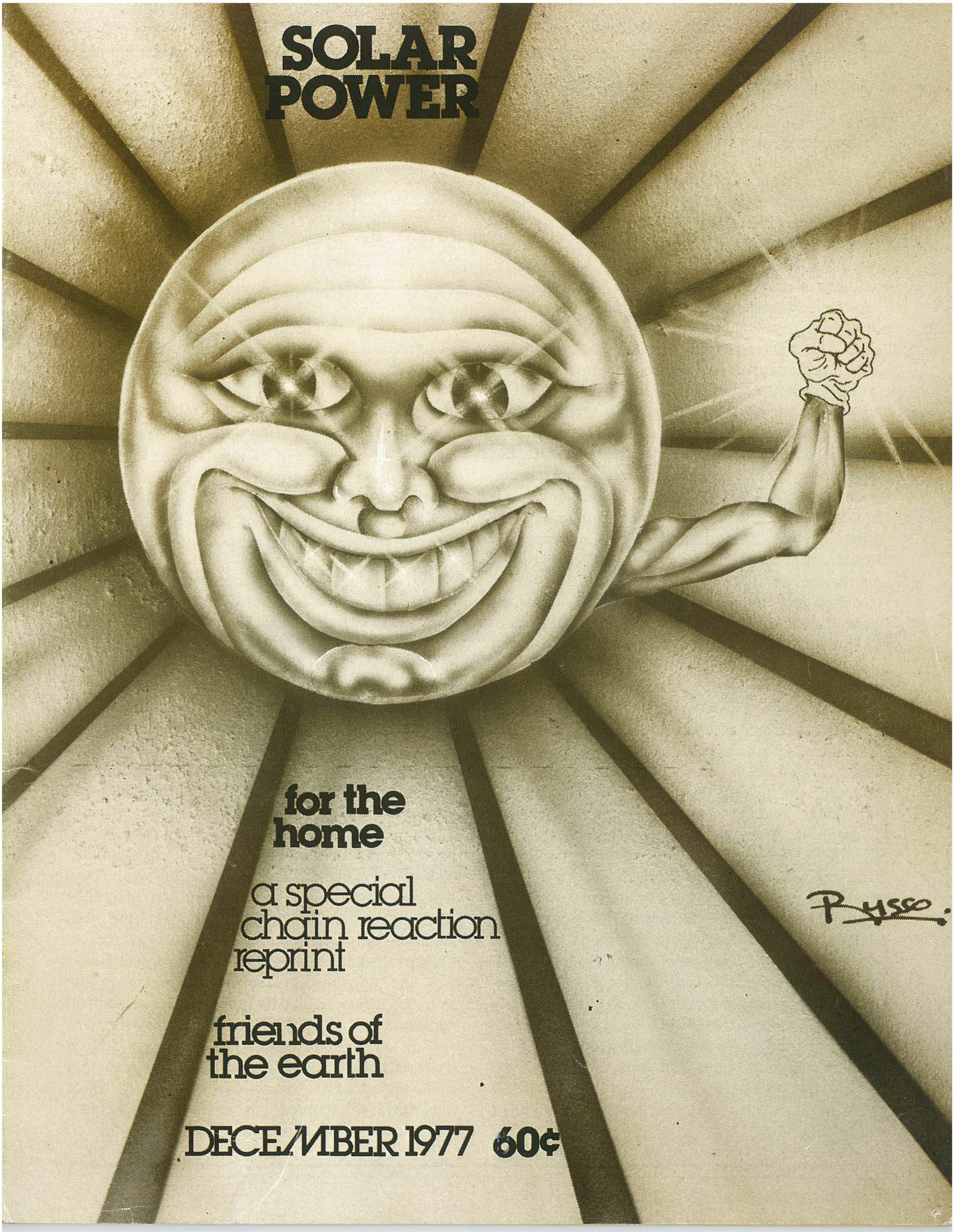
SOLAR POWER



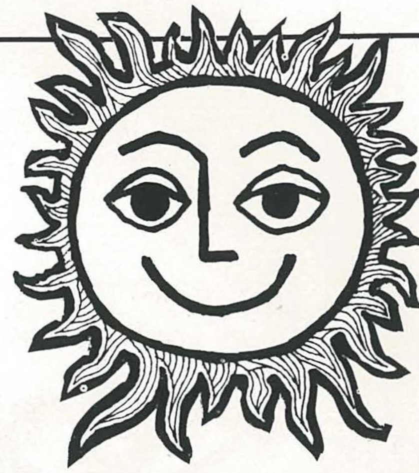
for the home

a special chain reaction reprint

friends of the earth

DECEMBER 1977 60¢

Introduction



Today, almost all the goods and services we consume are purchased as commodities. We live to work to buy in order to live. Many people are now trying to break out of this aimless cycle by producing some of their basic needs – vegetables, clothing, shelter – for themselves. In the face of depleting non-renewable energy reserves and the threat of nuclear power, solar energy has been added to the self-production list. A burgeoning literature has appeared picturing the dream of *total* self-sufficiency at a commune or family level. But how many people are likely to achieve this goal? Is it desirable anyway?

This is a booklet about solar energy, so let's use the energy part of self-sufficiency as an example. Solar collectors for household water and space heating have become an essential component of most schemes. The alternative technology purists would certainly attempt to make these collectors for themselves. Yet they would still have to buy or scrounge the copper pipes and sheet, black paint, glass, the sheet metal for the box, the fibre-glass insulation, aluminium strips to hold the glass on etc. Each of these materials has relied on an extensive high-technology industrial system for its production, and the labour of those still working in the system. At present the social and environmental impact of many of the production methods used leaves much to be desired. (Take, for example, the mining and refining of bauxite on Aboriginal land at Gove or Weipa to produce aluminium). If we are looking then for a solution in which society as a whole lives in long-term harmony with the environment and with itself, we must look at changes to our productive system as a whole, a political task extending far beyond the boundaries of any fledgling 'autonomous' group.

This is not to say that do-it-yourself construction or installation, or purchase, of solar energy devices has no relevance. For many this is an introduction to renewable energy sources and often leads in turn to a higher consciousness of the general energy problem and its political context. For those who do get into do-it-yourself construction there is immense benefit to be gained from first-hand experience of working with renewable energy. Hence we are releasing this booklet on solar energy for the home, which is a reprint of relevant articles in the special solar edition (vol. 2 no. 3 of *Chain Reaction*) published last year and which quickly sold out. These articles include "Solar Technology and Social Change", which discusses some of the broader social considerations involved in the introduction of solar energy.

We have updated the original *Chain Reaction* articles and added a current bibliography for the areas covered by the booklet, and for some which are not such as solar electricity and alternative energy strategies in the industrial, and commercial, sectors.

Above all, we hope that the scope of the questions this booklet raises on energy use in the home will be extended far beyond the garden fence into the workplace and general community. Unwittingly no doubt, but the environmental and resources debate which has raged since the late 1960s, and the nuclear controversy in the 1970s, have brought us to a uniquely favorable position in history for a radical change of technology. There was no environmental and social impact analysis as steam power rolled relentlessly over the self-sustaining pre-industrial economy of Eighteenth-Century Britain. But now, thanks to nuclear power and the environmental crisis, awareness of the reflexive interactions between technology, political and economic structures, and natural environment are at an all-time high. The challenge lies in extending and channelling that awareness so that solar technology is introduced in a way which maximises all people's participation in shaping a new society of their choice.

John Andrews
November 1977

Contents

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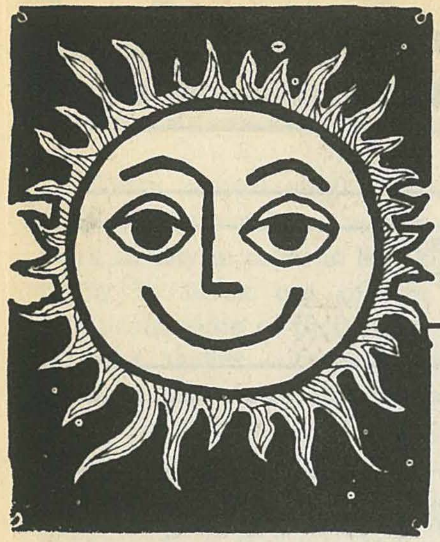


Renewable Energy Income from the Sun

SOLAR WATER HEATING

John Andrews

Taking the Initiative

The area of solar water heating is particularly suited to participatory creative technology on the part of people with no specialist training in engineering or the sciences, or in metal working, plumbing etc. In the bargain people can initiate directly a change in patterns of energy consumption, and become a bit more independent of centralised energy-production agencies. Solar water heaters are small-scale devices, reasonably inexpensive (and can be incredibly so if you're good at recycling throw-away materials), and they are not too complex for ordinary people to understand. However, so many variations in design are possible that they are great for bringing out the inventive talents which are so suppressed in most people's working lives today.

Compared with the **total** primary energy consumption in Australia at present, the percentage that would actually be provided by the sun if all houses were fitted with solar water heaters is quite small — only 1.5% of the total[2]. Currently, however, a meagre 0.01% is obtained from solar collectors, most of these being in Western Australia and the Northern Territory. The total energy consumption here though refers to industrial, commercial and household use, and when you limit consideration to just the household sector, the energy saved by fitting solar water heaters begins to look more significant.

In the average house in Australia, about 50% of energy consumed is for space heating, 25% for water heating, and 25% for cooking, lighting etc[3]. Water heating is thus the second major energy consumer in the home and by fitting a solar water-heating system between 60 and 90% of this demand can be met by solar energy, the precise value depending on where you live.

In *Chain Reaction* Vol. 2, No. 2. the idea of whole energy analysis was described[4], so: How long does it take for a collector to absorb a quantity of energy equal to that needed to produce the copper, glass, insulation etc., which have been used to make the collector? Well, CSIRO say[5] it's only about six months on the average in Australia, and with an estimated lifetime of a collector of 20 years, that's a very favourable energy balance.

Further, a recent estimate by CSIRO of the total quantity of primary energy in the form of low-temperature ($<150^{\circ}$C) heat which could in practice be supplied by solar collectors by the year 2000 suggests that there would be no materials-shortage problems — e.g. with copper or glass — if all houses were to be fitted with solar water heaters by the end of this century[6].

Systems

The following is an attempt to review information on solar water heating which is relevant to the Australian situation. The review is far from comprehensive, but references are given where points merely mentioned in passing here can be followed up in detail. Mainly I hope to communicate the principles behind the design of solar water heaters and then to give a few ideas and practical hints for people to improvise on for themselves.

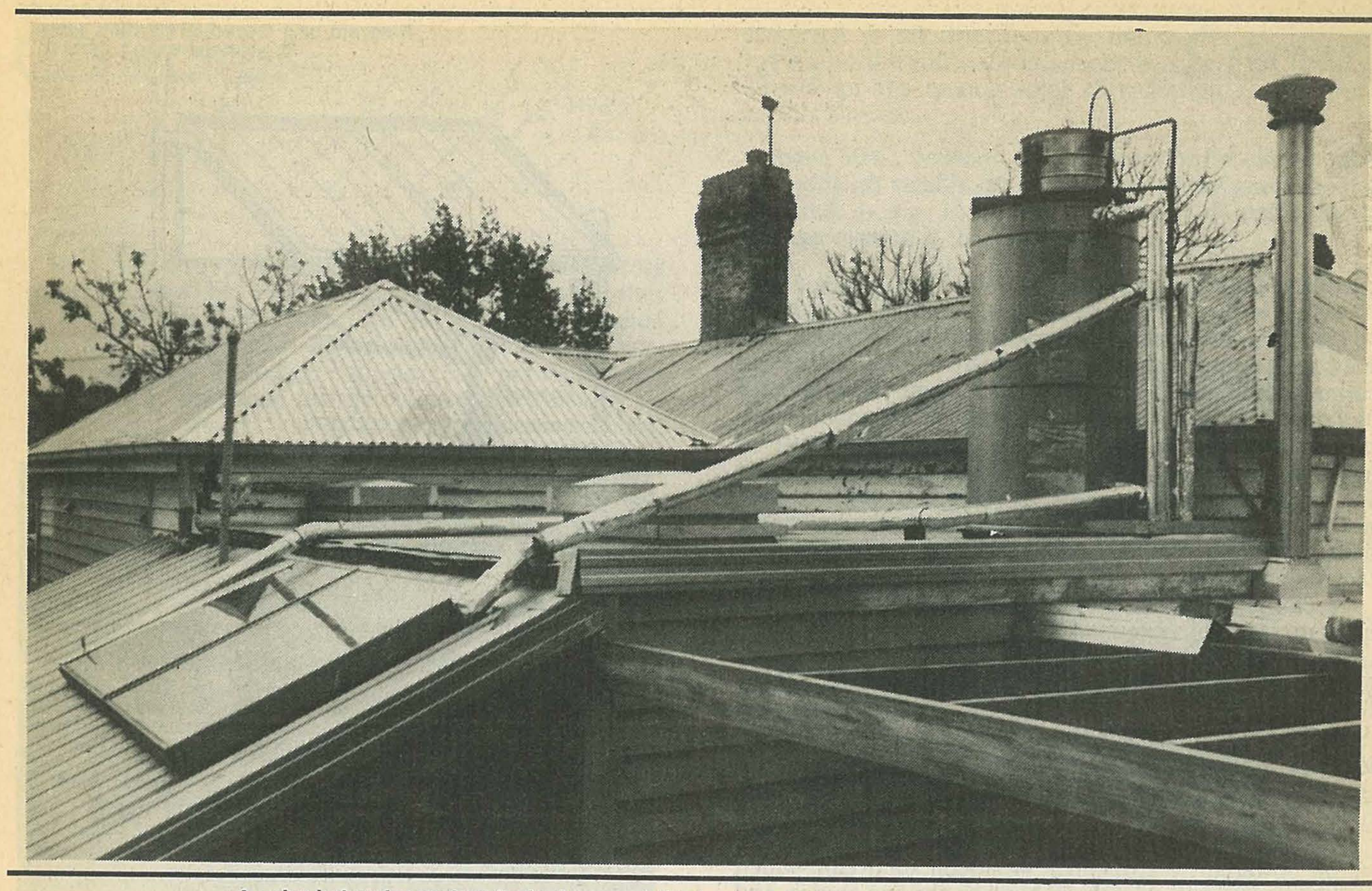
Type 1

There are two main types of solar hot water system. *Type 1* relies on natural circulation, called thermosyphon action.

The sun's rays heat the blackened collector plate which in turn conducts heat to the water in the vertical tubes soldered to the plate. The density of the water falls so it rises up the tubes, to the horizontal 'header' pipe at the top, and on up the insulated pipe to the hot-water storage tank. Meanwhile cold water flows from the bottom of the tank down to the lower header pipe of the collector, and so the cycle begins.

During the day hot water gathers in the upper part of the storage tank. Provided the top of the collector is below the bottom of the tank and the connecting pipes are well insulated, the circulation stops when there's no sun.

This is the type of system CSIRO have done most work on and which is used in the majority of commercial solar water heaters available in Australia. Unfortunately the 1964 CSIRO Circular No. 2, *Solar Water Heaters*, which gives full constructional details of such a system, is now out of print and I was told that there were no immediate plans to publish an **updated version**[7]. We therefore intend to publish do-it-yourself plans for a CSIRO-type thermosyphon system in a later *CR*.



A solar hot-water system tucked away at the back of a house in Surrey Hills, Melbourne.

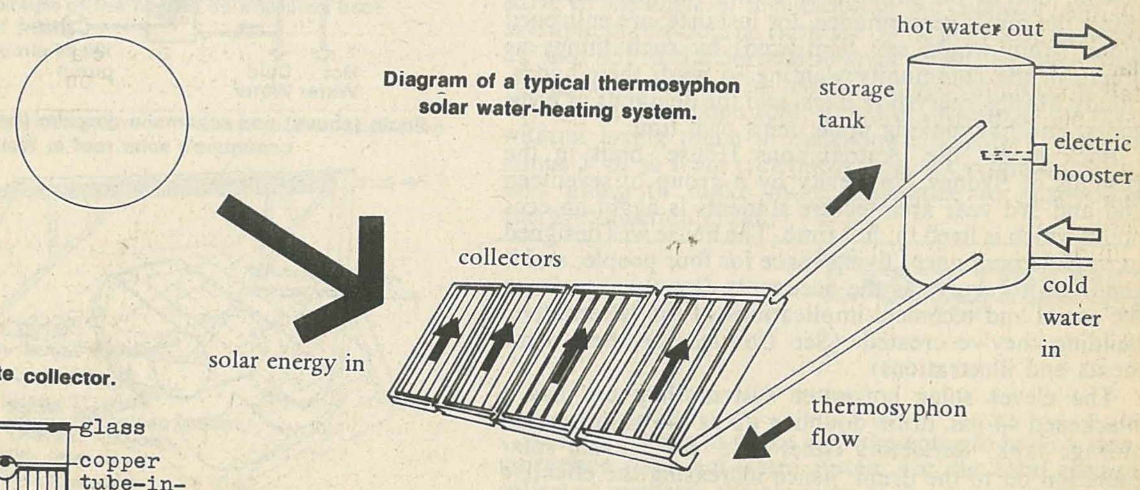
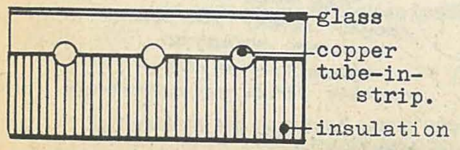


Diagram of a typical thermosyphon solar water-heating system.



