SOLUTION GUIDE

OVERHEATING IN TERRACE HOUSING

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FISHER & PAYKEL
HOME SOLUTIONS

Contents

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Combining architectural experience with a mechanical engineering background, Raj is uniquely placed to help guide improvements to the thermal environment, balancing considerations of aesthetics, costs, performance and product.

01. Introduction

More terraced homes, more overheating issues

With a housing affordability crisis and growing populations in the major cities of New Zealand, there is a need for greater housing intensification. Terraced houses and duplexes are an increasingly popular option within Auckland, with over half of new building consents in 2023 being for townhouses, flat and units.

A survey of over 1300 medium density homes by the Auckland Council has found that a significant number of townhouses suffer from overheating issues due to poor design practices.* Over half of participants living in terraced houses and duplexes have made changes to improve the temperature in summer. This demonstrates a clear need for design improvements to address overheating during the design stage and reduce reliance on retrofitted fixes.

Fixing overheating: Solutions overview

Key elements which can significantly lower the overheating risk in the terraced house typology include **solar shading** elements, **glazing design** choices, **ceiling fans** and **ventilation**. Solar shading and glazing design are solutions aimed at preventing the ingress of solar heat gain in summer. Ceiling fans and ventilation are aimed at lowering the overall cooling and heating demand of houses through air movement.

It's not the insulation: Misconceptions on thermal performance

There is a misconception that the recent updates to the New Zealand Building Code clause H1: (Energy Efficiency), have caused overheating due to increased levels of insulation. This is incorrect because it is not the insulation which causes overheating, but rather design choices. In winter, insulation slows down the transfer of heat from the interior to the exterior of the building. In summer, insulation slows down the transfer of heat from the exterior to the interior of the building. The impact of insulation is to keep the indoor temperature more stable. Overheating is caused by allowing too much heat into the building during summer and the largest contributor to this in townhouses is solar heat gain.

*Life in medium density housing in Tāmaki Makaurau / Auckland. Summary; Kathryn Ovenden, Melanie McKelvie; Auckland Council Economic and Social Research and Evaluation Team; 2024

Right image: Ngārara designed by First Light Studio. Photographer: Jason Mann Photography.

Terraced houses: A look into overheating

Fisher & Paykel Home Solutions has a dedicated design and thermal modelling team deeply involved in analysing and improving the thermal environment of buildings with an objective of reducing the operational carbon emissions of our built environment.

In this document, we are hoping to provide some tangible solutions, with specific data and case studies, to demonstrate the impact of considered design choices on the thermal environment of terrace homes. These design choices can have significant impact on the thermal comfort and energy use of terrace homes.

Most architects and builders understand the basic principles of thermal performance, but there is a lack of data connecting the theory and the performance outcome of these design choices.

This document sets out a few key principles and solutions appropriate for terraced homes, however, for your specific project, the Fisher & Paykel Home Solutions team can work closely with you from early concept stages to model the thermal impact of the design and make recommendations for improvements.

What is Fisher & Paykel Home Solutions?

Fisher & Paykel Home Solutions is a new offering from Fisher & Paykel Appliances. It is focused on integrated home energy and comfort systems that deliver on different goals, including: energy efficient, carbon zero and carbon positive* homes in Australia and New Zealand.

It combines front-end design consultancy, specification, hardware, installation and lifetime servicing all under one roof. Our goal is to deliver new design choices and coordinated systems that deliver warmer, drier, cooler and more energy efficient homes with reduced operational carbon footprints.

The Fisher & Paykel Home Solutions design service includes: thermal modelling and analysis, HVAC, solar and hot water design, specification and installation.

*https://www.yourhome.gov.au/live-adapt/zero-carbon as defined by the Australian Government in their Guide to Environmentally Sustainable Homes.

