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Sustainable buildings need sustainable design processes: the case of the Woodside Building for Technology and Design, the first University building in Australia to aim for the Passivhaus certification

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Abstract. Energy performance certificates (EPCs) are conventionally employed to certify the design according to different indicators. However, they are often used to evaluate the design outcomes, overlooking their potential as decision-making tools during the design process. Among those, Passivhaus is currently being debated in Australia. Currently, there are only less than 30 certified cases, and all of them are residential buildings. Thus, the question about its suitability for commercial cases in the Australian context is still open. This paper contributes to the discussion, analysing the case study of the Woodside Building for Technology and Design in Melbourne, the first University Building to aim for the Passivhaus certification. The paper quantifies the impacts of the Passivhaus criteria on the façade design, benchmarking the energy demand against the 2016 Building Code of Australia (BCA-2016) deemed to satisfy (DTS) design approach. Results show that the approach adopted in this case study leads to much better environmental performance when compared to the minimum performance required by the Australian standard DTS design approach. This building sets a new sustainability target in the Australian design culture, showing that it is necessary to change the way buildings are designed, toward a more sustainable and integrated design process.

1. Introduction

In the last decades, we witnessed an increased interest in energy efficiency as a primary mean to reduce the impacts of the construction sector on the environment. Tackling buildings efficiency is a key factor in the 1.5 Degree challenge [1] and for the global goals defined by UN SDG11, especially considering that buildings account for 40% of the global energy consumption [2]. Energy performance certificates (EPCs) are conventionally used to ensure that the performance fulfills the national requirements and to certify the design according to different indicators. However, they are often used only to evaluate the design outcomes, overlooking their potential as decision-making tools during the design process.

Among those, Passivhaus is currently being debated in Australia. Although this scheme has been internationally applied to different climates and contexts [4-6], only 27 certified case studies are available in Australia. These cases are all residential and only one is not a single detached or terraced house [7]. The reluctance of the market to use this certification scheme lies in the skepticism about the suitability of Passivhaus for the Australian context, market and construction culture, besides the lack of examples beyond the residential typology.

This paper contributes to this discussion, analysing the case study of the Woodside Building for Technology and Design in Melbourne, designed by Grimshaw Architects for Monash University, the first Australian university building and the biggest building in the Southern Hemisphere to aim at the Passivhaus certification. The integrated design process used to design the envelope, employs a parametric early-stage analysis as a decision-making tool, validating the design choices against the Passivhaus performance. This predictive approach allowed the architects to achieve industry leading environmental performance without overlooking the user experience or the architectural expression.

The paper aims at defining the impacts on the building energy demand of the early stage predictive assessment approach on the façade design, while benchmarking the design outcomes against the Building code of Australia (BCA) 2016 – Section J – Energy Efficiency* [8]. The ultimate goal is to identify the existing energy gap between the construction practice as defined by the Australian code and the international Passivhaus approach, and to demonstrate that an alternative and more efficient design and construction is viable also in the Australian context.

2. The Woodside Building – Passivhaus design features

The building has been designed as a "living laboratory": the passive design strategy shapes the architecture to showcase the performance-based approach and to provide unique learning opportunities. The high occupancy teaching spaces, characterized by higher thermal loads and stricter comfort requirements, are retained within the building core, away from fluctuating conditions typically found closer to the building envelope. This allows to optimise the dimension of the mechanical systems, by reducing the heating/cooling peaks. The spaces dedicated to collaboration and the major distribution corridors are located at the perimeter, and the workplace offices for the university staff and Ph.D students at the top. A series of atriums and multiple height spaces maximises the vertical and horizontal interconnectivity and provides natural light in the central part of the building, thanks to the presence of horizontal skylights. The Unitized Curtain wall façade is designed to adapt to the different orientations, in order to maximise the energy performance, create variety in the building aesthetic and user experience, and minimise wastage and costs through modularity.

3. Method

This paper investigates the design outcomes and environmental performance of different design approaches, based on two different certification schemes; Passivhaus and the BCA-2016 [8]. By comparing the performance requirements of both approaches, and identifying the main differences, a set of scenarios is defined. The scenarios are then simulated to assess the final energy performance. The analysis gives a snapshot of the existing Australian energy efficiency policy, and it opens the question about the necessity of updating the current standard requirements to offer a significant contribution to the international climate change conversation.

