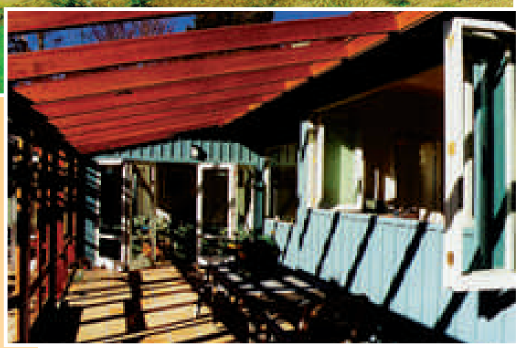
energy-wise Renewables
Energy Efficiency and Conservation Authority

Passive Solar Design for New Zealand Homes

1. Waitakere City Council's Ecohouse



2. Lambourne Architects, Auckland

Photo 2

The insulated concrete floor slab of the conservatory collects heat and stores it for release into the house later when the sun goes down.

In summer, sunshades keep the harsh sun from overheating the space.

The concept

Passive solar construction is a very attractive design philosophy as not only does it save energy, but it also reduces dampness and condensation, improves sound insulation, increases the durability of building materials and makes the home healthier. Passive solar construction uses the sun to warm the house. Heat is absorbed into the building and slowly released back into the house as it cools. Solar heating can be the sole source of warmth or can be supplemented by other sources. Consequently passive solar design has the potential to reduce New Zealand's greenhouse gas emissions.

Houses consume nearly 35% of the total electricity generated in New Zealand. Unfortunately the majority of New Zealand houses do not use energy efficiently. Space and water heating are the predominant uses of energy in a home, and energy savings in these areas are easily achieved (see EECA for further information). This leaflet introduces the principles of passive solar design for space heating in houses. Solar water heating is covered in the EECA information sheet "Energy Wise Renewables - 1".

Hot summers and cold winters are a challenging combination for solar buildings, and attention needs to be paid to both summer and winter conditions. Chilly weather conditions can be warmed with correct window design to admit as much solar heat as possible, the right materials to store as much heat as possible and plenty of insulation to conserve heat. A home can be kept cool in summer without the need for air-conditioning, by correct placement of shading, ventilation and insulation (although flexibility needs to be built into systems to allow for unusual weather conditions, eg hot winters or cool summers). These basic principles can produce year-round comfort in your home for little cost and can be applied to existing houses as well as renovations. The initial extra cost (if any) is paid back over time in savings on energy costs.

The issues

Since solar energy is free, why aren't many more homes in New Zealand designed to use passive solar principles to provide space heating?

All New Zealand homes are heated by the sun. Some are just better at using the sun than others. Passive solar design is basically optimising the heating effects of the sun while ensuring the house is well insulated.

Your builder or architect should be advised of your interest in passive solar design features so they can incorporate various options in your design quotes.

The most important feature of a solar house is good insulation.

The second most important feature is to ensure that the principal windows face the sun.

Lastly, considering how to store solar heat (in heavy thermal mass materials) while maintaining a balance of heating and cooling throughout the house, is crucial.

Passive solar designed buildings can be low tech and need not cost any more than standard construction. Leading edge technologies such as specialist window treatment films, automatic window controls or computer-aided design can be used but these are not essential to capture the age-old virtues of free solar heat. Once the correct principles are embodied in a house, little ongoing effort is required to achieve thermal comfort all year round.

The solar house needs to be considered as a holistic package, with all factors such as the site's microclimate, orientation, landscaping, external shading and shelter, internal planning, placement and size of windows, insulation and building form and thermal storage integrated. Careful design can maximise the use of the site's potential. Failing to attend to one area may compromise the comfort and energy efficiency of the whole design.

Site planning and orientation

Ideally the site will have a northerly aspect with the house elongated along the east/west axis. The house should be located and orientated so that winter sun is unobstructed but exterior shading restricts the summer sun. Obstacles to the north of the solar home, such as other buildings, fences or evergreen trees should be located away from the solar house by twice the height of the obstacle to prevent shading of valuable winter sun. It is often desirable to locate deciduous trees closer to help prevent summer overheating. Sites with hills or a slope rising to the north will not receive as much solar heat, but will still benefit from other solar design principles such as increased insulation levels.

The wind patterns of the region and the microclimate specific to the site should be examined. Cold winds can be buffered or deflected by strategic positioning of dense trees or unoccupied structures such as garages. Similar devices can be used to deflect hot summer winds, while cooling summer breezes should be funnelled through the house with landscaping features and building form. Also low inlets and high outlets on the house will assist natural ventilation.