Structure of a flat-plate collector.

Type 2

Type 2 systems employ forced circulation — that is, they use a pump, usually an electrically driven one, to circulate water from the storage tank through the collectors and back to the tank again. This arrangement has to be used if it proves impossible on a particular house to have the tank above the collectors. For example, you would use this arrangement if fitting a solar water-heating system in a house which already had a hot water tank at ground level and you wished to have the collectors on the roof.

A complication is though that you require a thermostatic control system which stops the pump when the temperature of the collector plate falls below that of the water in the tank — otherwise the water would continue to circulate on cold days or at night, radiating the heat collected back into space to warm up the clouds! A suitable control circuit is described in ref. 8. Ref. 8 also tells you about pumps, which need only be small, 3 watts or so, if the collectors aren't too far above the tank.

A neat alternative to a control system is to use a small pump powered by a 6 V, 0.3 A silicon solar cell, which automatically will operate only when the sun shines, and it requires no external power source[8].

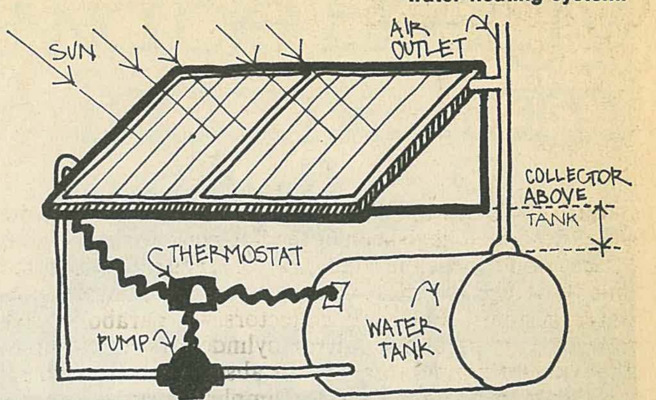
Another form of forced-circulation system uses the sloping roof of a building as the solar collector. This arrangement, first proposed by Harry Thomason in the USA (see ref 9 for three solar houses he's built), has been used by Biotechnic Research and Development (BRAD), originally a group of 10 adults and three children, on their communal house in Wales[10].

Unlike many 'experimental' autonomous houses where the interest is entirely on the hardware, the people in the BRAD commune actually have to *live* with the results of their work, and of course live with each other. As Phillip Brachi, one of the group describes[10]: "Experiments to gauge the roof's performance, for instance, are enlivened (poor Brum would say hampered) by such things as others in the community wanting to wash their hands, cloudy Montgomeryshire days, and the demands of bees, goats, and hay-making upon one's own time."

Back home, the 'Autonomous House' built in the grounds of Sydney University by a group of seventeen 2nd and 3rd year architecture students is again an eco-house which is lived in, full-time. The house was designed to provide permanent living space for four people, and it continues to evolve as the occupants directly experience the social and technical implications of the 'alternative' building they've created. (See *Comtec* for their comments and illustrations).

The clever solar hot-water system they use has a blackened 44-gal. drum doubling up as the absorber and storage tank. Reflectors either side concentrate solar radiation on to the drum, hence increasing the effective collection area. Improvements planned at present include an insulated cover to the system which can be opened during the day and closed up at night, and the use of a longer, narrower drum as absorber.

Diagram of a forced-circulation solar water-heating system.



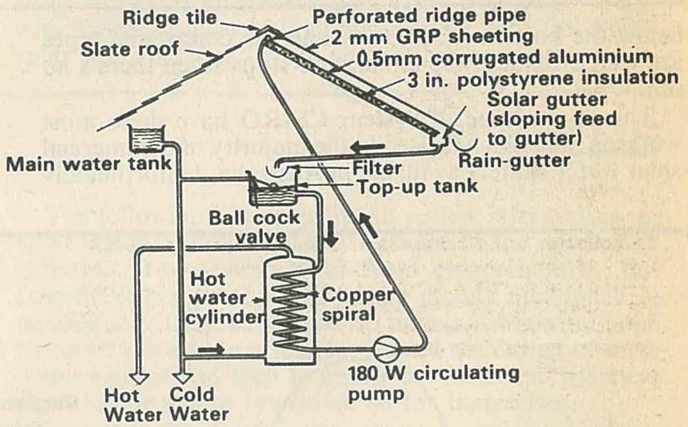


Photo (above) and schematic diagram (below) of the BRAD commune's solar roof in Wales, U.K.

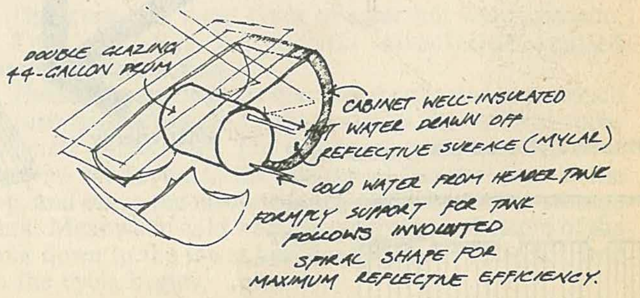


Diagram of the solar water heater on the Sydney Uni autonomous house.

Collectors

With the exception of the last system, all the collectors so far described have been of the flat-plate variety — that is, they don't focus the sun's rays. It is generally accepted that these are the most suitable type for domestic hot-water systems. Focusing collectors — parabolic dish reflectors or parabolic mirror cylinders (see below) — allow higher temperatures in the absorber to be reached, but this is of no advantage for simple hot-water systems where 57°C is quite adequate for all household purposes.

The parabolic dish reflectors also have to be fitted with a tracking mechanism so that they follow the sun across the sky, while the orientation of parabolic cylinders should be changed about once a month to allow for the change in the sun's path over that period.

Another disadvantage of focusing collectors is that they cannot make use of the diffuse component of sunlight. This is what you see when the sun goes behind a cloud, and it consists of solar radiation which has been scattered in all directions by the earth's atmosphere. Typically, the diffuse component accounts for between 20-40% of the annual total of radiation reaching the earth's surface.

Above 60°C, however, the efficiency of flat-plate collectors falls off rapidly, so that if this 'higher grade' heat is required — e.g. in a solar cooker — it's necessary to change over to a focusing type.

The structure of a typical flat-plate collector is shown on page 15. Copper is usually used in preference to steel or aluminium as the absorber plate, even though it is more expensive, because of its resistance to corrosion, and its ease of soldering and forming. A thermal paste can be used to ensure good thermal contact between riser tubes and absorber plate if aluminium or steel is used.

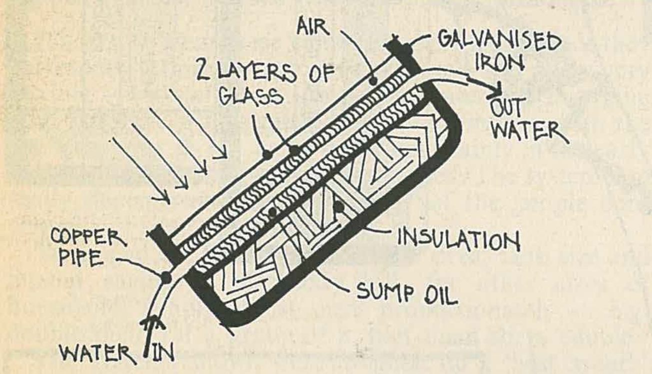
Other promising ideas for DIY collectors include using old pressed-steel central-heating radiators, painted matt black and set in a polystyrene box", and using old sump oil in a tray with double glazing[12]. See also ref. 13; and refs. 4-7, of Solar Space Heating article.

A good flat-plate collector transfers about 50% of the energy reaching it to the water flowing in the riser tubes However, when heat losses from the connecting pipes and storage tank are counted, the overall collection efficiency drops to about 40-45%.

Over the past years a lot of work has been directed at improving this efficiency. The problem is that copper surfaces painted matt black are good absorbers of solar radiation, but they are also good emitters of heat — infrared radiation — as well. To reduce this infrared emission CSIRO have developed 'selective black' surfaces which are excellent absorbers of sunlight, but poor emitters in the infrared. However, the efficiency of the collector is only improved about 5-6% by this treatment and three large tanks with heaters are required to prepare the selective surface on copper plate, making the process very expensive for the do-it-yourselfer. It doesn't sound too difficult though, and practical details are given in ref. 14.

Long-term measurements of solar radiation have shown that the best setting for a flat-plate collector at a particular location is to point it north, with its plane at an angle to the horizontal of 0.9 x latitude of place.

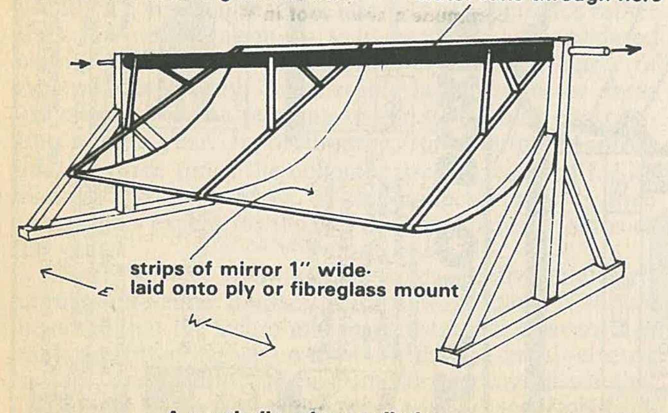
Luckily, however, the energy absorbed isn't too sensitive to the angle of inclination of the collector, and for example in Melbourne (latitude 38°S) anywhere between 25° and 45° to the horizontal gives about the same total energy absorbed[15]. This means that you can fit collectors flat against a ¼-pitch roof, or better, instead of the tiles, without losing much in collection efficiency[16]. Plus or minus 5° or so from true north (n.b. not magnetic north) isn't going to make much difference to year-round energy-collection either.



A collector using old sump oil (the more carbon the betterl) as the absorber. The designer claims the sump oil works better than a flat-black surface on copper because the steep temperature gradient across the black surface is avoided, and convection of the heated oil improves heat transfer to the riser pipes.

does not need tracking mechanism

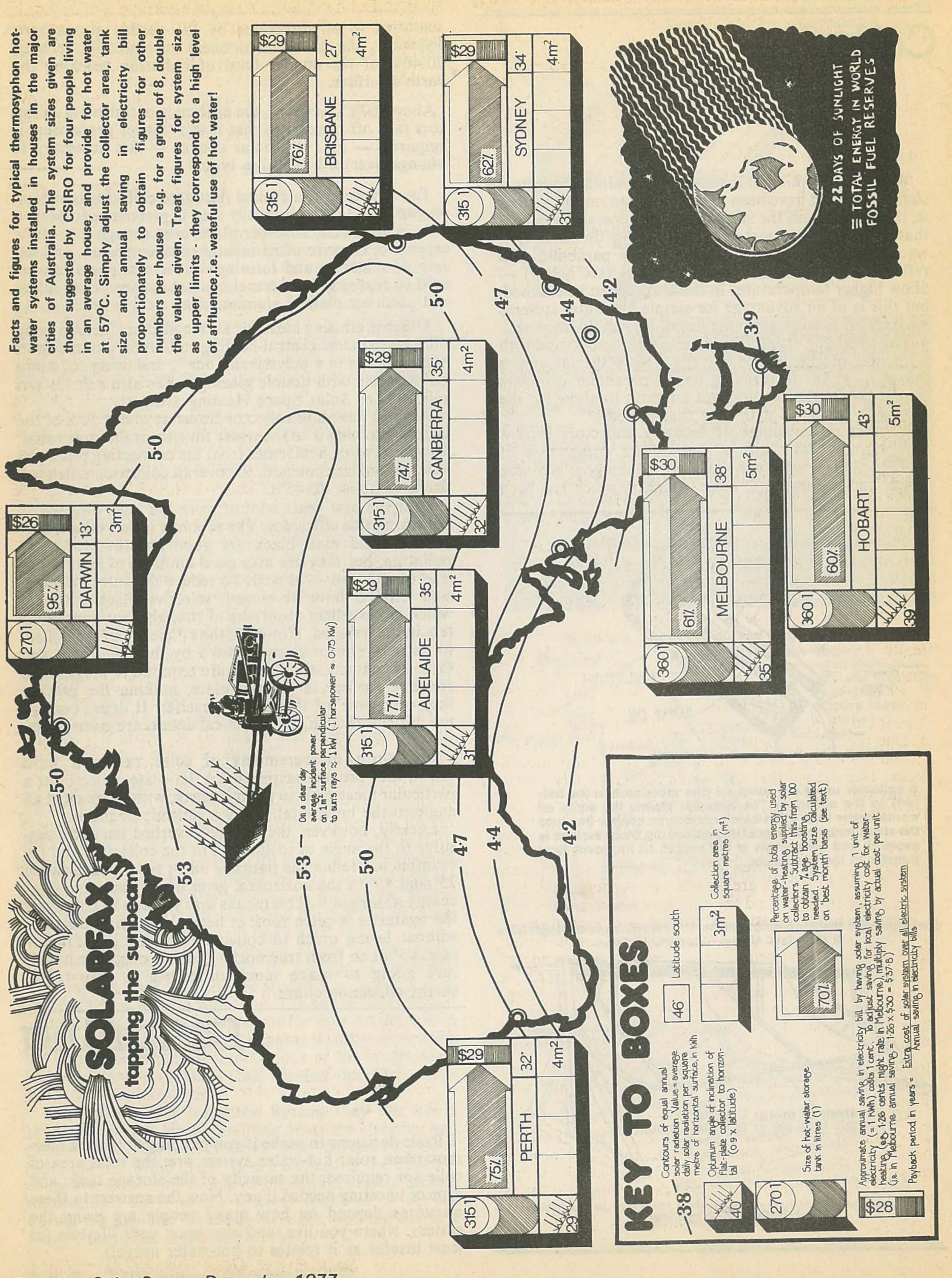
water runs through here



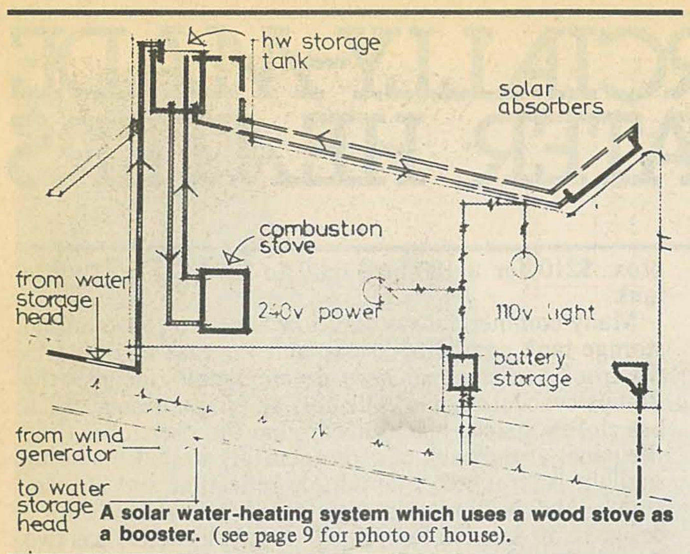
A parabolic mirror cylinder.

Designing

Basic decisions to make if you're going to build a thermosyphon solar hot-water system are: the total area of collector required; the capacity of the storage tank; and type of boosting needed if any. Now the answers to these questions depend on how many people are using the system, where you live, and also upon your lifestyle (at least insofar as it relates to hot-water usage!).



Facts and figures for typical thermosyphon hot-water systems installed in houses in the major cities of Australia. The system sizes given are those suggested by CSIRO for four people living in an average house, and provide for hot water at 57°C. Simply adjust the collector area, tank size and annual saving in electricity bill proportionately to obtain figures for other numbers per house – e.g. for a group of 8, double the values given. Treat figures for system size as upper limits - they correspond to a high level of affluence,i.e. wateful use of hot water!



A solar water-heating system which uses a wood stove as a booster. (see page 9 for photo of house).

The *Solarfax* map opposite should help you to make these initial design choices. The values quoted were obtained from CSIRO publications and refer to an average family of four in an average house. The tank sizes given allow 1½-2 days supply of hot water to be stored, assuming a daily hot-water usage of 45 litres per person. Larger tanks are recommended for higher latitudes since in these regions overcast periods tend to be more prolonged.

