activities. Sullage is very high in nutrients, whereas the nutrients in the toilet effluent are comparatively low, most having been removed in people's digestive systems.

This mixture provides the pathogens from the blackwater (possibly including those causing Hepatitis A, typhoid, TB, dysentry and poliovirus) with new nutrients, and the pathogens multiply very rapidly.

The most common manifestation of failure of the septic tanks is that the absorption trenches are clogged. In areas where septic tanks are common, it is a frequent sight to see the effluent from septic tanks running down over the surface of gardens.

To make matters worse, where septic tanks are used in areas which are in the catchments of water supply storages or National Parks, the effluent from septic tanks can (and do) contaminate waterways. Pathogens from septic tanks have been documented to travel hundreds of metres through the ground. A possible answer to this problem is the composting toilet.

Composting Loo's

Septic tank sewerage disposal is based on the conventional means of using water as the carrier. Conventional toilets require approximately 45,000 litres per person per year. Many areas are unsuitable for septic systems. These include clay, marshy, rocky, and very steep locations where little absorption can occur in the soil.

While regulations may prohibit their use in urban areas, compost toilets do offer a waterless, environmentally 'soft' alternative for use in country homes, holiday houses, ski lodges, camps, etc. There are a number of alternatives now available.

The principle of operation of the composting toilet is very simple. Human excreta is deposited from the pedestal into a container which is kept warm to promote the growth of bacteria. The bacteria digest the human excreta and render it into harmless compost, while a small fan extracts odours from the remaining wastes and expels them through a vent.

As long as the excreta is stored for long enough at a sufficiently high temperature, the pathogens in the human waste are eliminated. The excreta is normally stored in one of several sealed containers with air circulating through them. When the one container is full, it is removed and another container is put in its place to be filled. This continues until the final container is filled or the first container has had its contents thoroughly decomposed.

The first container is then emptied. This is quite safe to do, since the compost has been stored for one to two years, and the chances of a pathogen still being alive by then is very low; the risk is about the same as handling soil from the garden. The compost is then buried in a shallow trench for another six months, and by then no pathogens could still be alive. By this stage, even the Ascaris ova (roundworm eggs), which may have survived until now, are destroyed. The compost which is removed from such a composting toilet does not smell, and has the texture of leaf mould.

Environmentally Friendly

Composting Toilets **HELP** the Environment & Local Economies by:-

- Reducing pollution of our waterways and ground-waters;
- Reducing risks of infection;
- Reducing water consumption;
- Reducing waste handling costs.

Turn a disposal problem into a valuable resource
The Nature Loo not only saves water and avoids disposal problems, but it actually turns a waste product into a valuable resource. The waste product is turned into a rich organic humus that can be used to restore or improve the fertility of the soil without any harmful side-effects.

Compared to aerobic sewerage treatment it also saves you on power requirements as no sludge pumps or stirring mechanisms are required. Generally all that is required to be powered is a very small and energy efficient air circulating fan.

Sullage Disposal

If a composting toilet is installed for a residence, the following advice is given for treating sullage:-

- a grease trap to take out some of the fats and oils from the kitchen sink;
- a small septic tank to provide pre-treatment to the waste water - this tank should only require desludging every twenty years or so, since most of the solids have been diverted to the composting toilet;
- to help with uptake of nutrients and water, it is advisable to plant vegetables, grass, shrubs and trees near the absorption trenches. Care must be taken however, not to have plants with aggressive root systems which could clog the distribution pipes.

Greywater Treatment

Greywater is the water in a household which comes from the bath, shower, laundry, kitchen, and hand basins. If the toilet wastes are kept separate the greywater is easier to treat because:

- Water is reduced by about 35%. Treatment tank and absorption trench can be similarly reduced.
- Solids are reduced by about 70%. Less sludge in treatment tank quadruples intervals between desludging and reduces risk of clogging and replacement of absorption trenches.
- Nitrogen is reduced by about 90% and phosphorus by about 30% which reduces risk of groundwater pollution.
- Less risk of infection due to substantially reduced levels of disease organisms compared to septic tanks.

Application of disinfectants such as chlorine will not only kill some of the pathogenic bacteria but will also kill beneficial microbes and soil fauna responsible for treating the effluent. Chlorine may also combine with organic substances to form carcinogenic chloro-organic substances.

Comparison of On-Site Waste Disposal Systems

	Septic Tank	Aerated Wastewater Treatment[1]	Composting Toilet & Greywater Treatment
Eliminates viruses?	No	?	Yes
bacteria?	No	?	Yes
beneficial bacteria?	No	Yes	No
protozoan cysts?	No	Unlikely	Yes
helminth worms?	No	No	No*
Can bacteria regrow after chlorination?	N/A	Yes	N/A
Creates carcinogenic trihalomethanes?	No	Yes	No
Reduces phosphorus discharge to environment?	No	No	Yes
nitrogen compound discharge?	Some	Yes	Yes
sludge accumulation?	No	No	Yes
Requires chemicals?	No	Yes	No
maintenance contract?	No	Yes	No
Can be left unattended for over 3 months?	Yes	No	Yes
Approximate intervals between desludging	1-4 yrs	½-4 yrs	15-20 yrs
Is mechanical failure a risk to health?	High	Moderate	Low
Saves water?	No	No	Yes

[1] Assumed to have chlorination and spray irrigation of effluent. Effectiveness of chlorination of pathogens taken from 'Health Aspects of Excreta and Sullage Management' Faecham/Bradley/Garelick/Mara - World Bank.Wa

* Eggs of roundworm may survive in a composting toilet.

nature Loo Composting Toilets

Nature Loo Composting Toilet Options

Nature Loo manufacture three models to choose from. Both the Classic and the Ensuite come complete with almost everything required for installation, including pedestal and seat. The only items that are left out, for reasons of freight cost, are the external vent pipe and absorption trench materials, which can be bought locally from your garden or hardware shop.

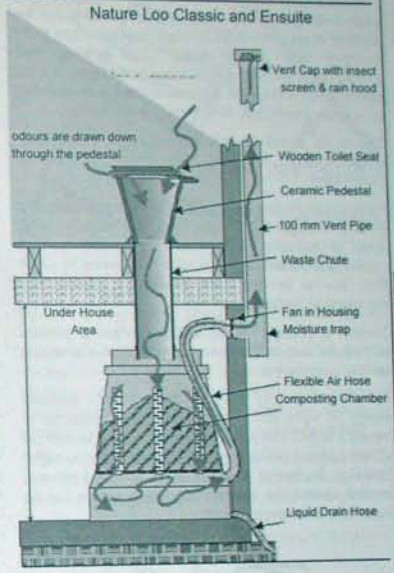
Included in both Classic and Ensuite models:

- 2 composting chambers (extra can be purchased)
- 70 cm waste collecting chute (can be cut to suit site)
- Ventilation system including 12 volt 2.8 watt air fan
- Transformer for fan to connect to 240V supply
- Vent cap, moisture trap, fan housing, flexible connecting hose and fly screen
- Easy to follow instructions and maintenance manual

Differences between the Classic and Ensuite models:

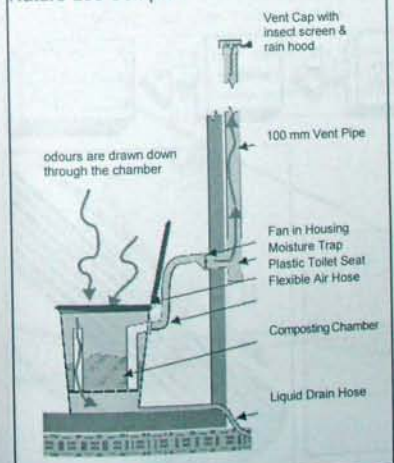
- Classic includes a warm white ceramic pedestal
- Ensuite includes a white hard wearing resin pedestal
- Classic includes two 85 cm high × 80 cm diameter chambers
- Ensuite includes two 60 cm high × 60 cm diameter chambers
- Classic includes a honey oak wooden seat
- Ensuite includes a medium density plastic seat
- The minimum height required to install the chamber beneath the floor:
  Classic: 1 metre
  Ensuite:75 cm

Nature Loo Classic and Ensuite



Classic: Cat.# TLT-010 Spare Bin: Cat.# TLT-010-P01
Ensuite: Cat.# TLT-020 Spare Bin: Cat.# TLT-020-P01

Nature Loo Compact



Nature Loo Compact

Cat.# TLT-030

The Compact is a minimum cost low volume toilet. Its most common application is for weekenders, outdoor work sites and temporary accommodation. Unlike conventional composting toilets, it does not require space beneath the floor as the Compact Pedestal and chamber sit directly on the toilet room floor. The Compact comes almost complete with everything required. The only items that are left out, for reasons of freight cost, are the external vent pipe and absorption trench materials, which can be bought locally from your garden or hardware shop.

Spare Bin: Cat.# TLT-030-P01

Customised variations from standard models.
A choice of pedestals, seats and collecting chute extensions are available.

Solar Panels

Electricity from Light: How?

Light striking certain substances causes the surface of the material to emit electrons. It is as if light somehow kicks electrons right out of atoms. Light striking other substances causes the material to accept electrons. It is the combination of these two substances that can be made use of to cause electrons to flow through a conductor.

This is the so called photo-electric effect. Photovoltaic means sunlight converted into a flow of electrons (electricity).

Photovoltaic devices, or solar cells, are like generators that work in sunlight. They make electricity without waste, noise or pollution. They produce electricity without combustion. A solar cell is a solid state device in which there are no moving parts (except for photons and electrons) so nothing wears out.

The fuel is "photons". These can be thought of as "packets of sunlight" that carry a phenomenal amount of energy to earth at a prodigious rate.

The Solar Panels of today make use of this abundant energy by using silicon crystals with small amounts of impurity added. This process of adding minute amounts of different elements into an otherwise pure crystal is called "doping". By having two thin layers of doped material bonded against one another, an electric current can be induced when exposed to light.

Energy Content of Sunlight

Sunlight has an energy content of 1 kW (1,000 watts) per square metre. The typical Solar Panel today achieves between 10% and 15% conversion. The theoretical maximum efficiency of a silicon cell is about 21%. Using a more costly technology 31% conversion has been achieved.

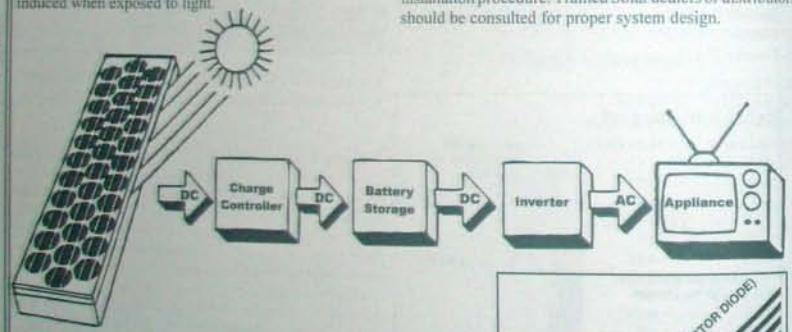
Solar Power as an Energy Source

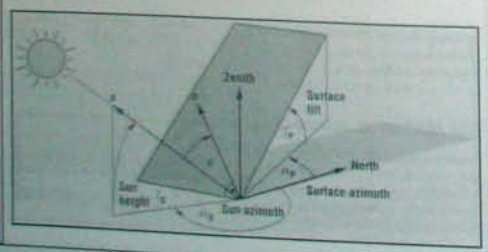
Solar Power has become a popular and dependable power source in rural Australia with the development and continuous improvement of Photovoltaic (solar electric power) over the last few decades. A Solar electric system has a very distinct advantage in that it is relatively quick and easy to install with a minimal requirement for site preparation.

