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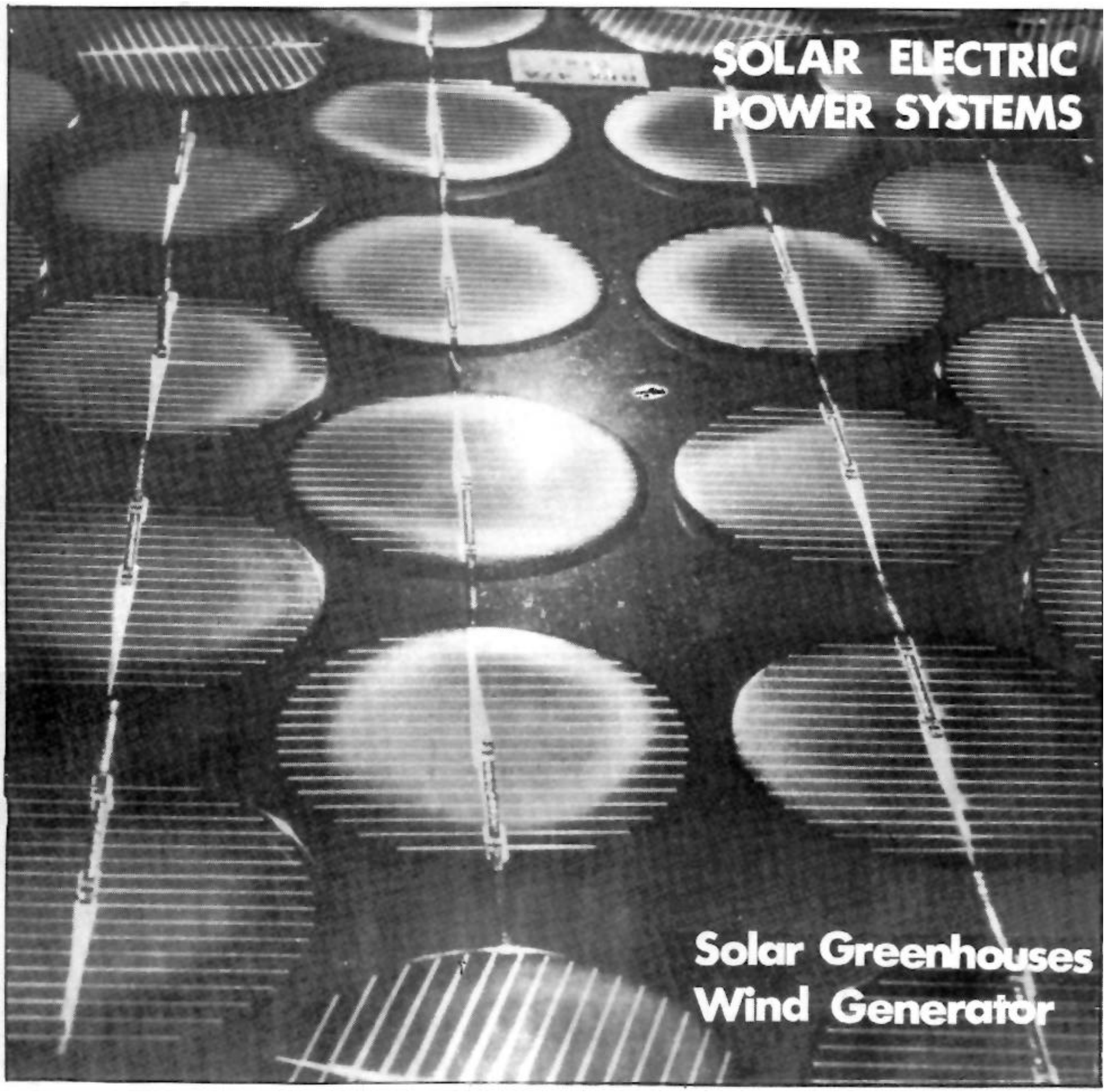
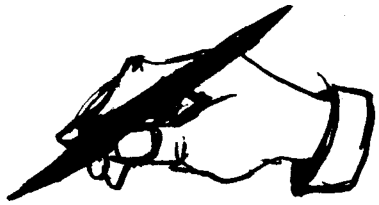
SOFT TECHNOLOGY

Alternative Technology in Australia

No. 7 Feb-Apr 1982



Editorial.



The energy debate all too often centres only on the finiteness of our energy sources, particularly liquid fuels suitable for transportation, and consequently the need to develop suitable alternatives. The environmental consequences of the possible solutions have tended to play second fiddle to other considerations such as technical feasibility or economics.

Recent statements by climatologists may hopefully start to put an end to this and force energy planners, politicians etc. to consider the environmental consequences of their actions. For the first time authoratative studies are making quantitative statements about the effects of raising the carbon dioxide (CO_2) level in the atmosphere. Up until now the debate has been very much of a qualitative nature with much disagreement in the scientific ranks as to what effect, if any, there would be from the continued burning of fossil fuels.

It has been estimated that the combustion of fossil fuel releases 5.6 billion tons of CO2 into the atmosphere every year. The CO2 level has risen from 280-300 parts per million in 1880 to 335-340 ppm in 1980. Studies by Dr. James Hansen and his team at the Goddard Institute for Space Studies in New York, (which is a NASA Studies Centre), claim that the global temperature rose by 0.2°C 'from the middle 1960's to 1980 as a result of the increased CO2 level. The total rise for the past century has been 0.4°C.

The reason for this is the so-called greenhouse effect. CO2 absorbs long wave or thermal radiation and the greater the concentration of CO_2 in the atmosphere the less the radiation emitted by the earth's surface and lower atmosphere can escape. This has led to the small but significant warming of the earth's surface.

Although there has been a general rise in the global temperature accompanying the rising CO2 level. it is still not regarded as conclusive evidence. There are still many unanswered questions and contradictions. The rises predicted over this decade, the 1980's, of a few tenths of a degree will, however, be the first unmistakable evidence that the burning of fossil fuels at the current rate is not only raising the CO_2 level but also the average global temperature as well. These changes in world climate could lead to events such as the end of agriculture in California and parts of Central Asia. Later on the melting of ice sheets could cause rises in ocean levels and consequent flooding of populated areas.

The table below shows the relative CO2 release per unit of energy compared with oil.

Oil	1
Coal	5/4
Gas	3/4
Oil Shale	7/4
Tar Sands	7/4
Heavy Oil	7/4
Nuclear	0
Solar	0
wood	0
Hydroelectric	0

It can be seen that the return to the coal based economy advocated by many will add 25% more CO2 for every unit of energy consumed, while the synthetic fuels would add nearly twice as much. The rising level of CO_2 should indeed be used as a powerful argument for the development of non polluting energy alternatives.

BOB FULLER.

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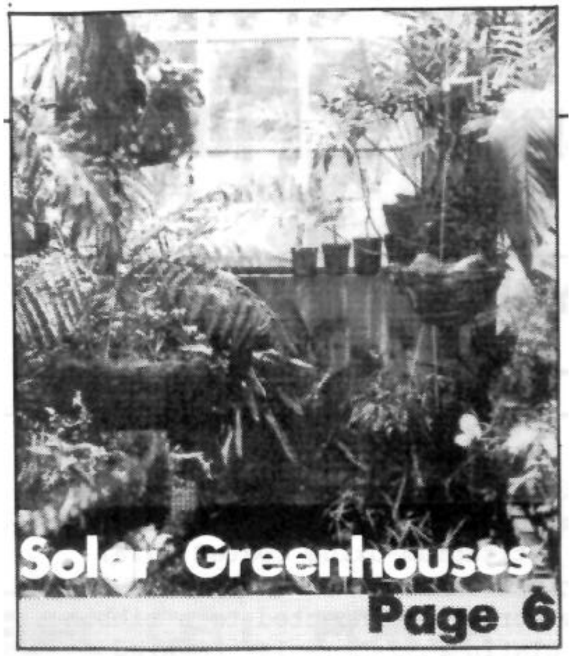

Front Cover: Phillips Silicon Solar Cell Panel.

Comments, Contributions and critisisms are welcomed and should be sent to the "Alternative Technology Association, 366 Smith St. Collingwood,Victoria,3066

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Energy Flashes ...

HYDROGEN FROM THE SUN

A novel cell has been developed which produces hydrogen by the use of the sun's energy. The cell is based on a titanium-oxide coated metal strip which collects the sun's rays. The strip is connected to a ribbon of platinum via a solar powered battery. Both the metal strip and the ribbon of platinum are immersed in water which fills a glass tube.

The glass tube is placed so that it is at the focus of a parabolic reflector. When sunlight shines on the titanium-oxide coating, hydrogen appears in the water next to the platinum ribbon.

The silicon cell provides a small electrical force required to make the cell produce hydrogen.

The cell could be used as a motor fuel production plant, attached to a suburban house. Six hours of direct sunshine falling on a solar collector the size of half the roof of an average house ($75m^2$) can generate enough hydrogen to drive a small car on a journey of 20km (9kWh of energy) and heat a water tank the size of a home swimming pool 3 degrees (180kWh of energy).

U.N. SOLAR PUMP STUDY

According to a study by the United Nations Development Programme solar powered water pumps could soon be cost competitive with diesel pumps.

