DAINTREE LIVING FACTSHEET

Power Systems

With the exception of a small group of properties on Thornton Peak Road (off Forest Creek Road) NO properties in the Daintree have access to grid connected power. This has been a continuing and very divisive issue in the area for over 20 years. The reality, is, that because of the current financial situation of the State Government, and the privatization of electricity providers, and the lack of a guaranteed market for electricity in the region north of the Daintree river; provision of grid power is highly unlikely. Local generating hubs are a possibility, but it would not be wise to bank on their appearance!!!

Unfortunately very few properties have sufficient permanent water flowing through them for Hydro to be a viable option, and even if they do, the head (that is the height drop between the upstream entry to the property and the exit from the property) is usually too low to extract meaningful energy, except at times of very high rainfall (when there maybe significantly large trees and branches flowing down as well).

Our wind resource is also very limited. unless your property is on a ridgeline or very near the beach- there is no effective wind generating capacity. It is recommended that if you REALLY want to have wind power, that you monitor your site for at least a year (with a recording anaemometer set at least 30 m high) If your average wind speed is less than 40Km hr. forget it. Wind generators require yearly maintenance and you must have the space and ability to drop them down for maintenance and the ability to furl them in cyclonic conditions.

In sum, solar panels are your most viable power system option.

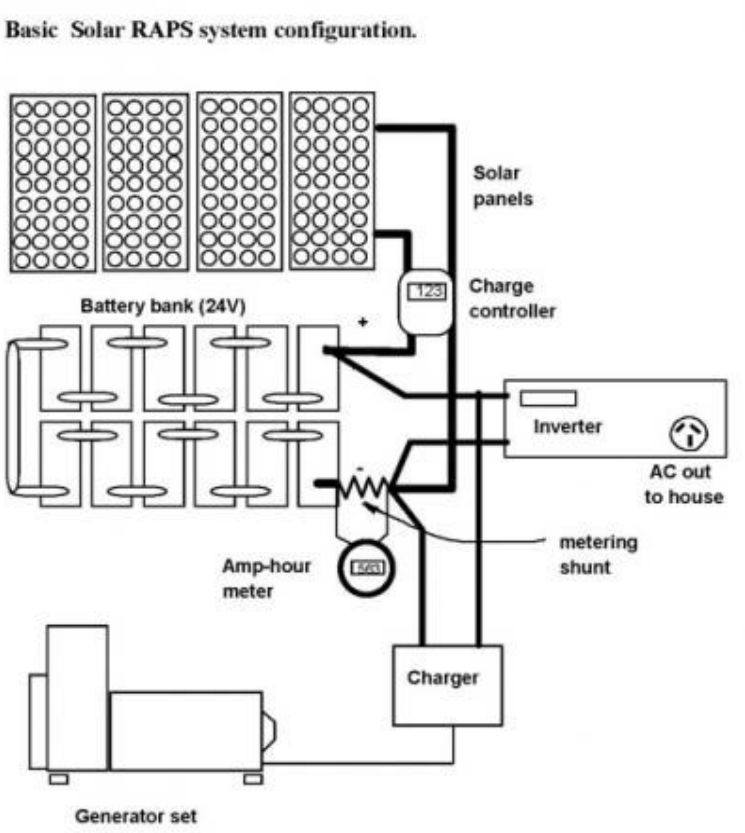
Related Factsheets

Water Sources (pdf, [file size]) *Water table and rainfall fluctuations; contamination and filtration; water conservation and recycling, Water system installation and maintenance issues for rain, stream/creek, and bore sources.*

Toilet Systems (pdf, [file size]) *Location, budget, power requirements, water supply, and maintenance for composting, waste water, and septic systems.*

Waste Management (pdf, [file size]) *Grey water systems, composting, recycling non-organics, e-waste options, creative reuse, burning or, as a last resort, the dump.*

Basics of Solar RAPS



If you have bought (or intend buying) a property here that has a **Renewable Energy Power System (RAPS)** already installed, get someone knowledgeable to look at it - it may be a very bad bargain. Many existing properties have solar systems that date from the mid 90s which were installed as part of the Daintree Rescue Package, when knowledge of solar (and especially of the climatic and environmental conditions here) was in its infancy. As a result, other than replacing batteries (the dead batteries from which will probably be piled up in the property somewhere for you to remove), little maintenance or upgrade will have been carried out. Solar panels, especially some of the early models, had very short lives and need testing and replacing (and it is quite a difficult exercise to properly test individual solar panels on the roof).

