# Two tools to inform thermal upgrades of apartments

Using specialist computer programs can achieve the best comfort improvements for the least cost.

**THIS FACT SHEET** is one of a series looking at practical, cost-effective measures to improve comfort, utility and occupant satisfaction when retrofitting residential rental properties. New Zealand has one of the least-affordable housing stocks in the world, and the rental market has often under-delivered as an affordable alternative to home ownership. Given that most of the current housing stock will be in use for many years to come, retrofits are a very important part of the rental property sector.

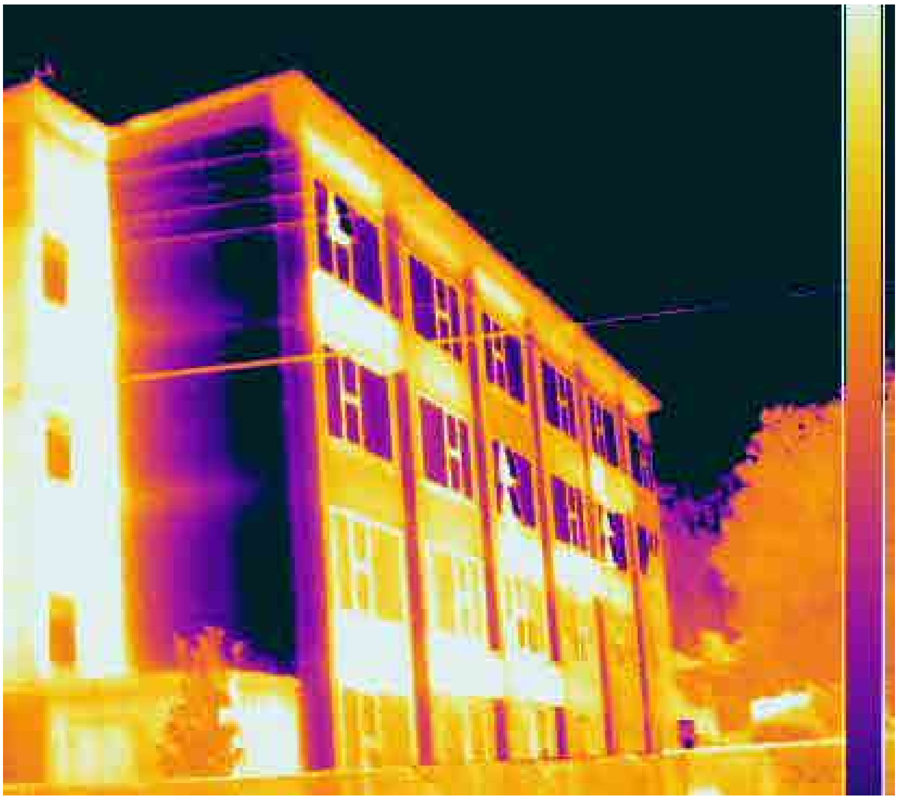
## Background

This fact sheet highlights two of the best tools to inform thermal upgrades planned by owners of apartment-style rentals: thermal imaging and thermal simulation. These tools are essential to understand how existing buildings perform and the potential impact of different thermal improvements.

The case study used to demonstrate the tools is the upgrade of Kotuku Apartments (Figure 1) carried out by Wellington City Council. The apartments are located near Wellington International Airport. The four 4-storey buildings were built in the 1960s, and their thermal performance improvement was part of a multi-million-dollar upgrade over 2013–2017. The total upgrade included considerable improvements to internal features (fixtures, finishes and appliances), the thermal envelope of the building (windows, wall, roof and floor) as well as the external landscaping and hardscaping.

## Thermal imaging

Thermal imaging uses a special camera to identify the location of heat loss in buildings, so that areas of high heat loss can be



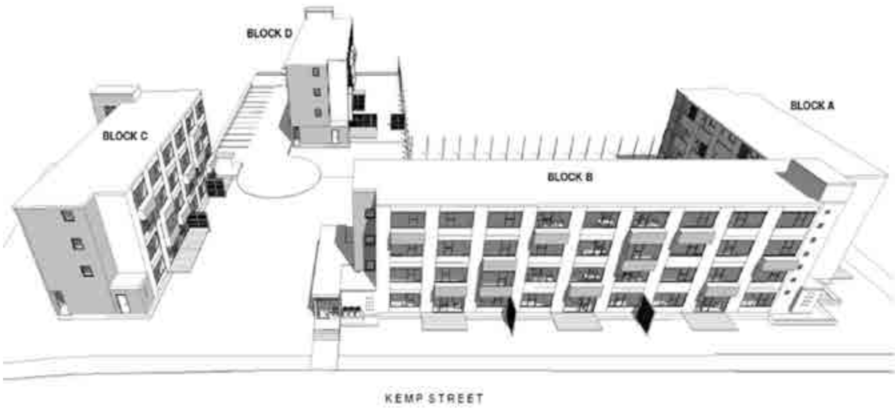





Figure 1. Kotuku Apartments (looking to the west).