It's best to treat these values as upper limits since they correspond to pretty high comfort levels and allow very flexible — wasteful? — use of hot water. By changing your patterns of hot-water usage to harmonise with the sun's rhythms — e.g. using hot water mainly in the early morning — smaller systems can be used. The system size really depends on the adaptability of the people concerned.

To amend the figures for collector area, tank size and annual saving in electricity bill, for other sizes of household, simply adjust them proportionately — e.g. double them for a group of 8, half them for a couple.

The systems shown were designed on a 'best month' basis. This means that the system would supply all the energy your hot-water needs during the best month of the year for solar radiation (Dec.-Jan.), but for the rest of the year some form of boosting would be needed to keep the water temperature up to 57°C. Values for the annual percentage of energy used for water heating which is supplied by the collectors are included on the map. Subtract these from 100% to find the amount of boosting needed.

The use of a booster represents a compromise — usually a compromise in the interests of economics rather than fuel conservation — so it needs to be considered carefully. The problem is that, in southern parts of Australia especially, considerably larger collector areas are required if you're going to get 100% solar contribution all the year. In Melbourne, for example, approximately three times the collector area is required for an all-solar system[17]. Most of this collector area is then superfluous except for the two or three coldest months of the year.

Nearly all the commercial systems employ an electric immersion-heater booster in the storage tank. It should be noted that the heater and thermostat in a solar storage tank are fitted higher up the tank than in an all-electric system, and in different positions depending on whether the supply to the electric heater is continuous or off-peak night rate only (see refs 17,18). For a neat way of fitting solar collectors to an existing all-electric hot-water tank, requiring no extra holes in or fittings to the tank, see ref. 8.

One of the best solutions to the boosting problem — avoiding the use of electricity altogether — is to use a slow-combustion wood stove as the booster. Such a stove is used most in winter, for cooking, heating etc., and this is just the time when you need the extra heat for the hot-water system.

Economics

The economics of domestic solar water-heating systems are a complicated business, and (excuse the puns) not a very profitable exercise.

A lot is made of the so-called 'pay-back period'. This is usually found by working out the **extra** capital cost of a solar system over and above an all-electric hot-water system, and then finding out how many years it takes to recoup this extra outlay by your savings in electricity — at current electricity prices. If you assume an extra capital cost of $100 per m² of collector, the values for electricity saved given on the *Solarfax* map allow pay-back periods to be calculated for cities around the country.

More sophisticated analyses of economic viability take into account the fact that you could have invested this extra capital spent on a solar system, so that the interest you would have received each year should be counted as an annual cost of the solar system[17]. They also consider maintenance charges, though these tend to be very low (especially if you clean the collectors yourself!).

Alternatively some analyses suppose that you *borrow* the extra capital required, and count your yearly repayments plus interest as an annual cost. Nicholls[21] has done a detailed analysis of the latter type for N.S.W., and concludes that "solar energy is far cheaper than electrical energy for low-temperature heating purposes, if it is given capital at the same price as that enjoyed by the electricity generating industry."

In summary then, economic viability depends critically on the cost of the energy you're saving with your solar system, and on the interest rates on your capital expenditure.

The cost of the fuel saved is really the key factor. For example, if you double the cost of off-peak electricity, you half the pay-back period. It's the fact that electricity for water heating in Perth is three times more expensive than in Melbourne (3.85 c compared with 1.31 c/kWh), not so much that Perth is so much sunnier, that gives solar water-heating systems in Perth a 3-4 year pay-back period compared with over 10 in Melbourne.

Rising costs of conventional fuels over the coming years are therefore likely to make any estimate of pay-back period for solar systems wildly inaccurate. Furthermore, if you make your collectors for yourself you'll save a great deal of money and recoup your extra outlay much more quickly than with a commercial system.

Economic analyses of solar energy are most notable for what they leave out. Most of the real benefits in going solar just cannot be expressed in economic terms. How can you estimate the monetary value of leading a life closer to natural rhythms which feels better? Of using a clean endless source of energy? Of gaining greater individual autonomy?

COMMERCIALLY-MADE SOLAR WATER HEATERS

Below is a list of the principal commercial manufacturers and distributors of solar hot water systems in Australia — a list I include with mixed feelings. As argued earlier, many of the rewards of solar energy are lost if you're not participating directly in the whole process of design, manufacture, installation, as well as using a solar device. Only this way do you get a deeper understanding of your relationship both with technology, and with the sun itself.

But, being realistic, I can't see most people at present having the time, resources (money, tools?), or inclination, to construct solar devices for themselves. On the other hand it remains important that solar energy is used right away: in Australia, mainly to reduce demand for electricity and hence conserve fossil fuels and reduce pollution at the power station end; overseas, to prove that nuclear power is unnecessary as well as being so undesirable.

In the short-term then, I think the solar - energy industry has a role to play — hence the list! — but longer-term, we should look for alternative modes of production, involving alternative relations of production.

A few notes on the list of commercial firms:

The Beasley collectors are the only ones to have a selective surface and are widely regarded as the most efficient of those manufactured in Australia. Each collector is 0.75 m^2 in area and costs (at present) $77.25.

Typical prices of storage tanks suitable for solar systems and fitted with electric boosters range from approx. $210 for a 180-litre tank to $270 for a 370-litre tank.

Many commercial systems now have the collector and storage tank combined in one unit for ease of fitting to the roof. Interesting new developments include the Philips evacuated tube collector, an Israeli design which has closely spaced black fins around the riser tubes (like the panel at the back of a refrigerator) so that incoming sunlight is 'trapped' by multiple reflection and absorption[19], and a fibre-glass reinforced plastic collector[20] designed by Applied Research of Australia which has two sheets of glass above a layer of black plastic, the water to be heated flowing between the plastic and the inner glass sheet.

But beware! In the words of Bob MacDonald, Laboratory Manager at Melbourne University's Department of Mechanical Engineering which is engaged in solar energy research and development, "A lot has happened in the area of commercial solar systems in the past few months and a lot of rubbish has come on to the market." No one I spoke to had a good word to say about the imported plastic collectors which have recently appeared in Australia, though Applied Research claim high efficiency for their new design.

There is one situation that I think should be changed. CSIRO have done tests on the performance of most of the commercial solar water-heating systems available but are not able to release these details to the public. There seems no reason why this information should not be publicly available.

SOME MANUFACTURERS AND DISTRIBUTORS OF SOLAR WATER HEATERS

NEW SOUTH WALES

Braemar Engineering Co (NSW) Pty Ltd
167 Bonds Road
PUNCHBOWL, 2196

Solarhot Water Systems
34 Flinders Road
EARLWOOD, 2206

Solar Boost Australia Pty Ltd
80 Wentworth Road
HOMEBUSH, 2140

Sunray Solar Systems
292 Pittwater Road
NORTH RYDE, 2113

George Wills & Co Ltd
45 Clarence Street
SYDNEY, 2000

Australian Solarway Pty Ltd
59 Hunter Street
HORNSBY, 2077

P.G. Solar Plates
10 Old Lake Road
PORT MACQUARIE, 2444

QUEENSLAND

Braemar Engineering Co (Qld) Pty Ltd
Bilsen Road
GEEBUNG, 4034

Queensland Solar Systems
Lot 141, Herbert Street
SLACKS CREEK, 4127

Solar Heating Services
14 Aerodrome Road
MAROOCHYDORE, 4558

Thermax Electric Water Heaters Pty Ltd
15 Curtin Avenue
HAMILTON CENTRAL, 4007

George Wills & Co Ltd
146 Mary Street
BRISBANE, 4000

SOUTH AUSTRALIA

Beasley Industries Pty Ltd
Bolton Avenue
DEVON PARK, 5008

Applied Research of Australia
13 Durant Road
CROYDON PARK, 5008

Braemar Engineering Co (SA) Pty Ltd
Findon Road
KIDMAN PARK, 5025

TASMANIA

Braemar Engineering Pty Ltd
14 Wenvoe Street
DEVONPORT, 7310

George Wills & Co Ltd
57-63 Canning Street
LAUNCESTON. 7000

VICTORIA

George Wills & Co Ltd
203 King Street
MELBOURNE, 3000

Wilson Solarlite
16 Thornton Crescent
MITCHAM, 3132

Yazaki Pacific Pty Ltd
16 Eastern Road
SOUTH MELBOURNE, 3205

Autonomous Energy Systems
25 McLachlan Street
MOUNT WAVERLEY, 3149

Earth Resources
74 Henderson Road
NORTH CLAYTON, 3168

Somer Solar Installations
Sandy Point Road,
SOMERS, 3927

WESTERN AUSTRALIA

S. W. Hart & Co Pty Ltd
112 Pilbara Street
WELSHPOOL, 6106

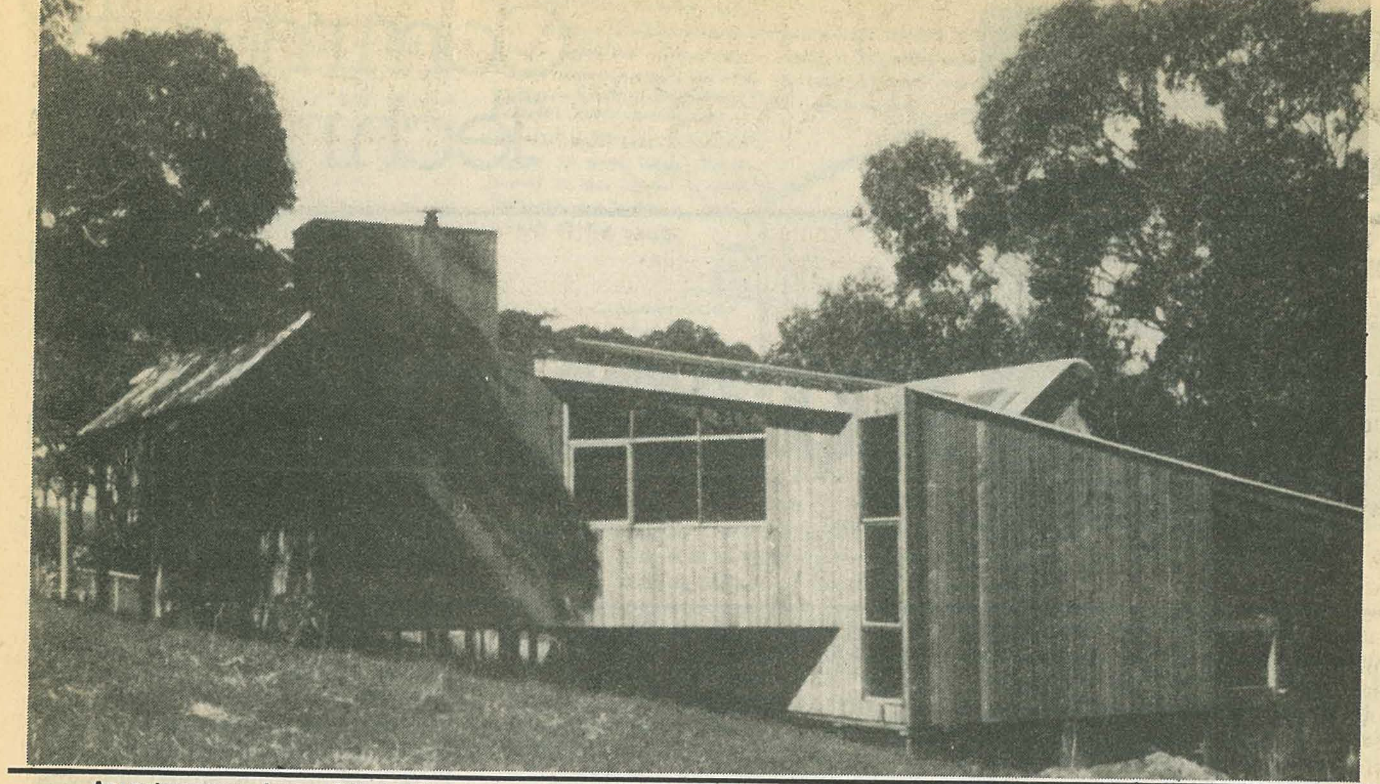
Smalls Solar Heeta Co
10 Goongarrie Street
BAYSWATER, 6053

Sola-ray Appliances
6 Boag Road
MORLEY, 6062

Western Iron Works Pty Ltd
1 Strang Street
SOUTH FREMANTLE, 6162

George Wills & Co Ltd
136 Fitzgerald Street
PERTH, 6000

Solar King
4 Collingwood Street
OSBORNE PARK, 6017



An autonomous house fitted with a solar water heater, wood stove, wind-electric generator and methane digester, located near Flinders on the coast south of Melbourne. (Thanks to John Baird, Cuthbert and Partners, the architects of the house, for photo and diagram on page 7.)

Storming Ivory Towers

Finally here are a few suggestions for getting more information about solar energy generally, and a way of making professional solar scientists more aware of the community's needs.

Although most solar scientists do not have much contact with the general public concerning their work, usually when you speak to them over the phone or go to see them they are more than willing to talk about their projects and help you out with technical problems. A comprehensive list of Australian solar scientists together with their area of specialisation is given in ref. 22.

Choose a scientist working in the area you're interested in, and get in touch. It should be a mutually rewarding activity.

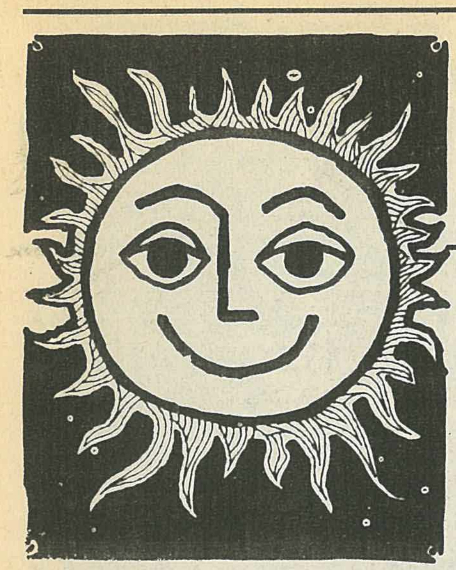
NOTES AND SOURCES.

1. Primary energy — fuels such as petroleum products, coal, natural gas and hydroelectricity. Any gas or electricity manufactured from a primary fuel such as coal is classified as a secondary fuel.
2. CSIRO Solar Energy Studies Unit, Submission to Senate Standing Committee on National Resources, Enquiry into Solar Energy, 28 May 76, p.5.
3. *Energy Costs of Dwellings*, E.R. Ballantyne, 5th Australian Building Research Congress — Resources *.
4. *Chain Reaction*, **2** (2), 30-3.
5. Estimate by R.N. Morse, CSIRO Solar Energy Studies Unit.
6. Ref. 2 states that there is no technological reason why 1×10^{18} Joules of heat per year could not be provided by the year 2000 from solar collectors. This quantity is about 5x the energy needed to satisfy the 1972 level of Australia's domestic *space plus water* heating demand, leaving 4/5ths of the solar energy collected for industrial use.
7. You might find it in libraries, though.
8. *The addition of Solar Collectors to Domestic Hot Water Systems*, J. T. Czarnecki, 1975*.
9. *Solar Energy and Building*, S. V. Szokolay, 1975 (Architectural Press, London), 81-3. This book has a good illustrated review of solar houses around the world.
10. *Sun on the Roof*, P. Brachi, *New Scientist*, 19 Sept. 74, 712-4.
11. *DIY Sun, Undercurrents*, No. 10.
12. Clive Coogan, CSIRO Div. Chemical Physics, Melbourne, has constructed a test-model sump-oil solar collector.
13. Over the past few years *Popular Science* has published many new ideas for solar collectors.
14. *Spectrally Selective Blacks for Solar Energy Collection*, E. A. Christie, International Solar Energy Society Conference, Melbourne, 1970.* *Selective Surface Studies*, A. F. Reid, K. J. Cathro, *Solar Energy Progress in Australia and New Zealand*, No. 14, July 75, p.15. See also H. Tabor, *Selective Surfaces for Solar Collectors*, ch. IV of ref. 30, "Solar Space Heating" article in this *CR*.
15. Yearly solar irradiation tables are available for about 20 locations from CSIRO Solar Energy Studies Unit, P.O. Box 89, East Melbourne, Vic. 3002.
16. *Solar Water Heating in Australia*, E.T. Davey, International Solar Energy Conference, Melbourne, 1970.* Quite a few helpful practical hints in this short paper.
17. *Solar Water Heaters*, CSIRO Div. Mech. Circular No. 2, 1964, p.11.
18. *Domestic Solar Water Heating*, CSIRO Div. Mech. Eng. leaflet, 1976.*
19. Available through Autonomous Energy Systems, 25 McLochlan St., Mt Waverley, Vic. 3149.
20. Made by Applied Research of Australia, Adelaide.
21. *An Economic Case for Solar Energy*, J. Nicholls, Total Environment Centre, 18 Argyle St, Sydney 2000.
22. Solar Energy Progress in Aust. and N.Z., No. 14 July 75. Costs $3.*

* Available from CSIRO Division of Mechanical Engineering, PO Box 26, Highett, Vic., 3190.