This has resulted in a general dislike and distrust of solar RAPS in the area and agitation for grid connected supply.

Things have changed a lot in Solar RAPS since 1995!

Essentially, a bank of solar panels on the roof generate direct current (DC) electricity when the sun shines on them, and this is fed, through a charge controller to charge a battery bank. The battery bank is connected in most cases to an inverter, which converts the battery power to 240VAC 50Hz mains power equivalent to operate most household appliances. In poor weather a fossil-fueled generator is used to charge the batteries, usually through a dedicated battery charger.

However - there is a lot of detail and choices in each of these steps nowadays, and for reasons unknown, for a large percentage of Daintree residents, the understanding and running of their RAPS appears to be in the **too-hard basket** which has resulted in lots of system failures and a high level of dissatisfaction with solar RAPS.

A well-designed and operating Solar RAPS here can supply most households needs easily, even in the wet, but without a good understanding of how it works and its limitations, it can be a source of immense frustration.

Basic design principles:

1. Solar panels are now cheap and reliable. It is wise to have a bigger panel array than you think you need - in grey or wet weather this will pay dividends and the generator run-time will be significantly reduced (or eliminated altogether).

2. **Don't even consider air conditioning** - the energy costs are bigger than most RAPS Systems can cope with and you would have to redesign the house so it is well-insulated and sealed. As we have the mountains to the west, nights tend to be cooler (as the cool air flows down). A small appropriately-designed and sealed dehumidified room for storage of computers and clothing etc., is a possibility (and could be integrated with your RAPS system).

3. **Don't get a battery bank larger than you need** (work on it being big enough to give you one day). Discharging lead-acid batteries regularly by more than 30% of their capacity leads to rapid failure. Remember, **the bigger the battery bank, the harder it is to recharge.**

4. Minimize your energy *wants*

5. Determine your (real) energy *needs*!

6. Understand the principles of solar RAPS enough so you can talk intelligently with your installer/supplier (and be able to diagnose common faults).

Solar Panels

Currently, solar panels (in particular the 250-watt variety used in grid-connected solar power systems (most of the ones you see on urban roofs) are now very cheap, about $2 per watt. These are crystalline silicon panels, which have withstood the test of time. The smaller 80-watt panels (which were once standard) are far more expensive and are only used to replace existing ones. Beware of bargain panels, - as you get what you pay for. Be even more wary of panels someone just happened to have in the shed unless you

have the wherewithal to test them.

While amorphous panels have been touted at the cheap alternative, despite a very few good (and expensive) varieties available, they have generally failed to live up to expectations.

PV panel prices are coming down (largely due to the uptake by grid-connected urban residents) – and the technology and efficiency is improving.

Installation

Solar panels require direct sunlight to produce maximum power but can produce significant power in lightly overcast conditions. Shading of any part of a panel (even though the rest is in full sun) will drastically reduce its output, a fact that needs to be borne in mind when choosing a location for your array. Conventionally, arrays are roof-

mounted. and in timbered areas, this is often the only option. As it is wise to have a clearing of about 50 meters around a dwelling (for cyclone protection and air movement - and maybe a garden) this should allow the array to get maximum solar exposure.

If you have a larger cleared area, mounting the array at ground level is a good option as it allows ease of maintenance and adjustment, whereas roof mounts can be difficult for many to access. (but see solar charging controllers)

The array must face north, but if possible, it should allow for easy adjustment of the sun angle - from almost horizontal in summer (when the sun is actually slightly to the south) to about 30 degrees N in the winter, when the sun is in the north. This greatly optimizes the effectiveness of the array throughout the year.