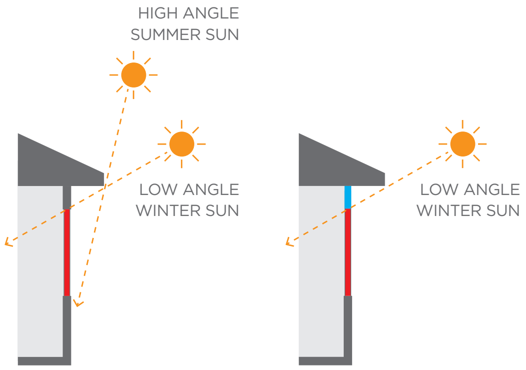
Top image: Neighbourhood project designed by Breathe Architecture. Visualisation by Gabriel Saunders

02. Solar shading: Eaves, awnings, screens and landscaping

Fixed shading devices: Eaves

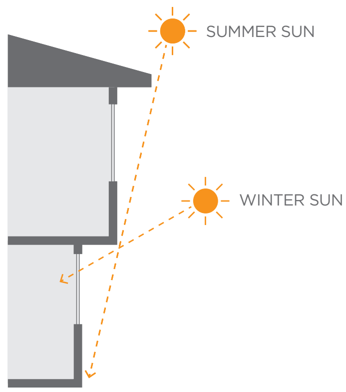
Horizontal solar shading can block out the high angle summer sun and allow the low angle winter sun into the building. One of the simplest ways this can be achieved is using eaves.

Not only do eaves provide solar shading, eaves also provide protection from the weather, which reduces weathertightness risk and allows occupants to make better use of natural ventilation by leaving windows open more often.



The specific depth of an eave to achieve good solar shading varies by project location, however it easy to calculate and BRANZ provides a good online resource to assist.* For reference, if a window is 1.2m in height and located 0.2m below the bottom of the eave, the eave depth for this window should be 0.34m in Auckland. The same window will need a 0.45m eave in Wellington and a 0.55m eave in Dunedin because the optimum angles of winter sun and summer sun change with the latitude of the building.

It is important to note that the window head should not extend to the underside of the eave, but rather be positioned lower than the eave. When the window head is at the same level as the underside of the eave, the top of the window never receives winter sun (shown in blue in the left diagram) and is only a source of heat loss during winter.



The form of the building can also be shaped to allow for a shaded deck area on the ground floor by extending the level above or allowing for a balcony. This allows for good solar shading, as well as a sheltered outdoor space.

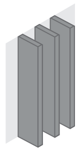
Fisher & Paykel Home Solutions has worked on townhouse projects, where trade-offs in cost between additional construction elements are balanced with reduced mechanical requirements. We can make recommendations of cost-effective small tweaks to optimise the thermal performance.

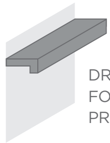
*https://www.level.org.nz/passive-design/shading/external-shading/

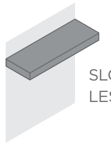
Fixed shading devices: Horizontal or vertical fins

In situations with tight footprints, where eaves will have too much detrimental impact on floor area, horizontal or vertical fins are a good option for select windows. It is important to calculate the required depth of the horizontal shading elements using the same methodology as for eaves and calculate the effective depth of vertical shading elements using thermal modelling.


STANDARD HORIZONTAL OVERHANG


VERTICAL LOUVERS OR FINS FOR EAST AND ESPECIALLY WEST FACADES

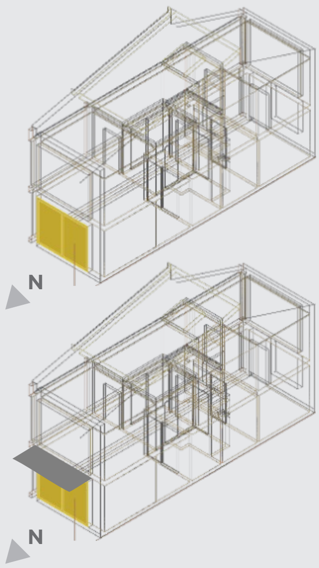

DROP THE EDGE FOR LESS PROJECTION


SLOPE IT DOWN FOR LESS PROJECTION

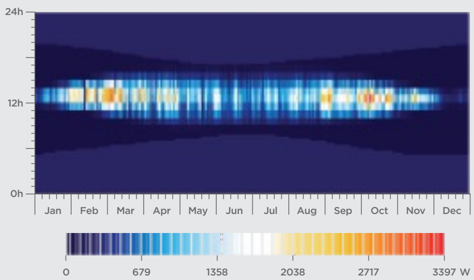
Case study: Melbourne townhouses

The effect of horizontal solar shading in a project on a north facing terraced house designed by Breathe Architecture.

