1 Introduction

The expectancy of the public regarding indoor environmental quality is rising, and the need for reducing the energy consumption in buildings is getting obvious. In the close future, they will ask for more energy efficient buildings and a higher quality of the indoor environment.

The Passive House is an ideal concept for the thermal comfort as defined by ISO 7730 and for energy efficiency. This paper is based on a study in which 35 parameters of an end-of-terrace house are examined, using climate data of Perth and the calculation software PHPP.

The results show there is a cooling potential during night time in the summer and a great heating potential due to long sunshine in the winter. These potentials make it possible to build a Passive House in Perth with far less effort than in Germany, where the Passive House is becoming the standard of the building industry.

1.1 General information on the reference Passive House and parameters

For the modeling an end-of-terrace house with a treated floor area of 127 square meters has been used, as shown in Figure 1. The same building model was used for the dissertation of Schnieders: “Passive Houses in South-West-Europe” and the Study by the PHI: “Passive Houses for different climate zones”. Using the same building model for the analyses makes it possible to compare the results and strengthen the evaluation.

The parameter variation of the different parameters always started with a starting parameter. Only one parameter is changed at a time, unless otherwise stated. Each parameter has two graphs, the first chart shows the annual cooling and heating demands; the second graph shows the daily maximum heating and cooling loads. However, for this paper only the annual demands are shown. For each variation of the parameter, the cooling loads are shown as negative figures and the heating loads as positive figures. The positive and negative values cannot be added together. The loads occur at different times and need to be seen as different values.

The annual temperatures in Perth since 1944, varied between $-1.3°C$ and $46.7°C$. It is expected that Perth’s Eastern region will see massive climate change by 2070 including a minimum temperature rise of 4 Kelvin.

Figure 1: End of terrace house as used for modeling

2 The study

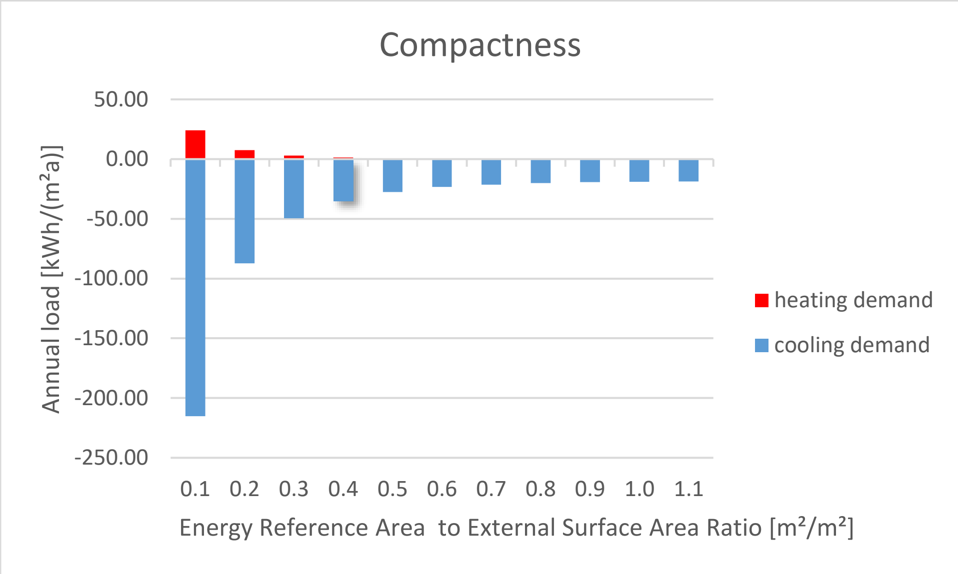

Figure 2 Annual load depending on compactness.

The Compactness of the building has the biggest impact on the energy demand for heating and cooling. The used compactness is the relation between the surface of the treated floor area and the surface of the building envelope. Figure 2 shows the compactness of the building model in relation to the energy demand. The cooling load is significant and has a magnetite of $200\ kWh/m^2a$. The compactness of the related end-of-terrace house is about $0.4\ m^2/m^2$. Energy Reference Area to External Surface Area Ratios below $0.3\ m^2/m^2$ must be avoided, because the relation is exponential.