Tracking arrays (which follow the sun during the day) increase the effectiveness of the panels even more, but given the current low cost of panels, and the greatly increased complexity (and maintenance issues) of trackers, it is cheaper (and simpler) just to install more panels.

If you have a house with a north-south axis – you can mount one set of panels on the east-facing roof, and another on the west (probably cheaper than other options!) – so in the morning you get energy, at midday you get 2x as much and in the afternoon, you still get power.

Some installers have a sun path analyser, which allows them to determine from which trees and at what season, you might have shading problems (usually during winter and with trees to the north of the array).

Please remember, installation can become a major cost, especially if your location is difficult.

Batteries

We seem to be stuck with lead-acid battery technology for some time to come. They do have the advantage of being a known technology, (although constantly improving) and are (theoretically, at least) almost totally recyclable (not that you'd ever guess looking around properties here!). Lithium technology for RAPS is still in its infancy and is being developed for automobiles but not for RAPS (different requirements). While Tesla "Power-walls" are in vogue, they have only been around for a few years. There are a variety of other battery technologies as well from flow-cells to NiFe (nickel-iron). Yes, there are loads of new battery technologies appearing – but really, of these, at present only Lithium is suitable and being manufactured in commercial quantities.

Batteries are made up of individual 2V cells (for lead-acid) connected in series to make up the required system voltage. While combination 6V or 12V batteries are available, these are not recommended for RAPS, since the failure of one cell, results in having to discard the lot. Besides their capacity is relatively small.

Flooded, or wet-cell lead acid batteries are being phased out for RAPS use, being replaced with the AGM (Adsorbed Glass Mat), or gel-cell design. These are totally maintenance free, there is nothing to fill, and they don't vent hydrogen gas when charging, so they don't have to live outside. They can be installed in any position - even on their sides in a rack!

Set and Forget! - a big load off your mind.

The life of most flooded cell battery banks tended to be very short, as contamination of the electrolyte through (all too) regular checking of specific gravity with a hydrometer

to measure state of charge and topping up, doesn't help (to say nothing of acid contamination and corrosion of connections - and clothes).

AGM batteries (which have the potential to live longer), do require somewhat more sophisticated charging regimes, however, modern charge controllers can do this easily.

Remember, that **to ensure maximum battery longevity, the battery bank should not be discharged below one-third of its stated capacity**. (This will be dealt with later on).

Solar Charging

Modern batteries (AGM) require modern solar charge controllers. the best and the only ones recommended for the Daintree are MPPTs (Maximum Power Point Trackers) - a.k.a. maximisers (first commercially developed in Queensland, by AERL).

These function a bit like an automatic gearbox between your panels and your battery bank, with 95% efficiency. In fact, they can increase the effective output of your panels by up to 30% in overcast weather and correctly charge your battery bank. There are quite a number of manufacturers now. However, as with everything else, you get what you pay for, especially in the service and warranty department!

One great advantage of MPPTs is that they convert a **high voltage** input from the solar array (which can be over 100V with the panels connected in series) to the **voltage of your battery bank**. This allows the same amount of power to be delivered from your array over much smaller (and far less expensive) copper cables and over longer distances without significant losses, ideal for the array mounted outside in the field. Cabling costs can be quite significant, especially at low voltages, as more copper is required to transfer the same amount of power.

Monitoring your system

This is CRITICAL for the long term survival of your very expensive battery bank.

- "**Most batteries don't die, they are murdered**" More PV systems fail because of poor battery/charge controller performance. (from a fact sheet from Sandia Labs)

  (USA) photovoltaic research section).

  And, I would add, poor maintenance.

Your lead acid batteries should not be allowed to discharge below 30% of their rated capacity on a regular basis. So for a 1000AH battery, that means maximum amount of power, is limited to 330 AH. **So two-thirds of your battery bank capacity is invisible** - you can only access it in emergencies and then it has to be recharged **immediately**.

Deep discharging of any lead acid battery (wet cell or AGM) reduces its capacity and if they are left discharged, they can die FAST!