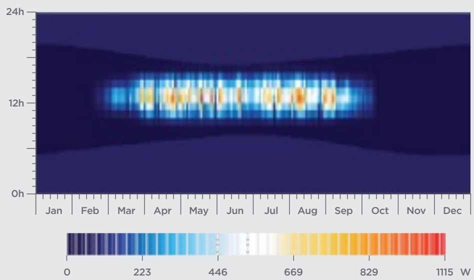
The graph below indicates the integrated direct solar radiation throughout the year on the sliding glass doors, with and without the shading element. As shown, the shading element can reduce the summer sun significantly while maintaining the winter sun exposure. The effect of the shading element in this model is predicted to reduce the peak summer temperature by 12°C in the living room and thereby reduce the cooling demand significantly.



NO NORTH OVERHANG



NORTH OVERHANG



User operated solar shading devices

User operated solar shading devices such as sliding screens or shutters can be more responsive than fixed devices as they offer the ability to change levels of shading to suit the occupant's needs. In winter, the occupants can keep glazing closed and the sliding screen retracted to allow sun. In summer, the occupants can keep glazing open and sliding screens closed to block sun while allowing natural ventilation, although this has a trade-off in terms of lowered levels of natural light and reduced views to the outside during summer.

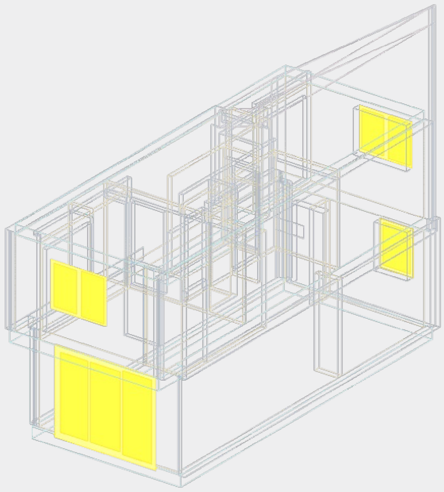
It is important that designers ensure these devices are easy-to-use and fabricated to be neither heavy nor difficult to move. Due to their movable nature, they often require more maintenance and can be more expensive than fixed options. However, when used correctly, they can achieve good levels of occupant satisfaction.

Left image: Toiora High Street Co-housing Project, designed by eHaus.

Case study: Māngere townhouses

In a large-scale terrace house project in Māngere, it was found during the design stage that the internal temperature of the upstairs bedrooms could exceed 25°C and overheat for up to 9.5% of the year. With the targeted addition of sliding external screens, we calculated it was possible to reduce the percentage of time that bedrooms overheated down to below 1%.

One of the principal advantages of user operated shading devices is that they can reduce the summer sun, without lowering the amount of beneficial winter sun. Alternative solutions such as reducing the solar heat gain coefficient of the windows will lower both the summer and the winter solar heat gain.

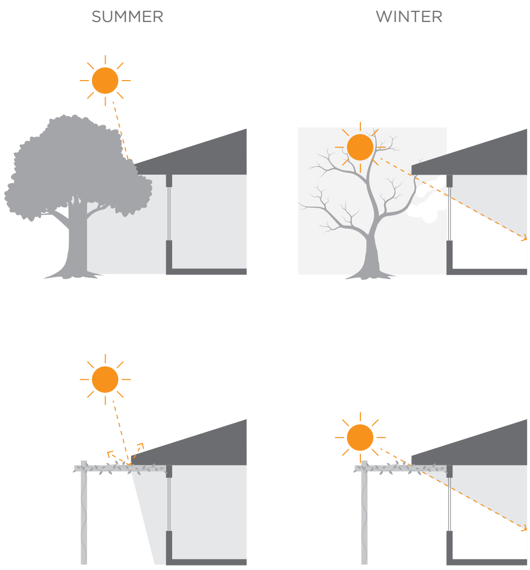


Solar shading through landscaping

Deciduous trees shed their leaves during winter. When deciduous trees are planted, they can block the summer sun and allow winter sun into the building. While the seasonality of deciduous planting will not match solar shading requirements precisely, they are a good way to utilise the area of the site which planning regulations require to be maintained as a permeable surface.

