Passive House – It's Happening Now in Australia

Part 2 of a two-part feature by Susan Morris Teacher – Advanced Diploma of Building Design (Architectural), Box Hill Institute

Buildings are responsible for 40% of energy use globally, with a large part of this attributed to the residential sector. Proven technologies and knowledge exist to reduce energy use by buildings. The Passive House Standard (translated from German 'Passivhaus') is one of these methodologies and results in ultra-low energy buildings. The standard originated in Germany in 1991 and is used across Europe where there are now more than 20,000 examples. The concept is appropriate for all climates. Passive House buildings' individual characteristics are optimised for local climatic conditions. In hotter climates, more emphasis is placed on passive shading of windows to enable comfort in summer. Passive House buildings can be found in the United Kingdom, North and South America, Africa and Asia.

The Passive House Standard is not a regulation, but a methodology and certification system for creating very thermally efficient buildings. Passive House design principles can be applied not only to the residential sector but also to commercial, industrial and public buildings. Passive House buildings allow for space heating and cooling-related energy savings of up to 90% compared with typical building stock and over 75% compared to average new builds.

Passive House Refurbishment in Australia

Internationally, as in Australia, an enormous percentage of existing building stock has very poor energy efficiency. In 2011, the Passivhaus Institute introduced a retrofit standard called EnerPHit, which defines the parameters for upgrading existing buildings to the Passive House standard. The energy consumption of old buildings can't usually be brought to the level of new-build Passive House standard, because some unavoidable thermal bridges may remain, and achieving airtightness can be problematic in inaccessible areas. For these reasons, the space heat demand and airtightness requirements are less stringent for Passive House refurbishments, but still challenging to meet.

For a user- friendly explanation of Passive House principles:
http://www.passivehouse.com/02_informations/03_informational-brochure/03_informational-brochure.htm

Australian Passive House Association:
http://passivehouseaustralia.org/

Passive House Database of certified buildings: search under 'Australia' for information about our first six Passive Houses:
http://www.passivhausprojekte.de/index.php?lang=en#s

This year marks the first Passive House refurbishment in Australia, with a picturesque villa in the Adelaide Hills undergoing an intensive upgrade. The owners, being passionate about sustainability, had previously installed a 10 kW Photovoltaic system and also geothermal heating and cooling. Their priority now is thermal comfort and energy efficiency and they have enlisted Bernward Bücheler of Passivhaus Australia to undertake a Passive House refurbishment.

1950s Villa in the Adelaide Hills – Photo by author

10kW photovoltaic solar array – Photo courtesy of owner

This 1950s villa is located on a steep slope with magnificent views and is subject to intense winds and temperature extremes. The traditional timber, single-glazed windows provided poor thermal comfort and also weathered quickly, due to exposure. The original construction is external stone and a combination of brickwork and timber framing internally. Creative insulation treatments externally and internally were required to preserve the aesthetics of the stonework and to ensure that air-tightness could be addressed. Existing thermal bridges needed to be eliminated or reduced. Stina Nygern, structural engineer and Passive House designer, is fortunately very slim and nimble. She was able to crawl through complex cavities between floors and within ducts and the roof spaces, to analyse the most effective methods to insulate and seal the building.

EnerPHit Passive House Refurbishment standard

To achieve the certification requirements for a certified Passive House Refurbishment, the space heating demand must not be more than 25kWh/m^2 of living space per year. In situations (warmer climates) when active cooling is required to ensure comfort in summer, the energy demand is also limited to 25kWh/(m^{2}yr). The building must be tested with an independently administered pressure test (blower door test) to confirm the building has an air-tightness n_{50} value of less than 1.0 air changes per hour (ACH). The primary energy requirement for the total amount of domestic hot water, heating, cooling, auxiliary and household electricity must not exceed 120kWh/(m^{2}yr).

View of construction works – Photo courtesy of building owner

Bernward Bücheler and Stina Nygern are not only well-versed in Passive House principles but also building biology. Careful material and equipment selection has been important in their processes, to deliver both excellent indoor air quality and superior acoustics.

Gutex, made from compressed wood fibre pulp, is used in thicknesses up to 140mm (80mm + 60mm) to provide insulation. It also achieves superior summer performance due to its high thermal storage capacity. Externally Gutex is rendered, while internal Gutex surfaces are hard-plastered. "Finding the right trades and then training tradespeople to understand the importance of airtightness has been essential to the success of the project," says Bücheler.

Bücheler has built demonstration stations in his Macclesfield office, to enable clients to compare insulation materials for both thermal resistance and acoustic performance. Speakers located within the insulated boxes enable audio comparisons to be made. There was a dramatic improvement in sound reduction with the compressed wood fibre pulp product compared to conventional fibre insulation and polystyrene. Although

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R-values for the three comparison materials are similar, the superior heat storage capacity of the timber product was demonstrated effectively.

Acoustic comparison of materials – Photo by author

Thermal comparison of materials – Photo by author

High performance double glazed windows – Photo by author

External application of wall insulation – Photo by author

A combination of external and internal wall insulation was required, with external insulation applied between the first and second floor to reduce heat loss and thermal bridges.

