

# Passive House

*A Passive House is not necessarily a passive solar design*

Passive House is a voluntary design and construction concept developed in Germany in the early 1990s that delivers ultra energy efficient buildings. If Australia and New Zealand follow a path similar to Canada and the United States, we will be hearing much about Passive House in the next few years.

## Airtight

Passive House involves an airtight super insulated building envelope combined with a clever ventilation system that provides fresh outdoor air

BY ERIC ZEHRUNG

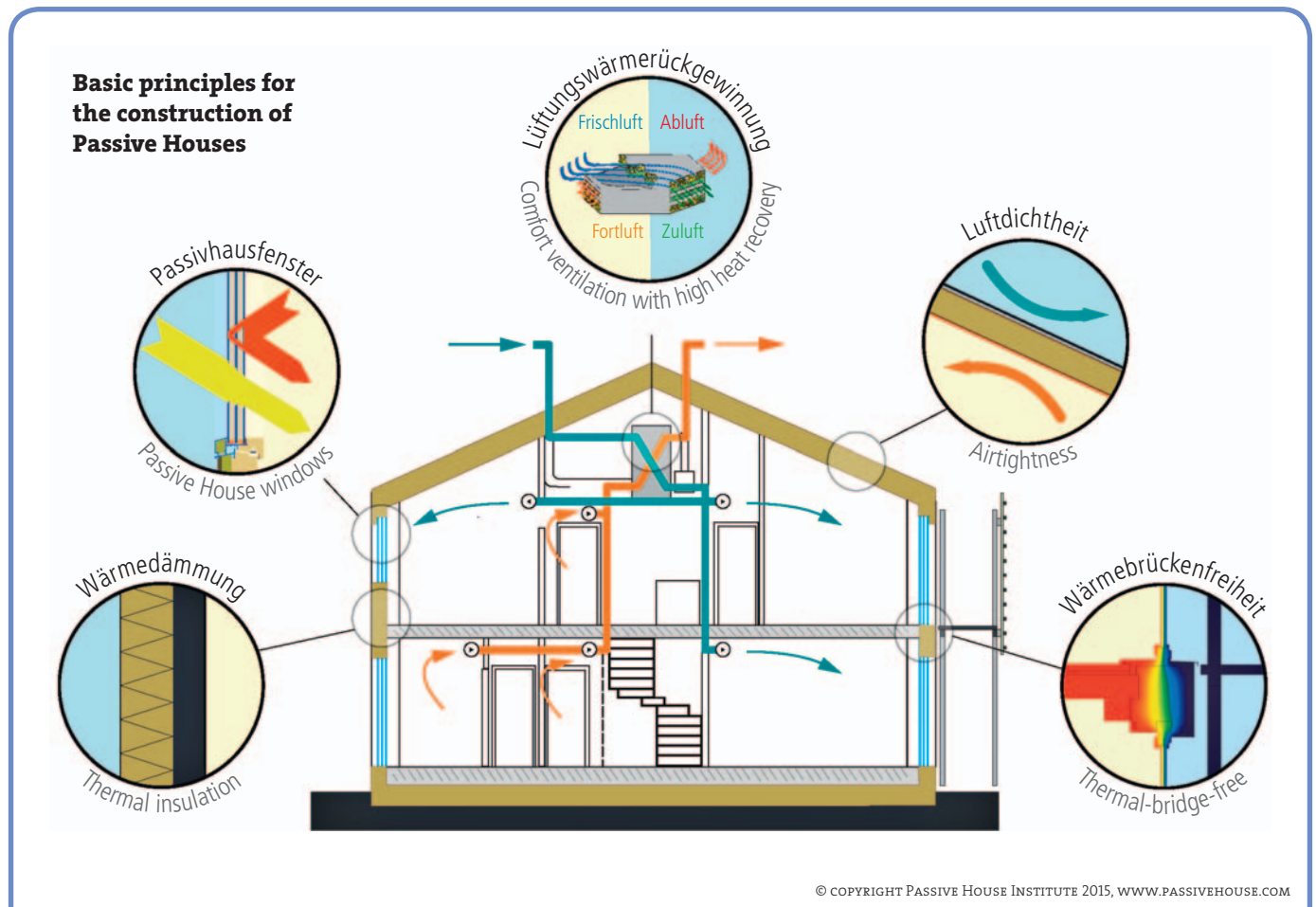
while recycling indoor temperatures. The buildings are designed to remain between 20–25 degrees Celsius and 40–60% humidity, using only a tiny amount of supplemental energy for heating and cooling. For example, a 200m<sup>2</sup> home is designed to be heated with a maximum of 2000 watts on the coldest day – the energy used by a common hair dryer.