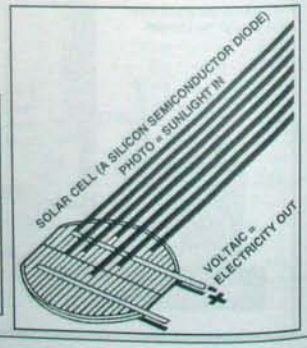
System Design

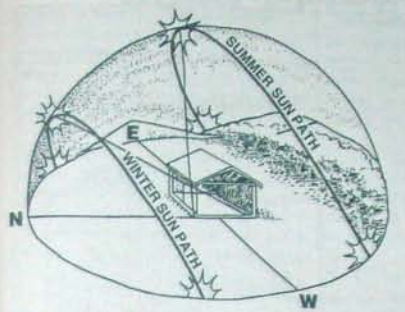
It is important to pick the best site for your solar modules. In order to get the most power, they need maximum exposure to direct sunlight for the longest possible time.

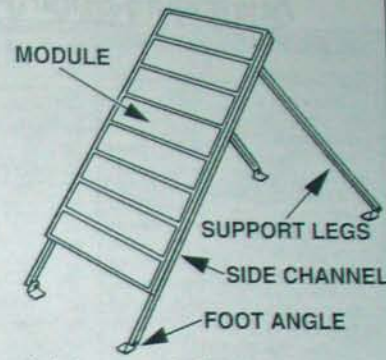
The following information is provided to give you an idea of what is involved in overall system design in relation to a photovoltaic charging source. Full system design should include proper mounting and location of the modules, proper wiring and circuit protection, choosing regulators, and fuses to protect the battery, as well as a proper and safe installation procedure. Trained Solar dealers or distributors should be consulted for proper system design.











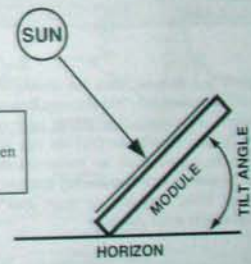
Mounting Solar Panels

If you are not using a solar tracker, solar panels need to face the midday sun at an angle roughly equal to the latitude of your location. This angle may be more than your latitude by between 10° and 20° if you have predominantly winter type loads (eg lighting and indoor entertainment) or less than your latitude if you have predominantly summer type loads (refrigeration, cooling fans and possibly water pumping). This deviation from your latitude angle therefore would depend on the time of year that you need the most power.

In the southern hemisphere you would of course face your panels to the north but whether you use magnetic north or true north is not critical. A variation of up to 15° will not make a great deal of difference in the performance of the panels. It is recommended that you have stationary solar panels placed at more than 15° from the horizontal so that they will automatically wash clean whenever it rains.

By having your panels following the sun with a solar tracking device you can gain greater benefits in summer than in winter. This is due to the difference in the arc that the sun sweeps across the sky which is more than 180° in summer and less than 180° in winter. The degree of variation depends on latitude and weather patterns with the greatest gain coinciding with clear skies and summer.

The following table shows the best array angles for 28 different locations around Australia. The solar array would either be facing north on a fixed frame (at an angle from the horizontal to get the best results); or on a polar axis tracking device (tracking the sun from sunrise to sunset).



One must consider the shadow cast by trees, buildings, hills etc (L) in winter when the shadow covers the greatest distance

Australian Solar Radiation Figures

Australian Solar Radiation Figures			Best Average Performance			Seasonally Adjusted			Sun Tracking	
			Tilt Angle	Peak Sun Hrs / Day		Tilt Angle	Peak Sun Hrs / Day		Peak Sun Hrs / Day	
Location	Longitude	Latitude		Best Month	Worst Month		Best Month	Worst Month	Best Month	Worst Month
Darwin NT	12°25'S	130°52'E	20°	Aug=7.22	Jan=5.03	15°-60°	Aug=7.64	Jan=5.21	Aug=9.64	Feb=7.56
Cairns Qld	16°54'S	145°48'E	20°	Oct=6.14	May=4.39	15°-60°	Oct=6.14	May=4.69	Dec=8.36	May=5.47
Halls Creek WA	18°14'S	127°40'E	25°	Sep=7.30	Dec=5.99	15°-60°	Jul=7.81	Jan=6.43	Nov=9.94	Feb=8.94
Townsville Qld	19°18'S	146°48'E	25°	Sep=6.47	Jun=4.94	15°-60°	Sep=6.53	May=5.25	Dec=8.97	May=6.19
Tennant Creek NT	19°36'S	134°06'E	25°	Sep=7.03	Jun=5.64	15°-60°	Sep=7.03	Feb=6.25	Dec=8.47	Jun=7.56
Port Hedland WA	20°23'S	118°37'E	25°	Oct=7.61	Jun=5.72	15°-60°	Nov=7.73	Jun=6.47	Nov=11.28	May=8.00
Rockhampton Qld	23°23'S	150°29'E	30°	Oct=6.28	Jun=5.36	15°-60°	Nov=6.59	May=5.81	Nov=9.06	May=6.97
Longreach Qld	23°26'S	144°16'E	30°	Sep=7.25	Jun=6.17	15°-60°	Nov=7.55	May=6.58	Nov=10.81	May=7.94
Alice Springs NT	23°48'S	133°54'E	30°	Mar=7.39	Jun=6.22	15°-60°	Jan=7.43	May=6.64	Jan=10.64	Jun=8.03
Brisbane Qld	27°25'S	153°05'E	30°	Jan=6.22	May=4.50	15°-60°	Jan=6.61	May=4.81	Jan=8.50	May=5.50
Oodnadatta NT	27°34'S	136°25'E	30°	Mar=7.53	Jun=5.42	15°-60°	Dec=8.09	Jun=6.06	Dec=11.50	Jun=7.06
Geraldton WA	28°48'S	114°47'E	30°	Dec=7.64	Jun=4.81	15°-60°	Dec=8.27	Jun=5.36	Dec=11.75	Jun=6.19
Kalgoorlie WA	30°47'S	121°30'E	30°	Dec=7.19	Jul=3.61	15°-60°	Dec=7.74	Aug=3.94	Dec=11.06	Jul=5.14
Forrest WA	30°50'S	128°07'E	30°	Jan=7.47	Jun=4.81	15°-60°	Dec=7.99	Jun=5.50	Dec=11.42	Jun=6.36
Perth WA	31°56'S	115°58'E	30°	Jan=7.61	Jun=3.86	15°-60°	Dec=8.06	Jun=4.39	Dec=11.47	Jun=5.03
Williamtown NSW	32°48'S	151°50'E	35°	Jan=6.03	Jun=3.95	15°-60°	Dec=6.96	Jun=4.31	Dec=9.47	Jun=5.14
Sydney NSW	33°56'S	151°10'E	35°	Dec=6.52	Jul=3.80	15°-60°	Dec=6.93	Jul=4.11	Dec=9.11	Jul=4.58
Mildura Vic	34°15'S	142°05'E	35°	Dec=7.36	Jun=4.14	15°-60°	Dec=8.07	Jun=4.58	Dec=11.56	Jun=5.22
Albany WA	34°57'S	117°48'E	35°	Jan=6.67	Jun=3.57	15°-60°	Dec=7.14	Jun=3.94	Jun=9.56	Jun=4.47
Adelaide SA	34°56'S	138°32'E	35°	Jan=7.86	Jul=3.22	15°-60°	Jan=8.18	Jul=3.56	Jan=10.94	Jul=3.94
Wagga Wagga NSW	35°15'S	147°28'E	35°	Dec=7.14	Jun=3.61	15°-60°	Dec=7.91	Jun=4.75	Dec=11.50	Jun=4.75
Canberra ACT	35°19'S	149°12'E	35°	Jan=7.18	Jul=3.58	15°-60°	Jan=7.65	Jul=3.83	Jan=10.00	Jul=4.28
Mt Gambier SA	37°45'S	140°47'E	35°	Jan=6.71	Jun=2.88	15°-60°	Jan=7.08	Jun=3.14	Jan=9.67	Jun=3.69
Melbourne Vic	37°50'S	144°58'E	35°	Jan=6.50	Jun=3.13	15°-60°	Jan=6.86	Jun=3.39	Jan=9.42	Jun=3.86
Laverton Vic	37°53'S	144°45'E	35°	Jan=7.00	Jun=3.02	15°-60°	Jan=7.11	Jun=3.36	Jan=9.53	Jun=3.73
East Sale Vic	38°06'S	147°06'E	35°	Jan=6.24	Jun=2.81	15°-60°	Jan=6.53	Jun=3.17	Jan=8.72	Jun=3.50
Launceston Tas	41°36'S	147°12'E	40°	Feb=6.58	Jun=2.67	15°-65°	Jan=6.92	Jun=2.94	Jan=9.42	Jun=3.25
Hobart Tas	42°50'S	147°30'E	40°	Jan=6.17	Jun=2.67	20°-70°	Jan=6.53	Jun=2.92	Jan=8.75	Jun=3.36

These figures are derived from the *Australian Solar Radiation Handbook*, April 1995 (Energy Research and Development Corporation). The above solar radiation figures (Peak Sun Hours per day) do not take into account system losses such as transmission cable, battery and inverter losses. Nor do they account for any shading from hills, trees etc or from dust or dirt accumulated on the solar panels.

Following is a simple calculation for working out how many solar panels are required for a 12V power system using the above solar radiation figures:

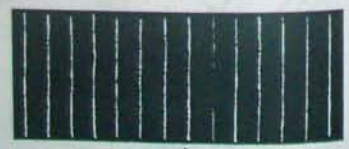
Number of Solar Panels = Daily AmpHours (of loads) x 21.8 ÷ Peak Rating of Solar Panel (Watts) ÷ Peak Sun Hours per day (from above Table).

Battery Size = Daily AmpHours x 13

The above calculations take into account average cable, battery and inverter losses.

1

2

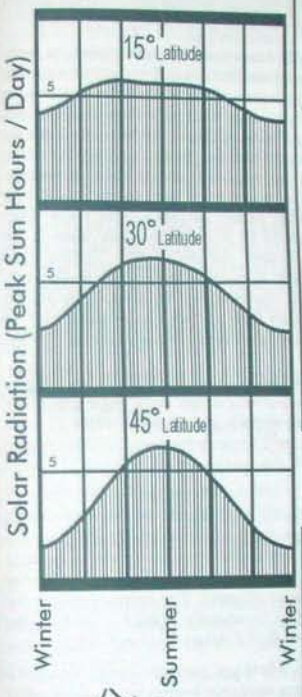


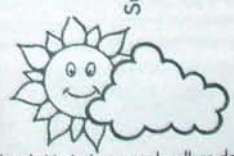
3

1 Polycrystalline 2 Monocrystalline
3 Amorphous

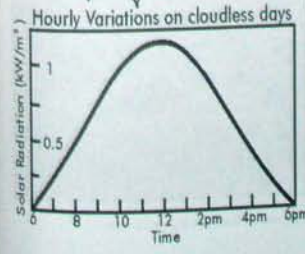
Solar Energy Variations

Effect of Latitude and seasons on cloudless days





Hourly Variations on cloudless days



mWh.cm^{-2} ÷ 100 = Peak Sun Hours / Day

kWh / m^2 / day = Peak Sun Hours / Day

Is Tracking Cost Effective?

Whether tracking is really worth the expense depends on a number of factors:

1. The cost of the Tracker.
2. The extra energy gained by tracking. It is not enough to say that the panel(s) may put out twice as much power under given circumstances. It is the accumulated amp-hours (amps times hours) over the course of the day that determines your daily gain.
3. The gain is not consistent throughout the year. The greatest gain is usually in summer when the hours between sunrise and sunset are the longest and the sun sweeps its greatest arc across the sky (refer to diagrams page 113).

   If this potential for an increased gain in summer also coincides with a wet season or consistently overcast weather then the actual gain may be very little or nothing at all. In fact, if you check against the figures on the tables (1 & 2) you will find that the horizontal (flat mounting) panels would frequently exhibit better performance patterns than the panels on fixed frames tilted to the north. This is because on mildly overcast days the sunlight is scattered and the best results on such days are often when the solar panels are facing straight up and getting maximum benefit of the diffused light rather than attempting to pick up the direct sunlight.
4. The gain is also dependent on latitude. At increased latitudes the sun's arc across the sky in summer is also increased but in winter it is decreased. The following table shows the daylight hours (between sunrise and sunset).