Figure 3 shows the house sizes from different countries around the world in the year 2009. By this figure, Australia has with $214\ m^2$ the biggest houses in the world. The average floor area per person is about 87 square metres, what is close to 3 times the size of the Passive House recommendation. (André Stephan, 2016)

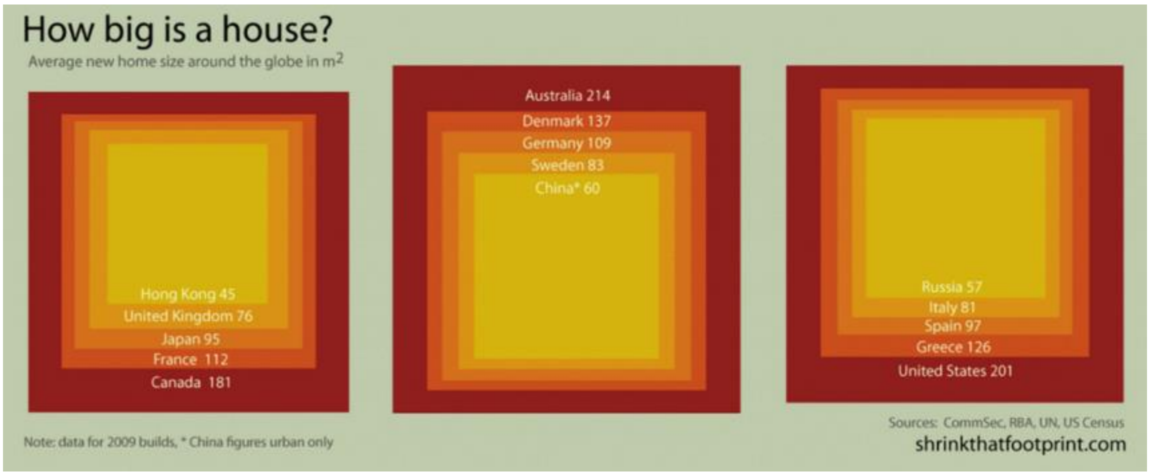

Figure 3: The average house size in m² for different countries in 2009 (Footprint, 2013)

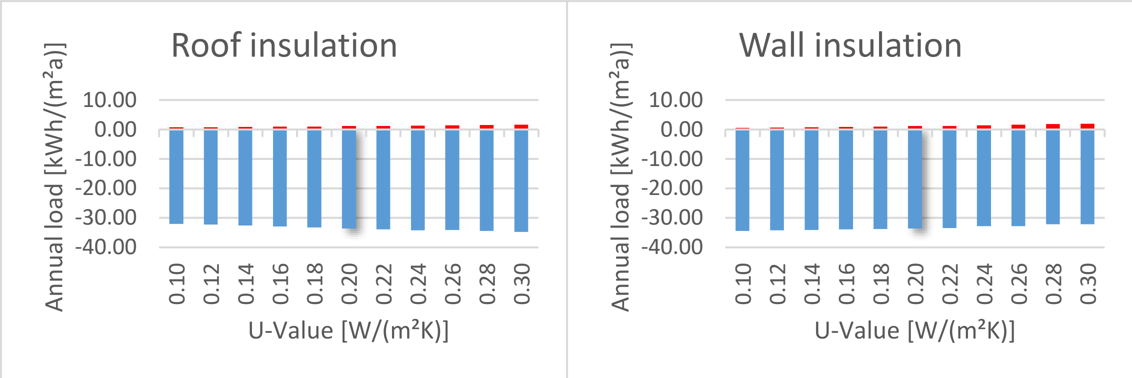

Figure 4 Annual load depending on roof and wall insulation.

The thermal insulation functions as a barrier for a building to separate the indoor environment from the outdoor climate thermally. Thermal insulation is needed for the roof and the wall. Below the slap of the building it is not giving a significant benefit. Figure 4 illustrates the effect of the adjusted U-value of the roof and wall. As expected a lower overall heat transfer coefficient results in lower loads. The economical compromise for the thermal insulation of the roof will be between a U-value of $0.13 - 0.18\ W/m^2K$ and for the wall a U-value of $0.18 - 0.22\ W/m^2K$. Thermal bridging should always be addressed and eliminated like it is required by Passive House standards.

