Rainbow Power Victron DIY Solar Operation Manual

Index

Introduction

The Rainbow Power Victron DIY Solar System are compact, do-it-yourself power systems. These systems can energize a lot of small gear, including an efficient fridge. Suitable for low-consumption or infrequent electricity users. Ideal for remote sheds, beach huts, motor homes or weekenders.

This system configuration is designed to power lights, a DC pump, an efficient fridge, laptop, modem, printer, fan, TV and other entertainment equipment. Please refer to your customized load design supplied with your quote to ensure your energy usage

Safety

It must be remembered that this system produces and uses electricity. If not used responsibly it is potentially dangerous. Safety precautions and procedures must be followed at all times.

All power should be isolated (disconnected) from any item that is undergoing repair or maintenance. This should be done using the shutdown procedure label on your Rainbow Power Distribution board. Personal Protective Equipment should be worn at all times when maintaining your batteries, eg Safety goggles, gloves, protective clothing.

Batteries.

No sparks or open flames near batteries.

- Safety goggles must be worn in case of explosion or electrolyte splashes.
- Battery terminals must have insulated covers over the terminals.
- Tools should have insulated handles to prevent sparks.
- When batteries are being worked on, all loads and charge must be disconnected.
- Clean water should be readily available near the batteries in case of acid contact with skin or eyes.
- Bi-carbonate soda mixed with water should also be available to neutralise any acid spills.
- No maintenance should be carried out if there is a strong smell of sulphuric acid. If not sure seek advice.

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Photovoltaic Modules
Climbing up the roof exposes you to the risk of falling off. A physical barrier (scaffolding) or a correctly supported safety harness is required whenever anyone climbs onto the roof. A dramatic change of temperature can cause glass to shatter when cleaning solar modules, if the modules are cold do not use hot and if hot do not use cold water. If any removal of stubborn dirt or growth on the solar modules is required then a dishwashing scourer should be fine.

Gensets

- 240V gensets present a number of hazards including:
- Risk of electrocution.
- Flammable and/or explosive fuel.
- Accidents from moving parts.
- Burns from the exhaust pipe.
- Inhalation of toxic exhaust gases.
- Hearing damage from the noise.

Do not use temporary extension cables in long term situations. Use a licensed electrician to install any wiring that may be required. Follow the recommendations provided in the genset manual. If any maintenance is required, seek the services of a qualified technician. In some installations the genset may start automatically and would need to be disconnected from the system before any maintenance is performed. Gensets should be housed in a childproof and well ventilated enclosure.

Damage to the battery due to incorrect settings
Incorrect settings lead to premature aging of the battery. Settings programmed into the Victron MPPT influence the charging behaviour of the System.

- Ensure that the values recommended by the battery manufacturer are set for the battery (refer to the technical data of the battery in the manufacturer documentation).

Always read the manuals provided with your system. The equipment manuals will give you a more detailed understanding of what your system and the equipment within your system are doing.

Product Description

Solar Array
The solar array produces your power from the sun's light. A solar array consists of a number of solar (photovoltaic) modules (panels). Each solar module is a sealed unit which encapsulates a number of solar cells. The power produced goes to the batteries for storage.

Batteries
Your batteries are the 'heart' of the system and may need to be maintained to ensure their full life span. Flooded lead Acid batteries will need demineralised water added periodically, 'Sealed' batteries will not.

MPPT Solar Regulator
Sometimes called a 'Solar charge controller' or 'Solar Regulator'. Its basic function is to control the charging of your batteries to ensure they last as long as possible. See 'Introduction to MPPT Solar charge controller'.

Inverter
The inverter converts the system's power from 12V/24VDC to 240V AC power. The inverter allows you to run any appliances that you would run if connected to the grid as long as it does not exceed the max output of your inverter.

Optional Battery charger
The battery charger allows you to recharge the batteries when overcast weather prevents the solar array from providing enough charge. The battery charger is plugged into a genset and connected to the battery bank to allow it to recharge the batteries when the genset is running.

DC Distribution Board
The DC Distribution Board is the "link" between the individual components of your system. It contains all Circuit breakers, fusing and connection points for your equipment and associated wiring.

Circuit breakers
These are to protect your wiring. Although they are primarily for safety, they can also be used as a switch, allowing you to disconnect separate parts of the system manually.

Starting and Stopping the System

The batteries need to be energise first for the MPPT Solar controller to recognise battery voltage. The PV should be the last item to be energised.

