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ScienceDirect

Energy Procedia 121 (2017) 214–221

Energy Procedia

www.elsevier.com/locate/procedia

International Conference on Improving Residential Energy Efficiency, IREE 2017

Chifley Passive House: A Case Study in Energy Efficiency and Comfort

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Abstract

Numerous mandatory energy efficiency building standards and rating systems have been developed globally. The International Passive House Standard is a voluntary alternative, but there is little data on the performance of houses built to this standard in Australia. One house in suburban Canberra demonstrates that the Passive House Standard can be used to build high-performance houses with predictable outcomes. Extreme energy efficiency and occupant comfort were key performance objectives in building the three-bedroom house. Like most energy efficient housing projects in Australia, the building was designed to take advantage of solar gain, thermal mass and cross flow ventilation, but what set this project and all Passive House projects apart was the careful attention to airtightness, mechanical ventilation, avoidance of thermal bridging and the use of energy modelling tools at the design stage.

The result was a house that required virtually no heating in winter despite frosty -2°C mornings; no artificial cooling in summer despite 37°C days and; overall consumed 64% less energy than similar households in the same city. Energy consumption, temperature and CO_2 levels have been monitored and confirm exceptional levels of comfort and indoor air quality. The total energy consumed was within 12% of predicted values thus supporting the effectiveness of the Passive House Standard.

Peer-review under responsibility of the scientific committee of the International Conference on Improving Residential Energy Efficiency.

Keywords: energy efficiency; comfort; monitoring; Passive House

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1876-6102
Peer-review under responsibility of the scientific committee of the International Conference on Improving Residential Energy Efficiency.
10.1016/j.egypro.2017.08.020

1. Introduction

Numerous energy efficiency building standards and rating systems have been developed with the aim of improving the performance of new buildings [1]. These developments have several drivers, including reducing energy costs, reducing CO_2 emissions and improving occupancy health and comfort. The International Passive House Standard [2] is a voluntary alternative that addresses each of these drivers and is slowly gaining widespread acceptance.

The measured performance of certified Passive Houses built overseas, particularly in Europe, is well documented [3]; however, there is little data on the performance of houses built to this standard in Australia. As the Australian climate differs from that in Europe, the demonstration of the performance of Passive Houses in Australia would build confidence in the applicability of the Standard to the Australian context.

This paper presents energy efficiency and comfort outcomes of a three-bedroom single-storey detached Passive House located in the suburb of Chifley in Canberra, Australia. The climate in Canberra has mild/warm summers and cold winters [4]. The house is home to a family of four including the owner/designer who is also one of the authors of this paper. Performance data has been collected from the house since its completion two years ago and this paper discusses the measurement results for the 12 months after November 2015.

2. Background

2.1. The Passive House Standard

The Passive House Standard is one of the world's leading comfort and energy efficiency building standards. Use of this standard is well established in Europe and has spread to 37 countries around the world, with a total of 1037 certified Passive House projects [5] and many thousands more that are not certified.

Despite the broad use of the Standard, its use in Australia is a recent development with the first Passive House built in 2014. The house in this case study is one of only seven certified Passive House buildings in Australia.

To meet the voluntary standard, a project must demonstrate compliance with the criteria in Table 1. This is achieved using the energy modelling tool called the Passive House Planning Package (PHPP) to model the design and demonstrate that its predicted performance is below the thresholds. The second part of compliance is demonstrated in the finished building with a blower door test to measure the airtightness of the building envelope.

Table 1 Passive House Standard design criteria

Parameter	Unit	Maximum
Heating demand	$kWh/m^2/a$	15
or Heating load	W/m^2	10
Cooling and dehumidification demand	$kWh/m^2/a$	15
or Cooling load	W/m^2	10
alternatively, Frequency of overheating	%	10
Airtightness (n50)	ACH	0.6
Primary energy demand	$kWh/m^2/a$	120

The tabled criteria cover heating and cooling demand, primary energy demand and airtightness. For houses without active cooling devices the alternative criterion for cooling is that the predicted portion of hours with temperatures above 25°C in a given year must be no more than 10%.

The Passive House Standard is challenging to meet. The heating demand is equivalent to an 8.5 star rating under the Australian National Home Energy Rating Scheme (NatHERS) for the Canberra Climate. This is a 66% reduction in the heating demand permissible in a new minimum-standard house (6 stars).

The Passive House Standard is also rigorous in its application. Thermal bridges are individually modelled and accounted for, the measured airtightness is used in PHPP, and third party verification is relied on for the building