In the northern European climates where Passive House was developed, the

primary demand is for space heating. In southern Australia, the demand is mixed between heating and cooling, and in the centre and north the demand is primarily cooling.

The approach is defensive in that we use a highly insulating skin then add a small amount of energy to create a comfortable indoor environment, retaining the conditions for as long as possible. It is not much different to standard energy efficient construction – it just takes the concept much, much further.

My first thought upon hearing about the Passive House approach was how



miserable I would feel on a beautiful spring day being sealed up in an airtight box. In such conditions, Passive House is nearly irrelevant. Go ahead and fling open the windows and enjoy the fresh air washing through the building!

Passive House becomes relevant once we wish to heat or cool the space. Most people would agree that we have a responsibility to use the resources sparingly and wisely, and Passive House construction results in a significant reduction of this use.

## What is Passive House?

Before describing what Passive House is, it is useful to explain what it is not.

Passive House is not synonymous with 'passive solar' although the concepts are entirely compatible.

The German term *Passivhaus* is somewhat unfortunate because it can lead people to think it is all about houses. 'Haus' refers to buildings in general. There are currently examples ranging from schools, skyscrapers, prisons, hotels, supermarkets and, of course, houses. There are Passive House certified buildings around the world in every climate zone from Arctic to tropical.

## Passive House criteria

Okay, let us get technical. In order for a building to be Passive House certified, it must be designed and constructed to meet the following:

### HEATING

- Maximum winter heating demand of 15 kilowatt-hours per square metre per year (kWh/m<sup>2</sup>/yr), or
- Maximum winter heat load of 10 watts per square metre.

### COOLING

- Temperatures exceeding 25 degrees centigrade for no more than 10% of the year, or
- Maximum summer cooling demand of 15 kilowatt-hours per square metre per year (kWh/m<sup>2</sup>/yr).

### PRIMARY ENERGY USE

- Maximum overall primary energy demand of 120 kilowatt-hours per square metre per year.

## AIRTIGHTNESS

- Pressure tested to a maximum of 0.6 air changes per hour when pressurised to 50 Pascals.

## VENTILATION SYSTEM

- 75% heat recovery
- Maximum electricity demand 0.45Wh per cubic metre of ventilated building volume.

There are a number of other criteria that must be achieved, but they will broadly be subsets of these.

In order to achieve the Passive House criteria, detailed modelling is undertaken at the design stage. Based on building physics, the outcomes are predictable, accurate and verifiable. The beauty of this approach is that design solutions can be compared and calculated early in the process, and the solution can be quantified in terms of tangible kilowatt-hours per year.

## Components

The primary components to consider are:

- Insulation
- Windows and doors
- Thermal bridging
- Airtightness
- Mechanical ventilation with heat recovery.

## INSULATION

There is typically more insulation in a Passive House than in a standard building. It is critical that the insulation layer is continuous around the walls, roof and floor with no gaps. Walls will likely be thicker than in a standard building. Any type of insulation can work provided that it meets the detailing and R-value requirements.

## WINDOWS AND DOORS

Windows are one of the biggest cost extras over a typical building. In Europe, most windows will be top shelf triple glazed units. In our more mild climate, good quality argon filled double glazed windows will likely work. Energy balances are calculated for each window to compare total solar heat gains with total transmission losses.

It is worth mentioning that the modelling calculations allow weaknesses in one area to be compensated for by

upgrading other areas. For example, if you want a large south-facing window to a terrific view, it is possible to compensate for the greater heat loss through windows by adding extra wall or roof insulation.