Collecting solar heat

New Zealand's climate, luckily, has a high proportion of winter sunshine hours. Even the cooler regions can make use of free solar heating. The South Island, which has the greatest energy need for space heating, is fortunate to have frequent clear winter skies. Direct sunlight is much more effective than overcast skies for warming the mass of the house.

It is fundamental that the main living areas should be on the north, sunny side of the house. The windows in these living areas are most useful if they are orientated within 20 degrees of due north. Due north is actually to the west of compass north by approximately 20 degrees. Rooms which require early morning heating or afternoon coolness, eg the kitchen, should be orientated to the east, while spaces which are occupied in the evening should be located to the west. Storage rooms, bathrooms, laundry and carparking that require less heating, should be located in the southern low sun zone. Urban settings may require a more complex response to achieve maximum gains when optimum orientation is not possible.

West-facing windows can cause late afternoon overheating at any time of the year. They should be shaded on the outside of the home in summer. Easterly windows help early morning warming and can be a little larger than westerly windows. South-

Figure 1: Seasonal paths of the sun and the cast of shadows

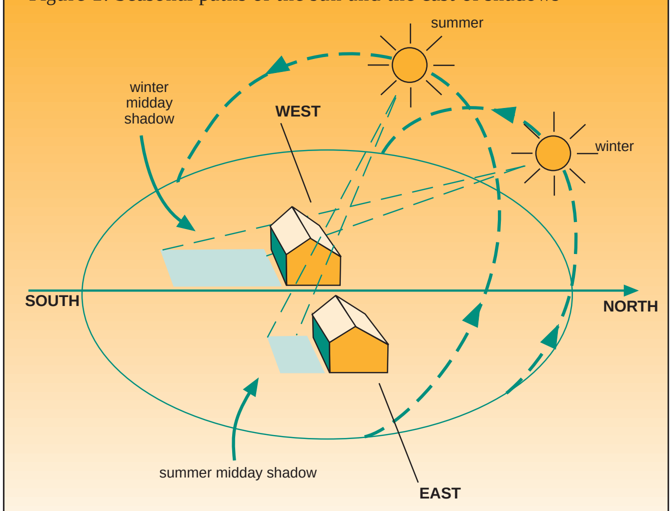
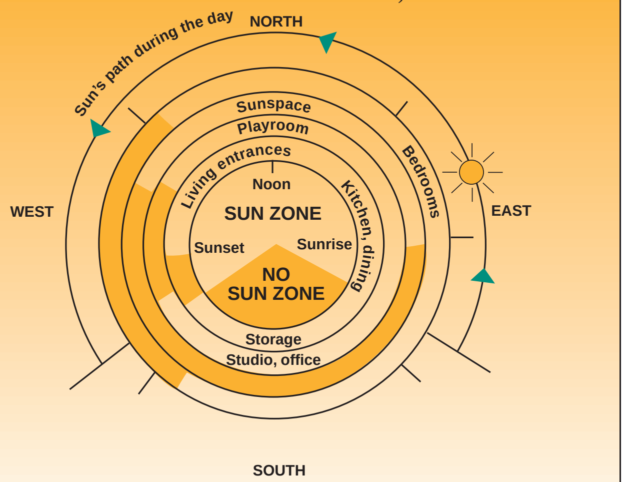


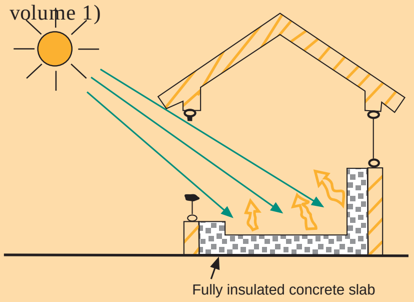
Figure 2: Ideal orientation of rooms for solar heating (adapted from David Pearson's 'The New Natural House Book')



facing glazing should be kept to the minimum required for ventilation.

Reasonably large areas of northern glazing (windows/skylights) are required to collect solar heat in winter. Optimum levels of glazing for solar houses are no larger in area than is normally found in New Zealand houses. It is very important that the total area of northern windows is balanced with the amount of thermal mass available to absorb the heat. Windows on the east and west are part of the total balance of solar gains and can help in colder climates. This can make up for a shortage of north glazing.

Figure 3: Direct solar heat gain and storage (from 'Design for the Sun' Working Manual volume 1)



Colder climates need larger areas of glass for solar collection. Shading of the north facing windows is generally required to prevent summer overheating.