The landscaping can also take various forms, such as a pergola with deciduous vines. This will perform the same function and create a usable private space within the townhouse building typology.

Although deciduous planting is effective and aesthetically pleasing, it does require space for landscaping and can take time for trees to grow to a maturity to effectively shade. During this time, mechanical and other solutions may already be retrofitted. Trees and other landscaping can also be at risk of pruning or removal without consideration of the impact on building performance.



Top image: Inside Out House by Breathe Architecture. Photographer: Tom Ross.

03. Glazing design: Sizing and solar heat gain coefficient

Sizing

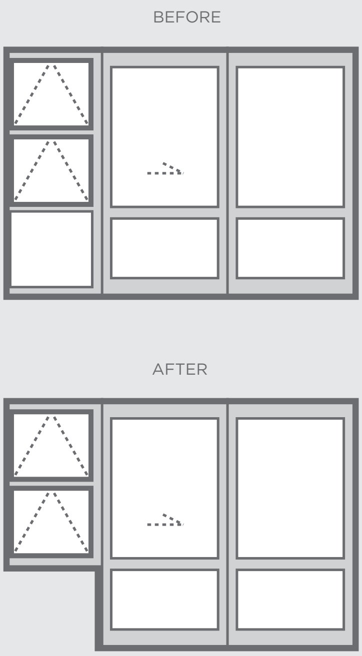
Windows in terraced houses are often designed to be large to maximise natural light and attract buyers. Conversely, this expansive glazing can contribute to overheating. Large, full height windows allow in a significant amount of solar heat gain. They are more difficult to shade with overhangs and do not allow for privacy.

It is important to carefully consider the amount of glazing and sun angles when designing the ratio of window height compared to shading devices. Fisher & Paykel Home Solutions can work with you on modelling window sizing, and make recommendations for reductions that optimise cost, aspect and solar gain.

Left image: Ngārara designed by First Light Studio. Photographer: Jason Mann Photography.

Case study: Māngere townhouses

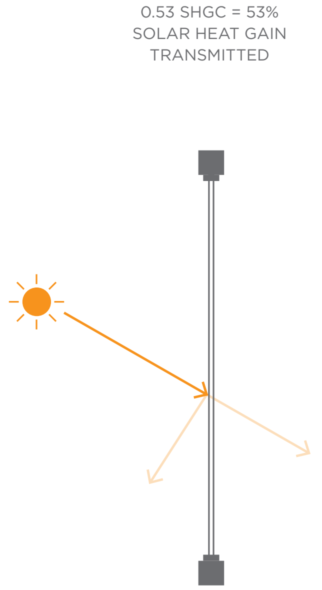
In a recent South Auckland townhouse development for Housing Foundation, we were able to reduce the incident solar radiation by 15.6% on the north facing glazing shown below by removing a fixed portion of glazing. This reduction in solar radiation improved summer comfort while also providing added privacy.



Solar heat gain coefficient

The New Zealand Building Code clause H1, which deals with energy efficiency specifies minimum standards for insulation in the building envelope, including R values for glazing. This regulates the heat flow into and out of the building in terms of conduction, however, does not account for heat flow through radiation. In New Zealand, there is no framework for regulating the heat flow into a building through solar radiation.

The amount of solar heat which can pass through glazing is measured by the solar heat gain coefficient (SHGC). If a window gets too much sun through summer and the room overheats, a Low-E window with a low SHGC can help to keep the room cooler. If the window is well shaded and receives largely beneficial winter sun, a window with a higher SHGC can allow more winter solar heat gain.

