Managing Your Energy

By Nev Sweeney

Acknowledgements

Kevin Mechelmans for his article on the Type Two rocket stove

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1.0 Introduction

We can use energy in our households in several forms, the most common being electricity, natural gas and petrol but wood, LPG and diesel can also be used by Australian households. Getting the most out of the energy we consume will not only save us money but reduce our environmental impact. To do that, we must understand not only how much energy we are using, but where the big energy sponges are, and the way to do that is to conduct an energy audit.

That is why conducting an energy audit is at the front in this eBook.

Once you have the figures at you command and you know how much of what sort of energy is being used where, you can use the information presented in the rest of this eBook and develop a plan to manage your energy.

In general terms, managing your energy has two sides, the first is to use conservation measures to reduce the amount of energy you need. The second energy management tool is to produce some of your own power. This has three parts, part one is to put in place technology to generate your own power, preferably by using renewable energy sources, part two is to develop means to use the suns' power directly, such as to cook (solar oven) or heat water (solar hot water system). Part three is to use biomass that can be grown or gathered to cook or heat spaces.

This eBook can take you through options for all three sets of actions.

Section two covers how to conduct the audit and interpret the results. Sections three, four and five provide some ideas on how to conserve energy in various ways and Section six covers using the suns' heat directly to cook and heat water. Section seven shows how we have generated electrical power from the sun and wind, and how we have used that power. Section eight goes through a number of techniques we have used to cook and heat with biomass.

The last section of the book, section nine lists a number of books that can be obtained to provide further information on the subjects discussed in this eBook. This is followed by several appendices that provide details and plans on how to produce items that we have made to help us on our journey to manage our energy consumption.

2.0 Energy Auditing

2.1 Conducting an Energy Audit

It seems worthwhile to me to know where your energy dollars (and related emissions) are going and how they can be reduced. As the quality guru, Edwards Demming once said “what you don’t measure, you don’t control” so that is where the idea of an energy audit or review comes in, to help you get a handle on and control those costs.

I suppose the first thing we need to talk about when we talk about a home energy audit, is what type of energy is it we intend to audit, because a household can consume energy (and generate greenhouse gases) directly or indirectly, a number of different ways. Energy is consumed directly by a household every time anyone turns on a power switch, but there is also an energy cost (called “embodied energy”) in the products that we purchase. For the purposes of this section, we will only be talking about direct energy use.

Also, while there are a number of different types of energy that a household can consume – electricity, town gas, LPG, wood, petrol, diesel etc. in this article will only be concentrating on electricity. I am doing this for a number of reasons –

- In general terms, households consume greater than 50% of their energy in the form of electricity (the next closest is natural gas at around 33%).
- Electricity prices have risen at a rate of 8% per year over the last 10 years which is greater than twice the growth of wages over the same period (3.1% per year).
- Like water through a sieve, electricity can leak out of your household, costing your money for no real benefit.

So assuming you want to save money as well as saving the planet, let’s continue on and get you the information you need to make informed choices about what you do next.

Bills, Bills, Bills!

The first part of our journey consists of you confirming what the big ticket items in your energy budget are (don't just take my word for it, I certainly wouldn't!) and you do this by downloading a copy of the household **energy audit form** or printing off the one at the end of this eBook, and then getting your bills together. Get hold of a year's worth of bills so you can get your consumption picture for an entire year. Your usage fluctuates with the seasons, and you may get an inaccurately optimistic or gloomy picture of your energy consumption depending on what quarter(s) you look at, so you need a full years' worth of bills. If you can't find a years' worth of bills, a quick phone call to your energy supplier will usually get the data you want. Petrol or Diesel may be a bit more difficult but they also tend to be somewhat more independent of the time of year so monitoring your consumption for a month or three, and then extrapolating the data to 12 months should be OK.

Once you have the figures for your energy consumption, in their various units, convert them all to megajoules so you can compare apples with apples. Needless to say, the biggest number is the one you need to start working with first and It makes sense to start looking at your biggest area of consumption first, but I am still betting it will be electricity.

Electricity

The next part of the audit is designed to help you work out where all that electricity goes. Part of the deal will be looking at the power consumption of your electrical stuff, either the nominal consumption you can read of the compliance plate, paperwork that came with the appliance or off the net or as measured. The measured figure is likely to be the most accurate, our microwave oven is rated at 1000 watts but when it is running it consumes 1500 watts (I suspect due to the consumption of the light and turntable motor which might not been taken into account in the rating figure.) The power consumption is only half the story however, no matter how much power an appliance is rated to consume, the actual consumption will depend on how often it is used and how long it runs.

Our microwave oven, as previously stated, consumes 1500 watts but we would run it for only minutes a day, whereas if we leave our TV on at the wall even when it is turned off at the TV itself, it still consumes 20 watts. That 20 watt consumption translates into 130 kilowatt hours over the course of a year (or just over $30 in our area) because it is on 24/7, so even a small “phantom” load can translate into real power consumption quite quickly.

Nominal Vs Measured Load

The nominal load is the number of watts that the manufacturer says an item of electrical equipment consumes. It can be recorded in the customer handbook that comes with most bits of electrical equipment these days or failing that it should be listed on the compliance plate somewhere on the appliance. If both information sources are unavailable a quick check on the internet or a call to the manufacturer will get you the information. Lighting is a bit trickier, and the power consumption recorded on the bulb is a good start. If, however, you run halogen down lights through a transformer, a trip into the loft can be avoided by talking to someone in a lighting store to give you an idea of what the transformer itself consumes.

The form has a whole lot of suggested loads and appliances that you might have but this part of the form is suggested only and you will need to alter it to fit your circumstances (hence it is in Word format rather than .PDF). If you have a TV in every room, the form as supplied does not cater for that. Rather than setting up the form, then taking the measurements it would probably be easier to customise the form on the run, as you take and enter your energy measurements on the form.

As you get the figures, record them on the energy audit form. If you are interested (and for me this is fascinating stuff) you can measure the consumption of your electrical bits and pieces directly, and that can be quite illuminating. It will also let you know directly how the appliances are performing in your house and if the measured figure is massively larger than the rated figure it might be prudent to check a bit deeper.

There are a number of ways of getting the numbers directly and I've tried two, the first one is a direct read meter (A Multifunction Power Meter MS 6115) which you plug in between the appliance and the wall socket. I found it less than optimal in a number of ways –

- While I'm no Luddite (OK maybe I am but that's not my fault) I found it to be very complicated to use, you needed to have the book of instructions next to you all the time.
- For each appliance to be checked, having to turn it off, pull out the plug, plug it into the meter, plug the whole assembly back into the wall, then turn it all back on again was somewhat of a pain.
- Any stuff that is not cord connected like the hot water, air conditioner and the lights could not be read.

Then we bought an "**Elite Classic**" wireless electricity monitor from Efergy, it has a remote sensor that connects to the feed in from the energy supplier to your house, it requires an electrician to set it up but it reads ALL of the electrical loads in your house in one go – no plugging in and out. To find out what a particular appliance or load consumes, just turn it on and note the change in the reading – it reads in kilowatt hours. It is easy to use and can calculate your costs and carbon production over time as well.

There has had one unforeseen effect for us; it has really focussed us on our electricity consumption. Before we might be lazy and leave the computer going overnight, or not turn off things like the TV, microwave or CD player at the wall, but now we look at the total number and see how far we can get it down. If the freezer hasn't cut in, we can get our consumption overnight or when we are out down to 35-40 watts which equates to a yearly base load of 310 kWh, which is not bad! The change in behaviour has meant that our latest bill shows a drop of almost 2 kilowatt hours per day, or about 50c, a saving of $180 per year. This meter paid for itself in four months just in these savings alone.

But wait, there's more!

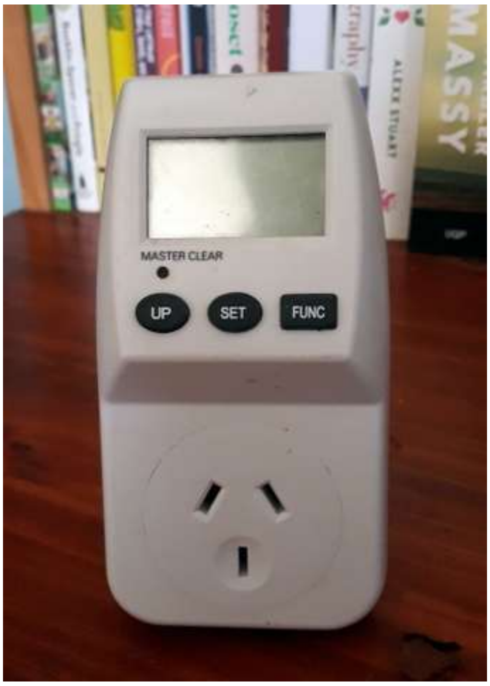
2.2 Measuring the Phantom Load

We have been using the Elite Classic for over 10 years and it has served us well, but recently I ran into some issues with it when measuring the phantom load associated with a new appliance.

If you haven't come across the idea of a phantom load, it is the amount of power (in watts) that an appliance draws when it is plugged into the power supply but not doing anything useful. Now you would think that when an appliance is turned off, it would not use any power at all, but this is not always the case. The power used may keep the appliance warmed up and ready for use, power an LED clock or have some other function. While the load may be very small, the appliance is likely to be plugged into the power supply 24/7 and even a small load can add up over time, increasing your electricity bill without doing you any good. Also, seeing as there are likely to be a number of appliances in this state, the power consumed would be additive.

I have been aware of this for many years and have a couple of bits of equipment that can be used to measure it and because there are a number of ways to do it, as it turns out, some are better than others.

I have two main classes of equipment that I can use to measure a phantom load. One is connected to the incoming electrical house circuit and measures the draw of everything in the house at the same time, the other is plugged in to the power outlet and then the appliance is plugged into it so it records the power usage of one appliance over time.



I started out with a plug-in Multi-function Power Meter, MS 6115, (See photo above and referred to earlier) which was cheap and complicated to use but did the job. What it could not do was tell me how much the big stuff that was directly wired into the house circuits was consuming. Things like air con, electric hot water, the electric cooking range and lights.

A bit over ten years ago I found out about the 'Elite Classic' energy meter from Efergy (See photo below), which was more expensive, connected directly to the incoming power supply (you need a sparkie to do this!) but gave a real time total of electrical energy being used at any one time. I could use it to check individual appliances by turning the appliance off and on and noting the difference in current draw.

Our energy meter remains connected to this day and as well as telling us minute to minute how much electricity we were using it had a couple of unlooked for benefits –

1. It really focussed us on the amount of power we were using, so we would tend to turn things off (including lights) when not in use to see how low we could get it, and
2. If something, particularly a large draw like the hot water (ours is solar with electric boost through a switch) or some other heater was left on when it was not supposed to be, it became immediately obvious. If the power consumption seemed a bit (or a lot) high when we walked past and looked at the meter, questions were asked!

So, our system seemed to be working well, all up until a few weeks ago when things just didn’t add up!

A while back our microwave oven died, requiring us to buy a new one. No problem really, bought it, set it up, plugged it in and away we went. The previous microwave, using the ‘Elite classic turn on and off’ method, I had measured its phantom load at 20 watts, and was interested to see what the new one was. Using the same method, it came in at 70 watts! I thought it was a bit large but it was what it was. Needless to say, when not in use it was turned off!

It became a problem when I posted on social media what I had found, suggesting to people that checking phantom loads was a good thing. This resulted in several people calling out my results, saying it was far too high and the measurement was inaccurate. This concerned me so I brough back out my old MS 6115 power meter, hooked it up and then turned on the switch. Low and behold it gave me a reading of 104 watts, (see above) which made even less sense! With the microwave oven turned on but not functioning, it was consuming the same as a 100 watt incandescent light bulb? That made no sense!

After putting up another post about the second reading I was directed to another piece of equipment simply called a Power Meter (Model No RRPM03) from Reduction Revolution, (See photo above) available for the tremendous cost of $20! (Plus postage) I got hold of one set it up and whammo! It gave me a reading of 1.1 watts (See below)!

This was more in line with what I had been led to expect but was in direct opposition to my main power meter, the Elite Classic.

I emailed the manufacturer (Efergy) using the ‘Contact Us’ form on their website explaining the issue and asking for their thoughts. No response! After espousing the benefits of the Elite Classic for over 10 years I have come to question whether it is accurate or not.

So, where to from here? My immediate thought was an electrician’s clamp meter, however after discussing my problem with a local electrician he said that the very low level of wattage may be an issue, I may need to use it on the supply wiring to the socket and that whatever happened I would need a good quality (ie expensive) meter not a cheapie. In the end it became a moot point because I was unable to get hold of one.

What I was able to get hold of was a ‘Home Energy Efficiency Kit’ (more on this later) which I could borrow from our local library for a couple of weeks. Part of the kit is a ‘Powertech Plus’ power meter (No MS-6108), which can be used to measure, among other things, the phantom load of appliance in watts. I connected it up and turned it on at the wall and – you guessed it! – 1.3 watts.

This result has shaken my trust in the accuracy of the ‘Elite Classic’ and caused me to re-evaluate its performance, particularly where small loads are concerned and as such, I can no longer recommend its use. It has also caused me to re-evaluate some of the readings taken previously by using the newer equipment.

So, to avoid paying the price for a phantom load, simply switch your appliances off at the wall when not in use!

2.3 Making Changes as a Result of the Audit

Simple First Changes

As far as reducing your greenhouse gas emissions, the first and biggest thing you can do is to talk to your electricity provider and, where it is possible, change your supply to "green" power, sourced from renewable energy suppliers. This won't save you much money (in fact it may cost you a bit more) but if reducing your carbon emission is your aim this will be a great first step!

To save money and reduce your carbon footprint with no outlay at all, all you need to do is modify your behaviour a bit – on the way out of a room, turn out the light and when not in use turn off all of your electrical equipment at the wall. When I was a teenager I was a real bugger for leaving the light on in my room, which caused my father to yell at me a lot (he was paying the bills!). Some 20 years later he took great pleasure in making sarcastic comments when I was yelling at my kids to turn out the lights in their rooms! (Don't you DARE say anything about Karma!)

Then the Bigger Stuff

Anything that heats or cools is going to use larger amounts of electricity –

Heating water – it takes a bit of investment but if your current hot water system is electric, changing to solar will give you the biggest return on investment of just about any other single action you can make. Our experience with solar hot water can be found in **Section 3.0** of this eBook.

You can waste a lot of water waiting for the hot water to run hot after you turn on the hot tap and if you have a lot of small hot water requirements even more is wasted each time. For these small jobs heating water in a solar oven or other solar cooker then transferring the hot water to a vacuum flask with a spout (eg. airpot) is a good thing to do. The water will keep hot and be available without needing to keep running the cold water out of the hot tap. In a similar way if you drink lots of hot beverages, boiling a full kettle or jug once, then transferring the boiled water to a vacuum flask will allow you to make hot drinks throughout the day without continually boiling the jug.

Some other ways of reducing the usage of hot water and the energy used to keep it hot includes keeping showers to 3 minutes, washing your hands & clothes in cold water and running your washing machine and dish washer only when full. If you have an electric hot water system and want to reduce your energy usage, turn down the thermostat to 60°C for storage heaters 50°C for instantaneous ones. The stored water needs to be kept at 60°C so bugs don't grow in it. If you are going away for any length of time you can also turn your thermostat down or turn the water heater completely off, but check your owner's manual first to ensure doing that won't cause a problem.

Cooking Range – There are a whole lot of different ways you can reduce the amount of energy to cook your food – the easiest ways are learning to cook with the lid on and using your current cooking gear more efficiently. If you cook with gas, a wok is a good investment and they are cheap and readily available, particularly the traditional one made from sheet mild steel readily available from Asian grocery supply shops. More detail on these techniques is available in **Section 3.1** of this eBook.

If you are a bit handy, making a stored heat cooker (also called fireless or haybox cookers) will give you a slow cooker that doesn't need electricity, for construction and operation details on stored heat cookers, check out **Section 3.2**. There are also solar cookers of varying degrees of complexity that you can build; we use our solar oven to bake bread all year around. For details on how to construct and use solar cookers, check out **Section 6.2.** Making a rocket stove will enable you to reduce your energy spend by cooking your food on twigs gathered for free. For rocket stove construction and operation details, check out **Section 8.1.**

Air Conditioner – We generally only use our air conditioner for those REALLY hot western Sydney summer days to prevent Linda becoming a puddle of goop on the floor (and me too). Insulation plays its part, but we also use exterior “blinds” to keep the sun off the back and polystyrene inserts in the western windows to block the sun. Not going berserk and running your air conditioner all the time and 20°C above or below the outside temperature will also save you heaps of energy, and cash. For more details on how to retrofit your dwelling to save energy and increase comfort, check out **Section 4.0**

Space heater – We have a couple of wood heaters (slow combustion – one in the lounge, which we can also cook on and one in the bedroom) which we use to burn a percentage of wood which comes from trimmings from out trees, use found waste wood or bought in when we have to. They usually get used on the weekend but during the week we find it easier to use our body heat to heat just our immediate area by using our wearable blankets, in fact it is winter here now and I am wearing mine as I type this! For more details on our use of wood heaters and other techniques for keeping warm, check out **Section 4.3**

With space heating and cooling the most important thing is insulate, insulate, insulate! The roof is a good place to start, and if you are up on piers underfloor insulation can be installed by placing batts between the bearers and then stapling chicken wire over the top to keep them in place. Technically this is an easy fix, but somewhat exhausting to carry out, which is why Sons-in-law were invented.

Insulating the walls, particularly on retrofit, is considerably more problematic. The most effective way to insulate you walls if your home is already built is to rip off the gyprock or plasterboard from your outside walls, put the batts in place and then replaster the walls – tiring or expensive, take your pick – which is why we haven't done it. If you have dark brick like we have an option is to render with a light-coloured render to reflect the heat although this presumes you like the look of rendered houses – we don't.

One way I thought of was to block up the bottom of the outside walls and pour polystyrene beads down between the outer brick wall and the inner plasterboard one. Unfortunately, when I talked to the guys who know this stuff they said I would need to rewire the house first. It seems that the existing wiring in our houses is designed to be in the air so heat can escape and if you insulate them a fire could result. The only way is to upgrade your wiring to a size the is designed to be in an insulated environment first so bang went my "easy fix".

Even if the walls are insulated there are whacking great holes thought the walls called "windows" that let the heat in our out, depending on what it is that we don't want to happen. There are a whole stack of retrofit options for windows that range from bloody expensive like replacing all your windows with double glazed down to much more modest retrofit possibilities. For more details on strategies for low cost retrofitting your windows to conserve energy, check out **Section 5.1**

Refrigeration

In the old days (back BEFORE I was born) evaporating water was used to keep food cool, usually in the form of a Coolgardie safe, but there have been recent developments out of Africa that use one pot inside another, called a pot-in-pot cooler. Details of both are available in **Section 5.2**.

One of the more innovative ways that I have heard of keeping your food cool (which I admit I haven't tried) is if you maintain a separate fridge and freezer is to freeze ice bricks or ice cream containers full of water, freeze and place in the top of fridge. This works in a similar way to the old ice chests, where you bought ice and put it in the top of an insulated cupboard and the cold air from the ice flowed down over the food to keep it cold. In the modern version you would need to make sure the ice was sitting in a container to prevent the ice waterlogging everything as it melted; the original ice chests were provided with a drainage system.

If you want to go hard core, it has been said that refrigeration is mostly needed for meat and dairy (although the above mentioned pot-in-pot cooler helps keep the veggies fresher) so you just might be able to turn off your fridge entirely if you went vegan.

Appliances

As mentioned above, the first thing to do is get used to turning off your appliances at the wall when they are not in use, but your energy audit will help you identify the energy hogs in this regard and they will be the ones to pay most attention to. Turning off the appliances costs nothing to do and can save energy and money, you just need to keep at it until it becomes a habit.

While I don’t recommend that you go out buy a whole stack of new energy efficient appliances, as things wear out, replace them with the most energy efficient appliance that you can (eg replacing your old, dud CRT TV a smaller LED TV rather than humungous plasma TV) Fortunately the government has made it easy for us by requiring manufacturers to put power consumption labels on the big stuff at least.

Sometimes it is possible to set up an appliance so that it is optimised in terms of its energy usage. A Television is one such appliance and for hints on how to optimise your TV check out **Section 5.3**

Also, instead of buying or replacing electrical gadgets with more electrical gadgets, consider using hand powered gadgets instead. This is especially true in the kitchen where a whisk or hand beater can replace the electrical kind and all sorts of food processing gadgets can be replaced by a knife. Using hand instead of power tools in the garage can also be very satisfying, even if it takes a bit longer.

The thing that has amazed me is the huge amount of stand-alone solar powered stuff coming onto the market - torches, radios, phone chargers, all sorts of stuff. When it comes time to replace an appliance have a look around to see if there is a solar equivalent.

Lighting

Also as mentioned above, getting into the habit of turning off all lights when leaving a room will go a long way to reducing your power consumption due to lighting, and replacing all incandescent & halogen with fluorescent bulbs or LEDs is such an obvious thing to do i won't even mention it.......oops! There are a few other things you can do, like buying a few solar lamps that you charge up during the day in the sun which you can use at night for effect spot lighting for reading, sewing or whatever. Beeswax candles are good, particularly for mood lighting, but as with any open flame you have to be careful and a few fires have been started around here this winter by unattended candles. It is also possible to make a lamp which burns waste vegetable oil and for much of human history this was one of the only forms of artificial lighting available, but I'd hate to try and read by the light of one. For more details on low energy/solar powered lights, check out **section 7.4.**

Alternative Energy System (low voltage)

While it is not for everyone, it is possible to design and install your own low voltage alternative energy system, to suit your needs. You can read about how I did it, and the lessons I learned, in **Section 7.0**

Where to from here?

OK, for the sake of the argument let's say that you have read through these two chapters and the audit form; where do you go from here?

Well, as an old mate of mine would say, seek to learn. Do the audit, collect your data and work out where the big, expensive items are and where the “low hanging fruit” are also, in other words where you can get some quick wins. Put a plan together that takes into account all that you have found out and what you want to do, you don’t have to write the plan down but I find it helps me if I do. Change your behaviour where that will result in energy and money wins for you, it does require effort and can be difficult to remember at first but keep it up, it is a no cost strategy that can save you substantial amounts of money.

Once the behaviour modification has started pick a bigger, more expensive project that will give equally big returns (like solar hot water) and start saving, once you have enough cash go for it! At the same time pick a smaller, cheaper project like making window quilts, a fireless cooker or pot-in-pot cooler then make it a family project and get making. When you involve the family, they will feel part of the energy reduction efforts and you will have lots of fun making stuff with them that can further reduce your energy consumption. What have you got to lose?

3.0 Reducing Your Energy Consumption - Cooking

3.1 Using conventional cooking gear efficiently

3.1.1 On the stove-top

Use the minimum amount of energy while cooking by bringing the pot to the boil on high then turning it down to low so it simmers rather than boiling vigorously.

Electric hotplates can be turned off a few minutes before the food is finished cooking so that the cooking is finished off by the heat remaining in the coil.

The area underneath gas burners or electric hotplates should be kept clean and shiny so more of the heat will be reflected back up onto the base of the pot.

When using electric hotplates make sure the bottom of the pot or pan is flat and has not warped, so that the energy from the hotplate is transmitted directly to the pan and not lost to the surrounding air, likewise ensure that the pot fits the size of the hotplate or burner so that no energy is wasted around the edge.

Thick walled, high quality cookware makes most efficient use of heat by distributing it better around the food being cooked; this allows a lower heat setting to be used. A tight-fitting lid also allows more efficient heat use by retaining steam within the pot.

One- pot meals using a large pot and dividers or a steaming basket can be used to cook a number of different vegetables on one burner or hotplate.

3.1.2 Under the Grill

The grill cooks quickly and cheaply and can be further speeded up by lining the grill pan with aluminium foil. Best use of the grill can be made by combining foods which can be cooked this way such as tomatoes and mushrooms to be served with grilled meat.

3.1.3 In the Oven

Make the best use of the oven's high energy consumption by cooking several courses or meals at the one time; an apple pie as dessert after the roast dinner or a number of casseroles, one for eating and the rest for freezing. If it is not possible or desirable to cook a number of dishes at once in the oven then increase the size of the one you do cook and use the leftovers as a base for another meal, for the next day's lunch or to freeze.

As with electric hotplates, ovens retain heat after they have been turned off, so turn your oven off 10 minutes before the end of cooking time and allow the stored heat to finish off the cooking free of charge.

Except for bread, cakes and pastries the oven should not be preheated, especially where the cooking time is an hour or more.

Check that the seal on your oven door is working by inserting a piece of paper between the oven and the door, if the paper remains in place when the door is shut the seal is fine. If not, it is letting the hot air out and wasting energy so the seal should be replaced. The oven door should be opened as little as possible during cooking.

Baking dishes of glass or ceramic ware make best use of the heat and allow the oven temperature to be set 10°C lower. Similarly dark or blackened bread tins are more effective for bread baking.

To make the best use of cheaper cuts of meat they should be tenderised by marinating the night before in a little lemon juice or wine, which can reduce cooking time by up to 30 minutes.

Make sure that any meat which has been frozen is fully thawed before being put into the oven; if this is not done, particularly on large cuts of meat, the cooking time can be doubled or more.

3.1.4 Cooking with the lid on

In many situations then cooking on top of the stove we don't think about it, but leave the lid of the pot off, whether it is so we can see what is going on, to prevent it from boiling over or because that is just the way we cook, we leave the lid off. There are, however, some situations where leaving the lid on can allow a reduction in the energy used to cook our food by as much as 75%!

During cooking, steam rises from the food and takes with it a proportion of the heat energy we are putting in with gas or electricity or whatever to cook the food. By keeping that steam and energy in the pot with the food we can reduce the amount of heat energy we need put in to cook a given amount of food. We can take advantage of this salvaged heat by reducing the amount of heat input applied to cook the food, or reducing the time taken to cook the food, or both.

In many cases you won't need to buy anything new, just use your existing cooking apparatus in a new and more efficient way. There are other environmental benefits which will follow too –

- Some of these techniques can be used to replace cooking under the grill or in the oven and both of these methods use more energy than cooking in a frying pan.
- By keeping the lid on you reduce spatter and mess to an absolute minimum so cleaning the stove top becomes quicker, easier and does not require a battery of chemical cleaning agents.

Now that I have your interest, on with the show! –

Lid-On Frying

For this technique it is best to have a heavy bottomed frying pan, to disperse the heat evenly, with a close fitting lid. My preference is stainless steel but enamelled cast iron works really well too (I must admit I distrust non-stick and aluminium cookware) the good ones can be expensive but will last a lifetime.

This technique is suitable for meat, fish and vegetables. For example, chicken pieces (free range of course!) can be cooked this way by putting a small amount of oil in your frypan. Place your chicken pieces skin side down, place the lid on the frypan and putting it on high heat until the chicken starts to sizzle, then turn the heat down to medium high for 10 minutes, then turn the pieces over for another 5 to 10 minutes and viola!

Steak can be done in a similar fashion (ours is local grass and fed, occasionally we feel evil enough to buy some). Assuming your steak is 2.5cm thick and you want it medium, place the steak(s) in the pan on high heat with the lid on for 2 minutes, then remove the lid and turn, cook for another 2 minutes. Now leave the steaks to rest with the heat source turned off but the lid of the pan still on for two minutes. This is only a guide and you should experiment with the technique until your steaks come out how you want them.

For vegetables, cut up 450 grams of mixed (preferably home grown, but at least organic) veggies so the pieces are about the same size, place them in the pan and add a splash of oil (we use Aussie olive oil for cooking) and cover. Place the pan over high heat and once the veggies start to sizzle, cook for one minute, toss the pan (while holding onto the lid of course) to redistribute the veggies every minute or so for about 5 minutes then remove from the heat. Bung in a bit of soy sauce or vegetarian oyster sauce (made from mushrooms), toss well and away you go. This technique is sort of a cross between stir frying and steaming your veggies and is very energy and nutrient efficient.

Freshly Cooked Broccoli and Cauliflower Mix

Lid-On Boiling

When I first learned this technique I found it to be a bit counterintuitive, I always brought the water to a boil with the lid on, but once it had boiled it was a case of the lid comes off, the food goes in and you get it up to a rolling boil again until the food is cooked. I must admit that when the water boiled over because I left the lid on my response was to take off the lid rather than turn down the heat. Oops!

Anyway, if you cook like me you can save yourself a fair bit of energy by turning the stuff you normally cook on a rolling boil down to a medium low heat and leaving the lid on. If you just cook at a low boil, try leaving the lid on and turning the heat down to low and if you need to simmer turn the heat down as low as it can go and leave the lid on. This one simple technique can save you money and energy, with no loss of cooking time or efficiency. It works for veggies, pasta, grains and dried beans and poached chicken or red meat.

This technique can also be used to cook pasta or using the energy stored in the water, retained through leaving the lid on. Bring the water to the boil in the pot as you would usually and then toss in your pasta, replace the lid and re-boil the water. When the water starts to come back on the boil just turn the heat off and cook the pasta for the amount of time your normally would. The pasta will come out al dente and you will save lots of energy (= money).

So there you have it, a simple technique that can save you energy, time and money; it is good for the environment too and requires little or no extra equipment, just a behavioural change. Why wouldn't you give Lid-On cooking a go?

3.1.5 Cooking with a pressure cooker

Some other methods of fuel-efficient cooking discussed in this section require only a small outlay on equipment, unfortunately this is not so with the pressure cooker which may cost over $200 if bought new. While I am a fan of buying second hand where possible, in the same way you would think twice about buying a second hand toothbrush, a second hand pressure cooker may not be a bargain either.

Pressure cookers operate at high pressure (the name is a dead giveaway, eh?) and while a catastrophic failure is unlikely it would certainly ruin your day if it happened. The pressure cooker in question may be being passed on due to previous problems and if you don't absolutely know its history, give it a miss. Also, older types may not have all the safety features that the modern cookers have (ours has three separate systems to prevent overpressure) so for the sake of peace of mind, I suggest sticking with a new buy only. And read the instruction FIRST, not after all else has failed!

For the investment however, the pressure cooker does cook 66% faster than cooking at atmospheric pressure, with a subsequent saving in time, nutrients and energy, also no laborious preparation of food or equipment is required. If you are going to spend the money anyway, go for a stainless steel model, it will last you a lifetime. I don't trust aluminium cookware generally but specifically for pressure cookers, stainless steel is much tougher and more forgiving of mistakes and rough use.

A pressure cooker works by allowing steam pressure to build up inside it to the tune of 70 to 105 kPa (10 to 15 PSI) above atmospheric pressure. At atmospheric pressure water boils at 100°C (212°F), no matter how long you boil it , but at 105kPa water boils at 120°C (248°F), so food can cook much more quickly. This allows the use of cheaper cuts of meat and ingredients that require longer cooking such as boiling chooks or dried beans. Dried beans can be cooked in 35 to 45 minutes in a pressure cooker and require no pre-soaking.

The main problem which can arise with pressure cookers is if the food swells up or foams up while cooking so that it blocks the pressure relief valve. To prevent this, the cooker should never be filled to more than two-thirds capacity and foods that

have a tendency to foam, such as split peas, should be avoided.

It was in my mind to buy a large pressure cooker so that we could also use it for food preserving work (ie pressure canning) and while I am not sure of the where's and why for's, I have read that pressure cookers SHOULD NOT be used for pressure canning. So I thought I would pass that little gem of information on, so you don't make the same mistake I did.

While they are a great way to save money, energy and nutrients if you are unfamiliar with the pressure cooker get hold of a good modern cookbook to help you through the initial stages of learning to use it.

3.1.6 Cooking with a wok

The Chinese cooking pan known as a wok has been in use in Chinese kitchens for somewhere around a thousand years and because of its cheapness, efficiency and versatility it deserves a place in more Australian kitchens. The traditional round-bottomed wok is adaptable to most heat sources such as the gas stove, rocket stove kerosene or LPG primus, methylated spirits camping cooker, wood burning fire or, when a hole is cut into the plate, the family barbecue. The one power source it cannot be used on is the electric stove, but these days flat-bottomed woks are available for just this purpose.

Woks are very cheap in the Asian shops to be found in most large cities (ten to fifteen dollars each), so cheap you can afford to have more than one. They are available in a number of materials, the more common being aluminium, stainless steel, pressed mild steel and cast iron. I prefer the traditional pressed mild steel wok but the other types would be just as good.

The dish for which the wok shines over all other pans is the stir-fry, where all ingredients are cut up very finely and then cooked very quickly over high heat; this is economical on both energy and nutrients. Cooking in this manner is also different and a lot of fun! The Asian practice of using rice or noodles and vegetables in quantity and then using meat in small amounts as flavouring is also a trick worth learning. There are lots of good Asian cook books, but once you have mastered the basics it is a cuisine which allows a lot of improvisation.

When you buy your pressed steel or cast iron wok you will need to clean it then "season" it, to give it a protective non-stick surface. First wash the wok with thoroughly with hot water, detergent and soap pad to remove any antirust or oily coatings, rinse, then dry.

Now rub the inner surface with a thick layer of good quality peanut oil and heat the wok until the oil appears to steam or smoke. After 3-5 minutes remove the wok from the heat and allow it to cool; then wipe away excess oil. The wok is now ready for use. After the wok has been used to cook in, it should only be rinsed with hot water to clean it. If detergent and cleaners are used on the inside surface it will need to be re-seasoned before its next use. When the wok has been cleaned and before you store it away wipe a thin layer of peanut oil onto the inner surface to act as a rust preventative.

The only absolutely essential accessory for your wok is the round-nosed shovel like implement (called a 'charn', see above photo) used to move food around the inside of the wok. If you are flush with cash other handy bits to have are a wire ladle for removing deep-fried morsels from hot oil, a solid ladle, a bamboo steaming basket or two, an aluminium or chrome steel ring to stick the wok on when it's off the heat and, of course, chopsticks. These add-ons increase the versatility of your wok so that it can be used to steam, braise, deep-fry and shallow-fry as well as stir fry.

3.2 Cooking with Stored Heat

3.2.1 Theory and Practice

The idea of cooking with stored heat has been around since medieval times, when they used to place their pre-heated cooking pots in a nest of hay, stray or dry leaves etc in a box or hole in the ground to finish cooking, thereby maximising fuel use. This practice continued in various guises and places up until the early part of the 20th century when, with advent of cheap electricity, we seemed to have forgotten about it. Hay box cookers, as they are sometimes called, did enjoy a revival in the late 70s to early 80s when the fuel crisis set in and you can find instructions on how to make them in the self-sufficient living books of the time. They are a great tool to help you live more sustainably so maybe there should be a revival of the haybox again now!

Why bother?

- You can save fuel used to cook your dinner from between 20% and 80% depending on the recipe and how long it would normally cook for, the longer the cooking required, the more you save.
- In line with saving fuel, unless you live on a bush block and only burn wood, whatever fuel you use you will have to pay for so you can also save money.
- Reduced fuel usage (gas or electricity) means reduction in greenhouse gas production as well so you are saving the environment too.
- Longer cooking at lower temperature means that you maximise nutrients and flavour in the food you are cooking.
- I don't know about you, but I get nervous about leaving appliances on while I am not home, so you can put you dinner on before you leave for work, as you would with a slow cooker, but with no external energy input you won't come home to a pile of smoking wreckage!
- They are cheap, easy and lots of fun to build
- The food can sit in the stored heat cooker forever and not get burned or overcooked.
- While they are ideal for winter soups and stews they will also reduce heat input into the kitchen in summer
- Surprise your friends & amaze family, they turn up expecting a feed and find nothing on the stove, after a few minutes worried conversation you can yell "Ta Daaaaaaaa!" and pull a fully cooked meal out of the stored heat cooker. (Yes, I do have a perverse sense of humour)

The Components

To build a stored heat cooker you need to have three basics; an outer container, insulation material of some description and the inner cooking pot.

The Outer Container

The outer container can be a Styrofoam Esky or recycled broccoli box, an old trunk, wooden box or barrel, in fact any container that is large enough to hold the pot and insulation and is airtight. Wooden boxes or barrels with cracks between the slats or staves will need to be lined with cardboard or aluminium foil to ensure they are airtight. If the material of the box is also a good insulator such as Styrofoam, so much the better. The outer container can also be made from fabric as the Wonderbox is, but more on that later.

One thing I have found is that if the outer container resembles a nice piece of furniture such as an ottoman, blanket box, wooden chest etc it is more likely to be given space inside the house and so more likely to be used. The original one I made out of an old esky (see article in this section) worked extremely well but suffered from the fact that it looked like crap, even after Linda gave it a coat of silver paint to spruce it up it just looked like a silver painted old crap esky. So starting out with a nice looking container is a good thing, if you can build it even better, but since I made my original one I have bugged the living daylights out of Linda by saying of every bit of furniture we see that is box-like "you could make a hay box cooker out of that!"

The Insulation

There are a whole stack of things you can use as insulation and some obvious (and less obvious) ones are listed below -

- Hay or straw
- Crumpled newspaper
- Polystyrene foam
- Vacuum
- Blankets / clothing
- Wood wool/shavings
- Sleeping bag
- Wool /Feathers
- Leaves
- Perlite
- Sugar cane mulch (AKA bagasse)

There are no doubt other materials not on this list that you have access to and that could be considered as insulation for a stored heat cooker, but there are a few characteristics that are worth thinking about before you make your decision. Obviously enough the insulation must be able to withstand cooking temperatures, at least 100°C should be allowed for and it should not pump out toxic fumes or fibres. On the face of it, fibreglass (glasswool) would make a good choice, cheap, light and a great insulator, but it is nasty stuff to deal with so would not be a good idea.

Any insulating material should be able to be formed nice and snugly around the pot to reduce heat lost through convection and should be dry and able to be kept dry as insulation loses much of its insulating properties when wet due to conduction of the heat away through the water. Depending on the effectiveness of the insulation, it should be a minimum of 50 to 100mm thick (the exception here is when using a vacuum as the insulator, but that is difficult to home produce!). A very effective insulator like polystyrene foam need only be 50mm thick but the more traditional hay or straw should be 100mm thick as a minimum.

The Cooking Container

The pot could be made of a material that retains its heat well, such as Corning Ware, heavy stainless steel, well-seasoned or enamelled cast iron, or stoneware but if your cooker is efficient enough, the material of construction of the pot won't make that much difference. More important that the material of construction is the shape, it should have the smallest surface area per unit volume that you can manage. Of course the shape with the smallest surface area per unit volume is a sphere and spherical cooking pots are not that easy to come across, but the hint is short and squat like a billy not wide and flat like a frying pan.

The lid should also seal fairly well, have a lip so any condensing steam goes back into the pot and it should not have a steam hole as seems to be popular in pot lids these days. If the pot you wish to use is not perfect in the lid department but it is probably best to make up a bit of flour and water dough and use it to seal the rim and any steam holes the lid should have. I've tried this and it works really well.

Other Types of Stored Heat Cooker

There are commercial brand-name stored heat cookers on the market but the cheapest and most readily available commercial stored heat cooker is the wide mouth thermos flask, which uses a vacuum as the insulating medium. The vacuum flask makes a good cheap feed for one person and is portable so you could start it before going to work then take it to work for a hot, cooked lunch.

Interested in the idea but not sure if you want to go to all that effort? You can make an expedient stored heat cooker by preparing your dish as you would if you were going to transfer it to a stored heat cooker and then wrap it up in a blanket or two and stuff it into an eski, polystyrene broccoli box or if nothing else is available and corrugated cardboard box. This will give you some idea how they work and it is a great idea if you get a blackout in the middle of cooking dinner!

Getting the best out of your stored heat cooker

You can cook many standard recipes in your stored heat cooker, particularly if they are "wet" recipes like soups, stews, casseroles and the like so trawling through your recipe books for these and recipes designed for slow cookers and one pot dishes should net a whole stack of possibilities. There are some things to look at though in adapting the recipes for use with the stored heat cooker –

1. Multiply cooking times by 3 at least so that the food is cooked through. There will not be a continuous heat input during the cooking process and although there is plenty of heat put into the dish at the start as it slowly cools the time taken to cook the food fully extends. Having said that, even cheap cuts of meat cooked in the stored heat cooker will come out moist and tender every time because of that long slow cooking.

2. Reduce water in the recipe by 25%. The pot will be well sealed and without the continuous heat input driving off water you will find that you don't need to put as much in to achieve the same consistency as you are used to.

3. Size the recipe so the pot is full, that way the maximum heat is stored in the food in the pot and it will retain its heat for the longest time, making for the most efficient cooking.

Using Your Stored Heat Cooker

OK, let's say they you have built your cooker and found or developed a recipe to try out in it and you are ready to go, what next? First off, bring your pot to the boil using whatever heat source you have available. Gas or electricity is most likely but it adds to the fun if you have built a rocket stove or solar cooker of some description and that way you know that no fossil fuels at all have been burnt to cook your food.