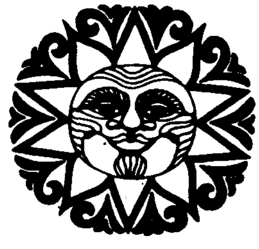
The study examined 11 photovoltaic pumps and 1 thermal pump used to supply drinking water and water for irrigation. While a number of significant problems were noted with solar pumps in service to date, it was concluded "these problems were not fundamental to the technology and can be overcome during the normal course of development as the technology matures. The systems have potential for reliable operation with minimum maintenance."

Causes of failures in the photovoltaic based pumps included incorrect wiring, faulty connections, overheating or overloading in electronic circuitry, dangerous d.c. voltage and suction pipes trapping air. Eradication of problems such as these would be likely to raise efficiency levels to about 5% compared to current levels of 2% to 4%.

NEW JAPANESE SOLAR CELL

A new gallium arsenide solar cell is being developed by Mitsubishi for use in artificial satellites. The cell is said to be 50% more efficient than conventional solar cells, converting solar heat into electricity at an efficiency of 18%, half as much again as the silicon cells now used as power sources on satellites.

A number of American Companies are also working on the cells, including Rockwell International Ltd., the company which built the space shuttle.



PLOTTING THE SUN

A simple devise which has been called a "Sun-path Finder" has been developed by Mr. David Hassel of the School of Building at the University of NSW

The devise checks the position of the sun relative to a particular site throughout the year. It is a small box with a viewing hole on one side and a transparent screen with a computer generated solar position diagram on the other side.

The finder is pointed north and tilted until a plumb-line hangs vertically through the location hole. The diagram on the screen then indicates the path of the sun through the year, making it possible to tell if an obstacle will block the sun's rays.

By using the "Sun-path Finder" it is 'possible to locate things such as solar water heaters or clothes lines in positions which will gain the maximum sunlight.

FUEL CELL POWER PLANT

Tokyo Electric is now completing an experimental fuel cell power plant 'based on hydrogen. The plant, due to go into test operation early in 1982, produces electricity by means of an electro-chemical reaction of hydrogen and oxygen. The hydrogen is produced by decomposing liquified natural gas and the chemical energy derived is directly converted into electrical energy.

The experimental plant has a capacity of 4,800 kw in direct current and 4,500 kw in alternating current. With current technology, about 50% of the chemical energy in the fuel can be converted into electricity, with the company's officials believing this could be increased to as high as 90%.

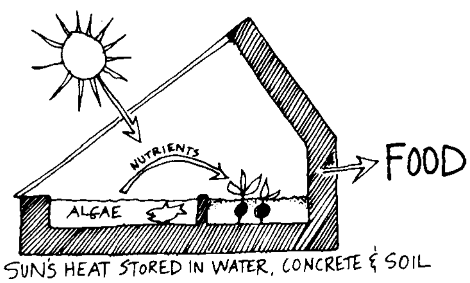
While the costs of the plant have turned out much higher than anticipated Tokyo Electric is confident costs can be reduced to a competitive level. The plant has the added advantage that the output can be controlled anywhere from zero to maximum in a number of seconds.

SOLAR GREENHOUSES.

A successfully managed greenhouse in your back garden will reward you in two ways. Firstly, depending on what you choose to grow, it will provide you with flowers or vegetables or a combination of both. Secondly, it can become a peaceful retreat from the pressures of city living where you may potter or just sit, surrounded by greenery and the accompanying effect that that seems to have on human beings.

Greenhouses have yet to catch on in a big way here, as they appear to be doing in some places like the U.S., if what is available in the market place can be used as an indicator. Greenhouses available here are still largely based on European design where maximising light is regarded as a top priority. Certainly no true "solar" greenhouses are available on the market. By "solar" greenhouse, I mean one that has been specifically designed to capture and store solar heat, while at the same time maintaining adequate levels of illumination. This, therefore, leaves us with no option but to "do-it-yourself".

But on what basis do we make our design? This article outlines a design method by which one can evaluate approximately the expected performance of a solar greenhouse.



A couple of preliminary notes at this stage are necessary. Firstly, the basis for this design method is from an American book entitled "The Complete Greenhouse Book" by Clegg and Watkins (pub. Garden Way). I have merely translated into Australian terms. My plans to validate the method were cut short by a move interstate. However the method and assumptions are reasonable, and should provide a rough estimate of a structure's performance. I would be extremely grateful to hear from anyone who builds a greenhouse using this method and can provide data, however crude, on its subsequent performance.

Secondly, the figures and degree days are for Melbourne. Anyone requiring data for other areas should write to me and I will see what I can do.

The method by which the thermal performance of the structure is determined is to evaluate in turn the heat gains and losses from the greenhouse so that we may carry out a simple energy balance. This will enable us to determine the sort of temperatures the greenhouse is likely to maintain.

The Heat Gains

A simple formula for describing the heat gains each month is given by the equation.

$$Qg = Hg \times DM \times GA \times SC \times CE$$

where Qg = Heat collected by the greenhouse each month

Hg = Heat gained through each square metre of glazing per day (measured in Megajoules per square metre per day)

DM = number of days per month

GA = Glazed area in square metres

SC = Shading Coefficient of the glazing

CE = The collection efficiency of the system.

Let us deal with each of the terms on the right hand side of the equation in turn.

HG

Table 1 gives the average amount of solar radiation falling each day for the month in question on the horizontal and various inclined surfaces for Melbourne (Latitude 38°), in Megajoules per square metre. Now, we are concerned with what enters the structure, so the appropriate value must be multiplied by the solar transmittance of the matterial being used.

Table 11 gives the solar emittance for a number of commonly used glazing materials. Remember that these values of solar transmittance are for new materials and aging, dirt and ultraviolet degradation will reduce these figures.

Table 1 figures are for north facing surfaces only. Fig. 1 shows the effect of turning a surface away from north. The amount of solar energy falling on the surface is reduced.

To find Hg, determine for each glazed surface

i) its slope

ii) Its orientation.

Therefore, Hg for surface (1) (if that surface is sloped at 30°, faces NW and is glazed with polyethylene) in the month of July will be

$$9.9 \times .75 \times .9 = 6.7 \ (MJm^{-2}d^{-1})$$

This must be done for each glazed surface of the greenhouse for the months of interest, (usually winter) say May, June, July and August. Add them up to give a total Hg.

DM and GA

These are self explanatory.

SC

All greenhouses require some structure. This will therefore further reduce the amount of solar energy entering the structure. Below are some typical values for this reduction.

Lightweight metal frame	5% reduction
Timber frame, deep members	15-20% reduction

Remember SC will be

$$\left(1 - \frac{\text{percentage reduction}}{100}\right)$$

Table 1

Latitude 38° Melbourne (MJ/M²/Day)

Solar Rqd. on Horizontal & Inclined Surfaces

MONTH	HORIZ.	30°	60°	90°
January	23.4	21.4	16.0	8.8
February	20.9	20.5	16.4	9.8
March	16.1	17.7	15.8	10.9.
April	10.6	13.5	13.7	11.0
May	6.9	9.8	10.6	9.3
June	5.8	9.3	10.7	9.8
July	6.4	9.9	11.2	10.2
August	8.4	11.3	11.9	10.0
September	12.3	14.6	14.0	10.7
October	16.6	17.2	14.6	9.5
November	10.1	19.1	14.9	8.8
December	23.3	21.3	16.0	8.9

GREENHOUSES

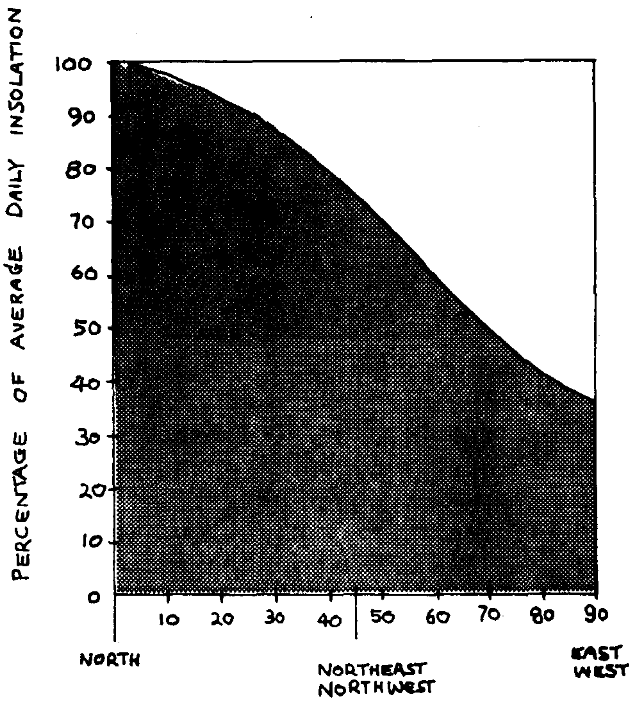


Fig. 1. Effect of *Turning a Surface away from North.*

CE

We are concerned here with estimating how much of the incoming radiation is actually captured and stored as useful heat. This will vary summer to winter, and will also depend on whether the greenhouse is full of mature leafy plants or just with seedlings. This is because a lot of incoming radiation is absorbed by the plants, which in turn transpire, turning the energy into latent heat, most of which is lost through condensation and ventilation.