## THERMAL BRIDGING

A thermal bridge is an area of wall, floor or roof that has a significantly higher heat transfer than the surrounding materials, resulting in additional heat transfer. Thermal bridges occur wherever the insulation layer is interrupted. Examples include cantilevered balconies, sharp corners, or even at repeating timber studs. In addition to heat loss, thermal bridges can result in condensation and subsequent moisture damage. Careful detailing and great care must be taken to eliminate thermal bridges.

## AIRTIGHTNESS

While Passive House buildings are well supplied with fresh air via the mechanical ventilation system, the external envelope must be nearly airtight. The level of airtightness required by Passive House exceeds a standard building's level by a factor of 20 or more. Vapour control is often considered along with the airtight layer, and is critical in eliminating condensation risks.

In cool climates, the vapour control layer is normally located on the inner face. In humid climates, it is commonly located toward the outer face. Finally, the outer face must be protected with a continuous wind-tight membrane in order to obtain the full value of the thermal insulation.

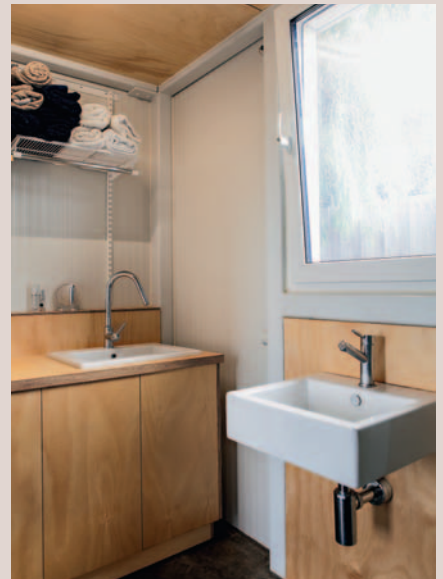
## MECHANICAL VENTILATION WITH HEAT RECOVERY

The heat recovery and ventilation (HRV) system is key to keeping the building comfortable for people. With such an efficient external envelope, the system can be small and run at a very low, gentle speed. It will provide eight or more air changes per day depending on the number of people and activity levels. The key to the system is the heat recovery.

In essence, while the incoming supply air and outgoing exhaust air never mix, they pass by each other through a system of small, alternating honeycomb type ducts that allows heat to transfer from one to the other. The system must be capable of transferring at least 75% of the heat to qualify for use in Passive House.



## SuperPod – an Australian Passive House project



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Cooling is fairly straightforward in climates with moderate levels of relative humidity. In warm, humid climates, cooling is much more energy intensive as the humidity must be lowered as well the air cooled. A variation on the HRV system called 'energy recovery and ventilation' (ERV) can help transfer heat as well as humidity between the incoming and outgoing air. Passive House allows for the extra cooling demand in humid climates. For example, the standard maximum allowable demand of 15 kWh/m<sup>2</sup>/yr for temperate southern areas is increased to 19 kWh/m<sup>2</sup>/yr in Brisbane and 61 kWh/m<sup>2</sup>/yr in Darwin.

### HEATING AND COOLING SYSTEM

It would be possible to design a building envelope with enough insulation to remain warm with only solar gains and other internal heat gains from people and appliances. However, the additional money and resources required to do so would not make economic sense. Instead, a modest amount of energy (up to 15 kWh/m<sup>2</sup>/yr) is deemed acceptable.

Any heating or cooling system is permissible. Sometimes a small heater is incorporated with the ventilation system. An independent system like a wood fire, electric split system and hydronic panels are all possible. The caveat is that the system will be much smaller than what we are accustomed to. For example, a single split system cassette or single hydronic panel normally used for each room might be suitable for the entire building.