When your pot has been brought to the boil you will need to keep it there for long enough to ensure that the heat gets right to the centre of portions of food that you are cooking, so that for something small like rice, five minutes on the boil might be enough but for larger food like, say, whole potatoes 15 minutes boiling would be required. Once the boiling time is completed seal up any steam holes or cracks with a flour and water dough and place the pot in the cooker. Leave the pot in the cooker for the calculated cooking time and remember NO PEEKING! It lets the heat and steam out, slowing down the cooking process.

Once the cooking time has elapsed remove your pot from the cooker and check the temperature, if the temperature has dropped down to cooler than you like, reheat before you serve it and then enjoy! If you have left the pot in a lot longer than you planned to it will not overcook but if it has cooled down to below 60°C, bring it to the boil and re-boil for 5 minutes or so just to make sure there are no problems with bacteria.

Other Uses

You stored heat cooker does have a few other uses that you can put it to, like making yogurt. Yogurt is simply made in your stored heat cooker by heating milk in the cooking pot to about 85°C for a few minutes then let it cool to 45°C, throw in a couple of tablespoons of natural yogurt or live culture and then place into your stored heat cooker and leave overnight. Add some fruit and (hush, hush) maybe a bit of sugar and you have homemade yogurt.

You and also use it to place bread dough in to rise in cold weather (if it is big enough), use it to keep food cold in hot weather. If your cooker is portable you can use it to keep food hot while travelling to give you a good hot meal on the road and if you have pots that fit your solar cooker, you can cook stuff during the day and then use the stored heat cooker to keep it hot until time for your evening meal.

Potential Difficulties

Like all technologies, this one is not a totally unmixed blessing, as with any slow cooker you can't decide you want to eat in half an hour, your meals must be planned to give you sufficient time to prepare them and then have them stay in the cooker long enough to finish the cooking time. The stored heat cooker's forte is not small meals, it is at its most efficient when you have the pots full, so if you are cooking for a crowd that's great but if not you may have plenty over to freeze for later! You also need to keep an eye on the insulating material, particularly if it is organic, as it can become damp with cooking steam and lose part of its insulating properties. The damp can also encourage bugs with the consequent smell and risk of contamination so air the cooker regularly and if in doubt replace the insulation.

3.2.2 Making a Stored Heat cooker – Furniture Based

My previous effort worked well, was cheap and easy to build, but had some shortcomings, I never did get around to building a nice wooden box for it to go into so it looks just like what it is, a crappy old esky, even after Linda gave it a coat of silver spray paint to tart it up for sustainable house day. Due to its crappy appearance it rarely made it

into the house so it didn't get used as much as it should have and these things are great for saving energy. I just had to come up with something better!
To make things better I needed to do a couple of things differently –

1. Build the thing into a nice looking piece of furniture that didn't look out of place inside the house and could be located near enough to the cooking area to make it readily useable.
2. Instead of using a billy or two as the cooking vessel, build it around cooking pots that we regularly use anyway making it easier to work out the recipes etc.

After some serious looking I found a comparatively cheap blanket box with a padded top that you could sit on, it was covered with a dark vinyl material and fitted our "decor" reasonably well, so I got it.

Converting it to a stored heat cooker was easy, I used the sheets of waste polystyrene foam that I had gotten hold of while working for the concrete precaster and cut them to size using a more sophisticated hot wire polystyrene cutter. We got hold of the cutter from a craft/model supply place in Gosford and rather than having a thin wire strung between contacts it had a stronger electrically heated wire attached to a handle that you can just push into the polystyrene and start cutting.

I cut a couple of sheets and put them into the box as insulation for the bottom of the pots and then cut three more sheets to act as insulation around the pots. The box is long and narrow so it took two pots easily; I selected a stainless steel 3 litre pot and a Pyrex casserole of about 4 litres capacity, then placed them on a polystyrene sheet, traced around the bottom and then using the cutter, cut out a disk, leaving a hole the same size as the pot. I test fitted the pot into the hole and had to make a couple of minor cuts but the stainless steel pot fitted well. The Pyrex pot tapered from the bottom outwards to the top so it was a bit trickier but in the end I was able to get a reasonable fit.

Electric polystyrene cutter

To ensure that the holes were in the right place, I put the cut sheet on top of an uncut one and using a pencil, drew around the inside of the hole, transferring the outline to the uncut blank. I then pressed the hot wire cutter into service and cut around the pencil line, placed the two sheets on atop the other and test fitted the pots again. I followed this process a third time, making sure the pots fitted the entire profile of the hole, and then fitted the cut sheets into the box.

One pot fitted and one pillowcase in place

While most of the pots were now covered by the polystyrene foam sheets, the tops were still exposed so I got hold of a couple of pillow cases and filled them with polystyrene bean-bag beans and then Linda sewed them up. During that operation it is REALLY easy to spray beans all over the place and the staticky little things get into the strangest places. We found the best way to do it was to sew up the open end except for about 10cm or so, then put a wide mouthed jam funnel into the opening and sticky tape it in place and pour the beans in through there. That method resulted in the least amount of beans lost.

Using the jam funnel to fill a (red) pillowcase with beans

Showing the underside

In the event we got carried away and put too many beads in, there needs to be enough so that the tops are covered by at least 50mm of beans but not so much that the pillow case is too hard to conform to the top of the pots. We had to take out about a third of the beans that we had originally put in to get the fit right.

The new cooker is getting quite a bit of use and both containers have been used to make a number of meals, and it has been working so well that we talked about it with our eldest daughter and she thought it sounded great. We picked up an ottoman that was hollow inside and had a removable top and she and I made it into a stored heat cooker together. She has made several batches of "ottoman soup" and has found that it works really well.

The ottoman, ready to make ottoman soup!

3.2.3 Making Stored Heat Cooker – Fabric Based

I have always wanted to try out a stored heat cooker based on an insulation filled fabric bag. They are light and easily portable, cheap to make and from what I can gather work tolerably well. A friend of ours has one she keeps in a cane basket and it looks pretty good and she likes it. So we got together with some friends one Saturday afternoon and made one, it was lots of fun and we had a great time. I would recommend it as a great activity for friends and family and you get a stored heat cooker at the end of it.

The basic idea is that you cut out two circles of fabric, place one on top of the other and sew a small circle in the centre which becomes the bottom when filled with polystyrene foam bean bag beans. Then sew a dozen or more radiating lines from the central circle, out to the circumference of the circle. Fill each segment formed by the stitches with polystyrene beads and sew the open end shut. Sew on a draw string around the circumference of the circle and then draw it up tight around the pot you wish to cook in. Then make up a circular "cushion" filled with beans to sit on the top, inside the draw string, to prevent heat being lost through there.

Simple hey?

If you want a look at the pattern, check out Appendix 1

This is how we made ours, in a bit more detail –

1. Get hold of the fabric you want to use. (You will need at least two and a half metres of cloth.)

2. It should be capable of putting up with contact with pots at 100^{o}C so a natural 100% cotton fibre material is probably best, for the inside at least. Fold the material in half and draw a 95cm circle on the fabric by putting a pencil in the centre, tying string onto it and then place some tailors chalk or soap at the 100cm mark on the string. Using the pen as a pivot, draw the circle with the tailors chalk or soap.

3. Cut out the circle, this will give you two disks of cloth. Turn the cloth so that the "wrong Sides" are together so that the pattern side of the cloth will be visible from inside and outside the bag.

4. Choose the pot you will be using inside your wonder bag and place it directly in the centre of your circle. Trace around the bottom of your pot with the tailors chalk or soap so that you have a circle drawn in the centre of the cloth disks the same size as your pot. This will most likely give you a circle 150mm – 200mm diameter.

Setting Out

5. Sew the two disks together using the centre circle but leave about 50mm unstitched, then use this gap to fill the centre circle with polystyrene beans until it is 20-25mm thick. Then sew the 50mm gap closed to form a central disk.

6. Lay out the cloth disks on a flat surface and draw 12 lines with the chalk or soap from the central circle out to the circumference of the cloth disk so that they are roughly equal distance from each other.

A bag ó Beans

7. Sew each line through both cloth disks from the circumference of the disk, into the central disk, forming 12 segments. Leaving a 2cm seam allowance fill each segment with bean bag beans. We found the easiest way to do this was to get hold of a 1 or 2 litre plastic or glass jug, pour the beans from the plastic bag into the jug then fill a segment using the jug(s). The 2 cm seam allowance will leave enough room to sew the segment shut. It works best if you fill one segment and then sew it shut before starting on the next one. Or the beans get EVERYWHERE!

8. Once all segments have been filled and sewn shut sew bias binding around the circumference of the bag. When we did ours the bias binding turned out to be about 35cm short, but rather than add on the extra, we simply hemmed it and it allowed us to pull in the top a bit tighter.

9. When the bias binding is in place, tie some cord or ribbon (we used thin ribbon) onto a safety pin and push it through the inside of the bias binding to form a draw string. It is just a case then of slowly working the draw string so that the edges of the segmented disk is drawn up into a cup shape around the pot to be used for cooking.

10. To make the top pillow cut out two disks of the same cloth as the cooker, a bit larger than the opening at the top of the cooker, ours came out at 260mm in diameter. Put the disks right side together and sew around the edge leaving 9-10 cm unsewn. Turn the sewn disk inside out so the fabric is right side out and fill with bean bag beans. Then sew the opening closed to stop the beans escaping.

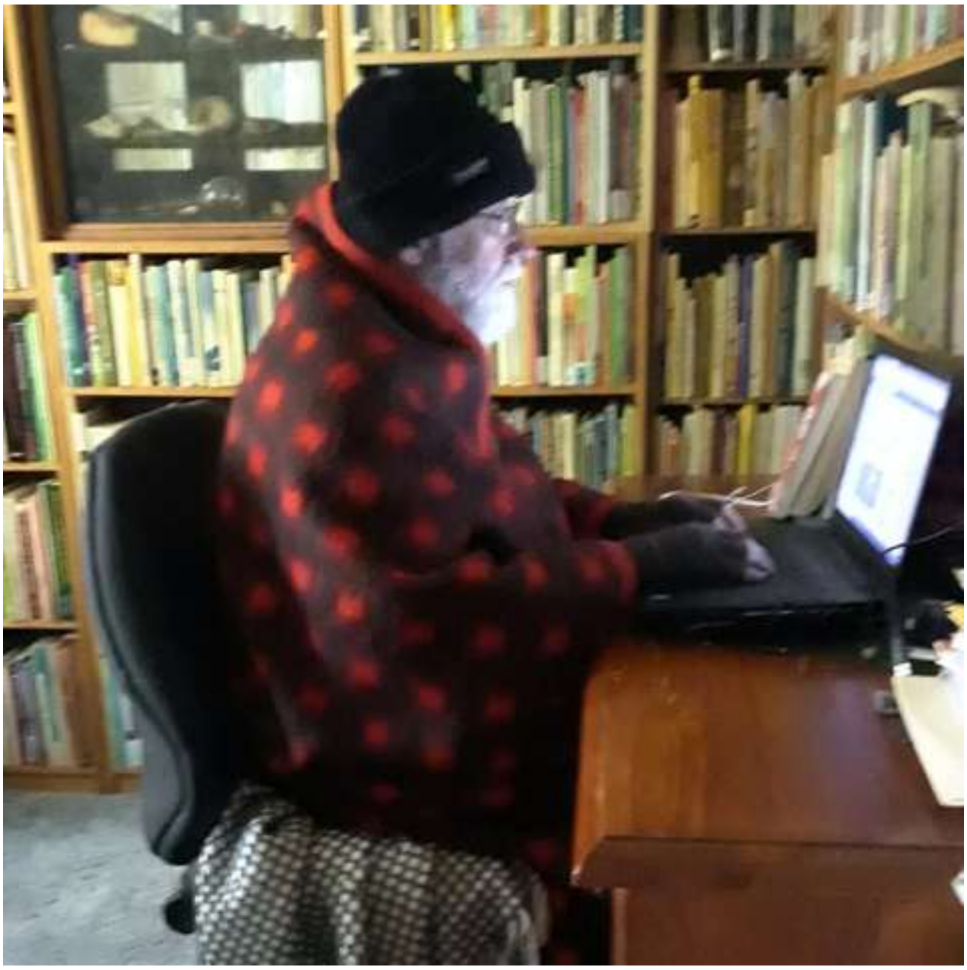
Your wonderbag is now complete and ready to start cooking in!

4.0 Keeping Cool (and Warm) Without the Aircon

4.1 Introduction

I would like to set the context of this eBook, by saying that we have lived in our brick veneer, 110m2 home here in western Sydney for 45 plus years. During that time we have found the summers are getting hotter. The title reads ‘Coping with Heat and Cool’ and in terms of living in western Sydney that means a lot more ‘Heat’ than ‘Cold’.

While we have been listed, at times, as the hottest place on earth, when it comes to ‘Cold’, it should probably read ‘cold’, or perhaps ‘cool’. The coldest that I have measured it at our place is -3^{o}C and that was some years ago now. We still get frosts, but they are a rarer thing than they used to be. So if your climate stretches to -10^{o}C or below like we experienced on a trip to Belgium a while ago, my apologies if you don’t get much out of the ‘Cold’ Section.



What I have learned - It's the end that matters, you can change how you get there.

The winter of 2020 was a fairly cold one and after the summer we had just come out of it was not a bad thing, but we still want to be comfortable.

Quite often the answer to 'how can I be comfortable in the winter' is 'let's heat the whole house!' Certainly we have applied that logic, by installing an open fire when we first moved in (replaced by the more efficient slow combustion cooker/heater some years back) and the Petite Godin slow combustion up the other end of the house when Angela was born.

Lots of people do similar things using reverse cycle aircon, gas or electric heating, and this certainly makes for a comfortable house to be in on cold days and nights, but it can also burn through a lot of energy and a lot of money as well. Yes, we burn wood, which is short cycle carbon, rather than fossil fuels which produces carbon dioxide originally locked away millions of years ago, but wood burners still produce greenhouse gases. So what to do?

If our goal is to remain comfortable in cold weather(without costing a bundle and screwing up the environment), we can shift how we get there by concentrating on keeping our bodies warm directly rather than heating the air around us and allowing it to then keep us warm.

We try to do this these days, using a number of techniques. We do use the wood burner at night to give us a bit of heat and to cook on, but we use clothing layers to keep us warm during the day. One idea we have found very useful is our wearable blankets as our outer layer. These are basically warm blankets which have been modified to make them…………………wearable!

The detail on how to do that is accessible in in **section XX** but it is about applying buttons or press studs so that you can wrap the blanket around yourself and then close it up to keep you warm. We find it works very well and when teamed up with a woolly hat, warm fingerless gloves and warm socks or other footwear you can still do most inside jobs and yet remain toasty without heating up the surrounding area.

We also use a heated throw rug while we are sitting down reading, watching a movie or whatever, we sit together and with the extra bit of warmth it provides we are quite comfortable. For us it makes use of the power our system generates, but even if you are using coal fired electricity it only uses 160 watts maximum whereas an electric space heater can consume ten times this much or more.

Oddly enough, we don’t use electric blankets on our bed but use a number of other techniques to keep warm including microfleece sheets, sleeping together and stored heat from a hot water bottle, or wheat bag etc.

So I have found that once we have worked out our objectives, it is a case of being open to new ideas as to how we can attain them by the most efficient, least wasteful means and at a reasonable cost!

4.2 Keeping Cool

4.2.1 Keeping Out the Summer Sun

Back in 2011 I put together an article about keeping the summer heat off the kitchen and dining room area, then in 2012 I added a sequel. Both of these articles concentrated on using a blind-type material to construct a barrier between the Western Sydney summer afternoon sun and the kitchen dining area, first with matchstick blinds and secondly with light coloured 90% shade cloth. But in the ten years plus since those were written I have put more effort into protecting the back (and other parts) of the house from the summer sun using a number of strategies.

Kitchen Dining Area

To be fair, this is still a priority area, but a few years ago I built a back deck, and while the roof is clear corrugated polycarbonate roofing, it is covered with a double layer of 90% shade cloth and there are a series of bamboo blinds across the western side of the deck. This works pretty well to keep the sun off this strategic area of the house. For more details on how I constructed the deck (with the help of friends) there is

The Rest of the West

Of course the deck only covers six metres of the western side of the house ie the kitchen, dining room and laundry (partially). There is still another other six metres of the back of the house, consisting of the bathroom, toilet and third bedroom, which is currently my office. To cover this area we have a number of layers of vegetation – defence in depth.

The first (and most westerly) part of this defence is the banana circle. As well as providing bananas, using greywater and looking really cool, the banana circle provides afternoon shade for the laundry, bathroom and toilet.

The banana circle

Closer to the house and a bit more northerly is the mandarine tree. It was originally located on the western side of the yard, but turned out to be where I wanted to put a shed, so I dug around the roots and pruned it back heavily then used a winch (and lots of pushing) to move it to its current position in front of the office/third bedroom. The mandarine tree provides shade mostly for the third bedroom/office back wall and part of the window.

Mandarine tree, passionfruit vine on the window and papyrus from the constructed wetland

The northern part of the office/third bedroom window is covered mostly by a passionfruit vine and, depending on the time of year, the vine will creep over to the southern side of the window as well, eventually melding itself into the mandarine tree. It does die back somewhat in winter and is trimmed to allow some winter sunlight into the window, but it regrows each year.

Shade from the assembled foliage on the back of the house

Between the banana circle and the mandarine tree and the house there is the constructed wetland. The constructed wetland grows large taro leaves and papyrus, which both provide some early afternoon shade on the lower part of the western wall off the house. The taro in particular dies back in winter and then comes back in spring.

The Northeast

The second bedroom/craft/spare room composes the northeast corner of the house and gets sun cover in the morning and early afternoon from our mature mulberry tree. The mulberry tree covers the east face of the room, part of the roof and probably half of the northern wall of that room. The north wall of the house does also get some sun protection from the 5,500 litre rainwater tank and a couple of storage sheds that prevent the sun coming in direct contact with the north wall.

From the north

From the south showing shade provided on a summer morning

The East

We have quite a bit of foliage in the front yard including three large melaleuca alternifolia trees, a large bay tree, a large olive tree and several smaller fruit trees along the front boundary, but the foliage is high up so that we tend to get early morning sun on the house. We also have the fruit tree circle directly in front of the lounge room, but due to the angle of the house on the block, we usually get some morning sun on the lounge room windows in summer, but not so much in winter, when we do want it.

Melaleucas from the East

Fruit tree circle and the hibiscus (olive in the foreground)

Next to the house at the front door and part of the main bedroom wall, we have a large hibiscus and a moderately sized bottlebrush and these do provide some morning shade for the eastern wall of the house.

The South

Usually the southern wall of the house is not that much of a worry because it doesn't get much, if any, sun. However, due to the skewed position of the house on the block, the south wall actually faces somewhat west of due south so that in late summer afternoons the sun would hit that wall. This is not a big issue for us, though, because the whole south wall is protected from the sun by the garage and so little sun falls directly on it.

Conclusions

So it can be seen that over time we have been able to put in place barriers so that the sun does not come into direct contact with the dark house brick and warm us up in summer. We have been able to do that, in the most part, with trees, shrubs and bushes that are productive in their own way, as well as providing sun protection for the house. This did not happen overnight. The mulberry tree on its own has probably been in place for over 30 years. Having said that, the banana circle and passionfruit vine have been working for us after only a couple of seasons.

I would love to say also that this 'defence in depth' was developed as a result of a coherent strategy and master plan. Unfortunately this was not the case and the whole thing has developed over a long time. Certainly it would have developed into an effective and productive sun barrier much more quickly if I had put a plan together first, and mistakes were made!

The banana circle was originally in the front yard in a totally inappropriate place. Where the banana circle and constructed wetland are now was originally the site of an unhappy and not very productive lemonade tree. Where the mandarine tree is now was a scrappy peach tree that acted as a very effective lure for fruit fly, which then went on to party in the veggie patches. It was only once I had done some study and hung around with some awesome permaculture bods that I was able to design things to be more productive and more effective.

I have made mistakes, so you don't have to! (That's rubbish but I always wanted to say it!). My suggestion if you want to do something similar to what we have is –

- Do your research, read the books, join a permaculture group, and do a course if you can.
- Put a plan together, it will give you a chance to think about things as you put them down on paper before you put them down on your land (which is also a lot more work to change!).
- When you have a plan, give it a go and implement it! Even if it doesn't work out it will hopefully still be fun and give you some good practical experience.

Good luck!

4.2.2 Setting Up a Cool Retreat

It seems to me that out here in western Sydney the summers are getting hotter. In the last two years (2017 & 2018) we have had several days over 45°C and more than I care to think about over 40°C. Along with this has been the feeling that levels of heat that never used to bother me are now causing me some trouble. I mentioned this to my doctor, and she made some comment that sounded like it was because I was getting bold, but I may have misunderstood.

One way of dealing with this, and it certainly is the method of choice for some of our neighbours, is to run the air-con 24/7. This is expensive and there has been talk of power issues on the really hot summer days and the possibility of blackouts. We have our own standalone power system, but when I was designing it the theory was that because the air-con is a major current draw and is only used for a few hours on the couple of hottest days of the year (ha ha), it would remain grid connected. Anyway, so much for that idea!

So what is the answer? A cool retreat!

A cool retreat is an area of your dwelling which has been set up to remain as cool as possible during heat wave conditions and which you can…….. retreat to. The area may be set up specifically to function as a cool retreat during construction or, as ours was, an area retrofitted into our standard 1970’s era dwelling. To work out where we were going to put our cool retreat we had to look at our house and identify the best location. The criteria we used to identify where our cool retreat was going to be were –

- The area was, or could be insulated and/or protected from high outdoor temperatures,
- It could be isolated from the rest of the house,
- It had existing mechanical cooling assistance, and
- There was sufficient area and facilities to be comfortably habitable for extended periods.

After looking closely at all rooms of the house we decided our cool refuge would be our Livingroom/kitchen/dining room area. We have a comparatively small house (120m2) and these three rooms add up to a total of about 30 square metres (or one quarter of the house floor area).

So, to look at the criteria and how this area fitted them more closely –

Insulation/Protection from Outside Temperatures

The whole ceiling is insulated with fibreglass batts, which was done the year after we moved in and they still seem to be working well. There is no wall insulation, much as I have tried to organise something, it would require electrical rewiring as the current wiring is rated for open air only (heat could build up and cause a fire if we insulated the wiring).

Probably 15 to 20% of this part of the roof is also covered with solar panels which will provide a bit of sun protection.

Our house is oriented so that the front faces a little south of east, and the back faces a little north of west. Due to the greater sun arc in summer, the nominally southern wall of the house gets a blast of afternoon sun, which would add to the heat load of the lounge and dining room, but the garage is along that wall so most of it is protected from direct sunlight.

Double 90% shade cloth cover over the deck and solar panels on the roof

Our biggest heat gain has always been from the west, and since the early days things would become uncomfortable from about 1:00pm onward, so this is where a large part of our efforts to provide protection to our cool refuge were expended. We have a deck built on the back of the house, protecting the kitchen and dining room western wall. The roofing is clear but we cover it in a double layer of 90% shade cloth for the summer and it provides excellent shade.

Bamboo blinds in place

We also put in bamboo blinds on the front of the deck so that the wall is still protected as the sun sinks lower in the west and the direct sunlight can get under the deck roof and hit the walls and windows. Due to the slightly off kilter orientation of the house there is an open spot between the deck and the garage which allows sun light and heat to hit the dining room window and part of the wall. To cover this area I installed another bamboo blind on the fascia board at the outside of the eaves, which now provides shade for that part of the dining room window and wall.

Bamboo blind covering the exposed dining room window and wall

The windows are obviously an area where the outside heat can be transmitted into our cool room. The lounge room window has a roll down shutter for insulation and we use thin (1 to 2 cm) sheets of polystyrene which fit inside the window frame and act as insulation against the heat.

Polystyrene sheeting on the inside of the windows

Isolation from the Rest of the House

There is an archway leading from the lounge room into the hallway and the front door, an open doorway leading from the kitchen into the same area and an open doorway leading from the kitchen into the laundry/back room area.

Temporary blanket door

Concertina door

In the lounge room arch and kitchen door way to the hall we have installed concertina style doors, which allow the area to shut off fairly well, but the laundry/kitchen doorway was still open so as a low cost fix we have attached a blanket to cover the doorway. We can still get in and out of the laundry but the blanket is very effective in keeping the cool air within our cool refuge.

Existing Cooling

The only air conditioning in the house is a split system on the outside wall of the kitchen dining room, which means we can cook and eat in relative comfort. We also have a ceiling fan in the lounge room to help keep the air moving and increase comfort. As we have put in more and more protection against the heat for our cool refuge, we have found that when we get those scorching days we don't need to put the air-con on until 4:00pm or sometimes even later.

Facilities for Comfortable Habitation

In the kitchen area we have……the kitchen! So we have facilities for cooking our food without leaving the cool refuge. This is good, because we don't need to leave the refuge to cook, but bad because it can act as a source of heat into the cool refuge. Generally the air-con can take care of that problem but it is something to think about. The fridge is also a small source of heat into the cool refuge.

The dining room provides a place to eat but also a place to set our computers up in the cool (to do things like writing this article) or to play games etc.

The lounge room has the TV, music machine and bookshelves etc as such rooms tend to do, but the lounge itself also folds out into a bed so that we can sleep in our cool refuge if required.

In general terms we have found the cool refuge concept to work fairly well for us. It has considerably reduced our reliance on air conditioning as our primary means of cooling, which has also reduced our electricity bills and increased our level of resilience in the event of blackouts, which have been threatened but not occurred in our area at least (so far!)

If you want more details on the "cool retreat" concept or other means of coping with heat wave conditions, the document "**A framework for adaptation of Australian**

households to heat waves" produced by the National Climate Change Adaption Research Facility (Part of the University of South Australia) is worth a look.

4.3 Keeping Warm

4.3.1 Sleeping warm without an electric blanket

Some fifteen years ago we were doing some work on reducing our power consumption and generally working our way through appliances to see if we could eliminate them or come up with another way of doing what it was they did for example a hand can opener to replace an electric one. It is coming up to winter here in Aus and we have a double electric blanket and while the power drain of an electric blanket may not be huge at around 200 watts for a double, they are a power drain. If you use them as intended, to warm up the bed before you get into it then turning it off this is not really a problem, but we would not only leave the damn things on all night, but they would also sometimes be left on all day as well when we forgot to turn them off.

After a while this sort of power drain could add up and not only that but weight placed on the bed that has an electric blanket left on high on it can cause a fire and there is also another hazard. Any electrical appliance will emit an electromagnetic field or EMF and these can affect the body in negative ways. The EMF produced by an electric blanket is emitted very close to the body, penetrating 150mm or more into the body and you can be exposed for 8-10 hours a day in winter. Epidemiological studies have thrown up a possible link between exposure to electric blanket EMF and childhood leukaemia as well as miscarriages.

Take it for what it is worth, we decided to get rid of our electric blankets. OK so call me a wimp but I don't like being cold, especially when I am trying to sleep and we can get down to -2°C out here in Western Sydney so we needed to do something. We cast around for some old ideas (they didn't always have electric blankets) as well as some new ones and this is what we came up with.

Insulation

It is hardly a new idea but one of the first things we tried was the old flannelette pyjamas and nightgown. I gave up wearing pyjamas to bed when I got married and with the exception of a couple of hospital stays haven't used them since, I find they get caught up and wake me up. So if I can't apply some insulation directly to me (Linda wears them OK) I needed to do something else.

One new thing was to introduce microfleece sheets. These sheets are warm to the touch, even warmer than flannelette sheets, and help you over that first plunge into a cold bed. They also keep you warmer through the night. They are available from Manchester shops but if not you could always get hold of some polar-fleece fabric as wide as you can and sew them together to form a sheet. They have a different feel than every other sheet we have used but they are very warm. We have always had a pair of woollen blankets but added a feather doona in between and a synthetic comforter on top and that with the microfleece sheets and man, we were starting to sleep WARM! There is an old saying when sleeping rough – to keep the feet warm, put on a hat – and seeing as 10% of the body's heat can be lost through the head this advice makes sense. A nice soft beanie or other form of cap can help keep you warm throughout the night by stopping the heat loss through your head.

Reflective Blanket

You can get those reflective "space blankets" that you find in first aid kits and camping shops. They are very thin silvered plastic and the idea is that they reflect body heat back onto the person wrapped in them and I wondered how they would work in a bed. Being plastic they would not be good in direct contact with the skin but if placed on top of the sheet they should do OK. I had a bit of difficulty finding one in our local shops but I was able to buy a couple of rolls of foil gift wrapping quite cheaply, one side was printed but the other was a plain silver reflective surface. I unrolled it and placed it on the bottom half of the bed to see how effective it was compared to the top half, which did not have any foil blanket. It seems to me that there was an increase in the feeling of warmth where the foil was and that part of the bed stayed warm longer if you had to get out for any reason. The downside was increased noise in the room do to the foil making a resulting noise when anybody moved, although it was not loud and certainly did not cause any problems with sleeping. It is a cheap easy way to get more thermal comfort from your existing bedclothes.

Biologic Heating

Keeping the heat in is one thing but it helps if you can generate some heat as well so at this point I want to introduce you to that most perfect biologic heater known to man – woman! But seriously folks, sleeping with your significant other shares body heat and can be a great way to keep warm.

We also have two cats, and they sleep on the bed when winter comes so we can all keep warm together and you could do the same with your dog(s), we have friends who do. The one thing that does bug me is that I can’t understand why on earth a cat would want to have a bath at 3:00am, and in the process vibrate the bed and wake me up (I’m a light sleeper). Drives me crazy!

Stored heat

The classic way to introduce heat into the bed comparatively safely is the old standard, the hot water bottle. They are still available and even come with nice fluffy covers so that your skin doesn’t come into contact with the hot rubber. I’ve never had one leak or bust, which is just as well because I don’t think either of us would enjoy that, but if you don’t have a hot water bottle or don’t trust them there are some other options.

Wheat bag - This is simply what it says on the tin, a cloth bag with or without quilting to ensure the wheat stays distributed that you heat up in the microwave for a minute or two and then put down the bottom of the bed to keep the feet warm. They are commercially available but it seems that they are ridiculously easy to make with even rudimentary sewing skills and if you could fill the bag with home grown wheat, how good would that be? They are usually used to reduce pain in sore muscles but there is no reason why you couldn’t use them as a sleeping aid.

Warm brick – You may not have thought of this one and certainly it is not all things to all people but if you are caught short it can be handy to know about. If you want to be a bit techo make yourself a cover or even a cloth (flannelette, why not?) bag to keep your feed off any sharp edges, then heat the brick next to your heater (wood fires work really well) or heat it in the oven making sure you don't get it too hot. Once it is nicely warmed put it back into tis bag and place in the bed. Instant warm feet!

4.3.2 Walkable Warmth – making a wearable blanket

We spend a lot of time, effort and (dare I say it) money on heating our homes in winter to keep them comfortable, even here in mild Sydney the winters still get below freezing at night, well at least where we are it does! The thing is though, if you FEEL comfortable, it doesn't matter what temperature the room is, so if you can keep yourself warm you don't need to waste all that energy heating the space around you. The classic thing is to dress up warmly even if you are inside, but we have found that by making a few small modifications to a blanket, you can carry the heat with you wherever you go.

A packet o' studs!

We have been using a commercial wearable blanket for several years and it is great, particularly when you are sitting still for any length of time whether it be in front of a computer, the TV, a sewing machine or just while you read. I say we have been using a commercial wearable blanket because we only had the one, and rather than fight over it, we have made ourselves a homemade one. We made some mistakes but we'll cover those so hopefully you won't make any, or at least you can pick some new ones!

The Blanket

Which blanket you use is obviously pretty critical to the whole enterprise, the commercial one is acrylic and while that doesn't sound too promising, it is wonderfully warm and has just enough stiffness to make it hold its shape well. The one we modified is a double layer polyester blanket and while it is softer to the touch it doesn't hold its shape well, and required an extra press stud on the neck to keep it on. It also takes longer to warm up, but once it is warm it is just as comfortable as the commercial acrylic one. It would be worth trying out a wool blanket to see how well that works.

The blanket needs to be a maximum width of 1600mm or about the width of a single blanket, any wider than this and the front tends to hang down and trip you up when you try to walk. For the length, it needs to be as long as the height of the person who is going to wear it, this makes sure you get good coverage but are still able to walk while wearing it. It is unlikely that you will find a blanket exactly the right size, so get the width right then trim the length to size and sew on bias binding to the cut edge to keep it from fraying.

The Tools & Fittings

To make a wearable blanket you don't need much, but you do need a few specialised tools and bits and pieces –

- A set of press studs – a pack of 20 should do the trick
- A punch and anvil to set the press studs in the blanket (you can get a set with the press studs but you get less studs in the packet)
- A hunk of steel to set the anvil on to absorb the shock when setting the press studs.
- A hammer, just about any kind will do, but I used a small ball pein hammer.
- Some chalk to mark where the holes will be in the fabric (we couldn't find the tailor's chalk so I used regular blackboard chalk ant it worked fine. Needless to say once the job was finished I found the tailor's chalk)
- Tape measure
- Something to make small holes in the blanket with and therein lies a tale!

It was my intention to use a leather maker's rotary punch to make the holes in the blanket, which makes sense in theory but soft cloth is not firm leather and it just did not work. That wasn't a problem though because I had a plan "B", a series of small hollow (AKA belt) punches and one of these would do the job. So much for plan "B"...I beat the living daylights out of the punch and it just wouldn't cut through the spongy material. Fortunately, my older daughter was helping me and she has considerable sewing experience, she said to use a sharp pair of scissors and push them through to make the hole. It worked like a charm so ignore plans "A" and "B" and just head straight for the scissors.

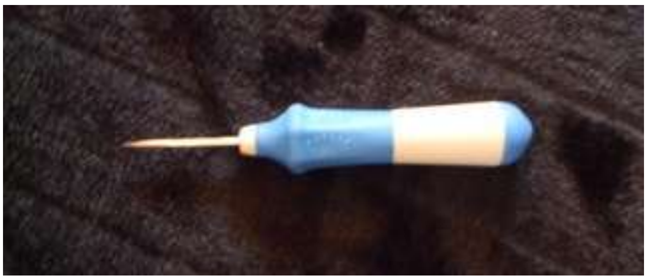
The Process

1. Assuming you have your blanket, it has been cut to size and hemmed or bias binding attached to the bottom of it, lay the blanket out on the floor so it is flat and grab your tape measure. Then...

Studs and Setting Tool

- Make chalk marks along both edges of the blanket about 100mm to 150mm apart, starting at the bottom corner, for about half the length of the blanket, then
- Make one more chalk mark on each side about 25mm towards the top
- Make three chalk marks along the top edge starting at the top left corner and spaced 150mm apart, then
- Make three more chalk marks along the top edge starting at the top right corner and spaced 150mm apart.

2. Using a pair of very pointy, very sharp scissors make a hole at each chalk mark 15mm in from the edge of the blanket.



The Awl (That didn't work either!)

3. To make sure the press studs go in the right way around (some of ours didn't) try setting them out next to each chalk mark so that the studs are the right type (male or female) and orientation (face up or face down). This reduces the work and thought later on when you are madly installing the studs.

4. Set the press studs in the blanket in accordance with the diagram using the accompanying tool and putting a lump of something heavy and flat (such as the cobblers last that I used) underneath it to act as an anvil and setting the studs with a couple of sharp hits.

5. When the studs are all in, hold a test fitting for the person who will be wearing it and see if there is any adjustment needed. As previously mentioned ours was a bit floppy and needed an extra stud higher up on the neck to keep the blanked from slipping off Linda's shoulders.

Note – The commercial ones make use of long zippers, particularly on the lower part of the blanket around the legs. We didn't use a zipper for a number of reasons –

- They are much more complicated to fit and require sewing expertise that I did not possess.
- A long chunky zipper of the type required would have added considerably to the cost.
- If the zipper stuff up (and they eventually do) they are almost impossible to fix and in most cases require replacement.
- If the zipper goes the blanket is buggered until you fix it, if one stud lets loose you are still good to go.
- If you catch your feet the studs may let go in time for you to stop a fall, if you catch your feet in a blanket with a zipper, you are going face first into the floor.

We love our wearable blankets, we wore them recently to a Permaculture meeting held in a (coolish) school hall and they kept us toasty, even if one of the ladies did christen us "Mr & Mrs Blanket"!

5.0 Conserving Energy

5.1 Retrofitting Windows

Windows are wonderful features of our houses; they let light and air in and make our houses nicer places to be. It is unfortunate that they tend to be energy black holes, accounting for up to 25% of the heating bill in winter, but this is Australia and they also let lots of heat in during our long hot summers. They cause you draw extra energy to keep the place cool if you have air conditioning or turn your house into a solar oven if you don't!

The design of our houses can help or hinder our quest to reduce energy consumption but still live with some comfort. I have an enduring grudge against the idiot who designed our house – a huge expanse of glass on the east and west faces of our house but absolutely none on the north wall. Unfortunately many houses are the same, and there are not many of us who can afford to just hack holes in the walls to open up new windows when we feel like it or design their own house. In many cases we have to live with what we are given so I have tried over the years to come up with low cost retrofits to improve the energy performance of our windows without replacing them with low 'e' glass or double glazing.

I'd like to share some of our successes and failures with you!

Before we move onto the good stuff though, I would like to put down a few words about blockout shutters, because we have had them fitted to our front windows for over 10 years. There were expensive and a quote to place the same kind of shutters across the back of the house (4 windows) was almost $4000 including a bit of tarting up of the original ones.

They do block out the sun and reduce internal temperatures; they also do work towards keeping heat in during winter too. Ours are a dark brown and when the sun is on them you can feel heat being transmitted through the shutter and then through the window, but it is definitely an improvement. You can open the shutters up slightly so that holes appear between the shutter slats for ventilation but the amount of ventilation provided is small. The reduction in feeling cold in winter due to the shutters from my experience has been small and I think there are better ways to achieve this. Shutters have their place if you have the money, but my focus was on low cost! So, on with the show!

Bubble wrap

One cheap way to reduce heat going out of, and coming in through your windows is to place a layer of bubble wrap against the inside surface of the window. This traps a layer of still air against the glass and acts like de facto double glazing, but at a much cheaper price. I was all for going ahead with this; it was cheap and appears to work while still letting some light in. Unfortunately, my lovely partner in sustainability declared that windows covered in bubble wrap looked like crap. So that was the end of that! If you are not likely to face veto from The Boss, this is a good, low cost energy saving measure worth trying.

Shade Cloth (eg Sarlon)

While this isn't much good for keeping the heat in during summer it is does provide a bit of respite from the heat. I made up a frame of 19mm x 50mm DAR pine (light, cheap and available) which fit into the brick surround of the outside window frame. I then fitted one or two braces across the frame, depending on the size of the window, to increase strength and give me extra surface to attach the shade cloth to. I then cut 70% shade cloth to size of the frame and secured it using the flat steel shade cloth, for want of a better term, nails. Bingo!

I just fitted it into place and secured it with a couple of wedges. I didn't do the wedge thing originally and the damn things would fall out when it got windy. They reduce the solar load on the window, but still let you see out and let a cool breeze come through. They don't have much effect on keeping out the cold in winter.

Gift wrap

Yup, strange as it sounds, the silver metallised plastic gift wrap that you get at the "el cheapo" shops for a dollar or two a roll can be used to reduce the heat load through your windows. Use a frame similar to the one mentioned above, but making sure that the braces are spaced so that they are no wider apart than the width of the roll of gift wrap. If you can get gift wrap that is plain silver on both sides, so much the better but gift wrap that is silvered on one side will do the trick. Apply double sided tape to one side of the frame and then roll the gift wrap shiny side out onto the double-sided tape on the frame. Once the frame is covered fit it to the window and secure with wedges.

The gift wrap will reflect solar radiation, reducing the heat load through the windows and keeping the house cooler. It may also reflect heat back into the house during winter. During the day you have a lower light level inside than out, which allows you to still see out through the gift wrap cladding, especially if you were able to get the stuff silvered on both sides. The gift wrap is a bit fragile and can be torn by high wind and also, the reflected heat and light can really crap off your neighbours if it is aimed at them. When setting the reflector up, make sure it is angled up or down so that the neighbours aren't in the firing line.

Window Quilts

If someone you know is into quilting, get them to make you up some quilts the same size as the inside of your windows. In the same way as a quilt on your bed keeps you warm in winter a window quilt puts an insulating layer between you and the thermal loss or gain through the window. You can make the outside face of the quilt white to reflect light and heat, and put a nice pattern or even a piece of material with a view on it facing inward. Unlike the solutions above, this will not let you still see out and may work a bit better in keeping the heat in during winter than keeping the heat out during summer.

Polystyrene Foam

We get large blocks of polystyrene at work, usually with a thin protective layer of polystyrene foam on the outside of the delivery which is thrown away. We cut the polystyrene to shape with a hot wire cutter so I measured up the interior of our back windows and got the guys at work to cut some of the polystyrene foam to size for me, in two pieces for the larger windows. They fit into the inside of the window and the effect is immediate, the room instantly feels cooler and they also keep the heat in during winter, reducing heating bills. The polystyrene foam I used varies in thickness from 10mm to 25mm and there doesn't seem to be much difference in performance with thickness although (obviously enough) the thinner the foam the more light is transmitted. You can't see through it but it will let enough light through to be able to carry on most household activities.