Estimates for this vary seasonally, but a greenhouse full of plants may turn 30% of the incoming radiation into latent heat in winter, while up to 50% in summer. Below are some average collection efficiencies.

Now that we can calculate Qg for any month let us turn our attention to the heat losses. To calculate the monthly heat loss from the greenhouse, we must first calculate the hourly heat loss (Q_{he}). This is divided into 2 components. The heat lost through conduction by the walls, floor and roof (Q_{hc}), and the heat lost by ventilation and infiltration of outside air through cracks, joints, etc (Q_{hv}). Again, we have an equation

$$Q_{he} = Q_{hc} + Q_{hv}$$

Some glazing materials like polyethylene are partially transparent to long wave or thermal radiation. This means that the plants, floor etc will radiate heat directly to objects that are outside the greenhouse and are colder than themselves. This can be a considerable heat loss mechanism under certain conditions but for the sake of simplicity, heat loss by radiation will be ignored here.

Again let us deal with the two mechanisms in turn. **CONTINUED PAGE 22.**

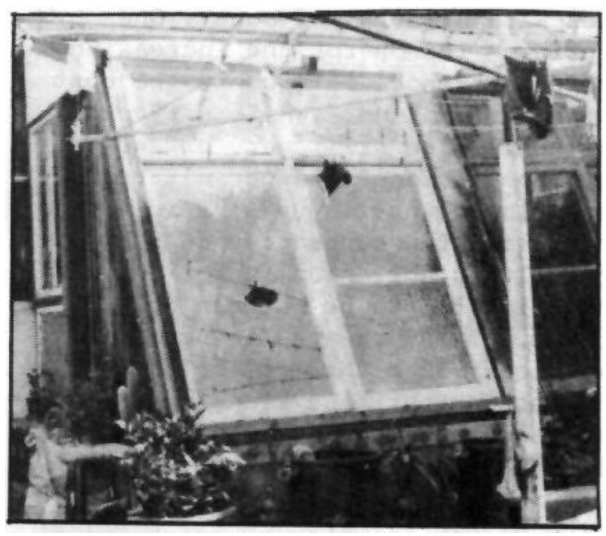


Fig. 2. A simple add-on greenhouse can be easily built on the wall of an established house.

Solar Electric Power Systems

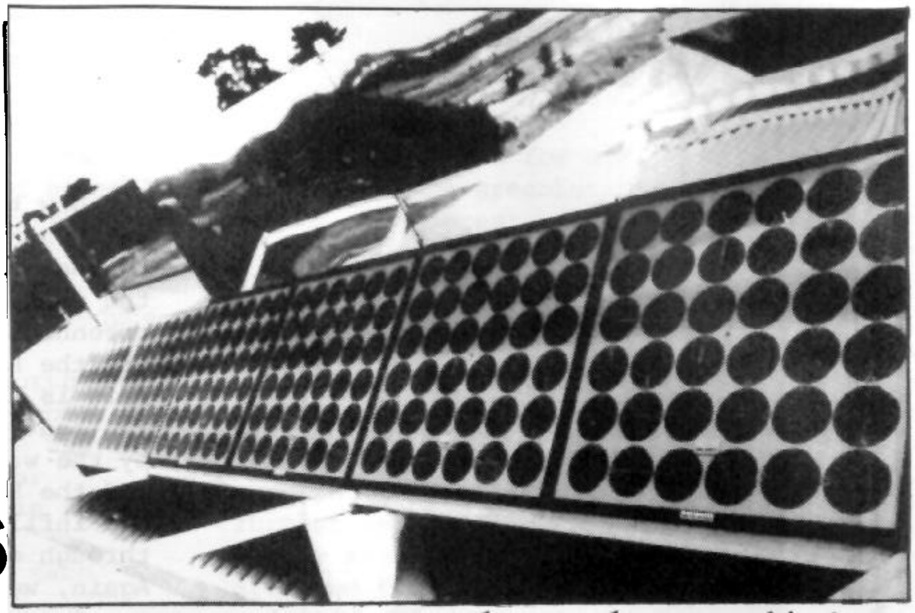


Fig. 1. Bos uses 8, 2.5 amp solar panels to run his home.

Until recently the high cost of photovoltaic cells has meant their use has been restricted. At first they were limited to the space programme, then to remote terrestrial uses and now finally they are becoming increasingly widespread in domestic situations. In fact an increasing number of houses are now using the humble photovoltaic cell as their only source of electrical power.

The houses using solar cells today range from small one or two room week-end shacks, to fully fledged suburban homes with all the mod cons. One surprising reason for the increasing interest in photovoltaics is the cost of the alternative. While silicon solar cells are still very expensive they can provide a cheaper alternative than mains power if you live in the country and the connection charges are high. It is not uncommon for the connection fee to be between $5,000 and $10,000 if you are living say half a kilometer from the closest power line.

Faced with these kinds of charges many people, especially those with relatively small energy needs are being attracted to solar cells as a source of electricity. Solar electric power systems have the benefit of being simple and easy to add on to over a period of time as money becomes available. This can be very useful if you have not got $10,000 to spend on a complete system straight off.

The savings with solar electricity are not only restricted to the initial installation costs. Once you have your system you have no power bills, and the savings from this can add up to a substantial amount over the years. Especially when you-consider the rate at which electricity prices have been rising recently.

Let's look at an example of how much you might save using solar cells. Say you have solar cell panels with a life of 20 years. Well let's look at what electricity from the power utility might cost during that period, assuming an increase in power prices of about 7% per annum.

year	cost ($)		
1	300	11	589
2	321	12	630
3	343	13	674
4	367	14	721
5	393	15	771
6	421	16	825
7	450	17	883
8	481	18	945
9	514	19	1011
10	550	20	1082
Total Electricity Cost $12,271			

So over the next 20 years you would pay about $12,300. That's assuming price rises are low (7% is well below the current inflation rate), and also that you use relatively little electricity, ($300 worth, many houses use $400 or $500 worth). In reality your expenditure on power could be much higher.

If you add to these costs a connection fee of say $8,000, then your outlay would be over $20,000. If on the other hand you installed solar cells, the entire system, (refer to costing later in article) could cost you about $11,000 and that includes one replacement set of batteries. Also keep in mind the cost of solar cells is dropping while the cost of both mains electricity and its connection costs are increasing. So the economics can only get better.

There is another reason why people are switching to solar cells: the independence it gives you. Many people get a lot of satisfaction from getting all their power needs from their own roof. Being self sufficient with no fear of blackouts or being disconnected if you pay your bills too late, is quite attractive.

All these advantages have added up to bigger and bigger solar cell systems being used in homes. One house which has received a lot of publicity recently is the one built by Michael Bos. His house gets all its electricity from silicon solar cells which provide all he needs to run his comfortable home. Here is a description of his electrical system.

Bos's Electrical System

The Solar Panels

The basis of the electrical system is eight silicon cell panels each of which supply *2.5* amps at *14.5* volts. The output of the cells is boosted in winter by the reflection off both the aluminium roof on which they are mounted and by the use of reflectors mounted above the panels. As a result of the use of the reflectors the output of the cells only drops off to 2/3rd of the summer output instead of the 1/3rd that could be expected.

Another effect of the reflectors is the additional light heats up the panels. If the cells get too warm their output, drops off. However the cooling effect of the surrounding air has been adequate to prevent the cells reaching a temperature where this could be a problem.

During summer the reflectors are not used as the output from the cells is adequate for all power requirements. The panels are mounted in such a way that

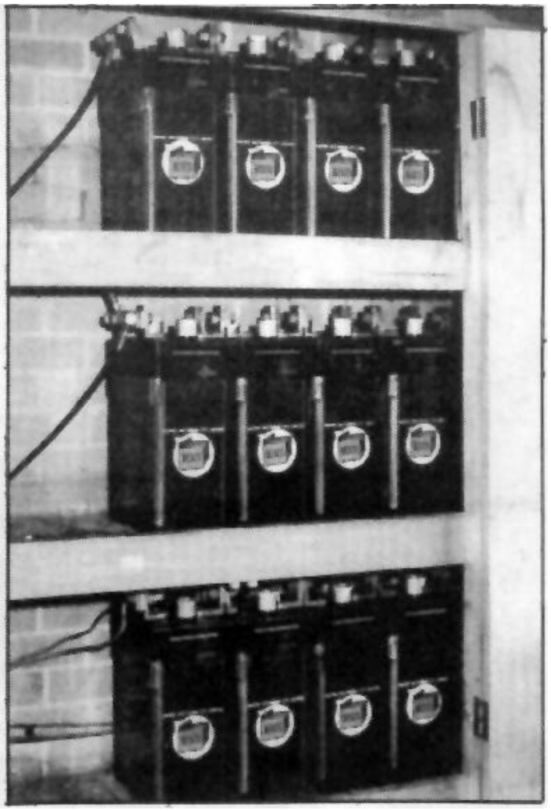


Fig. 2. The bank of Besco batteries have a capacity of 1780 amp hours.

their angle can be adjusted according to the season. In winter they are set on a steeper angle than in summer.