- Lead-acid batteries normally fail through a process called sulphation. The active chemistry of the battery involves converting lead to lead sulphate (discharging) and converting this lead sulphate back into lead (charging). However, with each discharge cycle, a small amount of lead sulphate crystals detach from the plates and the capacity is slowly reduced. The deeper and more maintained the discharge, the worse it becomes. In old clear-cased RAPS batteries this process could be seen as a white deposit (lead sulphate) lying on the bottom of the container.

Technology to counter this in large capacity lead-acid batteries is being developed …watch this space!

Battery Capacity

This is normally expressed as Amp-Hours (usually at the C10 rate, that is its capacity discharged over 10 hours from full charge to a specified final voltage). So theoretically, a 1000 AH battery should be able to deliver 100A current for 10 hours (don't try it!). But as described above, 330 AH is all that is useable from that battery without causing long-term damage.

The less current you take from the battery, the greater the capacity; the more you take, the less the available capacity. This relationship is called the Peukeut relationship.

- **Amp-Hours** (AH) has nothing to do with the voltage of the battery bank, just the amount of current it can deliver for so many hours. The amount of POWER that the battery bank can deliver, IS dependent on the voltage.

Power (watts) = Volts x Amps

So - a 12V 100 AH battery can theoretically deliver 1.2 KWH, 24V - 2.4 KWH and 48V 4.8 KWH (all at the C10 rate of 10 A over 10 hours). (1 KWH (kilowatt hour) is the same as 1 unit of commercial grid power).

So to ensure you don't take too much out of you battery bank, you need an AMP-HOUR meter - basically it's your battery's fuel gauge.

Some inverters have one built in - but that will only record the amp hours that the inverter has consumed, not much help if you are also running DC loads. Similarly, solar controllers will also display amp-hours, but this is usually only charge into the system.

So - understanding the complete picture requires a dedicated Amp-Hour meter which monitors the total power flowing into the battery and flowing out. There are a number of types available, the Austrop Foundation has found one of the simplest and basic units, the Trimetric 2020 (Bogart Industries) to be the most effective. It can be mounted anywhere in the house and shows the amp-hour status in large red glowing friendly numbers, so you can see battery status at a glance (without having to push buttons).

This display is telling you that your battery is almost charged. (17.7 AH left to go) (assuming you have a decent-sized battery!).

It also enables you to see the battery voltage and current - very useful for detecting faults.

Having a monitor such as this Trimetric ensures that all members of the household can easily become monitors of their power usage.

Where to house your system

When the RAPS systems were first installed in the Daintree, they were all installed in some kind of very basic enclosure outside or under the building, as there were quite real concerns about hydrogen explosions when the flooded cell batteries were gassing in their final stage of charging. Naturally the electronics and power controls were placed next to them in an equally basic cabinet, with the result that the local wildlife soon moved in and inverter and charger failures due to cockroaches and geckoes were very common. Plus, in heavy rain everything got very damp, fungal spores germinated and failures were common from that source. (the installers also seemed to think the owners were contortionists, as it was often extremely difficult to access the batteries for checking).

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A post-1996 installation. There are still many of these in the Daintree! The battery box is to the left (not visible).

Power Rooms

Now, with AGM batteries, there is no reason why the whole system cannot reside inside the house. The whole system generates quite an amount of heat, which in the Daintree can be used to good effect to keep clothes, linen and books dry (and in the process deter cockroach and gecko invaders). A small 2m square room, well-sealed and insulated will suffice and your goods will not get mouldy or acquire the distinctive Daintree “pong” during the wet.
The power system can be mounted on one of the walls, where it is easily accessible and the batteries on the floor, or on a suitably sturdy rack.

Power room at the Cape Tribulation research station. It also doubles as a laundry and clothing storage area.

A plus, is that modern electronics perform best (and last longest) in a slightly warm and dry (and hopefully clean) environment, which is exactly what your power room will provide!

Charger

If you have bought an existing house it will probably have either a small Dialomatic charger or a big Stanbury Scarf traction-battery charger. These are NOT designed to be used on AGM batteries, and the Dialomatic, as it has no automatic control, can irreparably damage your batteries through over-charging (“*whoops, Darl, I forgot to turn the generator off*” ….grrrr)

Some inverters also double as chargers and are quite efficient. This means that when the generator is running, it also powers the house, which means that you will require a larger generator than one that just powers the charger and while inverter outputs are electrically clean, generator power can be very electrically noisy (especially if the generator is old) which can cause damage to modern electronics.