While I cheated by getting hold of large sheets free, you can make the same thing by getting hold of a hot wire cutter (I got one from Hobbyco in Sydney) and slice up waste polystyrene veggie boxes etc into squares and then stick them together edge to edge with double sided tape. The polystyrene is light and easy to take in and out of the window but somewhat fragile so care must be used when taking them in and out of the window area.

Out of all these I really like the polystyrene sheets, perhaps because they work so well. We were going to spend the $4000 and get shutters across the back to try and reduce the solar oven effect (My wife doesn't put up with the heat well) but since I got hold of the polystyrene sheets we have agreed to put the money towards better things. In reality though, any and all of these are worth trying to see which one works best in your circumstances.

5.2 Keeping Food cool

5.2.1 The Pot-in-pot Evaporative Cooler

History

This little invention is absolute genius and exceeded my expectations from the very first. It was invented by Mr Mohammad Bah Abba (see pic below) a teacher from Northern Nigeria, Africa, he took a strong local tradition of pottery and found another use for it. I caught the end of a documentary about the idea, but wanted to know more, so I plugged "pot in pot" into the net and got a bit more information. He invented it back in the 1990s and in 2001 got the Rolex Award for Enterprise and used the money he received to make his invention available throughout Nigeria. Unfortunately, he passed away in 2010 at the age of 46. This article commemorates a great man!

(pic stolen from the 'net)

The idea is fiendishly simple, which usually means it takes a special kind of intellect to think of it. Take one large, unglazed terracotta pot and a smaller unglazed terracotta pot put the smaller pot inside the larger one and fill the space between them with coarse sand and then saturate the coarse sand with water. The water moves by capillary action into both unglazed pots and evaporates from the inside and outside clay surface. Bingo….one evaporative cooler.

The pot colour gets darker as the water comes to the surface

The idea is that the locals make the pots specially and use all local materials, everybody wins except the multinationals, life's hard ain't it? Theoretically you could win the clay (dig it from the ground) refine it, make the pots dry them and then fire them, all using low tech, local materials and processes.

Construction

I made a couple of them in one afternoon, but I bought the pots from the Reject Shop (they no longer appear to sell terracotta pots in 2023), at $6 for the smaller pot (27cm diameter) and $12 for the larger pot (35cm diameter). So my coolers cost $18 a piece to set up (2005 costing), plus a bit for the sand (locally in Africa they go for 40c a set). I suppose you could use the "flower pot" style pot, but the more rounded ones can store more food for the same size pot. So the ones I bought are much more spherical than the traditional pot. The pots made for this purpose also contain no drain hole so the first job was to put some putty in the drain holes of both pots and then cover the putty with a square of plastic sheeting to stop any leakage. I then placed a layer of about 25mm of sand in the bottom of the larger pot and sat the smaller pot in the larger one, it is then a simple matter to pour more coarse sand into the gap between the pots.

The pots are now ready to be charged with water, and there are a couple of points to note –

- If you leave the sand down about 12 mm instead of filling the space entirely it makes putting in the water much easier, and
- If you put too much water in initially the smaller one will tend to float out of the larger one.

Filling the sand with water takes some time because it has to percolated down through the sand, and if you do a bit and then come back to it, it gives the water time to soak into the unglazed terracotta, important for keeping the inside pot heavy.

The next thing is to arrange a lid or cover of some description, my original go-to was a couple of layers of wet hessian bags over the top, like potato sacks or the bags coffee beans are imported in. This worked fairly well but the inner pot still had a tendency to float. I got an appropriately sized terracotta pot saucer (mine was 32cm) to fit on top as a lid when upturned. The pot saucer was much more robust and rot resistant than the hessian bag, and also heavier. If that did not stop the inner pot from floating, a brick strategically placed on top of the pot saucer certainly did.

Testing

At the time I put them together I carried out a qualitative temperature test: once it was fully charged with water I stuck a few coke cans in it and then walked away for a while. When I came back a few hours later and reached in for the can it felt COLD! The thing worked like a ripper! Being of a scientific bent however I thought that I better test it to see if it was cold, so I used the most scientific test I had at the time and applied the "cold" can to the upper part of my wife's arm. The resultant scream and beating which I received confirmed (somewhat painfully) that I was on to a winner.

Having said that, I do like quantitative tests so I set up the cooler again and left it to cool. To check temperatures I used our Infrared thermometer. To get something close to the setup, but not affected by the evaporative cooling I took the temperature of the brick sitting on top pot saucer acting as the lid of the cooler and it showed a temperature of 28.0^{o}C, I then removed the lid (complete with brick!) and checked the temperature of the inner wall of the cooler and it showed 24^{o}C. This was not as much of a difference as I was expecting, but the humidity is currently at 82% which is pretty high for where we are. This does point out one of the disadvantages of the evaporative cooler (or anything that requires evaporating water to work), that it will be much more efficient and effective in a lower humidity environment.

Other stuff

A full charge of water lasts several days, depending on ambient conditions and it seems to work inside or outside, so long as it is in a shady spot, full sun easily overpowers the evaporative cooling. For best operation, site the cooler in a place that is out of the sun but exposed to the wind.

One thing that I have found to be an issue with this particular set up originally is that with use a crusty skin of salt forms on the inner and outer surface of the cooler, from salts leached out and then left behind by the evaporating water. Whether the salts are from the water itself (tank water so unlikely), the terracotta pots or the sand I don't know. It came through initially and needed to be periodically scraped off or it would interfere with the evaporation process and make the set up less effective. A bit of water and scotchbrite (or equivalent) seems to do the job admirably well. It has been some considerable number of years since this was a problem.

Another thing perhaps worth noting: If you store your coolers when not in use somewhere out of the way, ours is under the back deck, be aware that the space between the inner and outer pot is ideal as a home for tiny critters, especially spiders. The moral of the story is: look before you grab!

Final words

This is a simple and very effective invention, to help people in the lesser developed parts of Africa, but anybody can use the same technology in the cause of sustainability. While researching this invention on the net I came across a company who were going to make and sell an "improved" model with a solar powered fan, I can't help getting the feeling that they have missed the point though!

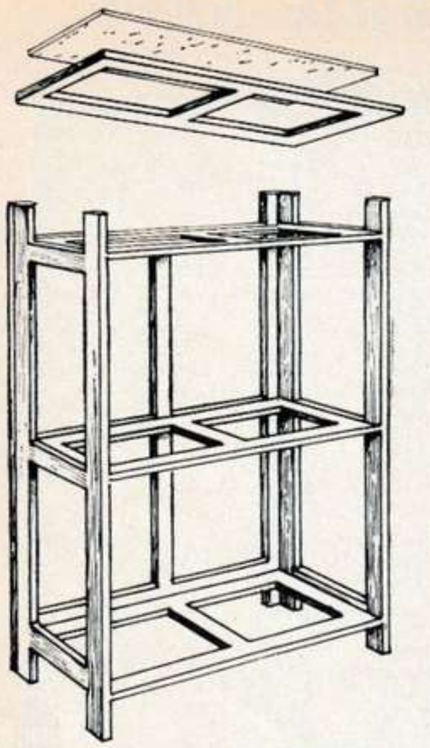
5.2.2 The Coolgardie Safe

The classic of this technology is the Coolgardie safe, invented and used in the hot dry environment of the WA goldfields. It is usually a wooden frame with a hessian or similar fabric wrapped around it, with a water reservoir on the top and sometimes a catch-basin at the bottom. Water is placed in the top, soaks into the fabric and then moves down the outside of the safe by capillary action to drain into the catch-basin and on the way some evaporates, cooling the inside of the safe. That at least is the theory, but how does it translate into practice?

To start with I did a bit of research to see what information was around, one book which was very helpful was "New Australian Home Carpentry Illustrated" by Alex Smith, published by Colourgravure. Is not dated but looks to be early post World War II and I still see it second hand on a regular basis. There is a design on page 69 to 71 that, while it was too big for me, I used as a base for my design. (see pics below)

The material of construction that I used for the framework is 19mm x 42mm DAR pine. I used this timber because it was cheap (less than $1 per linear metre), available, light and easy to work with. The frame whole frame stands 1.5 metres tall which, as luck would have it, happens to be as high as the original four lengths of pine that I bought, funny how designs work out like that. The pine is not treated in any way and so is subject to attack by the water, which meant I had to apply a couple of coats of paint before putting it into service.

To start the frame I connected three cross pieces, top, centre and about 100mm up from the ground to each set of uprights with wiggle nails, these are cheap and nasty and if I had known how much work the rest of the safe would be I would have used dowels and glue, although at that stage I didn't have a dowelling jig, but I do now! This gave me two sides which had to be joined together to make the carcass of the Coolgardie safe, but the question was how wide should it be? I decided to see what containers were around that could be pressed into service as a reservoir and catch-basin.



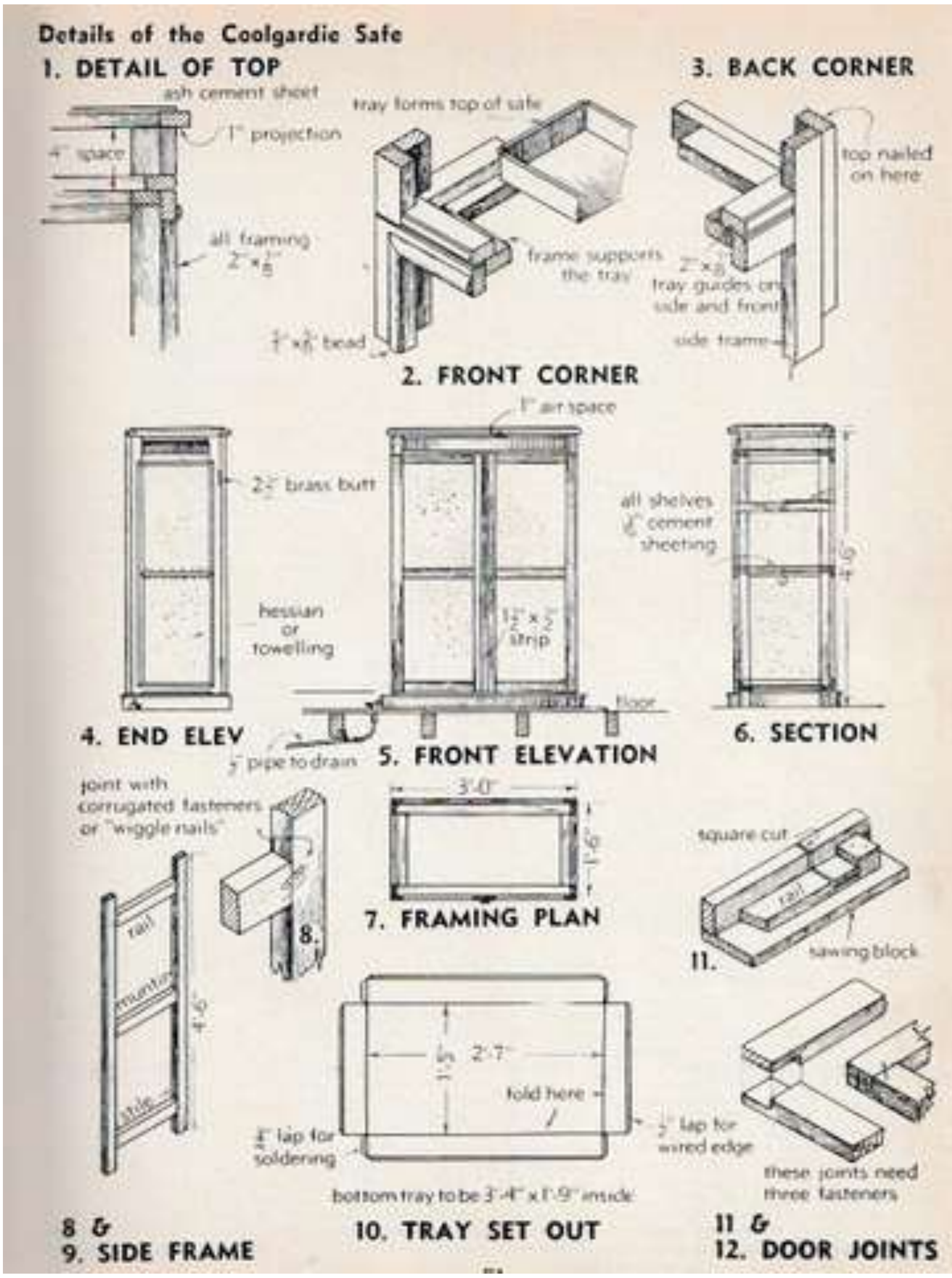
Frames nailed together ready for the doors.

Again it had to be light, cheap and readily available. My initial thought was the mind bogglingly useful pet litter tray, but in this case it proved too shallow, I wanted something with more capacity. I settled on two 360mm x 300mm x 120mm deep plastic basin (10-12 litre capacity) that retailed at the Reject Shop for the princely sum of $2.50 each, thus the distance between the uprights became 360mm, less about 15mm on each side so the overhanging ledge of the bowl would sit on it, thus providing a support. The lower catch basin would sit in the space formed by the lowest cross pieces if the overhanging corners were cut off.

The Coolgardie Safe - sitting between the tanks

So the next trick was to form up the carcase by installing a top, centre and lower rail on the back and a top and bottom rail on the front (to allow for the door), this I did by drilling and screwing through the side of the upright and into the end grain of the rail. Two screws on each side of each rail and the carcase started to look like a piece of furniture instead of a bunch of randomly assembled pieces of wood.

I needed to insert some shelves for the produce to stand on, my old friend the Aussie Home Carpentry Illustrated suggested using cement sheeting but due to lack of availability at the time and concerns for weight (I wanted the safe to be transportable) I constructed timber shelves. I suspect that the book was probably right in that the shelves would become wet and cool due to evaporation also, you can’t win ‘em all! I screwed in some supports to the sides of the uprights and then screwed pieces of the 19mm x 42mm pine to the supports to form an open grid for use as a shelf. Before the lowest shelf went in, the lower catch basin had to be fitted, because there was not enough clearance between the bottom shelf and the bottom rail to allow the basin to be slid in and out.



The door was a simple construction of two uprights with a top centre and bottom rail wiggle nailed to them, I didn't put in any diagonal bracing and it hasn't dropped………

yet! This I fixed to the front of the safe with screws and some mild steel hinges (I considered brass but they were a bit expensive) so I had to ensure that they were well painted to prevent rust.

With the carcase finished and the basins in place it was time to fit the fabric cover. Again, simple and cheap was the rule so I bought a couple of hessian sacks that are used for dog bed covers, they were only $2 a piece at a local pet barn. They are sewn up the edges and I decide to fit them length ways down the safe, to allow for an unobstructed water flow, so I had to undo all the stitching which was quite tedious but the thread could be (and was) used to tie tomato plants to stakes etc. Each sack went the full length of the safe with enough left over to overhang into the upper and lower basin and was wide enough to neatly cover two sides, so I needed two sacks.

I attached the sacks with dome headed drawing pins which gives a nice effect. The first sack covered the left-hand side and the back, the second covered the right-hand side and the door, the idea being that the drawing pins were fixed to the leading edge of the door so that it could be opened. When the door is opened wide, the overhang into the top and bottom basin has to be tucked in again, but it was either that or arrange some form of flap to allow water to pass from the top basin onto the hessian door cover.

Something to be aware of is that the sack which was attached to door acted as a very efficient wick, while the other one, initially at least, did not seem all that interested in soaking up the water regardless of my threats, begging or bad language. I suggest that if you try this, soak both sacks in water first, perhaps with a little detergent to help the water “wet out” the fibres. After some use, both seem to be OK now.

So….how does it work?

This depends on such variables as ambient temperature, humidity and air movement and I suspect that while a Sydney summer is no hotter than the WA goldfields it is somewhat more humid. If the top basin is filled, it will empty into the bottom basin in about 12 to 18 hours and will result in the material inside being a bit cooler than the surrounding air, but I have not measured by how much. Much of this water is caught in the bottom catch-basin and can be recycled.

The cooler did not work in the shady garage, due to the lack of air movement and it is now behind the rear window of the garage, I have intentions of putting a covering of shade cloth over the area to cut down on sun but allow some air movement. I must admit to being a bit disappointed with the cooler's performance. Improvements to think about could include –

- Retrofitting those compressed cement shelves.
- Wrapping another layer of hessian around the cooler.
- Installation of the above shade cloth.

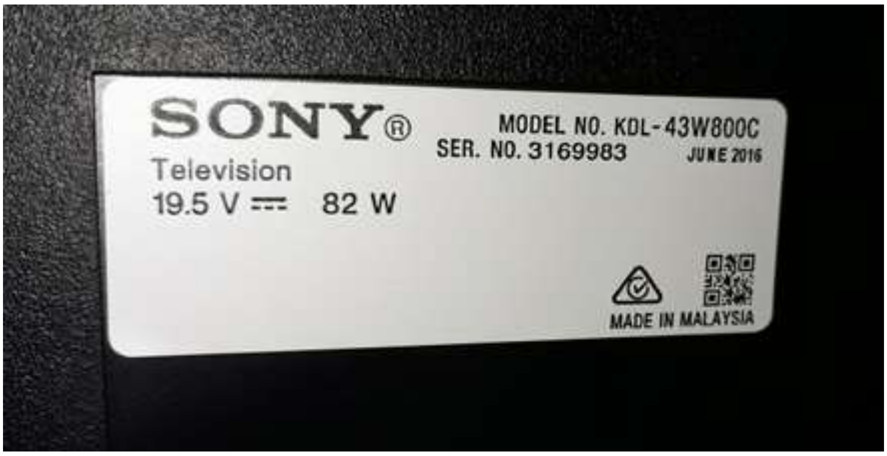
The installation of a tap in the bottom basin to facilitate water recycling.
It may be that I have just not found the right place for it yet. One initial thought was that the cooler was too tall and the water would evaporate before it got to the end of the cooler and into the bottom catch basin, but this has not proved to be the case.

5.3 Optimising Your TV for Energy Usage

This little titbit came out of a conversation with a mate of mine who is wise in the ways of energy use reduction, and it was a throwaway line from him about having 'optimised' the energy consumption of his TV. As a result of that comment I did some research and then optimised our TV, saving us energy (and money) in the process.

With two and a half TVs per house on average (and 31% of households having more than four!) TVs are a contributor to the household energy bill. While they are not the biggest energy consumer in the house, with a bit of research and half an hour or less fooling about, you can reduce their consumption considerable for NO cost at all.

Obviously the type of TV you buy will have a significant effect on the amount of energy they use and an LCD/LED TV will only use two thirds of the energy a plasma screen TV will. However, if you already have a plasma TV, rather than junking it (no one seems interested in second hand TVs these days!), optimise it and keep using it until it is no longer functional, then replace it with an LCD LED TV.



The idea is to set your TV for home use, not for store use. Televisions are set from the factory to look good when turned on next to a whole stack of other TVs in the large, open environment of a retail store, rather than to provide the best picture in your living room at home. Those settings also result in the TV using more energy.

In general terms the following advice applies, but the best way is to check out on the 'net how best to optimise your particular TV brand and model. Just type in the brand and model of the TV and 'optimise for energy use'.

General advice

Go into the 'settings' function of your TV and set the mode to one called Standard, Cinema, or Movie these will still give you an excellent picture, but use considerably less energy. Avoid modes called 'Dynamic' or 'Vivid' because, as their name suggests, they will suck more power for not a huge improvement in viewing quality.

Turn the brightness and contrast down to an acceptable level as these settings are also usually set for display in the shop. It is just a case of accessing the setting function again and then dialling down both the brightness and contrast to the point where they are at the lowest level where you are still happy with the picture quality. This may take a bit of time using trial and error, but in practice it only took us 5 to 10 minutes to come to the best compromise for us.

Activate ‘Eco-mode’ or ‘Energy Saving Mode’ if there is one, this will reduce the TVs energy consumption as well.

We had an older TV which consumed 128 watts nominally, but after I had optimised it, energy consumption went down to 80 watts. A couple of years after that, when that TV passed on, we bought a newer model which only use 82 watts to start, but I was able to optimise it down to where it now only uses 10 watts.

5.4 Reducing Your Cars' Fuel Consumption

Years ago I facilitated a **study circle** with a few friends based around the various aspects of sustainability. One of those aspects is, of course, transport and we talked about among other things the issues with car use (greenhouse gas production, fossil fuel use and consumption of other resources). Discussions around car use generally seem to find their way back to how much fuel we consume and what we can do about it.

Our circumstances (unfortunately) do not allow us to dispense with the car entirely so it was a case of understanding what we could do to reduce the amount of fuel we used in a meaningful way. This would not only reduce environmental damage but save money as well and as a result of the meeting we all agreed to do some work towards reducing our fuel consumption and then report back. This is what I did and how it worked.

Measuring the Base Line

Strange as it seems, to be able to work out how much you have improved this means knowing where you are starting from, so my first act was to fill up the car and note the mileage (kilometerage?) on my odometer. I then drove the car for a couple of weeks without making any changes to the car or my driving behaviours so I could work out where I was now.

We drive a Suzuki Alto and the manual says I should get 5.3 litres/ 100 kilometres, but these official figures tend to be pretty optimistic, and I needed to know what I was really getting. I filled the car up (first click on the nozzle only, fill to the same point every time for consistency) and took note of the mileage on the odometer. It was then just a case of doing what I always do and driving around as normal.

After the tank was getting down towards empty I filled the car up and noting the number of litres consumed and I checked the odometer again, writing down the reading.

To calculate your fuel consumption in L/100km just take the original reading on the odometer away from the second reading to give you the number of kilometres travelled, then multiply this number by 100, divide the resulting figure by the number of litres of fuel consumed. (or use an **on-line calculator**). This will give you your fuel consumption in L/100km. Mine turned out to be 6.4 litres/100km.

The longer you let the test go on the more accurate the reading will be, but I wanted to know what affect I could have quickly (I'm impatient OK?) so this would do me.

Making the Changes

There are a whole stack of changes you can make to your car and your behaviour to reduce fuel consumption, as far as making changes to the car you could –

• remove any unnecessary materials/weight from the car

• remove roof racks, external steps and brush guards when they are not required, to improve the cars aerodynamics, and

• Ensure the tyres are pumped up to the required pressure (not overpressure)

In terms of behaviour, changes might include -

• driving steadily, at or below the speed limit (operating speed)

• using the cruise control where possible

• accelerating smoothly to operating speed

• avoiding idling and turning the engine off where idling time is likely to exceed one minute.

• going slower up hills and faster down hills (within the speed limit)

When I checked the car over I found the tyres were down a bit so I pumped them up. We get the car serviced regularly, rarely carry a lot of extra weight and don't have roof racks or other protrusions to screw up the car's aerodynamics. In terms of behaviour I am, as much as is possible with a car with an engine capacity of 996cc) a rev head! I needed to slow down, drive more smoothly and concentrate on driving to minimise acceleration and braking. (yes, I am that idiot who hares up behind you then jams on the anchors, stupid, I know).

Well, I made the changes to my behaviour. It wasn't easy, there is always the tendency to slip back into old habits and after all, I have been driving for almost 40 years. Having a wife who supports the changes and is not shy in pointing out when I am doing the wrong thing helps. Sort of. You know how they say your fuel consumption goes up if you drive stressed?

Anyway, I know you are dying to know how it worked and it reduced my fuel consumption to 5.5 L/100km, a reduction of almost 15%. This was achieved at no extra cost to me (how do you cost in grey hairs?) and is a significant saving on fuel and cost. Just working out your fuel consumption on a regular can help you focus on your driving and how it affects your mileage, so start today!

6.0 Using Renewable Energy

6.1 Heating Water Using the Sun

6.1.1 Solar Hot Water systems – Our Experience

When we moved here in the late 70s the house was new and we had one of those titchy little electric storage water heaters, it must have been only 60 or 80 litres in size, to provide hot water for the house. This was all well and good when it was just the two of us, but once the kids started to put in an appearance it became more difficult. We decided at that point we needed a new improved hot water system and to make it sustainable, not to say save us money, it had to be solar.

Water heating can consume up to 25% of the household energy budget so it is no small matter how you do it when you are looking to live more sustainably, more energy efficiently and/or more cheaply so take your time and do your research rather than taking decisions in haste. Work out what is the best option for you and then go for it, and to help you out a bit here is what our experience of heating water by the sun has been over the last 35 or more years.

Solar Hot Water Vs Solar Electricity

Something that still surprises me a bit, probably because I have been dealing with these concepts for years and so they are second nature to me, is that people hear the words “solar Panel” and think of something that goes on your roof and generates electricity as well as making your water hot. I need to state from the start that there are two different types of solar panels –

1. Photovoltaic panels – these are composed of solar cells and generate electricity, either feeding that electricity to storage batteries or feeding it directly back to the grid through an inverter.
2. Hot Water Panels – these are generally an insulated box with a clear top surface to allow solar heat in onto a blackened copper or copper alloy absorbing plate which has tubes running through it to allow water to circulate and pick up the absorbed heat.

There is nothing in existence that I am aware of at the moment that will do both jobs and whenever you see the term “panels” written in this article it will be referring to type 2 panels, not type 1.

Solar Hot Water the First

There was not so much variety in the area of solar hot water systems back all those years ago, they were mainly the “Solarhart” style which consists of two panels and a horizontal mains pressure tank mounted just above them. After some research (this was back before the internet, of course)we did come across another style that Beasley Solar were offering which consisted of two panels on the roof, plumbed back to a tank inside the roof which was gravity fed.

The Beasley panels had a selective surface applied to the collecting area of the panel which helped to absorb the solar heat falling on them and reduced re-radiation of the heat. This was new at the time and the product of Australian research, but I remember reading years later that the coating only lasted a few years and then became ineffective.

We went for the Beasley style solar hot water for a number of reasons –

- The tank was located in the roof rather than on it, so we could get a bigger tank. We got a 300 litre tank which was big enough to get off-peak heating if we wanted to although in the end we never did.
- The system was gravity fed from the tank to the house rather than mains pressure and this meant we had the facility to connect one of our wood burning heaters to the tank to provide a back up means of water heating. I even had two nipples built into the tank when it was made so that we could set it up, but in the event we never connected the tank to the wood burners. The covers of the nipples were cast iron and the nipples themselves were some copper alloy so one afternoon there was considerable consternation caused when I noticed leaking from the tank to the drain outside. The nipple cover had corroded

entirely from the inside and I had lots of fun emptying the tank without soaking the ceiling and then replacing the nipple cover with a more appropriate one.

- Another side of being gravity fed was that if the mains pressure failed we would still have a (limited) hot water supply.
- We believed that the system looked better on the roof with just the panels rather than the panels plus tank, a reasonably crap reason I suppose but there you have it!
- The system was passive ie there was no need for a pump to circulate water between the panels and the storage tank so there was no need for electricity to run the system.

The system was not cheap, it was a long time ago but I remember that it was two to three times the cost of the equivalent gas or electric hot water, but over the years we would have made many times the purchase price back in energy savings.

The system had an electric boost for dull days and rather than have it totally automatic we had an on/off switch installed on the back wall of the laundry so we could pick when the boost cut in and when it was turned off. Of course, gas boost is quicker but there is no reticulated gas supply in our part of the estate so we were not able to take up that option!

We do get frost out here in the west so another option we invested in was to have anti-frost valves installed at the bottom of the panels so that if the temperature dropped below freezing, they would open and allow a trickle of water through. This stopped the water in the panels from freezing and the pipes in the panels being damaged by the expansion of the water when it froze.

The Good and the Bad (No Ugly)

The main good thing was we got free hot water for a fair chunk of the year for over 25 years, and let's face it, you can't ask for much more than that! To give you some idea of the magnitude of the reduction in our energy bill, we had a representative from the electricity supply company show up at our door after the new hot water system was installed. He wanted to know why our bill had reduced so much and obviously thought there was something shonky going on but when we showed him the solar hot water system he accepted that it was the reason for the drop and we never heard from them again.

A side effect of installing a gravity fed system in a house that was designed for mains pressure (ie the hot water pipes were ½ inch diameter rather than ¾ inch) reduced the amount of water we used considerably and resulted in significant water savings over the operational life of the system.

But as you can understand the whole thing was not sweetness and light. There were a couple of unintended consequences of the gravity fed water supply –

- It was difficult to get the water temperature on the shower "just right" and if you like your showers hot, strong and long you were in for a big disappointment due to the low hot water flow.
- Hot water flow at the kitchen tap was also slow so it took some time to fill up the sink. This meant there was a tendency to walk away and do something else

while forgetting about the running water entirely and only remembering when the kitchen was flooded. This happened lots of times and resulted in the death of at least one set of kitchen cupboards. While we tried numerous ways to get around this none were entirely satisfactory.

Another thing we did notice, and I am not sure why this happened, is that once the cold weather came in we started using the electric booster on almost a daily basis. Maybe it was age of the system or other factors that I haven't been able to discover but it did occur nevertheless.

Maintenance Issues and Breakdowns

As far as maintenance issues went they were fairly few. In the early days of the system we were expecting guests for the weekend (wouldn't you know it!) and the booster element failed. We had it replaced and it seems that it was incorrectly installed, allowing corrosion to cause it to fail. After it was replaced we had no more problems for the life of the system.

It seems that the design of the anti-frost valves was also not up to scratch and after about 10 or 15 years they started to continually leak. This was obviously well outside the warranty period so we just got the things replaced with a newer better design and that was that.

The only other problem surfaced towards the end of the service life of the system, another leak developed in the tubing connecting the two panels together and the water got down inside the panel itself. I had a good look around and found that there was corrosion where the water pipe went though the side of the panel and although it was not the cause of the current leak it would eventually cause problems. Once the leak was fixed we decided that we would need to replace the system in the near future.

Solar Hot Water the Second

You may or may not know what it is like, but when you get to our stage of life and the kids have moved out and you start to look at backing off a bit on the employment front and try finding out if there is more to life than just eating, sleeping and working. We looked around the house and realised that some of the major infrastructure was getting old and decrepit and that if we weren't careful we could wind up with some serious expenditure that we weren't prepared for. So we started a program to upgrade things and one of those "things" was going to be the solar hot water system.

We looked at the good and bad of what we had and decide that we wanted to go with something more efficient than the old flat panel solar collectors. The government rebate was in place but because we were changing from solar to solar rather than electric or gas to solar, we got no benefit from it. Anyway after some discussion we decided on the newer type of system that uses evacuated glass tubes as collectors for the hot water from the sun.

The evacuated tube type does have some advantages over the old flat panel collectors –

- The insulation on the flat panels only consists of a layer of fibreglass insulation below the collector assembly, whereas the water and black collection surface of the tube system are surrounded by an insulating vacuum which is very efficient at containing the heat absorbed within the tubes.

- The best heat transfer to the old style panels is when the sun is at 90° to the panel surface, which it only is for a short time each day. If the tubes are correctly oriented the sun is at 90° to the back of the tube for a much longer time because of the curvature of the tube.

Both of these factors result in a more efficient system. I have also seen claims that you get some solar heat gain even on cloudy days but I am not sure if that is the case or not. The new system is active and intelligent (sounds like our kids!) in that it does have a pump between the tubes and the tank and also has a “black box” that measures the temperature in the tank and temperature of the water in the tubes and switches the pump on when the time is right. The pump is switched off after a pre-determined temperature is reached in the supply tank. The pump and electronics do consume some electricity but so far the savings in electricity due to more efficient solar collection greatly outweigh the extra electricity consumed.

The system is also mains pressure so some of the advantages of the old system are no longer there and indeed our water consumption has gone up a bit, but to compensate for that we have really nice showers now! We have also installed a shut off valve on the shower lead so when applying shampoo or waiting for conditioner to sink in or whatever you can shut off the water supply at the source. When you want the water supply back on and open the valve again you get water at the same temperature setting as when you started your shower.

The tanks and black box are at the rear of the house and the tank is mounted on the ground. Due to it being mains pressure there is no option of rigging a back up heating system from the wood burners but I had the option for 25 years with the last one and didn’t get around to it so it is a small price to pay for a greatly improved efficiency of water heating.

When they put the new system in I asked them not to turn on the booster and leave it on automatically, I still wanted to control it manually even if they had (as they said they did) bypassed the old manual switch in the laundry. The first day we needed to turn on the booster (there have only been a handful of times it has been needed since the system was installed almost a year ago) I went out to the fuse box and flicked the switch to on. After some period of time there was no change in the water temperature and on further investigation I found that original switch was not bypassed, only turned off, so I turned it on and away we went. It pays to check!

I hope our experiences have provided you with some information you were looking for and that if you haven't got solar water heating at the moment, you decide to put it in soon. It is worth the effort from the point of view of the environment and from the point of view of your pocket. Good luck!

6.1.2 Small Scale Solar Hot Water

Hot water heating consumes up to 37% of home energy used (depending on who you read) and an obvious way to cut that down is to install a solar hot water system, but what if your site is not satisfactory or you don't have the money? Even if you have solar, another energy source like gas or electricity is required for cool and cloudy weather, and one of the things that bugs me is the water we waste while waiting for the water to run hot, both water and energy are wasted if you have a number of small jobs requiring hot water. This caused me to think about things based on other projects that I have completed and been able to share with you, thanks to the miracle of Grass Roots.

I used to do some work in China, and I know that in some parts of the country it is not possible to provide hot water on tap, so the residents by hot water from a vendor and then keep it hot in a thermos or series of thermos flasks. So the thought naturally came to me, why couldn't we use a solar oven such as the one I wrote about in GR 167 to heat the water then store it in the same way?

For this Christmas I got a Thermos Airpot, which is a pump action insulated jug that allows you to pump out hot water as you need it and by taking the 2 litre billy from the polystyrene insulated hay box, filling it with water and heating it in the solar oven – there you have it - free storable hot water! I am going to get a number of the standard type thermos flasks so that as you heat the water, you can store it. The 2 litre billy takes about 3 hours to come to the boil(Jan/Feb in Sydney) so you heat and store a number of thermoses in a day and they are efficient enough to keep the water hot enough overnight for a solar coffee or tea the next morning.

If you didn't have the thermos but could make a haybox insulated cooker, you could use that to keep the water hot overnight, and I have done that too, but you can't beat a thermos of hot water in the kitchen for convenience (convenience = the system gets used). OK, the system does not produce enough water to bath your kids, have a shower or put a load of clothes through, but it does produce enough for hot drinks, washing the dishes or wash your hands (when diluted with cold water of course!). These are the sort of jobs where only a small amount of water is used on a regular basis and you need to run it for a while before it runs hot.

With a bit of work and perhaps some already existing gear you too can have solar hot water and do your bit for self sufficiency and the environment – every little bit helps.

6.2 Cooking with the Sun

6.2.1 Introduction

When I think about cooking with the sun, I think of two possible ways to go –

a) The higher tech indirect method, and
b) The lower tech direct method.

The higher tech method requires quite a few bits and pieces including solar electric panels, batteries, a solar charge controller such as an MPPT (Maximum Power Point Tracker) and an inverter to convert the 12vac or 24vac from the batteries into 240vac. As well as this you need a whole lot of copper wire to transfer the power around your system, but it allows you to use your standard home appliances (depending on the size of your system) like an electric benchtop oven or induction cooker. This represents a fair bit of cash and requires work by licensed electricians to make it all come together but pays dividends in terms of convenience and allows you to 'cook with the sun' even after the sun has gone down!

In contrast, cooking with the sun using the sun directly is much simpler. There are many different designs out there of direct solar cookers and I have made and used quite a few. You don't need any assistance from tradies, you can do all the work yourself and the materials are comparatively inexpensive. Having said that, I do make use of professional glass cutters where glass and/or mirror cutting is required, but if you are, as they say 'skilled in the art' that might not be an issue for you. The rest of the construction requires only moderate DIY skills and I figure if I can do it, almost anyone can. There is also a certain satisfaction in cooking food using only the sun in a device you have build yourself. Every time I cook a meal in the solar oven I am amazed that it has been cooked wholly using the heat coming directly from the sun.

The downside is, of course, that you need a sunny day to do the cooking, plus you can only cook while the sun is shining and high enough in the sky to provide sufficient heat.

Our main meal of the day is our evening meal and the low tech route can cause difficulties for that approach. However, by teaming up with another low tech cooking method – cooking with stored heat, it is still possible to have that hot evening meal even if the time of year means cooking with the sun will finish a bit early.

We have and use both approaches here, although I will admit that the convenience of the high tech method makes things easier, it does not have the satisfaction associated with the low tech method. Also, we had direct solar cooking appliances many years before we had the money to put the higher tech cooking methods in place.

Hence the writing of this eBook. I want to enable people who don't have the means to put their own solar electricity system in place to still be able to save money and energy, reduce waste and pollution, as well as increasing personal satisfaction by cooking directly with the sun.

6.2.2 The 'No Tech' Solar Oven

I love the idea of using the sun's energy directly, no pollution, no waste and no (energy) cost, it's fun to experiment with to dry or cook food or generate electricity and helps you become more independent from the power grid. Over twenty years ago I became interested in solar cookers, they are the obvious answer for when you have no fuel to cook your meals with, you want to increase your level of self-sufficiency and/or sustainability, do something good for the planet or you just want save money. It was one of those ideas that was just so good!

After a quick trip around the net I found **www.solarcooking.org** with plenty of low or no tech plans for building solar ovens and after some consideration I decided I wanted to build solar box cooker, this is basically one cardboard box inside another, with a clear panel to let the sun in (construction details to follow). It was mind bogglingly, cheap and easy to build, real alternative technology ....and it worked like a heap of crap!

I made it as per instructions, tried to cook a number of dishes using several different food containers and the best that I could do was attain 60°C and that was in full sun! All it would do was warm the food and after a full day in the sun I still had to do most of the cooking in the gas oven.

The principle or theory that I was working on was that the inside box was insulated by then outside box and the inside box was then lined with aluminium foil to reflect the sunlight back onto the cooking pot once it had made it through the clear panel. So much for that theory! So I put it away in the shed and forgot about it for a while.

After doing some more searching on the net I found a small footnote on another website where a bloke who had been experimenting on his own account said that the secret was to have thin walled, matt black painted cooking pots and a matt black steel panel in the bottom to absorb the heat. This heat was then passed on to the cooking pot, in direct contact with it by conduction. This was exciting stuff and sounded like a serviceable new theory, but would it work?

Well, I put in a matt black steel panel and believe it or not, it did! All of a sudden I could get up to 90°C and was able to cook an aluminium billy full of spuds perfectly in less than two hours. This technology made sense and worked fine if you set it up right.

Here is how I made the no-tech solar oven –

Construction details

1. Get hold of a large cardboard box, a smaller cardboard box (one which allows at least an inch of dead space all around once it is inserted in the larger box) a Glad® or equivalent brand oven bag, some aluminium foil, PVA glue and the steel plate with some matt black paint. Car engine enamel works well and puts up with the high temperatures.

2. Centre the bottom of the smaller box over the top of the larger one and, using a Stanley knife or equivalent, cut a hole in the top of the larger box so that the smaller one can slide into the larger one.

3. Now line the larger box with aluminium foil, shiny side out. This can most easily be done by getting hold of some PVA glue and a paint brush and painting the glue onto the cardboard and then smoothing on the foil. If the glue is a bit thick to use a brush, thin it down by mixing in a bit of water.

4. Cut the corners of the top of the smaller box into flaps and fold them out so that they support the smaller box centrally in the larger box. If you are going to insert insulation this should be done before the flaps are glued into place, locking the smaller box into the larger one. The insulation could be crumpled newspaper, straw, wool, polystyrene beads or what-have-you, anything that provides insulating dead-air spaces.

5. The smaller box may now be lined with aluminium foil, also shiny side out.

6. Once the inner and outer box are assembled and glued, the lid can be made by placing a flat piece of cardboard over the top of the double box and cutting it to

leave a 25mm edge all around. The line where the box sits can then be scored and the ends cut to form flaps, the flaps are then folded down and around at the corners and glued, forming a tray shaped lid. This lid then has a three sided cut to put in the top of it to form a large flap the size of the inner box and then tape an oven bag over the hole to form a clear window to let the sun in.

7. The bottom of the flap should also be lined with aluminium foil to act as a mirror to reflect sunlight into the oven. A Z-shaped piece of wire is then inserted in the edge of the flap and the top of the box to keep the flap open at the right angle to act as a reflector.

8. To finish off the oven cut a piece of sheet metal to fit the bottom of the inner box, and hit it with some non-toxic matt black aerosol spray. Install the plate and you're ready to cook!

No Tech Cardboard Box Solar Oven

All it took was a couple of hours work and very little outlay (mostly for the oven bag) and I had raised my level of self reliance a notch! Well worth a go..... and as I said at the start - if I can do it, anyone can.