3.1. Design approach scenarios

The BCA-2016 - Section J deemed to satisfy (DTS) approach is prescriptive and it defines a set of minimum U-values and solar heat gain coefficient (SHGC) to be achieved for each building element (roof, solid and glazed walls, floors, etc) [8], completely overlooking the complexity embedded in the building performance design. Passivhaus tackles this aspect suggesting a holistic approach to the design and focusing on reaching high levels in comfort and energy efficiency. To be certified Passivhaus, a building must: 1) work within a temperature range of 20-25 °C, 2) consume less than 15 kWh/m^{2}year (operational energy); 3) generate 60 kWh/m^{2}year from renewable sources (photovoltaic); 4) be airtight (maximum of 0.6 air changes per hour). The comparison between Passivhaus and BCA-2016 – Section J approach to energy efficiency shows that the Passivhaus requirements are substantially more restrictive, especially in three main factors:

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- Envelope U value (glazed and solid walls) – to limit heat loss for conductivity;
- Thermal bridge rate – to limit heat loss for conductivity (not considered by BCA);
- Airtightness – to limit heat loss for convection (not considered by BCA).

Using these three factors as variables, five different scenarios have been considered, ranging from the Passivhaus approach to the mandatory minimum energy requirement defined by the BCA-2016 DTS. The combinations are created by varying one parameter at the time, in order to perform a sensitivity analysis of the inputs on the final energy consumption. The energy performance is calculated with the software PHPP (Passivhaus Planning Package), the Passivhaus certification tool. The efficiency of the mechanical systems, architectural and facade design are considered constant across all the scenarios, as the goal of this paper is to assess the impact of the envelope performance on the total energy demand.

As can be seen in Table 1, the reference scenario (baseline) is defined as a scenario that would reach the basic requirements of the Passivhaus certification. On the contrary, the scenario designed according to the minimum energy requirements (BCA2016-DTS) is Scenario 4. These two represent the extreme cases, while others are defined as follows:

Table 1- Envelope performance requirements - Scenario comparison

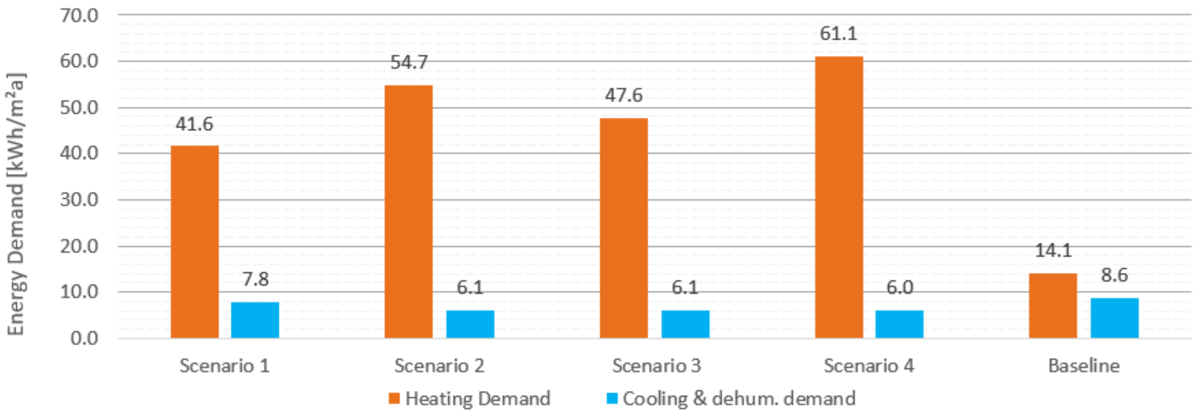
	$U_{\text{Solid Wall}}$ (W/m^2K)	$U_{\text{Glased wall}}$ (W/m^2K)	U_{Roof} (W/m^2K)	Thermal Bridges (W/mK)	Airtightness (ACH 1/hour)
Scenario 1	1.0* (NCC)	2.8 (NCC)	0.56 (NCC)	0.15	0.6
Scenario 2	1.0* (NCC)	2.8 (NCC)	0.56 (NCC)	0.15	8 (NCC)
Scenario 3	1.0* (NCC)	2.8 (NCC)	0.56 (NCC)	0.3 (NCC)	0.6
Scenario 4	1.0* (NCC)	2.8 (NCC)	0.56 (NCC)	0.3 (NCC)	8 (NCC)
Baseline	0.25	2.3	0.25	0.15	0.6