(Storage Batteries

The power from the cells is stored in a 1780 amp hour bank of Besco lead-acid deep cycle batteries. Bos predicts that the 2 volt cells should have a life of 20 to 25 years. The battery bank weighs about 1,300 kilos and needs topping up with distilled water about once a year. The batteries are kept inside the house in a cupboard that is vented to the outside.

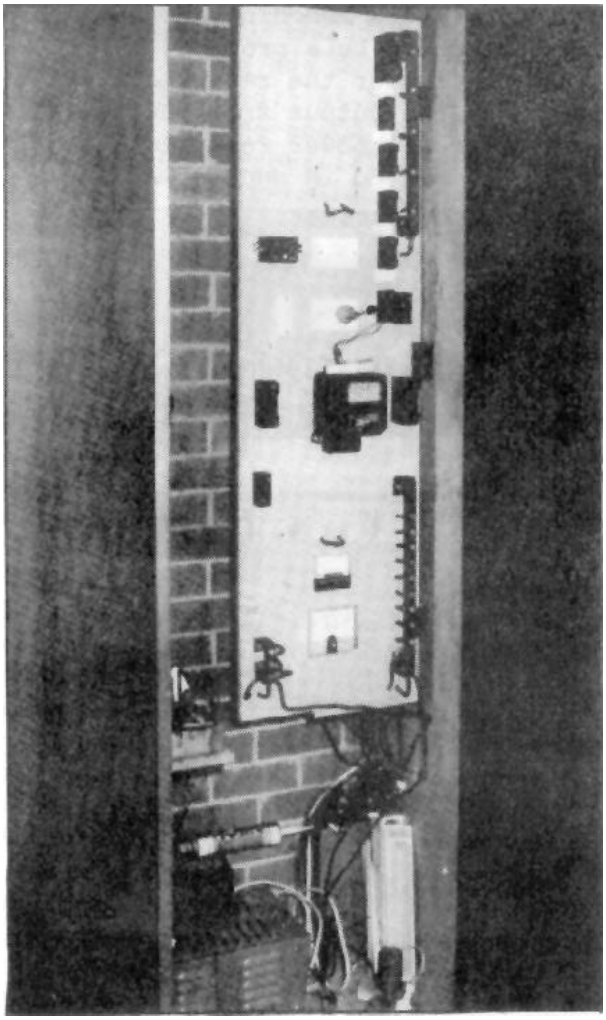


Fig. 3. The house uses a basic switchboard; note the inverter at the bottom of the photo.

Fig. 4. Michael Bos in the kitchen of his home.

Inverter

Although the majority of the appliances in the house run on 12 volt a number run on 240 volts AC These run from the inverter. When looking for an inverter Bos found the highest output he could get for an inverter going from 12 volts to 240 volts was 500 watts, with an efficiency of 85%. He is now getting one built which will be rated at 1,500 watt with and efficiency of about 85%. The inverter will also be able to handle power surges of up to 3,000 watts for up to 20 minutes. The inverter can be switched on from the power outlets, all of which have 2 switches, one for the power itself and one to turn on the inverter.

Appliances

Lighting in the house is

supplied by about 80 eight watt fluorescent lamps. However these lamps have been wearing out relatively quickly and are being replaced by 13 watt fluorescent lamps produced by Minitronics.

One of the major power users in the house is the refrigerator. This has been specially designed by Michael Bos to use as little energy as possible.

One of the major design features is the top opening door, 'unlike most fridges which have a side opening door. Thus when you open the door the cold air stays inside instead of "falling out" as it would with a conventional refrigerator. Another feature of the fridge is thicker insulation. The fridge uses 4 inches of polyeurethane insulation instead of the usual 2". With 2" of insulation Bos found the compressor in the fridge ran full time, while with 4" of insulation it only ran *30%* of the time. An improved compressor design using electronic commutation is also incorporated.

The fridge has a capacity of 67 cubic feet. It runs on 12 volts using 22 amp hours a day. This is about one twelfth of a normal fridge of a similar size.

One rather novel feature of Bos's house is his solar powered gate. The gate uses a 12 volt Solarex panel in conjunction with a small deep cycle storage battery to operate the motor which opens and closes the gate. The gate can be opened by pushing a button near the gate or by radio control from the car or the house. The solar powered gate is now being marketed by Renlita.

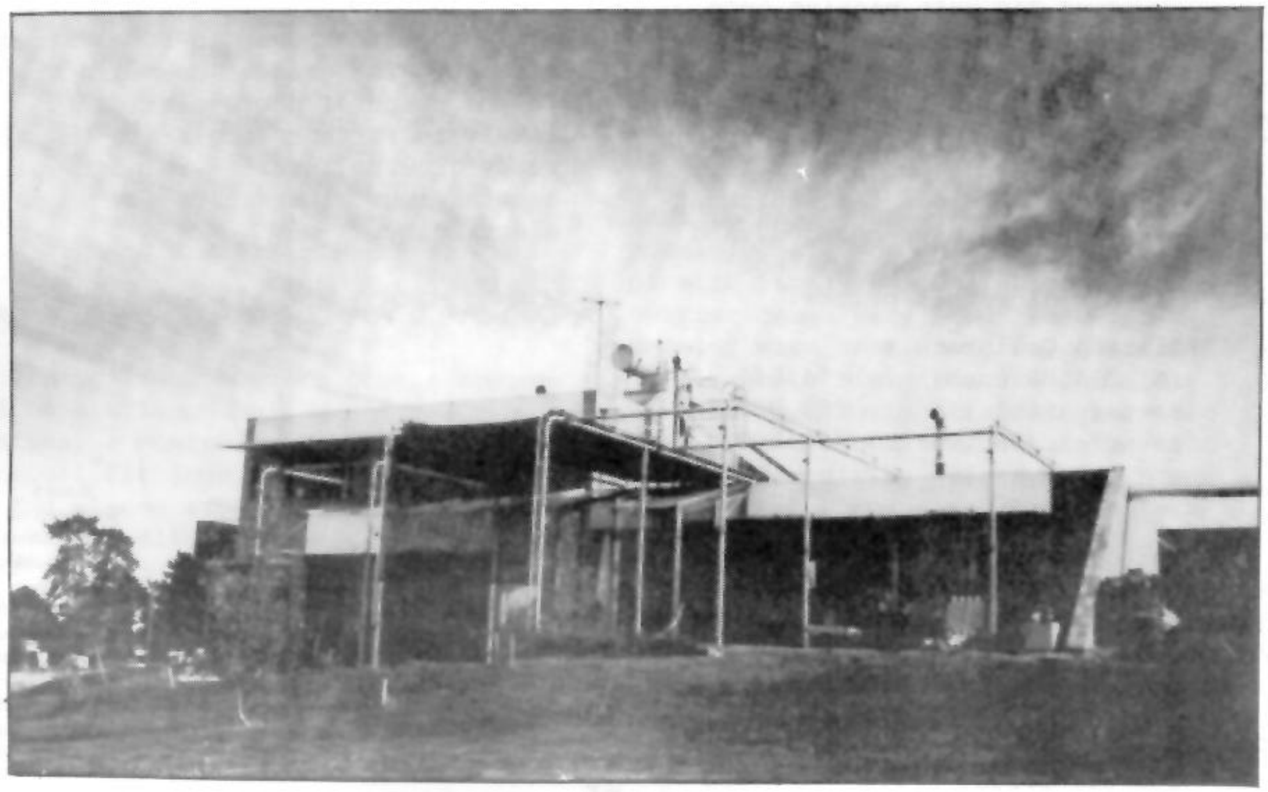


Fig. 5. The north face of the Bos family's home.

Solar Electricity

A varietyof other 12 volt appliances are used by Bos. The stereo system is one of the small compact systems used in motor vehicles. The pump is one of the ones commonly used in boats. It draws 7 Amps at 12 volts and can pump up to about a 19 foot head. Other appliances include an electric drill, soldering iron, an electric fence and a colour television

One of the more novel projects is a dual voltage automatic washing machine. The machine uses the standard 240 volt control system in conjunction with a 12 volt Japanese motor. The motor had to be specially selected to be capable of carrying the high start up load of the machine. When the new inverter is running the dual voltage washing machine will receive little use as Bos has come to the conclusion it will be easier to use a standard 240 volt machine once the power has been made available by the inverter.

The Costs

This costing of the system is only approximate. Since the equipment was purchased costs have changed, and also some of the equipment was not bought at normal retail prices.

Silicon Cell Panels *(8) @ $580* each	*$4,640*
Battery Bank	*$3,000*
Inverter (500 watts)	$500
Total	$8,140

In addition to these costs an estimate needs to be made for the cost of the control system, the house's wiring, and the appliances. This could cost several thousand dollars.

Conclusion

The electrical system of Bos's house demonstrates that solar cells can provide a viable working alternative to mains power in some circumstances. The gradual downward trend in the price of photovoltaics is likely to further accelerate the already growing interest in photovoltaics as a serious alternative source of electricity.