The Rainbow Power Distribution Board will have a 'SHUTDOWN PROCEDURE'' showing you how to turn off the system. To energise the system the 'SHUTDOWN PROCEDURE' should be followed in reverse.

Starting the System

1. Turn ON **'BATTERY**' Main battery CB. The Voltage meter should now show a voltage reading.
2. Turn ON '**SOLAR'** CB. The Blue LED lights on the regulator will now turn on. This will begin the charging process.
3. Turn On '**USB' and 'Light'** CB.
4. Turn ON '**Inverter'** CB.
5. Turn Inverter switch to ON. Green LED on face of inverter should turn on.
6. It is now safe to turn on devices and load test you system.

Stopping the System

1. Turn OFF and unplug all electrical devices on your system.
2. Turn Inverter switch to OFF. Green LED on face of inverter should turn off.
3. Turn OFF '**Inverter'** CB.
4. Turn OFF '**USB' and 'Light'** CB.
5. Turn OFF '**SOLAR'** CB.
6. Turn OFF **'BATTERY**' Main battery CB. The Voltage meter should now Turn Off.

Adjustable Parameters

Always read the manuals provided with your system. The equipment manuals will give you a more detailed understanding of what your system and the equipment within your system are doing.

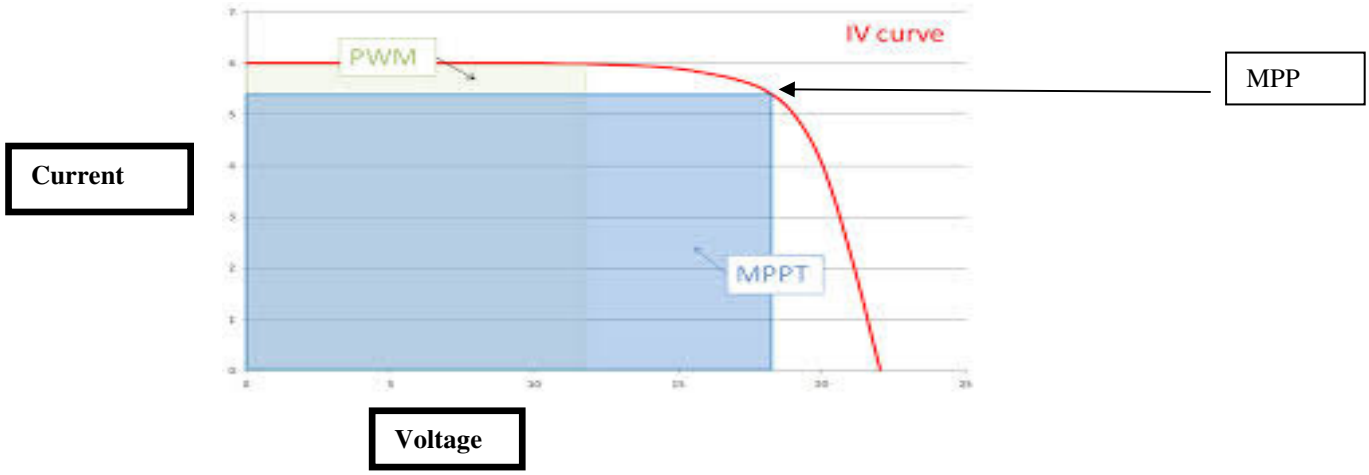
Incorrect settings lead to premature aging of the battery. Settings programmed into the Victron MPPT influence the charging behaviour of the System.

• Ensure that the settings on your regulator are correct for your battery as recommended by the battery manufacturer (refer to the technical data of the battery in the manufacturer documentation).

Victron MPPT Solar Regulator

The Victron MPPT (Maximum Power Point Tracking) Solar charge controller is able to charge a lower nominal-voltage battery from a higher nominal voltage PV array; for example you can charge a 12V battery from a 70V PV array. It does this by calculating and adjusting at what point the PV panel/array will produce the most power and then can deliver the maximum amount of charge to your batteries. This will change as the day progresses and is helpful in low light conditions.

The Maximum Power Point is at the knee of the red line.



The Victron MPPT solar charge controller is a 3 stage charger

- **Bulk**. This function lets the full charge of the solar array through to the batteries, allowing the batteries to be charged as quickly as possible to about 80-90% full.
- **Absorption**. Absorption slows the charging process down. As the batteries reach full charge the charge controller switches to constant voltage mode.
- **Float**. When in float mode, the batteries are considered full. The voltage is 'held' at a safe point with charging kept to a minimum, just enough to maintain voltage.