Infiltration has a smaller impact on the annual load as expected, due to the low heat capacity of air. The maximum daily average load depending on infiltration is substantial for the heating load. It must be noted that airtightness is not only important for the thermal performance but as well extremely essential for moisture management. Air exchanges above 1.5 at 50 Pascal are not recommended. Figure 5 shows the annual load depending on infiltration. The step in the graphs is due to a step in the used coordinates. There are no plausible reasons to aim for air exchanges below the required 0.6 ACH of Passive House in Perth.

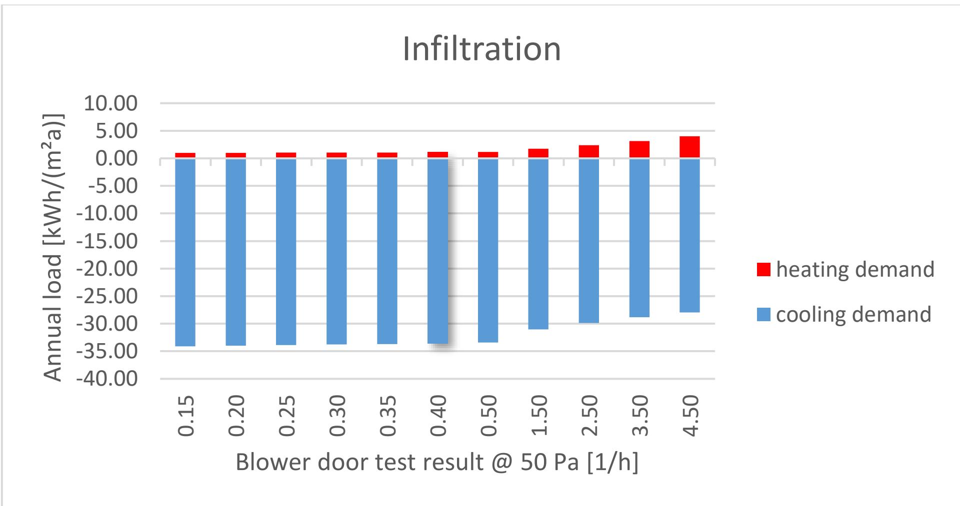

Figure 5: Annual load depending on infiltration.

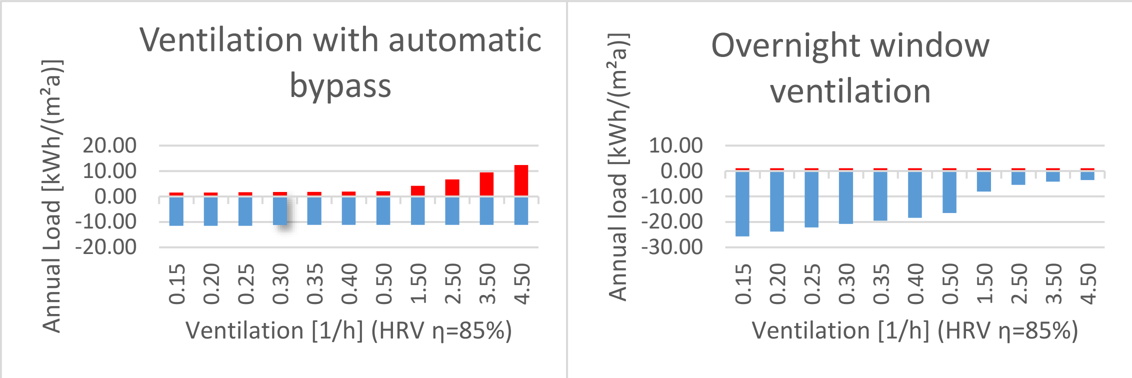

Figure 6: Annual load depending on ventilation with automatic bypass and overnight window ventilation.