Modern switch-mode chargers are available which are very efficient and which easily accommodate AGM charging requirements.

So running the inverter continuously and using a purpose-built charger and a smaller generator is a better bet. (See Fig 1).

Equalisation

As a battery bank consists of a string of 2V cells connected in series, not all cells will have the same capacity (see sulphation) and cells with lower capacity will discharge first. Eventually a cell will fail, as it has been discharged too deeply and too often and the whole system can no longer provide power (as the voltage will have dropped by 2V which usually shuts down the inverter). To prevent this, the **entire battery bank must be over-charged regularly**, so all cells are fully charged. This is called equalisation charging - most modern electronic charge controllers have this programmed into them but you need to check with your installer. Failure to equalise can have very expensive consequences (primarily the need to replace your battery bank earlier than expected!).

Inverters

Basically, all an inverter does is convert the DC power from the battery bank into 240V alternating current (AC) at 50 Hz, to run the conventional household appliances and lights.

There are several types of inverter to choose from, but it doesn't really matter what kind you get as long as it can deliver the peak wattage that you need *for the length of time you need it*.

Nowadays, **all inverters must be pure sine,** not modified sine (or even square wave inverters) Sine wave inverters generate the same quality (or better) of AC power that grid connection provides.

This is where your power demand management calculations are important. If you run a small household - a 1,500-watt (continuous, 2,000 watt, 10 second peak) inverter may be fine for running a vacuum cleaner. However, if you want to run a small welder, you may need a 3,000/4,000 peak inverter to the job - (or buy a gene for the welder!). You get what you pay for.

Generator

Again, it's a trade-off - if you have a big PV array, and enough battery to give you one day's carryover, then a 2KW generator is probably all you need. 5KW is usually the maximum size for a household, but if you use a dedicated charger, then the generator will probably run lightly loaded, which isn't very good for it. Diesel generators are highly reliable, but

the price advantage of diesel seems to have gone (unless you have an endless supply of fryer oil). We now have inverter-generators - Honda, Yamaha etc., which have an electronic inverter integrated with the generator which can be very efficient (when run in eco mode) - but there are lots of cheap knock-off models and as always, you get what you pay for.

Even if you hardly use your generator, run it from time to time and keep it full of fuel and oil - you may need it in a hurry when it is cascading rain (or the inverter has died)! Make sure you keep the generator protected from the weather - they don't like moisture either!

System Voltage

Unless you are living in a caravan, a 12V system is no longer recommended. While 12V devices (for caravanning) are readily available, for a serious house, the battery capacity to have useful power storage, needs to be large and this presents problems in charging.

So for 12,000 watts of storage (not that much!) - you would need 1,000 AH at 12V, 500 at 24, and 250 AH at 48V - but wait a bit. This has to be multiplied by 3 as you can't discharge the batteries beyond one third - so that becomes 3000AH at 12V, 1500 AH at 24V ,and 750 AH at 48V.

3000 AH of battery takes some serious charging electronics! - whereas 24 and especially 48V is far more manageable for the same power.

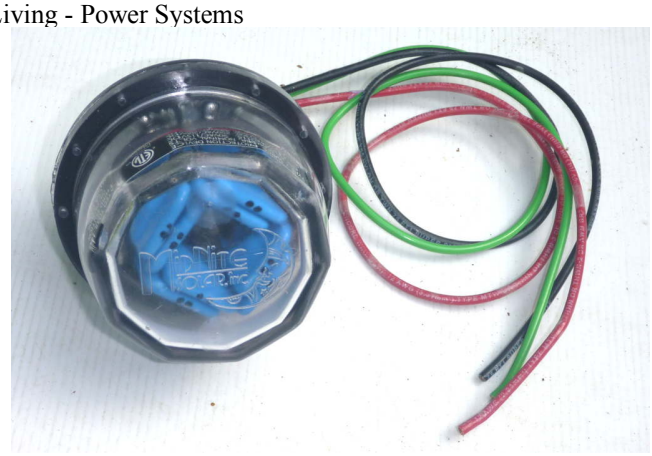
24V has become a preferred voltage, but is being overtaken by 48V as the control electronics become smaller for the same power. (But it is hard to get 48V appliances!).

and battery wiring become more manageable).

