Solar energy is a free energy source that we can use in various forms such as heat, light and electricity. Australia has an abundance of it. As yet it is neither charged for nor taxed by governments, multinationals or utilities. However as solar energy is cyclical and often required when the sun is not shining it costs money to harness it. Solar design comprises a collector, a storage system and a distribution system. Passive solar design is a way of doing this without using a mechanism.

Architectural features have a large influence on heating needs. Our comfort can either benefit or suffer from the decisions made about siting, layout, windows, materials and construction methods. A well designed passive solar house would reduce the need for supplementary heating (usually by gas or electricity) by about 80%. It is theoretically possible to heat a house using only solar and internal heat gains, thus making heaters quite unnecessary. Passive solar design of housing is the key to providing a sustainable lifestyle for the occupants.
CLIMATE AND COMFORT

Nowhere in the world do natural conditions provide a satisfactory physiological environment for humans. Natural conditions must be modified by wearing clothes and building shelters against wind, rain, snow, and climate extremes. Comfort for a healthy active adult requires a temperature between 18-27°C. Hobart, with a cool temperate climate (Zone 7 in Building Code of Australia), has over the last 10 years averaged:

- 321 days – 88% of year, with mean daily temperature below 18°C (365 – 100%)
- 221 days – 67% of year, with maximum temperature below 18°C (236 – 65%)
- 36 days – 11% of year with maximum temperature above 24°C (29 – 8%)

The figures in brackets are for the 90 years between 1900 and 1990. Whilst a 10 year spread may not be statistically significant, it is hoped that the figures are indicative of the climate change now taking place. The increase in daily temperature means more attention needs to be given to shading in summer. However the seven to eight month heating season combined with a high proportion of sunny weather means Tasmania remains an ideal place for solar heating with either active or passive systems.

- Active Systems use a mechanism to convert the energy to a useful form, eg. a fan or compressor. This increases energy use.
- Passive Systems use convection, conduction and radiation for all heat flows (Figs 2, 3).

SOLAR SPACE HEATING

Passive solar heating uses the building and the climate to heat the building. It is not a component that can be bolted on to a building. Only a building that has been carefully designed and built can give you good results. Without attention to detail its operation and performance is usually mediocre.

The collector

The collector needs to be transparent to short wave infra red radiation, opaque to long wave re-radiation (for the greenhouse effect) and shaded in summer to prevent overheating. A high performance double glazed window facing north with an overhanging eaves is ideal. The double glazed unit would comprise clear glass on the outside, a sealed air cavity 12mm-20mm wide (refer Fig 4) and clear low-emissivity glass on the inside.

The store

The store is provided by thermal mass inside the building. Thermal mass is any material capable of storing heat. Those most commonly used in building are high density materials such as concrete, bricks, blocks and stone (refer Fig 5), or high specific heat materials such as water. It is important to distinguish between insulation and thermal mass. Insulation is measured by an R-value (thickness /conductivity), which is a measure of resistance to heat flow, and thermal mass by capacitance or C-value (density x specific heat x thickness), which is a measure of the amount of heat it can store. Dense materials are poor insulators and good capacitors. The amount of heat absorbed depends on the colour, texture and temperature of the surface while its’ thickness determines the time lag required for heat to flow through. Rough dark walls and floors can absorb more heat than their smooth light counterparts and could result in a 1 star difference in performance. Insulation between the thermal mass and outside is essential to prevent heat loss by cold bridging.

Distribution

Distribution is by direct radiation or indirectly by convection through a fluid such as air or water. Room air is the usual fluid for indirect gain and distribution is relatively automatic, the room temperature becoming warmer by convection and re-radiation from the warm wall surfaces. Other rooms can also be warmed by natural convection, usually achieved with air flow along passages and through open doorways.

Insulation

Insulation is essential for realising the full benefits of solar heating. It is required by the building regulations, but remember that minimum standards will keep rising despite opposition from self interest groups, so whatever is standard today is sub-standard tomorrow. Insulation is always your “best value for money”. The more insulation you have...
the less fuel/energy you’ll need for heating. Always try to equalise losses through the five sources of heat loss. 1 Roof/ceiling. 2 Windows. 3 Walls. 4 Floors. 5 Drafts. Most building materials, being either too thin or poor insulators, have low R-values, so specialist materials are used for insulating. Bulk insulation reduces conduction heat losses, reflective insulation reduces radiation heat loss, and draft seals reduce convection heat losses.

Sunshine
Sunshine is admitted to the space to be heated through windows. The energy is absorbed by walls or floors or other storages during the day and then released directly from the surfaces of those storages during the evening. As this also results in warmer walls, a higher average temperature and a much lower temperature swing, comfort is greatly improved.

Sometimes the zone to be heated is separate from the collector, in which case heating is usually through a contiguous wall such as a “Storage or Trombe” wall. Sunspaces and Conservatories (Fig 3) can be attached or recessed (Fig 6), but because of their large glass to mass ratios they experience large temperature swings both day and night and need to be closed off from other areas of a house when suffering from extremes.

Their appeal is in maximising the amount of collector, providing very pleasant indoor spaces on cold but sunny days and as a buffer space to the outside.