Battery Voltage
Battery Voltage is an important measure of the healthy operation of your system.

Batteries charging will cause the battery voltage to rise.
Batteries under load will cause the battery voltage to drop.
The below voltage figures will only be relevant with no current flow in or out (charging or discharging). Allow batteries to sit (no charging or discharging) for at least ½ an hour before testing.

For Flooded Lead Acid batteries the Specific Gravity from a Hydrometer will give the most accurate SOC (State of Charge)

Below is a chart that will help you to understand your SOC. This is a guide only different batteries may have slightly different SOC values. (refer to manufacturers data sheet)

Battery temp 30°C	Voltage Open Circuit							
	Flooded battery			AGM		Sealed		
SOC	Specific gravity	12V	24V	12V	24V	12V	24V	
100%	1.277	12.70	24.40	12.80	25.60	12.85	25.70	Great
90%	1.258	12.58	25.16	12.72	25.44	12.77	25.54	
80%	1.238	12.46	24.92	12.64	25.28	12.69	25.38	OK
70%	1.217	12.34	24.68	12.54	25.08	12.59	25.18	
60%	1.195	12.28	24.56	12.51	25.02	12.47	24.94	
50%	1.172	12.22	24.44	12.30	24.60	12.35	24.70	Take action
40%	1.148	12.14	24.28	12.16	24.32	12.21	24.42	
30%	1.124	12.06	24.12	12.04	24.08	12.07	24.14	
20%	1.098	11.98	23.96	11.96	23.92	11.96	23.92	Bad
10%	1.073	11.90	23.80	11.88	23.76	11.88	23.76	
Take action: reduce load and/or charge with a genset and battery charger								

Optional Accessories
Volt Meter or BMV (Optional)

The essential function of the battery monitor is to calculate ampere-hours consumed and the state of charge of a battery SOC. Ampere-hours consumed is calculated by comparing the current flowing in or out of the battery.
Section 3.4, p10 of the BMV manual has descriptions of all the available functions of the BMV.

When the batteries SOC falls to 50% a warning alarm will sound. This is an adjustable level but it is not recommended to lower this value. To turn off press any button and reduce energy consumption and/or use supplementary charging with a genset and battery charger until batteries are recharged.

If you change the batteries or require a more detailed knowledge of the BMV (Victron Precision Battery Monitor) you should consult the 'Victron Precision Battery Monitor' manual.

The BMV is now ready for use and the + and – selection keys can be used to select the desired read-out:

Label	Description	Units
V	**Battery voltage:** this readout is useful to make a rough estimation of the battery's state-of-charge. A 12 V battery is considered empty when it cannot maintain a voltage of 10.5 V under load conditions. Excessive voltage drops for a charged battery when under heavy load can also indicate that battery capacity is insufficient.	V
VS**	**Starter battery voltage (BMV 602S):** this readout is useful to make a rough estimation of the starter battery's state-of-charge.	V
I	**Current:** this represents the actual current flowing in to or out of the battery. A discharge current is indicated as a negative value (current flowing out of the battery). If for example a DC to AC inverter draws 5 A from the battery, it will be displayed as –5.0 A.	A
CE	**Consumed Energy:** this displays the amount of Ah consumed from the battery. A fully charged battery sets this readout to 0.0 Ah (synchronised system). If a current of 12 A is drawn from the battery for a period of 3hours, this readout will show –36.0 Ah.	Ah
SOC	**State-of-charge:** this is the best way to monitor the actual state of the battery. This readout represents the current amount of energy left in the battery. A fully charged battery will be indicated by a value of 100.0%. A fully discharged battery will be indicated by a value of 0.0%.	%
TTG	**Time-to-go:** this is an estimation of how long the battery can support the present load until it needs recharging.	h

State of Charge SOC

Rainbow Power Co. suggests that your use a maximum of 20% of your battery capacity per day. Secondly your batteries should get to 100% SOC at least once a week. This can be indicated by your BMV or by seeing your regulator achieving the “floating” stage in the charging process

For Flooded Lead Acid batteries the Specific Gravity from a Hydrometer will give the most accurate SOC.