However, if you wish to run on DC (lights, refrigeration, and some devices) which can be very efficient, you will need separate 12 and/or 24V wiring to the 240V - it gets complicated and there are few devices available for 48VDC. On the positive side, new high efficiency DC technologies such as LED lights and refrigeration, draw relatively little power, so high amperage conductors are not usually required. However you would need a dedicated 24V (or 48V) to 12V Dc converter to run them if they are 12V.

Lightning

As this is a high lightning strike area, you can get lightning surge protectors which will absorb the energy from a quite large strike. While the lightning strike might be several hundred meters away the ground currents (as the electrical energy from the strike flows into the surrounding soil) can cause immense damage. Long lines (both DC and AC) to other buildings can be affected (as can buried copper water pipes!). Given the increasing frequency of thunderstorms here lately – they would be a good investment – both for the solar input and the 240V lines (especially if your power system is some way from the house).



A commercial lightning arrestor – this depends on components that only conduct electricity when a certain voltage is reached (as in a lightning strike)

They can be used on solar array lines as well as 240V lines (to protect the inverter). There are other approaches - inductors and capacitors (for DC) but these are not commercially available. Nothing will protect you from a direct strike - and if it looks bad - disconnect the solar array from the system (switches).

An additional insurance is to make sure you turn off the panel breakers (there should be two) which should be next to the charge controllers in the power room) if the lightning starts getting interesting. Don't forget to turn them back on!

Small hairy (and unhairy) things with teeth

Oops – but it was working ok yesterday!

Suicide gecko

Having your system in a vermin-proof enclosure is a recipe for peace of mind. Geckoes will insinuate themselves through unbelievable small spaces and lay eggs on that critical solar controller or commit suicide in the electronics of your fridge. Cockroaches leave crap on wires and circuit boards and they cease to function. Any organic detritus is a fertile ground for fungi which can destroy wiring, cabinets and electronics. Melomys (and white-tailed rats) like the warmth of a nice inverter or charger and eat the wiring. The solution is to have everything inside and if you can't seal the room, make sure that everything is screened off.

Fungus

One aspect of rainforest living, is that there is a continuous "rain" of bits of organic matter – from trees etc., plus an enormous number of fungal spores (of an enormous array of fungal species. These land on damp surfaces and germinate. While most plastics are unaffected (although they will look filthy), metals get attacked rapidly. Surprisingly this "rain" rarely causes human reactions, but it can destroy equipment very quickly. (Just see how dirty a recently cleaned table top becomes!) Computers with inbuilt fans (most older laptops) suck in this material and it gets deposited on the circuit boards – in damp weather, they fail. Keeping fungus out is a challenge – using pieces of ventilation filter across fan openings will reduce the problem. Having your equipment in a dry environment is ideal – you can buy dehumidifier cabinets on the web, and they take very little power.

Energy Efficiency

A difficult subject. If you are experiencing lots of fine weather, and your AH meter says 000 by early afternoon - don't eschew using electricity for some cooking - but not the hot-plate variety which is horribly inefficient! Many modern electric cookers and jugs are well-insulated - which vastly increases their efficiency. Boiling an electric jug for tea or coffee doesn't take that much power - and even less if you fill it from your solar-heated hot water system! Making toast does not use that much either. New electric pressure cooker designs on the market can cook soups, stews, vegies or whatever your imagination can come up with - and is so well insulated that it will complete cooking once the pressure is up and you pull the plug! (but put a thick towel over the lid!).

And you use no gas!

But you must ensure that the devices you buy are well thermally insulated.