Internal compressed wood fibre pulp insulation – Photo courtesy of building owner

Installation of air-tightness layer – Photo courtesy of building owner

The air-tightness layer is achieved using Intello vapour check and Siga tape, with careful treatment of all penetrations including wiring and ducts to eliminate air leakage. In many areas, hard plaster has been used to achieve the air-tight layer and this not-so-common trade has been effectively handled by local tradespeople. Internal wall insulation detailing for 500mm back from internal corners is installed, to reduce thermal bridges.

Internal insulation detailing to reduce thermal bridges – Photo courtesy of building owner

"In a leaky building, air infiltration can account for as much as 50% of the heating and air conditioning loads, and accounts for most of the discomfort due to draughts or excessive heat gains," says Clare Parry of Grün Consulting. Australian houses built before 2000 typically have airtightness of around 10 air changes per hour (ACH) with many homes up to 25 ACH. This figure is measured by pressurising and depressurising a building to 50 Pa using a blower-door test. The new build Passive House standard of 0.6 ACH is roughly 15 to 40 times better than Australian current practice.

A first run at blower-door pressure testing for the villa resulted in an air-tightness n50 value of 1.7 air changes per hour and, as work continues, an improvement is expected. An n50 value less than 1.0 ACH is required to achieve the Passive House Refurbishment standard. Although the requirements for achieving a certified refurbishment are not as stringent as for new build projects, they are still challenging to meet. Some areas of most existing buildings are difficult to get to without dismantling the structure.

Blower door testing – Photo courtesy of building owner

Mechanical heat recovery ventilation system – Photo courtesy of building owner

The large house, with an independent living area at ground level, is ventilated with two high performance Zehnder mechanical heat recovery ventilation units. Individual ducts to every room have been installed to eliminate sound transfer between rooms and achieve the quietest performance.

The villa, which is located in a windswept location, has been transformed from a noisy, draughty environment to a place with exceptionally quiet interior spaces.

The owners are extremely positive about their passive house refurbishment and commented: "The Passivhaus refurbishment of our family home has made it significantly more comfortable in winter and summer. The amount of time that the geothermal system needs to be on is substantially reduced; the inside temperature of the house is maintained for a long time after the system is cycled off, due to the better sealing, heat recovery ventilation (HRV), and insulation. The air inside the home is also noticeably fresher than before, also due to the HRV system. We have noticed a lack of draughts throughout the house, and a generally even temperature upstairs and downstairs that was not experienced prior to the refurbishment."

All the character of this spectacular villa has been retained, with improved energy efficiency, thermal comfort, acoustic performance and indoor air quality. The combination of Passive House principles, solar generation and the geothermal heating /cooling system are likely to achieve a Net Zero or Nearly Zero home.

If you are interested in finding more information about this project, contact Bernward Bücheler of Passivhaus Australia. Passivhaus Australia works Australia-wide and has just finished the design for a Passive House in cross-laminated timber and Glulam in Gippsland, Victoria, which will be built this year, as well as the design for a Passive House refurbishment in Sydney.

Learning More about Passive House

International expert Michael McCarthy, of the Passive House Academy in Ireland, in conjunction with Box Hill Institute, is delivering training in Melbourne in September. The Passive House Designer course is a nine-day course which focuses on the Passive House Design process. This course is mainly aimed at building designers, architects, engineers and other professionals involved in the building design process. The Passive House concept is routed in building physics and this course covers all of the key formulae associated with energy losses and gains in buildings. Once the participant grasps the concepts from first principles it becomes much easier to optimise the building design and energy balance for maximum energy efficiency and comfort in both the heating and cooling periods. The course will also include two days of tuition on the use of the Passive House Planning Package (PHPP). The participants will actively model a Passive House building in the Australian climate during this part of the course, giving them a first-hand insight into the climate-specific Passive House design process, and will pull together all of the theoretical learning from the rest of the course.

Michael McCarthy is convinced that "as we move towards more energy-conscious building design and construction, this type of training will become a fundamental component of our education. By signing up to these courses you are affording yourself the opportunity to move ahead of the curve and become an established player in the sector."

About the author

Susan Morris is a teacher of the Advanced Diploma of Building Design (Architectural) at Box Hill Institute, Passive House Designer, architect and Fellow of the International Specialised Skills Institute. Susan's report "Improving Energy Efficient, Sustainable Building Design and Construction in Australia – Learning from Europe" can be accessed at http://www.issinstitute.org.au/wp-content/media/2013/04/MORRIS-Report-LowRes.pdf

Practically Green Sustainability Festival

The Practically Green Sustainability Festival will be held on Sunday, 18 October (10am-4.30pm) at Eltham's Edendale Community Environment Farm. The House Hospital will offer advice to householders on fixing problems (eg hot or cold rooms, condensation) or suggesting creative solutions to unusual circumstances (eg insulating flat roofs, replacing heating systems). If you have a good knowledge of building products, appliances and sustainability in general and would like to volunteer a couple of hours to help residents make their homes more comfortable and efficient, please contact Romney Bishop on (03) 9433 3211 or at Romney.Bishop@nillumbik.vic.gov.au with a brief description of what you do and your availability. The Festival offers a range of exhibitors, market stalls, food and live music in a beautiful and relaxed atmosphere.