OTHER LITERATURE

1. *Energy Primer* (Portola Inst., Menlo Park, California) has a useful chapter on solar energy, plus a good bibliography and a detailed appendix on theory.
2. Another useful solar (and alternative technology generally) bibliography is given in Peter Harper's "Directory of Alternative Technology" published in the UK Journal, *Architectural Design*, Nov. 74, April 75, May 75).



Community Technology

AN AUTONOMOUS HOUSE

At a time when it is becoming common knowledge that the sources of energy and materials which our society has taken for granted in the past are being rapidly exhausted, alternative technology, which is independent of finite resources, is becoming increasingly relevant to our future. Technology which has a 'soft' impact on the communiity's environment creates a constant flow of energy, as opposed to the existing "hard" technology in which energy is used once and never recovered.

The idea of building an 'Autonomous House' using alternative technology came to a group of 2nd and 3rd year Architecture students at Sydney Uni in 1974. They sought an ecologically responsible alternative to conventionally powered and serviced houses, both because of the overall impact on the environment of the corporate forces (e.g. on Lake Pedder, urban creeks, etc.) and because of the ruthlessly profit-oriented organisations responsible (e.g. A. V. Jennings Homes).

The Autonomous House was to use only naturally powered energy systems and, ideally, demonstrate total self-sufficiency in all energy requirements. At the same time it aimed to provide a standard of living for five inhabitants (students) comparable to that of the ordinary community.

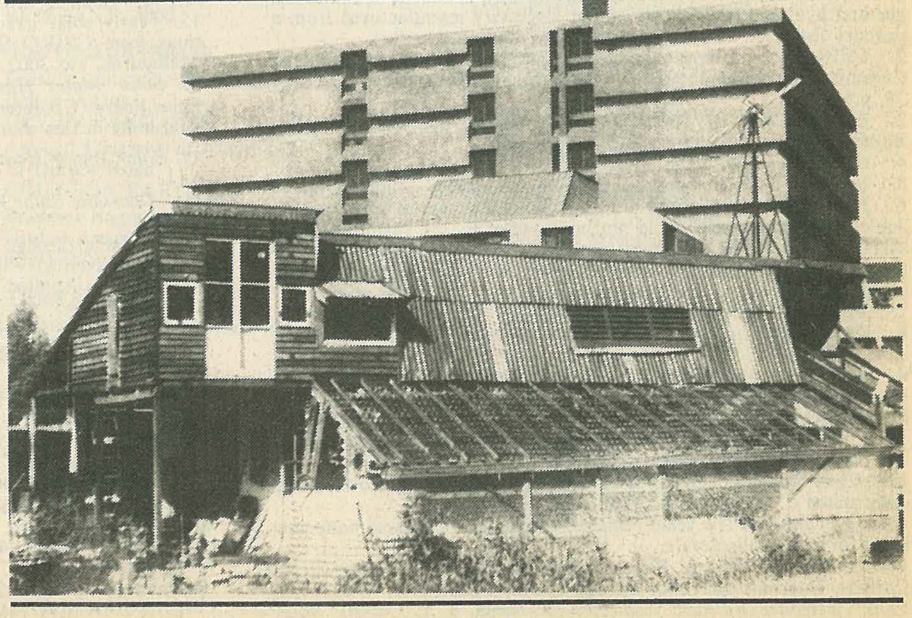
Design and work on the house was undertaken by seventeen students, resulting in a rectangular-shaped house with a large communal living area and kitchen at ground level, and separate sleeping quarters in a loft overhead. A north-facing beer-bottle wall is responsible for the heating and cooling of the house (the sun's heat is stored in old water-filled beer bottles and convection currents can be introduced to control the temperature). Doors and windows can be sealed to prevent heat loss and the house is equipped with fibreglass insulation, so that it is as thermally efficient as possible. Electricity for lighting and power is generated by a "Quirks" 12V/300W windmill and stored in batteries.

The floor of the house is made of rubble from a demolition site, the timber walls are built from scrap, the roof is old galvanised iron sheeting, and the floor of bricks comes from the driveway of a demolished timber factory.

A methane digestor is in use to convert human and organic wastes into a nitrogen-rich fertilizer, though a larger community system would be needed to produce enough methane gas for lighting and cooking. From just one house, too little waste is available to really get the system going. Rain water is gathered on the large roof area and stored in a tank for drinking and general use. A solar water heater is mounted on the northern side of the roof.

The Autonomous House is therefore built almost entirely from second hand materials, from what is normally treated as garbage. This ensured that construction consumed as little energy as possible — merely human energy and time.

Here are a few comments from individuals who have experienced building and living in the Autonomous House.



"The Autonomous House is not just a house with a series of technological systems used to supply an assumed amount of energy, water and shelter, but it is also one of our first steps in a search for a lifestyle more in harmony with the natural world and with other people."

"We feel that it is important to begin living the alternative way now."

*

"Most of our material resources in building in general are geared towards building barriers between one another, and yet, by circumstance or desire, people still live close to one another. The House is a small house (and uses less materials), yet inside there is still a feeling of spaciousness. The whole house is basically one room that can be adapted for our many uses, and we each have small visually-private alcoves between the rafters in the loft. A terrace house in the inner city for five people often seems crowded and claustrophobic, yet this house, at about half the size, feels spacious."

*

"It is very much a house of the present. Much of the interest in living in the House comes from a section of the present community that is aiming for an alternative lifestyle: a lifestyle closely sympathetic to the changing cycles of nature, seeking closer community with other people and greater fulfillment in all life's activities — aiming to embrace a wider range of activities in the fields of work and leisure and gradually eliminate the distinction between the two. An important aspect of this quest is to begin living the alternative way now. So, whilst seeking a reduction and scaling down of hardware, we seek an expansion of our software. As contacts between people in this search become more widespread, the products of their labours will surely become more refined."

"Living in the House, I began to see more and more of both the workings of my needs, and of the technology created to satisfy these needs."

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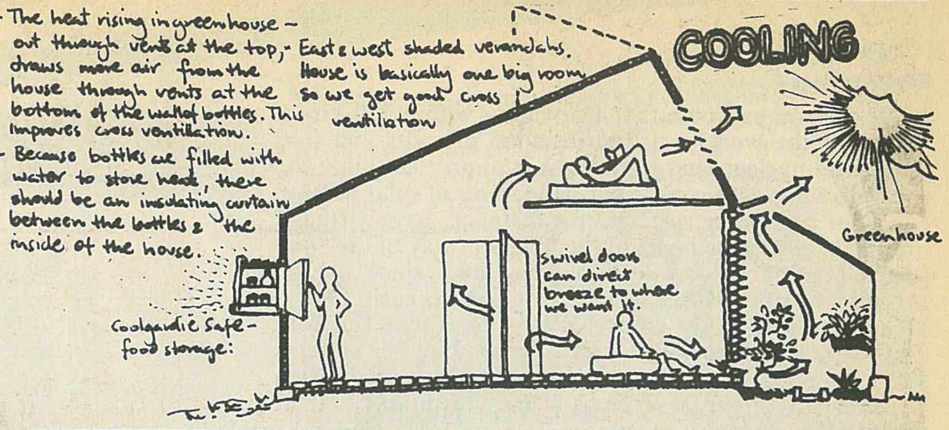
"If we really want to begin living in ecological harmony with the earth then we must reconsider our style of living as much as our techniques."



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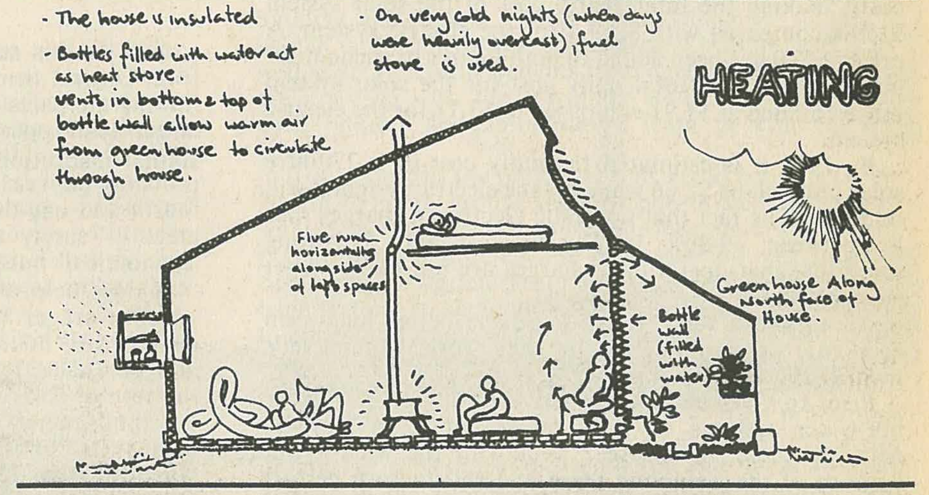
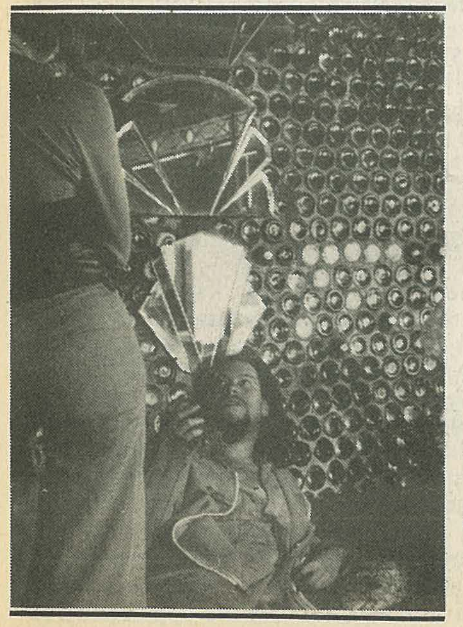
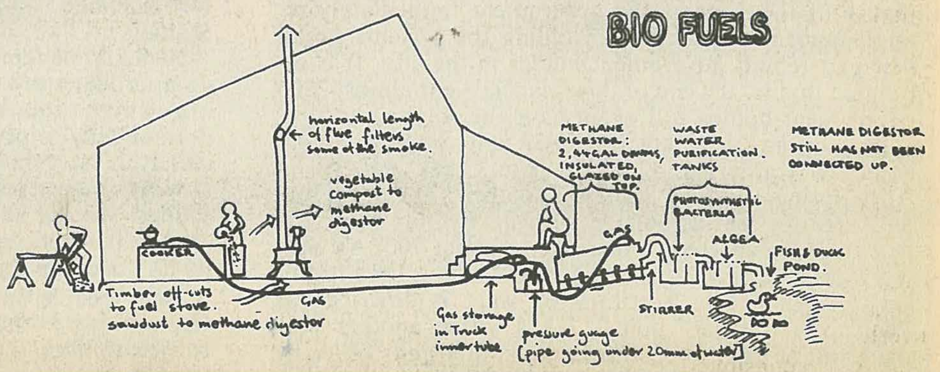






UNDER THE TROPICAL SUN

DARWIN TAKES OFF ON SOLAR POWER

Barbara James

It is perhaps ironic that Darwin — within 250 km of some of the world's richest uranium deposits and thus potential nuclear-energy source—is almost certainly the world's most enthusiastic per-capita user of solar energy.

Solar hot water systems, for instance, have virtually become an accepted part of the "Darwin way of life" and have been increasing in popularity ever since the introduction of the CSIRO-tested units in the early 1960's. And the fact that the Department of Northern Territory has chosen to continue its policy of installing the systems on all government homes following the devastation caused by Cyclone Tracy is persuasive testimony to their long-term economic sense.

Let's look at some relevant figures.

According to a Department of Housing and construction estimate, the total annual cost of using a solar system in Darwin/Alice Springs over a 15-year period is approximately half that of using an electric unit over the same time period. This is despite the fact that the capital cost of solar systems in the Territory is several hundred dollars more than electric systems.

The difference is accounted for in annual operating costs—nil for the solar system and an estimated $220 for the electric system. For instance, according to available figures, the approximate cost (including installation) of a 270-litre solar hot-water unit in the Territory in 1974 was $990 while for the electric system it was $600.

Over a 15-year period, the fixed charge (calculated with an 8.5% interest rate) for the solar system per year would have been $118.8,, while for the electric system it would have been $72. However, added to the cost of the electric system was about $177 per year operational costs, making the total yearly cost of the solar system $138.8 compared with $269.4 for the electric system. A price of $20 has been added to both figures to account for maintenance. The total daily cost for the solar system was estimated at $1.91 compared to $3.71 for the electric system.

By 1978 it is estimated the daily cost of a 270-litre solar unit will be $2.66 while for the electric system it will be $4.69. The fact that domestic electricity charges rose by between 39-50% in Darwin last July is strong testimony that operational charges are not likely to get cheaper.

All right, so solar systems are the better long-term economic proposition, but do they work? Again, let's look at the figures.

Prior to Cyclone Tracy, there were about 2270 solar hot-water systems on government homes in Darwin. Most of these, of course, "went with the wind". But because of the economic sense and satisfactory performance of the systems the government immediately re-implemented its policy of installing the systems on all new and rebuilt government homes in the city. It is estimated that by the end of this financial year almost 2200 government homes will again have the solar units.

In addition, there are 102 solar units on government homes in Katherine, 52 in Tennant Creek and 386 in Alice Springs, making a total of another 540 units in major Territory centres outside Darwin. By July next year that total is expected to increase to about 700. As well, there are another 968 solar units which have been installed throughout the Territory on what is described as "defence and other" homes. Thus within another year there will be near to 4000 solar hot-water units officially installed in Territory homes.

Add to this several hundred more for private sales from Darwin firms or agents and another hundred or so for private sales through southern firms — as well as larger units operational on several hostels, hotels and similar institutions—and the figures rise again. It would probably be reasonably safe to say that between one-fourth and one-third of Darwin homes have solar water units — surely an indication that they are not only 'economical' but also very satisfactory.

It does help of course, to be living in a tropical belt which averages 8.5 hours of sunshine daily, reaching a peak of 10.3 hours in August and a low of 5.9 in January and February. It has, for instance, been estimated that the rate of solar hot-water efficiency (the percentage of the total energy used to heat water supplied by solar means) in Darwin is 90-100%, compared to 80-85% for Alice Springs, 75-80% for Perth and Brisbane, 70-75% for Adelaide, 65-70% for Melbourne and 60-75% for Sydney.

It should be remembered, of course, that Melbourne is on approximately the same latitude as much of California where solar-energy usage is increasing quite dramatically at present. And, for those concerned about cloudy days, it should be pointed out that most collectors now can store at least a day's supply of hot water in an insulated storage tank — and that, if really necessary, electric boosters can be installed along with the solar units as "back-up" supplies.

Many people up North, the residents of Darwin in particular, are becoming interested in living more self-sufficient lives The cyclone which virtually destroyed Darwin in 1974 gave many residents the opportunity to reassess and to then change their values and lifestyles, and some interesting and exciting things are beginning to happen here. For one thing, many residents who are privately rebuilding their homes are trying to utilise as much salvaged cyclone material as possible — even if it only comprises a small part of the total home — i.e. doors or walls. Others are taking low-energy — low-cost ideas even further and designing their homes with more thought to incorporating natural ventilation systems and shading devices to help control the sun's heat, rather than be dependent on artificial cooling systems. Still others are attempting to become as self-sufficient as possible while maintaining a lifestyle more in harmony with the natural environment.

At least three families, for instance, have purchased 'eco' toilets which purport to achieve continuous, uniform and biological decomposition activated by mesophilic micro-organisms, and receive organic kitchen refuse, newspaper and waste paper as well as human waste. The toilets produce a fertilizer and a soil amendment and also reduce domestic water consumption.

Another family, who have purchased a five-acre block outside of Darwin, have dug their own water bore and have used salvaged cyclone material for much of their building program. To keep costs down they purchased a steel frame for a demountable house and have bricked it in for the necessary sheltered rooms such as toilet and pantry. The ceiling is to be made from discarded timber from glass crates and the verandah is comprised partially of salvaged louvre frames. The home is designed to catch maximum breezes and require as little centralised power as possible.

Another young family building a home on a five-acre block near Darwin plans to use the absolute minimum of 'artificial-type' power. For instance, they intend to experiment with growing cassava, the rootstocks of which yield a starch which can be used to produce alcohol for power and lighting purposes.

The Darwin Sun Club is awaiting approval of a 53-acre lease near Darwin where they hope to build a clubhouse, sports course and a few cabins for use by visiting sun-club members. Being obvious nature enthusiasts they are trying to design a system which will most retain the natural aspect of the area they hope to manage. They are investigating ways to use sewerage (i.e. as a fertilizer) and wind energy. They intend, for instance to use windmills to pump the water for the swimming pool they will build and would like to incorporate wind generation for power and lighting if they can get approval from the appropriate authorities!