targeted in retrofits. Colours in the images indicate the amount of infrared radiation coming from a surface, thus indicating the surface temperature. Cooler temperatures are represented by darker colours, while warmer temperatures are represented by lighter colours.

Moisture can be also inferred from the different colours in a thermal image, because the presence of water or moisture will be colder than its surroundings as the water evaporates, causing cooling. (The high thermal mass of water can also cause wet areas to change temperature more slowly than non-wet areas, leaving a temperature difference visible in the thermal image.)

Although it is a rapid way to identify areas of heat loss and moisture, interpreting the results of thermal imaging requires care and experience.

Thermal imaging should be used to:

- find thermal weak points, leaks and construction flaws
- check the completeness of remediation work
- identify with more precision building issues that are not visible otherwise
- identify opportunities in the design that can help to bring down projected energy costs.

Figure 2 shows thermal images for an external wall of the Kotuku Apartments, which indicate a problem that might be difficult to discern from a visual inspection alone. The image on the left suggests an issue with rain-saturated polystyrene wall insulation in the concrete spandrel panels on the exterior of the buildings. The colour and pattern in the thermal image are due to the irregularities in the insulation panels' infrared thermal profiles.

Saturated insulation is far less effective than dry insulation in providing thermal resistance, so the panels were replaced as part of the renovation. The dry panels after the retrofit are demonstrated by the even colour tones in the thermal image on the right.

## Thermal simulation (desktop)

Thermal modelling tools are computer programs in which a virtual representation of a building is constructed. Historical hourly weather information and standardised user behaviour are entered as inputs. A calculation engine then computes heat flows between internal zones as well as through the external building envelope over a specific time period – usually a year.

The implications of altering the building's physical layout, material properties (such as insulation levels), orientation or other aspects can be easily explored. Thermal simulation should be used early and often in the design process to explore the potential results of a variety of design and specification options. The designer can use the tool to prioritise design and material recommendations to give an optimal result. Simulation enables performance-based compliance and communicates the impact of design choices with more precision than would otherwise be possible.

Various possible alterations to the Kotuku Apartments' external envelope were explored with thermal simulation to assess year-round occupant comfort. Two features can be used to show the usefulness of thermal simulation:

- The number of days the apartments get critically cold (below 12ºC).
- The impact of high-quality glazing on space heating requirements.

By running the scenario models without any space heating, the passive performance of the building could be explored. This was particularly useful, as initial enquiries found that few tenants regularly used space heating during winter, with some never using space heaters at all. Figure 3 provides information on when indoor temperatures became critically cold for different types of apartments, before and after potential retrofits.

In the original very poorly insulated building, when no internal space heating was provided, all of the apartments fell below a critical temperature of 12ºC at some point during the year (the blue bars in Figure 3).