MICK HARRIS

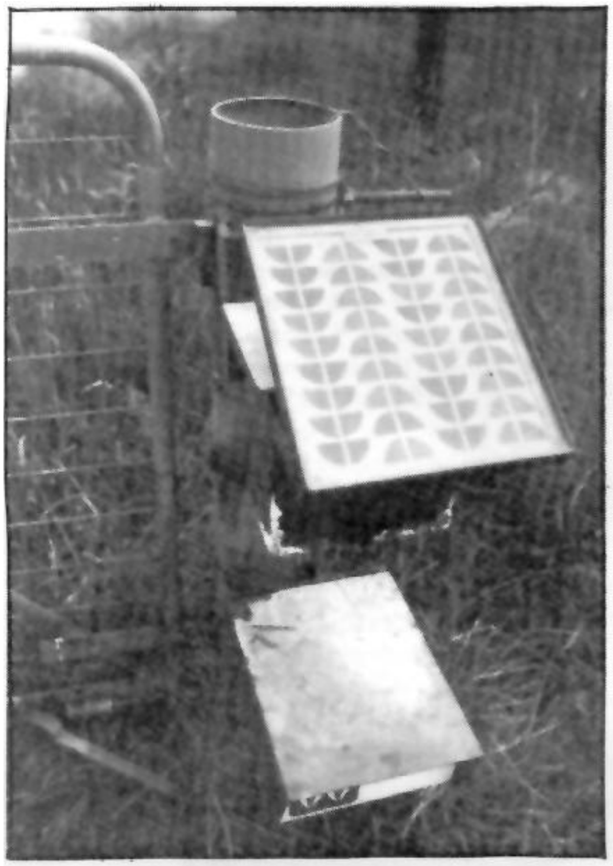
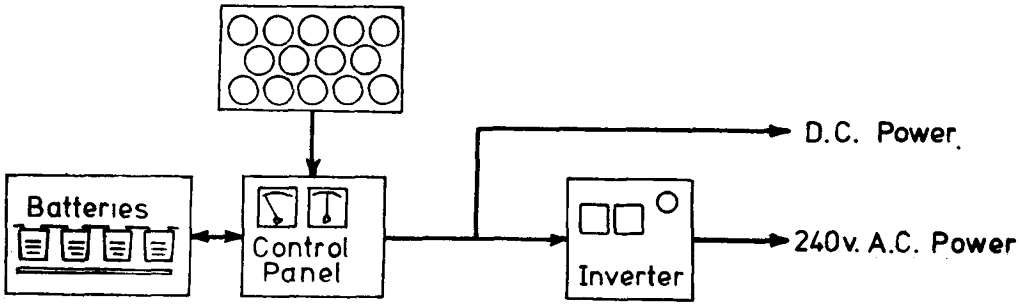


Fig. 6. The radio controlled solar front gate.

a simple solar electric system



One of the very real advantages If solar electrical systems are their flexibility. You can have a system of any size you choose ranging from a Large system costing 10 or 20 thousand dollars down to a small basic system such as this one (or maybe even smaller). What's more, once you have set up a system it is relatively easy to "add on" to it increasing its capacity as the need arises.

For many people a simple system which can provide light for a couple of rooms, power for a stereo or pump is adequate. The classic example of the kind of place this might be is the little weekend house where heating is provided by a stove or fireplace and power needs are minimised. Let's have a look at a solar electrical system for just this kind of situation.

The System

The basic components of the system would be a silicon cell panel, storage batteries, a control/switch box, wire, electrical fittings as well as other bits and pieces such as a frame for the silicon cells and shelves for the batteries. In terms of value for money it is better to buy a large sil--con cell panel than several small panels. With a system such as the one being discussed a panel with an out-put of around 33 watts (100 mm cells) would be desirable. Batteries with a capacity of 110 amp hours would probably be adequate. The control box would include a voltmeter, ammeter fuses and switches for lights and power.

Parts List

Item	Cost (approx)
Solar cell panel (33 watt)	$600
Battery Bank (2 x 6V. 110 A.H. Batts.)	$130
Control/Switch Box (inc. meters, fuses, switches)	$50 - $100
Odds & ends, (wiring, fittings etc)	$50 - $150
Total Cost of System	$830-$970

Wiring

Because of the high energy losses in the wiring of 12 volt systems it is best to keep your wires as short as possible. If you do have a long length of wire it may be desirable to use a heavier gauge wire. But then again heavier wire costs more so once again it's best to minimize wire lengths.

It is also important to have the best possible connections in the system. Solder wiring joints where possible rather than using screw on terminals.

One good idea is to have your solar cell panel mounted on an adjustable frame so that you can optimize the amount of energy you collect. When you have spent $600 on a panel it makes a lot of sense to spend a couple more dollars on a frame and a couple of minutes every 3 or 4 months adjusting the panel to get the maximum electricity.

Low Voltage Wiring.........

Low voltage power systems operate at rather high current levels. If the interconnecting cables are too small, a large proportion of the power available will be wasted in the cable itself. This loss can be reduced by using a larger cable but this increases costs. Tables 1 & 2 are provided to help in selecting the best cost/power loss compromise.

Metric cables are specified by the copper area (in square millimeters), the number of strands of wire, the number of conductors or cores in each sheath. Standard sizes for multistrand cables are shown in table 2; (this is not exhaustive). The use of multi-strand, (rather than single strand) cable is suggested due to potential problems with cable breakage creating hot spots, or breakage due to cable vibration. Normal soft drawn copper is not recomended for outside aerial use and hand drawn aerial cable should be used.

The following example illustrates the problem of power loss and the use of table 1. Suppose we have a 24 volt DC wind generator that can deliver 500 watts of Power at top speed.

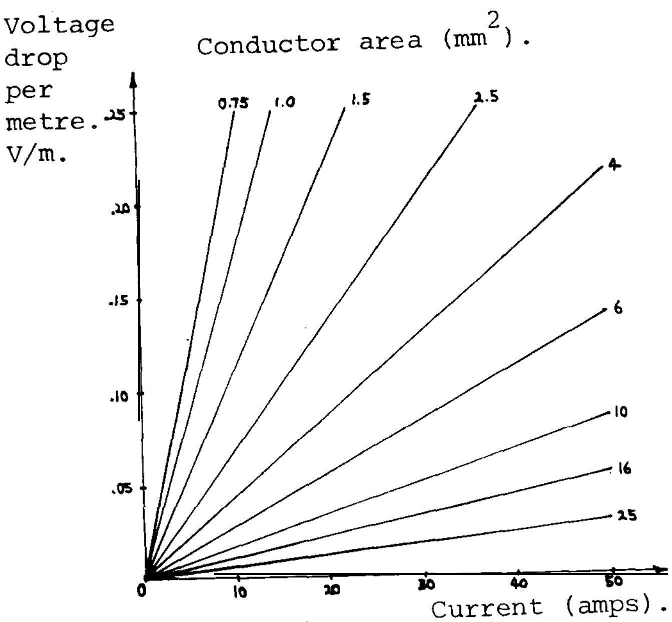


Table 2 Cable Costs - costs of various multistrand cables strand cables

copper area mm^2	number of strands/ strand diameter	description	Volt drop/ Amp/metre	Cost $/metre
0.75	24/0.2	ordinary duty 10amp PVC sheathed 3 core flex.	0.023	0.60
1.0	32/0.2	heavy duty 15amp PVC sheathed 3 core flex	0.017	1.00
1.5	30/0.25	ordinary duty 15amp PVC sheathed 3 core flex	0.011	0.80
2.5	7/0.67	twin core double insulated building cable	0.0068	0.60
4	7/0.85	single core double insulated building cable	0.0043	0.33
6	7/1.04	single core double insulated building cable	0.0028	0.57
10	7/1.35	single core double insulated building cable	0.0017	0.81
16	7/1.70	single core double insulated building cable	0.0011	1.22
25	19/1.35	Single core double insulated building cable	0.00068	2.16

Assume that the tower is 50 metre from the house and 10 metre high. If 2.3mm of cable is used, how much power would be lost in the cable at full power?

(1). Calculate the current in the conductor. A 24 volt source delivering 500 watts must put out a current of 500/24 = 21 amps.

(2). Find the voltage drop. Referring to table 1, for 21 A. & 2.5½mm, the voltage drop is 0.14 volts per metre. The length of the collector is twice (two wires) 50+10=120 metre. So the voltage drop along the cable is 120x 0.14= 17 volt.

(3). Calculate power loss. At 21 A., the power lost in the cable is 17 x 21 = 357 watt of the 500 watts delivered by the generator. Or 71% of the power would be lost in the cable. This is rather wasteful and clearly the cable size is too small.

Recalculating for $6mm^2$ cable gives a voltage drop of 0.06 v/m, a total drop of 7 volts and a power loss of 147 watts. This is only a 29% loss which is a lot less wasteful. The 120m of $2.5m^2$ would have cost about $36.00 (60 m of twin core) compared to $68.00 for the 6mm. One of the major problems with low voltage systems is that they operate at high current levelsand so large conductors are needed to keep losses small and unfortunately large conductors are expensive.

ALAN HUTCHINSON.

A Home-Made Wind Generator

This design is aimed at providing an alternative to the Winco Windcharger. It incorporated the use of motorcycle parts since these offer a considerable strength increase but are still readily, available. The design uses 4 curved plate aluminium blades attached to a motorcycle wheel. The rotor diameter is 1.8 metres. By using the rear wheel of a motorcycle, a range of sprockets can be used to drive from the wheel-hub to an alternator on the supporting frame. The vertical pivot for feathering still consists of a bicycle fork and head-stem but this has been substantially reinforced.