Latitude	10°	15°	20°	25°	30°	35°	40°	45°
Summer	12.71	13.02	13.34	13.70	14.08	14.52	15.02	15.62
Winter	11.54	11.24	10.92	10.58	10.21	9.80	9.33	8.76

5. Solar energy usually has its greatest strength in the middle of the day and often the greatest cloud cover is in the mornings and evenings. The energy from the sun has to penetrate through the greatest depth of atmosphere at the horizon.
6. Your immediate environment and your geographic location may play a major role in the hours of direct sunlight (without shading) that your panels may receive. Nearby mountains, hills, trees, tall buildings etc may considerably reduce the number of hours of direct sunshine that your panels receive. Shadow throwing objects tend to have their greatest effect on a solar panel site when the sun is lowest in the sky. Even the smallest amount of shading reduces panel output significantly.

   By refering to the table on page 114 you may get an idea of the advantage in tracking the sun for your area by using the figures for a location of similar latitude and similar weather conditions to yours. You simply compare the columns labelled *Sun Tracking* against the columns labelled *Best Average Performance*.
7. After having determined how much gain you could expect in mid summer and mid winter you may find that you get the most benefit when you least need it. An automatic solar tracking system usually costs more than a 75W solar panel. Unless your loads are predominantly summer loads (eg fridge, freezer, space cooling, pumping) and you already have at least 8 solar panels, you may be better off with another solar panel. An extra solar panel gives greater benefit in mid winter when there is the greatest demand for night time lighting and entertainment. If you need more power in winter for lighting and entertainment because of the shorter daylight hours then **an extra solar panel may be money better spent than having a tracking device.**

Seasonal Adjustments?

The seasonal variations in the sun's angle are 23°15' added to latitude at the winter solstice (either 21 or 22 June in the southern hemisphere) and 23°15' subtracted from latitude at the summer solstice (either 21 or 22 December).

By refering to the table on page 114 you may get an idea of the advantage in seasonally adjusting (in this case month by month) the solar array for your area by using the figures for a location of similar latitude and similar weather conditions to yours. You simply compare the columns labelled *Seasonally Adjusted* against the columns labelled *Best Average Performance*.

A simple system where you manually change the angle a few times per year would not involve much cost or effort but also gives you less gain than an automatic solar tracker.

Solar array on roof of Rainbow Power Company

Use of Reflectors *

By having reflectors to increase the amount of light falling onto the panels, you may be able to increase the output of a solar panel. Unfortunately this approach may have the undesirable effect of increasing the temperature of the solar panel. As temperature increases above 25°C the nominal voltage of the panel decreases. If the temperature of the panel is increased to 50°C the open circuit voltage (OCV) may be decreased by as much as 2 volts (for a 12 volt panel). If the panel happens to be a self-regulating panel such a voltage drop may have the undesirable effect of the panel ceasing to charge the battery altogether.

You must also be careful that these reflectors don't have the reverse effect by shading the panel at any time. This would best be insured by combining both tracker and reflectors (and hoping that the tracker doesn't fail). In this instance seasonal adjustments a few times per year should be considered. This idea should only be contemplated if the potential for a temperature increase could be kept under control.

* Warranty on solar panels is voided if reflectors are used.

Grounding

Although it is not essential for the satisfactory operation of your system, the manufacturers of solar panels recommend that solar panels be grounded. Grounding with respect to photovoltaic installations serves several purposes:

1. it bleeds off static electric charge built up from wind and rain;
2. it is an integral part of lightning protection;
3. it provides fault protection, whereby any shorts or faults in circuitry will conduct enough current to ground to trip circuit breakers or fuses and allow fault detection.

It is recommended that the earth stake should have a resistance to ground of 25 ohm or less. For adequate lightning protection, between 1 ohm and 5 ohm resistance to ground gives fairly reliable lightning protection. Often cold water pipes achieve a ground resistance of 2 to 3 ohms. You may need to find an electrician with a multimeter to set up a good grounding for your system. More detailed information may be obtained from the Rainbow Power Company.

The adverse effects of heat

Contrary to what you may expect, when photovoltaic solar panels become hot, their output is reduced. It is therefore advisable to install panels at a distance from hot tin roofs. This is to allow ventilation around the panels which helps to reduce the temperature. Unlike Solar Collectors (eg to heat water), photovoltaic panels depend on light (mostly visible light) to produce electricity and not on heat.

The effect on current due to increased temperature of a solar panel is not as drastic as the effect on voltage (assuming that the voltage is still high enough in order to charge the battery).

NOTE: In very hot conditions, such as in the interior of Australia, it is recommended to use a 36 cell panel (our larger BP panels have 36 cells).

What to expect from a Solar Panel

A single 83 watt solar panel should produce about 5 amps under sunny conditions. Each day of reasonable sunshine you should expect about 23.6 amp-hours from one such panel (based on solar radiation data for north coast NSW). You need to take into account the number of consecutive days when you may not see much sun, and allow for this by having a large enough solar array and battery bank to tide you over through such periods.

Self Regulating Panels

A self regulating panel has fewer cells so that the voltage produced is always less than with a standard panel. This means that the panel puts less and less power into the battery bank as it is charging and increasing in voltage as a result. This tail-off of charging rate starts at around 50% of battery charge and in the 70% to 100% range, where we recommend you operate, the differences are dramatic.

Under overcast conditions the self regulating panel may cease to charge where a standard panel may still be able to produce a reasonable charging rate. The wattage rating of a self-regulating panel in itself may thus be quite misleading. It is recommended that you use standard (not self regulating) panels in conjunction with a regulator in a home power situation. A fully fledged 36 cell panel will give better performance when the weather is overcast.

Once a month or so, it may be advisable to over-ride the regulator for a day to give your battery bank a boost charge.

NOTE: NiCad batteries have an OCV of 1.25 V per cell. Ten cells make up a 12 volt battery. The voltage of a NiCad battery rises higher when approaching 100% charge than a lead-acid battery. For this reason it is recommended to use a 36 cell solar panel and not a panel with less cells. Even a 33 cell solar panel behaves like a self regulating panel with a 12v Nicad battery bank.

Wiring up the Solar Array

You will find throughout "Energy from Nature" and particularly in the wire section near the back of the book, that a lot of emphasis is placed on using a sufficiently large wire to carry the current. Choosing the optimum size cable is often a compromise between minimising the voltage drop in the cable on the one hand and financial constraints on the other.

How much voltage drop is allowable in different circumstances depends very much on the difference in voltage between the battery voltage at full charge and the open circuit voltage of the solar panels. Because Nicad batteries will charge up to a higher voltage, there is less voltage difference between the panels and the batteries. To compensate for this, it is recommended to use the next larger size of cable than is presented in the tables below.

The following tables are a guide. Although you may use a larger cable it is recommended not to use a wire of lesser size. All the figures are based on the use of 36 cell solar panels. The wire sizes (in the body of the tables) are a measure of conductor cross sectional area and are given in square millimetres (mm²).

12 Volt Battery Bank

Cable size (mm²)

Cable metres	Solar Panel Current (Amps)							
	5	10	15	20	25	30	35	40
5	1.84	4.59	4.59	7.9	7.9	13.6	13.6	13.6
10	4.59	7.9	13.6	13.6	25.7	25.7	25.7	25.7
15	4.59	13.6	25.7	25.7	25.7	32.2	32.2	49.2
20	7.9	13.6	25.7	25.7	32.2	49.2	49.2	49.2
25	7.9	25.7	25.7	32.2	49.2	49.2		
30	13.6	25.7	32.2	49.2	49.2			
40	13.6	25.7	49.2	49.2				
50	25.7	32.2	49.2					
75	25.7	49.2						
100	32.2							

24 Volt Battery Bank

Cable size (mm²)

Cable metres	Solar Panel Current (Amps)							
	5	10	15	20	25	30	35	40
5	1.84	1.84	2.9	4.59	4.59	4.59	7.9	7.9
10	1.84	4.59	4.59	7.9	7.9	13.6	13.6	13.6
15	2.9	4.59	7.9	13.6	13.6	25.7	25.7	25.7
20	4.59	7.9	13.6	13.6	25.7	25.7	25.7	25.7
25	4.59	7.9	13.6	25.7	25.7	25.7	32.2	32.2
30	4.59	13.6	25.7	25.7	25.7	32.2	32.2	49.2
40	7.9	13.6	25.7	25.7	32.2	49.2	49.2	49.2
50	7.9	25.7	25.7	32.2	49.2	49.2		
75	13.6	25.7	49.2	49.2				
100	25.7	32.2	49.2					

m* Cable route length measured in metres.

NOTE: The route length is the point to point distance and it includes both positive and negative conductors (ie half the total conductor length).

These figures assume a maximum 10% transmission loss.

The wire sizes specified will give more than 90% efficiency in energy transfer. For a higher level of efficiency, use the next larger wire size. Where wire runs become prohibitively expensive or the distance too great, the use of a Maximizer is recommended (see page 105).

Self Discharge

All Solar Panels have a certain amount of self-discharge at night.

Blocking Diode

MONOCRYSTALLINE SOLAR PANELS, DO NOT REQUIRE A BLOCKING DIODE.

A blocking diode can be placed in series with a solar panel to prevent battery discharge back through the solar array at night. Battery discharge through polycrystalline panels can be quite high whereas with monocrystalline and amorphous panels it may be insignificant. A blocking diode causes a voltage drop of 0.6 volts which means a constant power loss whilst the array is charging. If the power loss through the blocking diode is less than the battery discharge back through the panel at night then a blocking diode should be used. The amount of battery discharge through the solar panel or solar array can be measured with an amp meter.

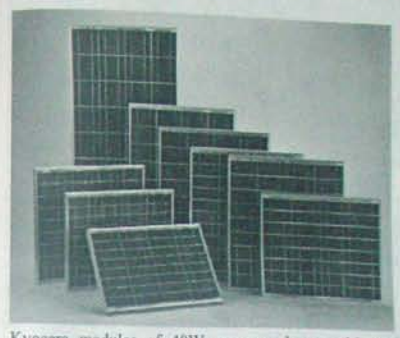
You do not necessarily need a blocking diode in the solar panel connector box, you may place a suitable diode to handle all the panels on the control board or the regulator. Some regulators will turn off the solar panels at night in which case the blocking diode will not be needed.

Bypass Diode

Partial shading of large solar arrays can cause solar panels to self destruct due to overheating of the shaded cells with a high current passing through them. The higher the voltage (ie the more solar panels are placed in series) the greater this potential hazard can be.

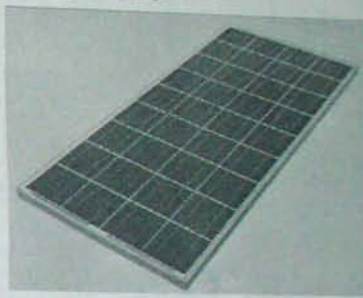
When individual solar cells are shaded they become less conductive to an electric current. To help overcome this problem bypass diodes are placed in parallel with short strings of cells (facing the opposite way to a blocking diode) to shunt the current around any high resistance (BP monocrystalline modules have 4 strings of 9 cells). A bypass diode allows the current to flow in the same direction as it normally does to produce a charge to the battery bank. Because the Bypass Diode would normally present more resistance to the electric current than the solar cells in direct sunshine, the current will flow through the cells and in the process increase the voltage. If there is a current flow when some cells are shaded, the cells develop a greater electrical resistance than that of the Bypass Diode and consequently the current flows through it as the course of least resistance.