Inside the outer box showing alfoil lining and wool used as insulation

Inside the inner box showing alfoil lining and matt black metal plate

6.2.3 Our Main Solar Oven

Original Build

So having now found out how to make a solar oven work, it was time to get serious. A cardboard no-tech oven (see above) is one thing, but I wanted something that would last and would be more efficient. Having said that, I still have the original oven and it must be almost 15 years old now, it hasn't had a lot of use but is very valuable for demonstrating the principles of solar cooking.

I had picked up a book called "The Solar Cookery Book" by Beth and Dan Halacy yonks ago, and in it was a description of how to make a more efficient, and more permanent, solar oven. The oven was an angled box made out of 3/4" plywood with a glass front and reflectors to make use of the sunlight over a greater surface area than just the top of the box itself. Here was a solar oven of substance! I have seen similar designs that require the glass front to be fixed and a door to be cut in the back of the oven through which the food is put in the oven and retrieved. This seems to me to create immediate problems with sealing the oven, so I much prefer the simpler design described below, where the glass front is openable and the main body of the oven is a sealed unit.

The only time I seem to find to complete these major projects is over the Christmas break, and so it was with this one, it took about two full days of work to put together as well as some running around to get the glass front. The main body of the oven is constructed of ¾ " thick marine plywood, and I was lucky enough to have a couple of three foot by four foot sheets of the stuff in my garage. A friend of mine in the business was able to get me some 25mm thick compressed fibreglass batts and I had some thin, galvanised steel sheet left over from a previous project.

CONSTRUCTION DETAILS

The box

The carcase of the cooker was made out of 3 sheets of 20mm marine plywood, the base was cut to 500mm x 440mm, the two sloping sides were made by cutting diagonally across a 440mm x 440mm sheet to give a long end of 330mm and short end of 90mm. The third sheet was to form the front and back of the cooker, it was originally 435mm x

540mm and a cut at an angle of 60° was made in the 435mm side 90mm from one end. All cuts were made with a hand held, 200mm circular saw, the guide being tilted to achieve the 60° cut.

The solar oven hot box without glass

These were assembled into an open topped, angle sided box by fitting the front, back and sides to the outside of the base and then gluing and screwing them into position. Once this was completed I cut the 25mm fibreglass insulation using a metal ruler and Stanley knife, first the one to go over the base and then the sides, back and front. To hold the base pad in place I secured it with four flat head nails about 50mm in from each corner, the other pieces rested in place temporarily.

Using tin snips I cut thin galvanised sheet to be placed over the fibreglass insulation, the one fitted to the base just rested on the four flat head nails, but the front, back and both sides were nailed in place using two flat head nails each that passed through the metal and fibreglass and into the wood, holding the entire assembly secure.

To finish off I applied two coats of matt black, high temperature enamel from a spray can over the metal lining, the edges of the fibreglass and the edge of the wood. To fully dry the enamel and remove any trace of solvents I then sat the whole box in the hot sun for a couple of days.

The next part was to get hold of the glass front, so I approached a local glasscutter and explained what I wanted. The Halacy book specified double strength window glass, which meant nothing to my glazier. Considering the temperatures that I hoped to develop (160°C+) he suggested special high temperature glass at a cost of over $200 for the 520mm x 520mm sheet that I wanted. After picking myself up off the floor I suggested that this was a tad outside my price range and was there no alternative? We agreed to try double thickness window glass (ie 6mm instead of the standard 3mm) but he was somewhat sceptical that it would work. At a price of $20 for the piece, I could afford a few mistakes!

Solar Oven Hot Box with Glass in Place

The case had by now dried sufficiently to continue work on it and I fitted some brown felt strips to the top edge of the box to seal the edge where the glass sat on it. The felt works well but faded to a light brown/crappy colour with the first use, so much for that idea. OK now comes the test for your cabinet making skills, the glass is absolutely flat and will show up any irregularities in the edge of your box…………..mercilessly. Yes, I did have a bit of fill in at the lower left hand corner, where the 60° started out a bit wonky, so I shaved down a bit of thin wooden moulding that I had hanging around and glued and tacked it in place with panel pins.

This left a 10mm strip around the outside between the glass and the edge of the top of the box, by tacking on some split moulding, this formed a frame for the glass to sit in, and sit it did…… reasonably well anyway. Of course the question could be asked "how the hell do you get the glass on and off?" and I'm glad you asked, because thereby hangs a tale! The ultimate idea was to drill a hole through the glass and fit a wooden knob secured by a screw, but at this time I lacked a glass drill so I quickly bent up a bit of galvanised steel into a U shape, drilled a hole for the knob, which I installed and then fitted the whole thing over the glass, it looked chatty but was serviceable.

Detail of corner showing steel, insulation, felt and timber

When I finally did get around to drilling the hole and fitting the knob, it was only a matter of weeks before there was a split through the centre of the glass plate, which seemed to originate at the hole. Hmmm……that glazier may have been right……..bugger! I did think that it may have been due to the metal screw and the glass expanding and contracting under heat at different rates, but to be sure (after going back, cap in hand to get a new $20 piece of glass) I re-fitted the chatty but serviceable steel and have had no further problems (that was over 8 years ago).

So, now that I had completed the box itself, I was impatient to try it out and in full sun I found that I has able to get to 90°C to 100°C………….but I wanted more!

The Reflectors

To increase the efficiency of the oven by increasing the area harvesting the sunlight, I made some reflectors. The more of the suns' heat reflected into the oven, the higher the possible temperatures and I considered making the reflectors out of mirrors, but mirrors are heavy, expensive and fragile. Other possibilities are polished aluminium or mirror stainless, but these also tend to be expensive. To keep costs and weight down, I decided to use aluminium foil glued to 3mm medium density fibreboard (MDF) which has white melamine applied to one side.

The reflector was made up of two different shaped sections, with four pieces of each section. The rectangular sections were 540mm x 610mm, these were screwed onto the box with the 540mm side against the side of the box. When these were screwed on, it left four triangular spaces in between the rectangular reflectors, these were filled by triangular sections 610mm x 610mm x 390mm. The rectangular sections were fixed to the solar oven using two galvanised sheet metal brackets about 40mm x 100mm, bent to the required angle. The triangular sections were initially taped to the rectangular sections with packaging tape for testing, but this started to fall off and has now been replaced with two 50mm galvanised hinges bolted between each section.

Prior to fitting, the reflector sections had to be covered with aluminium foil (you guessed it…..shiny side out!) glued to the plain side of the MDF sheets. The best and most wrinkle free way of doing this is to paint the MDF with glue (in this case PVA) and then set it down on the already laid out aluminium foil. This worked well with the triangular sections, but because of the size of the rectangular sections they could only be partially covered this way. The rest had to be applied by placing the foil onto the pre-glued surface, which resulted in more wrinkles.

There is an aluminium foil tape available at hardware stores, and I have intentions of getting hold of some and using it to tape up the joints, to reflect more light and give a neater appearance. The reflector is then attached to the solar oven box by self-tapping screws. If built to size the angles should work out pretty well correct but to help in setting up, the angle between the back of the side panels and side of the cooker box should be 150°, the angle between the back of the top panel and the back of the cooker should be 180°(ie a straight line is formed) and the angle between the lower panel and the front side of the cooker (not the glass face) should be 120°. I used an ex-school protractor and the angles worked out OK.

The oven, once assembled, takes up a lot of space, and unless your have large amounts of free space (which we don't) it is handy to be able to separate and flatten out the reflector into sections for storage. As my elder daughter's boyfriend asked when he went out into the backyard and saw the completed solar oven – "Wow! What are you doing with the satellite dish?"

The oven works pretty well and in summer will develop 160°C to 180°C. It has produced some wonderful roasts and casseroles, and I think that it could do a lot more. The next trick will be to try baking bread in it. The oven is designed to be tipped up in winter, with what is normally the base of the oven becoming the back wall. This allows the lower angle of the suns rays to be made use of more effectively, but even so the best I have been able to do in mid winter is 120°C. This is still hot enough to cook most things, even though it takes somewhat longer.

Although quite a bit of work, the building and using of both ovens has been both educative and fun, and when the sun shines we can use it directly and cut down our use of fossil fuels, which is a win for us and the environment.

Update

The oven has now been in service for many and is still working well. The main problem that has emerged is that is it big, bulky and a pain in the bum to manoeuvre. When pulled apart it takes two people about 10 minutes to re-assemble, which reduces the likelihood of reassembly (especially seeing as I am the only one who does it!). So it tends to sit on the back deck partially in the weather and this is starting to have a detrimental effect on the ply, I consequently have applied 3 coats of oil based gloss paint (fire engine red!) and it now looks a lot happier. To make using it easier I have now installed it on a small trolley and store it under in one of the sheds so that to use it means it only needs to be wheeled out and turned towards the sun.

Over the last 3 years I have been using it to bake solar (sourdough) bread, and it turns out beautiful bread all year round, contrary to my initial expectations. The bread tin that I use was my wife's grandmother's and is ideal for solar making, it is made out of thin tin plate, it has a flat bottom and is sprayed black on the outside. I don't time the bread but just keep an eye on it until it looks browned enough. The only concession to using the sun is that you need to turn the tin around so that the other long surface faces the sun about half way through otherwise one side is perfectly cooked and the other is still a bit doughy – a trap for young players!

The aluminium foil – not as reflective as it once was

After 3 years in service the aluminium foil was starting to look a bit worse for wear, so I have covered it with a thin sliver coated plastic wrap, the type sold by the roll to wrap presents in. I haven't used the whole roll yet and it only cost me about a dollar – good value. It appears to be more reflective than the alfoil. I used the same old faithful PVA glue to attach it straight over the alfoil and it appears to have stuck so far. The problem was that I was unable to place the reflectors on the silver film so it looks like the surface of the moon in reverse (bubbles not craters!), but that notwithstanding it works well.

2015 Refurb

Our solar oven has been in regular use for over 15 years and has been starting to look a bit ……. worn. The reflectors are not flat anymore and are not so reflective anymore either. The reflective surface becomes dusty and oxidised over time and just doesn't work as well, some of the hinges holding the reflectors in place have come off also. The main box of the oven is still in good nick, although the felt edge seal is a bit worse for wear too. All up it is time for a refurb.

The oven as it was

The original set of reflectors were made from 6mm MDF (Medium Density Fibreboard) with a melamine coating on one side. They worked pretty well and were light enough but over time they have warped so that not all of the light falling on them is reflected into the oven box, reducing the oven’s efficiency. This time I am having a go with 6mm 3 ply plywood which is a bit heavier but is also more rigid and resistant to warping because of the laminations. The plywood is also a bit more expensive. I was able to pick up 3 600mm x 1200mm sheets which is more than enough to make the four square main reflectors and four triangular corner reflectors.

To start I removed the originals from the oven box and recovered as much of the hardware (screws and hinges) as possible. I then marked out the new reflectors based on the dimensions of the originals with a one metre stainless steel rule and pencil, then made the required cuts with my hand circular saw. There was a bit of damage to the sharp points of the triangular corner sections but generally the approach worked fairly well.

The carcase of the oven with reflector attachments in place

After some consideration I decided it was easier to apply the reflecting material to the reflectors before installing them on the oven. The reflecting material which I used was the same as last time ie metallised plastic film gift wrap, with the unprinted reflective side facing out. It must be going out of fashion because I found it much more difficult to locate this time, so if you are going to make one of these ovens, start looking in newsagents and "el cheapo" shops now. If you can't find the metallised plastic film then use aluminium foil with the shiny side out.

My original idea was to use some double-sided tape to secure the film to the reflectors – bad idea! First off if I pulled it off the reel too fast it left most of the adhesive of the other surface and my double-sided tape became single sided. Even when I was able to secure it to the reflector with an adhesive side out, id did not stick very well to the plywood so as I tried to apply the film the tape came away from the plywood and of course stuck to itself and to the reflecting film making one big mess!

The plywood reflectors cut out and ready to coat

I ended up by going back to the way I made the first one, painting each of the boards with a mix of PVE glue and water (50:50). The PVA is not an instant stick to you can remove and re-fix the film if there is a problem and by rubbing the surface over with a cloth you can move air bubbles to the edge of the plastic film and then out, making the surface flatter. To make the job easier I also cut the film oversized, then once the glue was set and the film stuck to the plywood well and truly I trimmed off the edges with a VERY sharp knife.

With the reflectors now in good shape I had a look at the bent steel brackets which connected the main square reflector panels to the plywood carcase of the oven. There a two of these on each side, each one connected by a single screw fixed into the side of the oven. They had become a bit deformed and bent out after being well used for 15 years or more so I unscrewed them and panel beat them back into shape with my trusty ball pein hammer and using the flat spot on the back of one of my engineers' vises as an anvil. The ones on each side of the oven had a tendency to slip back and forward if I tugged on the reflectors because they were only secured by a single screw, so I installed a second screw on each one to prevent this happening again.

Installing the second screw to stop the attachment from rotating

To fix the triangular corner reflectors to the main square side ones I used hinges at the top and bottom of each reflector. The easiest way to put the oven back together is to screw the square reflectors back into place on the oven carcase, affix the hinges to the triangular sections and then screw the triangular sections onto the square sections, thereby tying everything together (I hope!).

The freshly coated reflectors

The one downside of reassembling the oven with the film in place on the reflectors is that I do it by placing each hinge on the outside (uncoated) surface of the reflectors and then drilling through from the outside to the inside (coated surface) of the reflectors and then putting a bolt through each of the holes. Why is this a problem I hear you ask? Well, drilling the hole in from the uncoated side means that, more often than not, the drill dislodges and mangles the film rather than cutting through it cleanly. The only way I have found to do it without screwing it up is to hold a piece of wood firmly over the film and then drill through the reflector and film into the wood block. If you can hold the wood in place the hole is very neat and no other damage is done. (if you can't it still screws up!)

I worked my way around, first securing the square reflector which stands vertically at the back of the oven, and then the one on the right-hand side. I then then secured the corner reflector between the two squared ones. I then fitted the next square reflector in the series and the next corner one until they were all fitted.

The Finished Article

With the reflectors replaced the oven looks more like its old self, and is working better than ever. It has been well worth the effort and was long overdue!

6.2.4 Parabolic Reflecting Solar Cooker

We have had the solar oven for many years and it will do most things that a normal oven would do, but I also wanted a solar cooker that would allow me to fry onions or boil up soup or other things that are traditionally done on the stovetop. I found the design for a parabolic reflector style solar cooker in the book “Cooking with the Sun” by Beth and Dan Halacy and used that as a basis for the cooker I put together.

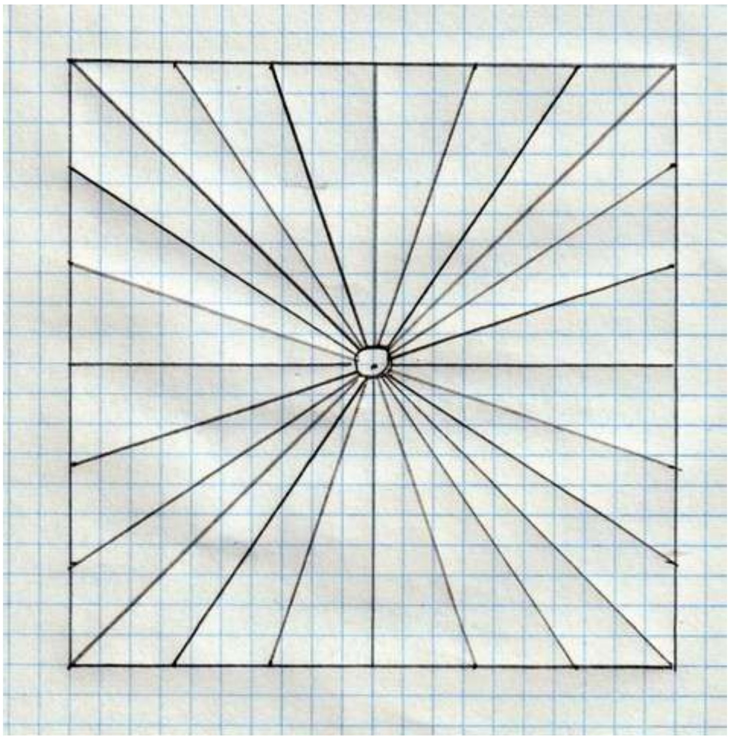
The way it works is that the reflective surface of the dish is pointed towards the sun and all the light (and heat) falling on the dish is reflected onto a single focal point. This is the point at which the cooking pot (or whatever) is placed, harvesting the heat coming off the reflector.

The base

In the original design, the primary material of construction was corrugated cardboard, but I was after something a little more robust and so I decided to use 6mm MDF for the base and 3mm MDF for the ribs. The original design also called for sides to be installed as well but I never bothered with those. In hindsight, they would probably be a good idea!

I bought a sheet of MDF and then cut it down to 820mm x 820mm with my circular saw. With the base now cut to size I needed to mark out where the ribs were to go and to fit the pipe flange (which would allow the pipe to be fitted which supports the cooking equipment).

To mark out the base I took a pencil and my one metre stainless steel rule and drew a line between each of the diagonals on the base, and then drew in lines joining the midpoint of each side, so that I had the positions for 8 ribs now in place. With these lines in place it was now just a case of measuring between each set of lines (which was, of course 410mm) dividing it into thirds and making a mark at each point. I then drew a pencil line from each marked point into the centre.

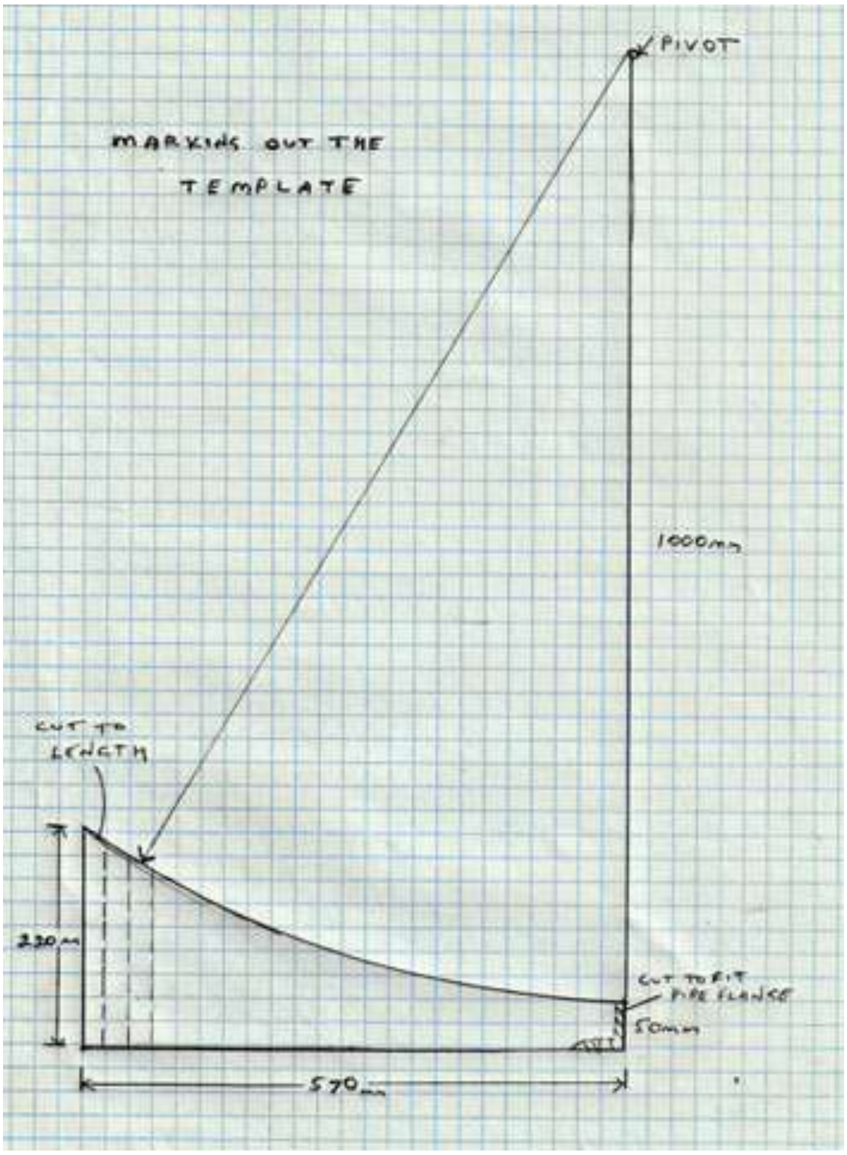


Thus, the base now had lines marked for 24 ribs.

The next trick was to install the centre pipe flange. The flange itself was 100mm in diameter and was set up to take 25mm diameter galvanised pipe. (Well, that is what you would get nowadays, the stuff I had was sitting around for years and was all imperial, the new stuff works just as well). I sat the centre of the flange over the centre of the base, where all the radiating lines converged, and then marked where two opposing bolt-holes were onto the base, drilled them out then bolted the flange in place. We were on our way!

Making the ribs

To mark out the ribs, the first thing to do is construct a template for the longest rib, which can then be used to mark out all the other ribs. The longest rib will be 220mm high at the highest end, 50mm high at the low end and 570mm long. Draw it out onto the material you wish to use as the template, (I used the 3mm MDF but you could use corrugated cardboard) get hold of a thin strip of wood a bit over a metre long and secure it such that one end pivots one metre away from the low end. Holding a pencil or pen at the end of the wood closest to the rib, use it to draw a curved line between the high and low ends of the rib. That is my best description of the process, but for a bit of clarity see the pic below.



With the rib set out, cut it along the lines with a knife, saw or if you have one, a band saw, making sure to stick exactly to the line. If all else fails cut the rib out a bit larger than the line, then use sandpaper to remove the material outside the line. Obviously, the more accurate the template is, the better all the ribs will be. There will also need to be a cut out from the bottom of the low end so that it can be fitted over the pipe flange in the centre of the baseboard.

To make the rest of the ribs it is just a case of using the template to mark them out and then cutting them out using a knife, hand saw, band saw or whatever you have on hand. Since only the diagonal ribs will be as long as the longest one, all the other ribs will need to be cut back so that they will fit on the baseboard.

Assembling the ribs

This means attaching the pre-cut rubs to the baseboard, which already has the pipe flange in place. To do that I used a construction adhesive, liquid nails. It was just a case of running a bead of adhesive along the bottom of the rib, putting it in place that then holding it for a short time to give the adhesive some time to set up, then moving on to the next rib. They can be done in stages or all at once, it is then best to leave the set up for at least 24 hours or even better for 7 days to give the glue time to reach full strength.

Applying the Reflective Surface

There are a number of ways to do this, but the one I used and which seems to work best is to get hold of some mirror finish card from our local newsagent.

To make the sections of the mirror I measured up the longest triangle and made a pattern from cardboard, overhanging the ribs on each side. I used this to cut out four triangles from the mirror card, then turned it over and cut out four triangles of the opposite side. I then followed the same process (measure, pattern, cut from one side then cut from the other) to make the rest of the mirror triangles. There is no need to get too finicky with cutting and gluing the pointy ends, they will be covered once the mirror is finished.

To apply the mirror card reflective surface to the ribs, it is just a case of applying adhesive (construction adhesive will work) to the ribs and then placing the mirror card, face up onto the ribs on each side, smoothing it out and holding it for a few minutes so it will stick. It works best if only every second set of ribs is used first, and then left to cure. The next day the infill mirror card between each existing mirror card can be applied. To finish off I cut a 100mm disc of the mirror card, then cut a 25mm hole in the centre. I then glued the ring of mirror card over the centre of the mirror (mirror side up of course!) so that the centre of the reflective area was tidied up and covered with reflective surface.

Cooking surface mount

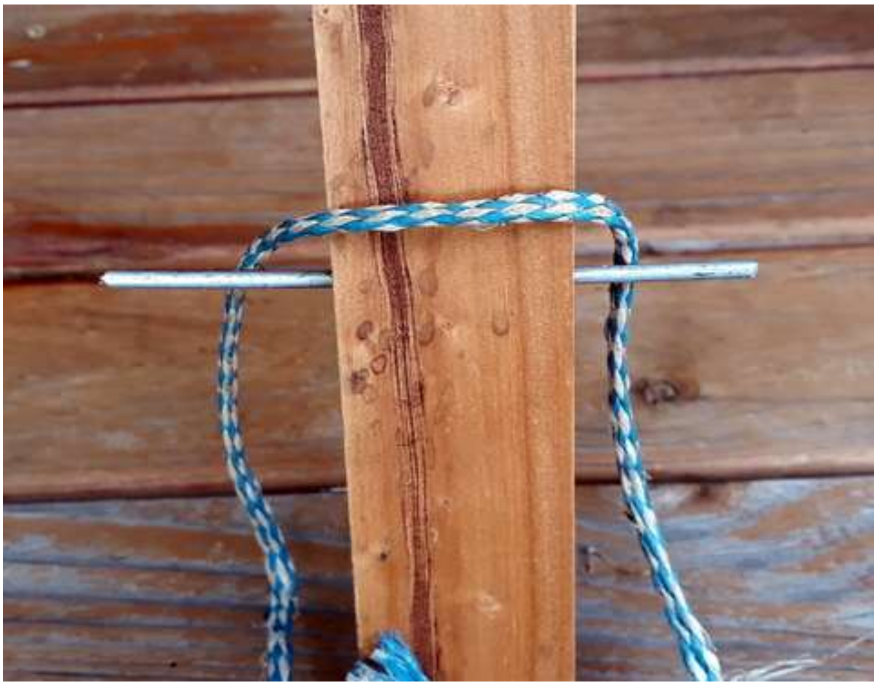
The idea is that the focal point on which the sun's rays are to be concentrated is on the bottom of the cooking pot or hotplate to be used. To achieve this, I screwed the 25mm steel tubing into the galvanised pipe flange in the centre of the completed parabolic dish, then using the shadow of the pipe on the mirror surface to point the dish directly at the sun. The curve of the dish is based around a 1 metre radius curve so the focal point of the reflected light should be around 500mm along the steel tubing (so your steel tubing should be 550mm to 600mm long to allow for some variation).

I made a mark around the pipe where the focal point was (quickly! It heated up remarkably fast!) then turned the cooker out of the sun. When the pipe had cooled I traced around the pipe at the focal point parallel to the ground, removed and then cut the end of the pipe off with my angle grinder. That way the end of the pipe would be flat when I wanted to put anything on it.

Obviously, sitting a pot on the end of the pipe would be anything but secure so I welded a piece of 330mm x 3mm threaded rod and 290mm x 6mm steel bar (it was what I had available) into a cross formation on the end of the tube to support the cooking pots etc.

Cooker support

Unless you live on the equator, having the cooker lying flat on the ground won't achieve much so there has to be a way to set the correct angle of the cooker so that the focal point is on the bottom of the cooking pot.



To make the support I got hold of some 42mm x 19mm DAR pine about 1100mm long. I then drilled a series of 4mm holes through the 19mm sides of the pine, starting at 600mm from the ground and then every 30mm for seven holes. I then inserted a length of mm aluminium welding rod 120mm long to secure the twine to. To hold the reflector and support together I cut 450mm of twine and tied both ends together to form a circle. To hold the twine onto the reflector I screwed a small rope cleat to the back of the reflector at the top.

To use the support it is just a case of hooking the twine over the cleat and then around the aluminium welding rod through the pine support. The angle can be varied by moving the aluminium rod through a higher or lower hole, depending on the angle of the sun.

How does it work?

It actually works very well! I used to do some work with paraffin wax and used the parabolic cooker to melt the wax on many occasions. I did also use it for cooking, usually as a way of boiling water and making soups or stews, but I also used it for frying in a frypan and that worked well too. As far as I could see there were three drawbacks to this type of solar cooker and the first one may be (OK, was) due to my crap design –

1. The location of the pot on the supports was not hugely secure. The pot or pan could slide about a bit when being inspected or stirred. In fact one day a billy can full of wax fell of due to the effect of wind and paraffin coated a part of the reflective surface. This can also cause problems when trying to move the apparatus so that it continues to face the sun during the cooking period. It would be better to remove the pot, move the

reflector, then replace the pot on the support. Not a big issue, but an issue nevertheless. A better pot support design could fix the problem I am sure!

2. Speaking of wind, due to the particular design of the cooker, the pot or pan in use sticks out and away from the cooker so that on a day with good sun, but a cool or cold wind, some of the heat is taken away resulting in the pot being cooled by the wind and the cooking time extended.

3. As with other solar cookers, you need to be careful when looking at the pot to ensure you don’t cop a face full of reflected solar. Dark glasses should always be worn and care taken when performing such operations.

Bearing the above points the parabolic solar cooker has given us many years of faithful service and I would highly recommend it, either as a standalone or in conjunction with a solar oven

Postscript

I have heard it said that all good things must come to an end and so it has proven with our parabolic reflecting solar cooker. Recently, we were subjected to three years of La Nina, or in other words – long spells of very wet weather. This meant there was not much use for our solar cookers and so they mostly stayed in the shed. What I did not know is that the shed had also developed a leak over the area where the cooker was stored. When I finally removed it from the shed, it was so water damaged (the MDF had expanded and broken apart) as to be irrecoverable. It is, therefore, with heavy heart that I announce that our parabolic reflecting solar cooker is no longer with us.

6.2.5 The 'Primrose' Reflecting Panel Solar Cooker

I first came across this type of solar cook about 20 years ago and determined to make one. I saw similar constructions on two websites, one was French and the other German, one referred to it as the 'Nelpa' (an anagram of 'panel' evidently) and the other called it a 'Primrose' (no idea where they got the name!). The thing I found interesting was that, while each site had plans, they left out certain critical dimensions. Fortunately (for me) they left out *different* dimensions so that I was able to put the two plans together and build one for myself!

The cooker may be broken down into two pieces:
– The carcase – which supports both the cooking gear, consisting of a matt black painted pot, and the reflector, and
- The reflector unit itself

The way it works is that the reflector is a series of rectangular glass mirrors mounted in such a way that, when faced towards the sun, the reflection of the suns' heat from the mirrors all hit the bottom of the cooking pot. The carcase has a glass bottom on the box that supports the cooking pot allowing the sun's rays to heat the bottom, and some of the sides, of the pot. The reflector is mounted in the carcase so that its angle can be changed to ensure that the heat hits the pot. It is also constructed so that the reflector can be pulled up against the carcase to make storage and transport easier.

How I built the Carcase
The carcase is composed of four legs with a plywood box at the top that has a glass bottom and supports the cooking pot. There is some insulation inside and outside the box to reduce heat loss.

I made the two sides (each consisting of two legs) from 42mm x 18mm DAR pine. I cut two 910mm lengths of the pine to form the vertical legs and joined them together with two 395mm horizontal braces, one 115mm up from the bottom and the second one across the top, all of them being screwed into place with a single countersunk wood screw, in from each end. I then added in another piece of pine, angled so that the top of the pine was 100mm from the top on one side and 200mm from the top in the other. This would form the support for the glass bottom of the box. I then made the second side, same as the first!

On the legs closest to the reflector I attached on each a piece of thin galvanised steel sheet that was 110mm x 42 mm on the outside of the leg about 200mm up from the bottom end of the leg with two screws. I then drilled a 6mm hole through the leg and steel sheeting 50mm up from the bottom of the plate. This is to act as the pivot point for the reflector.

I then joined each side together using a single piece of 19mm thick DAR pine which was 660mm long by 220mm wide and held in place by 4 countersunk wood screws. The sides of the box are rounded out by a piece of DAR pine 620mm x 112mm x 20mm which is angled back slightly from the bottom to the top to allow the reflector to rest against it when it is folded up. It is covered by 20mm thick fibreglass insulation 600mm x 120mm and secured by two wood screws and washers.

Insulation removed

Insulation in place

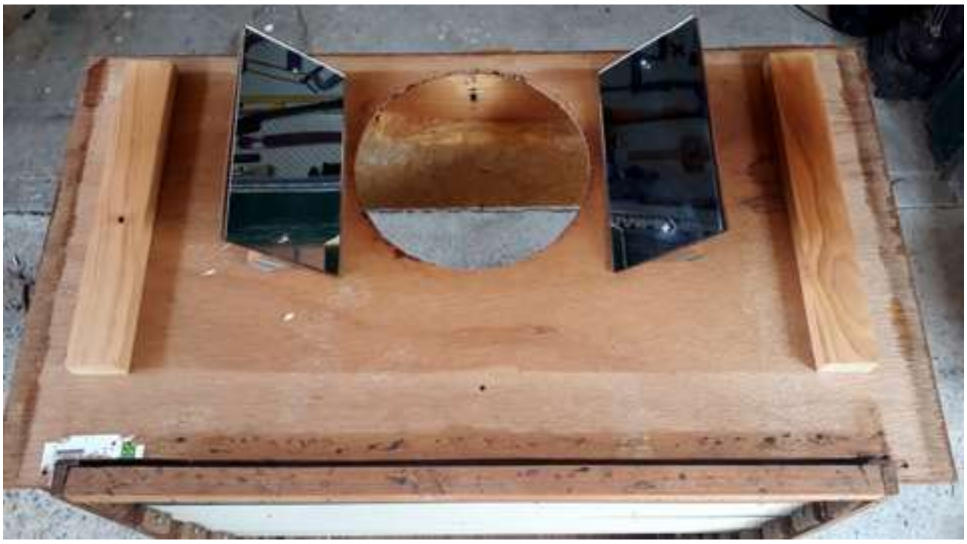
The side with cover removed showing insulation in place

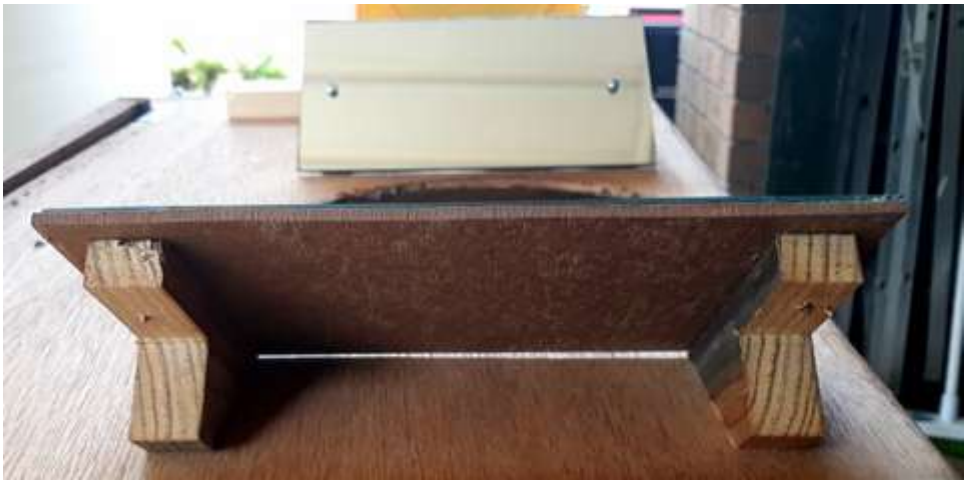
The bottom of the box is formed by a piece of 3mm glass, 620mm x 350mm in size, secured against the bottom of the box by 5mm plywood tacked in place all the way around it. The top of the box is formed by a piece of 10mm plywood 720mm long x 400mm wide. The top has a 205mm hole to support the cooking pot and a cutout on the front of 620mm x 20mm also to allow the reflector to be folded up against the face of the carcase. To make a better seal but still allow the top to be removable, I put some felt between the top and rest of the carcase to prevent the heat escaping.

Looking down into the carcase, top removed, through the glass bottom

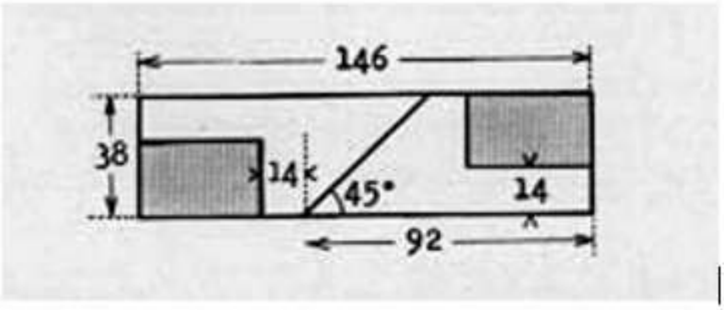
The top from above

Due to the cooking pot being so much smaller than the width of the cooker, there is also a fitting each side holding a piece of mirror angled at 45° to reflect more of the suns heat onto the sides of the pot. The diagrams below show the dimensions of the fittings (two per side mirror) and where they are fixed in place.





How the fittings are fixed to the underside of the top



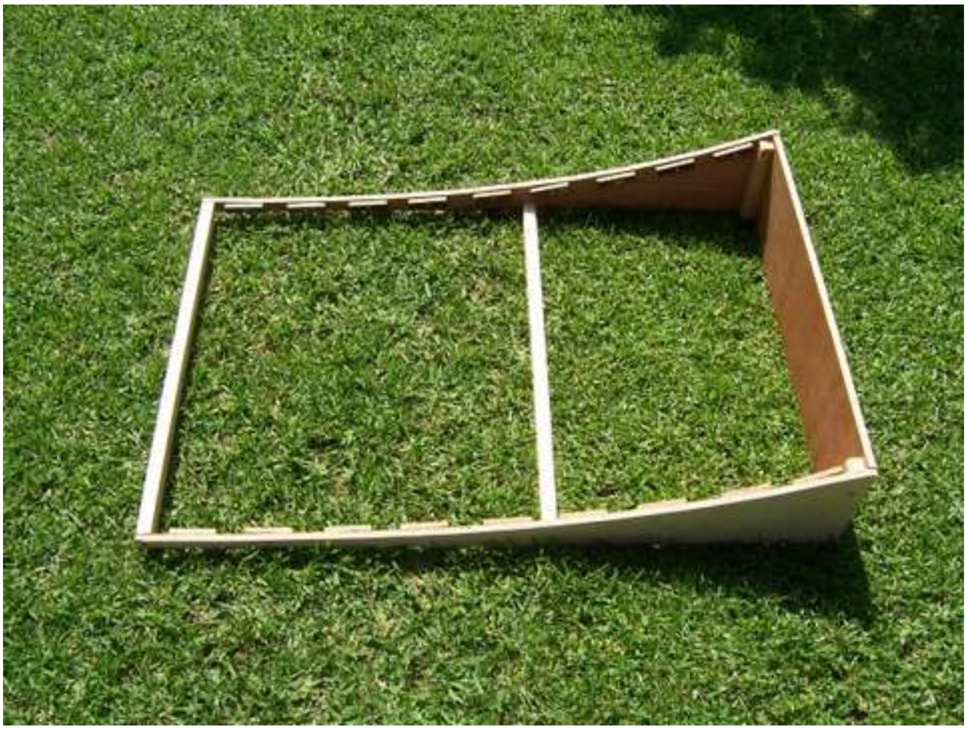
Dimensions of the fittings

The pot is a 205mm stainless steel pot and lid, with the outside of the pot painted with matt black engine enamel. I removed the handle of the pot so it would fit into the hole and made sure the pot I used had a flange on the top edge so most of the pot would sit down into the cooker but not fall through.

I probably could have made the cooker a bit narrower, but I wanted to make sure that things were stable, and it was unlikely to tip over.

How I built the reflector

The reflector is a box 900mm long by 620mm wide, and the sides are graduated from 20mm thick at its thinnest point up to 172mm at its deepest point. It is made from 10mm 5 ply. Mounted on the reflector are 9 x 100mm wide by 595mm long pieces of mirror glass. Due to the mirrors I had available there are a number of different thicknesses of glass. (hint: thicker is more robust, so better).

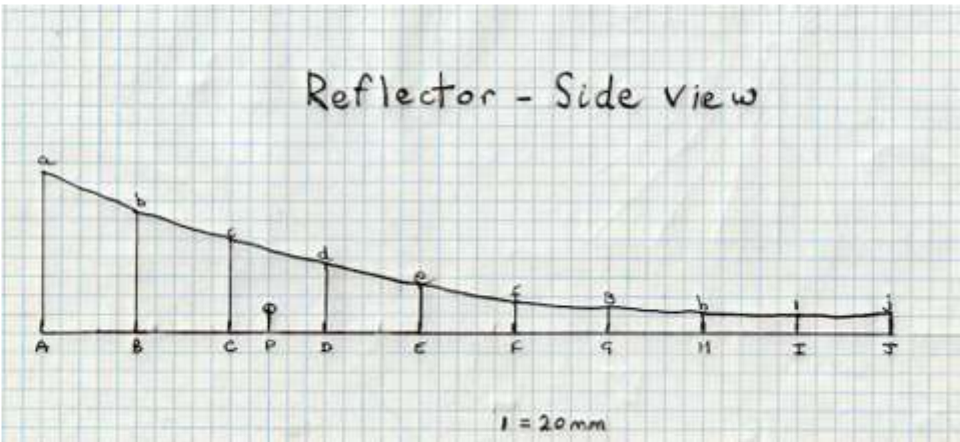


Regarding the mirror glass reflectors, it had been my intention to cut them to size myself, using a hand glass cutter. I had enough mirror glass to cut the 9 pieces I needed for the reflector plus some spares. Having irretrievable stuffed the first couple I had tried to cut, I decided this was a job for a professional and approached a local glazier to cut them for me, which they did. I can't remember how much it cost, but it wasn't too much and being 20 years or so ago would be no indication of what that might cost today. Moral of story: there is no shame in getting help with the more technical parts of a project!