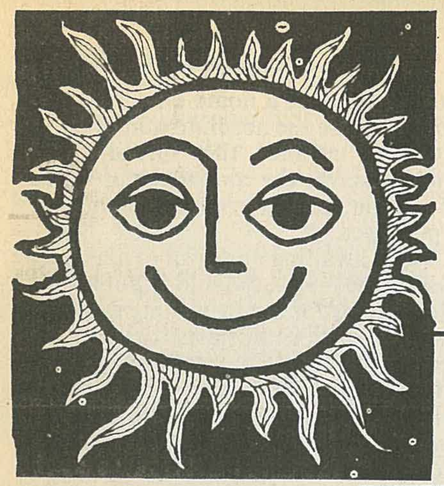
Another group of people is examining the feasibility of building a fully autonomous house in the near Darwin area with cooking and lighting powered by solar, wind and other alternative energy sources. They will emphasise an integrated, decentralised self-sufficient system. As a start they have built a five-foot solar cooker, using mirrors for the reflective surface, and report that it is an excellent solar 'crock pot', letting food cook slowly all day.

The group which is perhaps dealing with the low-energy — low-cost concept most seriously and on the most ambitious scale is the Northern Territory Environmental Council. The Council, through a "low-energy alternatives" project it has initiated under the name "Solarwise", is examining aspects of designing, building and costing a total energy village for about 50 people in a semi-rural tropical area. Local architects as well as architectural students from queensland University are assisting with the feasibility study. There has also been interest and co-operation from government officials.

It is envisaged the project village would house between 20 and 50 family groups and incorporate such concepts as solar power, residential conservation, a sewerage system maximising the efficient use of wastes and recycling excess water for agricultural purposes, and a recycling garbage system. It would also make maximum use of shared facilities and equipment. More details of this solar village, as it is being unofficially termed, will be made available as plans progress.

The Environmental Council has also been promoting the concepts of soft technology, solar in particular, by organising workshops and seminars with acknowledged experts in the appropriate fields. Author-architect, Mr Steve Szokolay, of Queensland University; Dr Don Close of North Queensland University; and Dr Mat Darveniza, of Queensland University have been among those assisting to enthuse the Darwin public about alternative energy sources. They have discussed in detail solar storage, cooling and collectors as well as solar power systems for isolated rural dwellings.

So that at least in Darwin, and some other Territory centres, the public is being informed of alternatives to nuclear and other high-energy sources. And until many of those concepts become more widely used and readily available to people throughout the world, it is encouraging to see at least part of Australia taking great advantage of its greatest natural resource — the sun.



Technology For The People By The People

CAPTAIN EDDY'S LEGACY

John Andrews

Out of the many domestic household solar hotwater systems I've been to look at in Melbourne over the past month — rather, out of the few I've been able to find — I think Marie Nurse's up in the suburb of Heathmont is going to stick in my mind longest.

Marie, who remembers as a girl in the industrial north of England "being woken up by the clang of clogs against cobbled streets as the women walked to the mills and the men to the mines," is a kind old lady of 81. She's never heard of alternative, soft, low-impact, radical or whatever-you-want-to-call-it technology. Yet she enthusiastically sings the praises of solar hot-water systems, knows all about pesticides and pollution, and composts all her kitchen wastes for a little vegetable garden which a friend now helps her keep going.

I went to see her because I'd been told about the ingenious rotatable solar collector made by her husband Eddy well over ten years ago. And indeed it turned out to be quite an invention, and a very pleasant visit.

The collector is really one rectangular metal panel, about 4 metres by 1 metre in area, set in a wooden box and covered with glass — double glazing over the top 2/3rds. A metal pipe running through the centre of the box is fixed at one end to the eaves of the house, then supported by a piece of 4"x4" timber near the eaves, and again by a short stub of 4"x4" at the other end near the ground. The pipe serves as a pivot about which the whole collector can be rotated.

A flexible plastic pipe bringing cold water in at the top runs inside the box of the collector to the base, so it's kept well-insulated. The water is then heated and rises up the collector, and on via another flexible pipe to a hot-water storage tank in the roof.

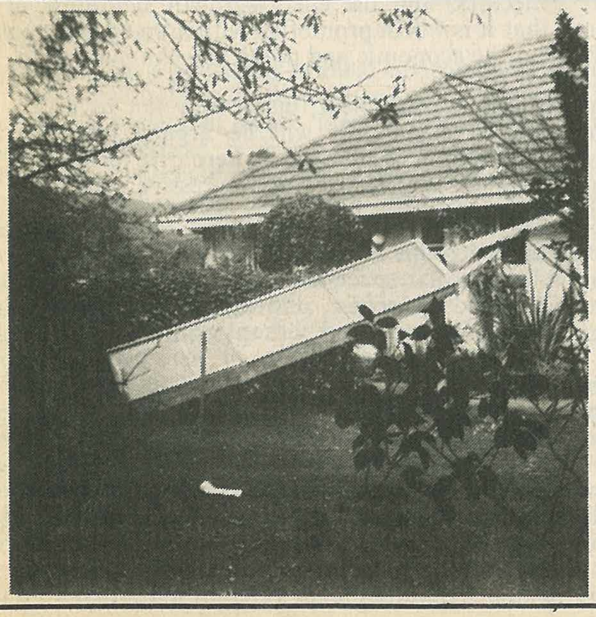
Marie still moves the weighty collector around during each day to follow the sun and she proudly showed me how easy it was to do, securing the collector in any one position by means of a dog chain hooked over a nail.

"First I point it over towards the east to get the morning sun," she said. "Then I have it flat for the midday period, and over towards the west for the setting sun. My husband always said you have to chase the winter sun. In summer you can just leave it flat, and there's plenty enough heat. Sometimes it gets too hot, you know, and you have to turn it away form the sun. We've even had the water boiling on a very hot day."

The system also has an electric booster, which is needed on cold overcast days in winter, but only occasionally in summer.

Marie's husband Eddy was a captain in the Australian navy. He died four years ago, but he is still very much in

Marie Nurse and her rotatable solar collector.



the forefront of Marie's memory, and lives on in the numerous ingenious inventions around the house.

Although he did a course in engineering in his youth, Captain Eddy was essentially an 'amateur' inventor, not a professional engineer or scientist, and it's something of that tradition which I think must be rediscovered if increasing use of solar energy is to fulfil its many promises. There is no doubt that creative technological and scientific skills are distributed much more widely among the population than our educational classification scheme and division of labor would have us believe, and there seems every indication that alternative technology must largely be done by the people, if it is to be truly for the people.

Certainly the deeper experiences to be won by 'creating' a new piece of technology and through it attaining a more harmonious, sympathetic relationship to the environment are lost if say a solar water heater — one of a million all the same — is simply bought over the counter and installed 'professionally'.

Whatever you think of Captain Eddy's solar system — you've got to admit it's original!

And what do the Solar Companies say?

Sandy Poulsford of FOE (S.A.) interviews John Hibell, Marketing Manager of Beasley Industries Pty Ltd, Adelaide, the largest Australian manufacturer of solar hot-water systems.

FOE: What do you see as the main barriers to increased use of solar energy?

J.H.: I think there will always be a problem with the price of raw materials involved in any hot water system. The first object will always be to keep costs down.

If we could have reduced our pricing on solar to only 50% more than an electric system, the market would have developed to a great extent long before this, so I think we have to say that cost is the major factor.

FOE: In South Australia the government is looking at the possibility of legislation to require new houses to install solar water heaters. Is this a realistic move at this stage?

J.H.: I think it is very realistic. Already the local Housing Trust has indicated very strong interest in solar hot-water systems, and only three or four weeks ago quite a number of our units went up to Whyalla to be installed for a testing period.

I would say without doubt that if the government is satisfied with the performance of these units over the next 12 months, then for a start every government home in this state would have a solar hot-water system installed.

Eventually, this may pass into the consumer area. But we're still up against this cost factor. That's the main thing to the consumer.

FOE: How do the economics of solar compare with conventional systems?

J.H: If you look at total supply and installation of an average size family unit, you are probably looking at around double the price of replacing an existing electric hot-water system and installation. From what we know of current power costs in this state, the extra outlay for solar would probably be recouped in round about five years assuming that the power authorities raise their charges on the same scale as they've done over the last 2 or 3 years. If they go over that, obviously the recovery period is a lot shorter.

FOE: Who constitutes the main market at present for solar hot water systems?

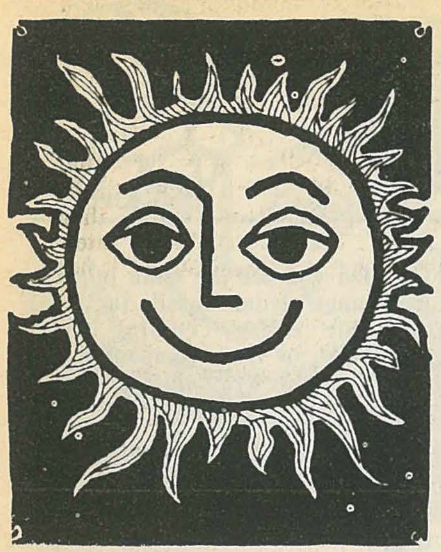
J.H: The market for solar in Australia is still, I believe, in the domestic side, probably 99%.

FOE: Do you see the main impetus for change from fossil fuels to renewable energy coming from government, or from companies like yourself, or only by gradual public acceptance.

J.H: The consumer, or public acceptance, is going to force the government into this anyway. Let's face it, every government in the world is very aware of this. We've had so much talk about the energy crisis over the last couple of years particularly. And I've got no doubts in my mind that governments world-wide are now treating solar energy, very, very seriously.

FOE: Coming back to Beasleys—is this just another job to staff and factory workers, or do you feel part of some sort of historical process?

J.H: Very historical. A lot of our factory workers and our staff are long-standing employees of Beasleys. They go back to the days of the founder of the company. Some of the employees in my division have been here 18-22 years. It's very much a family concern. We suffer probably the least amount of industrial strife of many industries.



SOLAR TECHNOLOGY and POLITICAL CHANGE

Brian Martin

with help from other members of FOE-Canberra

To many people in the environmental movement, low-level solar technology is assumed to be a good thing. Is this necessarily so?

In the complex relationship between the structure of society and technology, it is useful to separate out two sorts of influence. First, the social, economic and political organisation of a society has a strong effect on the type of technology imagined, developed and promoted in that society. One reason that present-day capitalist and state-socialist societies are promoting nuclear power is that this form of energy generation fits nicely into existing patterns of centralised economic and political control.

Nuclear technology is seen by elites to be desirable because it must be developed and run by experts (well-paid and docile): this effectively cuts off the possibility of community control of the technology. Another reason why ruling groups promote nuclear power is that it requires large amounts of capital; these groups then maintain more control, through control over the investment, over social and technological developments in the future. Last of all, the nuclear option is promoted because its very enormity and dangerousness seem to justify the existence of the scientific, managerial and political elites who promoted it in the first place.

The second sort of influence between technology and society works in the other direction: the technology adopted by a society helps determine the type of social, political and economic organisation of society which seems most workable and desirable. The widespread adoption of nuclear technology, for whatever reason, would reinforce the control of political and economic institutions by ruling elites, and foster an even more splintered and alienated social framework than already exists under present technology.

For many of those who promote low-level solar technology, the hope — whether explicit or implicit — is that solar technology will help promote a better society through this second sort of influence. The idea is first to introduce an energy technology which is environmentally safe and ecologically sound, inexpensive, simple to build and operate by individuals and small groups, and which is easily integrated into a life-style based on self-sufficiency and widespread participation in vital activities (growing and cooking food, making clothing and shelter, operating community-based health and education).

Establishing this technology hopefully will help lead to a society in which economic and political power is more widely distributed, in which people get satisfaction in doing those tasks which concern them directly, and in which a satisfying interaction between people, and between people and nature, is part of everyday life.

So Why Worry About The Social Implications Of Solar Technology?

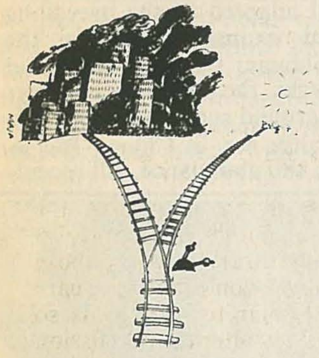
To argue in this way is already to go beyond the promotion of solar technology for purely environmental and ecological reasons. But is it necessary to worry about the social and political implications: won't they take care of themselves? Surely low-level solar technology is so much better than its high-technology alternatives (fission and fusion, high-technology solar power as from massive desert collectors, and the energy-growth syndrome in general) that it is worth promoting without worrying too much about the economic and political techniques of doing so.

The attitude is convenient; but it may not be as appropriate as it sounds. It will be argued here that widespread adoption of all sorts of alternative technology is quite compatible with a highly-repressive social and political structure.

Let's take a possible scenario. Individual energy needs are provided by solar space and water heating, methane cookers powered by refuse, and lighting and back-up energy from hydro, wind and perhaps geothermal power. All containers are recyclable or completely biodegradable; food in shops is produced with the greatest abundance of nutrients, and is collectable from large containers in vurtially unlimited amounts. Transport is provided by a highly efficient public central network, augmented by small personal vehicles powered by methane or hydrogen produced from solar energy. But travel is not so necessary, since cheap electronic communication means that one never needs to leave home. Working hours are minimal or voluntary. There is a wide variety of entertainments provided on tapes and video-discs, ranging from sports and computer games to drama and music. A wide variety of pleasurable drugs are free.

Enough of this scenario. It's not everyone's cup of tea, but it's just an illustration. Let's look more carefully at it. This hypothetical society satisfies the ostensible aims of the environmental movement: minimum use of non-renewable resources and energy, and low environmental impact. Yet it is possible that the majority of the people living in it would be repressed, in the sense that their real human potential for creative and interactive living would be submerged. Solar heaters and methane cookers might be sold or distributed just the way heating oil and electric ranges are now, perpetuating alienation from material possessions. Food might be centrally produced and processed just as it is now. The transport system might lead to just the same faceless anonymity as at present. The easily accessible entertainment and drugs might provide the same escape from an empty reality that is so prevalent today.

Many people in this hypothetical society would be 'satisfied'. No doubt many today would like to live in such a society. But the number of people actually stretched to their capacity, given the chance to involve themselves in challenging and rewarding activities, would be small — as it is now. The people so challenged mainly would be those who designed highly efficient solar heaters, who developed ecologically-sound and highly-productive agricultural techniques; who administered the public transport system. and who produced the wealth of diversionary entertainment.



What To Do?

Assume that a politically-minded environmentalist (or an environmentally-minded political activist) wishes to promote a society in which there is widespread community involvement in local decision-making and in producing the necessities of life, in which social roles and structures, technology, and moral codes are purposely designed by the community to maximise each individual's opportunities for a satisfying and challenging life, and in which life-styles are consciously put in harmony with the evolutionary needs and potential of humans and nature. (Isn't this high-sounding?) What is such a person to do?

It is not sufficient just to promote alternative technology, such as solar technology, in any way possible. By accepting uncritically the existing political and economic structures, it is likely that this technology will be introduced (if ever) in a way and in a form that leaves these structures essentially unchanged. Solar heaters will be sold on the market like other commodities: the poor will lose out as the price of conventionally produced energy rises. Design of technology and of community organisation (housing, transport, communication) will remain in the hands of the scientific-technological elites: the technology and community organisation promoted by these elites will be designed (unconsciously or not) to reinforce their power. (For example, capability for local design and production of living quarters will not be encouraged.) A social organisation will be encouraged that does not threaten those who hold power: people will be given entertainment and drugged escape, rather than vital decision-making power. So just promoting alternative technology and ignoring the political context is not enough.

Neither is it sufficient just to change the existing locus of economic and political control. For although technology does not *determine* the structure of society, it certainly helps to push it in particular directions. If the people took control of all work places today, it might not be enough to stop continued promotion of private motor transport, or even to stop the technological attraction of nuclear power (or other forms of centralised power production).

The takeover would need to be tied to a programme of promoting technology that lends itself to different life-styles and patterns of decision-making. Such a programme is not inherently part of a political stance based on community control (although in practice it is in many cases). The existing social and economic organisation of society, its buildings and tools — even its very knowledge — will tend to stimulate a similar organisation of society in the future, whatever groups are in control. That is, the ruling elites promote technology (such as nuclear power) that maintains their political power; this technology then makes the existence of ruling elites (of whatever origin) more natural and inevitable. This technology, as well as the ruling elites, must be replaced.