Wind Generator Construction

Frame - This consists of mild steel (M.S.) rectangular hollow sections (R.H.S.) of various sizes ranging from 15 x 15mm R.H.S. to 25 x 50mm R.H.S. This is relatively cheap to buy and easy to work. Gas welding was used on the thinner sections and electric welding on the heavier sections (2.5mm wall thickness and above).

Pivot - The vertical axis about which the blades turn to feather is constructed from a bicycle fork and head-stem, heavily modified and reinforced. A motorcycle steering head could also be used.

Blades and Hub - These consist of curved aluminium plate (0.6mm thick) mounted on a motorcycle rear wheel (minus tyre, tube and brake assembly). The rear wheel has a sprocket attached for the chain drive to the alternator. Present ratios are about 1:4 for P.M. alternators and 1:5 for car alternators.

A wooden template is made by planing a piece of wood to form the upper surface of an airfoil e.g.

The aluminium blades are then cut from recycled flat sheet and bent around the template. This curved plate blade generates lift in a similar manner to a solid airfoil: A curved-' plate of constant radius will also perform satisfactorily. Before shaping around the template, the leading edge is rolled to give additional stiffness in bending. The blades are supported at the root by metal brackets bolted to the wheel hub and about ½ way along their length by a bracket bolted to the wheel rim. All bolts are used with spring-washers and locktite to prevent loosening due to vibration. It is important to balance the blades, particularly with larger machines. Weights were added to the motorcycle wheel spokes for balancing.

Tail - The tail is constructed from 15 x 15mm R.H.S. and aluminium sheet. This is pivoted to allow the tail to turn the blades out of the wind for storm protection. A spring controls the action of the tail in strong winds.

Tail Operation for Strong Wind Protection

The horizontal axis about which the blades rotate is offset from the vertical axis about which the blades feather.

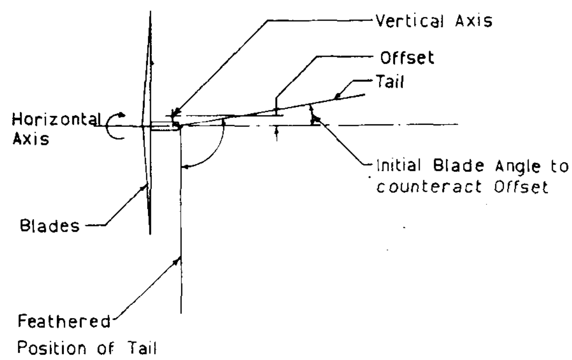
Wind Generator

This offset produces a turning moment about the vertical axis when the wind strikes the blades. The turning moment is counteracted by positioning the tail at some angle to the wind to create an equal and opposite turning moment; This keeps the wind striking the blades perpendicularly. As the wind speed increases, the wind pressure on the spring-loaded tail will eventually overcome the spring tension and turn the tail about the pivot. This feathers the blades. The tail will reset itself by means of the return spring when the wind speed decreases significantly. The tail can also be locked in the feathered position by means of a cable and pulley system connected to a winch at the bottom of the tower. This allows the machine to be completely shut down during storms or for maintenance.

By using a smaller amount of offset (say about 25mm) of the horizontal axis from the vertical axis, less angle is required for the tail to keep the blades perpendicular to the wind. This also causes less disturbance of airflow through the blades. The tail should be about the length of the blade diameter. This system is simple in operation and easy to make. However, it does tend to place considerable stress on the blades

Fig. 1. Preparing the generator for testing.

Feathering Action of Tail



as they feather, due to gyroscopic forces and unbalanced lift and drag forces on the blades.

Alternators

I have used two types of alternators on this wind-generator. These are permanent magnet alternators and car alternators (self exciting type). If possible, obtain a speed/power graph for your alternator connected to a battery load. This allows for a better estimation of the gear ratio between blades and alternator. Automotive electricians can help here.

(1) P.M. Alternators - I obtained two 60 watt P.M. alternators for Honda Zot cars (water-cooled model) from car wreckers. These can be re-wound or windings added to increase their output to 80-100 watts, at about 16-17 volts. These alternators gave good performance for starting and power at moderately low wind speeds (see Fig. 1). However, the only readily available source of P.M. alternators would be motorcycle wreckers. These are available up to about 200 watts but housing and bearing supports would need to be made for the rotor and stator. P.M. alternators don't allow the blades to turn unless there is enough wind to charge the batteries and they also act as a brake when the blades are feathered.

(2) Car Alternators (Bosch Type) - This type of alternator is readily available and cheap ($25.00 from wreckers).

Wind Generator

Some types have a self-exciting magnetic field. This necessitates the use of a wind-sensitive switch to regulate the switching on of the battery load to the alternator at wind speeds sufficient to keep the blades turning. Alternatively, a diode (O-40 amps) can be used. Both the diode and the wind-sensitive switch prevent discharge of the batteries at windspeeds lower than those required to charge the batteries. Car alternators are more suited to use with rotor diameters of 2.4 to 3.0 metres since this size has enough power to turn the alternator at lower wind speeds (3 m/s i.e. 10 km/hr).

Electrical Output

(1) The output from the P.M. alternator. is rectified, using full-wave bridge type rectifiers, and then passed via an ammeter and voltmeter to battery storage. The car voltage regulator was not used. Voltage regulation is generally considered necessary if the daily output of the wind-generator (or photovoltaic system) in amp-hours exceeds 5% of the battery capacity in amp-hours. A Zener diode could be used for voltage regulation with the P.M. alternators.

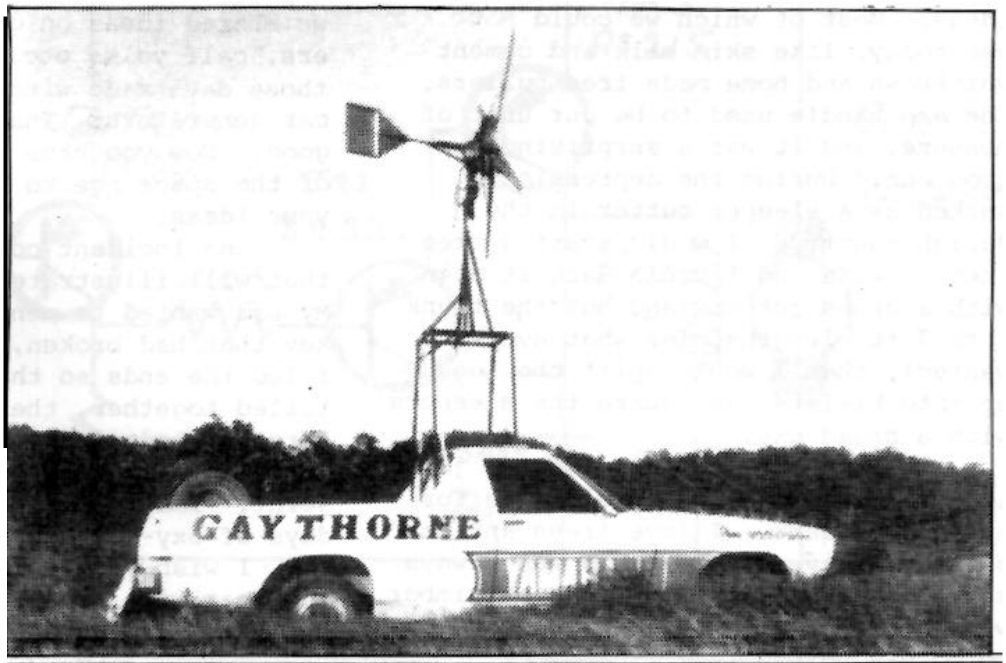
(2) The output from the car alternator is rectified in the alternator and fed via an ammeter and voltmeter to battery storage. An additional diode (O-40 amps) is placed on the positive side of the circuit before the meters to prevent battery discharge in very low or no wind conditions.

Conclusion

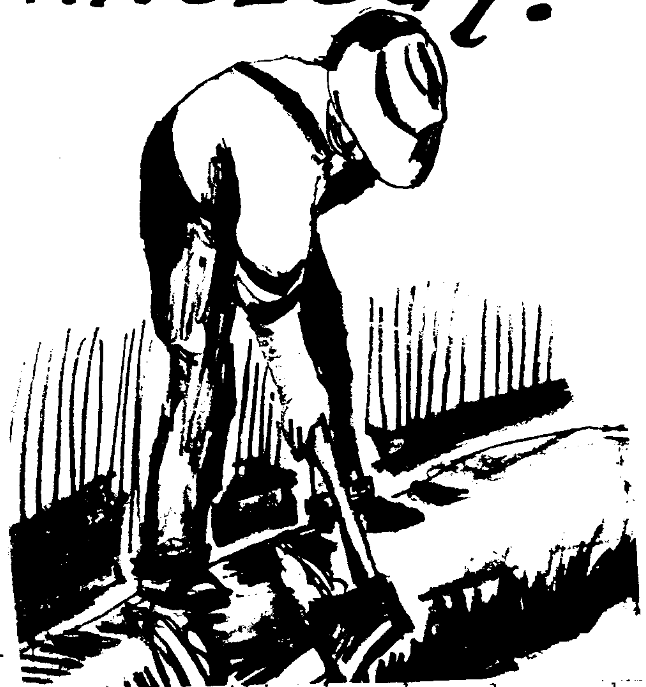
Using mostly recycled materials, the total cost, excluding tower and batteries, is less than $200.00. The only disadvantage to date has been some noise generated in the chain drive and amplified in the blades and tail. This can be minimized by careful alignment of the drive sprockets and rubber mounting the blades and-tail. Use of a tooth-belt drive system would eliminate this minor problem, and also would not require oiling.