Storing solar heat

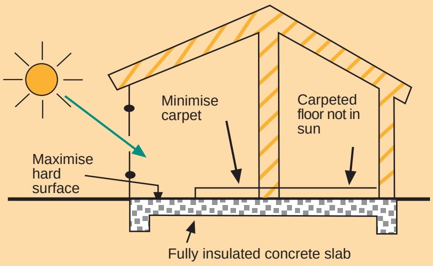
Heavyweight materials, such as concrete, terracotta or ceramic tiles and brick, can absorb solar heat during the day if they are exposed to direct sunlight. At night when the interior temperature drops, the stored heat is released back into the room. They act like a rechargeable battery for storing heat.

Thermal mass is most effective if it is located within the insulated north-facing area of the home. Thermal mass can be incorporated into any surface of the home but it is twice as effective if it receives direct sun rather than diffused rays. Exposing thermal mass products to heated air but not direct sunlight has little value in storing solar heat and should be minimised. Thermal mass that is located on an exterior surface should be insulated to prevent heat escaping directly to the outdoors.

Given that many modern homes have a concrete floor slab (ideally fully insulated), it is very economical to design a house so that the concrete slab is exposed to direct solar heat within the northern areas. Heavy mass materials, such as terracotta tiles, can be used to finish the slab without inhibiting the heat transfer process. Carpeting or covering the thermal mass with other non-dense materials will reduce the effectiveness of heat collection. Textile floor coverings should be restricted to parts of the building which are not being used for solar heat storage.

'Thermal mass' can be walls as well as floors. If a thermal mass wall is an outside wall it should be insulated on the outside to stop the heat escaping. The trick with this type of wall is to find ways for the sun to heat the wall inside the heat trap created by the insulation.

Figure 4: Exposing the thermal mass to the sun's heat (from 'Design for the Sun' Working Manual volume 1)



The balance between window area and placement and thermal mass is fundamental to effective solar design. Too much mass will make the house difficult to warm up while insufficient mass or solar admittance will reduce comfort and energy savings.

Conserving solar heat

Increased insulation diminishes the escape of interior heat in winter and heat gain in summer. It provides increased thermal comfort for occupants close to an external wall, as they are not radiating their body heat to a cold surface, hence they will feel warm at cooler air temperatures. Increasing the level of insulation is a good investment as it will also prevent the formation of condensation and the degradation of building materials. Current building codes specify only a minimum level of insulation that may be less than the optimum for heat conservation. Installing insulation above the building code requirements is beneficial, especially in colder climates.

A lot of heat can leak out through even small gaps in insulation, so care needs to be taken to properly insulate all parts of the building envelope. Squashing insulation around structural components or building services or leaving gaps can seriously compromise the whole insulation scheme. Most insulation loses its effectiveness if it gets wet and complete replacement should be considered. In addition it is important in an energy efficient home that unwanted air leakage is minimised through draught-stopping and floor insulation.

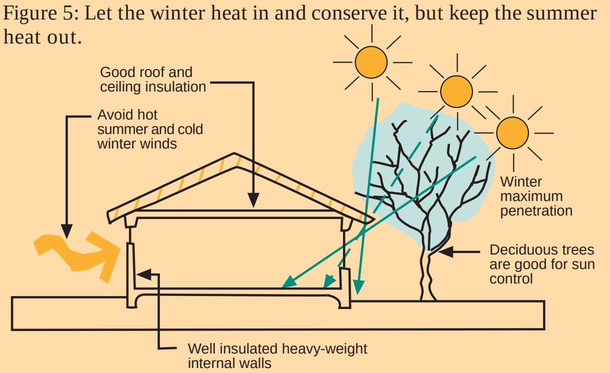
Windows should also be insulated. The heat loss through uninsulated glazing can be ten times as much as through a wall with average insulation. Double glazed windows will reduce heat loss through windows in winter by nearly 50% and reduce the heat gain in summer by 10%. They have additional advantages of eliminating condensation and noise intrusion. They can be relatively costly, however they can be only a small additional cost in a new home. Heavy curtains, which are fitted with a pelmet and overlap the surrounding wall by 10cm, are an alternative method of insulating windows. In addition, the energy efficiency of the whole window can be enhanced by using modern, well designed window frames that minimise heat loss.