Errors
Mistakes commonly made in designing passive solar heating systems are:
1 Not enough insulation is provided and cold bridges in construction sabotage the value of insulation.
2 Windows do not face north and/or receive unobstructed winter sun because features such as wide verandahs or tinted glass cut out solar radiation.
3 Windows are not shaded in summer.
4 Mass is not sized in relation to glass and incident solar radiation.
5 Where views require large windows away from north, insulation values are not increased to compensate.

BUILDING LAYOUT
The following group of issues related to building layout are essential if passive solar heating is to work efficiently. As the major source of energy is the sun these issues are related to gaining the maximum possible exposure to the sun from mid March to late November. To an observer on earth the sun’s path across the sky corresponds closely with the seasonal needs for heating and cooling. In winter the sun rises in the NE, travels in a low altitude trajectory and sets in the NW. At the equinox it rises due east and sets due west and in summer it rises in the SE and travels in a high altitude trajectory and sets in the SW (Fig 7). The north slope of hills and in areas that are not shaded by large trees, thick bushes, tall buildings, cliffs or cuttings. Road patterns are usually set according to yield and engineering requirements, so the different block orientations require different plans and street setbacks. Whilst a long east-west configuration is convenient it is by no means mandatory and there are many different designs that all produce effective passive solar buildings (Fig 9).

Orientation
True north allows maximum sun entry in winter and easiest shading in summer. A 20° deviation from north gives up to 5% reduction in performance, and a 30° deviation gives approximately 10% reduction. This allows some scope for divergence. Based on a preference of morning sun for an early warm up and a dislike of overheating from the late afternoon sun “north” in this note means within the limits of 30°E of N and 15° W of N (Fig 8).

Windows
Window position is critical and a northern exposure is definitely required. A well designed passive solar house has 80% of its windows facing north. This doesn’t mean that large windows can’t be placed elsewhere, particularly if there is a view. But the increased heat loss (or summer overheating) must be compensated as the insulation value of a single glazed window is slight.

Double glazing halves the heat loss over a single glazed window and in Tasmania’s climate, really should be the norm. Windows can also be insulated with curtains if they prevent air flow. Most don’t, regardless of the good intentions of their owners. Fitting an additional window, usually on the inside, is another way of insulating windows, particularly to preserve a building’s architectural style.

Frames influence the performance of a window. Wood and plastic frames insulate while metal frames act as a heat sink. Metal frames with a thermal break between the inside and the outside can improve their R-value by 20%.

Fig. 7 Seasonal variation of the sun's trajectory Lat 42½ S
Fig. 6 Recessed sunspace beyond, separated by dividing wall
Fig. 8 Orientation
Fig. 9 Various designs for different orientations

GOOD
IDEAL
PERMISSIBLE
large heaters become unnecessary. Heat losses are reduced and the indoor environment remains comfortable. Changing the infiltration rate from two to ten times per hour makes it possible to reduce the infiltration rate to one air change per hour. A healthy indoor environment is still maintained, heat losses are reduced and large heaters become unnecessary.

Thermal Comfort
As the phrase suggests is the feeling of comfort experienced by a person when they are in balance with their surroundings, neither too hot nor too cold. In a poorly insulated house, wall, floor and window temperatures are much colder than the warmed air. This is often experienced as a feeling of cold feet and/or stiffness which is to be avoided. Too high a heat gradient and the body loses heat by radiation to the colder surfaces and is bathed in cold convective currents from windows. Turning up the temperature is futile. When walls floors and windows are well insulated their surface temperatures are much closer to the room air temperature which could probably be set at 18º or 19ºC without any loss of comfort.

Solar Electricity
Solar electricity is another passive solar system, collecting light from the sun and converting it to electricity. Using the grid as a store overcomes the problem of providing electricity at night when the sun is not shining. An inverter changes the direct current (DC) from the panels to alternating current (AC) making it compatible with house wiring. Orient the panels to the north, tilted (35º in Hobart) in order to maximise the amount generated over 12 months (Fig 10). The power is supplied to the house with the surplus exported directly to the grid and additional needs imported from the grid. If there is a surplus of export over import the supply authority will credit you for that surplus. (Fig. 11) Solar electricity produces no carbon dioxide, is quiet, clean and above all sustainable.

Sizing and Energy Conservation
The system you install depends on the amount of power you use, the subsidies on offer and your budget. Aim for a minimum 2kW system. Solar panels are modular so you can start small and increase over time. If you do this then size the inverter for the capacity of the eventual system. Buy the most efficient panels available at a price which is to be avoided. Too high a heat gradient and the body loses heat by radiation to the colder surfaces and is bathed in cold convective currents from windows. Turning up the temperature is futile. When walls floors and windows are well insulated their surface temperatures are much closer to the room air temperature which could probably be set at 18º or 19ºC without any loss of comfort.

Further Information
This pamphlet, one of the Solar Design Series for cool temperate climates, is produced by the Tasmanian branch of the Australian Solar Energy Society which may be contacted at www.auses.org.au It is supported with a Hobart City Council, Dr Edward Hall Environment Grant.


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