At present, I am drawing plans for this design. These should be available in October '81 from "Alternatives", 37 Bangalla St., Torwood, Q. 4066 for approx. $8.00 mail order.

*Fig. 2. The wind-*generators are *test-*ed.@ mounting on a *frame above the cabin of a utility and* driving *to stimulate windspeed.*



Past Technology?



The words, Your Comments, on the membership application form, started me thinking and my mind went back to the days after the first world war, when my Dad, along with many other returned soldiers decided to try their luck on the land.

Conditions were so different then, that it is impossible to make comparisons between those times, and now. Radio and T.V. had not been invented, and gramaphones were a luxury, but nearly every home had some musical instruments, usually mouth organs, button accordions or violins, and in those days when clearing and fencing were the main projects, the settlers were very community minded. 'Our dances and picnics were really enjoyable occasions. There was never any drink at them, until the advent of motor cars, when people from town used to come out to them.

It was a time when ideas and inventions were freely shared, and W.A.'s Western Mail gave a lot of space to the Cockys' letters and ideas. Most of which we could not use today, like skim milk and cement whitewash and home made tree pullers. The axe handle used to be our unit of measure, and it was a surprisingly good one. During the depression I worked as a sleeper cutter in the Jarrah country. I would scarf a tree then my wife and I would back it down with a cross cut saw and cut the trunk into 7 ft. lengths, (or what ever was wanted), then I would split the logs up into billets and square the sleepers with a broad axe.

After the depression I got a job in a timber mill and worked there for nearly 30 years. I love trees and am a conservative at heart and was always sad about the appalling waste of timber, when it was milled what couldn't be sold, was burnt.

Everything has changed so much since my day. I could be living in another world. Our money, our measurements, our form of entertainment and even our arithmetic, now they use calculators, but we still must be the same underneath it all, and where we shared ideas on gates, wire strainers, calf yolks etc, and even in those days made wind chargers out of car generators: That were never much good. Now you have all the resources of the space age to help you with your ideas.

One incident comes to my mind, that will illustrate the difference. My Dad wanted to mend the stem of a key that had broken, so he carefully filed the ends so that they dove tailed together, then put it on the forge heated it and spread spelter on it which melted and made a good brazed joint. Imagine doing that in these days of oxy-A.

I wish you a happy and successful year with lots of new ideas.

Yours sincerely,

W. J. Buckland.

Windcharger Regulator

Here is an idea for fitting a variable solid state voltage regulator to a Winco generator (12 Volt model). This unit uses a shunt wound field coil (field coil in parallel with armature). The advantage of an adjustable regulator is with long cable runs, losses can be compensated.

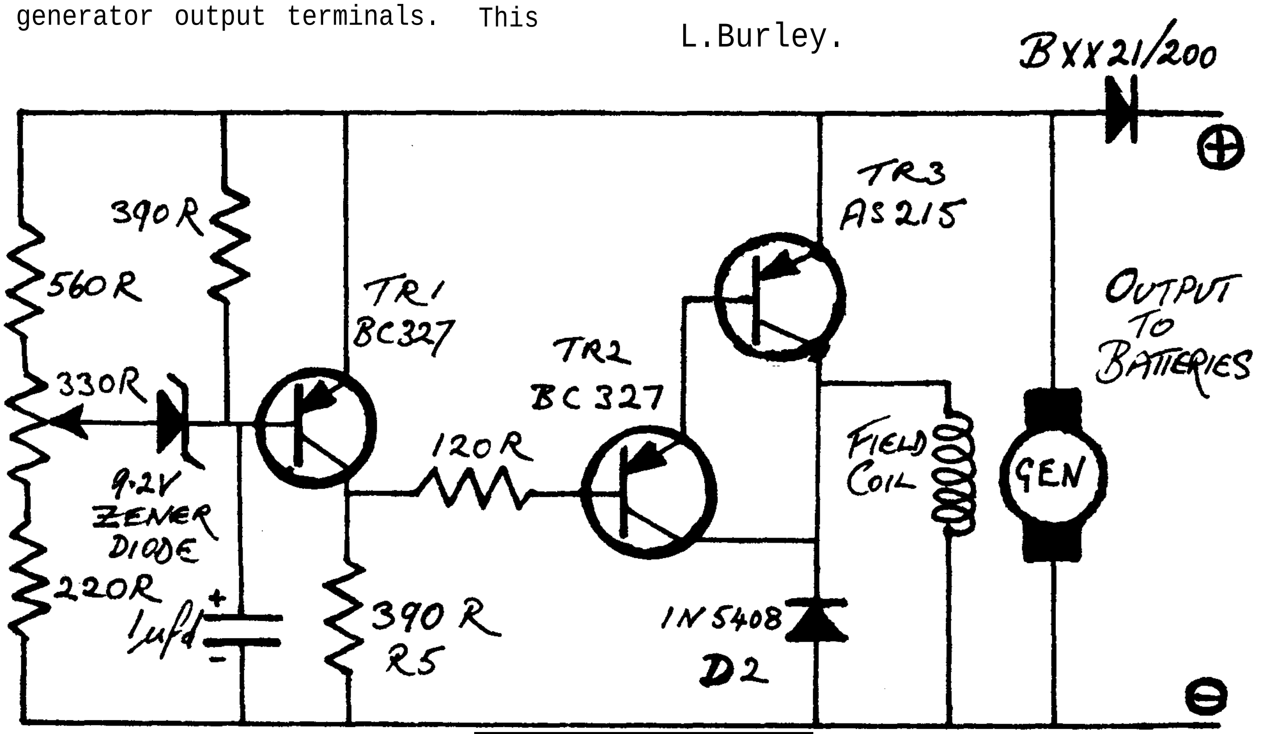
When the generator starts to run, a voltage is induced in the armature due to the residual magnetism in the field coil. This in turn induces more current in the field windings until the generator reaches the required output voltage. The unit described can vary the output voltage from approximately 13 volts to 18 volts. This can be achieved by varying R2 and so overcome the losses of long cable runs.

Rl, R2 and R3 are connected across the generator output terminals. This forms a voltage divider network. When the output voltage from the generator is low, TR2 and TR3 are turned on due to bias from R5. This causes the field coil to be energised and TRl is turned off.

When the output voltage increases and exceeds the breakdown voltage of Dl (zener diode, 9.2 volt) TRl turns on and removes bias from TR2 and turns TR3 off. This reduces the output voltage which regulates the generator output voltage. D2 is in parallel with the field coil and serves as a surge quench diode to protect TR 3.

The circuit in figure 1 uses a AS215 P.N.P. germanium power transister in TR3. This devise was chosen due to its low saturation voltage. In the prototype this was .45 volts from the emmitter to collector.

L.Burley.



Heat loss by Conduction (Q_{hc})

This is calculated by taking each wall, floor or roof area (A) in turn and multiplying it by the overall heat transfer coefficient (U) for that surface. The heat transfer coefficient is a mean of the surface's ability to transfer heat. That depends on the material's physical properties and the thickness.

Hence $Q_{hc} = (U_1 x A_1) + (U_2 x A_2) + (U_3 x A_3)$

Table 111 gives some typical 'U' values for materials likely to be used.

To get Q_{hc} in the right units, it must be multiplied by (0.0036).

Heat loss by infiltration, ventilation (Q_{hv})

Every structure, no matter how well built, will have small cracks, holes etc through which the outside air will penetrate. Heat will be lost through this way.

The following equation will calculate this heat loss

$$Q_{hv} = N \times V \times 1.22 \times 10^{-3}$$

where

N = the number of air changes per hour

V = volume of the greenhouse in cubic metres

(1.22×10^{-3}) = volumetric heat capacity of air per degree difference (MJ $m^{-3} K^{-1}$)

Listed below are some typical values of N which you might expect.

Tightly sealed plastic film greenhouse	0.5
Well made solar greenhouse	1.5
Old and leaky greenhouse	4.0

Q_{he} may. now be found (Remember $Q_{he} = Q_{hc} + Q_{hv}$).