Avoiding overheating

It is important not to have too much glazing on the east and, to a lesser extent, the west sides of the house. Windows need to be shaded in summer, with wide eaves, verandahs or deciduous plants. A grapevine or wisteria grown over a pergola is an attractive solution that is most effective for shading north-facing walls. Vertical shading, such as louvres or tall trees, is more efficient for shading western and eastern walls than overhangs. However, it should be noted that even bare, deciduous trees or vines can shade 20-30% of the sun.

Windows and doors should be located and opened in the direction of the prevailing summer breeze. Locating another opening on an opposite wall will help to bring cooling breezes through the house. In very warm areas, roof vents, opening clerestorey windows and ceiling fans can help remove excess heat. Skylights can also improve solar gain and, when opened, improve ventilation.

Figure 5: Let the winter heat in and conserve it, but keep the summer heat out.



Conservatories can be effective for collecting heat for other areas of the home, but they need careful planning. To maintain comfort in summer a conservatory needs exterior shading, exposed brick, tile or other heavy mass flooring and plenty of openings for ventilation, preferably at both a low and a high level. In winter, conservatories can overheat during the day and freeze at night. If they have exposed thermal mass, and insulation to conserve heat, they can be made to work well. During winter, warm air from a correctly designed conservatory can provide much of the heating requirements for the rest of the home. The cost of conservatories can be high but if they provide other amenities (such as an indoor/outdoor living space) as well as being designed for solar heating, they can be an option worth considering.

Environmental impacts

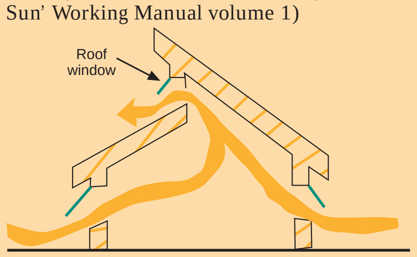
New Zealand's temperate climate has an abundance of free, non-polluting radiant heat supplied by the sun, waiting to be collected with the correct building design. Passive solar design has no known negative environmental consequences beyond those associated with building a standard house. It only has benefits. It does not contribute directly to emissions of CO_2 or other climate changing gases. It can help to lower the total production of CO_2 if utilised as an alternative to other CO_2 producing energy sources.

The cost

Passive solar design is easiest, and cheapest, to incorporate during new construction. Some buildings are easier to retrofit than others. However measures to increase the use of solar heat and thermal performance, such as increasing insulation of roofs, floors, and windows can be retrofitted to most buildings.

The cost of measures such as double glazing and the building of conservatories can be high when judged purely as a mechanism to capture and store heat. However other benefits and amenities may result and these need to be part of the cost-effectiveness assessment.

Figure 6: Controlling ventilation for summer cooling and fresh air (from 'Design for the Sun' Working Manual volume 1)



The cost of adding passive solar design into a home is highly variable, depending on the site, size of house, construction materials used and many other factors. These factors obviously affect the payback period and make generalisations difficult. However, as the average life of a New Zealand house is 80 years, the additional cost will be saved many times over during the life of the building.

For Further Information

1) Design for the Sun, Residential Design Guidelines for New Zealand, Volumes 1 and 2, EECA 1994, $50.

2) New Zealand Institute of Architects has available a list of its members, by region, identifying those who offer the specialist service of 'Green Architecture'.

New Zealand Institute of Architects National Office, PO Box 2516, Auckland, New Zealand
Phone: 0-9-623 6080 • Facsimile: 0-9-623 6081
Email: info@nzia.co.nz
Web page: http://www.nzia.co.nz/contacts/index.htm

3) Sustainable Home Guidelines, a folder of New Zealand information covering energy, water and materials is available for $35 from the Waitakere City Council, Private Bag 93109, Henderson, Waitakere City. Email: Info@waitakere.govt.nz Facsimile 0-9-836 8001.

4) The New Natural House Book, David Pearson, Harper Collins Publishers 1989.

5) Green Architecture - Design for a Sustainable Future, Brenda and Robert Vale, Thames and Hudson, 1991.

6) Sustainable House, Michael Mobbs, University of Otago Press, 1998.

7) Building Research Association of New Zealand, ALF3 manual, also see the Greenhome Scheme - A design guide for new homes.
BRANZ, Private Bag 50908, Porirua City Phone: 0-4-235 7600 • Facsimile: 0-4-235 6070
http://www.branz.org.nz/branz/news/Greenhome/greenhouse.htm/

8) New Zealand Standard. Energy Efficiency - Housing and small building envelope. NZS 4218:1996.

9) The Passive Solar Energy Book, Ed Mazria, Rodale Press, 1979.

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