Inverter

When buying any appliances you need to check their ratings and try to buy appliances that have the lowest power (watts or VA) rating possible, this will help to ensure you do not exceed your inverters capabilities. The daily energy consumption should, on average, be less than your daily energy production. This amount is indicated in the System design. The less energy taken out of your battery bank, the longer it will last.

When electric motors turn on they typically use 6 to 10 times their power rating for only a second. For example a fridge that uses approximately 100W on average will surge to 1400W for a fraction of a second. Inverters are made to deal with this, but if the inverter is running close to its limit a motor start like a fridge or a water pump could cause an overload and may either shut the inverter down or cause damage to the inverter. Refer to Inverter Manual.

Battery Charger / Generators

Battery chargers should be supplied by either 240V mains power, an inverter generator or power from a generator with automatic voltage regulation. If the unit is plugged into a generator with poor quality power damage may occur.

As generators run out of fuel their output voltage can become highly unstable. Ensure you turn off the battery charger prior to the generator running out of fuel otherwise damage may occur. Repairs for this type of fault are not covered by warranty. If you have any questions about usage please call RPC before proceeding.

Living With Solar

Living on a Stand Alone Power system will take a little getting used too. Stand Alone Power systems requires more awareness of power usage than a household on the mains electricity grid. You will need to be conscious of the power you use hour to hour, the appliances you choose to run and when you run them. Hopefully this manual will help, but if you have any questions do not hesitate to ask Rainbow Power Co. for help. We have provided a dictionary of terms at the end of this manual to assist you.

Total Energy Usage and your Energy Balance.

Living on a Stand Alone Power System is similar to living on rain water. The solar panels are similar to your roof and gutters collecting the energy from the sun. The batteries act as a storage tank so you can use this energy at night when the sun isn't shining. As with water in your rainwater tank you cannot use more energy than you are collecting and have stored.

Rainwater tanks typically have the capacity to store enough water for months at a time. Batteries differ as they only store energy for a few days. Like your rainwater tank, when you use energy from your batteries it must be filled up again.

This Battery/Solar based system is designed for 'Cyclic' use, approximately 10-20% usage per day will allow 3-5 days autonomy for overcast days.

Your system will have been designed with reference to a certain 'Load profile' (Appendix B). So that whatever power is taken out on one day can be replaced the next, as long as the panels are in full, non-cloudy sunshine. If the days have been overcast then you may need to either supplement the solar charging with a generator or use less power until you do have enough sunlight to fully charge the batteries again.

Peak Power

Your system allows for a limited amount of power to be used at one time. This limit is dictated by the continuous, intermittent and surge capability of your inverter and the size of you batteries. It is good practice to stay well within that limit. This means that you must be aware which appliances are on at one time and what they're power rating is. The power rating, in Watts or VA, is always written on the appliance, whether on the back, underneath or inside the lid or door. To keep cost down, the inverter will not be designed to run every appliance at once. You will most likely not use every appliance in your home at once so this is not a problem.

Calculating Energy Usage.

It is good practice to become aware of how much energy different appliances use. For example a medium sized domestic refrigerator requires roughly 980Wh of energy per day to run, depending on ambient temperature and how often the door is opened. These are rough figures and it will depend on the actual ratings of the appliance. A 6W LED bulb will use 6W of power, to run for one hour = 6Wh, whilst a 15W compact fluoro will use 15W of power, to run for one hour =15Wh. So a 15W compact fluoro over 3 hours will use 45Wh while a 6W LED will use18Wh.

The Energy (Watt-hour) usage of an appliance is equal to the amount of power (Watts or VA) that the appliance uses multiplied by the number of hours it is used for. So Watts x hours = Wh.

Using more energy than your Battery can supply is the major cause of problems with battery powered systems. This often occurs when there is overcast days and the output from your panels is diminished. It is at this time when you will need to be aware of power use, or alternatively use an external power source like a generator and a battery charger. Do not deplete your Batteries below 50% SOC.

Most problems occur in systems because of battery over use i.e. Battery failure problems or loss of power. This problems may not appear for a few years. Knowledge and understanding of your power use is important in order to prevent these problems.

Maintenance

Your system will need regular maintenance, checking tightness of all electrical connections throughout the system, cleaning your PV panels and checking your batteries including the water level (Flooded batteries only).