The sides of the reflector are graduated so that the reflection from each individual mirror will hit the same spot, ie the bottom of the pot through the glass bottom of the carcase.

To build the reflector I got hold of some 10mm plywood as mentioned above. Three pieces were required – 2 x 879mm long by 172mm wide to make the sides and 1 x 600mm long by 172mm wide. For the fourth part of the reflector box (at the thin end) I used some 20mm x 20mm pine.

To make the curve on the sides of the reflector box and thus ensure the mirrors were at the correct angle, I marked what would be the bottom of the reflector at intervals as per the ‘Horizontal Distances’ in the table below. I then measured out the ‘vertical distances’ as per the table below. By joining up the tops of the lines, this gave me the correct curve to place the mirrors on and I then cut out the curve from both sides of the reflector box.



Horizontal Distances		Vertical Distances	
A-B	91.5mm	A-a	172mm
B-C	94.5mm	B-b	131.5mm
C-D	96.5mm	C-c	99mm
D-E	98mm	D-d	73mm
E-F	99mm	E-e	53mm
F-G	99.5mm	F-f	38.5mm
G-H	100mm	G-g	28.5mm
H-I	100mm	H-h	22.5mm
I-J	100mm	I-i	20mm
A-P*	240mm	J-j	21mm
		P*	27mm

Using some 20mm x 20mm pine in the corners as braces I put the reflector box together using wood screws and added a 20mm x 20mm pine brace 365mm from the high end of the reflector box.

To put the mirrors in I screwed supports made from 20mm x 5mm rounded edge moulding with one side sawn off to make it flat, to the inside of the sides of the reflector box so that the mirror could be put in place inside the reflector box and at the correct angle. Once the mirrors were in place I secured them by screwing more 20mm x 5mm rounded edge moulding along over the top of the ends of the mirrors.

I drilled a 6mm hole in each side of the reflector at point 'P*' (P standing for 'pivot!) and then slid in a 6mm x 50mm bolt with a wingnut on the outside to tighten the pivot and secure the reflector to ensure it remained at the correct angle.

Advantages and disadvantages

Advantages of this design

- The lid is accessible (as opposed to a solar oven where the whole pot is enclosed) allowing the food to be tasted, added to, stirred etc.
- The bottom of the pot is heated, allowing parts of the recipe to be fried before putting the lid on eg, when making spaghetti Bolognese the onions and garlic can be fried off, then the mince added and browned before adding sauces etc. This is impractical when using a solar oven style cooker.
- Steam escaping when the food is heated does not condense on the reflector.

Disadvantages of this design

- It is far and away the most complex design I have ever put together.
- Some heat will be lost to the system in the steam escaping from the lid and through the uninsulated lid itself.

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While it is a complex build, it was a lot of fun and has now been in existence for 20 years and still is working perfectly. There has only ever been one issue, when we had an open day and it was out for inspection, the child of one couple decided it was built to be climbed in and when our backs were turned, he did just that, breaking one of the mirrors. It was only a minor hiccup as I had spare mirrors prepared for just such an occasion.

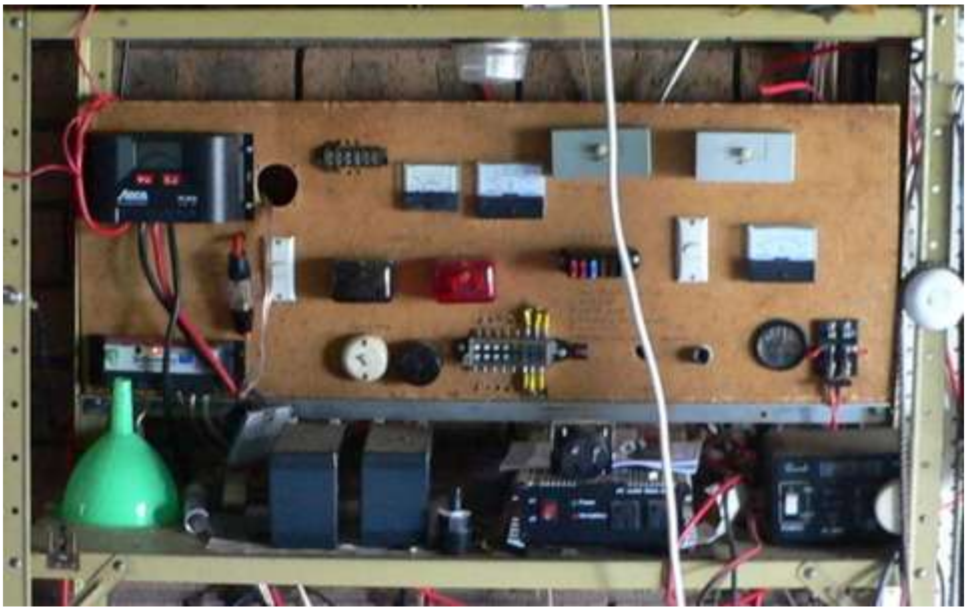
Note the missing mirror

7.0 Generating Power from the Sun and the Wind

7.1 Our 12 volt Power System

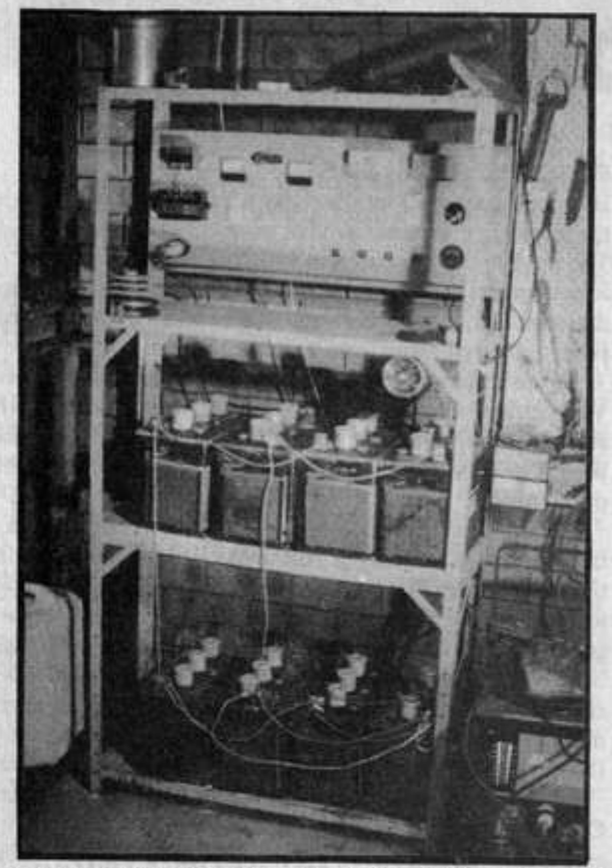
Introduction

While it is not for everyone, it is possible to design and install your own low voltage alternative energy system, to suit your needs. I know because I did it, originally over forty years ago and there is nothing special about me, I am neither a sparky nor electrical engineer. Following is a summary of what I did and the lessons I learned from the process.



The system started out in reverse: instead of getting a power source, storage system, then wiring, I did some initial wiring, put in some lights and switches and then got a couple of batteries. To charge the system originally I used a 240v battery charger.
Over 10 years ago the federal government were offering good deals on grid connected solar systems (panels plus inverter) and a feed in tariff of 60c per kilowatt-hour pumped back into the grid as against a cost of 22c per kilowatt-hour which we bought from the energy supplier. By that stage our stand alone solar system (panels, plus batteries) was running the lights and a 12 volt fridge. Unfortunately about three years ago the good

deal dried up and the energy supplier now pays us 8c per kilowatt-hour for what we pump into their system but charges us 28c to buy a kilowatt-hour from them.



The battery storage and fuseboard for our 12V system, which provides power for lighting and small appliances.

At that time we decided to go off grid (more or less) with a professionally assembled and installed 24 volt DC system feeding a 3000 watt 240vac inverter which powers the whole house. The 12 volt DC lighting is still in place and in use, the rest of the system is 240 volts AC.

The 12 volt system evolved, and worked well, for over 35 years. I have no training in this field, but put it all together based on reading books, discussions with other enthusiasts and learning from my own mistakes. The system was the vindication of the amateur and on one of our open days a gentleman asked me if I was an electronic engineer (turns out he was!). If I can do this, almost anyone can.

The following information is current up to the time the system was partially decommissioned and replaced by the new system in February 2017.

Wiring

All the wiring used in the circuits throughout the house is multicore, plastic coated, two run (ie two sets of wires) polarized (ie one wire has white marker along it so I can tell at any point in the circuit which is negative and which is positive), and the thickest wire that I could afford at the time. Originally that was 3.5mm thick (including plastic coating) and obtained from Tandy, the wire I use now is from Jaycar Electrical and 5.0mm thick. The multicore is more flexible and generally thicker than the single core used for 240 volt house wiring.

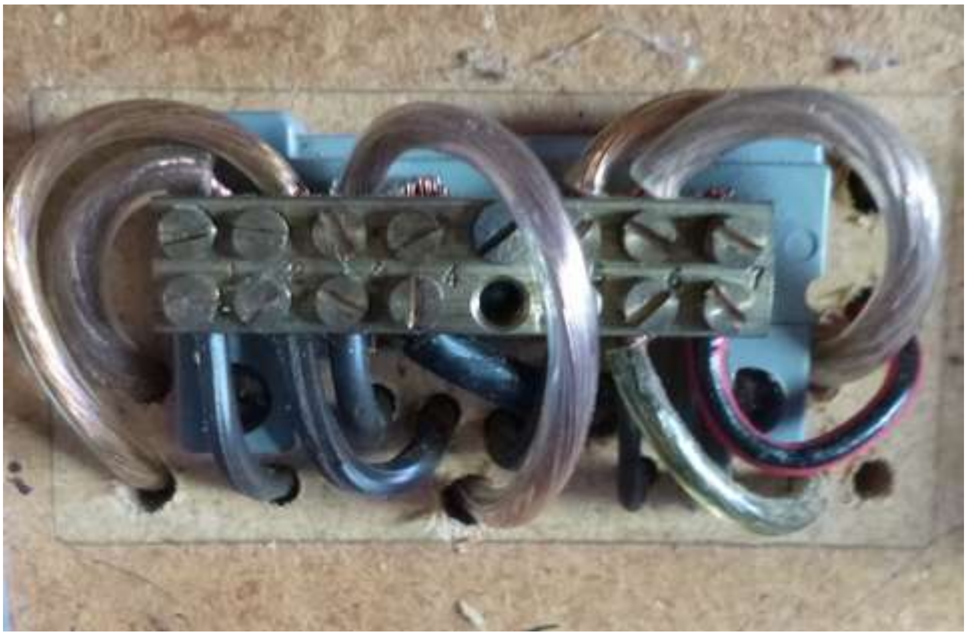
The original lighting circuits have up to half a dozen high efficiency 12 volt fluorescent lights or 12 volts LEDs on them. The longest circuit with the fluorescents on (the bedrooms, bathroom and hall) can have a problem with the fluoros not starting up if the batteries are down a bit and there are two or more fluoros already on. This effect has not been an issue with the LEDS.

The newer circuits have only two lights per circuit and with the thicker wire, there is little or no dimming. This is the result of line losses which can be devastating in a low voltage system, so to reduce this to a minimum keep your wire runs as short as possible and your wire as thick as possible, or rather as thick as you can afford!

To connect the wires I originally used the 3M Scotchlok connectors which are designed for use on auto wiring. They usually give a quick, solid connection but can be difficult to get, and over a long time due to build-up of corrosion or whatever they can give a bit of trouble and lights can refuse to work. These days I tend to use 240v terminal blocks – cheap, accessible, easy to use (although not as quick as the Scotchlok) give a good solid join and they can accept the thicker wires much more easily. I have replaced almost all of the Scotchlok with the terminal block type.

Each circuit has a wired in auto-style fuse on the positive wire so that any short circuits do not result in a fire, and this is critical as one short circuit can burn your house down! So the lesson is – don’t energise any circuit until there is a fuse in line. Initially I used the cylindrical glass automotive fuses, which did the job, but each fuse had to have its own separate mount, which is spring loaded. Over time the little plastic lug that held the spring and fuse in place would harden and eventually snap, so that at the least convenient point in time the lights would go out and I would have go into the garage and play hide and seek with the fuse, (annoying!).

The system I use now is based on the European style blade fuses in a fuse block that can take six or eight fuses in a row, the new system also allows me to use the push on type spade terminals to attach the wire, where the other type required soldering (which I never got around to). Overall the new system takes up less space and allows me to number each fuse so that I can record what is on the circuit that each fuse covers.



Wiring between the solar panels and the batteries and between the batteries and the bus bars is single run, either red or black plastic coated (red for positive and black for negative) 8mm multicore copper wire. To run multiple circuits I run a single supply wire to the bus bars, then run the multiple circuits from the bus bars (one positive one negative) otherwise you get a messy collection of lugs attached to the main battery terminals which can cause supply issues if they become corroded (due to the sulphuric acid). The bus bar system is much simpler, tidier and makes it easier to prevent interruption to supply.

Lessons:

- Get the thickest wire you can afford
- Run a number of smaller circuits rather than one long one
- Use bus bars to run the circuits.
- Don't put too many loads on each circuit
- Install a fuse on EVERY circuit!

Switches

I use the normal surface or wall mounted 240v switches. The books say that the surface mounted switches give a faster break of the connection and so result in less sparking and therefore less erosion of the switch terminals. They also say that the normal wall mounted type are unsuitable for low voltage and erode quickly. While not being sure of the theory, all I can say is that I have had some wall mounted 240v switches in regular use for over 30 years and have yet to see one fail in service. I have had one fast-break type act up intermittently, however.


Lessons:

- Most switches will be OK

Batteries

When you decide that you are going to use battery storage it is important to decide where your battery storage area will be, while modern batteries are reasonably robust they do need some basic amenities in their accommodation. The area must be out of the weather, not too hot or cold (ie below freezing) and have good ventilation. Charging batteries results in hydrogen gas being produced which is highly flammable and too much of a build-up that come in contact with a source of ignition (which can be as little as a light switch being turned on) and you have a most disconcerting bang! You will also need to be able to get to them easily, that will make it more likely they will get maintained. If you are using lead acid batteries they are also likely to leak sulphuric acid and so they should be placed in tubs or whatever to contain any spillage, I originally used small melamine trays but the couldn't cope with the sulphuric acid, so I moved over to plastic trays, slightly larger than the base of the batteries and about 50mm high.

I still have my copy of Wind and Wind spinners by Michael Hackleman and it was this book that advocated the use of 6 volt batteries in series to obtain 12 volts. I have used that system mostly since. My first batteries were obtained in 1983 and they were a pair of 138 amp hour reconditioned second hand truck batteries and they served me well for 4 years, but they were not deep cycle (Note - deep cycle batteries are specifically designed to survive deep discharge and recharge cycles, but having said that repeated deep discharge will reduce their life). Some time after I commissioned the first set, I put in a second set, the same batteries from the same reconditioner, but they never would hold a charge and when connected in parallel only served to drain the originals. They were certified as OK by the reconditioner, but I was never able to make them work. I suppose this illustrates the first law of battery banks – thou shalt always buy all thy batteries at the same time and install them together.

In 1987 I was offered 8 x 90 amp hour deep cycle batteries ex telecom, standby batteries out of a telephone exchange from a friend of mine (see the B&W photo in the intro). They could have been in the exchange for ten years, and my friend had them under his house for five years, by the time I recycled them 13 years later they wouldn't carry a charge in a bucket but I got pretty good use out of them. In 2000 I inherited some money about the same time that the batteries shuffled off their mortal coils and used some of it to buy 4 x 6 volt 220 amp hour deep cycle batteries. They are American – (US2200 made by US Batteries) - generally I prefer to buy Australian, but they were by far the best price per amp hour that I could get.

This gave me 440 amp hours of storage, but I got greedy and put on another bank of 4 of the same batteries. Initially I broke the above rule and wired them into one large bank, but the performance was down so I had split them and manually change over the charging lines to keep both banks charged. There are regulators that will automatically switch between banks as one becomes charged, they are expensive but I got one (the Morningstar SunSaver Duo 12 volt) but it only lasted a couple of months before refusing to transmit any charge at all to either battery bank. I have a replacement (under warranty) which I installed but it lasted a similar amount of time. They are rubbish.
In the end I set up the two banks completely separately, powered by different sets of solar panels through 2 separate regulators. The top bank ran the lights and a few small plugs for 12 volt appliances, including a 12 volt pump on the 5500litre water tank around the side of the house and the bottom bank ran the 12 volt fridge.

About 15 years ago several batteries in the original bank had cells collapse, rendering them useless. This necessitated buying in another bank after only 6 years. This was my own fault as I had discharged the batteries to a ridiculously low level (9 volts) and let the electrolyte reach critically low levels before topping up. The result was poor battery life. Thus the second law of batteries is – look after them and they'll look after you. Check the electrolyte levels at least monthly and give them a wipe over to clean off dust, and don't discharge them below 12 volts if you can help it. Deep discharge means 12 volts not the 6 to 9 volts I originally thought it did!

I replace the faulty battery bank with another set of four 6 volt 220 amp hour deep cycle US 2200s from US batteries and they lasted 12 years, up until the new system went in. About 10 years ago the other bank of batteries failed and I shopped around actually getting four 12 volt Superstart MF86B 130 amp hour marine maintenance free batteries, which were just about ready to fail when I replaced them with the new system.

Lessons:

- Get deep cycle batteries and understand what that means!
- Replace whole bank rather than one or two batteries in the bank
- They will leak sulphuric acid
- They will give off hydrogen
- Check electrolyte levels

Generating power

Early on I tried several ideas here but only one with any degree of success. The first method has direct connection to the power grid via a battery charger…..hardly self-sufficient but it helped me test the system before I could come up with anything more sustainable. The second was a 12 volt petrol generator that I build based on a car alternator and motor mower engine, for obvious reasons this was also a flop!

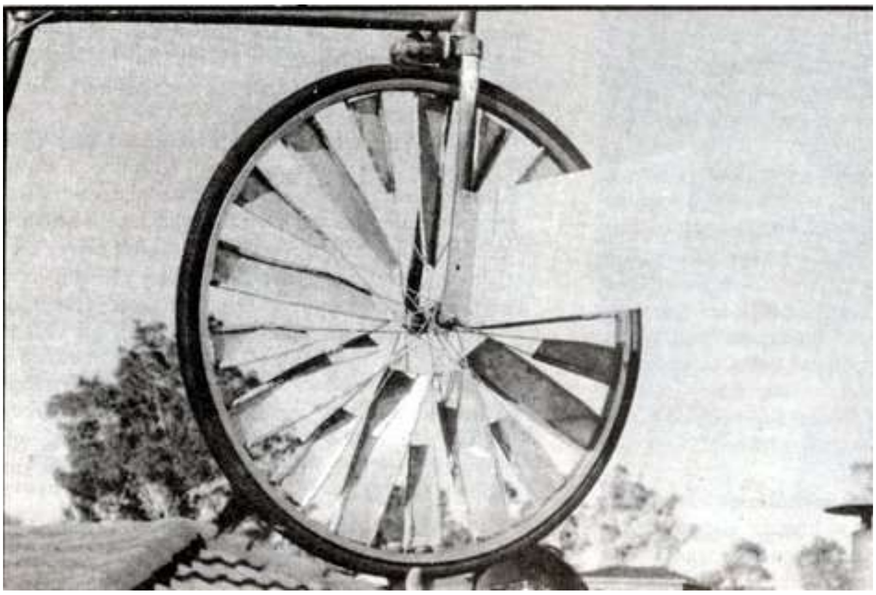
The third idea was a SolarexX44 BG photovoltaic panel, which cost $351 about 35 years ago (it is based on the old round solar cells). It is rated to produce 1.35 amps but on a good summers day will hit 1.8 amps, and after 35 years it was still in place and there had been no loss of output, up until the panel was replaced by the new system.

About 27 years ago I added a BP Solar Panel to the system which gives a peak output of about 2.5 amps (Sorry I can't be more technical here, the specs went west long ago) and likewise it is still going strong. Twenty years ago I saved up my pennies and added a third solar panel, a Photowatt International PW 750 which on a good day can pump out 4 amps which about doubled my generation capacity at the time. It cost a bit at $600 but was the best cost per watt unit that I could afford. All of these units continued to pump electricity into my batteries whenever there is light shining on them, up until the system was replaced.

The last addition to the old system was 4 x 80 watt Solarex panels, donated by my brother – or at least on loan – I could charge up to 25 amps – a huge boost to the system. One of the down sides of a system which develops like this, all wired in and running through a single regulator was that over time the charge degraded and from an original 25 amps, over time it dropped to a 15 amp maximum charge. This worked for us but designing a system from scratch and obtaining it all in one go can provide better performance.

As mentioned in the battery section, I originally had all of the batteries wired together but this did not work very well, so I ended up separating them into two battery banks with separate regulars. The top one (4 x 6 volt batteries) powered the lights and was charged by the original mish mash of panels, the bottom one (later to become the 4 x 12 volt low maintenance batteries) ran the 12 volt fridge and was powered by the 4 x 80 watt Solarex panels.

I did some work about 30 years ago on a bicycle based wind generator. It was a bicycle wheel, forks and head set, with metal over the spokes and a roller style bicycle generator. After being a local landmark (and eyesore) for a number of years it finally bit the dust about 25 years ago. It proved to be all that the photovoltaics were not: it was not attractive, gave off a noise in high winds that did annoy the neighbours, required frequent maintenance and at full belt delivered less that an amp to the system. It was just not practical, even if it was home made from recycled parts.



The lure of the wind generator is strong. However! I always wanted to make my own, hand crafted and based on a car alternator, but with so many projects I never go the time. In early 2005, there were some Chinese wind generators doing the rounds, producing around 200 watts at 12 volts, the kit was self-contained but the whole thing weighed 70kg, add wind load to that and it was a substantial amount of kit to mount on the garage. It was also comparatively large with a blade diameter of 2.5 metres. I figured I better get council approval (it was a bit difficult to hide!) and after the obligatory 1 minutes silence for weirdo identification the told me that inspections etc would cost over $300 which added considerably to the original $450 price tag. In the end I shelved the idea after concerns about the weight as well as council hassles, it was donated to Mamre Farm in 2010.

As I said above, the lure of wind generators is strong and while overseas 10 years ago I saw some much smaller and less obtrusive units. After research back in Aus I found the AirX 400 watt 12 volt wind turbine. It was double the cost of the Chinese unit but it also produced twice the power, only had a blade diameter of 1.17 metres and weighed 6.5kg, it was about as obtrusive as your average TV aerial! Needless to say I bought and installed one on the side of the garage and afforded me endless pleasure as I watched it rotating in the wind while working in the garden.

Unfortunately what it didn't do was produce much power due to turbulence. It should probably have been mounted about four or five metres higher, but then it may have attracted attention, possible complainants, followed by the ire of the council. In the event, for the 8 or so years it was installed it did not cause any issues. With advent of the new 24 volt system (the wind generator was 12 volt) it became redundant and I passed it on to a mate who has a farm in Cootamundra and tiny house of sorts on top of a hill in the country. A much better situation to get power out of a wind generator. For the full details on our journey with wind generators check out the following section.

Lessons:

- Go with solar (no noise, doesn't upset the neighbours, less hassle)
- Wind is only good for very windy sites
- Get an engineer to look at your wind system installation if you are going to get one

Regulators

For those who don't know, the whole point of a regulator is to prevent the batteries of your 12 volt power system being overcharged by your solar panels (or whatever you are using to charge them). When I first built my system, I did not have a regulator, I had read that if you are charging at less than 10% of your battery storage capacity (ie below 44 amps for a 440amphour battery) you didn't need one. It turns out this is rubbish and after seriously decreasing the life of a brand-new battery bank it turned out a regulator was something I should invest in.

Originally, as referred to above in the battery section, I got hold of a Morningstar SunSaver Duo 12 volt to keep both banks charged from the one input, but it turned out to pretty much be a waste of space (and money). The Sunsaver debacle resulted in me splitting the two banks into two totally separate systems, but it did have one redeeming feature which I will talk about in the 'Metering' section.

For the top battery bank (powering the lights) I bought myself a STECA 30 amp photovoltaic regulator, it cost several hundred dollars but seemed pretty much what I was looking for. I installed it and while it worked well, the place where you insert the wires from the panels and to the batteries was a connector block designed for wire about 3 - 4mm thick, but I used wire 8mm thick. This meant that I wasn't able to get all the wire into the connection block and over time the end of the wire got a bit ratty with little bits of frayed copper wire all over the place. The more I tried to push it in, the rattier it got and evidently the less wire was available to transfer the current.

It got to the point where the wire would occasionally fall out and the system would stop charging. This is where the remote voltmeter in the kitchen earned its keep and allowed me to see there was a problem. Anyway I had come up with a fix but had not implemented it when disaster struck. Due to a lot of amps going through not much wire the increased resistance caused the regulator to heat up, then make expensive smells, then cease to work. Yes, my friends I had burned something in my regulator out due to stupidity.

Unfortunately to replace the one I had fried with an equivalent was several hundred dollars, but for under a hundred I could get a new regulator that would do the job – a Powertech Super Solar Charge controller (it was, after all, SUPER, so how could I go wrong?) It also had spade lugs for attaching wires from the panels and the batteries. This meant I could solder on a spade lug and not have to worry about things overheating. Winner!

A slight diversion at this point… The Steca regulator works by sensing the charge of the batteries and then allowing power from the panels to flow into the batteries, cutting back slowly as the batteries approach full charge. This approach worked very well. After reading the instructions on the power tech, it appears that it acts like a switch, switching current from the panels on when the batteries are below a certain DC voltage (13 volts) and then switch it off when it hits around the 14 volt mark, allowing the surface change on the plates to be absorbed, dropping the voltage below 13 volts and switching on the panels again. Makes sense to me.

Unfortunately in practice, not so much. As soon as the new regulator went in the battery voltage drop at night (as we used the lights) was much sharper than with the Steca regulator, even if we only used a couple of lights. The system was working but not as well as it had so it looked like I needed to revisit my options and have a go at fixing the original regulator. Fortunately this did not prove as much as an issue as I thought it would be.

Now that I had access to it (after removing it from the system and could open it up) I found that the plastic terminal block connector for the positive side of the solar panel output had just melted due to the heat from the poor connection, hence the expensive smells. I was able to replace the burned out section by cutting that bit off and inserting a new section cut off another terminal block (bought from the hardware for the purpose), but that still left me with the problem of fitting the wire into the connection block.

As alluded to previously I did have a fix. I got hold of some Gold Locking Banana Plugs, (from Jaycar Electronics) two with red rings, two with black rings. I have no idea what their official use is but they accept the 8mm wire easily in one end and allow it to be secured with two grub screws. The only issue is that there is a ferrule on the outside of the plug which makes it a bit wide to go into the connection block on the regulator without touching its neighbour. It is not necessary for my use so I just unscrewed it and left it off.

The pin out the other end can then be easily fitted into the connector block in the regulator and secured with the fitted screw, allowing sufficient power transfer so that they don’t even get warm, let alone hot.

By contrast, the regulator which used I for the bottom bank of batteries which supplied the 12 volt fridge was a Powertech MP3129 20 amp regulator, which performed flawlessly until it was decommissioned along with the Steca 30 amp regulator when the new system was installed.

Lessons:

- Use one!
- Install one per bank of batteries

Inverters

My original idea was to run what I could using 12volts directly, so I needed 12 volt appliances and whatever. Unfortunately a lot of 12 volt gear has been designed to be cheap and nasty for the auto/camping market and can lack power and certainly longevity. Also there were some things which were just not available in any power requirement other than 240vac, and this is where an inverter (which converts 12vdc or 24vdc into 240vac) is needed, hence my journey into the world of inverters!

Originally I purchased a little Zurich DA-100 inverter for less than $100, it is a small inverter providing 100 watts of 240 volt AC power and is a square wave not sine wave inverter, this results in a hum when I use it to run my CD player. Theoretically 100 watts is enough to run a small TV and video but my experience seems to suggest that it is either/or and not both. I tried to find out if running my computer on a square wave power source will do terminal things to it but any computer techo's that I ask just go quiet and walk away muttering something about weirdos.

I also have a 500 watt invertor and my brothers' old 1400 watt monster that will handle 5kw in short bursts, both are modified square wave invertors. While they do produce 240volt AC it is not the same as the stuff delivered to your house by the power company, you have to be a bit careful, I killed the charger for a cordless drill with it, but it does power the charger for my electric bike (mind you I contacted the bike manufacturer first and asked if it would be OK). I used the big one to run my power tools, a whipper snipper and an old Hoover twin tub washer that also used water from the rainwater tanks pumped in by a little 12 volt pump.

If you are wiring up your own system and intend to include an inverter, please be aware that the stuff that is produced by the output sockets of the inverter is every bit as lethal as your house current and deserves the same amount of respect. Any permanent wiring of the 240 volt output must be carried out by an electrician.

If you still want to get an inverter to run some of your 240volt gear from your solar or wind system, the theory on how they work needs to be understood and it took an electrician friend several goes in very simple language to explain it to me. Even then I wasn't sure I believed it until I took some independent measurements and confirmed it was exactly as he said.

Say you want to run a 100 watt, 240 volt AC appliance, at 240 volts it will consume 100/240 or 0.4 amps but when run through the invertor at 12 volts it will consume 100/12 or 8.3 amps which is a pretty solid drain on the batteries. As you can see if you want to run a 1000watt 240 volt heater it ain't gonna happen with a small stand-alone power system like mine.

Lessons:

- Go with Sine wave if you can afford it
- Ask the manufacturer of what you want to power if it will cause a problem if you can't
- Don't leave them connected (especially the bigger ones) they draw power
- They put out 240vac which can kill you!

Metering

A DIY power system, at least in my experience, is not a set-and-forget type of experience the way the 240vac system is, it needs to be monitored because you don't want your first indication that something is wrong being when everything stops working. You want to have time while the batteries still have some life to identify, diagnose and fix any problems that crop up. This means that you need to have some indication of how the system is doing, and I found that to be a piece of equipment which tells me the battery voltage in real time.

Now I know I bagged out the Morningstar SunSaver Duo 12 volt regulator which I installed, but it did have one redeeming feature – A remote meter which I could install anywhere within the range of the 50 metres of telephone cable which connected it back to the regulator. When I decommissioned the SunSaver I left it connected to the batteries, not in any regulatory capacity, but still connected.

While the remote meter did provide lots of information, the main thing I used it for was to keep tabs on the voltage of both banks, but particularly the upper lighting bank. I mounted it on the wall of the kitchen, where I would be walking past most often. I would keep a check regularly and if something was off (usually a reading lower than I was expecting) I would follow up and check things out. It saved me heaps of hassles over the years.

Lessons:

- Use a good quality digital real time remote voltmeter and monitor it regularly

Loads

Lights

The use of lights has been a continually evolving part of the system. I started out using round, clear steel and plastic trailer lights with festoon 18 watt (double ended) bulbs. They were cheap, gave good light in a small area and were readily available. I still have one operating at the side of the house over the wood pile. Robust ones have become difficult to source and they have been replaced by other, much better technology.

As previously mentioned the trailer lights are good for small rooms, but for large rooms or where enough light for reading or for detailed work like the kitchen/dining room or lounge room they do not give enough light. I even found some fittings that held two festoon bulbs in a boating shop, they looked more professional but the cover/diffuser absorbed most of the light. So much for that idea!

Originally I did a bit of experimentation with a hand held fluoro but is seemed less effective than the trailer lights so they were it for a number of years. Eventually I did get onto caravan style fluorescent lights from the same boating shop and gave them a go. They worked very well with a few reservations. At $30 (at the time) they were still reasonably priced and with two 8watt tubes they gave considerably better light, to the point where I could read in the lounge room, for less power consumption. You beauty! On the down side each tube cost $4-$5 each (two per light, remember) and under heavy use could last as little as a few weeks and that gets expensive! They are very sensitive to low voltage and while the old trailer lights kept going, getting dimmer and dimmer, the fluorescent lights refused to work and the tubes wore out rapidly. They also show up line losses like nothing else!

Then I discovered halogen down lights – cheap, good point lighting and the bulbs last a long time. I installed two over our bed as reading lights and they have given good service for 10 years or so. Now I have one over the stove, one over the sink and two over the dining room table. The downside is that they chew power, and as a hint, use the 20 watt bulbs not the 50 watt ones supplied otherwise you're likely to give your batteries a heart attack!

The search goes on and when the fluoro in the lounge room finally expired, I consulted a specialized 12 volt remote area power shop. They turned me on (pardon the expression) to high efficiency 12 volt fluorescent lights, and they are very impressive. Low power consumption, the tubes are rumoured to last forever.

The light level they produce is as good as any 240 volt light I've ever used but the downside (there always is one!) is that they cost $120 each! At the point of their maximum use, we had a high efficiency 12 volt fluorescent lighting installed between the kitchen and the dining room, in each bedroom and the hall, one in the bathroom and two in the lounge room plus one out over the back deck. They can be difficult to get hold of, the average hardware shop has never heard of them, but the specialist alternative power system suppliers do carry them. While they do give excellent light and last for long time (mostly 10 years plus), when the light does fail it is usually the whole light rather than just the bulb, requiring replacement of the entire unit. That gets expensive!

At the moment we still have high efficiency 12 volt fluorescents (powered by the new system via a 24vdc to 12vdc converter) in 2 bedrooms and the hall, plus one in the lounge room and on over the back deck. All the halogen downlights previously mentioned have been replaced with 12 volt LED downlights 8 years ago and as the 12 volt fluoros fail they are replaced by 12 volt LED downlights which are much cheaper, use less power and give almost as good a light.

Lessons:

- LEDs are the way to go!
- Keep a few spares

The 12 volt fridge

There are compressor-based fridges that run on 12 volts on the market but they are expensive. I was also not sure how our system would cope with the drain, the batteries charge during the day but the fridge runs 24 hours per day. I know of people turning off the fridge over night to reduce the power drain, but when I mentioned this strategy to a refrigeration mechanic friend his hair just about stood on end!

My original idea was to get a Danfoss 12 volt compressor and absorber from Bias Boating Warehouse (Which was running at about $1000 at the time) and then build a super insulated chest fridge around it. My lovely wife was unsure how that would look and so expressed some concern (IE was dead against it!) so back to square one. Fortunately the above-mentioned fridge mechanic had his own business and was interested in 12 volt cooling so he said if I got a fridge and paid for a Danfoss 12 volt compressor he would put them together for nothing - Woo Hoo - sounded good to me!

So we went out and bought a "Homemaker" brand el cheapo 317 litre fridge from Kmart for $350 or so and stuck it in the back of the station wagon we had at the time. It is a very basic fridge and somewhat smaller than the main fridge we were using at the time, but with the kids moving out, and this being and experiment I thought it would suffice. My friend got the compressor and I reimbursed him the $600 or so, gave him the fridge and away he went. Two weeks later and I had a 12 volt fridge!
In any case, it became clear that the current system would not support the fridge in longer cloudy periods or around the winter solstice so I bit the bullet and bought two $1000 7.5 amp solar panels and added them to the fridge system. I still kept a Powertech 12 volt 12 amp DC power supply (ie it converts 240 VAC to 12 VDC) to run the fridge off the mains power in the event that the 12 volt system has troubles. It operated successfully up until I decommissioned the old system.

Strangely enough I ran the 12 volt fridge on the 240v off grid system using the DC power supply for about 12 months after the change over, but it then became obvious even to me that to generate 24vdc, convert it to 240vac, then back again to 12vdc just to run the fridge was a bit silly. The 12 volt fridge went to my mate with the tiny house and we got a bit bigger 'fridge only' unit which works on 240vac, has better insulation and is frost free.

Lessons:

- If you are going to make your own fridge, automatic defrost is good!
- The poor insulation level of the el cheapo fridge means it uses more power than it should.
- This experience REALLY focussed us on the amount of power refrigeration uses.

Others

We have a few other loads that have stood the test of time and are still in operation even after the changeover, that run on the new system through the 24vdc to 12vdc converter. We have a USB plug that fits into a car style 12 volt socket I wired into the dining room which we use to keep our phones, ipads etc charged. There is also the

12volt pump connected to the 5500litre tank which we use to water the front and back yards. There is also blower for the forge in the garage which is a 12vdc ex-car fan. We played around with other stuff over the years but most had been decommissioned as not being practical by the time the new system was installed.

Conclusion

There you have it, the results of over 35 years of tinkering and experimentation by a person who is non-technical in the field of electronics. My recommendation is that if you want to design and install your own system, then go for it, but make sure it stays absolutely separated from any 240vac wiring and each and every circuit you install has the appropriate fuse in place before you energise it. I have had lots of fun with it over the years and I hope you do too!

7.2 Wind Generators in Suburbia – The Detail

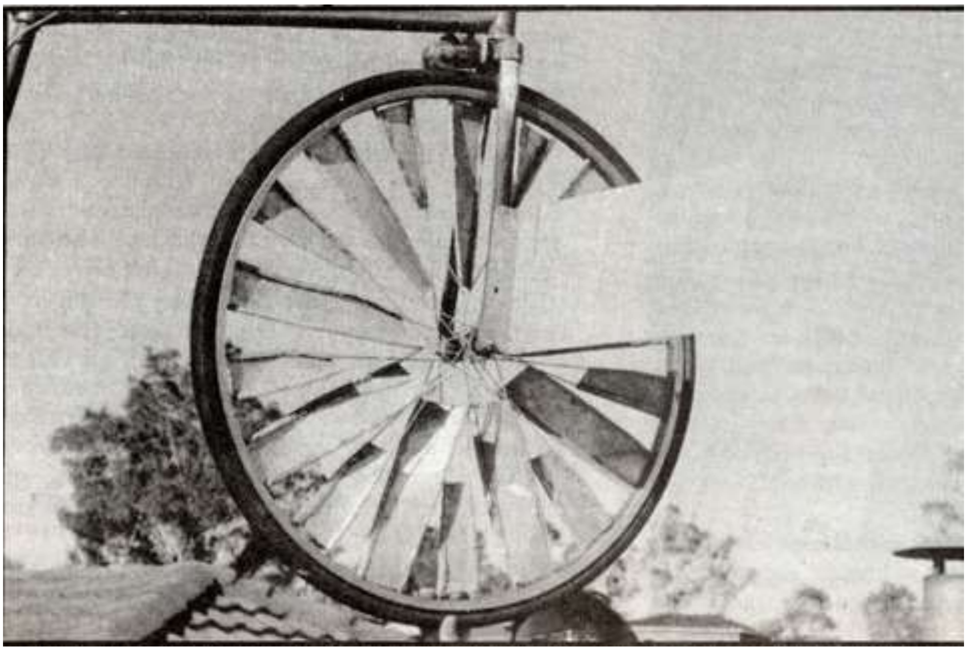
The idea of a wind generator has fascinated me since I first found out about them from an Earth Garden magazine article back in the '70s. Even in the early days I wanted to generate at least some of our own power and photovoltaics were still very expensive. There is also the issue of what to do when the sun wasn't shining and a wind generator fitted the bill precisely, the wind blows at all hours not just during the daylight hours.

I looked at the available designs from the Savonius rotor made from old 200 litre drums or made from scratch with lighter (but more expensive) sheetmetal (see the photo below taken at the **"Sun Powered Eukey Complex"** in Queensland), through to more conventional horizontal shaft generators where the wind turns a propeller, which turns the generator. In those days commercial models were expensive (if you could find one) and we had zero extra cash so anything I could get would have to be a home build.

First Generation

I came across a design for a bicycle-based wind generator which was not only within the price range I could cope with, it was also within my capabilities to be able to build it. It was a bicycle wheel, forks and headset, with metal over the spokes and a roller style bicycle generator (see photo). After being a local landmark (and eyesore) for a number of years it finally bit the dust over 20 years ago. Unfortunately, it proved to be all that photovoltaics were not:

1. It was not attractive, if you don’t believe me see the attached photograph. Speaking of the photograph, the reason for the poor quality is that the original (film) photo has gone walkabout and all I have left is this scan of the photo which appeared in Grass Roots Magazine no 71 (February 1989).



2. It gave off a noise in high winds that did annoy the neighbours, not to mention us too. The generator was mounted on the top of steel pipe which was in turn mounted on top of the garage roof, but braced to the house. The result of this method of securing it was that every little vibration was transmitted not only to the garage, but the house as well. It was mounted outside the dining room so this area got pretty noisy in high winds!

3. It required frequent maintenance, being a home build the wires were connected directly to the generator, no slip rings in between. The result of this is that every time the wind shifted (and here in suburbia with lots of turbulence it shifts pretty damn often!) the charging wire wrapped it self ever tighter around the support pipe. If I did not climb up and untangle the wire every couple of days it would either pull it out of the connector or stop the wind generator from turning to face the wind. Either way generation stopped.