Ventilation can have a negative or a positive effect and is dependent on the user and settings. Less ventilation is beneficial for the thermal performance in general, a minimum of ventilation is needed for air quality requirements. If the external temperature is in benefit of the internal temperature, more ventilation without heat recovery is beneficial. Figure 6 shows that ventilation with an automatic bypass has no notable impact on the cooling load and an impact to the heating load. The overnight window ventilation has only an impact on the cooling load and as expected a lower cooling load with higher air exchange rates, as shown in Figure 6. The step in the graphs is due to a step in the used coordinates.

In traditional buildings, windows are often the biggest energy highways per square meter between inside and outside and are extremely important to get right in a Passive House. The Study shows that, the ideal amount of window area of the facade is between 12% and 20% depending on orientation and shading. The window frame is an unwanted necessity and should be reduced to a minimum, the U-value should be below $1.5\ W/m^2K$. The glazing area should be maximised, and the g-value is the driving factor for its performance. The g-value has a huge impact on the performance of a building as shown in Figure 7 and should be as low as 0.25. If the g-value of 0.25 cannot be achieved, additional mechanically or fixed shading could be required to stop overheating in the summer. The U-value of the glazing should be below $1.1\ W/m^2K$.

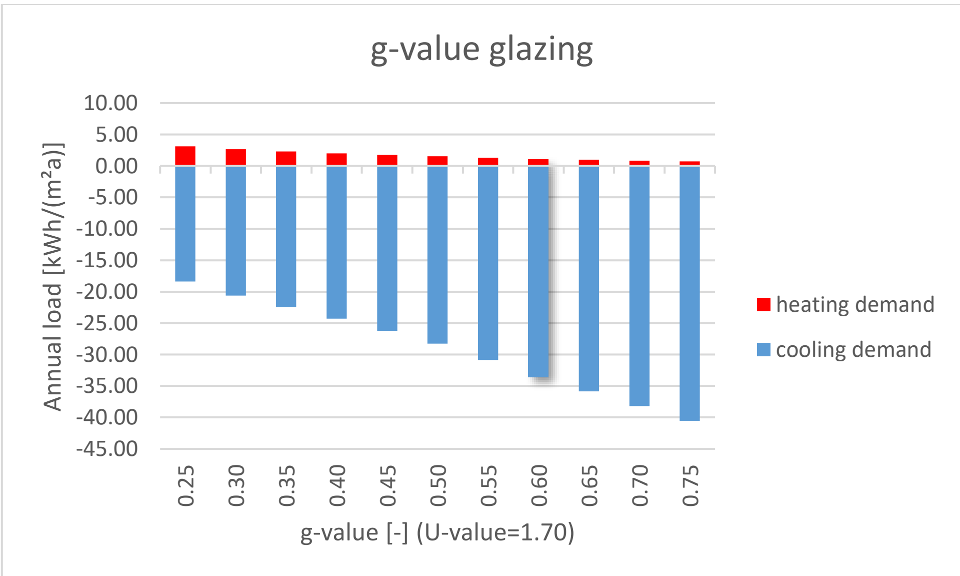

Figure 7 Annual load depending on g-value glazing.