* Note 1: *The BCA-2016 – Section J requires a U-value for spandrel = 0.35 W/m^2K calculated in the "centre of pane". A U-value of 1.0 W/m^2K factors-in the impact of thermal bridges due to the presence of the aluminium frame. The SHGC has been considered 0.3 across all scenarios.*

4. Results

The comparison between the different scenarios shows the following results, divided for cooling and heating demand:

Figure 1- Energy demand - Scenario comparison



The Woodside Building appears to be a heating-dominated building across all scenarios, largely due to the relatively low average internal heat gains and the envelope being designed to screen most of the solar radiation. The heating demand varies across all scenarios, increasing from the baseline (14.1 kWh/m^2a) to Scenario 4 (61.1 kWh/m^2a) and resulting in an annual heating demand four times higher than the Baseline. On the contrary, in terms of cooling demand, none of the parameters have significant influence. This can be attributed to the large surface of the building (18.000m^2), the efficient envelope to volume ratio, the well-shaded façade design, and a relatively low window to volume ratio (WWR = 50%). Furthermore, scenarios 1 to 4 present a lower cooling demand compared to the Baseline, as the envelope's lower thermal performance allows the envelope to dissipate the heat more effectively, thanks to the cooler summer nights and mild average temperatures of Melbourne. When heating is considered, the parameters can be ranked according to their influence on the final demand, with the total system U-value as the most important, followed by airtightness and, at last, the thermal bridging. On the contrary, the cooling demand is almost constant in all scenarios, revealing low sensitivity in changes. For each scenario, the energy gap between heating and cooling demand is highly significant, except for the Baseline (Heating 14.1 kWh/m^{2}a – Cooling 8.6 kWh/m^{2}a). In particular, Scenario 4 presents the highest difference, with a heating demand ten times higher than the cooling demand. This analysis reveals that, compared to a standard Australian building designed to meet the BCA-2016 minimum requirements, the Woodside Building, designed to reach the Passivhaus certification, reduces the total energy demand by 65%, offering a more efficient solution.

5. Conclusions

This paper aimed to investigate the differences in the final energy demand considering a façade performance design based on the Passivhaus certificate and the minimum performance requirements set by the DTS provisions (BCA-2016 - Section J).

The BCA-2016 DTS sets minimum façade performance requirements that result in a total energy demand that is three times higher than a well-established efficiency standard, like that of Passivhaus. Furthermore, the negative effects of a low performing envelope are greater on the heating demand, while the cooling demand remains almost unvaried. The comparison between the scenarios reveals how each parameter (U-value, air tightness and thermal bridging) have a great impact on the energy performance with the most important factor being the envelope total U-value.

The Woodside Building is still under construction (completion in April 2020), and the Passivhaus certification will be issued after the blower-door test. However, this case study sets an example of efficient construction and design methodology, and it demonstrates how the use of Passivhaus as a design tool enabled the design team to overcome the limitation of the Australian building code, towards a more efficient building and construction process. The Woodside Building for Technology and Design contributes to the discussion over the suitability of the current Australian energy efficiency regulation for the global challenge defined by the UN SDG 11, highlighting the necessity of urgent improvements.

6. References

[1] IPCC 2018. Summary for Policymakers, Global warmign of 1.5°C.
[2] International Energy Agency 2018. World Energy Outlook 2018.
[3] Hoffmann C, Geissler A. 2017. The prebound-effect in detail: real indoor temperatures in basements and measured versus calculated U-values. *Energy Procedia* **122** 32–37.
[4] Schnieders J, Eian TD, Filippi M. et al. 2019. Design and realisation of the Passive House concept in different climate zones *Energy Efficiency* doi:10.1007/s12053-019-09819-6
[5] Matsumoto H, Tsuzuki K, Susanti L 2017. Bioclimatic analysis in pre-design stage of Passive House in Indonesia *Buildings* **7(1)** 1-24
[6] Schnieders J, Wolfgang F, Ludwig R 2015. Passive Houses for different climate zones *Energy and Buildings* **105** 71-87.
[7] Passive House Database *passivehouse-databse.org* (accessed 28-12-2019)
[8] Board AB 2016. NCC series 2016: Building Code of Australia Class 2 to Class 9 Buildings

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