Retrofit Case Study: Achieving Comfort and Health in an Existing Canberra Home with the PHPP Modelling

Introduction

This case study explores the use of the Passive House Planning Package (PHPP) energy model to inform the retrofitting process for a 4-bedroom brick veneer home in Canberra. The house has timber floors and single-glazed steel windows and is oriented to have east and west-facing windows.

Retrofitting Considerations

It is crucial to fully insulate the building envelope and minimise air leakiness for comfort. The use of blow-in wall insulation in the 140mm cavity between the brick veneer and plasterboard is viable given the absence of moisture risks in the subfloor, which could otherwise complicate the insulation of wall cavities. The ceiling and underfloor will be insulated with polyester rolls.

Ventilation Strategies

Ventilation is a critical factor for occupant comfort and health as it guarantees good indoor air quality. This is arguably even more important than insulation for health. Traditional approaches, such as intermittent extraction fans and opening windows, are insufficient, especially opening windows in colder climates like Canberra.

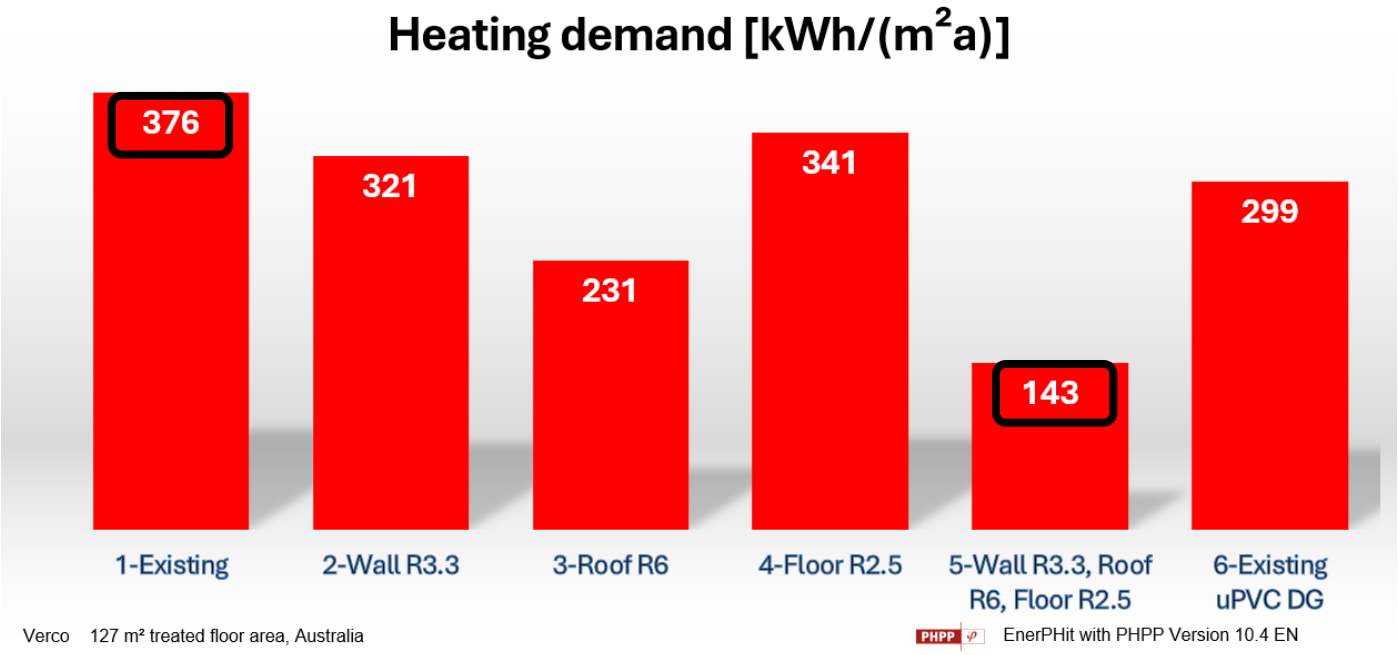
Initially continuous extract ventilation fans will be installed in the bathroom and kitchen. These modern, efficient fans are designed to provide constant air extraction, appropriately addressing moisture management and improving indoor air quality. Ventilation is essential in preventing indoor air pollutants and managing humidity generated by occupants.

A subsequent stage will add a Heat Recovery Ventilation (HRV) system to the home, this is the ultimate in health and comfort and actually should be the first stage of any home retrofit.

Heating Demand Analysis

In Canberra's heating-dominant climate insulating the roof contributes the most significant reduction in heating demand. However, to achieve a meaningful decrease in energy usage and improve occupant comfort, it is essential to insulate the entire building envelope otherwise the heating system is unlikely to be able to heat the surfaces that allow us to feel comfortable.

With a completely insulated envelope we see a 62% reduction in the heating demand to 143 kWh/m²a to maintain a comfortable 20°C. For a 127 m² floor area, this translates to about 6,000 kWh annually, or roughly $1,800 (assuming a heat pump Coefficient of Performance (COP) of 3 and electricity at $0.30/kWh).