It has been claimed here that a society run using all the panaceas of alternative technology, and at the same time separating people from the activities that maintain their lives, is possible — in principle. But could present monopoly capitalist (or state socialist) society possibly survive the transition to such a society? For example, could a massive redirection of investment occur — as from nuclear to solar power—before disastrous environmental deterioration set in, spurring citizen action against the social order? It *might* be that environmental degradation can continue to be blamed on people, the same way that automobile accidents, universally are blamed on bad drivers and poor roads rather than on inappropriate technology backed by vested interests. Capitalism has surprising adaptive capacities in this and other areas, and it would be wishful thinking to believe that making the transition to low-level solar technology *automatically* will present insurmountable problems to the system. At the same time there *will* be serious problems for capitalism in making the transition while maintaining control by the few over the choices of the many. It will be the task of the politically-aware environmentalist to use these problems to work for a society run completely and directly for and by the community.

The conclusion here is obvious, so it might as well be short. What is needed is action based on an integrated perspective, aimed at changing the existing distribution of political and economic power *and* changing the existing technology that is both the product of and the prop for this distribution of power. Promotion of solar power and opposition to nuclear power both have this potential, but only if carefully linked with political goals. What this means in terms of tactics, however, is something that must be worked out by each individual and each group.

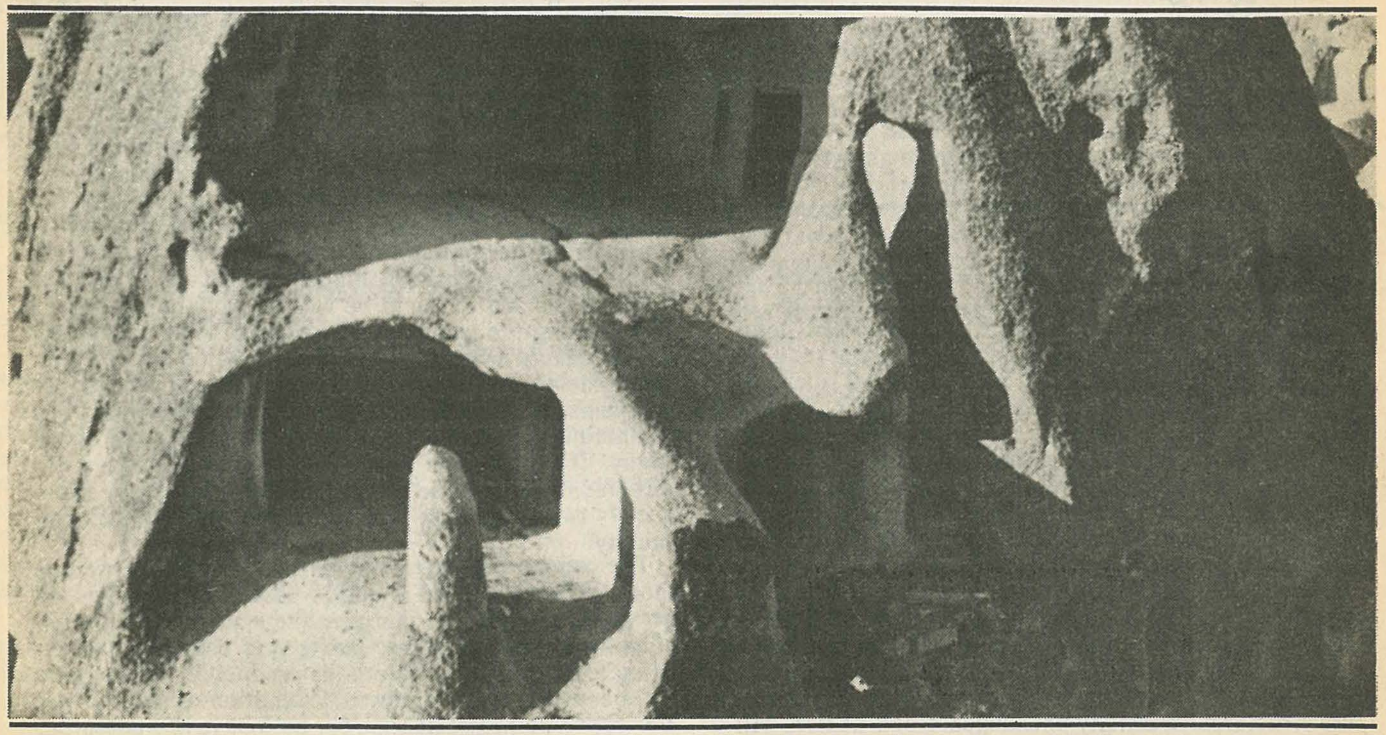
Renewable Energy Income from the Sun

SOLAR SPACE HEATING

Peter O'Hannessian John Andrews

Fossil fuels for space heating or cooling? Who needs them? From Hobart to Darwin, from Perth to Sydney, in fact wherever you live in Australia, if your house is well designed it should require very little fuel for either space heating or space cooling. Fuel consumption for these purposes can be kept to a bare minimum by using a wise mix of shading, glazing, wall, roof and floor materials, and insulation, and design so that the sun's warming rays enter the building and are absorbed when you want heating, but are reflected away when you want to keep cool. Conversely, the extent to which you simmer inside your house on a hot summer's day, and how often you reach for the heater switch in winter, are direct indicators of how badly your house is designed from a thermal performance point of view.

Older cultures than our own, cultures which have had a much deeper respect for nature, show copious examples of architecture which is well adapted to the prevailing climate. Particularly vivid examples include the American Indian adobe buildings, the Sudanese mud huts, the Aegean Island Villages, the cool narrow alleys of Marrakesh, and the underground suntrap dwellings in the provinces of Honnan, Kansu etc. in China[1]. But in modern western architecture, the abundance, till recently, of cheap fossil fuels for powering space heating and cooling appliances has too often been the excuse for almost totally ignoring the sun in architectural design.



Entries to rock dwellings in the Cappadocia region of Turkey. Clever shading and the good insulating properties of the volcanic rock keep these houses cool in summer, and (with the help of a small wood stove nowadays) comfortably warm in winter.

In this country, largely as a result of rising comfort levels, the domestic sector has become the fastest growing energy consumer[2], accounting for some 13 per cent of the total primary energy consumed each year[3]. On average 50 per cent of the energy consumed in Australian homes is used for space heating, so taking action to reduce this demand is the most significant step people can take directly to promote fuel conservation.

Solar Homes

Solar energy is ideally suited for space heating. Firstly sunshine is uniformly spread over a given area, for example a city, and each building can act as its own solar collector. There are therefore no problems in distributing the energy to its point of use from central production stations as is the case with electricity, gas or oil. Secondly house heating needs only 'low-grade' energy, that is, a large amount at low temperatures, so the use of a 'high-grade' energy such as electricity for this purpose is very wasteful from an energy-efficiency point of view. 75 per cent of the energy content of the fuel used to produce electricity is actually lost before the old amps and volts get to your power point.

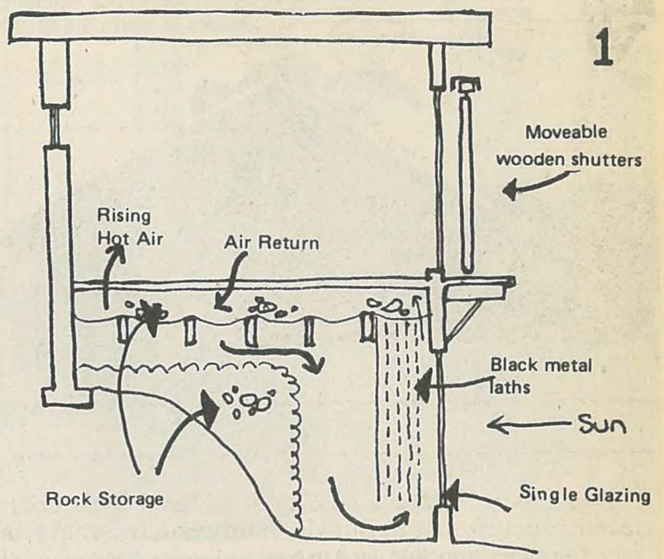
In a sense then all houses are 'solar' houses. They are subject to incident solar radiation throughout the year and the manner in which they respond to this, and to the surrounding air by losing heat, will largely determine their thermal performance and hence the amount of auxiliary heating they require. For example, in Melbourne a well-insulated house with a large area of north facing windows, with a suitable overhang of the eaves to shade out the higher summer sun, will use far less energy and be more comfortable than one with the same area of south-facing windows with little or no insulation.

Of course, some houses are more 'solar' than others and here we're going to be concerned with those which satisfy a large proportion of their heating demand by solar means. In the discussion that follows we'll distinguish between (a) **passive systems** in which by careful building design solar energy is used for heating purposes without the addition of special equipment; and (b) **active systems** in which solar collectors are installed to capture solar energy and this is conveyed by some means to the space to be conditioned or to an energy store. In type B systems the heat-transfer fluid may be either air or water, the latter having the potential of being used for both heating and cooling.

Passive Systems

These are the simplest and most elegant solutions to the problem of heating a house by solar radiation. Passive solar houses can be built using 'low-technology' systems and can therefore be reasonably cheap. There are some very beautiful examples of houses of this type now in existence, so here's a quick review of some of these which should also show the basic design principles involved. (Note that the references given allow a follow-up of the detailed design of these houses.)

Masterson Studio[4]



1. The Masterson studio.

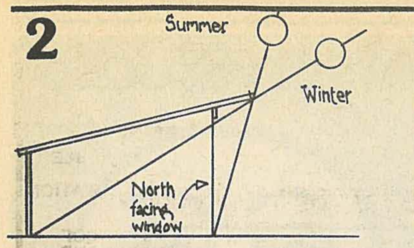
This is a one-storey one-room pottery workshop designed and built in 1972 by Mr and Ms Masterson at La Cienega, New Mexico, USA (lat. 35°N). Solar radiation is used in two ways. Firstly there's a large south-facing (we're in the northern hemisphere now!) single-glazed window allowing sunlight to enter the building directly, and keeping the heat in by the greenhouse effect. Two sliding covers, like barn doors, that can be closed manually are used to shade the window during summer and prevent excessive heat losses at night.

Secondly there's a vertical south-wall collector below the south window. This collector has a single layer of ordinary window glass at the front and the absorber is a corrugated steel sheet painted black. Four layers of black metal lathes between the glass and the sheet serve to increase the heat-transfer area. All air flow is by natural convection.

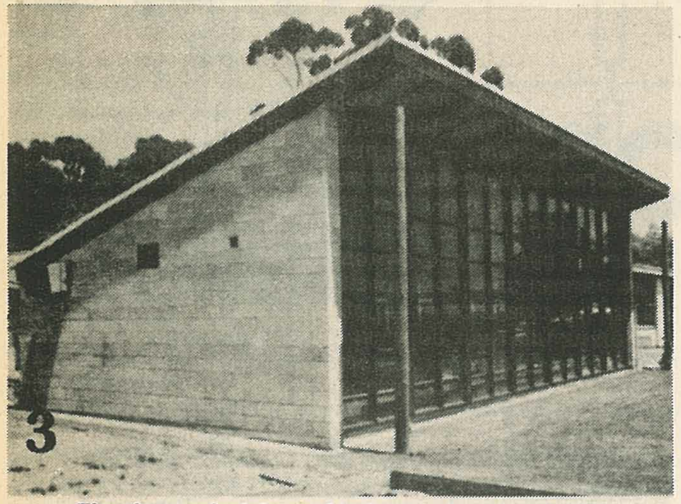
Air from the collector rises and flows through a layer of stones (20 tonnes) underneath the floor. Some heat is retained by the rocks, while the rest rises up through the floor by conduction, or through registers, into the studio above. Colder air falls into the basement space and back to the base of the collector.

The percentage of heat supplied by the solar system has been estimated as 80 per cent with a wood stove providing the rest. The solar system has been found to provide heat to the studio even on snowy winter days.

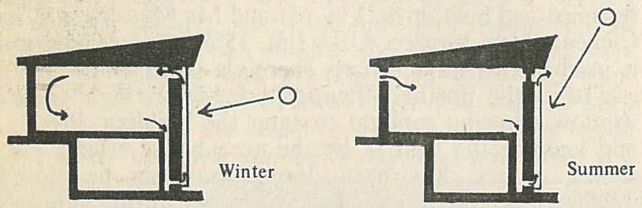
A somewhat similar system has been used to heat a building at the Waite Research Institute[5, 6] in Adelaide, with the important design change of using an overhang of the roof over the north (back down under again) - facing windows to shield the inside from the summer sun (diag. 2). This building is used only to house insects and plants but then they too like to keep their little bodies at a pretty constant temperature! (diag. 3). This overhang design can be used throughout southern Australia but note that it isn't suitable for use in locations of low latitude, e.g. Darwin, where the sun is always high in the sky during the important mid-day period.



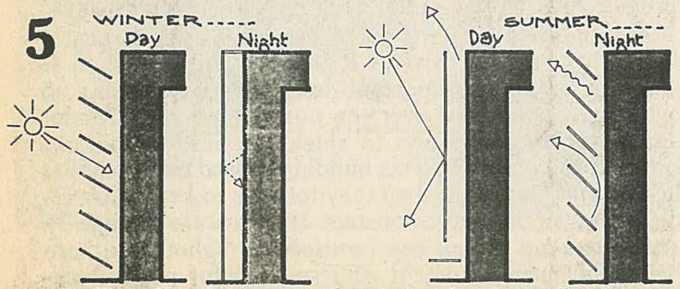
With a suitable roof overhang, the summer sun can be shaded out from a north-facing window (southern hemisphere), while the winter sunlight enters to warm the house.



The above principle used to heat an insectary building at the Waite Research Institute, Adelaide.



The principle of operation of a Trombe-Michel solar wall and a house at Odeillo, France, which uses this system to supply 60-70 per cent of the annual energy needed for space heating.



5. Marseille slats — another type of solar wall using louvres to give four heating/cooling modes.

On a larger scale, another interesting building which uses the large mid-day sun-facing window principle is St George's Secondary School at Wallasey near Liverpool in the north of England. For over 20 years now no auxiliary heating has been required for the classrooms and labs inside (7).

Odeillo Houses[8,9]

Almost in the shadow of the giant French 1000 kW solar furnace, these houses (31 of them) were built by the Centre National de la Recherche Scientifique for some of its employees at Odeillo, high up in the French Pyrenees (altitude 1300m, lat. 43° N). They use the Trombe-Michel solar wall principle (diag. 4), which is hard to beat for simplicity and effectiveness.

In Australia a house of this type would have a north-facing concrete wall (recommended thickness 25cm) with a dark surface on the outside, and single glazing in front of it leaving a space for air convection. A roof overhang shades the summer sun from the wall, as in the insectary described in the previous section.

Air in the space between wall and glass is heated and rises, passing into the building at the top through a port, while cold air is drawn out of the building through a lower port into the air space to be warmed. Hence a natural heating cycle is started, which can last for two or three hours after sunset depending on the amount of energy received from the sun during that day. Heat also enters the building by radiation from the storage wall, after a time period for conduction through the wall depending on the thickness and nature of the wall material.

One of the authors (Peter) is studying the performance of a Trombe-Michel system at the Department of Mechanical Engineering, Melbourne University, and present indications are that a 25cm wall thickness gives the best all-round effect[10]. This thickness is in fact considerably less than that used at Odeillo. Odeillo also experiences much lower temperatures than say Melbourne, so double glazing in front of the concrete wall was employed on the original houses.

The most recently built houses at Odeillo receive about 60-70 per cent of their annual heating energy from the solar wall, the rest coming from auxiliary electric heaters. However, a wood stove can also be used, as at similar Trombe-Michel systems at Chauvency-le-Chateau in France[11].

Other Solar Walls

The following are three more novel design ideas for solar walls which should be useful as a basis for improvisation, either in designing complete new buildings or adding solar walls to existing ones.

Marseilles Slats[12] A neat way of getting four heating/cooling modes from a plain old concrete (or other absorbent) wall with a dark exterior surface, by having a set of aluminium (or perhaps wood covered in aluminium foil) louvres in front. The illustration (diag. 5) should be self-explanatory.

Baer Barrels[13,14] Designed by Steve Baer, this wall has been described in most of the alternative technology books (e.g. [15,16]) and consists of 55-gallon steel drums filled with water, stacked in racks behind single glazing with their axes pointing south (we're up north again, in New Mexico, USA). A large insulating door, hinged at the lower end of the wall, covers the drum wall completely, and it is lowered in the morning in winter to allow the sun to shine in and warm the barrels. At the same time, laying flat on the ground the door acts as a reflector to intensify the heat from the sun. The door is raised when the sun goes down to prevent heat loss, and the barrels lose their heat to the inside of the building. During summer the door is kept closed, the cool water in the drums acting as a sink for the heat inside and keeping the room at a comfortable temperature.

This wall provides 75-85 per cent of the building's heating needs, wood stoves making up the difference. The one drawback with the system is the problem of corrosion of the steel in contact with water. Anti-corrosive additives can be added, but it remains to be seen what the lifetime of the drums will be.