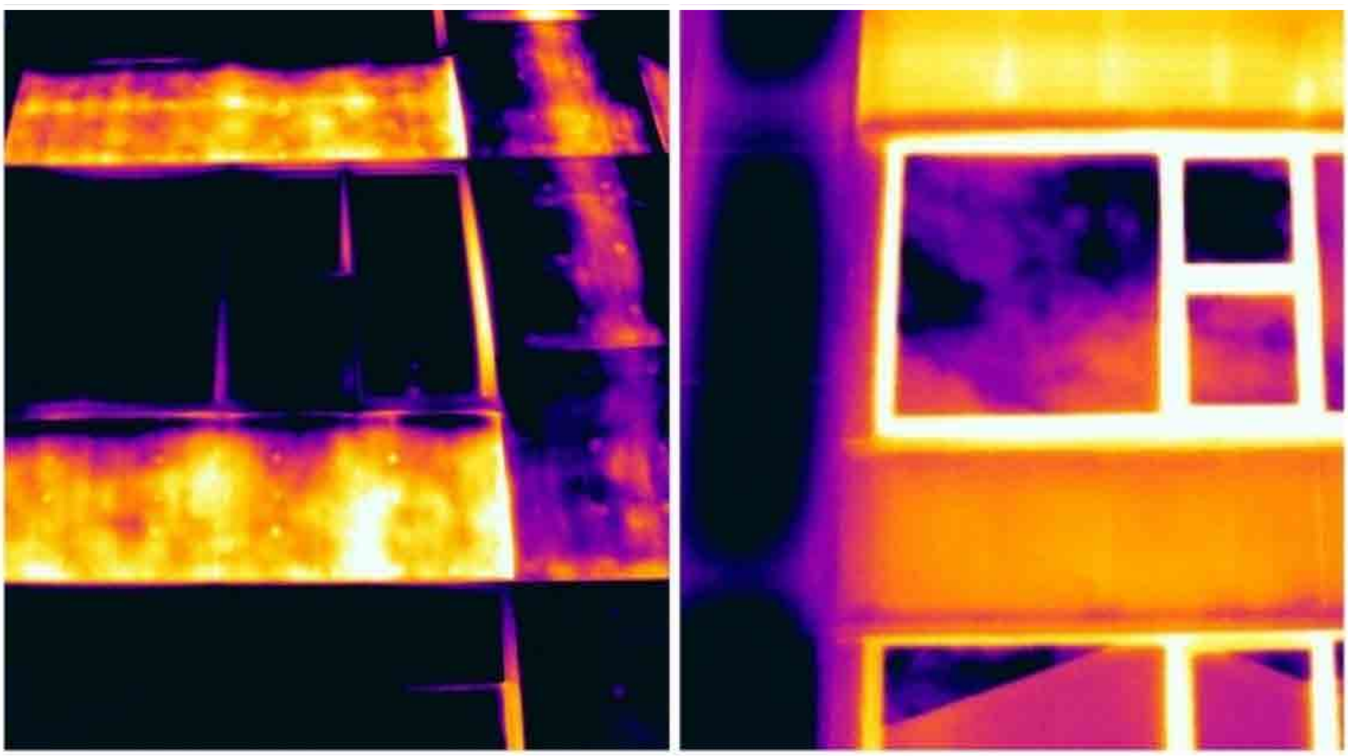


Figure 2. Thermal images showing (left) water ingress in wall panels under the windows before the retrofit and (right) no evidence of water after the retrofit.

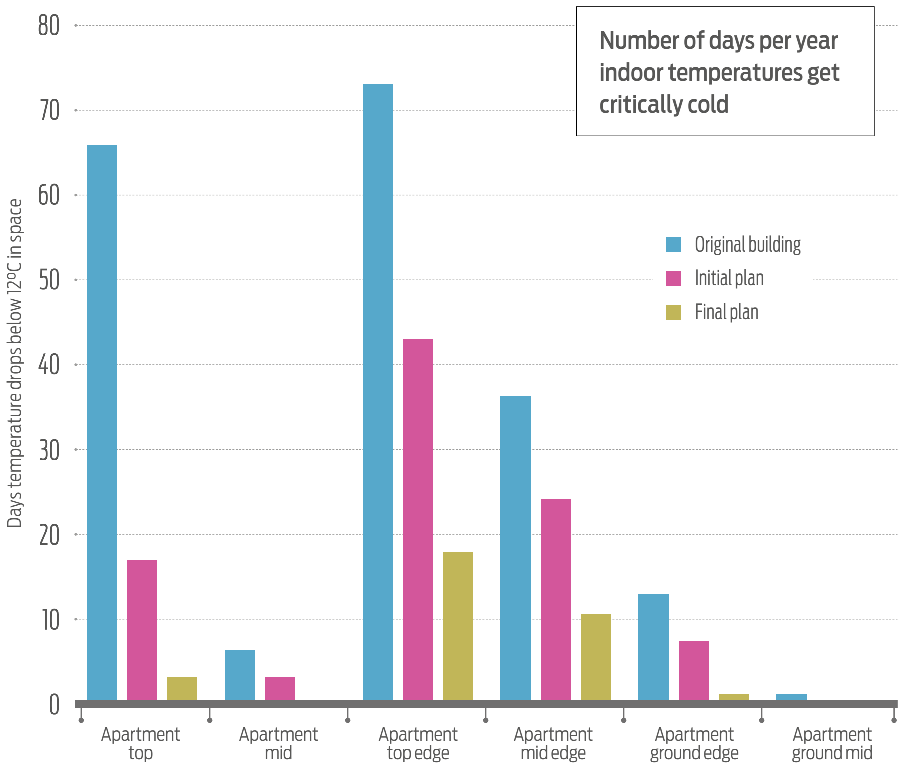



Figure 3. Number of days per year the indoor temperature gets critically cold (below 12ºC) for apartments in different locations.

