DESIGN RIGHT

Back to solar design basics

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Developers subdividing land and owners commissioning new homes have one chance to get the basic solar design principles right. Siting and designing new dwellings can be done cost-effectively and will substantially increase performance over a dwelling's lifetime.

WHEN I BEGAN my study towards an architectural degree at Victoria University in the 1980s, an initial goal was to learn as much as possible about energy-efficient design and building. This was in anticipation of what I thought would become one of the primary factors driving the construction industry during my career.

Passive solar houses around since the 1920s

Fuelled by writing such as Christopher Alexander's *The timeless way of building*, I was hungry to learn about the harmonisation of the buildings and the natural environment they would be created in. It seemed obvious that there would be a powerful synergy when the two were in step, but exactly how much I wasn't so sure.

Some of the first modern-era passive solar houses appeared in Germany in the 1920s, but with mixed results. Interest grew through the counterculture 1960s and 1970s, and the theory had consolidated around a few first-principle design ideas by the 1980s. The main passive solar design emphases I was first taught were location and orientation, thermal mass, insulation, efficiency of plan design and ventilation.

NOW Home set new standards

By the turn of the century, these principles were fast becoming entrenched in the minds of Kiwi designers – sometimes with a little help from government legislation. It was the Waitakere NOW Home, however, built by Beacon Pathway in 2005 and continuously monitored after construction, that put these theories to the test.

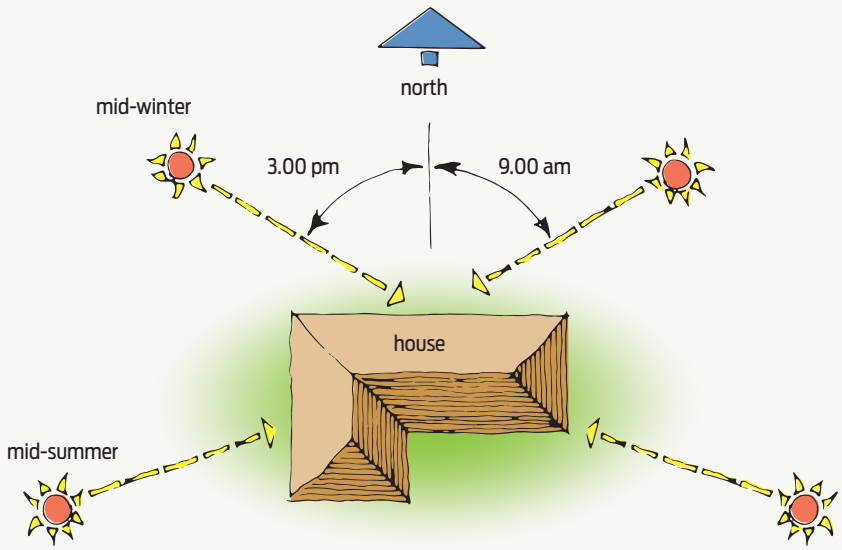

Figure 1 **Azimuth angles (mid-winter and mid-summer).**

This dwelling was a relatively modest straightforward structure but with many passive solar design features incorporated.

Subsequent BRANZ studies have established that, even over a decade later, almost all randomly selected comparable new-build houses fail to match the energy performance statistics and passive comfort levels of the eco-consciously designed NOW Home.

Passive solar design principles

Incorporating passive solar design principles in new dwellings can increase these performance statistics, often with very small and sometimes zero cost implications.

The principles of passive solar design usually require more thought and planning than expensive physical construction features. They include:

- site location and orientation
- building location and orientation
- a compact floor plan
- incorporating thermal mass
- insulation to all external interfaces
- glazing selection
- passive ventilation and shading.