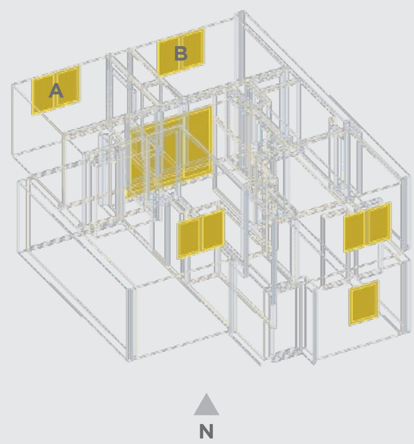


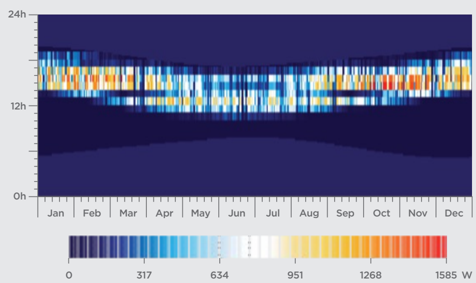
A HIGH SHGC ALLOWS A HIGH LEVEL OF SOLAR GAIN.
A LOW SHGC ALLOWS A LOW LEVEL OF SOLAR GAIN.

Case study: Māngere East townhouses

In another townhouse development which we modelled in South Auckland, we were able to halve the number of hours a northwest facing bedroom overheated by reducing the SHGC.

The graph below indicates the integrated direct solar radiation on the north-west facing bedroom glazing (labelled A and B) in a four bedroom townhouse unit. The glazing received evening sun with the highest levels of exposure concentrated in the summer. This exposure caused the bedrooms to overheat for over 751 hours per year. Introducing a Low-E coating which reduced the SHGC to 0.39 was able to reduce this to 341 hours per year.



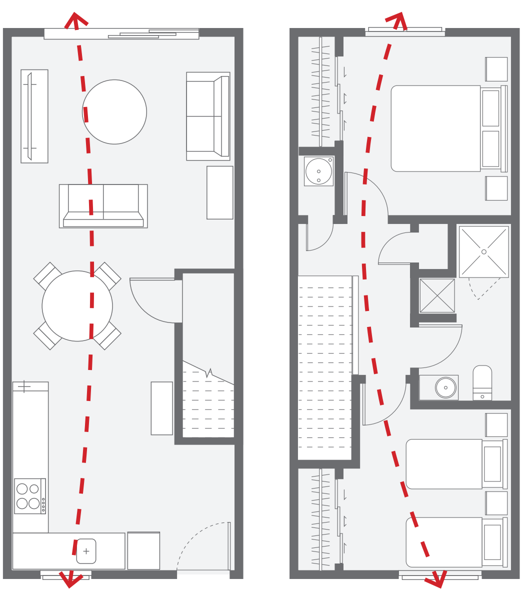


04. Ventilation: Natural, mechanical and ceiling fans

Natural

Ventilation is key in promoting air movement, shifting hot, still and polluted air out of the building, and replacing it with fresh air.

To create natural ventilation, the openable area of windows should be maintained. As the townhouse layout does not typically allow for opening windows on two opposing sides of the same room, it is advisable for occupants to allow flow through ventilation by leaving doors open. Designers should consider air flow in the planning of upper storey layouts, making way for an uninterrupted path of fresh air from front to back through windows.



The various types of windows have trade-offs in terms of openable area, infiltration, security and weather protection.

WINDOW TYPES

Like slide shading, natural ventilation is often controlled by the occupant. Where possible, natural ventilation should be designed to require low involvement from the occupant.

AWNING, CASEMENT AND SLIDING WINDOWS

Awning windows, which open from the bottom provide decent protection from weather, and if coupled with eaves and stays, will usually be able to stay open in most weather conditions and remain secure and safe.

Casement and sliding windows are difficult to protect from rain, and the impact is that occupants tend to not open them because of the need to close them when the weather turns, reducing the real benefit of ventilation. With good eaves, these concerns can be mitigated.

When used on the upper levels of terraced houses, designers need to ensure that a small child cannot fall through the window to comply with the building code. This is often done by limiting the openable area with the use of restrictors, however the restrictor also severely limits the openable area and the amount of natural ventilation possible.

LOUVRE WINDOWS

Louvre windows have the largest openable area and allow the highest levels of airflow for natural ventilation, whilst also being weather protected. In the past, louvre windows have not been as well sealed as other window types and designers should pay attention to selecting modern louvre windows with seals around each louvre blade. In particular, the infiltration rate of louvre windows should be considered. High infiltration rates will lead to reduced levels of building airtightness, which decreases the efficiency of any heating, cooling or heat recovery ventilation system.