Simple devices such as a “hot box” (or straw box) cooker - a large basket and a pile of old blankets - can save enormous amounts of energy - gas or electric and you can’t burn the food! (see *Renew* Magazine)

Refrigeration

A freezer working as a refrigerator the Temperature controller is on the upper RHS

This is, for most households, a major energy hog. Upright refrigerators are inefficient in hot climates; every time you open the door, cold air flows out and is replaced by very warm ambient air, forcing the refrigerator’s compressor to run longer and more frequently to maintain refrigeration. Using a chest freezer is far more efficient (uses about one-third the power because the cold air stays in the body of the refrigerator when the lid is opened). Using a DC freezer as a refrigerator or freezer is even more efficient, using only one-fifth the power of a conventional upright fridge.

They do require the installation of a separate temperature controller (Actrol, Heatcraft) and the **sensor should be in a bottle of water inside the refrigerator to smooth out the temperature shifts** as the refrigerator is used. A 5 C chiller will keep dairy and vegetables in good condition for weeks (saving you many shopping trips!).

Unfortunately, you would have to get a qualified person to connect the controller, as most freezer thermostats won’t work at +5C. This refrigerator uses 400 WH per day. (conventional refrigerator 1500 WH/day).

There are two drawbacks - they are less convenient to use and in the case of the DC units, substantially more expensive to buy. But the energy savings can be immense.

Gas refrigerators are really a total no-no. They are very inefficient - in real terms about a third as energy efficient as a conventional refrigerator of comparable size, so waste a lot of fossil fuel, produce lots of moist heat from the flue gases and can be very temperamental (especially with mud wasps). Plus, their failure rate is high (the refrigeration plumbing is made of iron (which does not react with the ammonia refrigerant), which rusts in this climate and punctures and cannot be replaced.)

Hot water

Traditionally Daintree residents have relied on instantaneous gas hot water systems - almost all of which require a continuously burning pilot light, which in small households with not much hot water use, could account for half the gas consumption. Propane is becoming expensive.

Again, technology has changed and developed. The conventional solar flat-plate collector has given way to the evacuated tube collector, which is about 2x more efficient than a newly-installed flat plate, especially in grey weather.

A modern evacuated tube collector (e.g. *Run On Sun*) this is capable of producing very hot water even in grey weather, and needs minimum maintenance.

Evacuated tube collectors have the great advantage that the collector tubes cannot leak, and the tanks and frame are stainless steel, so do not degrade with time.

Conventional flat-plate hot water collectors tend to fail around the edges of the glass (or the pan rusts), water gets in and a white fungal film develops on the underside of the glass slowly rendering it useless. They can be cleaned, but it’s a difficult operation - especially on a roof!

Getting rid of those dead batteries

You have a pile of dead cells against the shed? Yes, you can take them to the Cow Bay Transfer Station, or if you can – take them to Qld Metal Recyclers (Federation Street, Cairns) and get paid for them. It will probably more than cover the cost of your trip! Just be careful with the sulphuric acid as if spilt it will strip the galvanisng from your trailer and really make a mess of your clothes. Best to drain them into a plastic tub and neutralise the acid with washing soda (available at Woolies).

Connections

A source of failure and fires is poor electrical connections. Poor connections can become very hot – enough to melt plastic and set it (and your house) on fire. The heat causes increased corrosion, the chlorine from PVC plastics released by the heat, speeds up the corrosion – and it gets even hotter - until you have a catastrophic failure.

It happens all the time. It is important that all electrical connections be either soldered or if screwed, that the wire is bright and the screws are really tight. Accumulation of organic material will cause chemical corrosion as well (especially in wall power outlets). Outdoors – connections should be within a waterproof, fungus- and vermin-proof box, especially on your roof-mounted array.

Cleaning solar panels

In this environment, panels get dirty – especially during summer if they have been oriented to be close to horizontal and the rain can't wash the superficial dirt off. It doesn't take much dirt to impact a panel's performance and a couple of strategically placed large leaves can almost shut down a panel (or even an array if they are series-connected). Most noticeable is a buildup of a purplish black growth that grows in from the edges. Spraying straight bleach, followed by scraping it off with a steel wool pad, seems the most effective way of dealing with it.