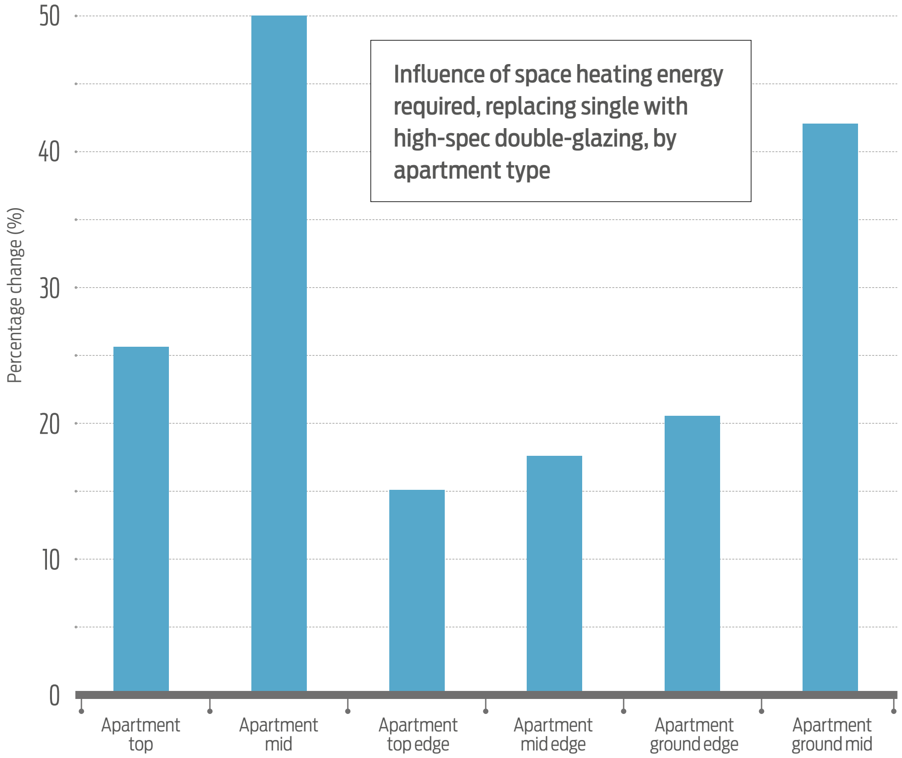



Figure 4. Percentage of predicted space heating energy required after replacement with high-spec double glazing, compared to original single glazing, by apartment type.

This is the point that is thought to have debilitating health impacts, especially for the vulnerable such as the elderly or disabled. The worst-performing apartments were those on the ends of the top floor as they had little in the way of a thermal buffer.

Two further calculations were then done: one for an initial retrofit plan and one for the plan finally adopted. In both cases, the number of days with temperatures dipping below 12ºC fell significantly. The biggest improvement by far was seen with the final plan, when the number of days with temperatures dipping below 12ºC fell to just 2–6% of the original number of days, depending on the location of the apartment in the building.

There was considerable variation in the level of passive thermal comfort between apartments, based on their location in the block. As Figure 3 shows, the worst-performing apartment (at the top edge of the building) spent about 30 times the amount of time in very cold temperatures (below 12ºC) compared to the best-performing apartment (ground level in the middle of the building).

The dramatic influence of more thermally efficient glazing on the amount of space heating required to keep the apartments at a comfortable temperature can be seen in Figure 4. All other construction details have been kept constant, so only the influence of improved glazing is targeted. The result of the calculation is that only 15–50% of the original space heating energy will be required after retrofitting with high-spec glazing. Once again, the wide range of thermal improvement is dependent on the location of the apartment in the building. The biggest saving is for an apartment on the top edge, the smallest (50%) for an apartment in the middle of the building.

## Further information


Buckett, N. & Jaques, R. (2016). *Kotuku Apartments thermal modelling – design stage*. BRANZ Study Report SR362. Judgeford, New Zealand: BRANZ Ltd.

BRANZ Bulletin BU602 *Thermal modelling tools for houses*. Judgeford, New Zealand: BRANZ Ltd.

www.level.org.nz – the BRANZ website on sustainable residential construction.





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