Window Performance and Insulation

The home's 20% window-to-floor area ratio is modest (but still allows for ample daylighting) compared to modern standards, which can be as high as 40%. From a simple return on investment perspective, the cost of insulating the entire house is comparable to that of replacing all the windows, making insulation the choice for energy efficiency. However, the health and comfort benefits of new windows—such as reducing air leakage, condensation, and lowering sound transmission—are significant factors to consider. It can be argued that windows are more important that insulation.

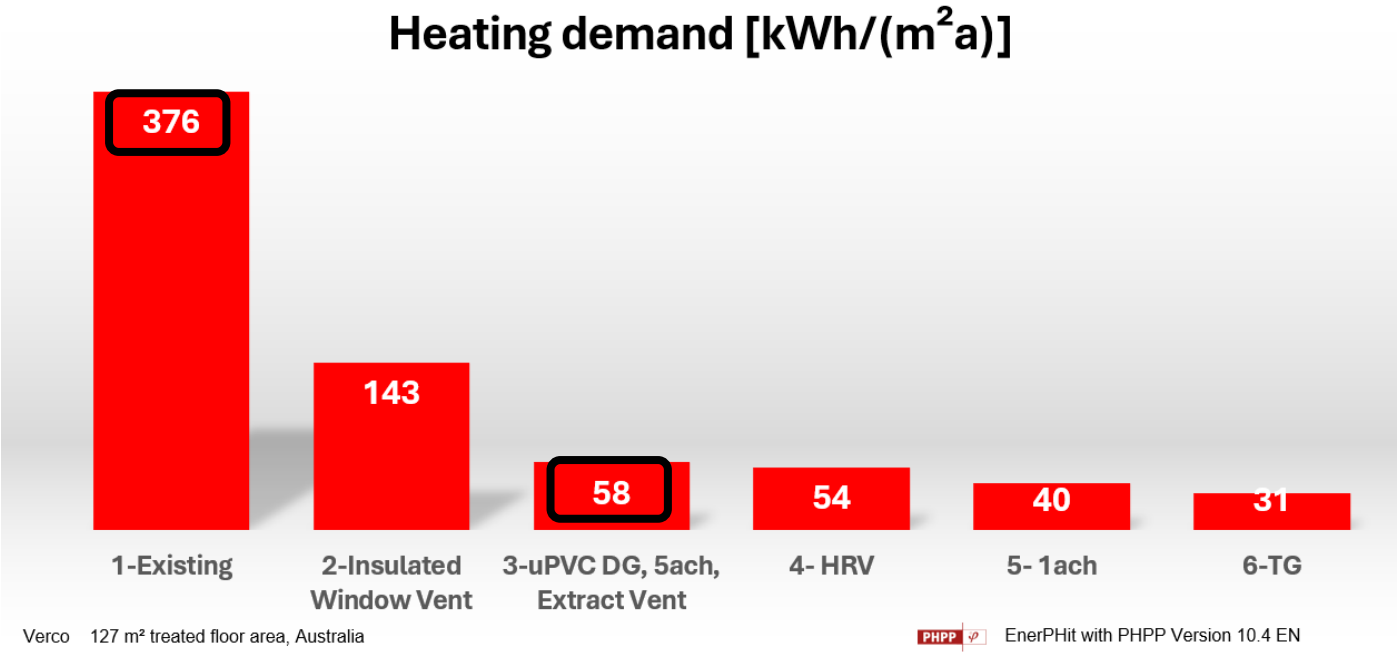
Energy Consumption Insights

An uninsulated house would require approximately 376 kWh/m²a to maintain 20°C, leading to a total energy demand of 47,752 kWh annually. Even with a heat pump this results in around 16,000 kWh of electrical energy use. It is the case that reducing the target temperature to 18°C can lower energy needs to about 12,000 kWh annually, demonstrating a 25% reduction in demand but this lower temperature significantly increases the risk of condensation forming.

Modelling and Performance Outcomes

The existing building is modelled with an air change rate (ach) of 15, that is the volume of air inside the home is replaced 15x every hour (when measured at a pressure difference of 50Pa or a 32km/h wind). This is a conservative assumption for an older home.

Retrofitting with insulation, improved windows, reduced air leakage and extract ventilation can reduce heating demand by 85%. These improvements will ensure that surface temperatures of walls, floors, and ceilings within a few degrees of the air temperature, ensuring a comfortable and healthy living environment. Further gains are possible with the addition of a HRV system, less air leakiness and even triple glazed windows but the relative benefits against costs are far smaller.



Summary

A typical 1960's brick veneer home in Canberra can be made comfortable and healthy and would use 85% less energy to heat to 20°C than the existing home would use.

Addressing ventilation, air leakiness and insulation together ensures a healthy home is the outcome.

A more thorough analysis of this case study is available on request and this looks at cooling energy demand and overheating risk and how this is balanced against heating energy demand.