Beer Bottles. You can see a nascent version of this type of solar wall outback of any true ocker's home, but as yet the solar potential of this structure has not been so widely realised. At Sydney University 'autonomous house', however, a group of architecture students have recycled those dark-brown beer bottles as one of their north-facing walls inside a glazed 'greenhouse' area. The bottles, water-filled with their tops pointing outwards, act as a heat store (See **Comtec** for illustration). But those living in the house aren't happy with the wall's performance and are considering replacing it with heavy curtains and a dark masonry floor inside the building, exposed to northern sunlight during the day.

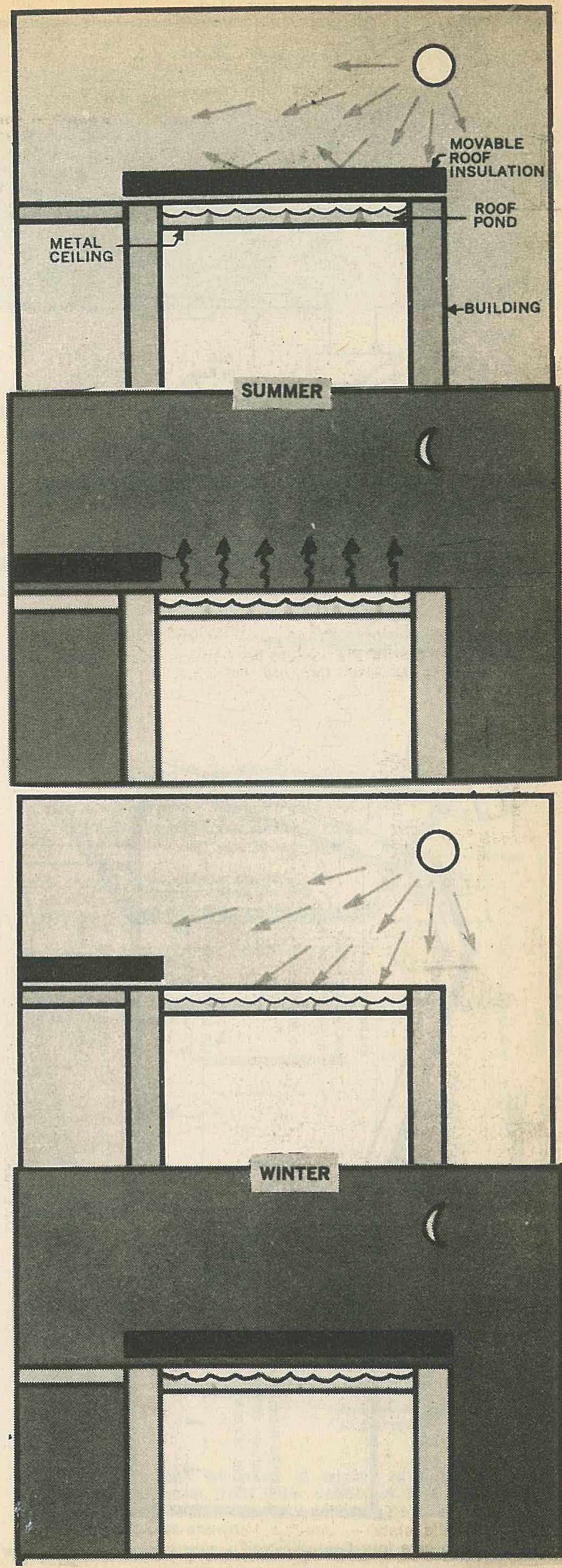
Solar Roofs

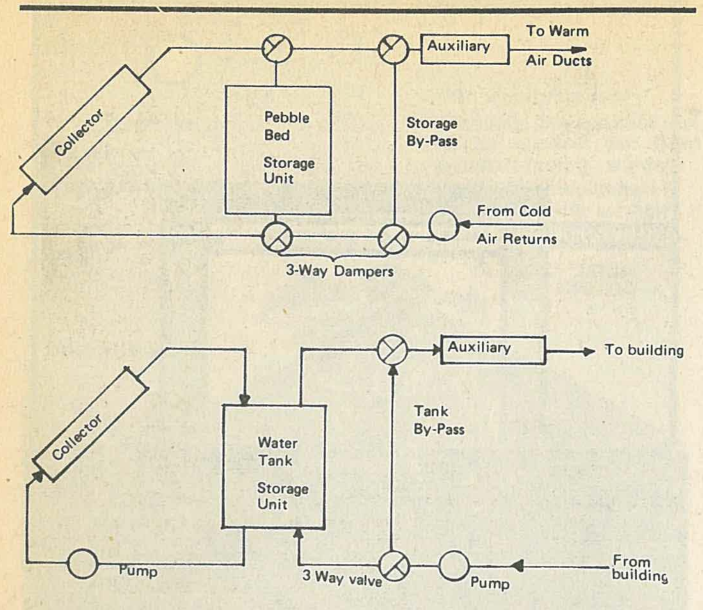
Haystacks. Harold Hay [17,18,19] designed this system of natural air conditioning which has been used successfully in a house at Atascadero in California (lat. 35°N; n.b. Sydney is 36°S). Also called "Skytherm", it provides 100 per cent of the house's needs for heating and cooling throughout the year.

Water is stored in PVC (0.1mm thick) bags on top of a metal roof. Above each bag there's a transparent UV-resistant PVC sheet sealed to the bags along their edges and held (by air pressure from below) so that there is an air gap to provide top insulation. Beneath each bag there is a black PVC sheet which rests on top of the metallic roof. Panels of insulation can either be drawn over the bags to cover them, or stacked at one side to leave them exposed.

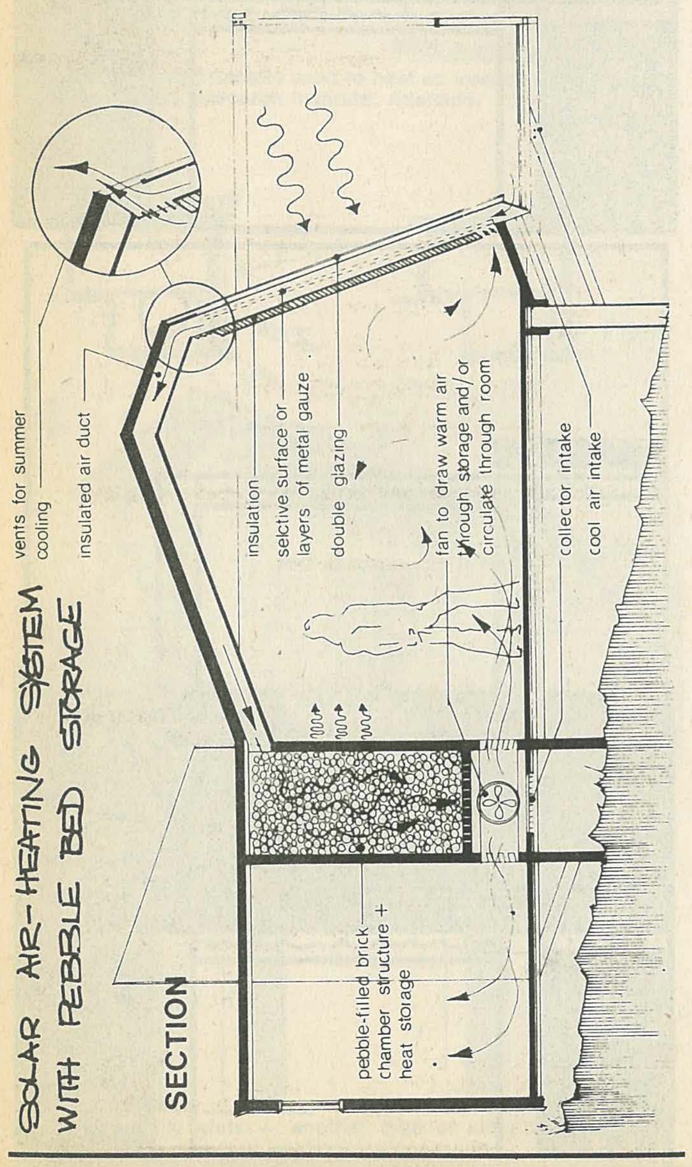
The illustration shows the various heat-transfer modes available. On a winter's day the bags absorb heat and transfer it to the room beneath; this continues at night when the insulation panels are drawn over to prevent outwards heat loss from the bags. On a summer's day the bags are covered, preventing heat from entering the house from above; then at night the covers are removed and the cold water acts as a sink for the heat inside the house, and radiates energy back out again.

The horizontal roof collector is a disadvantage for winter heating in regions of high latitude, though such a system could probably be used over most of Australia.





Schematic diagrams of basic solar space-heating systems using air (above) and water (below) as the heat-transfer fluids.



Active Systems

The diagrams below[20] show the two basic types of active' solar house-heating systems: one in which air is used as the heat-transfer fluid to carry heat from the solar collector to a pebble-bed storage unit or to a room where it is needed, the second in which water circulates through the collectors and is also used as the heat store.

Firstly it can be seen that both of these active systems are pretty complicated—requiring pumps, valves, a lot of piping as well as special collectors and storage units. So we're entering the realm of 'higher' technology, and hence higher cost. Many of the solar houses with active solar-heating systems are really glorified laboratories — the well-publicised Philips House at Aachen is an excellent example. It may prove impossible, however, to use a passive system in a particular location (for example, north-facing wall or window types require a very open site to the north), or on an existing building. In such a case some form of active system would have to be considered, since with the collectors as separate components greater flexibility is possible in their positioning on the house.

Air or Water?

What are their relative merits and demerits as heat transfer fluids?

Advantages in favour of the air-type system are that there is no problem with freezing in the collectors or with overheating during periods of low or zero energy removal. Corrosion problems are also minimised and there are no complications with water leaks or water penetration. Disadvantages include relatively high pumping costs compared to water, and the large volumes (e.g. of small rocks) of storage needed.

On the other hand, using water the heat absorbed in the collectors can be stored directly as hot water, without having to transfer this heat to some other storage medium as is the case with the air system. Also a given volume of water can store about four times as much heat as the same volume of small rocks. Roughly, 2000 gallons of water operating between 32 and 65°C are equivalent to 42 tons of rocks working between the same temperatures!

So, pros and cons on both sides, and there's no simple answer to which is best, air or water.

Solar houses using these two types of system have been described in detail in many places, therefore, to save trees, here we'll just give references to a good example of each. Dr G. Lof's residence in Denver, USA, uses a combination of air collectors and rock-bed storage for space heating[21, 22, 23], while the Colorado State University's first solar house uses water collectors and a water storage tank to provide most of the required energy for winter heating and summer cooling[24].

Heat Storage

There are three main methods of heat storage in use today: hot water, rock piles and eutectic salts (also called heat of fusion storage). The first method is obviously used when water circulates through the collectors, the latter two when air is the heat-transfer fluid. Water and rock storage are well-proven methods, while storage in eutectic salts is still very much at the experimental stage.

A solar air-heating installation together with a rock-pile storage unit has been operating at the CSIRO Division of Mechanical Engineering at Highett in Melbourne for several years[26]. The system heats a section of lab and office space during the winter months, and the thermal storage is also used for summer cooling by evaporative cooling of the rock pile at night. The pile consists of three galvanised iron tanks (total volume $32m^3$) filled with 17mm basalt rock screenings. Approximately $56m^2$ of solar air heater (collector area) are required to condition a working area of approximately $130m^2$.

Small rocks, usually basalt or granite pebbles, 1.3-2.5cm in diam., are used in a rock-bed store to increase the area of contact of air with rock and so give good heat-transfer properties (ref. 15 gives a diagram of a typical pile).

Some eutectic (low-melting point) salts, e.g. Glauber's salt (sodium sulphate decahydrate), are useful for heat storage because they freeze/melt at convenient temperatures for space-heating purposes — in the case of Glauber's salt, around 32°C. As this salt is heated through 32°C, a great deal of extra heat is absorbed as it changes from a solid to a liquid. This heat is released again on cooling and solidification. Glauber's salt is in fact capable of storing eight times more heat than water of the same volume between the temperatures of 25°C and 37°C. This system of storage is used in Dr Mario Telkes' Dover House[27].

Problems emerging with eutectic-salt heat storage, however, are that the melting temperature seems to change with repeated cycling, and that the salt corrodes its metal containers.

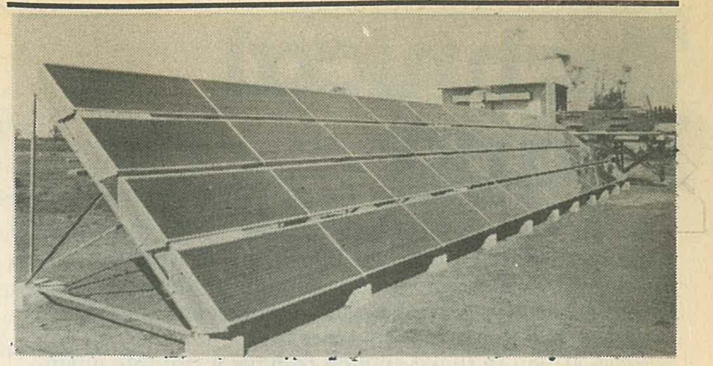
To end with, two more quick ideas for storing heat: eutectic mixtures of metallic fluorides[28]; and what about good old paraffin wax, which melts at 55°C with a latent heat of fusion of 40 Watt hours/kg — i.e. a lot of storage capacity?[28]

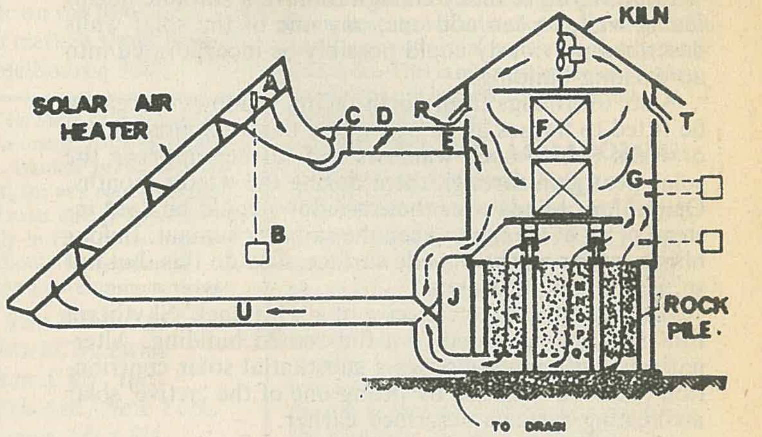
Collectors

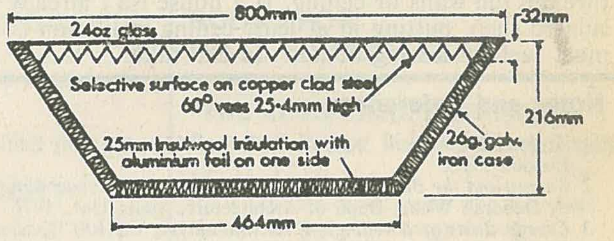
Flat-plate collectors for water heating are discussed in the Solar Water Heating article in this *CR*, and the same type can be used for water-circulation space-heating systems. As detailed a review of both water and air solar heaters as any one should require is given in refs. 29-32.

In this country CSIRO have developed a simple solar air heater which is used on their lab heating-cooling system already described, and on an experimental solar timber drying kiln at Griffith, NSW[33].

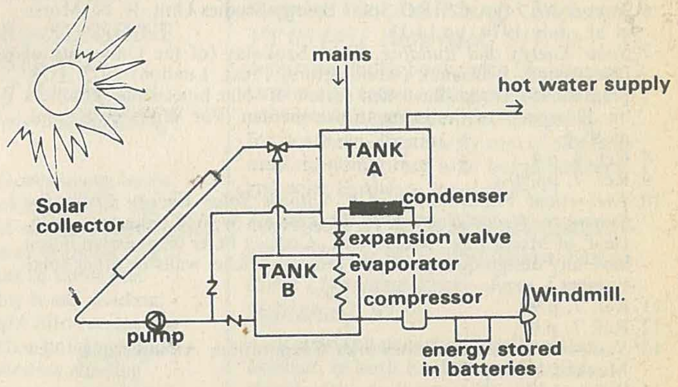
The use of solar collectors in conjunction with heat pumps is currently arousing a lot of interest. In one arrangement water is heated by collectors and stored in a tank and then a heat pump (think of using the heat coming out the back of a refrigerator!) is used to draw off heat from this store and 'pump' it up to a higher temperature for getting even hotter water, or for higher-temperature air heating. The attraction of the heat pump is that the quantity of heat transferred to a higher temperature is several times greater than the energy required to run the pump.[34]







CSIRO's solar air heater and its use in a timber-drying kiln at Griffith, NSW.