4. At full belt it delivered less that an amp to the system, so even when it was working perfectly the output was miniscule.

It was just not practical, even if it was home made from recycled parts. However, if all of this has still not put you off, you can find more information on how I built it **here**.

Second Generation

The lure of the wind generator is strong.

I always wanted to make my own, hand crafted and based on a car alternator, but with so many projects I never go the time. In early 2005, there were some Chinese wind generators doing the rounds, producing around 200 watts at 12 volts, the kit was self-contained (including a steel pipe tower) but the whole thing weighed 70kg, add wind load to that and it was a substantial amount of weight to mount on the garage roof.

(Note: These are not photos of my Chinese wind generator. These are the nearest approximation that I could find on the net)

It was also comparatively large with a blade diameter of 2.5 metres. I figured I better get council approval (it was a bit difficult to hide!). When I rang them and after the obligatory 1 minute's silence for weirdo identification, they told me that inspections etc would cost $700 (although after much discussion I talked them down to a bit over $300) which would still add considerably to the costs of getting the damn thing up and operating (the original price tag was $450).

I also figured I would need to consult a structural engineer (expensive) because I did not have the technology to work out what loads would be involved and whether or not the garage was up to it. Would I have to reinforce the structure so it could cope with the loads? (more expense).

In the end I shelved the idea after concerns about the weight, costs and council hassles, I donated it to a local farm about 5 years ago.

Third Generation

As I said above, the lure of the wind generator is strong and while overseas I saw some much smaller and less obtrusive units in use beside the roads in the UK. After research back in Aus I found the AirX 400 watt 12 volt wind turbine, which is made in the US.
It was double the cost of the original Chinese unit but it was also twice the power (ie 400 watts versus the original 200 watts). Also it only had a blade diameter of 1.17 metres and weighed 6.5kg and was about as obtrusive as our next door neighbours TV aerial! It was perfect, so I ordered one.

To install it I mounted it on top of the pipe which used to support a Stationmaster CB aerial, which I no longer had a use for. That puts it about 4 metres over the top of the garage.

To be fair, vibration is still an issue and in moderate winds there is noticeable vibration in the garage but because it is mounted on the other side of the garage from the house, there is no detectable noise in the house, even in high winds. It is noticeably quieter and has been no problem for the neighbours to date.

It had comprehensive instruction along with it, giving wiring dimensions for various distances between the generator and batteries, fuse requirements (50 amp!) and the earthing requirements which had me hammering a 50mm pipe two metres into the soil. This last requirement was for lightening protection. A comprehensive set of instruction was a pleasant and welcome surprise!

It does work as well as can be expected, but it needs to be about another 4 – 5 metres higher along with all of the added costs and council hassles associated with that. Even in a strong wind the output is minimal, about 5 amps, purely because the turbulence due to the surrounding houses means that the wind direction whips around quite a bit. To get the most out of a wind generator it needs to be high up, near the ocean or on the edge of a plain where the wind can build up speed and blow continuously from one direction for a while.

Mind you, I do get a kick out of watching it rotate and there is a small red LED that tells me when it is charging the batteries. Yup, just because the blades are turning doesn't mean you are generating power. There is a critical propeller speed, below which you don't get any power, for the AirX that is 500rpm.

Years ago there was a discussion on a UK based self-sufficiency forum I was part of where suburban wind generators were described as "chocolate teapots" and not as a term of endearment! Unfortunately after all these years of mucking around I have come to the same conclusion, at least in our area of suburbia. My suggestion is that if you really want one of these bad boys, take careful wind measurements in the area where you intend to mount it. Take into account not only wind speed, but direction as well. Does the wind blow steadily or is turbulence and issue?

More designs are coming out all the time so the one you choose may work better in your situation than ours did for us. Good luck!

2019 Update

Well, the old wind generator has gone, gone to a friend who has a property down in Cootamundra. We have had a new solar electric system installed since this article was written and it is 24 volt not 12 volt. The wind generator remained connected to a vestige of the old 12 volt system which still powered the lights, but now even this has now been superseded and the supporting pole was in the way of a new water tank so it has been decommissioned and passed on to someone who will be able to make better use of it.

It has gone to a better place!

7.3 The 24 Volt DC/ 240 Volt AC Power System

Electricity Usage

Over the years we have worked hard to reduce electricity consumption to the point now where our electricity bills are telling us we consume between 4 and 6 kW hours per day for a two person household. Anyone thinking of going off grid should first conduct an energy audit and get hold of an energy meter (as we did) and then work at bringing their electricity consumption down as far as they can. This will reduce the overall cost of the system you put in and ensure that the system is sized appropriately for your needs.

There are other factors to consider too, and to size our system so that we could still operate but it would not cost the national debt to install, we had to make some decisions. After much to-ing and fro-ing we decided to do the following –

- We would design the system so that several large but rarely used loads would still draw from the grid, but all of our power points and the few lights still using 240v would draw from the new off grid system. These grid connected loads consisted of –

- the electric boost for our solar hot water heater (used 3 times last winter),
- the air con, (used a half a dozen times a summer to keep Linda from melting on those hot western Sydney summer afternoons), and
- a 15 amp socket in the garage, used to power my electric welder, which I have used approximately 3 times in the last 5 years.
- We would leave the current 1 kW back to the grid system in place, even though we would receive considerably reduced compensation for the electricity we put back into the grid. The idea being that it would work towards covering us for when we used the above-mentioned high consumption but low usage loads.

Batteries

The low maintenance deep cycle 12 volt battery bank which powers the fridge have had one battery fail in service already and from their current performance it was likely that others were heading the same way. The entire bank (4 batteries) were decommissioned and recycled. The original lighting bank of 4 x 6 volt deep cycle lead acid batteries are 10 years old and while they are still working well and retaining a charge, they are nearing the end of their projected service life. They were integrated into the new system originally, but only lasted a few months before they too failed and had to be decommissioned and recycled.

The two new battery banks for the off-grid system are each composed of 19 x 1.2 volt 100 amp hour nickel iron batteries. The batteries in each bank are connected in series to provide 24 volts and then the two banks are connected in parallel to double our storage capacity. But the issue is that the original system was designed around 12 volt lead acid batteries, whereas the new system is set up to be based on 24 volt nickel iron batteries. So, why change?

In Terms of Voltage

The change in voltage is all about current draw. To power the lights meant we were drawing somewhat less than 100 watts at 12 volts (or <8.3 amps) and so the wiring had to reflect that. The larger number of amps, the thicker the wiring needed to be to withstand the current otherwise the wiring could overheat and cause a fire. Another contributing factor was I wanted to be able to use comparatively cheap and readily available 12 volt technology like fans, radios, pumps etc directly without having to go through any extra electronics.

It is a general rule of thumb that you should not have a continuous current draw from your system in excess of 100 amps. While my inverter is oversized at 3000 watts, my usual draw is < 500 watts (42 amps at 12 volts or 21 amps at 24 volts) but I can draw 1500 to 2000 watts over time when we are using the microwave, sandwich press, vacuum cleaner or washing machine. This will result in a draw of up to 167 amps at 12 volts but only 83 amps at 24 volts, hence we designed our system to run on 24 volts. To design a system, it is a good thing to start by looking at your projected draw in terms of amperage then work backwards.

In Terms of Batteries

I know lead acid batteries. I have talked, read and experienced them and that familiarity meant that was the technology I turned to first, but there have been some new (and old) technologies becoming more available lately. The things I learned from working with lead acid batteries were that –

- They use sulphuric acid solution as the electrolyte and some WILL leak during charging. So make sure that you have something to catch it in (plastic trays under batteries etc), that it can't come into contact with metal components like steel shelving and that you wear acid resistant clothing when working with them. I have not increased my popularity in my household by getting large acid holes in new shirts, jeans etc.
- Deep Cycle does not mean DEEP CYCLE – to make sense of this you need to understand that I thought that you could discharge a 12 volt deep cycle battery down to ohhh, I dunno…….9 volts? When I did this I found it reduced the life of the battery bank significantly (ie they got less than half normal service life). It seems that lead acid batteries of the type used in cars are designed to start the car then run back up to full charge straight away. Deep cycle batteries can be run

down to 12.0 volts, but the more they cycle down this low the shorter their service life.

- The reverse is also true. If you overcharge the batteries their service life will be drastically reduced as well, so it is really important to have a good quality battery charge controller to prevent this happening. This is important regardless of the amount of charge going into the batteries, even if it is just a few amps trickle charge.
- The best possible performance you can expect from your batteries ie how much charge they will store, will be the very first time you hook them up. After that it is a (very) slow decline to where in 8 to 10 years, even if you treat them well, they won't carry a charge in the proverbial bucket. If you don't treat them well, as referenced above, it will be a lot shorter time than that.

Nickel iron batteries are new to me, but I am learning quickly and what I have learned is –

- They use potassium hydroxide solution as the electrolyte. This is nowhere near as rough on clothing or steel parts as sulphuric acid is, and there is no external leakage from the batteries, so your chances of coming in contact with it are reduced considerably. If you are buying your batteries dry and making up your own electrolyte, please be aware that potassium hydroxide solution is more hazardous to the eyes than even sulphuric acid is – so PLEASE wear chemical goggles and/or a face shield!
- Deep cycle means DEEP CYCLE! My 24 volt banks of batteries can be run down to a bit above 19 volts and will still be OK the very next day when the sun comes up to start charging them again.
- These batteries are robust! You can charge them up to 30+ volts without damaging them too.
- When you connect your batteries up and use them to power something, and you keep an eye on battery voltage (as you should) you may be shocked (as I was) to find that initially they hold charge like a sieve holds water. DO NOT be alarmed! This is the way this type of battery works and may take a month or more to bed in and hold a full charge.

Another thing in favour of nickel iron is that they have a projected life that may be 20 or 30 years and I am aware of one set that is still going after 50+ years. So this set will see me out!

My problems mostly stemmed from thinking of the nickel iron batteries in terms of lead acid batteries, but in some aspects (as discussed above) are totally different animals. So while I thought I had a lack of storage capacity, I actually needed more generation capacity.

The big hint is – do your research! Don't take my word, or anybody else's for that matter, have a look at some of the good info out there on the net, and see how you

Power Generation

The solar panel part of the system basically developed in three distinct spurts –

Spurt 1

On the day we did most of the work on the installation I had a working bee at our place to give people an opportunity to learn how to do this. My solar guru (I dunno……. Let's call him Mike!) ran it, I charged people to come, and it covered the cost of his services for the day. (win – win!).

On that day the guys made up a support frame for the 6 solar panels I already had which were going to form the nucleus of the new system, ie 2 sharp panels (130w 22v 8.09 amps each) already in use plus the four SolarE panels (130w 17.3v 7.51 amps each) which had been sitting in the garage since I bought them some years ago. They made the support frame out of 50mm x 50mm x 2mm aluminium angle, bought specifically for the purpose, and pop riveted them together.

The southern end of the panels are supported by the framework made up of a top and bottom horizontal piece, connected by four vertical pieces to support the panels at an angle of 45° approximately. The top horizontal piece is pop riveted to the panels and bottom is pop riveted into the roof of the garage (more about that later). The bottom of the panels are supported in a single horizontal run of aluminium angle which is also pop riveted into the roof of the garage.

Now, the roof of the garage is composed of steel Hidek profile roofing, which means that it has wide flat bits, with stiffening ribs every 200mm or so. Anyway, I have always mounted panel supports on the top of the stiffening ribs to reduce the likelihood of leaks, but the guys installed the panel supports on the flat bits in between. I expressed my concerns but was told the pop rivets would be tight enough to stop leaks. Word to the wise – they're not!

With the system installed and the panels in place it was just a case of waiting to see how much power we developed, unfortunately it was not enough! Hence….

Spurt 2

To increase the power we were getting to somewhere (hopefully) where it needed to be, I bought in four Stion brand 140watt thin film panels, they were recommended by mike as being particularly good in low light conditions and that has certainly been the case.

They were installed professionally with their own isolator on the western facing back roof of the house. We have only a small amount of north facing roof which has, for the last 35 years or so, been home to one sort or other of solar hot water system, so the new Stions were installed on the back as it was the largest continuous bit of roof we have.

This resulted in a total power output of 1200 watts, maximum, which in high summer is fine. Our house consumes about 5kWhr of electricity per day, minimum and so on the shortest day, and for a month or two either side, 1200 watts would not be enough. The output of the panels was still well within the maximum amperage the MPPT could deal with, which was 50 amps, so this lead on to –

Spurt 3

To make sure that I had enough power for the shortest day I bought and had installed professionally another 8 Stion brand thin film panels. I had them installed in two sections so that it would spread my power generation over the course of the day, rather than flood the batteries with power and exceed the ability of the MPPT to direct all the power to the batteries. So five panels went onto the western side of the roof, just north of the original four, and the remaining three we put on the front (eastern side) of the house roof to catch the early morning sun.

The closest 5 panels were in Spurt 3

Theoretically the system would yield a bit less than 2.5 kW but practically the maximum we get is about 1.8kW, which is a bit more than the MPPT can deal with but anything over the 50amps it is rated for doesn't get fed through to the batteries, it hasn't caused a problem so far.

The result is that if the shortest day is clear, we get about 5 to 5.5 kWhrs for the day so it works!

Electronics and Control Gear

The Maximum Power Point Tracker (MPPT)

To get the best out of an off grid system there needs to be some form of charge controller or regulator between the energy source (in our case, solar panels) and the energy storage, in our case nickel/iron batteries. The original solar/lead acid battery system I had put in years ago did not have a regulator originally, because I had read that charging at a rate less than 10% of the battery storage capacity meant you didn't need one. In practice it turned out that not having a regulator resulted in reducing the battery life by over 50% and this was a pretty basic, low tech system. In the newer more high tech off grid power systems having an appropriate regulator is even more critical. For my previous systems I had used regulators which operated as Pulse Width Modulators (PWMs). They work by sensing the battery voltage, then switching the voltage coming out of the solar panels off and on, and varying the 'on' and 'off' cycles of charging so that the battery gets charged effectively without overcharging and wrecking the batteries. They also prevent charge being lost from the batteries by power being fed back to the solar panels at night, although some panels do have diodes in place to prevent this too.

The MPPT (or Maximum Power Point Tracker). Rather than switching voltage off and on uses algorithms to constantly adjust itself so that the voltage output from the panels is constantly at the optimum required to charge the batteries. Due to the fact that MPPTs are more efficient at extracting power from the solar panels, they provide improved power harvesting low light/overcast situations.

Certainly, our new off grid system is more productive on cloudy days than our original PWM regulated system. There are other differences between systems also but this does seem to be a critical one.

Our MPPT

The MPPT we installed is a Victron Energy BlueSolar Charge controller MPPT 50/100 and the way it is configured it will accept up to a maximum 50amps from the panels at 24 volts. As we are up to (and at times a bit over) that from the existing panels, if we want to install more panels we would need another MPPT.

All outputs from the three arrays of solar panels (Front roof, rear roof and garage roof) are all run through the single MPPT and while I have had people comment that it would be more efficient to have a separate MPPT for each panel array, the current system works for us.

As the batteries are charged by the panels through the MPPT, they go through three different states which are managed by the MPPT –

Bulk – This is the first state, which starts up when the sun first hits our panels, and when the batteries are less than 80% full, allowing the panels to feed in as many amps as possible thus charging the batteries quickly.
Absorption – depending on the voltage this is set for, usually when the batteries are 80% - 90% full, the batteries remain at a pre-programmed voltage (which will vary depending on the type of batteries used) with the amperage being provided to the batteries slowly dropping as the batteries fill.
Float – at this point the batteries are fully charged, as read against the pre-set voltage and the amperage fed into the batteries becomes a trickle, set to maintain that pre-set voltage.

Our MPPT has three lights in the lower right-hand corner, showing whether the batteries are in the bulk, absorption or float state.

There is another term of interest here – Equalisation charge – This is where a pre-set overcharge is fed into the batteries on a regular basis (automatically or manually) which removes a build-up of sulphate on the batteries, improving battery life. This is also managed through the MPPT.

Our MPPT is set up so that we can monitor the system from inside the house (all the solar electronics being in the garage) to an app installed on our phones, but it can only be read up to about 15 metres away from the MPPT and on one phone at a time. There are three screens on the app providing data on how the system is operating –

Status – real time readings of solar charging wattage, current and voltage, and battery voltage, current and charging state (see photo at left).

History – Daily kilowatt/hour total for today and the last 30 days, maximum solar current and voltage for each day and maximum and minimum battery voltage for each day.

Trends – real time graphs of what is happening in the system over time for two of the following: solar current, solar voltage, solar power, battery voltage and battery current.

The MPPT operated pretty flawlessly for 4 years. There was a bit of an issue about 12 months ago when it appeared to have stopped working. I was able to get a replacement to trial within a couple of days, but it showed the same symptoms as the original. The problem turned out to be a burned out switch.

Unfortunately, due to a loose connection on the main positive line from the battery
It is important to have the right gear to control and monitor the operation of your off grid energy system and we have found the MPPT which works well for us.

The Inverter

The inverter, in a sense, is the heart of our system, it takes the energy produced by the solar panels and stored in the batteries and turns it into something that can be used to run the entire house. An inverter takes DC current, in our case 24 volts DC, and turns it into 240vAC, allowing mainstream appliances and lighting to be used with an alternative energy system.

I have fooled around with inverters before as part of our old 12 volt system, going from 12vDC to 240vAC, but most of the old house system was built around 12 volt lighting and appliances so the inverter was for small and specialised gear not available in 12 volt.

All that had to change when we went with the new system, because it was designed to operate the house as it is, using the standard 240 volt system wired in when the house was built. Needless to say the wiring up of a built in inverter is not something I could do, it needed to be done by someone with electrical qualifications and experience in this area.

The discussion around how big an inverter to get (ie how many watts at 240v it could supply) was interesting. There are two main things we needed to know when sizing our inverter and the first one was – how much power were we likely to want at any one time? We just looked at the sorts of appliance we would run regularly and then worked out the one which used the most power. We found the dishwasher at about 1800 watts maximum was the most energy hungry appliance, but we still needed enough energy over that to continue to run lights, the fridge, freezer etc at the same time.

We sized our inverter at 3000 watts to be able to do what we wanted to, but if we run the microwave or the sandwich toaster at the same time it will crash the system, but more on that later. So once we knew what we wanted to run it was then a case of asking how much energy the system could supply. In our case it was a moveable feast and I added more panels in a couple of steps until the system has a nominal generation capacity of 2500 watts total although in reality it produces somewhat less than that at any one time.

At this point I would like to mention that we left three things off the new system so that they draw directly from the grid due to their high power draw but low usage rate ie we don’t use them much, but when we do they really suck power! These items are –

- The air conditioner,
- The electrical boost on the solar hot water system,
- A single 15amp socket in the garage which I use to power a small electric (stick) welder.

The inverter reads the power in the batteries and the sucks it out to power whatever it is we want at 240 volts. Obviously it can’t do this indefinitely or the system will run out of power, but what does that look like? Basically the inverter reads the battery voltage and when the voltage from our 24 volt system drops below 20 volts the system shuts down, and that is exactly what it sounds like! All power coming to the house from the inverter stops.

Thankfully, because there are some lights which were part of the original system and are still connected directly to the batteries via the 24vDC to 12vDC converter, when the system shuts down we still have some lights. And when we were first getting used to the system we shut it down A LOT! It still happens occasionally if we do something stupid but we are much better than we used to be.

The inverter does have the capacity to remain connected to the grid, and switch across to the automatically and seamlessly (most of the time, occasionally there is a glitch that will shut the system down even if the inverter is operating on back-to-the-grid mode). There is a black switch in the switch box next to the inverter which allows us to take the entire off grid system off line and go back on grid full time. The second (orange) switch allows us to be totally off grid (down) or have the option for the inverter to switch us back to the grid if needed (up). The problem is if the inverter is left in the “auto back to the grid mode” it will consume a small amount (20w – 40w 240vAC) of power from the grid in maintaining the link. Because of this, in mostly I leave the switch in the “off grid” mode.

Maintaining us in off grid mode means that we occasionally have accidents if the weather is not good for charging but I keep tabs on the batteries through the MPPT phone app and change over as required. The inverter has worked well since installed, with the exception of the aforementioned glitch that will occasionally shut the power down instead of going back on the grid.

The 12vDC to 24vDC Converter

The off-grid system puts out 24 volts DC, which then goes to the inverter and is converted to 240 volts AC, so it can power all of the 240 volt stuff in the house. However, there are parts of the old 12 volt system still in use, including all the lights, a small pump and a few other bits and pieces. Rather than go and replace everything, I wanted to keep it operating.

The answer to my prayers was a small DC to DC converter (ie 24 volt to 12 volt converter), which would enable me to run the old stuff on the new system. I still wanted to be able to run the old stuff on the old lead acid battery bank if I needed to. Having the lights running on the old system proved to be particularly handy when I was bedding the new system down. Every so often I would get things wrong, overstretch the new system so that the inverter shut down and we lost power. If this happened at night, we would have lost the lights as well but because they were still operating on the old system, I could at least see to work out what I had done wrong with the new system.

Unfortunately, as mentioned above, they operation of the old 12 volt batteries became a moot point when they crashed and had to be decommissioned and recycled. The lights and a few other selected bits of gear still run on 12 Volts and this is both good and bad. It is good when we (still) try to run too much and shut the system down, which is easier to do at night when there is no charging, and the lights still work. It is bad when we have protracted bad weather, particularly in the cooler parts of the year when we get less sun anyway. This is because the system uses the grid as back up, but does not put charge back into the batteries so that they are drained by the lighting, with little charge going back in. This is not a huge problem and probably happens for a few days less than once a year so we generally make our way through it if we are mindful of what we are using.

7.4 Low Energy Lighting

These days it is possible to install a back-to-the-grid solar generating system based on photovoltaic panels and an inverter for a few thousand dollars. It will help to offset our electricity bill while a favourable feed-in tariff is in place and reduce our carbon footprint. However, the system won't be much use during a power outage.

Similarly it is possible to install a stand-alone alternative power system using photovoltaic panels, wind generators or micro hydro or a combination to generate power. The electricity generated is stored in deep cycle lead acid batteries and then conveyed to the point of use, with or without recourse to an inverter. This system will be of use in the event of a power failure but requires time, effort, expertise and (dare I say it?) money to design and install.

You may not have the cash for either system, be a renter instead of an owner or just not want to go to all that trouble. If you do want to design-your-own 12 volt power system, Check out Section 7.0 to read about my experiences. But if you don't, what are the options?

I'm glad you asked!

There are a number of small, inexpensive, solar charged components which can be used either by themselves or in combination to help you develop your own solar lighting system. If you are not flush with cash and/or do not own the property where you are living this could be the answer for you. You can save money on your electricity bill as well as reducing your carbon footprint and still have light if the power goes out!

Solar Garden lights

These come in a huge number of designs and can be very cheap, as low as a couple of dollars each in the el cheapo shops or upwards of $50 each in the more upmarket establishments, depending on the design. Needless to say, I am talking about the low end of the market!

These lights are generally composed of a small solar panel which sits on top of the casing and faces the sun, a single LED light, an off/on switch and a battery of some description. The set-up can also sense the sun so that the light only comes on at night. Quite often the solar panel/light/battery assembly can be removed from the casing which allows it to be charged and used as a light inside your house. If you are shopping around, go for the one with the biggest battery so that it will give you the longest life on a days' charging in the sun.

A friend of mine was having difficulties with the battery not contacting the metal contacts and so the lights were not working. In the configuration of light he had, he pulled everything apart and secured the small panel, light and battery to a baseboard and soldered the contacts to each side of the small round watch batteries which powered his lights. He lined four up together to make a light that he would leave out in the sun and then bring in at night when it was ready for use.

The type I found allowed the whole top assembly to be removed from the lens and the rest of the casing so they could be used as a small unit individually. They are square and can be left on their sides with the photovoltaic panel facing the sun. To charge the switch must be in the “on” position, then when the sun goes down they come on automatically.

Either way this type of solar light is cheap to buy and easy to use, although one small LED doesn’t light up much. They work well where you need light to move around, especially in a small room where they provide enough light to do what you need to do. One by itself works well in a toilet and two work well in a bathroom or laundry room. I bought four and even when they are all on together they only provide enough light to allow safe access in the lounge room or larger bedroom. Although all four in a smaller bedroom allows you to do some stuff but reading and fine work is out unless you want severe eyestrain.

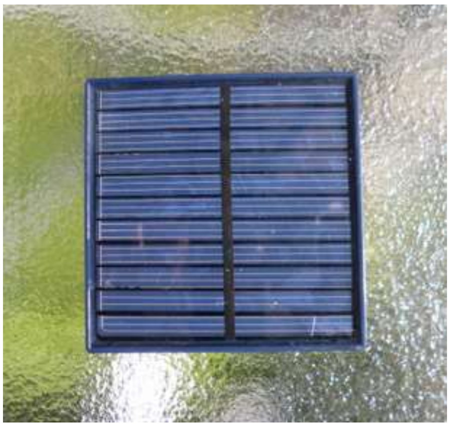
One issue is that they provide a fairly intense point source like a candle rather than the more diffuse light from a fluorescent or incandescent bulb which we are used to. Speaking of candles, did the old put-the-round-wine-glass-full-of-water-in-front-of-the-light-to-increase-the-beam trick. While it did provide a narrow beam which could be directed onto something to highlight it, the beam itself did not light up the room any better.

I also tried putting all four lights in front of a mirror to reflect the light back into the room, it also didn't seem to do much. So I put some diffusers over them to improve the light, one from the original garden light set-up and one from a caravan 12 volt fluorescent light. The only effect seemed to be to reduce the amount of light put out into the room. The only thing which did seemed to improve matters was to place a sheet of white cardboard or paper behind the lights. It not only reflected light into the room but scattered it so that the light level actually seemed to improve.

Sunnan Solar Light

These were available pretty cheaply (about $20) from Ikea but have become more difficult to get hold of. They are a unit with three light emitting diodes in a flexible lighting head that curves around and down to a base which contains an integral solar panel and battery unit. This unit provides the weight to keep the light upright and can be removed from the base and placed in the sun during the day to charge. A friend of mine has even made a frame out of wood to keep the units at the right angle so that they get the most out of the light when facing the sun. You can get a couple of nights use on a day's charge.

They are ideal for task lighting such as reading, sewing, typing on a keyboard or preparing food. They provide quite bright light over a small area, say a diameter of 30-60cm. They can be carried with you also to facilitate moving around. We have a couple and find them to be very handy, our daughter even had one set up in her bathroom when the overhead light blew.



Solar Shed Lights

These come in various sizes and shapes and are composed of a small solar panel which is connected remotely by wire to a light (usually LED) which has a built in battery and an on/off switch. The idea is that the solar panel is mounted permanently outside the space you want to light and the light/battery combo is mounted inside with the wire being fed into the building to connect the two. If you can get access to an area of sun close enough to a window, door or other access these are a good idea.

While they are designed to remain wired in place, if the area you need light does not provide access from outside or a sunny area for the panel to charge from you can still remove the whole assembly and place the panel in the sun outside. Once the battery is charged outside, bring the assembly back inside and mount the light where you need it. It is more of a pain to operate this way but will still work.

Another option is to secure the panel in an appropriate place (full sun for as much of the day as possible). There is usually a plug and socket join in the wire somewhere between the panel and the light so you can connect up the light during the day to charge and then unplug it and take it inside for use at night. The light generally has some slotted screw holes (keyhole in shape) on the back used for mounting the lighting assembly. By affixing some screws to the wall or furniture, you can mount the light where it will do the most good.

The one I have has 10 LED lights and cost me less than $15. It is reasonably bright and allows for moving around and doing stuff like washing up, food preparation and eating plus possibly playing games depending on where the light is mounted. It does not produce enough light to read by if mounted to provide room illumination but if mounted a couple of feet from the book you could read by it.

An Integrated Approach

Each of the different types of solar lights have their merits and drawbacks so it makes sense to have a number of each. The solar garden lights can be useful in the smaller rooms like bathroom and toilet and to allow movement through hallways. The Sunnan lights are great for task lighting so you can read or sew in the evening, whereas the shed lights provide better lighting in the larger rooms and where more light is needed for food preparation, cooking and eating.

All of the lights are comparatively cheap and for less than $100 you can have a basic system that will help you move away from the power company and generate your own power, for lighting anyway. This will reduce your electricity costs, eventually paying for itself, as well as improving your carbon footprint and the neighbours will be jealous of you next time the power goes out!

7.5 Cooking with Solar Electricity

It's funny, but when we were living mostly on the grid with only the lights and fridge running through a 12v solar/battery set up, we passed on a lot of our electric appliances to friends to reduce our electricity usage. We did this especially with the appliances which used electricity to generate heat for cooking and replaced them with a number alternatives such as the solar oven, rocket stove, wood heater (with cooktop and oven), stored heat cooker and the gas stove. Now, while we still use those alternatives, we are producing more solar electricity than we use in summer, and I was looking for ways to take advantage of some of this excess.

But I also wanted more!

I wanted appliances that would reduce our need to burn gas for cooking, thus reducing costs and greenhouse gas emissions (the electricity being solely produced by the sun. I also wanted appliances which were versatile and could be used to produce a number of different types of dishes. They should not be too expensive (OK no 3 is a bit pricey but it makes sense when you think about it) and they should not be too power hungry so that the batteries would not be swearing at me when I turned them on. Again, no 3 is a bit different but it is controllable. This is what I have come up with:

1. Rice Cooker

Addesso brand (Model No CFXB22G) 5 cup rice cooker rated at 400 watts

Rice cookers are remarkably convenient, once you set them up and turn them on they will run until the rice is cooked and then switch automatically from “cook” to “warm” keeping your cooked rice or whatever warm until you want to serve it. They are also wonderfully versatile! We started out just cooking rice, but then moved on to our own recipe for **rice and beans** which also contains diced veg, which we serve with a curry sauce.

Obviously the rice cooker was designed to provide well cooked rice every time and riced based dishes such as vegetable biryani, chicken rice, risotto, rice salad, Asian style paella and various fried rices, will all come out well cooked each time. However, you can cook lots of recipes that are not primarily rice as well. These include –

- pasta dishes and noodle dishes
- Beef, chicken, pork or seafood recipes (any number of curry recipes exist for these proteins)
- Legume dishes like lentil soup or chick pea curry
- Egg dishes including curries, omelettes and even scrambled eggs
- Plain or spiced vegetable dishes like steamed veg or vegetable curry.

The rice cooker does not use lots of power, well within the demands of our system, and it generally takes only 10 to 15 minutes for riced based dishes but can take longer for other styles of rice cooker cooking!

2. Slow cooker (AKA crockpot)

Russell Hobbs brand (Model 4443BSS) 3.5 litres, rated at 160 watts

While I am a fan of stored heat cookers (see above), there is an undeniable charm around the set and forget cooking style of a slow cooker. We have enjoyed making a number of dishes generally around wet cooking ie soups, stews, and casserole type of stuff.

A favourite is a wonderful **freezable vegetarian dish** based around legumes such as red kidney beans, black beans and chick peas, veg such as corn and Mexican type spices. I make it and then after eating it one day, freezing the rest for ready meals. We found the recipe on Tasty.com but there are lots of cookbooks out there. We are moving towards a vegetarian diet but the humble slow cooker is renowned for its superpower of making cheap cuts of meat tender.

It is only recently that I have become aware that slow cookers can do other things than the standard soups, stews and casseroles. They can, in fact, be used to bake bread, make yoghurt, cook porridge, as well as making cakes, sauces and desserts. They are a remarkably versatile device, which will enable you to get the most out of your solar electricity a while preparing delicious meals.

3. Induction Hot Plate (Portable)

Philips brand (Model HD 4992) Rated at 2100 watts

This hot plate is considerably more expensive and certainly uses lots more power than the previous two appliances – but!

It has been a recent acquisition for us because up until recently I saw the power consumption and thought “my poor batteries” and didn’t bother. However I saw one operating at a friend’s house and realised that you can turn them down!

Induction cookers have a number of things in their favour, and one is very efficient conversion of electrical energy to heat. The hotplate does not heat up itself, but induces a current in the conductive bottom of the cooking pot so that up to 90% of its heat is transferred to the pot versus 35% to 40% for gas. It can boil our kettle for tea or coffee in 3 minutes flat! I wanted it also so I could take advantage of the long summer days when preserving tomatoes and tomato sauce to boil water for processing the jars without going through a stack of gas.

It is not all beer and skittles however. The cooktop does need a cooking pot with a magnetic bottom (you can test using a magnet) or it will not work. Also, while it excels in boiling water, cooking wet stuff and steaming our veg, it has taken some getting used to for frying, and it does have a tendency to burn if not monitored well. Some things (like my world famous veggie patties) I still need the constant low heat of the gas on low to get right.

They can be very cheap (around $50), but my researches turned up that the cheaper ones don't last as well (surprise surprise), don't have the flexibility and don't have cooling fans (which improve service life) so we paid $175 for ours. While it is rated at 2100 watts we have found that for most things 1800 watts seems to be its maximum setting and for some things, like frying, it can be turned down to 300 to 400 watts and still work very well. That way I can monitor the state of the batteries and if there is a problem I can turn the hotplate down. Overall, we are very pleased with it though.

It has been interesting getting back into cooking using electricity again, and if you'd said to me a couple of years ago that this is what I would be doing, I wouldn't have believed you!

8.0 Cooking and Heating with Biomass

8.1 Cooking with a Rocket Stove

8.1.1 Introduction to Cooking with a Rocket Stove

To start it, crumple up a bit of newspaper and push it down into the combustion chamber without completely obstructing the air intake, get some thin dry twigs and push them into the fuel chamber until the protrude into the combustion chamber. Then drop some lit matches down onto the paper until it catches, it may take a few or you might want to add a few drops of accelerant like kero or metho, but not petrol (Which is too damn dangerous!). Even with the metho make sure not to look down into the combustion chamber when you drop in the match or you may lose an eyebrow or two, think Adam Savage on Mythbusters.

While I have read reports of these things starting up “like a rocket” that has not been my experience, it tends to start slow and may take a few minutes to really get going, especially if the fuel is not bone dry or if the weather is cold. Use the same process you normally would for starting a fire – start out with thin easily combustible twigs and then once the fire (combustion chamber) has warmed up you can use twigs up to 10 -12mm in thickness and it will go like a rocket!

Due to the output of the rocket stove hitting the bottom of the cooking vessel and then being directed around the sides, it seems to me ideal for use with the rounded shape of a wok and the high heat, high speed also suit the wok style of cooking. The wok ring used to support the wok on top of the rocket stove keeps it pretty close to the right distance from the outlet for the hot gases and the ventilation holes in the side are close to the same surface area as the combustion chamber outlet. In other words, all the heat from the twigs hits the bottom of the wok. As an experiment I half-filled our most used size of wok half full of water and was able to heat it from dead cold to over 90°C in a 20 minutes or so.

While it takes a bit of food preparation, usually done inside, the cooking done on a rocket stove outside is essentially no different in concept from cooking on a barbeque, just a lot quicker and more efficient. I have cooked fried rice, Chinese style omelettes and a number of stir fries using our rocket stove, and I continue to be amazed at how easy, efficient (and fun!) the cooking is, and it floats my boat that I can cook out dinner with a few twigs grown in the front yard. Following is how I do it –

Preparation is important in this style of cooking so I harvested the veggies I was going to use and cut them up into strips, rounds or small lumps and set them out on two cutting boards ready to be taken outside, I also broke a half a dozen of our home produced eggs into a mug and whisked them with a fork. Alas the noodles I was using were not homemade but bought fresh from our local supermarket. I took all of the ingredients as well as the sauces out onto the back deck in preparation for cooking. I have not gotten around to making legs for the rocket stove so placing it on the back deck while I stand on the ground brings it up to the right height and the deck itself provides plenty of workspace to set things out where I can get at them.

Once everything is in place I started the stove and waited until we were getting a good draught of flame out the top, the wok went on top and some oil went in to heat, once the oil was smoking (just a minute or two) the egg went in I moved it around until it was cooked and cut into lumps, I then removed it from the wok into a container. The wok reheated within seconds, and I added the veggies one type at a time, onions and hard veggies first, followed by the softer ones with about a minute of cooking between each one and then put the cooked egg back in to reheat.

With the eggs and veggies cooked I tossed in the noodles and heated them through and added the sauces, in this case some oyster sauce and char siu (Chinese barbeque) sauce. While the additions and cooking was going on I was keeping an eye on the heat and adding new twigs as the originals burned down. A stoker would be handy but I have been quite able to keep the fire going and still cook with all the dishes that I have made with the rocket stove so far.

The dish was finished so I took it inside to eat, removing the largest of the still burning twigs and letting the fire burn down. Once the fire was out, I tipped the small amount of ash left onto one of the veggie patches. So I was able to cook a meal for three, with leftovers, in about 15 minutes or less using just trimmings from the mulberry tree taken last year.

I did put the rocket stove in the garage as rain was predicted and water in the wood ash insulation removes or reduces any insulating properties and causes it to all clag together, so if you are using wood ash to insulate your rocket stove, keep it dry!
You can even barbecue over a rocket stove (Vegetarians avert your eyes)

8.1.2 Making a Rocket Stove – Type One

This little low-tech wonder of high efficiency cooking was developed by an American gentleman, Dr Larry Winiarski for use in the third world to reduce firewood usage. I have also seen them referred to as right-angle stoves.

I had been aware of them for some time but made a critical error in understanding how they worked and only recently realised their true value and made one for us to use. They are ideal heat sources when the sun doesn’t shine and use sustainable, renewable biomass (wood).

In principle you take a right-angle tube about 100mm in diameter or 125mm square and insulate the firebox heavily so that head from the fuel goes into cooking your tucker rather than heating up the stove. You can use thin wall steel for your right-angle tube- like tin cans or galvanised stove pipe, I used a bit thicker wall tube because it was what I had lying around, but also it will last longer. You can use a mixture of clay and sawdust to make insulating bricks to construct the right-angle combustion chamber but you have to work out a way to fire them. By and large the steel combustion chamber works for me!

Construction details

The outer casing of the stove is easy to build out of a recycled 20 litre tin which, again, is what I had hanging around, I also had the 90mm steel tube and some ashes hanging around to use as insulation. I could build this thing for virtually nothing!

I cut a roughly 90mm hole about 35-40mm in the side of the tin about 35-40mm up from the bottom and another 90mm hole in the centre of the top. I did this by first using a set of steel dividers to scribe where the holes would be, then using an electric drill and a 2mm or so drill (all the marking get worn off my drills, comes from not tightening up the chuck enough) holes inside the circumference of the scribed circle. By jiggling and angling the drill back and forth you can sever the small webs between the holes. Then using a round file and ball pein hammer you can clean up the hole so it actually looks round! Due to the curve of the tin the hole in the side will need to be a bit wider than the scribed circle but a bit of extra filing and a bit of tapping with your ball pein will sort it out. Try your tube for fit often to make sure you don't go too far.

That part was relatively straight forward except that I chose a Sydney heat wave day when it was 45ºC in the garage and I was sweating like a pig! I then had to cut the pipe on an angle so that when I turned the pieces around they met at a neat right angle. I figured I would do this the same as I would for a bit of square timber by marking off the section to cut with two parallel lines around the tube 90mm apart and a then marked an angle around the tube between the two lines so that I had a line at 45º around the tube. I then cut this line using an angle grinder (my favourite tool!) fitted with a metal cutting disk. This should have meant that when I turned the two cut ends of the tube around, they would meet at a neat 45º. Did I ever tell you that I don't understand the 3 dimensional geometry of tubes? The cut surfaces had a really weird profile and lots of open space, but with my trusty angle grinder, this time fitted with a grinding disk (did I mention it is my favourite tool?) I tapered the angle off to something closer to 40º and the fit was reasonable.

My next trick was to weld the tube in the right-angle position. Ummm I'm not as good a welder as I thought I was either, but with the arc welder on 70 amps and with a couple of 1.6mm rods I managed it with a minimum of blow-throughs and curse words. It don't look pretty but it will hold together and be a sealed joint. If I had had an oxy-acetylene set I would probably have done a better job, but I didn't so there you go.

All of this just goes to illustrate why people buy an already formed right-angle section of stove pipe, so they don't have to go stuffing around like I did to sort out that part of the design. All in all to cut and weld the tube probably only took me about 4 hours…………….easy! If I was doing it again I would probably make a tin-can or paper mock up first so that I could work in some easier material and get the real thing right first time. I'm a bugger for not doing that though!

I hunted through my stock of scrap metal and came up with a length of 6mm steel strap. It was somewhat thicker than I was looking for but would do the job and the width and length looked good. It had a couple of angles welded to it but judicious application of my favourite tool and they were gone. I then tack welded this piece into the bottom of the combustion chamber so that the fuel would sit on this plate but as the fuel burned, air would be drawn in underneath to ensure that there was efficient combustion. The plate should sit in the horizontal fuel chamber but not protrude into the vertical combustion chamber.