The selection of louvre windows has become more complex with the increased R values in the new H1 requirements. To make louvre windows compliant, the calculation or modelling method will likely be required for H1 compliance and there can be trade-offs such as increasing the R values elsewhere in the building envelope to compensate.

Within the townhouse typology, high performing louvre windows with low infiltration rates can be a viable solution, especially for the upper levels. On the upper levels, they can ensure safety from falling without restrictors and thereby allow adequate natural ventilation.

Mechanical

Mechanical heat recovery ventilation (MHRV) can be a low-energy solution to support moving hot air from upper levels and replacing it with fresh, cooler, air.

MHRV systems are primarily ventilation systems that simultaneously supply outside air into a building and extract stale air out of a building, while also exchanging heat between the two airstreams. This is becoming more important as new building practices and materials are ensuring that newly built homes are achieving better levels of airtightness. In the absence of good ventilation, this increase in levels of airtightness can have the unintended consequence of reduced indoor air quality. MHRV systems can improve indoor air quality by reducing indoor contaminants and moisture levels.

MHRV systems can recover over 85% of the heat from the warmed indoor air, providing significant energy savings. The ability to lower indoor air temperatures is a secondary benefit of the system, however it should not be overlooked. When the internal temperatures are higher than comfort conditions in summer, they are also able to supply cooler outside air into the space in bypass mode. This process of supplying unconditioned outside air into the space is termed "free cooling" in the air conditioning industry.

A limitation of MHRV systems is that they require ceiling space for the ducting, which in some terraced homes is limited aside from the upper levels if there is a roof space. A MHRV system is also difficult to retrofit due to this reason and should be integrated during the building design phase.

Right image: Haier ERV system

Fisher & Paykel Home Solutions can design and specify HVAC systems, including MHRV systems that are aligned with the projected thermal performance of each project.

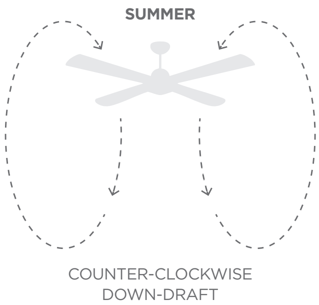
Ceiling fans

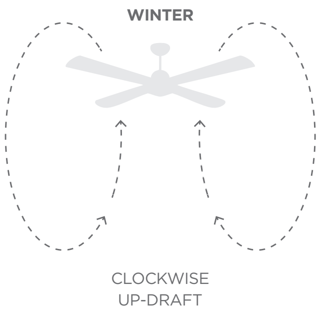
Ceiling fans consume significantly less energy to run than active cooling or heating systems. They are cost effective solutions which can be used in both summer and winter. This is a fact which is often overlooked in New Zealand.

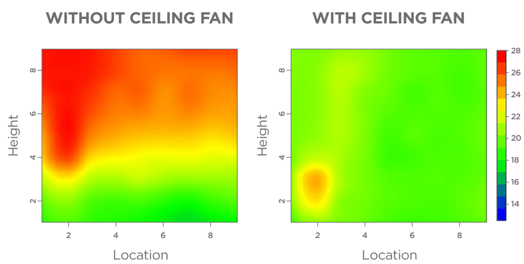
During summer, the ceiling fans provide a sensation of cooling through air movement along our skin. This is called the wind-chill effect and simulates 2°C of cooling. To make the best use of this effect, ceiling fans should be run concurrently with the active cooling system if one is installed. This will allow the user to set a higher temperature set point on the cooling system. For example, if the comfort temperature on an active cooling system is set as 22°C during summer, it is possible to increase this to 24°C while the ceiling fan is running. This difference in temperature set point in the active cooling system will save considerably more energy than that consumed by the ceiling fan.

During winter, the ceiling fans should be run in winter mode and operate concurrently with the active heating system. This mode allows the fan to spin slowly and circulate air within the space.

Without the ceiling fan, the air that is heated by the active heating system will naturally rise and accumulate at the top of the space. The system will condition the space to a higher temperature such as 26°C at the top of the room, to achieve a set point temperature of 18°C at the occupied lower levels of the room. With the ceiling fan operating, it will circulate this heated air towards the lower levels of the space. This saves considerable energy as the heated air is distributed evenly and the heating system does not waste energy over conditioning the space. The effect is particularly strong in spaces with high ceilings and large internal volumes.