A heat pump can be used in winter to raise the temperature of water from solar collectors to a useful level. The heat-pump compressor could be powered by a wind generator, as shown.

Technical Fixing

So far we've been largely looking at the design of whole new solar houses, but in conclusion we'll transfer attention to what can be done to enlarge the solar contribution towards heating existing houses, and to improve their thermal performance generally.

First, if you're lucky enough to have a suitable north-facing wall, or can add one, any one of the solar walls described previously could possibly be incorporated into an existing building.

Also, overhangs from north-facing windows can easily be fitted to houses as an extra, and dark-coloured floors or walls behind such windows will further improve the solar heat gain through them during the winter months. Or outdoor blinds over these windows could be used instead of an overhang to keep the summer sun out. Indoor blinds, white on the outside surface, also do this, but not so well as outdoor ones.

It is not difficult to conceive of a 'Haystack' Skytherm roof pond being added to a flat-roofed building. Alternatively, with many houses a substantial solar contribution could be obtained by fitting one of the 'active' solar air-heating systems described earlier.

However, with all these solar space-heating systems, and with fossil-fuel heating systems, it's not much sense getting the heat in if it's going to leak out just as quick through the walls or ceiling. If a house isn't already insulated then, putting in at least ceiling insulation is **the** most fuel-conserving action you can take.

Ceiling insulation can cut domestic heating bills by about 40 per cent, the exact amount depending on the house design nd thickness of insulation installed. Higher percentage savings can be achieved if the walls are also insulated[35]. Moreover, an insulated house stays much cooler in summer.

In Victoria it has been calculated that if all houses had adequate ceiling insulation now, there would be a 7.2 per cent saving in the States **total** secondary-energy requirements. (So much for Newport's necessity!)

The following table gives the recommended insulation requirements (using mineral wool batts) for some cities, together with the period it would take for savings in fuel bills (October 1975 prices) to pay back the cost of installing the insulation. This costs $260-365 for the average house, except in Canberra where it is $470.[35]

	Thickness (mm)	Payback Period (years)
Adelaide	50	4.0
Canberra	100	3.3
Sydney	75	4.7
Melbourne	75	4.1
Hobart	75	3.8

And of course there is always the Eskimo solution: personal insulation by wearing warmer thicker clothes inside during winter!

Notes and References

1 *Architecture without Architects*, B. Rudofsky, Academy Editions, London 1973.
2 *Energy and the Built Environment*, submission to Ranger Enquiry, by Deborah White, Dept. of Architecture, Melb. Uni., 1976.
3 *Energy Costs of Dwellings*, E. R. Ballantyne, CSIRO Division of Building Research, Highett, Melbourne.
4 *Solar Houses: A General Appraisal of Solar Building Design and Technology*, C.N.D. Stambolis, UNESCO/World Meteorological Organisation Solar Energy Symposium, Geneva, 1976. Very helpful review of solar houses throughout the world. Well worth getting a copy.
5 *A Rock Pile Thermal Storage Heating and Cooling System*, H. L. Chapman, 1970 International Solar Energy Society Conference, Melbourne.
6 *Report No 74/1*, CSIRO Solar Energy Studies Unit, R. N. Morse et al., July 1974, pp.14-15.
7 *Solar Energy and Building*, S. V. Szokolay (of the University of Queensland, Brisbane), (Architectural Press, London) 1975. (UK price £6.95). Good illustrated review of solar houses plus chapters on all aspects of designing to use the sun. For Wallasey School, pp.85-6.
8 Ref. 4, p.4.
9 Ref. 7, pp.90-1.
10 *Theoretical Performance of a Natural Solar Energy Collection System for House Heating*, P. Ohanessian, W.W.S. Charters, 1975, Dept. of Mech. Eng., Melb., Uni., Contact Peter Ohanessian if you have any design queries about Trombe-Michel walls or other solar systems.
11 Ref. 7, p.90.
12 Ref. 7, p.92.
13 *Sunspots*, S. Baer, Zomeworks Corporation, Albuquerque, New Mexico, 1975, p.97.
14 Ref 4, p.19.
15 *Energy Primer*, Portola Inst., Menlo Park, Calif., USA, 1974, p.12. Very helpful on all aspects of alternative technology.
16 *Radical Technology*, Eds. G. Boyle and P. Harper, Penguin Books, 1976. pp.68-9 for Steve Baer's wall. This is another excellent AT sourcebook — for political implications as well as hardware.
17 A Naturally Air Conditioned Building, *Mechanical Engineering*, Vol.92, No.1, pp.19-23, H. R. Hay and J. I. Yellot. See also *Mech. Eng.* Oct. 1972, Nov. 73.
18 Ref. 4, p.7, 18.
19 Ref. 7, p.94.
20 Ref. 4, Figs 7 (a), (b).
21 Ref. 4, p.9.
22 Ref. 15, p.10.
23 Ref. 7, p.73.
24 Ref. 4, p.11.
25 Ref. 15, pp.10-11, gives a short but helpful review of heat-storage methods.
26 Contact Fred Darby, CSIRO Division of Mechanical Engineering, PO Box 26, Highett, Vic., for further info on rock-bed storage. See also: ref. 6, p. 13, and *The Design and Performance of a Thermal Storage Air Conditioning System*, 1968, D. J. Close R. V. Dunkle, K. A. Robeson — available from above Division of CSIRO.
27 Ref. 7, p.70.
28 *Living on the Sun*, G. Boyle, 1975, Calder and Boyars, London, pp.33-4.
29 Ref. 15, pp.6-9, good simple review of collectors. And for more detailed info on solar collectors; refs 30-32.
30 *Low Temperature Engineering Applications of Solar Energy*, published by A.S.H.R.A.E., 1345 East 47th St, New York, NY 10017, USA.
31 *Solar Energy Thermal Processes*, J. A. Duffie, W. A. Beckman (Wiley, New York) 1974. *The* text book on solar energy.
32 *Development of Flat Plate Solar Collectors for Heating and Cooling of Buildings*, Honeywell, 1975 (available through National Technical Info. Service, Rep. No. N75-26495).
33 Ref. 6, p.15,19.
34 Ref. 4, p.17; Ref. 28, p.53.
35 Mineral Wool Manufacturers' Association of Australia, Submission to Government Oct. 1975. Contacts for further info. on insulation: Min. Wool Manuf. Assoc. of Aust., Manufacturers House, 370 St Kilda Road, Melbourne. Vic. 3004. Deborah White. Dept. of Architecture, Melb. Uni. CSIRO Division of Building Research, Highett, Vic.
36 See note 1, Solar Water Heating article in this *CR* for definition of secondary energy.

PRINTED BY WAVERLEY OFFSET PUBLISHING GROUP—560 5111

SOLAR POWER BIBLIOGRAPHY

Most of the important technical breakthroughs in solar energy technology have occurred in the last five years, although highly efficient solar flat plate collectors have been commercially available for twenty years in several countries including Australia. In this rapidly progressing area of technology bibliographies become out of date by the time they are published so an attempt has been made to list most of the books written for the lay-person or do-it-yourselfer on the basis of whether they are available through booksellers. All such books marked thus* are available from the *Whole Earth Bookshop*, 81 Bourke Street, Melbourne 3000.

SOLAR ENERGY DIRECTORIES

Australian materials on solar energy are indexed in the *Australian Solar Energy Data Base* (ASEDB) which is maintained by CSIRO in both printed and machine-readable form.

SOLAR ENERGY SOURCE BOOK, *edited by C.W. Martz (Solar Energy Institute of America, Box 9352, Washington, DC 20005. Feb, 1977). 400 pages, 5½ x 8½, loose-leaf, $12.*

Update sheets are planned as the solar energy industry grows. One of the more comprehensive solar energy directories.

SOLAR ENERGY UPDATE, *published annually by EIC-Environment Information Centre, Inc, as part of its Energy Directory Update Service. Address: 292 Madison Ave, New York, NY 10017, 1977 edition 84 pages. Paperback*

Need a guide through the maze of federal and state government agencies, trade and professional associations, information systems, centres and publications concerned with solar energy conversion in its many forms?

While not all-inclusive, this 'select guide' to this information may be just what you are looking for. Write the publishers for prices, etc., on this and their many other energy services.

OVERVIEWS

***EARTH, WATER, WIND AND SUN: OUR ENERGY ALTERNATIVES,** *by D.S. Halacy, Jr., hardcover $11.95. (Harper and Row.)*

An entertaining and highly readable little book by a skilled professional science writer who believes that, while none of the currently available alternative energy sources is a magic solution for fossil fuels, they can, taken together, provide a solution to the world's energy crisis.

***DIRECT USE OF THE SUN'S ENERGY** *Farrington Daniels (Ballantine, Random House, New York, 1974)*

This is a reprint of the original 1964 Yale University edition. The State of Winconsin has produced Aldo Leonard, John Muir all from the same cloth. Daniels' book, selected to be one of the texts for our course, is still the best overview of solar energy applications around, but especially in view of its emphasis is that solar energy should be developed first to aid the poor and developing nations.

RAYS OF HOPE: *The Transition to a Post-Petroleum World, by Denis Hayes. (W.W. Norton & Co., Inc., Publishers, 500 Fifth Ave., New York, NY 10036). Hardcover, 5½ x 8¼, 240 pages, $9.95 (paper $3.95).*

***ENERGY FOR SURVIVAL – the Alternative to Extinction:** *Wilson Clark. $6.95 (paperback). (Anchor Press/Doubleday, Garden City, New York.) – 1974.*

AUSTRALIAN SUNLIGHT DATA

CONTROL OF SUNLIGHT PENETRATION, INDUSTRIAL DATA SHEET A.2

Department of Labour and Immigration, 1974 – $1.75. Available from Federal Government bookshops.

EBS BULLETIN No.8 – SUNSHINE AND SHADE IN AUSTRALIA. *R.O. Phillips (Dept. of Housing and Construction, Experimental Building Station). $1.85.*

Available from Federal Government bookshops. Both of these booklets enable the user to find the extent of sunlight penertration and shading on buildings or in modifying an old one, it is important to know the extent to which a building is self shading, the penetration of sunlight into rooms, the shadows cost on it by other buildings and trees and the effect of window shading devices. The plastic protractors supplied with both of these booklets is used with solar charts to enable the designer to find as easily as possible the angles at which the sun's rays will fall on a building at different times and seasons and places.

ARCHITECTURAL AND ENGINEERING

SOLAR ORIENTED ARCHITECTURE *John Yellot et al. (American Institute of Architects, 1975). $12.50.*

Prepared by the Solar Energy Applications Team of Arizona State University for the AIA; order from the AIA or from the Architecture Foundation, College of Architecture, Arizona State University, Tempe, Arizona 85281. This is far and away the best step-by-step description of the architectural design principles inherent in different ways of harnessing solar energy for home heating, with detailed and well-illustratedexamples of actual homes employing these principles. This is my primary resource for the slides I use in class and public talks. A beautifully done book.

SOLAR HEATING AND COOLING: Engineering, Practical Design and Economics. *Ian F. Kreider and Frank Kreith (McGraw-Hill, 1976). $22.50.*

This is the most widely used (but, I think, also the most rigorously marketed) book that focuses quantitatively on solar heating and cooling of buildings. The first part contains the usual fundamentals of heat transfer and solar energy collection, while the rest applies these principles to buildings and hardware. Actually, the book is written in a not-too-advanced style, which makes it usable by a person with limited technical background.

BOOKS FOR DO-IT-YOURSELFERS

***THE AUTONOMOUS HOUSE,** *by Brenda & Robert Vale, (Universe Books, 1975). $7.50*

It's not for the casual reader who is curious about solar and wind energy and other aspects of self-sufficiency. It is a well written, illustrated and tabulated book for those seriously interested in planning, designing, building, and testing a self-serviced house for themselves or for others.

***DESIGNING AND BUILDING A SOLAR HOUSE:** *by Donald Watson. (Garden Way Publishing, Charlotte, VT 05445). Paperback, $11.50.*

A nuts-and-bolts book, with chapters on passive and active solar systems, energy conservation measures, and designing for northern climates, by one of the foremost contemporary solar home builders and solar hardware innovators.

***AN ATTACHED SOLAR GREENHOUSE:** *by W. E. and Susan Yanda. (The Lightning Tree –Jene Lyon, Publisher). $7.95.*

A concise (18 pages) and well written booklet, in both English and Spanish, showing the do-it-yourselfer just how to to about adding a greenhouse to his home for a very modest outlay (about $2.50 per square foot). The attached greenhouse offers a number of advantages such as lengthening the growing season (fresh tomatoes from May, January), adding heat to the home, helping in insulation, and adding a pleasant living space in which certain plants can be grown all year round and vegetable and flower seedings can be started early in the season.

***THE SOLAR HOME BOOK:** *by Bruce Anderson with Michael Riordan. 8½ x 11, 297 pages, many illustrations, tables charts, etc. $9.50. (Cheshire books).*

Clearly written, easily read chapters cover solar architecture, solar fundamentals, direct solar heating, soft technology approaches, indirect solar energy systems, do-it-yourself projects, perspectives, and an appendix covering climatic data, design data, information and supplies. Contains practically everything you need to know about the solar home, including SED's SolarSan™ solar water heaters. Highly recommended.

***LOW-COST-ENERGY-EFFICIENT SHELTER FOR THE 'OWNER AND BUILDER':** *Eugene Eccli, Ed, (Rodale Press, 1976). $8.95.*

Order from Rodale Press, Emmanus, Pennsylvania 19409. This is a remarkably fine extension of Ref. 24 above, covering the material in more detail and adding an emphasis on designing smaller houses that use space and materials more efficiently, on recycling old buildings and used materials, and on balancing energy and esthetic needs. Specific how-to-do-it construction details are given, again in a framework of cost-saving. The book then moves into the design of the "solar-tempered home", followed by the best introduction I have seen to the integrated north-wall greenhouse. Some good examples of designs, integrations, and renovations are given. Soft-cover.

***THE 1977 SUN CATALOG:** *available for $2.00 (Solar Usage Now).*

Lists absorbers, blowers, collectors of many types, controls, foil pumps, tanks, lenses, and just about everything else you need to get started in solar energy.

A good overview of solar energy hardware and software available today.

***COMPONENTS CATALOGUE** *(Southwest Solar Systems, Tucson Arizona). $2.00.*

Southwest Solar Systems' brand new solar components catalog is now available, featuring tracking devices, collectors, pumps, controls, design service, product availability research service, literature, ideal for the professional or the do-it-yourselfer.

SOLAR POWER GENERATION

***SUNLIGHT TO ELECTRICITY: Prospects for Solar Energy Conversion by Photovoltaics,** *by Joseph A. Merrigan, 6½ x 9¼, 163 pages, with index, footnotes, and bibliography, (MIT Press, 2nd Printing, March, 1976). $15.95.*

In this interesting and realistic assessment, the author considers current and expected energy usage in the US to the year 2000, the state-of-the-art in photovoltaics and the economic and business considerations in developing photovoltaic energy conversion on a large scale. Dr. Merrigan envisions an almost immediate and rapid application ot low power systems in communications, recreational vehicles and mobile homes, and projects the use of photovoltaic converters for supplementary and peak power generation by about 1990, and general power generation around the turn of the century.

***ENERGY: THE SOLAR HYDROGEN ALTERNATIVE,** *by J. O'M. Bockris, 6 x 9½, 365 pages (Halstead Press, New York, NY). Hardcover. $35.00.*

This is a most timely book ona subject of first-rate importance written by a distinguished physical chemist perhaps best known for his work in the 'The New Electrochemistry' concerned with electron exchange with other phenomena at metal-solution interfaces, but whose work and interests cover a broad spectrum. Professor Bockris has more recently truned his attention toward the great question of the world's future energy supply, its economis, and its relation to environmental and ecological matters. All these are discussed in the book.

INVENTIONS AND PATENTS

***SOLAR ENERGY INVENTIONS AND DESIGN PATENTS 1976.** *Paperback 8½ x 11, is available from the author and publisher, Stanley Garil, Research Specialist. $10.00.*

Briefs most of the US general, chemical, electrical, mechanical and design patents issued on inventions in the area of solar energy and conversion in 1976.

POLITICS OF SOLAR ENERGY

ALTERNATIVE TECHNOLOGY AND THE POLITICS OF TECHNICAL CHANGE. *David Dickson (Fontana, 1974, 224 pages). $1.50.*

CHAIN REACTION, VOL. 3, No.2, 1977. *Quarterly magazine published by Friends of the Earth. $1.00.*

Continues a special series of articles on the politics of alternative energy, and the interconnection between job creation and use of reasonable energy sources.

SOFT ENERGY STRATEGIES

ENERGY STRATEGIES, THE ROAD NOT TAKEN? *Amory Lovins (Friends of the Earth, Australia, 1977). $1.00.*

SOFT ENERGY PATHS *Amory Lovins (Penguin, 1977). $2.95.*

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