Site location and orientation

Site orientation is critical. An ideal site will receive good solar access throughout the year. Aspects to consider include the local sun path – summer and winter (see Figure 1), the site's shape, any slope and

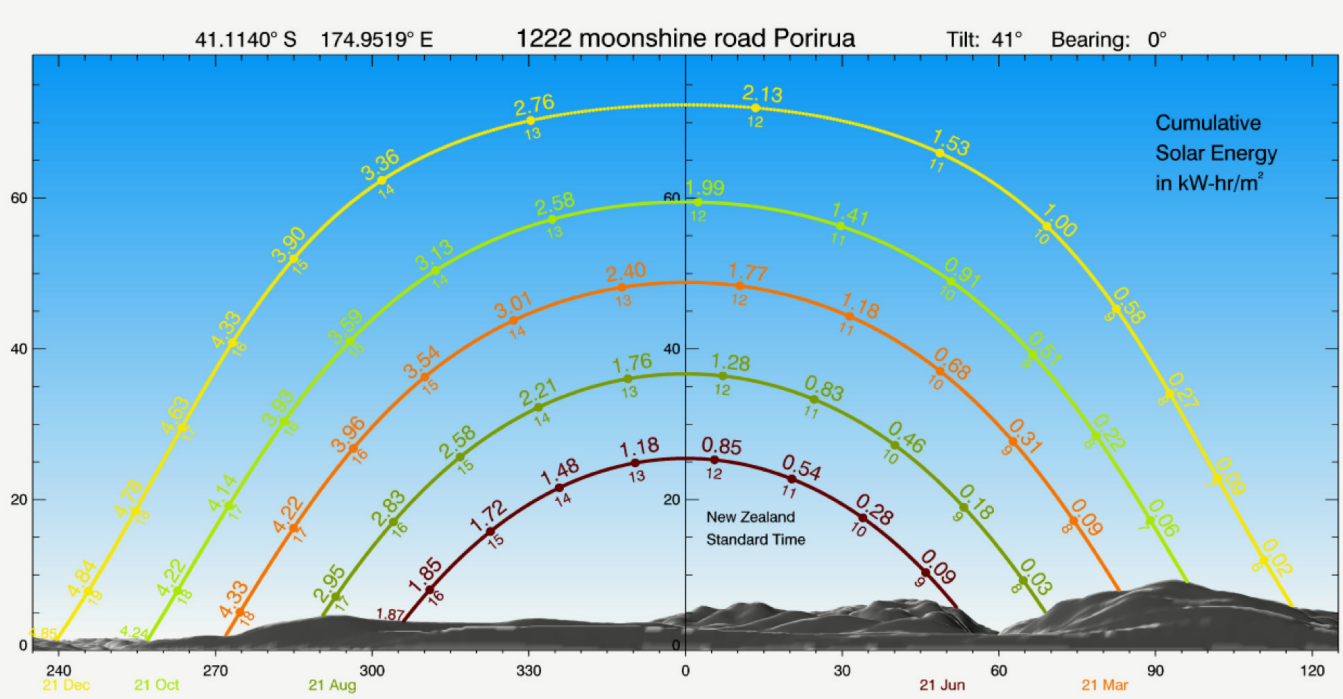

Figure 2 **Sample output from NIWA SolarView tool.**

obstructions such as neighbouring buildings, hills and trees that may affect the sun's access.

A detailed solar site analysis should be undertaken by experienced design professionals (see Figure 2). However, a rough initial evaluation of a site's potential can be established by a lay person with a compass and looking at different sites at various dates and times.

Building location and orientation

The building's location on the site is another crucial decision. The priority for passive heating or passive cooling will vary over different regions of the country, so there is no one best solution – all optimums will be site specific.

For passive heating, the main living and outdoor areas should face within 20º of north, while passive cooling should aim to exclude midday sun and enable cross-flow air movement within the building. While building close to the south boundary will maximise solar gain, consider the effects of overshadowing on the adjacent neighbour.

Consider also the space for outdoor living such as sun, shelter and privacy and any vehicular access and garaging. If possible, these should not compromise the solar attributes of the property – the best of which should enhance the lifestyle of the occupants.

Compact floor plan

A compact floor plan will provide the best start for an efficient passive solar house design. The ratio of net floor area to perimeter wall length should be maximised, and a relatively simple rectangular footprint often helps achieve the optimum ratio.