Solar Panels

Solar Panels require very little maintenance but they should be cleaned regularly, once or twice a year at least. Dirt and bird droppings may affect the ability of the panels to charge batteries as expected. Regular washing down of solar modules will improve their performance and can possibly be done with a hose from a distance without the need to climb up onto the roof and exposing yourself to the risk of falling off, as long as you remember not to put cold water on a hot panel. Periodically it may be necessary to clean them with a cloth or scourers. Always use water that is at ambient temperature. Hot water on cold panels or cold water on hot panels may cause the glass to shatter. It is recommended that the cleaning of solar panels be performed early in the morning. A physical barrier (scaffolding) or a correctly supported safety harness is required whenever anyone climbs onto the roof. If any maintenance of the solar array is required then call your solar installer.

Regulator

Check that the regulator is still charging the batteries.

- Check that all connections are tight. If they are loose shut down or isolate the Solar Modules and the Batteries from the regulator and tighten or reconnect cables.

Generator

- Check oil levels regularly.
- The generator should be run at least once a month. To help establish a routine it is a good idea to pick a particular day such as the first or the last Sunday of the month. Regular running will keep all internal parts lubricated with oil and so inhibit rust.
- Diesel and petrol have a life span of approximately 6 months. If kept for longer than this, a fungus will start to grow and spoil the fuel. Write a use-by date on the container.

Batteries
Batteries should be **inspected monthly** whether they are Flooded or Sealed. Before you carry out any battery maintenance, be sure to have the appropriate safety equipment and tools.

We suggest that you mark the batteries i.e: A, B, C or 1, 2, etc and then writing down the measurements, Specific gravity and cell voltage, made during maintenance. This will provide a history of your battery condition for you and for a technician if any problems occur.

Battery Leads and Terminals
Check that the battery leads are clean, tight and that there is nothing to cause a 'short' or connection between the **POS** and **NEG** terminals.

Without over tightening check that the battery terminal bolts are tight with an insulated spanner.

Check that the battery and battery terminals are clean. A relatively safe procedure is to pour hot water over one terminal at a time if they have a build-up of oxidised material on them (usually blue, green and white coloured like oxidised copper). Be careful water doesn't connect the terminals of the same battery.

Battery Housing should be inspected once a month. Checking that the batteries have good ventilation to prevent build-up of Hydrogen gas, and that no animals have destroyed wiring or are creating a short between the POSITIVE and NEGATIVE terminals. Signage is important and needs to be left in place and intact.

Sealed Batteries (VRLA, GEL)
The tools that you should have on hand include:
1. A multimeter to be able to check individual cell voltages,
2. Correct size spanners with insulated handles,
3. A plastic type dishwashing scourer for cleaning the batteries and terminals,
4. Baking soda and hot water for cleaning battery terminal posts and connectors at the battery,
5. Anti-oxidant coating with which to coat the battery terminals and connectors.

Check the following:

- We would advise you to check and record each cell voltage, this should be done when the battery has reached and can maintain float voltage. Voltage readings from cell to cell should not differ more than +0.2V and -0.1V

Flooded Lead Acid Batteries

Of all the components of a solar power system the 'Flooded lead acid' battery bank usually requires the most amount of maintenance. Batteries also present a degree of hazard, both from the possibility of explosion with a spark or naked flame, and from skin and/or eye damage from being exposed to the electrolyte. It is very important to wear appropriate protective gloves and goggles. Battery acid will also destroy most fabrics, so don't wear your best and most expensive clothing. Always have free flowing water available close to your battery bank to wash acid from your skin, or eyes, if splashes occur.

The tools that you should have on hand include:

1. A multimeter to be able to check individual cell voltages,
2. A hydrometer to measure the specific gravity of the battery cells,
3. Correct size spanners with insulated handles,
4. A plastic type dishwashing scourer for cleaning the batteries and terminals,
5. Baking soda and hot water for cleaning battery terminal posts and connectors at the battery,
6. Anti-oxidant coating with which to coat the battery terminals and connectors.

Check the following:

- Check the electrolyte level by removing the cap of each cell to look inside. Do not use a naked flame or anything that sparks as the battery will often contain an explosive mixture of hydrogen and oxygen. The lead plates inside the battery must not be exposed to the air. They must remain submerged in electrolyte. There are often indicators (eg an embossed or painted line) on the battery to show the minimum and maximum electrolyte level of each cell. Fill each cell to between 30 to 50mm below the top of the cell. **Do not** fill to the very top of the cell as it will spill out when the battery is charging. **Do not** use tap water, boiled tap water, bottled drinking water, creek water or rain water collected off a roof. **Only add distilled or demineralised water**