Kyocera & Uni-solar Modules

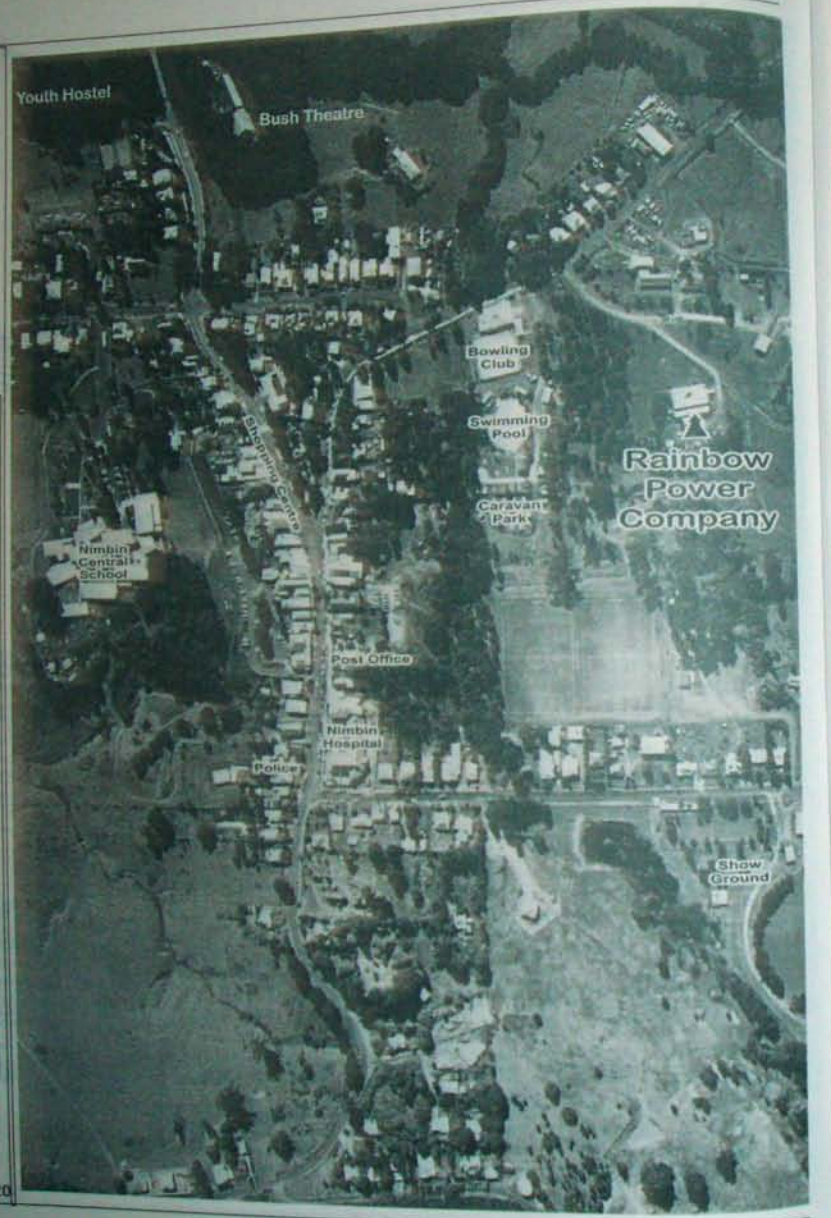


Kyocera modules of 40W or more have a 25 year warranty. Kyocera's advanced cell processing technology and automated production facilities have produced a highly efficient multicrystal photovoltaic module. The conversion efficiency of the Kyocera solar cell is over 14%.

Uni-Solar modules are made of amorphous silicon deposited onto stainless steel sheet. Unlike crystalline modules, Uni-solar modules have a bypass diode connected across each cell, allowing modules to produce power in partial shading.



Cat. #	Rated Power Watts	Current (A) Typical	Dimensions (mm) L	W	D	Weight Kg	Warranty Years
Polycrystalline Modules							
SOL-Y05	5	0.3	257	237	23	0.9	15
SOL-B20	20	1.22	424	502	50	3.0	10
SOL-B30	30	1.84	594	502	50	3.9	10
SOL-K40	40	2.4	526	652	52	6	25
SOL-K50	50	3.0	640	652	52	5.7	25
SOL-K65	65	4.0	751	652	52	7.8	25
SOL-K85	85	5.2	1009	652	52	9.6	25
SOL-K130	130	7.96	1425	652	52	11.9	25
SOL-K175GT	175 Grid Tie	7.42@23.6V	1290	990	36	16	25
SOL-K200GT	200 Grid Tie	7.61@26.3V	1425	990	36	18.5	25
Canon Unisolar Amorphous Modules							
SOL-U64	64	3.88	1366	741	48	11.8	20

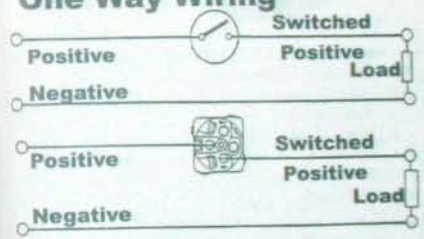


Switches

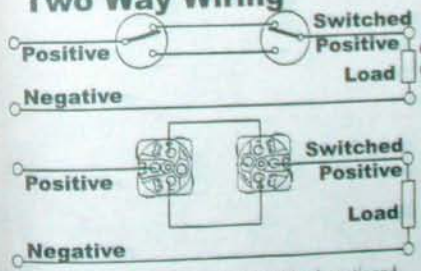
You can use 240 volt AC switches for low voltage DC lighting because these lights are more efficient and use less power than their 240 volt counterpart, so long as you use low wattage lights(eg no more than 50W) or use a switch with a higher rating. Because the arcing potential in a DC system is far greater than in an AC system you need to lower the amperage rating of the switch. If an AC switch is designed to handle 15 amps, you may get quite a long and reliable service out of it if you limit the current to 2 amps. The more the switch is derated, the more reliable and the longer its service life will be.

Switches may either be used individually (ie one switch for one light) or may be arranged in such a way that two switches operate the same light, where you can switch the light on with one switch and off again with the other. A pull cord switch can often simplify the wiring as this kind of switch can be mounted on the ceiling somewhere along the wire going to the light, hence it is not necessary to bring a wire down the wall especially for the switch.

One Way Wiring



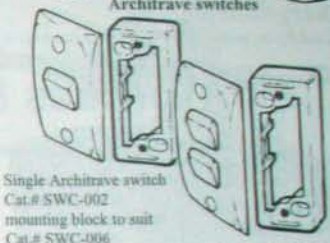
Two Way Wiring



The above diagrams show the wiring in both schematic and point-to-point representation of both one-way and two-way wiring (one switch or two switches operating the same load). The switch mechanism shown is the same as that found in the architrave switch and the 1, 2, 3 and 4 gang flush mounted switch.

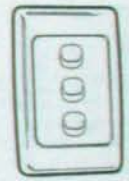
Round surface mounting switch
Cat.# SWC-010

Architrave switches



Single Architrave switch Cat.# SWC-002
mounting block to suit Cat.# SWC-006
Double Architrave Switch Cat.# SWC-003
mounting block to suit Cat.# SWC-007

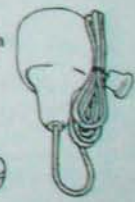
Standard Flush Mount Switches



1 Gang Switch Cat.# SWC-015
2 Gang Switch Cat.# SWC-016
3 Gang Switch Cat.# SWC-017
4 Gang Switch Cat.# SWC-018

Mounting Block to suit all of the standard flush mount switches:
Cat.# PWP-011

Pull-cord switch
Cat.# SWC-004

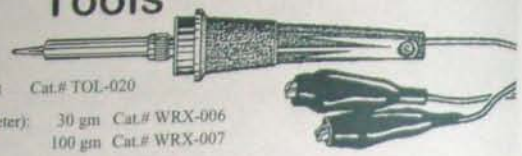


Cordline (in-line) switch
Cat.# SWC-008

Sundaya Broco Switch
Cat.# SUN-AC162

Sundaya Pull On Switch
Cat.# SUN-AC160

Tools



Soldering Iron 12 Volt 60 Watt Cat.# TOL-020

Resin Core Solder (1mm diameter): 30 gm Cat.# WRX-006
100 gm Cat.# WRX-007

Rechargeable Tool

Makita and Ryobi, make a range of rechargeable tools as well as 12 volt chargers to suit.

Torches & Lanterns

Cat. # TOR-010

Hand Powered Torch

Does not use batteries but operates by hand-power. The regular pressing of a lever turns a dynamo which produces current to power the light. It is sturdily built with a locking device for the lever and an adjustable focus.
It measures 138 × 62 × 44 mm and weighs 200 gm.

Cat.# TOR-008

Super-Bright LED / Cold Cathode & Xenon Torch

- Choice of 3 different lights
- 3 LEDs provide over 80 hours of light per set of batteries
- Cold cathode tube provides over 7 hours of light
- Xenon light bulb provides over 3.5 hours of light
- Xenon bulb and superbright LEDs used in hand-held torch mode
- Cold Cathode tube used in general lighting mode (eg illumination inside a tent)
- Requires 4 × 'AA' batteries (1 set included)
- Water resistant
- Xenon bulb can be focussed

The Rainbow Dolphin®

Rechargeable Torch

Don't waste your money and squander the earth's limited and valuable resources on disposable batteries.

The Rainbow Rechargeable Torch can be recharged hundreds of times and save you hundreds of dollars in disposable batteries.

A Torch that won't leave you in the dark:
- No sudden fade out
- Spare bulb inside

Bright, Reliable and Sturdy
- Based on rugged Dolphin® torch
- Leak proof, maintenance free battery
- 200-1000 recharges depending on usage

Cat.# TOR-001

LED Head Torch

- Ultra bright long life LED light (3 LEDs)
- Lightweight / small / compact
- Swivel tilt adjustment
- 80 hours of light with 3 × 1.5V "AAA" batteries
- Handy headband attachment for hands-free operation
- Adjustable headband or attach to wrist, belt, hat or bike etc

Cat.# TOR-013

Testing a micro solar lighting system in Vanuatu

Solar Toys & Educational Kits

Junior Solar Educational Kit

Experiment with solar power or make up your own kits using the components of this kit to add a solar powered propellor or rotating disk. This kit includes:

- Solar Cell Module
- Solar Powered Motor
- Screws and Nuts
- Wire and Motor Clips
- Propellor and Spinning Coloured Disks
- Solar Energy Information Booklet
- Paper Aeroplane and Bird Models

Cat.# TOY-004

Photos: (Left) A pot of cooking food being transferred from the Parabolic Dish Cooker to a Thermos insulated slow cooker. (Below) A 4 pot stainless steel solar box cooker.

Wind Turbines

The Power of Wind

Air moving at 40 Kph through one square metre theoretically has an energy content of 400 watts if it were stopped. The power extracted from the wind cannot exceed 59% of the power in the wind.

Wind Variations

Whereas with Solar or Hydro-electric power the batteries receive some recharge on a daily basis, at times there may not be any significant wind for charging the batteries for weeks on end.

Winds are notoriously variable, and most installations must include an auxiliary generating system to recharge the batteries in low wind periods.

Winds are the result of differences between temperatures in the atmosphere, the turning motion of the planet and the varied topography of the earth's surface. The winds that are significant to a discussion of wind-plants may be divided into two categories: the planetary winds and local winds.

Planetary Winds

Planetary wind systems, normally called prevailing winds, are those great moving air masses that dominate whole areas and show constant directional characteristics, varying only with the movement of high or low pressure systems and with the seasons of the year.

In many locations these are the dominant winds, and good wind-plant sites are those that take maximum advantage of prevailing winds. Included among such sites are exposed hill tops; shore lines facing the prevailing winds; an open plain or plateau; the floor of an open valley running parallel to the prevailing winds, or the windward side of a gently sloping hill.