Another built-in efficiency gain can be achieved by using the discipline of a fixed grid (for example 1.2 m) to simplify the floor plan and minimise both internal heat loss and the per square metre construction cost for the new dwelling.

Outdoor living spaces, such as decks and courtyards, are an often overlooked but important part of passive design. They enable relatively low-cost extensions to living spaces, usable when conditions are suitable, that provide no demand on the performance of the building proper.

Thermal mass

Thermal mass is the ability of a material to store heat energy and release this heat slowly as the surrounding temperature falls, effectively temperature smoothing the interior spaces. High-density materials such as concrete, bricks and stone are the most suitable.

The simplest thermal mass has traditionally been concrete floors, and to a lesser extent Trombe walls, heated via solar gain through adjacent northern-facing glazing. Decor fashions, especially in the volume build sector, have latterly seen polished concrete floors superseded by ➤

overlay timber flooring systems, carpet or tiles. Except for the use of floor tiles, the other options negate the thermal mass function of the concrete slab, but this remains a handy option in the passive design toolbox and is still often used in bespoke homes.

When thermal mass is not an option, the designer can utilise higher specified and more sophisticated insulation options to compensate.

Insulation

Insulation to all external interfaces of the dwelling is paramount. If an effort has been made to harvest the free warmth via solar gain, we must slow the loss of that heat to the exterior to keep the house warm in winter. In summer, insulation reduces heat gain from high summer temperatures to keep the house cool.

Good insulation and incorporating passive design principles reduces the need for active space heating to a minimum, sometimes even zero.

Insulation must be continuous for all of the thermal envelope. Poorly installed insulation can dramatically decrease its effectiveness, and thermal bridges in the structure must be minimised.

Glazing

Part of addressing a building's overall insulation is addressing the weakest link – the windows. Glazed doors, windows and skylights will typically have the lowest R-value ratings in the thermal envelope of the building. Fortunately, the use of newer features such as insulating glass units (IGUs), low-E glazing and thermally broken frames is becoming more cost-effective as their use becomes more expected and hence more common.

Expert advice is needed to tailor the amount of solar radiation that is reflected, absorbed or transmitted through the glass – but all play a part in the passive solar performance of the dwelling.

It is primarily better thought and planning rather than expensive physical construction features that will deliver the best result.

If heat transmission through the glass is considered at the design stage of the project, window performance can be significantly improved at minimal conditional cost. Careful consideration of window size and orientation are also critical, and the use of well fitted thermal curtains or shutters at night helps the equation.

Passive ventilation and shading

Passive ventilation and shading are the final factors for consideration in any passive solar designed residence.

Passive ventilation is the supply and removal of indoor air via the building envelope using natural wind flow and temperature differentials within the building. It is the least expensive and most environmentally friendly way to ventilate a home, suiting most parts of New Zealand.

Along with cross-flow ventilation, a combination of low and high ventilation openings can utilise the stack effect to passively ventilate spaces, driven by temperature and pressure differentials within the building.

Hotter days increase need for passive solar design

More emphasis has been given to shading as part of passive solar design schemes in recent years, and cooling will become even more important as we live with warmer temperatures in the future. The trend for greater areas of glazing in new homes also means the emphasis on shading will continue to increase in importance. The role can be filled with carefully planned planting, extended roof overhangs and more sophisticated louvres and shade structures – adjustable or fixed.

Even with all the technical advancements in glazing, insulation and detailing and the improved understanding from scientific research, it is still the first principles I studied decades ago that have the biggest impact on the effectiveness of passive solar designed residential buildings.

Choose a designer who understands

The most important decision you may make is selecting an experienced designer familiar with the principles and practices of passive solar design. It is primarily better thought and planning rather than expensive physical construction features that will deliver the best result.

While this is a very general overview of passive solar design principles, there are many excellent texts published by BRANZ that are of enormous help when considering these matters. Also, there are many groups and organisations available to assist, including Passive House NZ, Eco Design Advisor, Beacon, Superhome and others.

For more **See BRANZ Facts Sustainable construction #1 *Passive solar design*. To find out more about the Beacon Pathway NOW Homes, see www.beaconpathway.co.nz.**