Left diagram: The summer mode simulates -2°C of cooling with a wind chill effect. The winter mode circulates heated air from the top of the room to the bottom.

Top right image: Forecourt House designed by Breathe Architecture. Photographer: Tom Ross.

Right diagram: Thermal diagram showing the impact of ceiling fans, reproduced with permission from Consumer NZ. https://www.consumer.org.nz/articles/use-your-ceiling-fan-for-cheaper-heating

05. Product solutions

In addition to thermal modelling and analysis, the Fisher & Paykel Home Solutions team can design and specify energy-efficient products, including Haier air conditioning, ventilation, and heat pump hot water systems.

With terraced housing, the constraints of the site, orientation, and construction may mean that additional heating or cooling is still required.

HAIER AIR CONDITIONING AND VENTILATION

- 40+ years of expertise in cooling and heating
- World's #1 connected air conditioner brand in 2023*
- World's #1 healthy Self-Clean air conditioner brand in 2023**
- More than 250 models across residential and commercial

HAIER HEAT PUMP WATER HEATING

- Manufactured hot water systems since 1986
- Over 5M heat pump hot water systems sold
- Efficient and effective hot water supply year-round

*Claim: Haier is the number one brand of connected air conditioner (including smart air conditioner) in the world in terms of retail sales volume in 2023. Data source: Euromonitor International Ltd., measured in terms of retail sales volume in 2023, based on research completed by February 2024. Connected air conditioner is defined as air conditioners with connectivity capability to communicate with other appliances and/or other devices and/or consumers.

**Claim: Haier is the number one brand of healthy Self-Clean air conditioner in the world in terms of retail sales volume in 2023. Data source: Euromonitor International Ltd., measured in terms of retail sales volume in 2023, based on research completed by February 2024. Healthy Self-Clean air conditioner is defined as the air conditioners which can processes frosting (freezing), peeling off, defrosting, discharge sewage, and high temperature heating (56°C and above) in turn, to clean the heat exchanger (evaporator) and realise the health self-cleaning function. And it is one of the key marketing claims of the air conditioner, usually ranked one of the top 5 in the marketing manual.

Top right image: Haier Quartz Plus (Heating and Cooling) Wall Mounted Split System

Bottom right image: Haier Monoblock Heat Pump Water Heater

06. Conclusion

It is often prohibitively expensive to fix the core issues behind overheating once the terraced house is built. Occupants are then forced to implement retrofitted solutions such as active cooling systems. The problem should instead be addressed during the design phase through thermal modelling, which can identify an appropriate solution for each individual house.

The benefits of increased occupant comfort, lower energy consumption and reduced carbon emissions can be realised through good design. The comfort is especially important because many townhouse occupants can be families with young children and elderly retirees looking to downsize. These are both groups of people who benefit greatly from temperature regulated spaces.

Further steps

The solutions in this guide are not an exhaustive list. They are the solutions which through our experience can have a significant impact for the terraced house building typology.

Reducing the energy demand through thermal modelling is the first step within the Home Solutions design process. We can further reduce the energy demand by introducing energy efficient heat pump hot water systems, HVAC systems and appliances. We can also provide renewable energy solutions with a complete solar system to offset part of the energy consumed.

An important note

While we are suggesting design improvements like eaves, it is important to recognise that current planning regulations have contributed to the avoidance of eaves. In order to maximise usable floor space, designers are often made to choose between eaves and complying with regulations such as heights-in-relation-to-boundary and impervious area requirements. Likewise, safety regulations in the Building Code around falling from heights requires restrictors on open windows on upper levels. This has the unintended consequence of restricting the openable area of windows and reducing natural ventilation.

We would suggest that for widespread uptake of best thermal design practice, the interactions between sections of the New Zealand Building Code should be reviewed with a holistic view of contemporary building types, and clear goals of what we are aiming for with our new building stock. Until then, design practitioners will be placed in the unenviable position of trying to navigate conflicting requirements.

The information provided here is of a general nature and not intended to be used in any construction or renovation project. Before embarking on any construction or renovation project please consult an appropriately qualified professional.

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