Local Winds

Local winds, by contrast, are caused by temperature differences created by local topographic conditions. Land-sea breezes, for example, will blow from the land towards the sea by night, simply because land temperatures are more subject to change than the great mass of the ocean.

Mountain and valley breezes are caused by the same local effects. On a warm sunny day winds may rise strongly off the floor of a valley and up the slopes of adjacent hills. The best site for a wind-plant is one where dominant planetary wind patterns are reinforced by local winds.

Site Evaluation

In order to know if a wind powered system is either feasible or cost competitive you need to have some facts and figures. Because of the site preparation and work that needs to go into a wind tower, you need to have done all of your home-work before you take the big step. Unless you have a particularly good wind site, it is recommended that either you have a hybrid system (ie wind and solar or wind and diesel) or no wind system at all.

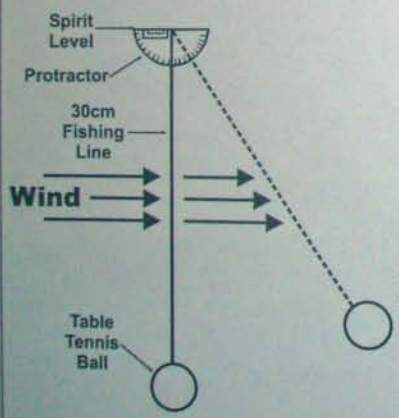
In order to find out if you have a good wind site you may need to spend a few hundred dollars on an anemometer to give you the data. If you want to save yourself this cost or do a feasibility study on whether even the cost of the anemometer is worth it, then the following information may be of use to you.

A Simple Evaluation Method

A very simple method of measuring the strength of the wind can be carried out as follows. You need 30 cm of thin fishing line (or similar), a table tennis ball, a protractor, and a spirit level. You fix the ball to the end of the fishing line, and fix the other end of the fishing line to the centre of the protractor. When the wind blows the ball moves and the angle of the line changes. By reading the angle on the protractor and using the chart below you can estimate the strength of the wind. The spirit level is used to make sure that the top edge of the protractor is horizontal.

Measuring the Wind

Angle	m/s	Kph	Description
90°	0.2	0.5	Calm; smoke rises vertically
85°	2.4	9.7	Light breeze; smoke drifts; leaves rustle
80°	3.4	13.1	Gentle breeze; leaves and twigs in motion
75°	4.5	16.2	Moderate breeze; raises dust and loose paper
70°	5.2	18.9	Fresh breeze; small trees sway
65°	5.9	21.4	Fresh to strong breeze; created waves form on inland waters
60°	6.6	23.9	Strong breeze; large branches in motion
55°	7.3	26.4	Strong breeze; difficulty with umbrellas
50°	8.0	28.9	Near gale; whole trees in motion
45°	8.7	31.4	Near gale; impedes progress
40°	9.5	34.2	Gale; breaks twigs off trees
35°	10.4	37.4	Gale;
30°	11.5	41.3	Strong gale; slight structural damage
25°	12.6	45.3	Strong gale; tiles lift off roof
20°	14.4	52.0	Storm; seldom experience inland. Anything beyond this is a violent storm or a hurricane accompanied by widespread damage

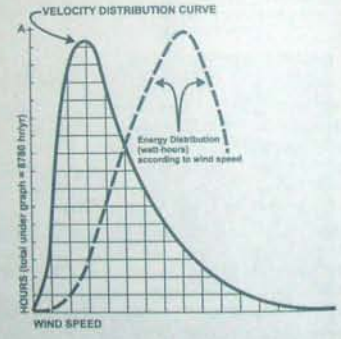


Getting Results

Sampling the wind variations over a period of a few weeks will not necessarily give an indication of the yearly wind cycle. Since most people don't want to twiddle their thumbs for a year while taking readings, then approximate schemes must be found. A good start (after talking to the locals) is to establish a correlation between your site and the nearest meteorological station that you can obtain wind-speed data for. A period of one month is hopefully a sufficient time to take measurements over to establish this correlation.

Does the average of the figures acquired at the weather bureau equal the ten year average for that month? If it is not even close you may end up with particularly optimistic or pessimistic results. You may either keep collecting data until you find a good, consecutive period that, at the weather bureau station, averages out to close to the ten year average for that month, or adjust the figures for that month from the weather bureau and your site by the same amount to be a little closer to the ten year average.

Now find what factor you should multiply the selected weather bureau data by to get the yearly average. Multiply the average at your site by this number as well to get a close approximation of the yearly average. To ensure that a wind generator produces a worthwhile output, an annual average windspeed in excess of about 15 kph is desirable. Knowing the average wind speed, we can immediately extrapolate certain things from the chart below.



The chart is called the velocity distribution curve. It is a similar shape for all wind power locations, and gives a good indication of amount of time the wind blows at a particular wind speed.

Having established the relationship between wind- speeds at the two sites, you can also use the meteorological bureau figures to estimate the seasonal variations at your site. This information can give you an idea of the seasonal variations of the output of the wind-plant.

Wind Velocity and Rotor Diameter

The power from the wind increases as a function of the cube (third power) of the wind velocity. Increasing the diameter of the rotor increases the power output as a square function. Power from the wind can be derived by the formula:

$$W = 14.3\ PAV^3$$

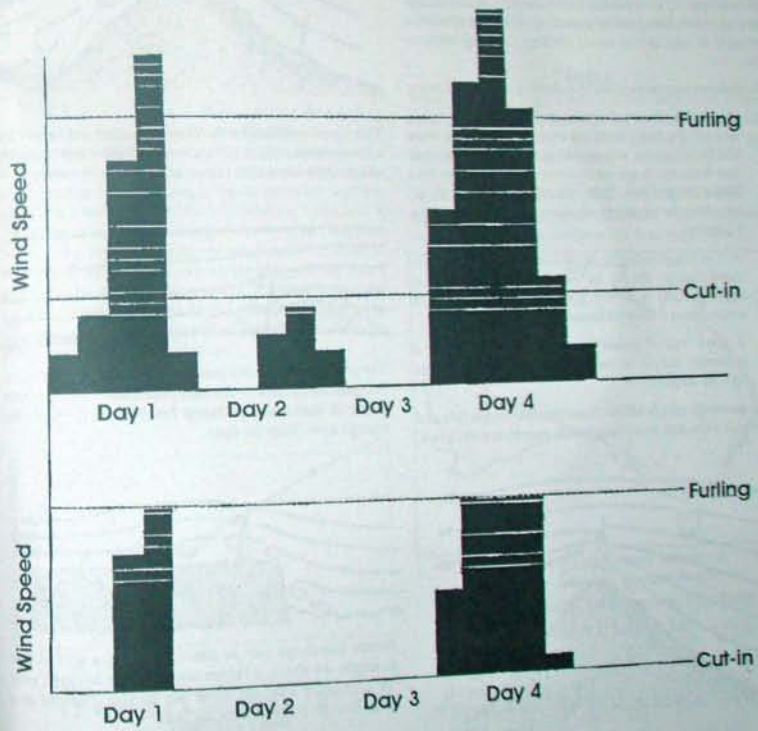
where:

P = air density (2.3×10^{-3})
A = area swept by turbine blades (sq. metres)
= radius (m) squared x 3.1416 (π)
V = wind velocity in kph

The air density figure is for sea level. Power from a 30 kph wind will be 10% less at an elevation of 1,000 metres, 25% less at 3,000 metres.

The following graph was generated from a wind survey, taking 4 wind samples per day (sunrise, midday, sunset, 10 pm) over 6 days. This graph was then modified, using the characteristics of the wind generator considered for the site. The information used was the cut-in wind speed and the furling wind speed. The cut-in wind speed is the amount of wind required before the generator starts producing power. The furling wind speed is the amount of wind required to produce the maximum power that the generator is capable of; any wind in excess of this will not generate more than this maximum.

The period over which there is no wind with sufficient force to generate power is the period when either the battery storage or another energy source must provide the required power.



Choosing the Correct Tower Height

The two most important considerations in planning the tower height for a wind turbine are avoidance of turbulent air flow produced near ground level by the 'roughness' of the terrain over which the wind flows, and avoidance of excessive ground drag which lowers wind velocity near the ground and severely restricts the performance of a wind turbine.

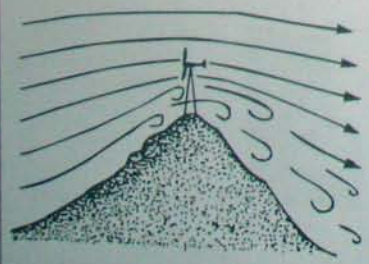
Turbulence

A wind turbine must never be located such that it is subject to excessively turbulent air flow. Light turbulence will decrease performance since a turbine cannot react to rapid changes in wind direction, while heavy turbulence may reduce expected equipment life or result in wind turbine failure. You can detect turbulence by streaming a long ribbon from a guyed pole or mast to see if it streams easily in high winds from various directions. The mast should be roughly as high as you would envisage the wind tower to be.

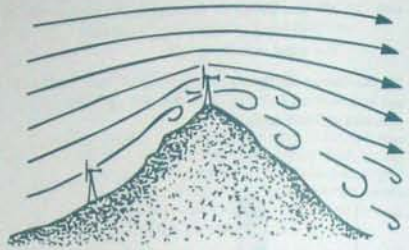
Turbulence may be avoided by following a few basic rules:

1. If possible, the wind turbine should be mounted on a cleared site free from minor obstructions such as trees and buildings for at least 100 m in all directions and free from any major obstructions such as abrupt land forms for at least 200m. Even over clear ground, however, the minimum recommended tower height is 12 metres.
2. If it is not possible to avoid obstructions as above, tower height should be increased to a value of approximately 9 metres greater than the height of obstructions within 100 metres.
3. A good "rule of thumb" is to locate the turbine at a minimum height of three times that of the tallest upwind barrier.

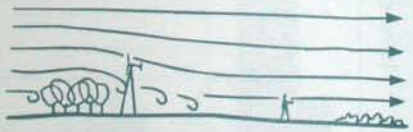
The drawings which follow illustrate some of the do's and don'ts of siting and tower height with respect to turbulence.



High, rough hilltops may produce substantial turbulence in the wind-stream. Tower number 1 is located on the relatively gentle smooth lower slope and will be clear of most turbulence when the wind-stream is left to right in the drawing, but will be in the wind shadow of the hill when the wind reverses. Tower number 2 is too low and while exposed to high velocity winds is also located in severe turbulence which may destroy the wind generator.



This drawing illustrates the proper location and height for a tower on this hill. It is fully exposed to the high velocity winds and is above the region of harmful turbulence.

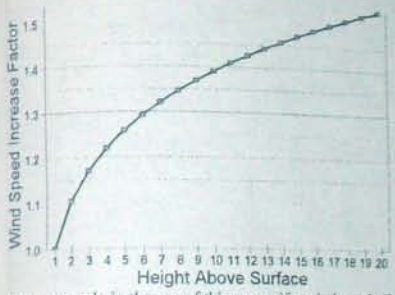


The grove of trees in this example will produce turbulence. A higher tower close to the trees places the wind generator above the turbulence. A shorter tower is safe if placed far enough away from the trees.

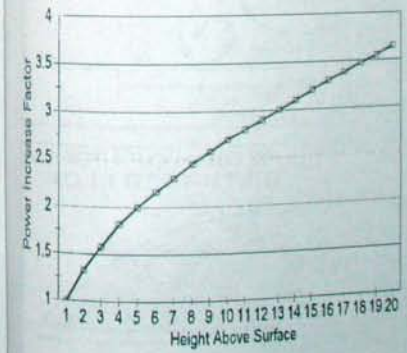
Severe turbulence may be created by the sea cliff in this example. As above, a higher tower will be required near the cliff while a shorter tower will be safe if placed at a great enough distance from the cliff.