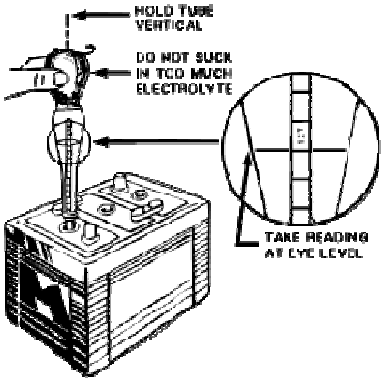
- Electrolyte density (Specific Gravity or SG) measurements is a much more accurate and reliable way of checking state of charge than voltage measurements.
- If you spill any acid for any reason you can use baking soda and water to neutralise the acid, but with great care as baking soda and battery acid can react very violently (foaming, heating up and in a confined space like inside the battery it can be explosive).

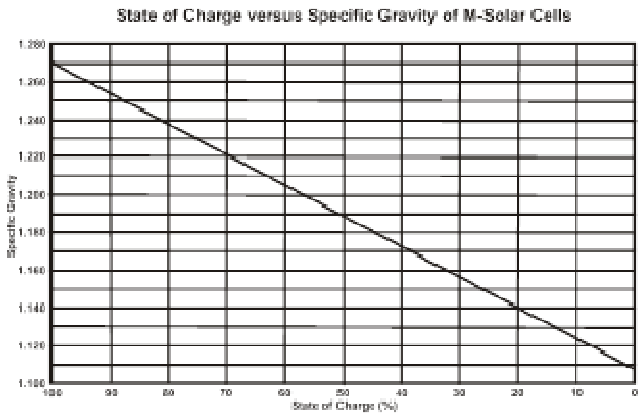
Specific Gravity

Specific Gravity is the measure of the electrolyte density of individual cells. This test is done using a Hydrometer.

How to use a Hydrometer

Expel the air inside the hydrometer by squeezing the bulb and keeping it squeezed before inserting the hose at the base of the hydrometer into the electrolyte. Holding the hydrometer vertically, suck up the electrolyte of each cell that you wish to test by releasing the squeeze on the bulb and make sure that the float inside the hydrometer floats freely. If it doesn't float freely lift the hydrometer to just above electrolyte level and squeeze it again. The float has line markings and numbers printed on it. If you hold the hydrometer at eye level you can read the number which is level with the fluid. This number indicates the electrolyte density which directly correlates to state of charge. The lower the float sits in the electrolyte, the lower the battery's state of charge. It is recommended to number the cells, measure every cell of the battery bank and record the results for future reference. Take note of any cells which give consistently poorer results and label them as "pilot" cells. This allows you to only measure these cells if you are just checking the overall state of charge. If the pilot cell reads a low SG then you should measure all the cells to see how much the SG varies. SG reading should not differ by more than 0.020





The rest of the system

Clean Mud wasp nest from the black finned 'heat sinks' of your inverter and regulator. Make sure nothing flammable is touching your inverter and regulator and that possums or rats are not chewing on any wiring or your batteries.

If any maintenance is required, seek the services of a qualified technician.

Trouble Shooting

Some faults with your system can be traced to usage. For example, if you switch on an appliance and the power suddenly turns off then you may have exceeded the amount of power you are able to use at one time. So the first thing to do is to check whether the inverter is still switched on. If it has switched itself off then, first manually turn off the inverter and switch off all appliances. If the wattage of the appliances that you turned off is known, then add up these wattages and compare that to the inverter rating. This will tell you if you have theoretically exceeded the inverter rating. Turn the inverter back on again and then turn on whatever appliances are required, one by one. If everything seems OK this could have been the problem, in which case you will have to be careful of how much power is being used at one time. As mentioned earlier, when a motor is turned on it will use 6 times the power rating for only a few seconds. The Inverter has an allowance for a power surge for a few seconds (see Surge rating in inverter specifications). The surge rating of an inverter will usually allow for surges of this type.

If the **battery** Specific Gravity (SG) and/or the voltage reading are low then the battery may be discharged too deeply. This may indicate that too much power is being used and the charge rate is not keeping up with your use. You may have to analyse your power usage and/or check that the system is still charging. Check the data records of your BMV and use your genset/battery charger to supplement the solar charge.

If you have any questions or the problems persist then please call RAINBOW POWER COMPANY or qualified solar technician.

Contact

If you have any problems or question please call Rainbow Power Co. on (02) 6689 1430.