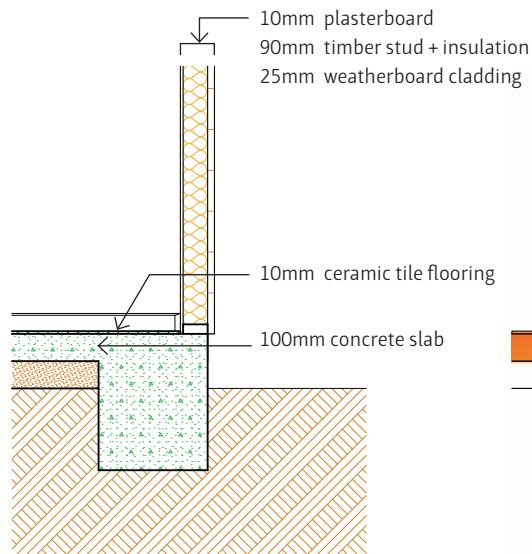
### Partial compliance

If you decide that constructing a building to the full Passive House standard is too onerous, it is recommended to ease off on all five elements in concert. For example, reduce the insulation levels slightly, downgrade the specs for the windows, and accept a less airtight construction in even portions.

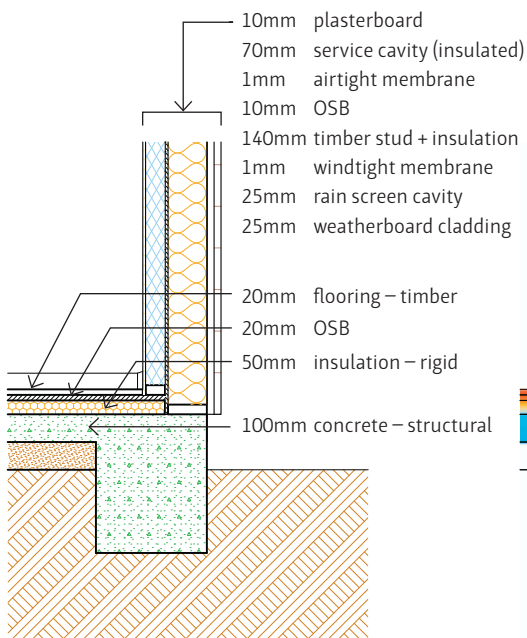
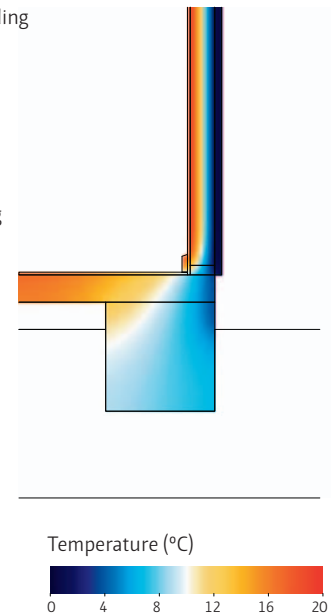
Changing one element on its own can lead to very serious problems. For example, constructing an excellent building envelope but omitting the ventilation system will lead to a stuffy and uncomfortable building. Retaining the high insulation levels but omitting the airtight layer and vapour control could lead to condensation and severe moisture damage inside the walls.

## Energy modelling to show heat transfer

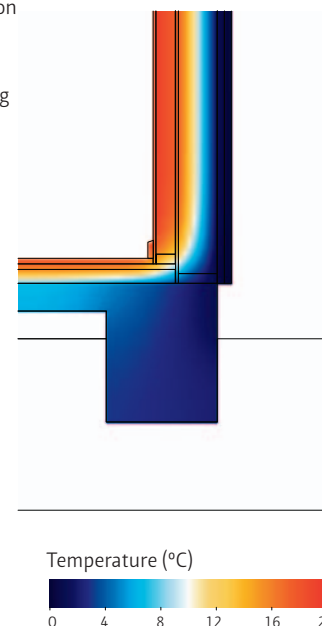
What we are looking for in energy modelling details are thicker bands of red on the inside and blue on the outside. This indicates less heat transfer through the building envelope.



**A common wall detail**



**Typical Passive House wall detail**





## Stages

### DESIGN

A Passive House can look like anything; there is no prescribed aesthetic. The same common sense issues arise as for any other building. For example, in cool southern areas, a compact form with windows facing the north is a good starting point. Once the design concept has been established, data can start to be entered into the Passive House Planning Package (PHPP).

The PHPP is essentially a very detailed Excel spreadsheet that addresses and calculates climate data, heat gains, heat losses etc. If any weak areas are detected, they can be fixed. The compliance data will eventually be submitted to an independent certifier to check for accuracy. This provides the designer with control to optimise the final design outcome.