I then installed the right-angled tube into the supporting steel 20 litre container and poured in the ashes that I was going to use as insulation. I had been saving ashes from our two wood burning heaters for use in the garden but in keeping with the ethic of using stuff that I had on hand, in they went. You could use perlite or vermiculite, anything that would stand up to the heat and contain trapped air to act as an insulator. Sand and earth etc. are good thermal mass, ie they absorb and retain heat but are not good insulators so should not be used in this case.

The next thing is to set up some chocks for the cooking pot, wok or whatever to support it the right distance above the hot gases coming out of the stove chimney. To make sure that as much of the hot gases as possible are used, the pot should be arranged so that the area between the end of the chimney and the bottom of the cooking pot is the same as the cross sectional area of the chimney itself.

I use ours quite a lot with our wok for stir fries, omelettes and the like and find that the commercial wok ring that I use to support the wok over the output of the combustion chamber works really well. I have a cast iron square fry pan sort of thing I use with it for barbeques and that works well with the wok ring too.

Fuel

One of the reasons that I have taken such a shine to the rocket stove is that around where I live the parks and roadsides and park like areas have lots of tall gum trees. There trees seem to drop a constant stream of twigs and small branches which accumulate until they are hit by the council mower. These sticks are an ideal size for use in the stove, plentiful, sustainable and free but any small sticks such as cut up pallet wood or other waste timber could be used.

8.1.3 Making a Rocket Stove – Type Two – By Kevin Mechelmans

Make a list of materials you think you'll need to make the rocket stove and then collect them. I initially intended to use two Alpen blend drinking chocolate tins and a 1kg coffee tin (free from work) but ended up substituting one of the chocolate tins for a longer asparagus can as the chocolate tin did not have the height.

I drew up circles on the 1kg tin and the chocolate tin which will serve as my combustion chamber. I removed the bottom of the asparagus tin with a can opener.

I then drilled 3.5 mm holes just inside the line marked on both tins and then cut out the circle with side cutters. After removing the cut-out I made small cuts every 2-3 holes to make the metal more pliable and pushed down the sharp ends into the tin.

Draw up a circle using the asparagus can as a mould on the lid of the coffee tin. Then drill and cut out the mould as previously done.

I then pushed the chimney (asparagus can) into the combustion chamber (chocolate tin) and fixed them together with two small screws.

I took the cut-outs and fixed them together as shown to serve as a base for the combustion chamber and chimney until the perlite went in.

I glued the combustion chamber in place with a glue-gun (I know it wouldn't last once the stove got going but I needed the extra support until the perlite and lid where in place). At least it was designed to be heated up and release a minimum of toxic fumes (Nev's still alive).

I still needed to divide the fuel and the airflow so I made some cut-outs from a drink can, I know what you're thinking the combustion chamber will reach up to 1000 deg C and more and aluminium will melt at around 660 deg C, but it was all I had on hand. Did some consulting with Nev on the firing day and going to make some modifications to the combustion chamber so I can fit a steel plate in there and still fit the lid on.

I made some pot stands out of a spaghetti tin but they proved to be too flimsy to hold a 2litre pot of water so a trip to Bunnings was needed where I picked up the perlite and 2 pieces of metal with holes every 5mm which I cut in two to produce 4 brackets.

I marked up where I wanted to put the brackets ensuring I have enough clearance to allow for airflow I then drilled the holes in the stove and used pop rivets to hold them in place and then bend them down to the required height. Tip: add in the perlite before you put on the brackets, luckily the brackets are pliable so I could still get the lid off.

With the perlite added it was time to find some fuel and fire up the stove! Tip: use a pot/kettle that either your missus or the mother-in-law does not mind getting black. As Nev provided the kettle, fuel, some tools and some good advice he was the one to fire up the stove.

We used a whistling kettle with approx 1.5 - 2litres of water. It took around 15mins to boil the water. There was a fair amount of smoke, but that could have been due to the glue and fuel holder (aluminium drink can) melting.

All in all it was a fun and productive project that used the minimum of bought materials that in my opinion worked out pretty well.

Also in the end I made Linda a cup of coffee with the boiled water (it had the old campfire taste to it) and cleaned the kettle after letting it cool a bit to hoping to ensure I stayed in her good books.

I am already drawing up plans for my 2nd and 3rd and 4th stoves. I have two more 1kg coffee tins and one 500gr coffee tin, might do the 500gr one first, would like to use 2 chocolate tins as initially intended.

8.1.4 Making a Rocket Stove – Type Three – by Don Lanham

Why a rocket stove you ask, I happen to have a lot of twigs fall from trees around me and this is all that is needed to fire up the stove for a quick meal. I don't need all those big logs you normally associate with an open fire, and it burns so clean, without the risk of setting the surrounds alight.

On the other side, I work with metal and find certain bits and pieces laying around destined for the scrap bin. A good permie finds a way to reuse these sorts of things so from an old piece of 125mm pipe which used to water mushrooms and some bathroom floor off cuts when combined, make what you see here.

How to Make It

First I started with the old pipe and mitred the end at 45° and re-welded it to form a right angle. Using some off cuts off a flooring job, I've bolted the sides together with angle strips. Size was carefully calculated using the formula "use what you got". The little piece of RHS (rectangular hollow section) you see on the bottom is just to make the pipe stand up during its initial trial, at the moment it's inverted.

The lovely scalloped top 'just happened' so my billy would fit inside and still allow airflow around and up the sides. From another 2 equal length off-cuts of the pipe, I laid them in a piece of channel (to make straight lines) and marked out 4 equal sections in each, which were then slit with a skinny wheel on my little grinder, thus giving me 8 equal sections which when tacked together were the right diameter to insert my billy and looked quite cool too.

What insulation to use

Again, using the formula from above "use what you got", it was time to collect some dry grass and moist clay to make a mix. This was mixed together and placed inside the stove and rammed tight enough not to fall out when it came time to turn the stove back up the right way.

Now the heavy bit, turning it over. It's so easy to push over but to stand it up the right way again I had to use a bar up the chimney for leverage and carefully pack some more mix on the ground to steady it in the vertical position. Note, this is not what you might call mobile but rather a fixture, an outdoor cooking centre.

There, done and tested, you should hear the stove when it fires up, sounds like a rocket as the air flow gets going up the chimney, hence its name.

You can see three little bolts on which the frying pan sits (giving free flow for the heat to surround and flow over the frypan) and the billy sits inside, or rather hangs by its handle over the hole collecting nearly all the heat exiting the chimney, a rather efficient cooking method.

As you can see by the times taken from photos, it cooked a damper, steak and eggs, all served up in under 30 minutes.

On another occasion, pot of vegies boiling in 3 minutes, all on small sticks otherwise useless except for kindling.

Conclusion on viability of the Rocket Stove being fit for Purpose – Resounding success

8.2 Cooking on an Open Fireplace

8.2.1 Making and Using a Pot support

When we bought the place over 35 years ago, one of the first things that went into the house was a “Burning Log” brand open fireplace, we were sleeping on a mattress on the floor but that didn’t matter, we had our own open fire! We love it and we have given it plenty of use since we’ve had it, but it is pretty inefficient, and a lot of the heat goes up the chimney. I also suspect that it wouldn’t meet modern emission guidelines either, so we are planning on getting a more efficient wood burner that we can cook on and bake in.

Having said that, years ago we did make up a couple of fittings to allow us to cook on the fire and both worked fairly well, the first one is a steel frame I made to support a cooking pot over the fire and the second is a reflector oven.

Pot Support

The support is designed to go over the fire grate so that it is possible to have some wood burning underneath it to provide cooking fire, but this is obviously designed to fit my grate and I have no idea how standardised or otherwise fire grates are. Needless to say you may need to alter the dimensions of your pot support to reflect the size of your grate.

It is fairly simply made from 12mm square steel bar, the two bent sections that sit over the fire and on the fire grate are 420mm long with the two stringers joining then and providing the support for the pot being 150mm long. To make this you do need to have welding gear, or know someone who has it and can use it.

Mark off about one third in from each end of the longer sections with engineer's chalk (soapstone). Apply heat to the marked area with an oxyacetylene set, when it is glowing red (make sure you have a thick pair of welders leather gauntlets so you don't get burned) take hold of the end and bend it to about 130 to 135°included angle, then do the other end and then complete the process by bending the other long section.

Once the steel has cooled try it on your grate and make sure that there is enough overlap on each end to keep the pot stable and that the angles are right so that the flat top section will level when the pot support is in place. If things are not good you may need to re-heat and re-bend the bars until the fit and remain stable. Once you have got it where you want it, set it up with the bent legs in the air and the two longer sections separated in the middle by the two stringers, forming a box. Use your arc welder to run a bead along the join between the long sections and the stringers so that they are held reasonably firmly. Re-check again to make sure the post support will fit over the grate and if all is well, run another bead on what is now the top side to secure the steel bar together.

With a bit of luck it is now right to go, but before firing up the fire place and giving it a go, do a trial run with the pot you intend to use full of water and make sure that everything fits where it is supposed to and it is stable. A pot of boiling stew in your lap is not that great when you would rather be eating it!

It works quite well in practice but is certainly not a “set and forget” type of cooking. The area under the pot support limits the size of the logs you can place under it and a few smaller ones keep the fire hot enough to cook well, but burn down quicker so you do need to keep an eye on the fire and the food every so often. Although, if everyone is gathered around the fire and having a good time, this won’t be a problem. You also need to have good, thick cookware, cast iron is ideal, to distribute the heat and prevent the food being cooked scorching.

8.2.2 Making and Using a Reflecting Oven

I put this together with assistance from my brother a few years ago, you don’t have to have a sheet metal worker in the family but it sure helped me. The plans for this little gem can be found as an appendix at the end of this eBook.

Using a thin felt tipped marker, I transferred the lines from the plans onto some galvanised 0.5mm thick sheet steel that I had floating around, and then using some offset tin snips (Wiss brand if you must know) I cut the shapes out for the oven body and the oven reflector. While it doesn't take a lot of words to say that, to cut the shapes out of sheet metal with any pair of tinsnips is a crap-load of work.

The straight kind of tinsnips are OK but for any large work an offset pair is much easier to work with, although these days I would be much more likely to connect up my nibbler to the battery drill and use that. The nibbler is much easier and quicker to work although if you are good with the tinsnips you may find them to be more accurate, it is easy (or at least easy for me) to get off line with the nibbler.

Anyway that was then (well before I had bought my nibbler) so tinsnips were my only real option. If you are using tinsnips too, it makes sense to have a pair of sturdy gloves handy because the cut edges are SHARP and sheet metal running with blood is not easier to work with, especially if the blood is yours.

Once both shapes are cut out, we can get into the real work! At this point it is probably worth mentioning that there will be a requirement to fold the metal to make the body of the oven and then fold the edges of the reflector over so they can be wired. This can be done in a number of ways and if you don't have a press brake hidden away in your garage somewhere you may wish to consider making a **simple sheet metal bender** first. They are comparatively easy to build and handy if you intend to do almost any sheet metal work because you will no doubt need to bend or fold it at some stage.

The body of the Oven

OK, so you have either built the folder and/or have some wide jaw vice grips (often called flat jaw welders vice grips, both will come in handy!) to help bend the metal, cut the profile of the body out of sheet metal and scribe all fold lines. Mark the hole near the apex of the side, centre punch it to prevent the drill wandering and then drill out a hole the appropriate size of the wire you intend to support the food, the thicker the better. You could use fencing wire, I used 5mm rod salvaged from an old pram, with the ends bent straight.

With the hole drilled insert one end piece of the oven body into the bender down to the scribe line and bend up at than 90°, then repeat with the other end. Using the welders vice grips bend the sides of the bottom tray up to 90° to form the bottom tray and the corners back so they will fold around the outside of the bottom tray and form a leak proof edge. Bend all edges of the sheet which are to be wired out using a pair of welders vice grips to start the wiring process. Wiring the edges increases strength and stiffness of the finished product as well as removing any sharp edges on the metal which could result in cuts.

Complete the assembly of the oven body by placing a piece of hardwood on the inside of the bottom tray and hammer the corners around the end of the tray to lock them in place.

To wire the edges, cut a 740mm length of wire (I used 2mm galvanised wire) and make a 90° bend 180mm in from each end leaving a 380mm length in the centre, this is important so check the measurements! Support the oven body on a hardwood block and place a 180mm section of the wire into the fold along the edge of the oven upright. Using a cross-pein hammer, fold the bent edge of the oven upright over the wire such that the wire is held snugly. Take the wire around to the other side so that the 380mm section acts a bridge between the apexes of the two uprights and do the same on the other side. The result should be a wire running down each side of the oven and across the top, holding the two apexes steady and reinforcing the top of the oven. All of the other edges can be wired using a similar process.

Making the reflector

Assuming your reflector is cut out in accordance with the plan, scribe all fold lines and using the welders vice grips, bend all the edges over to about 90° in accordance with the plan. Using the cross pein hammer, bend the two 380mm sides and the 386mm edge with the 13mm corner cut off over so that they are sitting flat against the reflector. Place the remaining edge of the reflector over the top wire of the oven such that the side of the reflector without the folds faces in. Using the cross pein again, hammer the last remaining fold down over the top wire of the oven, securing the reflector and the oven together.

Using the Oven

The food to be cooked is hung from the main (5mm thick) support wire and then the whole oven is place facing the oven, about 30cm away from where the flames are, we had to get a couple of bricks to get the oven up high enough to cook properly. We found that this oven roasts chooks pretty well if you wire them, feet first, to the support wire.

Note: The plans for the oven body and reflector are available as Appendix 4 of this eBook.

8.3 Making a Cob Oven

Introduction

I have made two cob ovens in my time, the first one didn't really work very well, not because of the process but rather my design. The space I had to fit it into at the time was rectangular rather than square so my choice was either to make it exceptionally small or to make it more like an ellipse rather than round. I decided to build it in the longer ellipse shape, and that turned out to be the wrong decision!

The oven never did draw very well, even after I added a chimney. It did get hot and we mucked around with it but it needed an insulating layer it never got and after sitting around and looking more and more dilapidated the cob part was broken up last year. I am currently working on a few different ideas because I still want a homemade wood oven in the backyard. I did make another one for a local farm with a group of volunteers and it was round, and worked well, but again due to the vagaries of chance, the farm has a new manager and that oven too has been broken up.

While my track record with ovens still in existence has not been good, I have had an opportunity to learn the process of actually making them pretty well. This is what I have learned.

Making a Cob Oven

Contrary to popular belief, building with cob has nothing to do with corn, it is making up a mix of clay and straw and forming it into hand sized lumps called "cobs", so the name pretty much becomes self-explanatory. So, I suppose the next question you may ask is, "why bother?" Wood fired pizza or bread ovens have become a popular back yard accessory, they produce great tasting food and make a great centrepiece for back yard living, but they also use a readily available (even in suburbia) and sustainable fuel that costs virtually nothing. So they must be a great thing to have. You can pick up a DIY oven kit for $1500 (ouch!) or even get one built on your site for a little over $3000 (ouuuuuuch!!), so they do have drawbacks.

It is possible, however, to build your own from scratch for very little cash and you can lure family members into helping with the promise of the previously mentioned wood fire cooked bread, pizza and roasts etc. and rest of this article will show how you can do it.

This is the process that I used -

1. Select your site
2. Gather your raw materials – sand, clay, straw, bricks and material to make the base out of.
3. Set up the base
4. Install fire bricks
5. Set up the inner sand form
6. Make the oven itself
7. Decorate the oven

1. **Site Selection** – You may have some choice in your site or if your place is like ours, there is not a lot of room so you fit it in where you can. In the best of all possible worlds your site should be –

- Flat,
- Close to where you are going to prepare the food for cooking,
- Sheltered,
- Located so that smoke will not bug your neighbours, your family or (trust me here) smell up your wet washing,
- Located so that the oven opening faces away from the prevailing wind, and
- Be free of fire hazards

Let's face it, no site is going to be perfect, but tick as many of the above boxes as you can manage.

2. **Grabbing the Raws** - There are a number of things you will need to get together to make your oven and it is much better if you can have them all ready to go before you start. First off you will need something to make a base for the oven out of such as stone, concrete blocks, wood, bricks..... I think you get the picture! You want the oven to be high enough up to be easy to work with so waist height for the cook would be ideal (say 900mm to 1000mm). Clay is a no-brainer, you may be able to dig it from your

own property but failing that see if you can find someone willing to let you dig out a few garbage bins (quite a few probably) of clay from around their dam or any other open section of the property.

I had a connection with a clay tile and a brick making company, so I was able to put the bite on them for some clay. The brick clay was very good, but the tile clay was more like pottery clay, very pure with not enough sand. It shrank a lot during drying so I had to add a lot of sand but it still shrank quite a bit. The second oven was made from clay dug from a dam on the property hence my earlier comments.

You could try talking to any local brick or clay tile manufacturers to see if you can get access to their quarries for a bit or as a last resort talk to your local landscape supplies place, that is likely to be the most expensive option. You could possibly dig some out of any cuttings at the side of the road, but some of these government types may take a dim view of this practice.

Brickies sand and straw can be bought from hardware and gardening places or rural suppliers. You will also need bricks to form the floor of the oven, the best kind are fire bricks and to get these you will need a specialist wood fired oven or barbeque supplier, try your local yellow pages to find one. Normal building bricks can be used but they will not stand the heat as well and will eventually burn through, if you do not intent to use the oven that much they may be a reasonable, low cost option.

3. Setting up the base – How you do this really depends on what materials you have earmarked for the job. I used concrete blocks left over from the destruction of an old incinerator/ barbeque with two appropriately sized concrete pavers on top and for the farm we used bush rock cemented together with a formed concrete top to act as the base for the oven. Just make sure that it is strong enough to hold the (considerable) weight of clay that will form the oven itself.

4. Installing the fire bricks – There are a number of ways to set this up, insulating bricks on the bottom and fire bricks in a second layer on top, just a layer of fire bricks or just a layer of normal house building bricks. In both cases we have just used one layer of fire bricks as the oven base, but if you were using normal bricks install them on edge so that there is a flat surface to cook on and more mass of brick to withstand the fire.

Put a layer of clay over your base about 50mm thick to set your bricks into, making sure you have enough bricks to cover the entire baking area of the oven. We started by putting a couple of bricks at the outer edge of the base in the area we expected to put the oven opening. Once you have a brick located in the clay where you want it, install others by sliding them down the face of any brick(s) already installed, this ensures that you get a close fit and avoid getting clay in between the fire brick faces. In that way you can be sure of a smooth and gap free cooking surface and not have to worry about ash getting lodged in any gaps between the bricks.

5. Setting up the inner sand form – The outer shape and size of the sand form will set the inner dimensions and contour of the interior of the oven. It is best to use a fine brickies sand that will hold its shape when moist. Draw a circle on your bricks that sets out where the inner wall of the oven will be, then pile on your sand making sure it is moist and will hold its shape. Form a nice round high dome such that the dome is 65% to 75% of the dome diameter, or, if the dome is 1 metre in diameter it should be 650mm to 750mm high. In practice, if you think you have it right by eye, measure it. Odd on it will still be too low, so the hint here is to actually measure it. Once the dome is roughly formed, smooth it off to a nice smooth surface with a steel concrete trowel which we found gives a great finish. Once the firm is to your liking cover it with one to two layers of wet newspaper, this will help you tell where the form finishes and the cob starts when you dig out the sand form.

6. Making the oven – Now the fun starts! This process is fun anytime but will be more comfortable in warmer weather; wet clay can be bloody cold!

a. Mixing the Clay - The process starts by laying out a decent sized tarpaulin, at least 3 metres square. The first layer will be the thermal mass layer and so contains no straw, so put a couple of garbage bins-full of clay onto the tarp and one or two of sand depending on how much sand is in your clay, if there is already lots you don’t need to add much sand, if there is very little, add more.

Roll the mix in the tarp and get it as homogenous as you can, then get your volunteers and do the barefoot stomp and twist on the clay mix to incorporate the sand. As the mix spreads pull up the edges of the tarp and roll it back to the centre. At this point looooots of volunteers would be handy, the original oven was made by just my son-in-law and myself but the second one had lots of volunteers and this made the job much easier and more fun. Add water if the clay is too stiff for the sand to be incorporated properly but not so much that you get a sloppy swamp.

b. Forming the Cobs - When you have a batch of clay/sand mix ready to go, shovel it into a wheelbarrow or two, to make it easier to get at and start forming the clay into cobs by moulding it with your hands into a form that is slightly bricklike about 100mm wide, 100mm in height and around 300mm long. Place this around the edge of your form at the base, then place the second one behind it and so on one after the other.

Make sure you smooth them in to form a continuous layer and continue the process until you have the first layer finished. Subsequent layers can be applied in the same way, but keeping the tup surface of each cob at right angles to the sand form so that by the time you get to the top the last cob is like the keystone in an arch, helping the dome of the oven support itself when the sand form is removed.

c. Cut the Door – Cut a semi-circular hole in the side of the oven that you intend to use as the access. This will form the doorway and should be 63% of the height of the inner sand dome to allow for correct draw for ventilation. You can use a long knife to cut through the cob and mark out the shape of the door, then scrape out the soft cob material until you get to the inner sand form covered by newspaper.

d. Scrape out the Sand – The sand has done its job of supporting the cob to form the dome of the oven and now it has to be removed to leave the inside ready for firing. If you are building a large oven or the cob is really wet and sloppy, you might want to let the oven dry out for a couple of days before attempting this! You can use anything available to scrape the sand out, but your hands will work the best. Work slowly and scrape the sand into a garbage bin or similar for later recovery.

Work with your hands slowly to remove the sand, you will be able to feel when you hit the layer of newspaper over the top of the sand and the big hint when you do, is to stop digging. Keep going and clean out as much of the sand as you can, leaving the inside of the oven to dry out ready for firing. Once the inside is dry it will make it much easier to sweep out any sand residue.

Making the Door

One of the doors I made myself, it was just some timber bolted together until it was about 50mm thick then cut to shape. It charred up pretty quickly and I don't know how long it would have lasted in heavy use. The other one was made for us by a fitter and was black painted steel with a hand/bracket on the outside to keep it upright and it worked very well.

8.4 Wood burning Heaters – our experience

When we moved into our house over 45 years ago, we decided that the first thing we wanted to have in our new home was an open fireplace. It came before a lounge suite, a dining room table or even a decent bed (we were sleeping on a mattress on the floor). In the intervening years we have picked up some experience with wood burners which I would like to pass on to those who are interested.

The Burning Log Open Fireplace

We looked around at what was available on the market and even then, good wood burners were expensive, but we settled on a "Burning Log" brand open fireplace made in Australia and it cost us about $700. Burning Log are still around but no longer make open fireplaces, I assume because of tighter emission standards. It was basically a double skin black sheet metal hood mounted on a raised brick hearth and a sheet metal chimney, with a plain Chinamans' hat on the top and lead flashing.

The hearth could be mounted on the ground or raised up three bricks to allow wood to be stored underneath, it was also more comfortable to sit on at that height so that is the one we chose. They were originally made with a single skin which got hot and radiated heat into the room but by the time we bought one they had the double skin, which kept the outer skin cool. This meant that although you were less likely to get burned if you touched the outer skin, more heat went up the chimney and less went into the room.

The first year we had it was particularly cold; we did not have any doors fitted to section off the lounge room from the rest of the house and no insulation in the roof. We spent a lot of time sitting on that brick hearth trying to keep warm! After putting in the doors and the insulation it worked much better for the next winter but it was a true open fire place and a lot of heat went up the chimney. There was a damper where the hood met the flue but if you closed it down at all the only result was to get smoke in the room so the only time it was used was if there was a lot of wind and the fire wasn't going, it stopped any heat getting sucked up the chimney.

OK, so it wasn't super-efficient, but it was 110% on atmosphere and ideal for those winter nights at home just the two of us (well the house kept us broke so we had no money to go out) and when the kids came along they loved it too. Family winter nights in front of the open fire, toasting marshmallows were absolutely wonderful and gave us memories we will carry for the rest of our lives. When we finally came to update it I thought our eldest would be upset but in the end the kids were OK with it.

We did cook on the open fire occasionally but for the most part we used it for heat only. It heated the lounge, dining room and kitchen very well but due to the layout of our house the other end, comprised of bedrooms, bathroom and toilet stayed pretty cold. If we waited for the lounge room to heat up and then opened the connecting doors we were able to get some heat up the hall, but the bedrooms themselves just about had the chill taken off them. Hence our next foray into wood heating.

The Godin Slow Combustion Stove

When our eldest daughter was born there was no fixed heating up the bedroom end of the house and the thought of bringing home a baby in the middle of a bloody cold winter (she was born in April) did not fill either of us with enthusiasm. So we put a wood heater in the bedroom. It was a French brand, Godin and it was the smaller one of the two available at the time and hence was a “petit”. It is an upright cylinder approximately 26cm in diameter and about 65cm high. There is a cast top opening to admit the fuel which is covered by a decorative cast iron lid and a door on the front which has clear mica window set into it. With the cast iron lid down it looked very nice but seemed to reduce the amount of heat getting into the room quite a bit so the lid was left up while the fire was on and down only when the fire was not burning.

The door is opened for lighting and to remove the ash, and the chimney comes out of a cast iron fitting in the middle of the back. The place where the chimney is turned out to be very handy because rather than take the chimney straight up and out the roof, we took it through the wall and into our daughter’s room and then up through the roof. This enabled the hot flue gases to keep both rooms toasty.

To get the most out of it we would light it up with the bedroom door closed and then when the bedroom got to the temperature where you couldn’t keep your clothes on, we would open the door. This allowed all the hot air to flow into the bathroom, toilet, other bedrooms and the hall. Unfortunately it wouldn’t really do much for the kitchen/dining room/lounge area and on rare occasions when we had all the family over we might keep both going for the night.

The Godin is a firebrick lined slow combustion heater which could theoretically be used for cooking on the cast iron lid where the wood went in but we never found it to be all that successful, it took forever even to boil water. The Godin is multi-fuel in that you can use wood or coal but we have only used it as a wood stove.

As it is slow combustion it is much more efficient than the burning log fire place, but it is an absolute bugger to start! I don’t know if it is because of the extra run of horizontal flue running into the next bedroom or if they are all like that. You have to get the fire burning hot very quickly, or you get no draw and a room full of smoke. This happened regularly at the start of every winter until I got the knack of how to do it back; I was not popular on those occasions! The trick is to put enough scrunched up paper and thin twigs in to get it going quickly, but not to obstruct the place where the smoke exits at the back of the stove. A little bit of encouragement in the form of a firelighter or some metho helped, but if you didn’t have the packing right, you were going to take up smoking quick smart.

The other problem was that the firebox was too small to be able to efficiently bank it so that it would burn overnight. Whatever I did I had to get up at 3:00am and refill it or it would be stone cold by morning.

Apart from those minor flaws the Godin has given us great service for over 30 years and is still going strong, although with our new and improved wood burner in the lounge room, we did not use the Godin at all last winter. Which brings me to –

The Nectre Stove

We all dearly loved the old burning log, but I was concerned that after 35 years it was starting to get a bit tired, and it was as inefficient as hell so I decided before the winter of 2013 was on us, we would have a new wood burner. We had seen a wood fired heater that was also a baker's oven the previous winter and after much searching, many enquiries and several quotes we decided that the Nectre bakers oven was the one for us. Again, it was Australian made and the guy who installed it for us was a local

fellow who made his own flues. To remove the old one (we kept the bricks) buy and install the new one didn't give us much change out of $4000.

It has been pretty much worth it. It has a good draw and is easy to light, as with all slow combustion stoves it takes a while to get going and it takes a while for the oven to heat up to baking temperature. It is far more efficient than the old open fire so we use less wood and because it is easy to cook on we use less gas during the winter. I cook on it as much as I can and Linda doesn't mind cooking on it either. Even a simple task like boiling the kettle for a hot drink can be done by putting the kettle on the cook surface rather than the gas stove. It also warms the house better. We have experimented with fans to push some of the hot air up the other end of the house and they work OK, but if the Nectre is going all day it will keep the almost the whole house comfortable and the lounge, kitchen, dining area toasty!

According to the blurb you can bank it up, close the vents down, it will smoulder all night and be ready to go the next morning. We have not tried that yet. One issue has been that the fire box will not take the size of logs the old open fire would, but this just means chopping the wood up into smaller pieces. Remember heating with wood warms you twice, once then you chop it and once when you burn it!

Feeding the Fire

When we got the open fir originally put in I needed to get some wood, so I went to see our local timber yard (yup 35 years later it is still there!) and talked to one of the managers. Every few days they would send a dump truck full of off cuts and sawdust and crap to the tip, so I took in a slab of beer for him and the driver and a load appeared beside the house the next week. This was back before the garage so we had an open area for the truck to dump in. The sawdust was composted and the off cuts kept us going for most of that winter, but they were all softwood and burned away pretty quickly. It got very tedious constantly feeding the fire but the price was right and we did it a few times the first couple of years to keep us warm.

After those years our wood came from a number of sources. We bought some, some loads I was to get through friends who had properties or waste wood floating about. Having a chain saw was certainly a help and enabled me to cut stuff up that was too big to get into our little Toyota station wagon. Even if you live in an urban area you can pick up a surprising amount of unwanted wood, some we got in some area which had been left treed by the developers (not a lot) and these trees would drop limbs every so often. Over the years we have cut down an apple and a carob tree, both of which provided lots of good burning wood, and we also burn off cuts from the melaleucas and the mulberry tree regularly.

One thing which can be difficult to do but is important to remember is that you should not burn wet timber in any wood burner. This can cause tar and creosote to distil out, head up the chimney and then cool on the inside of your flue, forming a layer on the inside of the flue which builds up over the years. This layer is combustible and under the right circumstances can catch on fire resulting in a flue fire, which is bad news indeed. To prevent this only burn wood which has been seasoned or dried for at least 12 months.

Around here lots of wooden fences were replaced over the years by colourbond steel fences and I know that some people took advantage of the free wood for wood fires or worse yet, barbecues. Unfortunately the fences had been treated with CCA (copper chrome arsenic) and I would never burn them due to the risk of poisoning. Another trick we tried was to burn some particle board off cuts we were given. They really burned very quickly and very hot, I was afraid that I might do damage to the hood of the fire, especially when it started giving off a hot metal smell we had not had before. We let the fire die down and didn't try that stunt again.

We have tried using newspapers with only limited success. The first time was with a newspaper roller where you wet the newspapers, roll them tightly together and the tie them off and let them dry. When dry you can burn them like normal logs, or so the blurb said. The just seemed to continuously come apart and the burn like........well, sheets of paper! Out it went. I did try another type a few years later; this was more like a steel box with lots of holes in it. You soak the paper and tear it up, which was remarkably time consuming, then scoop it out (cold and wet!) and place it in the box. The lid of the box was then levered down onto the paper, forming a brick, which was again left to dry before burning. It worked better than the roller but was still a lot of work and did not burn anywhere near as well as the wood. Bugger!

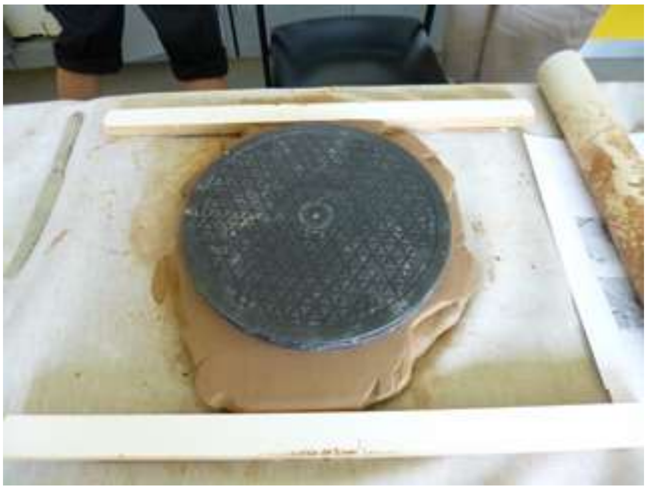
The wood heaters have been a wonderful part of our family and they still continue to be of service. They allow us to make use of our own sustainably grown timber as well as found wood, supplemented by some wood bought in. They are a great way to keep warm sustainably, but if you want to get one do your homework and make sure you find the right one for you.

8.5 Making a Portable Clay Stove

This is something that you can make from the clay you prepare yourself and then you can use it to cook your food using sticks and branches from around your local area. It won't be as efficient as a rocket stove but it will be more efficient that three stones supporting s cooking pot over a fire and you can make it from local materials.

To start out roll some clay out about 20 to 25mm thick and then cut out a round to form the base of the stove, I used my 250mm diameter **lazy Susan** to act as the template. Once you have the base, knead up and roll some more clay to form a roll about 25mm thick, lay it around the edge of the base and give it a bang with a wooden bat to make sure the two bits of clay meld together. Then smooth it over the inside and outside so that rather than looking like a round bit sitting on a flat bit with your fingers and make sure there are all smooth lines.

From this point on it is just a case of building up the stove roll by roll until it is a high as you want to make it and flaring slightly outwards, banging and smoothing each roll in as you go. If you leave the project for any time, wrap it up in two or three layers of plastic or plastic garbage bags to stop it drying out too much. If the weather is hot or you leave it for more than a week or two you will probably need to score and slip the top of the clay before putting on the next roll once you come back to it.



The finished dimensions for my stove were about 250mm high and about 350mm wide at the top, but the dimensions are really up to you and the size of pot(s) you will be using on your new wood stove. Remember that when stove is dried and fired (if you go that far) it will be 10% smaller!

If your stove is built up as high as you want, while not being strictly necessary it is good to give it a few taps all over the outside with your **bat** and smooth it off inside and out with a rubber kidney. While making it look nicer, but both of these processes will cause the surface of the clay to be denser and stronger, so it is worth a bit of extra time to get this right.

With the main part of the stove built, the next three operations will be to put on the pot supports, cut the hole in the side for the fuel to go in and put the handles on the side so it is indeed a "portable" stove. The finished fired weight of my stove is a bit over 10 kilograms so a couple of handles for carrying are really handy!

There are three pot supports, for the same reason that spinning wheels have three legs so that they are stable on an uneven floor, three supports means you don't have to have them all on exactly the same level for the pot to be stable. I made three clay triangular prism shapes, set them on the rim of the stove with the apex facing down, then moulded them in to the inside of the stove. They ended up like 3 ski jumps so that a number of different diameter pots can sit centrally on them and remain stable. I use the rubber kidney on all sides to smooth them off to the finished the profile.

The hole was comparatively easy, in an area of the side between two pot supports I carved out the edge of what seemed to be a reasonable sized hole and then used my pottery knife (ie recycled butter knife) to cut and remove the excess clay. The hole is 120mm wide by 90mm high and seems to do the job. I did let it dry out for a while and harden up, then used a surform tool to tidy up the opening and round things off somewhat.

The last thing to do was put in the handles, the majority of the clay would be contributed by the clay I cut out of the hole where the wood goes in. I marked out an ellipse 120mm long and about 50mm wide on each side of the stove so that the hole for the wood was in the middle. I then cut a central line down the ellipse and dug out some clay from the bottom half to form a shallow depression. I then formed a couple of clay handles and attached them to the side of the stove and smoothed them in so that they were well blended into the stove.

Once all this was finished it took 4-5 hours to do all up, but I wasn't in any hurry and took it in 2 hour sessions, I then set it aside for 3 weeks to dry. I was intending to use it in a dried but not fired state but the lady where I do my potting convinced me to fire it in a commercial kiln. It came out pretty well and I am very happy with it. The big things are to make sure the object is DRY and then take the kiln up to temperature s-l-o-w-l-y!





9.0 Resources

9.1 Energy - General

There are a mixed bag of alternative energy books here. Some are DIY how-tos, others are more about what sort of technology was available at the time of writing and still others cover history and theoretical concerns. Some of the books date back to the energy crisis back in the '70s (yes, am that old!) but still contain information useful today. Thankfully, due to the internet, these days you can scrape up a book which interests you even if it was published that long ago.

The Carbon Buster's Home Energy Handbook – Godo Stoyk – New Society Publishers (CAN) 2007 ISBN 978 0 86571 569 1 – This book not only covers home energy usage, particularly electricity, but also covers transportation options and touches on water, and household consumption too. It goes through how and why of energy reduction but figures are based around North American consumption. Home design is also covered and green options for heating and cooling are discussed.

The CSIRO Home Energy Saving Handbook – J. Wright, P. Osman & P. Ashworth – Pan Macmillan (AUS) 2009 ISBN 978 1405 039611 – This is a great book, lots of info, drawing and colour photos. It covers the why and how of reducing household energy consumption not only through direct consumption but also though waste, water, transport and buying stuff. Lots of tips and discussion of options that could be for retrofit or new build.

Converting to an Eco-Friendly Home (The Complete Handbook) – Paul Hymers – New Holland Publishers (UK) 2008 ISBN 978 1 84537 406 8 – a small book with lots of line drawings, it reflects the UK experience but still has great retrofit ideas. Chapters cover light, power, heat, shelter, air, waste and water. Good stuff on new technology and some innovative ideas including a good section on siting solar panels. Overall a very good book.

The Big Switch – Gavin Gilchrist – Allen & Unwin (AUS) 1994 ISBN 978 1 86373 750 2 – This is not so much a “how to” as a “why you should” book. It is a good snapshot of the sorts of things that were going on around alternative energy in Australia in the mid-nineties. Unfortunately events have overtaken the book and it is a bit dated. Photovoltaics, solar hot water and wind energy are discussed at some length. There are a few graphs and line drawings to illustrate the text.

Energy Works! – Keith Smith – Nelson Publishers (AUS) 1985 ISBN 0 17 006577 4 – This book was put together by the people who used to bring out Earth Garden Magazine. It is a “how to” book for home power enthusiasts. Lots of good information on developing small scale solar, wind and (more unusually) water power. There are also sections on batteries, inverters and wiring as well as converting 240 volt appliances to low voltage. Lots of black and white photographs and some line drawings.

The Earth Garden Book of Alternative Energy – Alan T. Gray – Thomas C. Lothian Pty Ltd (AUS) 1996 ISBN 978 0 85091 701 7 – This book is also “how to” but also with discussion of available technology. It has 3 sections – “generate”: covering power generation by solar (electric and hot water) wind, micro hydro and steam, based around a power plant by the now defunct Strathsteam Company which was based in South Aus. The second section called “store, regulate, invert” is predicably enough a digest of batteries, inverters and regulators available and their use. The third section, “consume” covers appliances and the energy efficient home. The book has a good mix of line drawings and black and white photos.

Making Your Home Sustainable (a Guide to Retrofitting) – Derek F. Wrigley – Scribe Publications Ltd (AUS) 2005 ISBN 1 920769 49 8 – A retrofitters bible! The book covers solar hot water, improving performance of windows, using wasted sunshine, rationalising electricity consumption, rationalising water usage, making a useful landscape and even some advice for renters. A great book with lots of information with lots of line drawings and black and white photos to illustrate concepts in the text.

Warm House Cool House – Nick Hollo – Choice Books (AUS) 1997 0 947277 22 6 – This is mainly for the new build, although there is some discussion of existing houses, mostly using extensions and additions. The book gives a simple explanation of the principles of low energy housing design and then illustrates these principles with more than 110 examples from around Australia. There a whole stack of floor plans (if that is your bag) which help you work out which of the ideas might work at your place. Lots of line drawings and black and white photos with a colour photo section in the centre of the book.

The Energy Freedom Home – Beyond Zero Emissions – Scribe Publications P/L (AUS) 2015 ISBN 978 1 925106 71 8 – The book helps you work through a series of steps to reduce you household energy consumption including lighting, draught proofing, insulation, windows, appliances and cooking, heating and cooling, hot water, energy monitoring and control and solar power. The last section is about "putting it all together". Most of the info is about what is on the market but there is a little bit that could be DIY, but because it is a new book it can make you aware of the latest technology out there. Lots of colour photos are used to illustrate the text.

The Mother Earth News Handbook of Homemade Power – Staff of the Mother Earth News (US) 1974 ISBN – This is a small, paperback size book but has over 350 pages of information. It is really a digest of what people were doing at the time (think energy crisis) to provide their own energy systems. The book covers energy produced using wood, water, wind, solar and methane. There is some good basic DIY mixed in with interview with people who were developing their own systems. Lots of line drawings.

Energy Alternatives – Editors of Time-Life Books – Time-Life Books (US) 1982 ISBN 0 8094 3494 6 – This is primarily a DIY book for retrofitters (yay!). It starts off with strategies to make your home more energy efficient including window treatments that save energy and superinsulation, then moves on to various ways of harnessing the suns heat including a trombe wall. The third part of the book examines other energy sources including heat pumps, wood and coal, heat pumps, water and photovoltaics. Some stuff (like furnaces) does not apply here in Aus and be circumspect on some of the electrical and plumbing recommendations but this is a good book. Lots of line drawings are used to illustrate how to carry out the work they recommend.