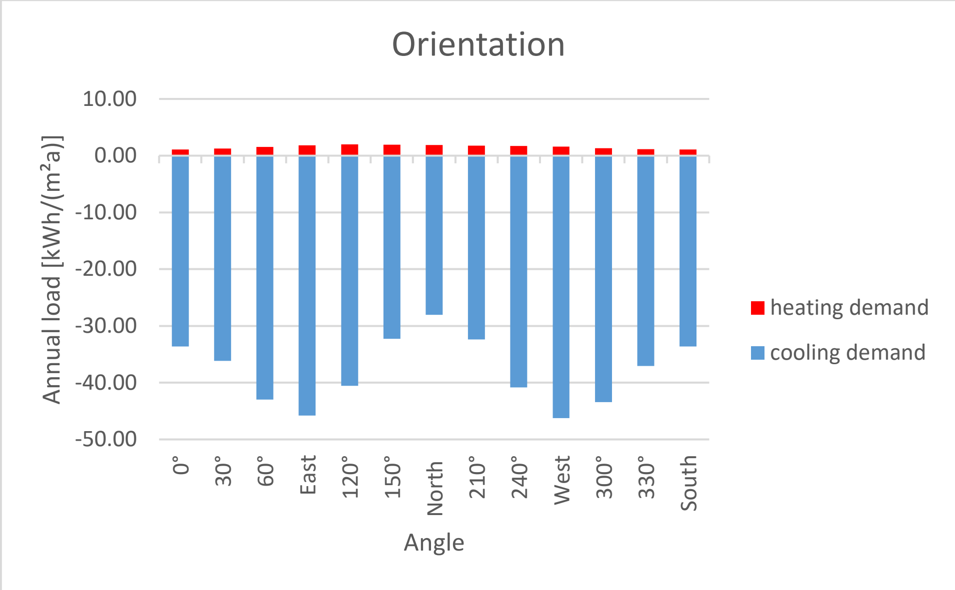

Figure 8 Annual load depending on orientation.

The orientation has a huge effect on the cooling demand and cooling load as it is shown in Figure 8, the heating demand and the heating load are not affected as strongly. The results show that if the windows are orientated to the East and West, the cooling demand and cooling load are higher than if the windows are orientated towards the other two compass orientations. These results are expected.

The specific heat capacity is the measurement of the heat storage potential of the building materials, which affects the inner heat capacity commonly known as thermal mass. High heat capacity makes the indoor environment more stable. Figure 9 shows the positive effect of heavier buildings on the annual loads of the heating and cooling demand. The overall positive effect is not significant, and the heat capacity should not determine the structure or be seen as an important design element.

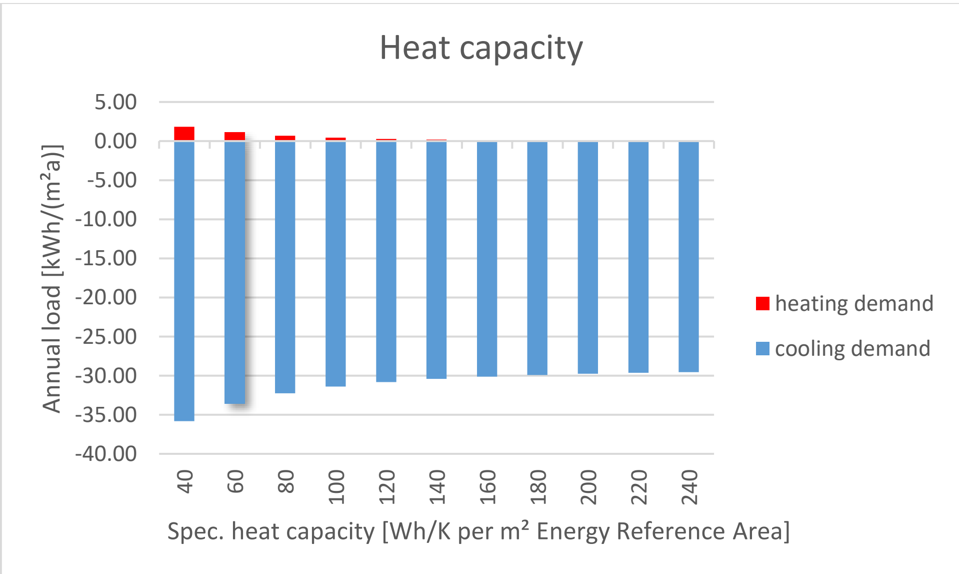

Figure 9 Annual Load depending on heat capacity.

3 Conclusions

The results of the study of an idealised end-of-terrace house show that it is possible to build a Passive House in Perth and comfortably meet all Passive House criteria. It is even possible to build without a heating or cooling system if certain thermal variations are excepted.

The compactness has the biggest impact of all the parameters and is extremely difficult to get across to clients and architects. Smart designs putting the functionality before pretty designs are required to improve energy efficiency and affordability.

We have to learn to build with the sun and not against it. Orientation of the building has a huge impact on the energy consumption for conditioning the building. The direction of a block needs to be considered in the town planning stage where the lot shape and direction is put into stone.

The five main Passive House components: thermal insulation, thermal bridge free construction, airtightness, high performance windows and heat recovery ventilation are the key parameters, whereby the compactness and the orientation are the main influential factors.

4 List of Figures

5 List of sources

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