Ground Drag

The avoidance of ground drag will increase performance dramatically. Up to a considerable height, the least expensive way to increase your power output from a wind turbine is to increase tower height. A generally recognised 'rule of thumb' is that wind speed increases as the 1/7th power of the height above ground. The following curve illustrates this theoretical increase in wind speed with increasing height above ground:



As an example in the use of this curve, if a windspeed of 4 m/s were measured at 2 metres above the surface, the windspeed at 20 metres height can be predicted from the curve. At 2 metres height, the 1/7th power is 1.104, and at 20 metres it is 1.694. Dividing 4 m/s by 1.104 and then multiplying by 1.694 yields the predicted windspeed of 6.14 m/s at 20 metres. However, the energy in the wind, and therefore wind generator output, is proportional to the cube of the windspeed. So, in this example, by increasing the tower height from 2 metres to 20 metres increases the wind-turbine output by 3.6 times.



Tower Construction

The smaller wind generators (up to 100 watts) can be mounted on a sturdy pipe with guy wires. The larger machines would need a more substantial tower in which case it is advisable to contract a person experienced in the erection of wind generator towers. Check with the local Council to see if there are any regulations concerning the erection of poles or towers, especially if you live in an urban area.

Safety

Do not place a wind-plant in a turbulent area, to avoid severe stress on wind turbine components and tower.

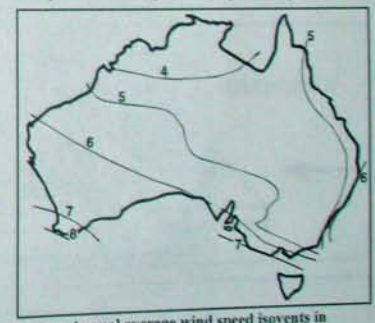
All the controls, necessary safety (governing and feathering) devices to protect against excessively high wind speeds, instruction manual etc should come with the machine that you purchase. What may not be provided is a suitable regulator to prevent your battery from being overcharged.

Noise

Wind generators may produce a fair amount of noise, particularly in high winds. Beyond a couple of hundred metres, the noise of the wind itself generally drowns out the noise of the wind generator.

Australian Wind Assessment

High wind areas are often associated with coastlines. Away from the coast you are away from high winds.



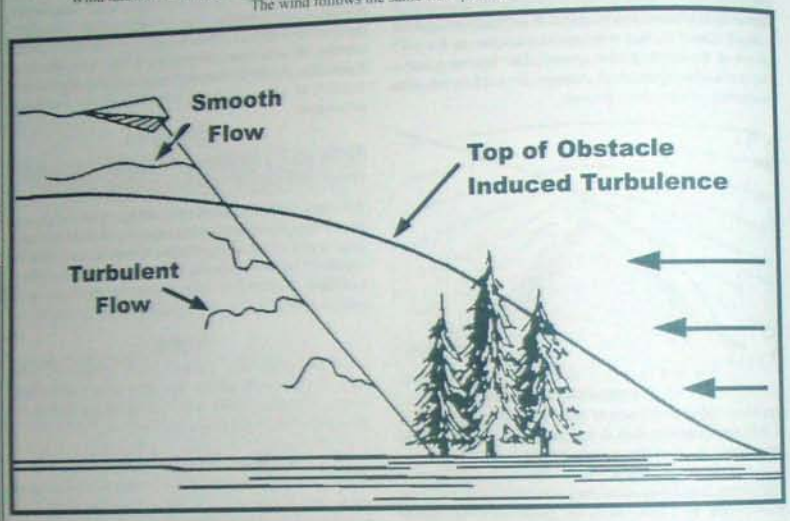
Annual average wind speed isovents in metres per second at 30 metre height.

Wind Speed Conversion Factors

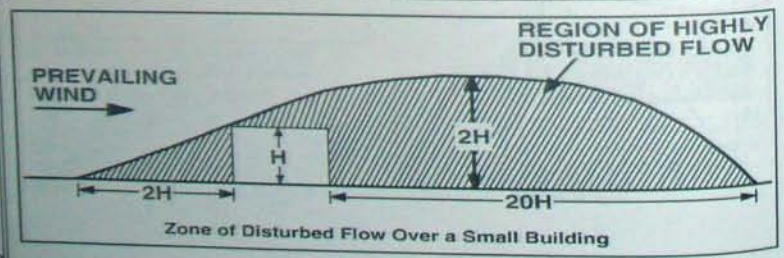
	mph	ft/sec	knots	kph	m/s
1 mph	1	1.467	0.608	1.609	0.447
1 ft/sec	0.682	1	0.592	1.097	0.305
1 knot	1.152	1.689	1	1.853	0.515
1 kph	0.621	0.911	0.54	1	0.278
1 m/s	2.237	3.281	1.943	3.6	1

THE KITE TEST

A sturdy kite with a strong string and crepe paper ribbons or strips can give a good indication of air turbulence. Wind turbulence can be visualised by studying a small river with many obstacles such as boulders. The wind follows the same flow pattern.



Airflow Near a Shelterbelt (Van Eimern et al., 1964)



Zone of Disturbed Flow Over a Small Building

Soma Wind Turbines

The Soma wind turbines are rugged, durable machines designed to withstand long-term wear and fatigue.

Performance

The large rotor diameters ensure high efficiency in light to moderate windspeeds. The brushless, permanent magnet alternators used on all Soma wind turbines are designed to produce a power curve that matches the output of the 2 bladed propeller while operating at optimal tip speed ratios.

Tower

There is a choice between using a wooden pole or galvanised pipe for a tower. The wooden pole is set in the ground and guy wires are used for support. The wind turbine is assembled on top of the pole after it has been raised.

The galvanised pipe tower utilises 2 or 3 lengths of pipe to form a tower 13 or 20 metres high. The wind turbine is assembled on the ground and is raised with the hinged tower.

Control Panel

Soma wind turbines are supplied complete with a voltage regulated control panel and dump load. When the batteries are fully charged, the excess power is burned off as heat. The Soma 1000 features a tapered charge regulator which progressively reduces the supply of current to the battery as it reaches full charge. By adjusting the control dial, the upper voltage can be reset to enable equalisation charging.

Feathering Mechanism

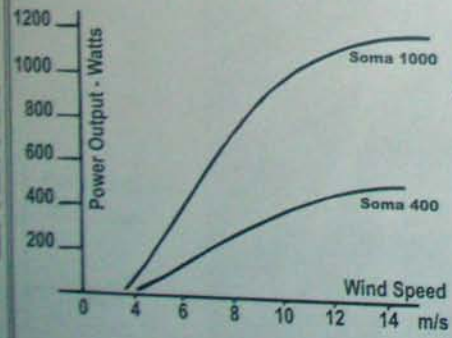
The tilt back action relieves pressure on the wind turbine and tower in strong winds. This is a fail-safe design with mechanical simplicity. A hydraulic dampener limits the feathering action in gusty wind conditions.

Distance

The maximum distance from the tower to the battery bank depends on the system voltage. A 12 volt Soma 400 can be sited up to 150 metres away, and 300 metres at 24 volts, while the Soma 1000 can be sited up to 750 metres away if 110 volts is used.

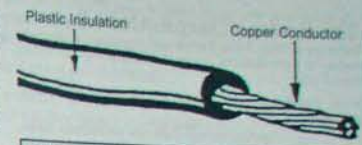
Specifications:

Model:	Soma 400	Soma 1000
Rated Output	400 W	1000 W
Peak Output	500 W	1200 W
Rotor Diameter	2 metres	2.7 metres
Voltage	12 or 24 Volt	24, 48 or 110 V
Controller	Voltage Controlled Relay	Mosfet Switching
Cut-in Wind Speed	4 m/s	3.5 m/s
Rated Wind Speed	10 m/s	10 m/s
Max. Wind Speed	50 m/s	50 m/s
Operating Speeds	300-1200 rpm	250-800 rpm
Feathering	Tilt-up	
Number of Blades	2 Blades	
Blade Construction	Hollow Moulded Fibreglass GRP	
Alternator Type	Permanent Magnet - 3 phase	
Shipping Volume	0.15 cubic metres	
Shipping Weight	40 kg	50 kg



Wire

Low voltage power systems often operate at rather high current levels. If the interconnecting cables are too small, a large proportion of the power available will be wasted in the cable itself. This loss can be reduced by using a larger cable, but this increases costs. The acceptable maximum voltage drop for DC loads is 5% of nominal battery voltage. The chart and the formula on this page are provided to help you in selecting the best cost / power loss compromise.



All the methods of determining voltage drop on this page are for DC only. AC electricity behaves quite differently.

WIRE CHART

12 Volt

acceptable cable size (mm²)

Amps	Cable Length (metres) 1	2	5	10	15	20	25	30
0.5	0.4	0.4	0.4	0.4	1.84	1.84	1.84	1.84
1	0.4	0.4	0.4	1.84	1.84	1.84	1.84	1.84
1.5	1.84	1.84	1.84	1.84	1.84	1.84	2.9	2.9
2	1.84	1.84	1.84	1.84	1.84	2.9	4.6	4.6
3	1.84	1.84	1.84	1.84	2.9	4.6	4.6	7.9
4	1.84	1.84	1.84	2.9	4.6	7.9	7.9	7.9
5	1.84	1.84	1.84	4.6	4.6	7.9	7.9	13.6
7.5	1.84	1.84	2.9	4.6	7.9	13.6	13.6	25.7
10	1.84	1.84	4.6	7.9	13.6	13.6	13.6	25.7
15	1.84	1.84	4.6	13.6	25.7	25.7	25.7	32.2
20	2.9	2.9	7.9	13.6	25.7	25.7	32.2	49.2
25	4.6	4.6	7.9	25.7	25.7	32.2	49.2	49.2
30	4.6	4.6	13.6	25.7	32.2	49.2	49.2	
40	7.9	7.9	13.6	25.7	49.2	49.2		
60	13.6	13.6	25.7	49.2				
80	25.7	25.7	25.7	49.2				
100	32.2	32.2	32.2					
125	49.2	49.2	49.2					

24 Volt

acceptable cable size (mm²)

Amps	Cable Length (metres) 1	2	5	10	15	20	25	30
1	0.4	0.4	0.4	1.84	1.84	1.84	1.84	1.84
2	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84
3	1.84	1.84	1.84	1.84	1.84	1.84	2.9	2.9
4	1.84	1.84	1.84	1.84	1.84	2.9	4.6	4.6
5	1.84	1.84	1.84	1.84	2.9	4.6	4.6	4.6
7.5	1.84	1.84	1.84	2.9	4.6	4.6	7.9	7.9
10	1.84	1.84	1.84	4.6	4.6	7.9	7.9	13.6
15	1.84	1.84	2.9	4.6	7.9	13.6	13.6	25.7
20	2.9	2.9	4.6	7.9	13.6	13.6	25.7	25.7
25	4.6	4.6	4.6	7.9	13.6	25.7	25.7	25.7
30	4.6	4.6	4.6	13.6	25.7	25.7	25.7	32.2
40	7.9	7.9	7.9	13.6	25.7	25.7	32.3	49.2
60	13.6	13.6	13.6	25.7	32.2	49.2	49.2	
80	25.7	25.7	25.7	25.7	49.2	49.2		
100	32.2	32.2	32.2	32.2	49.2			
125	49.2	49.2	49.2	49.2				

NOTE: The Cable Length in the above tables are route length which is half the total conductor length. If the positive and negative leads are different lengths an average must be taken.

Metric cables are specified by the copper area (in square millimetres), the number of strands of wire and the number of conductors or cores in each sheath. The voltage drop is the same regardless of voltage, assuming that amps, distance and cross sectional areas are the same. If the wattage remains the same for different voltages, the amps can be calculated by dividing watts by volts.

The Formula

If you need to calculate the voltage drop under a given set of circumstances, there is a formula by which it can be determined.