Two monthly heat loss (Q_{me})

This is determined by using the above, Q_{he} and a unit called the degree day. This is a unit commonly used to evaluate heating and cooling requirements for buildings. IV is the total of the difference in degrees between some base temperature and each

Table 2 Solar Transmittances of Covering Materials (Normal to beam)

Standard Window Glass (3mm)	.83
Stabilised Bubble Plastic	.81
Polyethylene (15 thick)	.90
Plain clear fibreglass (no protective coatings)	.86
Tedlar coated fibreglass	.86
Polyester film coated fibreglass	.83
Double skin acrylic	.83

COVERING MATERIAL	THERMAL CONDUCTANCE U W/m²K
1. **Single Glazing Sheets & Films**	
Glass - 3mm	8.1
Polythene Film - 150 micron	8.2
Fibreglass - 1200	6.5
2. **Double Skin Sheets**	
Acrylic - 1600 g/m^2 (Acryflute)	4.8
Acrylic - 1200 g/m^2 (Acryflute)	4.9
Acrylic - 900 g/m^2 (Acryflute)	5.2
H. D. Polyethylene - 750 g/m^2 (Polyflute)	5.7
Bubble film - 3 layer	3.9
3. **Double Glazing Combinations**	
Glass with poly film liner - 25 mm air gap	3.6
Double poly film liner - 25 mm air gap	3.7
Fibreglass with poly film liner - 25 mm air gap	3.3
4. **Wall Materials**	
Single brick	2.8
Double brick with 50 mm air space	1.3
Concrete block	3.2
Double concrete 'block with 50 mm air space	1.5
Double asbestos cement sheet with 50 mm of polyurethane foam	.5

TABLE 111 THERMAL CONDUCTANCE VALUES FOR GREENHOUSE MATERIALS

Notes

1. The unit of thermal conductance is Watts per metre squared per degrees Kelvin (W/m K). The degree Kelvin is the same magnitude as degrees Celcius and so the difference between inside and outside temperatures in degrees Celcius is used in heat loss calculations.

2. The thermal conductance values have been determined on the basis that the air within the greenhouse is moving and that the inside film co-efficient is .09. An outside air speed of 6 metres per second (22 kph) has been used to estimate heat loss from outside surface.

Ref. G. Connellan, Heat Saving Techniques for Nursery Structures, Proceedings of Nursery Trends and Developments '80, Burnley Horticultural College.

Greenhouse Type	Full of Plants	No. of Plants
Double glazed conventional greenhouse with forced air circulation and rock pile storage system	25%	65%
Double glazed solar orientated greenhouse with adequate water storage capacity in direct sun	35%	75%
Double glazed solar orientated greenhouse with forced air circulation and rock pile storage	45%	85%

Remember CE becomes $\frac{\text{(percentage efficiency)}}{100}$

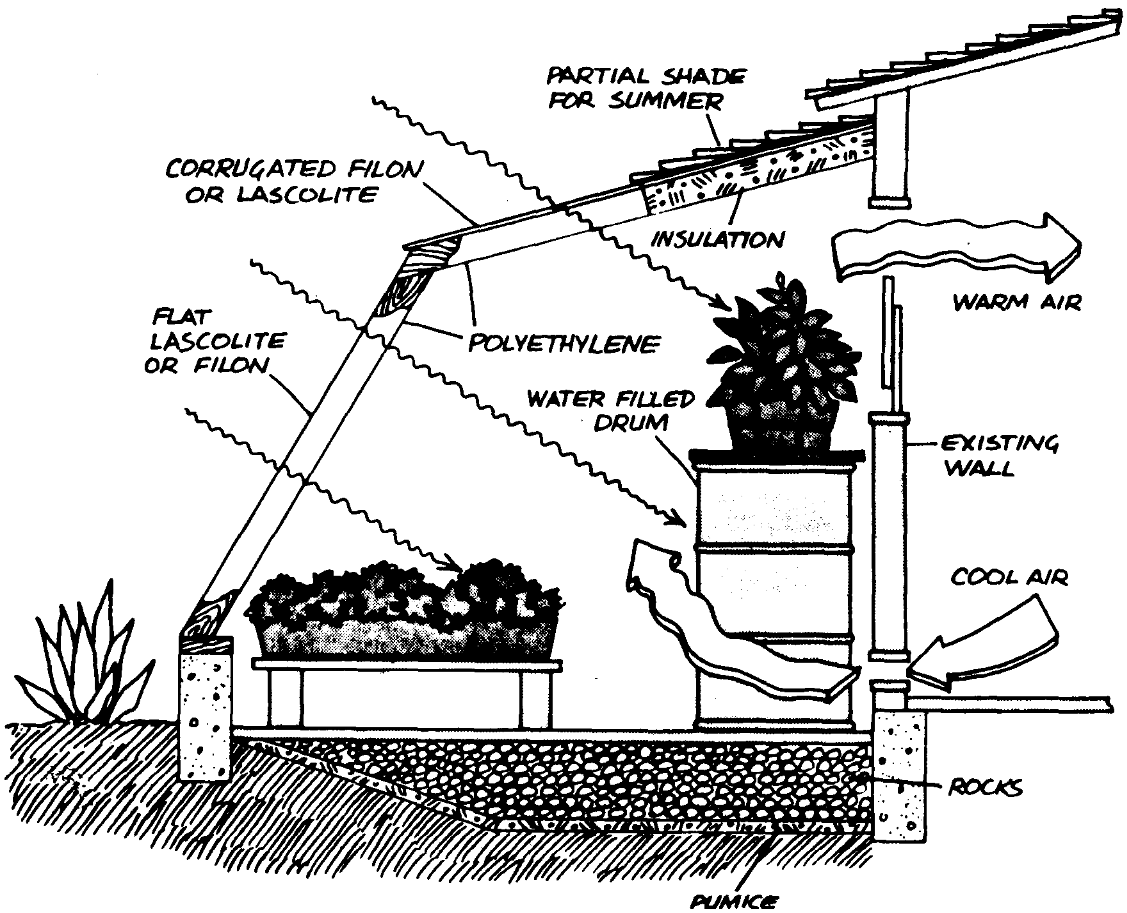


Fig. 3. Cross section of an add-on solar greenhouse. Source: The Solar Home Book; Anderson.

day's mean temperature for the month in-question.
Therefore

$$Q_{me} = Q_{he} \times 24 \times DDM$$

where DDM is the number of degree days per month. See Table 4 for degree day data. Choose the appropriate base temperature depending on whatplants you are likely to grow.

What must now be achieved is an energy balance. Having calculated the heat gained for the month, Qg, it must be sufficient to balance the expected month heat loss, Q_{me}. If the losses are greater, you have 3 choices.

1. Increase the heat gain by, for example, higher transmittance glazing, more glazed area, different shape.
2. Decrease the heat loss by, for example, better insulation in non glazed walls, less leakage, operate at a lower base temperature.
3. Auxiliary heating - Making up the deficit by some other energy source, e.g. electrical or kerosene heaters.

For a truly energy autonomous solar greenhouse the latter should be avoided if possible.

In the next issue of Soft Technology, I will give a design example using the above method together with some discussion on calculating the amount of storage required to tide the greenhouse over the cloudy days.

BOB FULLER

Table 4 Mean Degree Days per month

	12°C	15°C	18°C
January	1	5	21
February	1	4	17
March	1	8	33
April	4	22	72
May	21	80	168
June	49	128	218
July	71	160	253
August	47	129	222
September	22	79	162
October	11	43	107
November	4	22	66
December	2	12	40

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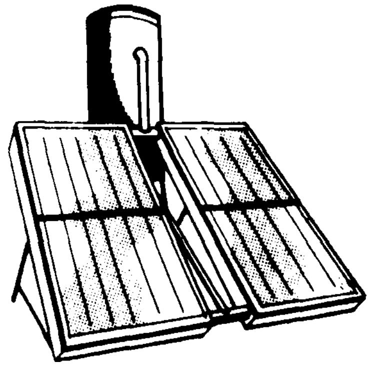
SOLAR WATER HEATING

....follow up



Regarding the article on solar collectors in the 5th issue, I would like to comment on the criticisms of the design by Geoff Hopkins.

Firstly, the spacing I used was the same as recommended in CSIRO publication. I agree that the spacing of tubes and sheet thickness and material determine the rate of heat flow to the tubes and water. But when building your own system and using 2nd hand materials to reduce cost it is sometimes necessary to accept a little lower efficiency of energy transfer. This can be compensated for by either a small increase in collector area or by conservation of hot water use.

Secondly, hardwood timber is only used on the sides of the outer casing. This material is easier, I feel, for most people to work with compared with galvanized iron. Also, it should easily last 20 years or more with a little paint every 5 or 10 years.

Thirdly, I recommend the use of 0.6 mm thick aluminium sheet since this is easy to work into grooves for the tubes to sit in. The use of 1 mm aluminium sheet as mentioned by Geoff to give the same performance as 0.55 mm thick copper sheet would be impractical for most people to shape.

I also costed the construction of a collector about two years ago and came to a similar conclusion i.e. unless you can get major parts of your collector for next to nothing, it is worth considering buying commercially made collectors. My suggestion to people who can't scrounge enough 2nd hand materials for the collector is to buy new collectors commercially made and make a storage tank as I suggest in my plans.

Again the storage tanks I have used i.e. mains feed copper coil in low pressure tank, give a slight drop in efficiency of heat transfer but are simpler and more reliable than other tanks for many people who still want mains pressure at their hot water taps. I do not believe that a home built system has to be as efficient as a commercial unit to give satisfactory performance.

I hope these suggestions are helpful. Keep up the good work.

Regards,

Trevor Berrill.

Coming Soon

- WORKING HYDRO SYSTEMS
- ELECTRIC VEHICLES
- BUILD A CHEAP INVERTER
- GREENHOUSES (PART II)
- AN EXPERIMENTAL METHANE DIGESTER

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