### CONSTRUCTION

By the time construction starts, the key decisions will have been made. The wall assemblies and windows will have been selected and verified, and the thermal bridge free detailing will have been resolved. The biggest worry at this stage will be airtightness. While a membrane system will have been nominated, its installation must be done with extreme care. Every gap or penetration must be sealed with a proprietary tape. To picture the level of detail this requires, imagine that the sum of all gaps in the external envelope can be about the size of a credit card. Independent blower door tests are conducted several times.

### CERTIFICATION

In Europe, Passive House construction is commonplace enough that only a fraction go through certification. It requires submitting the construction details and PHPP data for assessment, photo records of construction details, and the blower door test results. There is also a fee of \$3000–4000. The benefits of being certified are an assurance that the building was designed and constructed to the standard and will perform accordingly.

### OCCUPATION

Once the building is completed, it is yours to use as you wish. A common question is whether windows can be opened or the heater turned up. Of course they can, and the way a building is used is up to the owner. Even though

the calculations are based on an indoor temperature of 20 degrees C, if the occupant decides to run it at 18 degrees or 22 degrees, it is entirely their choice. They will just use a little less or a little more energy.

## Economics

It is possible to predict the financial outcome of building to the Passive House standard using a calculation method called 'present value.' This compares the additional building costs with the annual savings in energy bills over a period of time, say a 20–25 year mortgage. In Europe in the early days, Passive House construction had a 15% premium over standard buildings. It has dropped to about 5% as Passive House becomes more commonplace. Here in Australia, it is too early to tell what the additional costs will be. As with many new ideas, the early adopters will most likely factor in a degree of enthusiasm and good will along with the financial return.

## Comparison with other standards

The landscape of sustainability standards is crowded. Standards like GreenStar and LEED (Leadership in Energy and Environmental Design) deal with a broad range of criteria like transport, embodied energy, water efficiency along with energy efficiency. The Passive House approach was to focus exclusively on energy and indoor air quality and take them to extreme levels. It is entirely possible to combine Passive House with other ideas. For example, some people in the US have combined Passive House with LEED to create near zero-energy buildings.

Residential buildings in Australia are assessed with star rating software. Passive House and star ratings both consider building volume, orientation, glazing and insulation. Star ratings do not consider airtightness or thermal bridging in much detail. It is also useful to see tangible information like kilowatt-hours per year, which is easily converted to \$/year.

## Other Passive House standards

Renovations are certified using a slightly lower standard called *EnerPHit*. Each of the criteria is relaxed a little

to take into account the extra cost in retrofitting existing structures.

New buildings can also be certified as Passive House Plus or Passive House Premium, which takes into account varying levels of renewable energy generation.

Europe has taken to the Passive House standard and is incorporating it with an overall approach to reducing greenhouse gases. By 2020, the building codes across Europe will be aligning with the Passive House standards. While Australia is comparatively behind with our energy efficiency technology and regulation, this is an exciting time to be involved in the building industry. The next few years promise to bring some inspiring developments. ♦

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## Links & resources

### ♦ Green Point Design

Creating sustainable architecture by giving careful thought to how you live.

03 5338 8260

[www.greenpointdesign.com.au](http://www.greenpointdesign.com.au)

### ♦ Australian Passive House Association

An independent, not-for-profit organisation that aims to promote and support Passive House principles.

[www.passivehouseaustralia.org](http://www.passivehouseaustralia.org)

### ♦ Passive House Institute

An independent research institute that has played a crucial role in the development of the Passive House concept.

[www.passivehouse.com](http://www.passivehouse.com)

### ♦ Passipedia

A vast resource of Passive House relevant articles.

[www.passipedia.org](http://www.passipedia.org)

### ♦ How to build a Passive House

The UK Passivehaus knowledge base

[www.howtopassivhaus.org.uk](http://www.howtopassivhaus.org.uk)

### ♦ Superpod

Clean, uncluttered, easy living – low energy, sustainable, high quality materials, healthy filtered air and comfortable temperatures.

[www.superpodhome.com](http://www.superpodhome.com)