The Green Technology House & Garden – Michael Harris & Claire Beaumont (Eds) – ATA Publications (AUS) 1993 ISBN 0 646 15196 7 – This is a series of articles around improving the energy performance of your home and garden. Some are a bit light on detail but others would enable you to replicate what they have done. The section on turning a disaster into a low energy house is very good. There are also sections on building and design, greening your garden, getting practical and living with alternatives. Lots of black and white photos and line drawings.

Renewable Energy Resources – John Twidell & Tony Weir – Taylor & Francis (UK) 2006 ISBN 0 419 25330 0 – This is a book for the technically minds, with lots of equations and all you needed to know about the physics of renewable energy. Not one iota of DIY in sight! The book covers everything from fluid dynamics to heat transfer, solar heating and photovoltaics, hydro and wind power even biomass, wave and tidal power. Over 500 pages of technical good stuff with the odd black and white photo and line drawing thrown in.

9.2 Specific Technologies

Biomass

Build Your Own Barrel Oven – Max and Eva Edleson – Hand Print Press (US) 2012 – 978 0 9679846 9 8 – This is another one hit wonder but a ripper! Everything you wanted to know about turning a 200 litre steel drum into an outside, biomass powered oven. Construction instructions are detailed and there are lots of colour photos and line drawings.

Rocket Mass Heaters – Ianto Evans & Leslie Jackson – Cob Cottage Company (US) 2014 ISBN 978 0 9663738 4 4 – Just what we all wanted (well I did!), a book about rocket stoves! While, as the name suggests, this book is about designing and building space heaters using rocket stove technology, there are also instructions on making small scale cooking stoves as well. Maintenance and fuel choices are discussed and there is a surprisingly honest page or two on the drawbacks of using this technology and some interesting case studies. Lots of line drawings and colour photos.

Build Your Own Earth Oven – Kiko Denzer – Hand Print Press (US) 2004 ISBN 978 0 9679846 0 2 – This is THE manual on how to make your own cob pizza oven. It covers a bit of history, tools and materials required to construct it, making the base, step by step instructions on making the oven and the tools required to operate it. Some black and white photos but lots of line drawings to illustrate what you need to do.

Lorena Stoves (designing, building and testing wood conserving cookstoves) – Ianto Evans & Michael Boutette – The appropriate technology project of volunteers in Asia (US) 1981 ISBN 0 917704 14 2 – This a manual on how to desing and build your own stove using local materials and low tech processes. Construction is mainly of clay and how to win and process the clay so it is ready for use is covered in detail. There are some black and white photos and lots of line drawings of stove designs and how they work.

Solar

Solar Homes and Sun Heating – George Daniels – Harpers and Row (US) 1976 ISBN 0 06 010937 8 – Some interesting ideas in this small book, some could only be included during construction but some retrofit options like insulation and solar collectors. There are detailed instructions on building your own flat plate active solar heating system.

Cooking with the Sun – Beth & Dan Halacy – Morning Sun Press (US) 1992 ISBN 0 9629069 2 1 – This is another oldie but goodie, it is the book responsible for my interest in solar cooking and the plans in the book are what I based my solar oven on. The book covers some history then gives detailed instructions on building a solar oven and hotplate. The rest of the book is given over to recipes appropriate for use in solar cookers. Some black and white photos and some line drawings to illustrate construction methods.

How to Use Solar Energy (in your home and business) – Ted Lucas – Ward Ritchie Press (US) 1977 ISBN 0378 06380 4 – This is technical book, not “how to” which discusses the use of technology available at the time, including some stuff I’ve never heard of (eg the Northrop concentrating solar collector using linear Fresnel lens…..what the?). Info on air type and liquid type solar space heating, passive solar, solar water heating is detailed. Lots of historical interest. Black and white photos with some line drawings and circuit diagrams.

A Golden Thread (2000 years of solar architecture and Technology) – Ken Butti & John Perlin – Van Nostrand Reinhold Ltd (US) 1980 ISBN 0 442 24005 8 – This is a great coffee table style book showing the development and use of solar technologies over the last 2000 years. It covers early use of the sun including roman solar architecture and solar hot boxes, then goes through using the sun to power engines, heat water and heat houses. There are lots of black and white photos and line drawings. A good book if you are interested in the history of solar power.

Wind

Wind and Wind Spinners – Michael Hackleman – Peace Press (US) 1974 ISBN 0 915238 02 0 – This was another watershed text for me, all about making a wind generator using automotive components and catching the wind with a vertical shaft savonius (S) rotor. The theory and practice are all here, including how to make and secure the tower that the generator sits on. The book has a few black and white photos but lots of line drawings.

The Home Built, Wind Generated Electricity Handbook – Michael Hackleman – Earth Mind/Peace Press (US) 1975 ISBN 0 915238 05 5 – The name is a bit of a misnomer because it is really about finding and refurbishing old pre-US-rural-electrification horizontal wind generators (lots of luck finding any in Aus today). However there is a lot of detail on making and erecting the tower including where to site the tower, use of batteries (lead acid) and how to construct a control box. Lots of line drawings with a few black and white photos.

Better Use of Your Electric Lights, Home Appliances, Shop Tools - Everything That Uses Electricity – Michael Hackleman – Peace Press (US) 1981 ISBN 0 915238 50 0 – The book shows you how to convert appliance etc (old stuff anyway, I don’t know how modern appliances would be to convert.) to run directly on 12 volts. Very interesting stuff on the theory around wire thicknesses and which ones to use for low voltage. A bit dated but still has some interesting stuff. Lots of Black and white photos and line drawings.

Harnessing the Wind for Home Energy – Dermot McGuigan – Garden Way Publishing (US) 1978 ISBN 0 88266 117 5 – This is not a “how to” but more a “what’s on the Market”. Some interesting historical photos and information on estimating wind energy in your area, but apart from that pretty much out of date. Some line drawings and black and white photos.

Wind/Solar Energy (for radiocommunications and low power electronic/electric applications – Edward Noll – Howard Sams & Co (US) 1975 ISBN 0 627 21305 2 –Lots of info in a small book including wind generators, lots on batteries and inverters and a small amount on rudimentary solar which is interesting from a historical standpoint. There is some info on (then) existing installations. Lots of line drawings with a few black and white photos thrown in.

Hot Water

The Compost Powered Water Heater – Gaelan Brown – The Countryman Press (US) 2014 ISBN 978 1 58157 194 3 – This is pretty much a one hit wonder but it can give you all the information you ever wanted about space and water heating using the heat given off by decomposing organic matter. There is information about large and small scale installations around the world. There is step by step (with photos) project plan for a small scale unit and details on making a larger scale unit. There are lots of colour photos and line drawings.

Handmade Hot Water Systems – Art Sussman & Richard Frazier – Garcia River Press (US) 1978 ISBN 0 932708 00 5 – This is a DIY manual for those who want to make a hot water system which used wood or uses the sun. There is a review of general issues around how water heaters work, then detailed instructions on making a wood powered and a water powered not water heater, then information of how to plumb it all together. I am not sure how the US plumbing instructions translate into the AUS experience. Lots of line drawings to illustrate what is going on.

Methane

Methane: The Anaerobic Flame – Raymond Spargo – Nowra Printing and Publishing (AUS) 1981 ISBN 0 9595720 1 5 – This is a fairly technical manual that covers the use of methane in vehicles, how to make a gravity bell so you can analyse your gas for methane/carbon dioxide, using methane to flame cut and solder, using a methane flame and thermocouples to generate electricity, methane gas lighting, several methane powered radios and a methane generator based on 200 litre steel drums. Mostly black and white photos with a few line drawings.

Methane: Planning a Digester – Peter-John Meynell – Prism Press (UK) 1976 ISBN 0 904727 12 2 – Lots of interesting detail around the process of methane digestion but it is a very technical, mostly text book written around the large scale process rather than the DIY backyarder. Nevertheless a good book if you are interested in the technical side of methane digestion. Has the odd black and white photo and line drawing.

A Chinese Biogas Manual – Michael Crook (translator) – Intermediate Technology Publications Ltd (UK) 1979 ISBN 0 903031 65 5 – This is a basic manual on how to make a small scale biogas digester. Rather than use the 200 litre drum style however they are primarily designed as brick or concrete lined pits. There are details on building a number of different pit style digesters, information on how to operate them and even data on how to make appliances which can use biogas as a power source. Lots of line drawings.

9.3 Car Fuel Efficiency and Alternative fuels

Making Your Own Motor Fuel – Fred Stetson – Garden Way Publishing (US) 1980 ISBN 0 88266 163 9 – This is a book about how to make alcohol fuel for your car using various size stills including a 200 litre drum monster that might get you shot here in Aus, I'm not sure of the legal ramifications but if memory serves a 5 litre is the biggest you can have. Also covered is how to make your car run on alcohol and how to ferment the stuff in the first place. Lots of detail, line drawings and black and white photos.

Methanol and Other Ways Around the Gas Pump – John Ware Lincoln – Garden Way Publishing (US) 1976 ISBN 088266 051 9 – This is not so much a "how to" as "what's out there" and discusses methanol, producer gas, fuel cells, and hydrogen, with a focus on methanol. Some line drawings and black and white photos.

Pumped – 101 Ways to Beat Petrol Prices – Roz Hopkins – Hardie Grant Books (AUS) 2008 ISBN 978 1 74066 713 5 – A little local book with some obvious and less obvious ways to minimise your fuel costs. Chapters include filling up for less, preparing and maintaining your car for greatest fuel efficiency, driving tips, choosing the right car alternatives like car pooling, public transport and bike riding. There is also a 101 tips section. A couple of graphs, no illustrations.

Cutting your Car Use – Randall Ghent with Anna Semlyen – New Society Publishers (US) 2006 ISBN 0 86571 558 0 – Another little book to help you reduce your reliance on your car including why you should, what alternatives are out there, changing your travel habits, living without a car. There is a large "resources" section but most only pertain to North America.

From the Fryer to the Fuel Tank – Joshua Tickell – Tickell Energy Consulting (US) 2000 ISBN 1 74018 149 2 – A very technical book that helps you turn vegetable oil into biodiesel including how to press your own veggie oil, plant and processes for making biodiesel and how to run your car on straight vegetable oil. There is also a chapter on trouble shooting and success stories. Lots of line drawings and black and white photos. Also published in Aus by Fast Books.

A Few Books with Sections on Fuel Efficiency Etc.

547 Ways to be Fuel Smart – Roger Albright – Storey Books (US) 2000 ISBN 1 58017 369 1 – This book is about being fuel smart in the larger sense but chapter 10 (pp83 to 90) covers reducing your car's fuel consumption. Basic stuff.

Time to Eat the Dog – Robert and Brenda Vale – Thames and Hudson Ltd (UK) 2009 ISBN 978 0 500 28790 3 – Chapter 2 (pp72 to 126) covers transport with a well researched and scholarly discussion of the options including bikes, walking, cars, railways, planes etc. And what you need to do to make the correct decision about how you get to where you want to go.

CSIRO Home Energy Saving Handbook – John Wright, Peter Osman, Peta Ashworth – Pan Macmillan Aust (AUS) 2009 ISBN 978 1405 039611 – Chapter 8 (PP163 to 187) explores minimising greenhouse gas emissions from various transport alternatives. Colourful graphs and full colour photos but not particularly information dense, covers the usual stuff.

Greeniology – Tanya Ha – Allen & Unwin P/L (AUS) 2003 ISBN 1 86508 929 X – The Green Garage (pp 131 -142) – Tanya Ha's stuff is usually pretty good and this book is no exception. Her chapter called the Green Garage covers some easy and not-so-easy things to implement to improve the carbon footprint of your car usage. Simple and easy to read.

Appendices

Appendix 1 – Energy Audit Form

Energy Audit Form

Date of Audit:

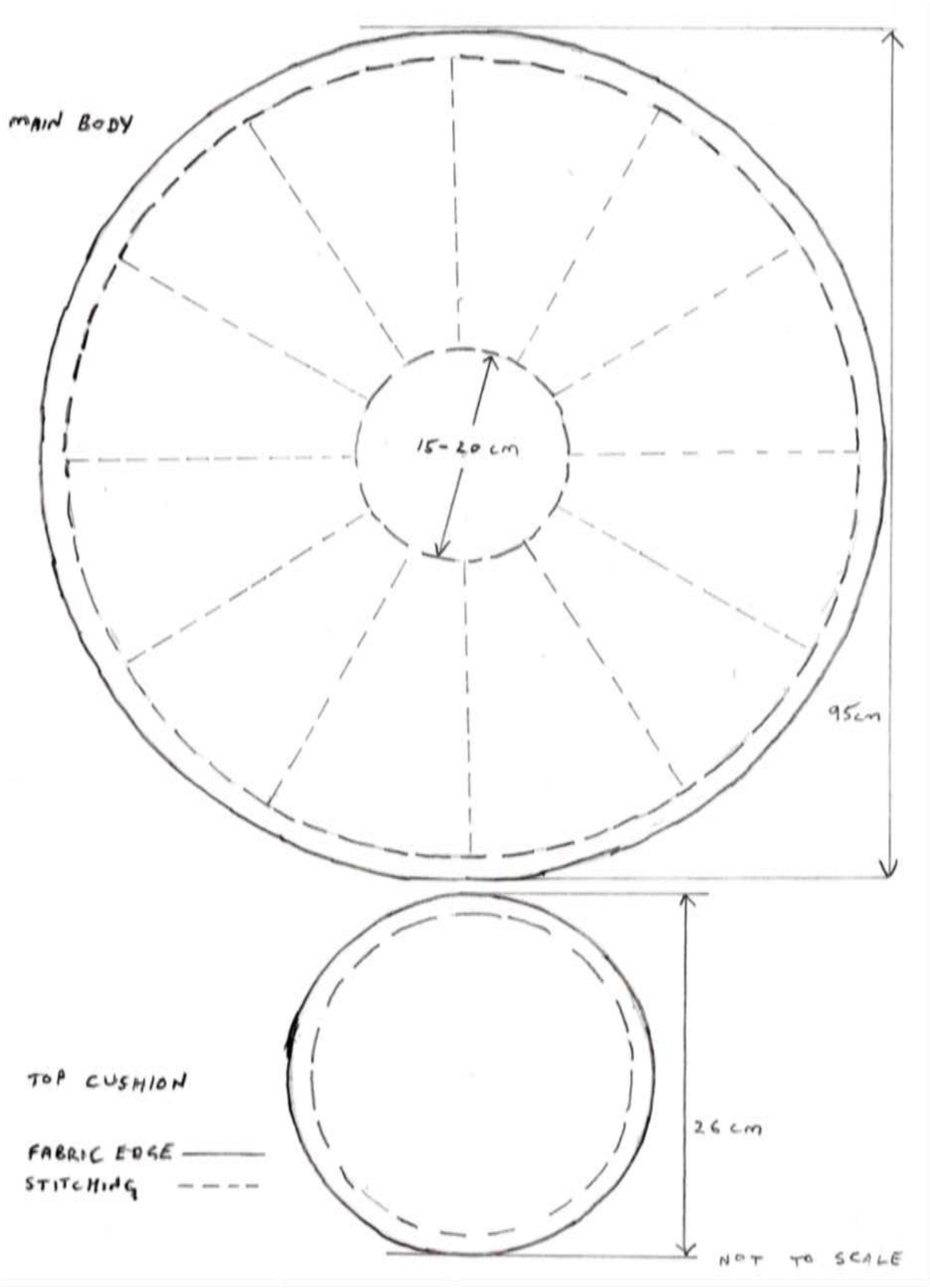
Household Direct Energy Supply or how much energy was supplied to your house in the last 12 months (Energy In)

Energy Source	Unit	Annual Total	Multiply by (conversion Factor)	Mega Joules MJ	Comments
Electricity	KwH		3.6		
Natural Gas	MJ		1		
Liquefied Petroleum Gas (LPG)	Litres		26		
Wood	Cubic Metres		550		
Petrol	Litres		36		
Diesel	Litres		36		
Total Yearly Energy Supplied					

Appliance	Power consumption in Watts (information)	Power consumption in Watts (Measured)	Estimated hours use per year	Kilowatt hours per year (watts x hours/1000)	Actions
The Big Stuff					
Water heater					
Cooking Range					
Air Conditioner					
Space heater					
Kitchen					
Toaster					
Frypan					
Jaffle maker					
Electric jug					
Microwave oven					
Refrigerator					
Freezer					
Dish washer					
Entertainment					
TV 1					
TV 2					
Computer 1					
Computer 2					
CD player					
Laundry					
Washing machine					
Clothes drier					
Iron					
Garage					
Drill					
Power saw					
Welder					
Sander					
Grinder					

Appliance	Power consumption in Watts (information)	Power consumption in Watts (Measured)	Estimated hours use per year	Kilowatt hours per year (watts x hours/1000)	Actions
lighting					
Outside					
Lounge room					
Kitchen					
Dining room					
Hall					
Bedroom 1					
Bedroom 2					
Bedroom 3					
Bedroom 4					
Bedroom 5					
Garage					
Miscellaneous					
Clock					
Fan					

Appendix 2 – Fabric stored heat cooker pattern



Appendix 3 – Reflecting Solar Oven Plans

Yes, I know, all the measurements are in imperial. I made the oven many years ago and these are the measurements I followed, so get used to it!

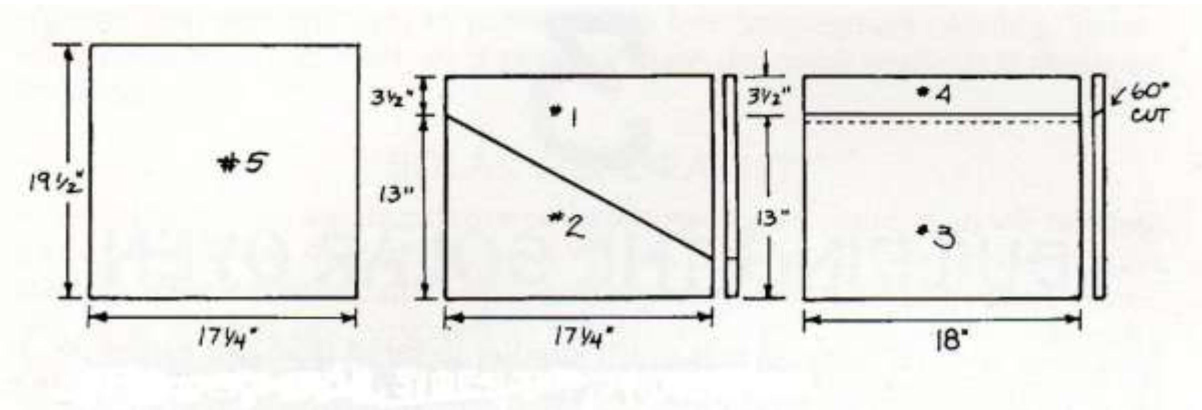
Materials List

Plywood
1 off 16 ½”x 17 ¼” by ¾” thick (to make the sides)
1 off 16 ½”x 18” by ¾”thick (to make the top and bottom)
1 off 19 ½”x 17 ¼”by ¾”thick (to make the back)
4 off 18”x 18” by ¼”thick (to make the main panel reflectors)
4 off 15”x 18”x18”by ¼” thick (to make triangular corner panel reflectors)

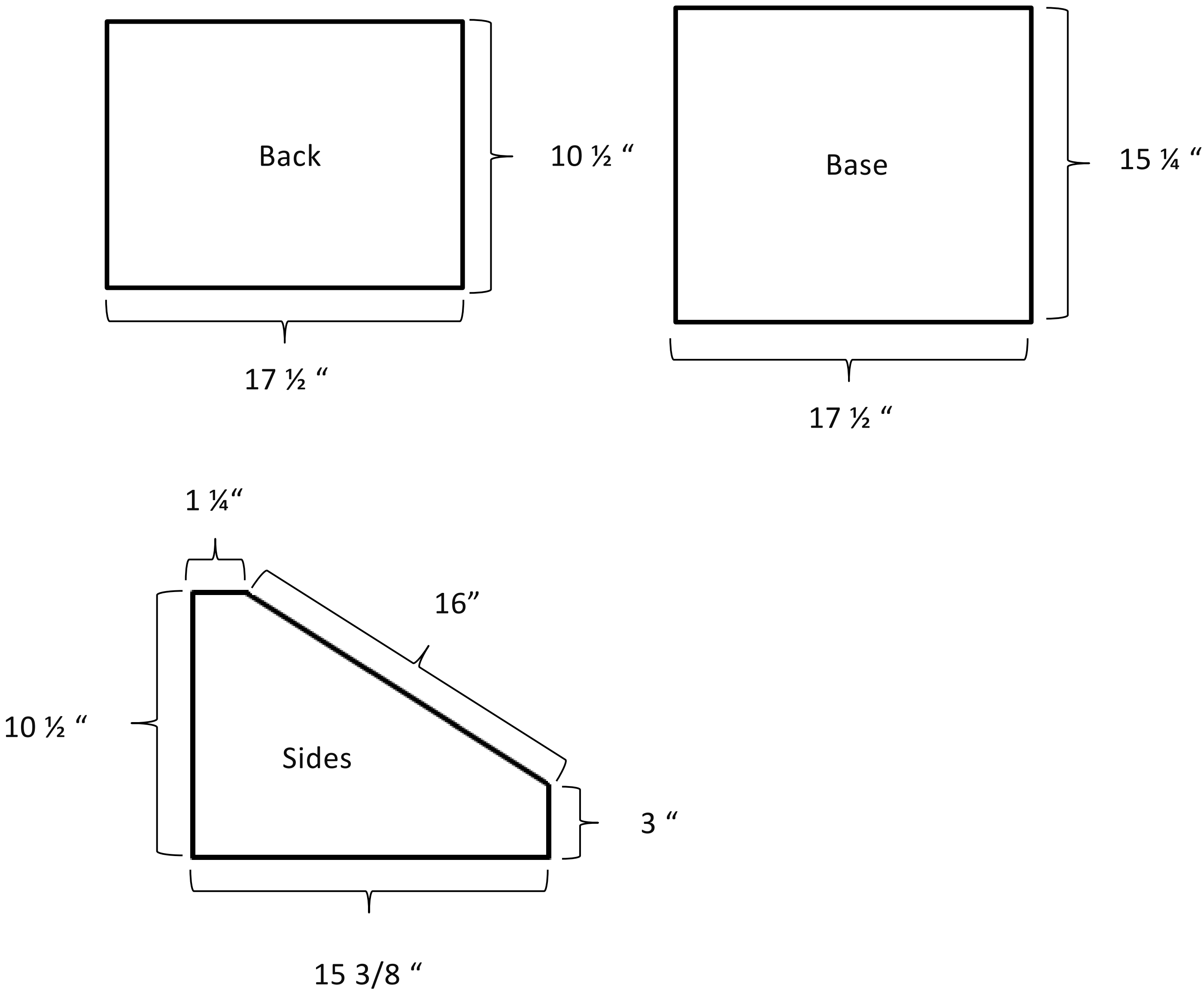
Galvanised Sheet Steel
1 off 10 ½”x 17 ½” by 1/32” (0.5mm) thick (back)
1 off 15 ¼”x 17 ½”by 1/32” (0.5mm) thick (base)
2 off 10 ½”x 15 3/8” x 3”x 16” x 1 ¼” by 1/32” (0.5mm) (sides) – see diagram

Other stuff
8 square feet of compressed glasswool insulation 1” thick
1 off ¼” (6mm) thick window glass 18 7/8” x 18 7/8”
4 off wood strips 1/8”x 3/8”x 20”
8 off aluminium or sheet steel 1” x 4” for attaching reflectors to oven body
1 off wooden drawer knob and attachment screw
Assorted screws and nails
A can of matt black engine enamel

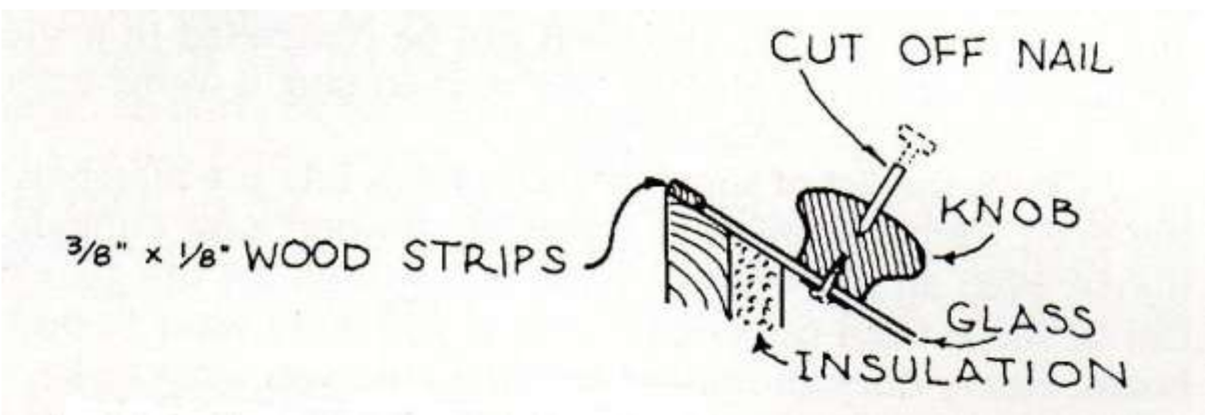
Plywood Shapes



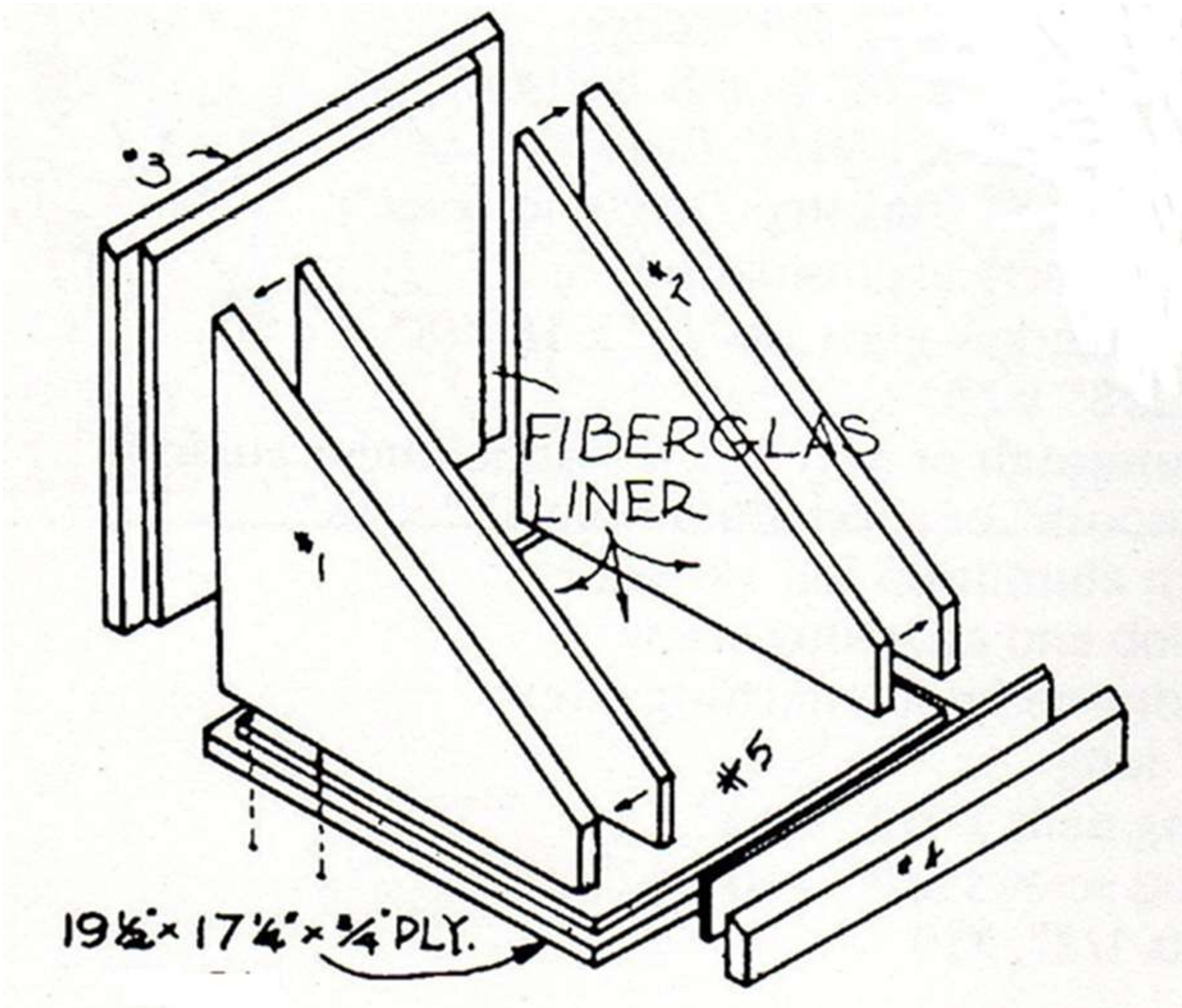
Sheet Steel Shapes

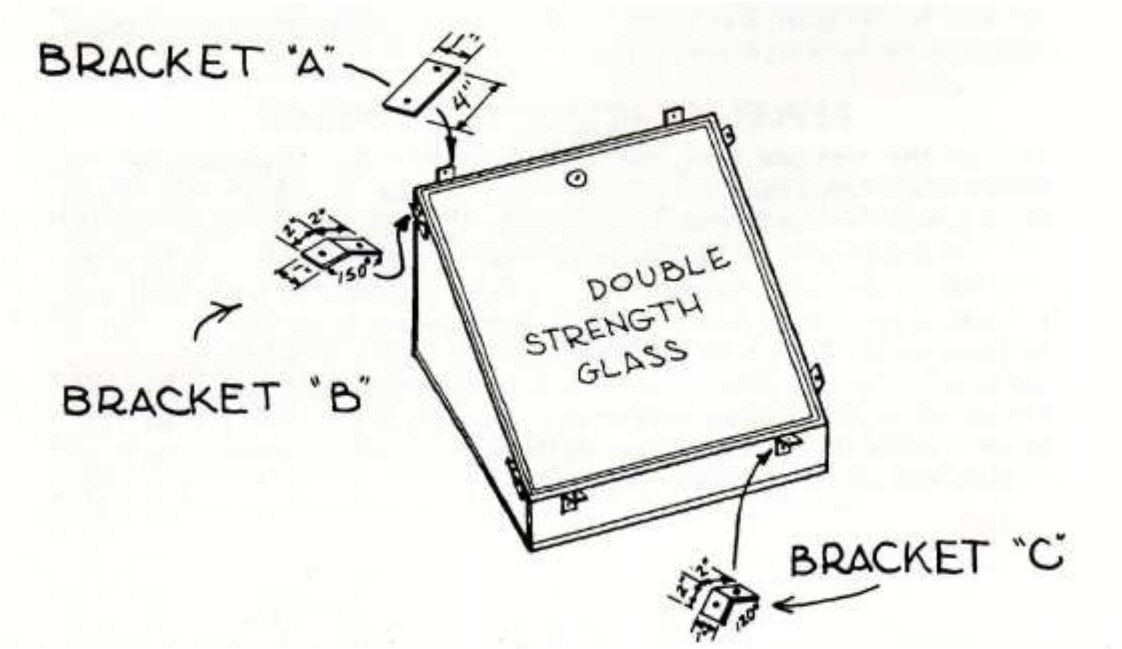


Wood Strip and Knob Attachment

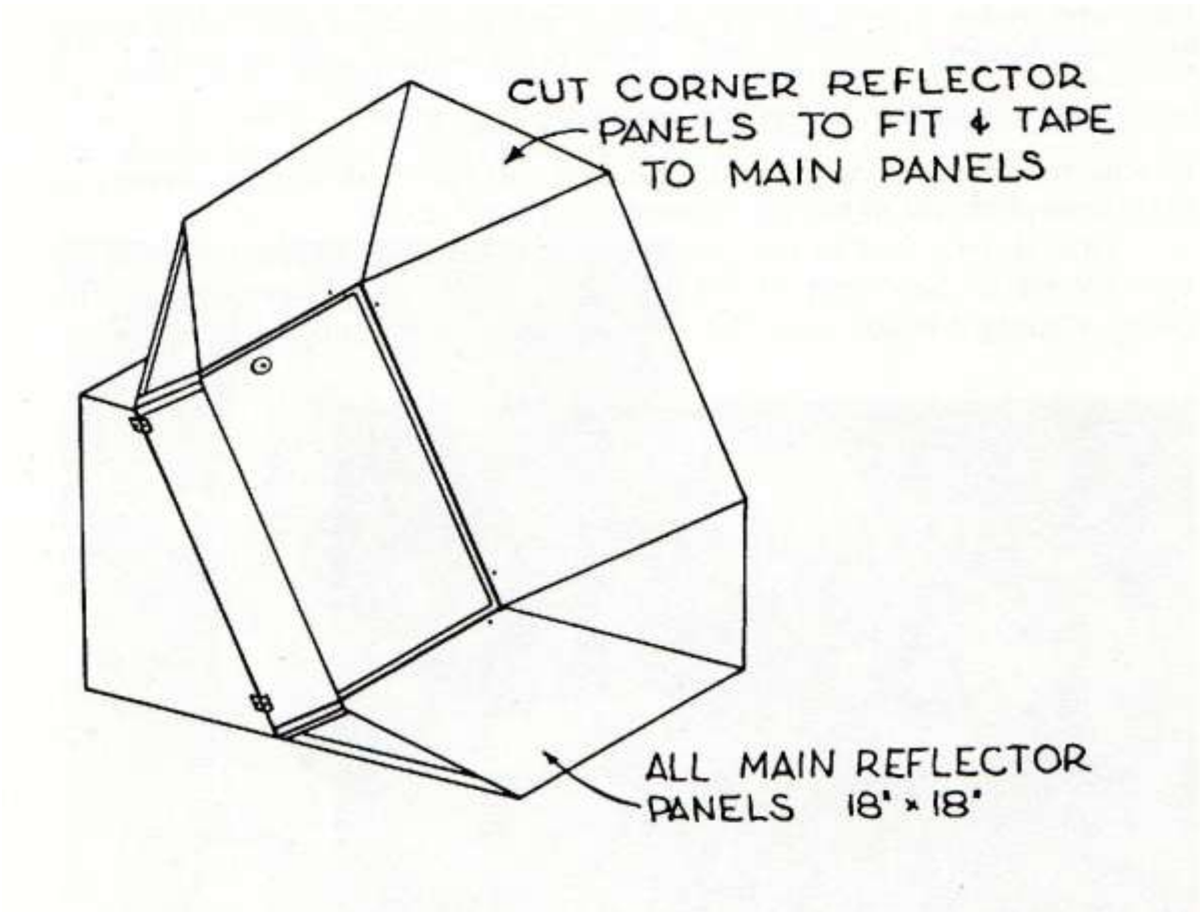


Oven Body Assembly
Fitting Brackets to the Stove Body

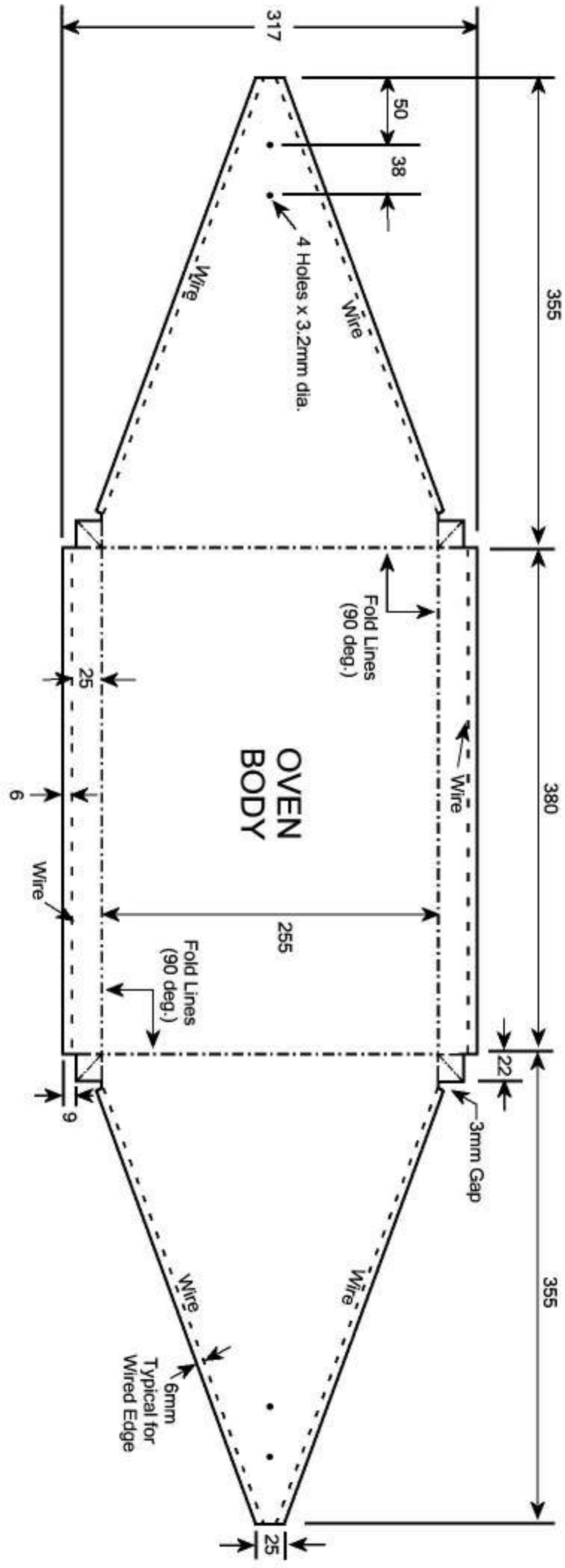


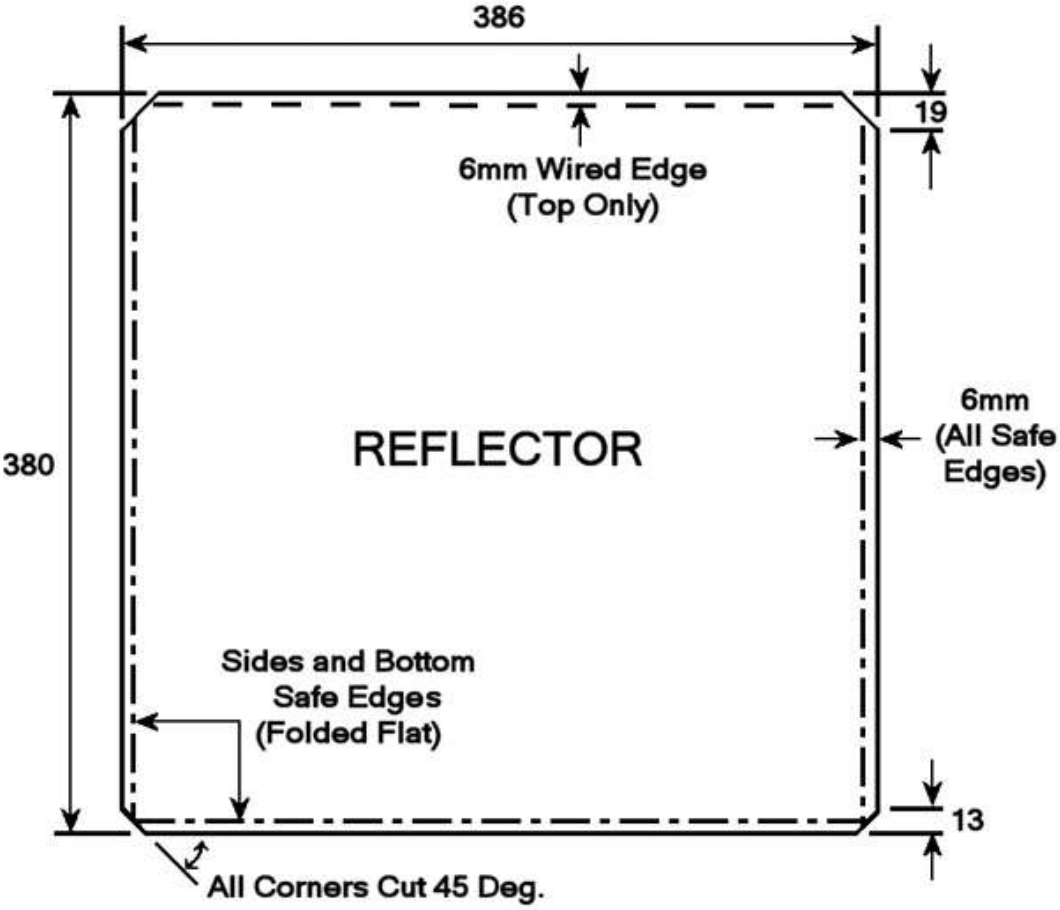


Reflectors Fitted to the Oven



Appendix 4 – Fireplace Reflecting Oven Body and Oven Reflector Plans




386
19
6mm Wired Edge
(Top Only)
380
REFLECTOR
6mm
(All Safe
Edges)
Sides and Bottom
Safe Edges
(Folded Flat)
13
All Corners Cut 45 Deg.