Let: A = cross sectional area of cable in (mm²)
L = route length in metres
I = current measured in amps
R = resistance of cable (Ω)

resistance of copper = 0.017 Ω aluminium = 0.028 Ω
steel = 0.18 Ω

Voltage Drop = 2 x L x I x R ÷ A

Example:
You have a power point connected to a power source. The route length is 8 metres. If the wire is 4.6 mm² multi-stranded copper cable and the expected current is expected to be 10 amps, we have:

A = 5 L = 9 I = 10 R = 0.017

Voltage drop can then be calculated to be 0.58 volts. If this figure is considered to be acceptable it would avoid spending more money on larger wire.

mm²		per metre	30 m roll	ampacity
1.84	twin sheathed	WIR-M02	WIR-302	15 amps
2.9	twin sheathed	WIR-M03	WIR-303	20 amps
4.6	twin sheathed	WIR-M05	WIR-305	25 amps
7.9	single (black or red)	WIR-M08	WIR-308	45 amps
13.6	single (black or red)	WIR-M14	WIR-314	70 amps
25.7	single (black or red)	WIR-M25	WIR-325	90 amps
32.	single (black or red)	WIR-M32	WIR-332	110 amps
49	single (black or red)	WIR-M49	WIR-349	150 amps

NOTE: The above cables are rated for extra low voltage

SUMMARY

The Basics of Stand-Alone Power

Power input from Solar Panels and other power sources need to be more than the power consumption at the worst time of year.

Partial shading of solar panels will significantly reduce their output.

More or bigger battery storage does not necessarily mean a better or more reliable power system. The opposite may be the case. The battery storage needs to relate to the size of your charging source. In the case of a solar-electric power system it should not be more than 100Ah of storage for each 50W - 60W Solar Panel. You should not ever take the lead-acid battery bank beyond 50% discharge and you should have some reserve for a rainy day or two (usually at least 5 days of power reserve).

Keep the battery bank in a well ventilated position not too far from where the power is used (it can usually be further from the charging source) and OUT OF REACH OF CHILDREN! Battery acid can cause serious injury.

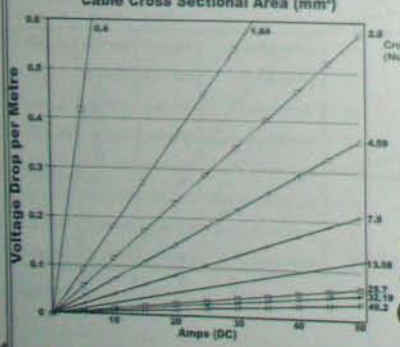
The power supplied by a battery bank presents just as much of a potential fire hazard as a 240V grid connection. Ensure that all cabling is properly fused.

Do not make multiple connections onto the battery. You should connect all house wiring to a set of links and have only one set of heavy duty (eg 13.6 or 32 mm²) cables connecting these links to the battery bank. You should connect the inverter and 240 volt battery charger to a connection point as near to the battery bank as is practicable.

The wires to the battery bank should be soldered into corrosion resistant lugs of a suitable size and bolted onto the battery terminals. Use a marine battery terminal if necessary (see p.47).

Smear petroleum jelly (eg vaseline) or grease on battery terminals before bolting on connections.

Voltage Drop. Battery based systems providing very low voltage (eg 12V) DC power are very susceptible to unacceptable voltage drop due to undersized wire and poor connections. A voltage drop of greater than 5% (0.6 volt for a 12V system) is considered too much. Check all connections and upgrade the wire if necessary. Following is a voltage drop graph:



Unless you have a power system that is very much larger than your basic needs; it is recommended to have some form of back-up. This back-up may be in the form of a petrol or diesel generator and a large battery charger (at least 20A charge). Other options include a steam engine or being prepared to revert to kerosene or candles in case the state of charge of the battery goes too low.

If you have lots of 240V appliances of less than 350W and a few of more than 1000W (eg washing machine, iron, vacuum cleaner, circular saw) it may be a good idea to operate a petrol or diesel generator for the large appliances a few hours per week (with a battery charger also connected) and a small inverter for the small appliances. A large inverter may cost as much as a petrol generator. The generator would provide back-up power when the state of charge of the battery bank is low (eg after days or weeks of overcast weather). The smaller inverter would mean better power efficiency with the smaller appliances and the convenience of being able to turn them on and off with a switch.

Inverters and Generators produce a dangerous voltage. Do not use the same kind of plugs and sockets for extra low voltage DC (eg 12V or 24V) and 240V AC as this could cause a lethal accident.

It is recommended to have an amp meter to measure the charge into the battery bank or at least to know that it is still working. It is also recommended to have a volt meter to see at a glance how your system is behaving (with a 12V system it should be between 12V and 15V).

It is strongly recommended to have a regulator to prevent your battery from overcharging. A switching or shunt regulator is suitable for solar panels, but with most other charging sources a shunt regulator is recommended.

12V DC appliances are nearly always more energy efficient than their 240V counterparts. Operating all the lighting (fluorescent lights with dedicated inverters built into them) and as many as possible of your appliances from the battery voltage can mean a significant saving in power and the overall cost of a stand-alone power system. 12V DC fridges us less than half the power of a 240V AC fridge and DC pumps use between one quarter and one sixth of the power of 240V AC pumps powered through an inverter. A 12V Laptop Computer consumes about one sixth of the power of a 240V Desktop Computer. A portable battery operated cassette deck usually draws about one half of an amp and a battery operated radio usually draws about one third of an amp if connected to a 12V source. The same kind of appliances in 240V may draw many amps from the battery bank (via an inverter).

Cross Section of Copper (Not including insulation)

- 1.84 mm²
- 2.9 mm²
- 4.59 mm²
- 7.9 mm²
- 13.6 mm²
- 25.7 mm²
- 32.2 mm²
- 49.2 mm²

Generate heat by burning some kind of fuel and/or have a passive solar designed home because it would be very expensive in order to have a large enough solar electric system to generate very much heat with electricity.

Fluorescent lights with a built-in dedicated inverter use between one sixth and one seventh of the power of an incandescent light of the same brightness (measured in lumens).

12V or 24V?

To reduce the size and cost of your stand alone power system it pays to have lights and a number of appliances such as a radio, digital timer, laptop computer and pump that are designed to operate at a low DC voltage such as 12V or 24V. There is a larger range of 12VDC appliances than 24VDC.

Question: Should I choose a 12 volt or a 24 volt stand-alone power system?

Reply: The voltage you choose would be based primarily on one or more of six factors. If your power requirements are very large you may need to choose a higher battery voltage than 24V.

Limitations to Battery Size

1. **Battery Bank Size.** With solar panels as the primary energy source, it is usually recommended to have a minimum of 5 days battery storage with the battery bank still retaining a minimum of 50% charge after the end of those 5 days. The largest single battery bank available will provide 550 amp-hours over a 100 hour period to be 50% discharged at the end of that period. It is not recommended to increase storage capacity by connecting two or more battery banks side by side (in parallel). By doubling the battery voltage, the current (amps) from the loads is effectively halved, so doubling the voltage has the same effect as doubling the amp-hour storage capacity of the battery bank without having the battery bank connected in parallel.

The battery voltages generally used for stand alone power systems are 12V,24V,48V,110V and 240V DC.

2. **Size of Inverter** required to meet expected 240VAC loads. For any particular battery voltage there is a limit as to how large an inverter is available. With higher battery voltages larger inverters are available.
3. **Cable size and length** to carry DC loads. Doubling the voltage effectively halves the DC loads and halves the voltage drop. Because the battery voltage is doubled the percentage of the voltage drop in relation to the battery voltage is only a quarter of the percentage drop with the lower battery voltage. Unless the cable runs are exceptionally long or the power draw (amps) of the loads is exceptionally high this consideration would not be an issue.
4. **Number of solar panels required.** Solar regulators are generally limited to 30 amps maximum. With a large 12 volt system you may require twice as much cabling and twice as many regulators as with an equivalent 24 volt system.
5. **Maximum Charging Rate.** The maximum charging rate for a battery bank is usually 10% of its amp-hour capacity measured at the 10 hour rate. A 600 Ah battery should therefore not be charged at more than 60 amps.
6. **Voltage of charging source.** If a large wind turbine or large DC generator is incorporated into the system then the system voltage will be dictated by the availability and voltage of these charging sources.

Recommendations to Overcome Limitations

Some techniques for overcoming some of the aforementioned limitations:

1.1 Batteries may be placed in parallel with a battery isolator between the charging source and the batteries. You would then use one battery bank for some of the loads and the other battery bank for the rest of the loads. You may, for example connect all DC loads to one battery bank and inverter loads to the other.

1.2 Batteries may be placed in series with separate charging sources, regulators and loads. With this technique you can also have the advantage of being able to use both the individual and the combined voltages. You may, for instance, have 12VDC and 24VDC loads and/or use a 24V to 240VAC inverter. You may also have solar panels to charge either or both 12V banks and a 24V wind turbine to charge both banks.

1.3 Less battery storage and more reliance on generator back-up.

2. You may be able to overcome the inverter shortcoming by having several inverters or having inverters that can operate in tandem such as the larger model of InvertaPower.

3. Instead of opting for a higher voltage, an increase in cable size could also have solved the problem.

Both the battery voltage and the Amp-Hour storage capacity of your battery bank should be appropriate to your needs. Avoid placing many small batteries in parallel. Battery cells connected in series is OK.

4. This limitation can be overcome by having several solar arrays separately wired through separate regulators. It must be remembered that maximum charging rate of most battery banks is 10% of their amp-hour capacity (see limitation 6.).
5. This limitation can be partially overcome by adopting the recommendation 1.1 above. If one battery bank is full and the other is not, you would still have to throttle down the charging rate to 10% of the capacity of the one battery bank.
6. See recommendation 1.2 above.

Installation Guidelines

In order to comply with industry standards, the following guidelines must be followed.

Battery Rooms and Enclosures

Batteries must be installed in a dedicated battery room or enclosure. A divider or partition wall which separates and encloses the batteries from all other equipment extending a minimum of ½ metre above the vent level of the batteries is satisfactory. Where the top of the enclosure is less than ½ metre above the vents, the divider must be continuous to the top. Ventilation must be in accordance with Australian Standard AS 3011.

Lead acid and Nickel Cadmium batteries must be kept in separate enclosures as the fumes from the one type of battery will destroy the other type. Only equipment associated with the battery may be installed or stored in a battery enclosure.

Batteries

All interconnects and battery output connections must be shrouded with a non conductive material. This will include any shunts incorporated for current monitoring. This is to prevent accidental shorting if for instance a tool is dropped onto the batteries. Connections should have a facility for inserting meter probes without removing the shroud.

All interconnects and battery output connections must be fitted with crimp lugs applied with an approved crimp tool.

Batteries shall not be sited directly on a concrete floor. Shelving used for mounting of battery banks shall comply with the requirements of AS 3011.

Fusing

All battery banks must be provided with main circuit protection and an isolation switch in each active lead as per AS 3011. This may take the form of a combined circuit breaker main switch, a switch fuse unit or separate switch and protective devices. This must be installed as close as practicable to the output terminal of the battery and below the level of the vents.

All sub circuits must be fused in accordance with AS 3000, including charge output wiring. There shall be no connection direct to the battery terminals except for the main battery output cable and an earth wire if all active leads are not fitted with protective devices.

Remember that the purpose of the battery fuse(s) and sub circuit fuses is to protect the cables against overloads and short circuits, protection of appliances is a separate consideration.

Generating Sets

Generating sets will not be installed in a battery enclosure or room. There must be no possibility of sparks or fumes from the generator entering the battery area.

All other equipment such as inverters, battery chargers and control systems should be installed as per manufacturers guidelines and Australian Standards.

Solar Arrays

Solar arrays are to be securely mounted with consideration given to wind loading in accordance with AS 1107.2. Arrays should be installed to the north aspect (in the southern hemisphere) within 10° of true north for fixed arrays. Tracking arrays must be installed to the manufacturers specifications. Arrays fixed in altitude angle must be optimised for latitude and load profile considerations. Cabling shall be protected from physical damage and exposure to the effects of temperature and ultra violet radiation.

Micro Hydro Installations

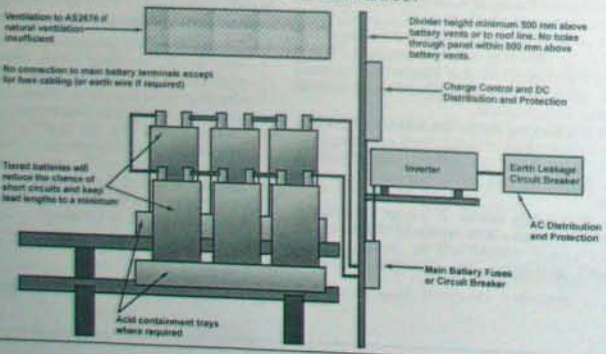
Access to water resources must be via the relevant state government body. Permits must be obtained and sighted before any micro hydro system is installed.

Wind Turbines

Small scale wind systems (eg 50 watts) may not require specialised skills, but any unit requiring a guyed tower must be installed by trained personnel only. Lightning protection (AS 1768) is required.

Adapted from Solar Energy Industries Association of Australia Guidelines.

BATTERY INSTALLATION - PREFERRED LAYOUT



Definitions

Amps - is the measure of the flow rate of electrons through a conductor.

Amp-Hour - is the number of amps (charge or discharge) multiplied by the number of hours for which this charge or discharge continues.

Amp-Hour Capacity - is the number of amp-hours normally available from the fully charged state to the end of discharge (about 11 volts for a 12 volt battery). The standard discharge rates are either 8, 10, 20 or 100 hour discharge.

Automotive Battery - (also referred to as Starting/Lighting/Ignition Battery) - a battery specifically designed for motor vehicles with many thin plates to provide a high current for a short period and yet be relatively small and light.

Boost Charge - is a recharge which takes place at a voltage higher than the normal floating voltage. Is also referred to as gas charge, refresher charge and equalising charge.

Charge - is the process of chemical change when a battery receives and stores energy from a charging source.

Cycle Operation - is a method in which batteries are taken through a process of discharge and recharge.

Deep Cycle - is a working cycle in which the discharge proceeds beyond 50% of the 10 hour rate capacity.

Deep Cycle Battery - a battery designed to be able to cope with some deep cycling without losing too much amp hour capacity. One way of achieving this is by the utilisation of a thicker pasted plate than is found in vehicular batteries.

Desulphation - is the treatment given to a sulphated battery. See Sulphation.

Discharge - is the process of chemical change when a cell delivers energy to the load.

Electrolyte - in the case of lead-acid batteries is a diluted solution of sulphuric acid which acts as the medium by which chemical change takes place between itself and the lead-plates with which it reacts during charge and discharge.

Equalising Charge - is a process which brings all cells of a battery to a fully charged state by correcting small irregularities in the state of charge of individual cells. It is a form of boost charge with the intent of equalising cell voltages.

Float Operation - is a method in which batteries are theoretically preserved in a fully charged state by maintaining all cell voltages above but close to the true open circuit voltage (OCV).

Gas Charge - is a boost charge which takes place at the end of a recharge and at a voltage above 14.1 volts for a 12 volt battery bank.

Headroom - liberated space in battery container above the normal acid level.

Open Circuit Voltage - The terminal voltage of a battery while at rest (neither charging nor discharging).

Plate - inside each cell of a lead acid battery are a series of positive and negative plates. All the positives plates are connected to each other and to the positive terminal of each cell, and likewise with the negative plates and the negative terminals. Between each alternate set of plates are non reactive plate separators.

Recharge - is the restoration of the battery to its maximum amp hour capacity after a discharge.

Sediment Space - The space between the bottom of the plates and the bottom of the container. Also referred to as footroom.

Shallow Cycle - is a working cycle which does not discharge beyond 50% of the 10 hour rate capacity.

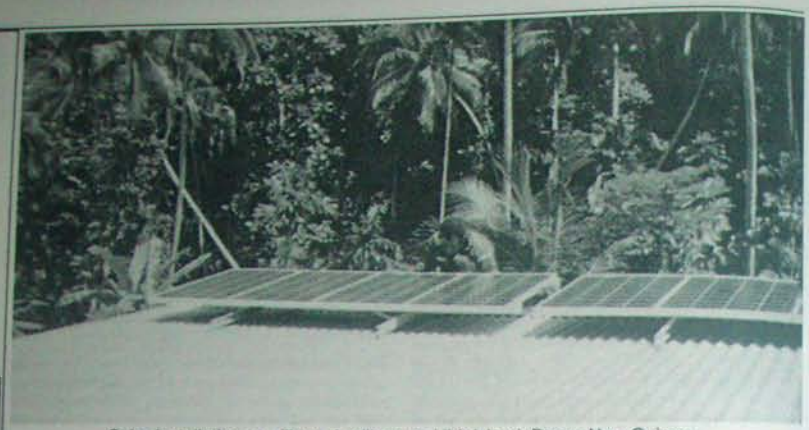
Specific Gravity - is the ratio between the weight of equal volumes of a substance and pure water.

Sulphation - an undesirable process that takes place on the plates of a lead-acid battery as a result of the battery being left in a discharged or semi-discharged state for a long period of time, resulting in the seriously reduced capacity of the battery. Deep Sulphation may cause permanent damage or may be reversible with an involved treatment.

Volts - is the force that causes electrons to flow between two points of a conductor. Also referred to as electromagnetic force (emf) and potential difference.

Watts - is a combination of volts and amps. With a 12 volt system, the wattage of an appliance is the amps used by the appliance multiplied by 12. With a charging system such as photovoltaic solar panels which are rated in watts, your expected charge rate (in amps) may be as low as watts divided by 15 (instead of 12) because of the voltage differential between charging source and battery and the fact that a fully charged 12 volt battery may be in excess of 14 volts. Watts is a measure of power. Also referred to as volt-amps or VA.

Watt-Hours - is the same as amp-hours multiplied by voltage.



Solar Installation on village dwellings on Lihir Island, Papua New Guinea

Alan Robson on his way to work on Lihir Island

Product Index

The page number for each item in the following list of Rainbow Power Company products refers to the beginning of the group section that deals with the product. This is merely a sample of available products and is by no means an exhaustive list. If you do not find what you are looking for in this catalogue please contact us.

Each section contains information and/or instructions on assembly, installation and maintenance.

Please note that specifications on all products are subject to change without notice.

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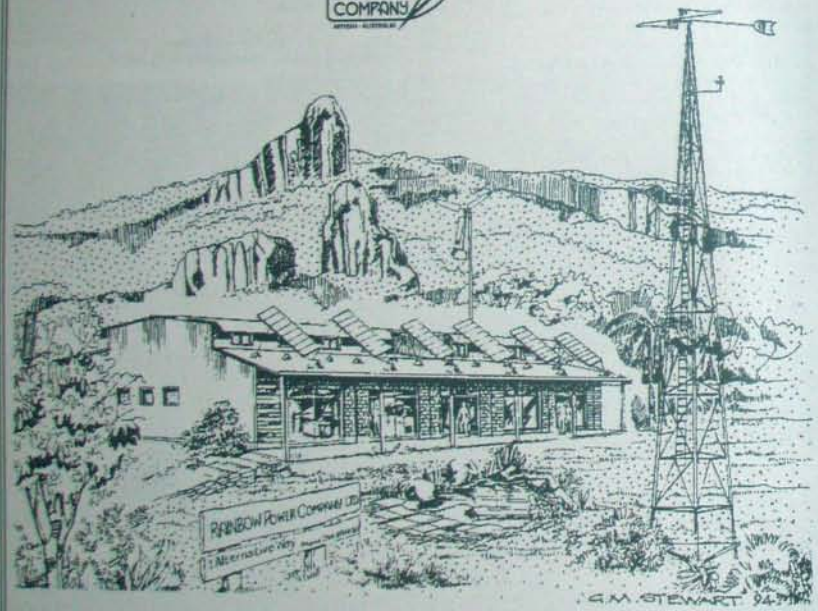

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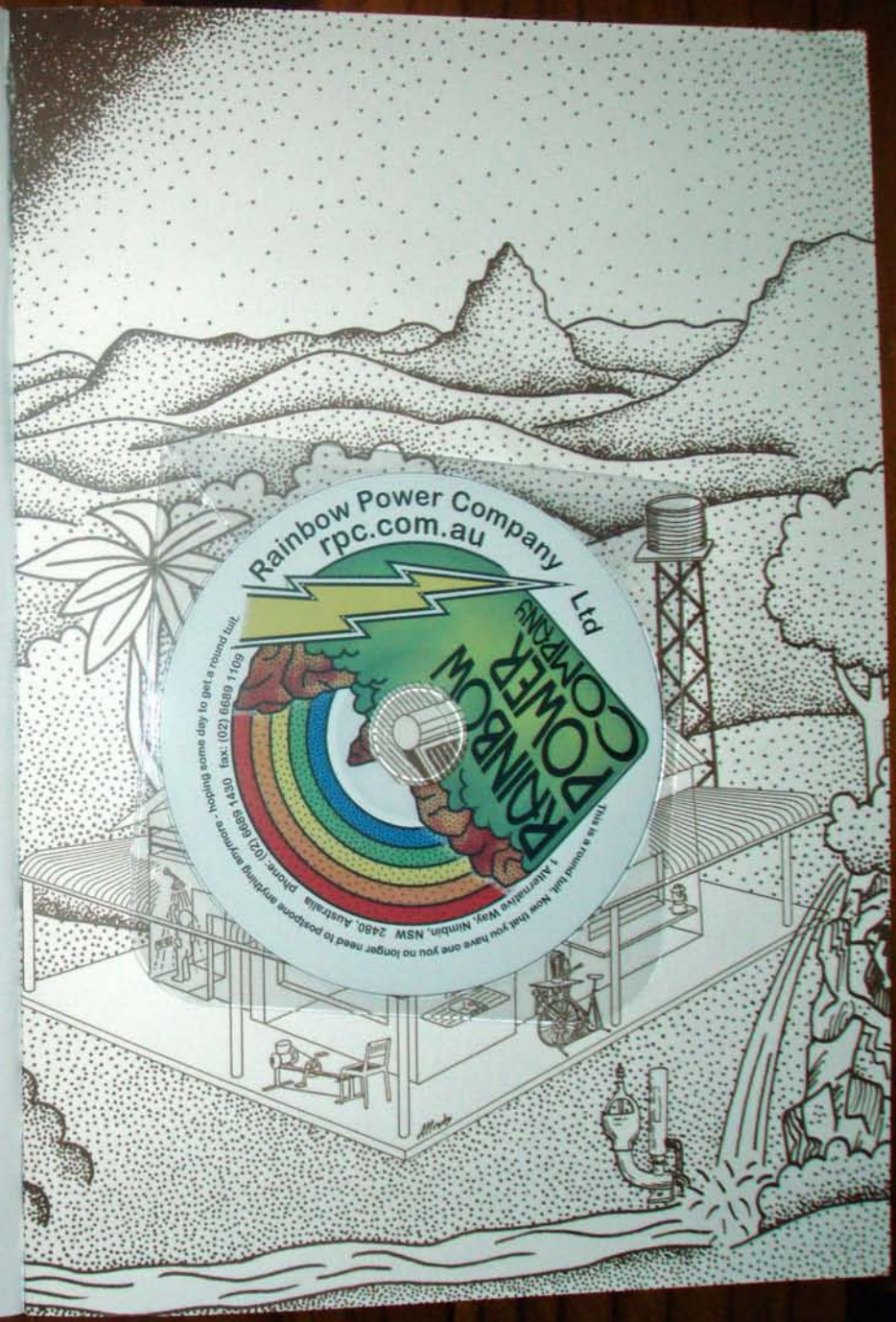


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Manufacture, Sales and Installation of Appropriate Home Energy Systems