The avoidance of overheating

HC2: Summer Comfort

HC3: Ventilation

Fundamentals of overheating

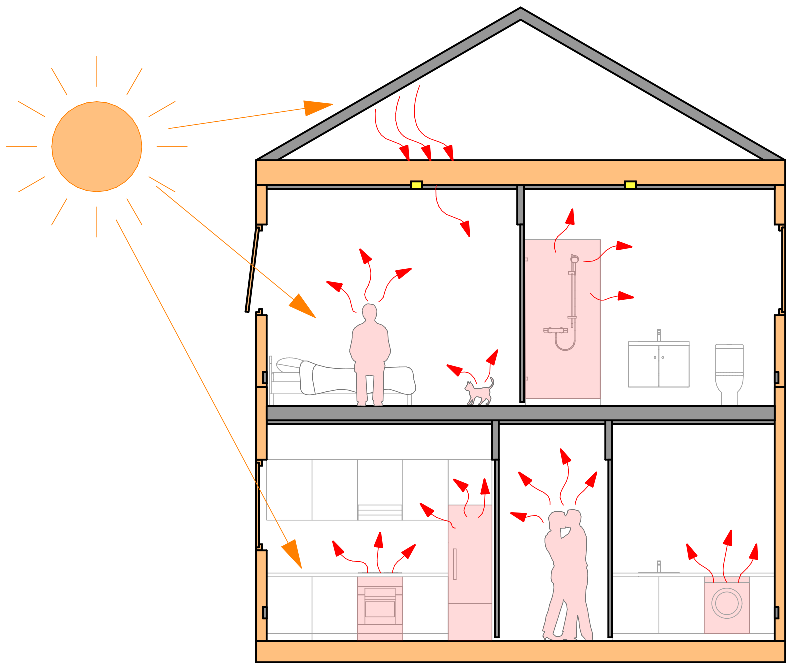
The indoor temperature starts rising when the net heat gain exceeds the net heat loss. When the temperature exceeds 25 degrees C, it is defined as overheating in ECCHO and the Homestar Summer Comfort credit. The maximum allowable frequency of overheating is represented as a percentage of the year for each star band.

Sources of heat gain include
- Solar gain through windows, walls, and roof on sunny days
- Internal heat gain (occupants and appliances)

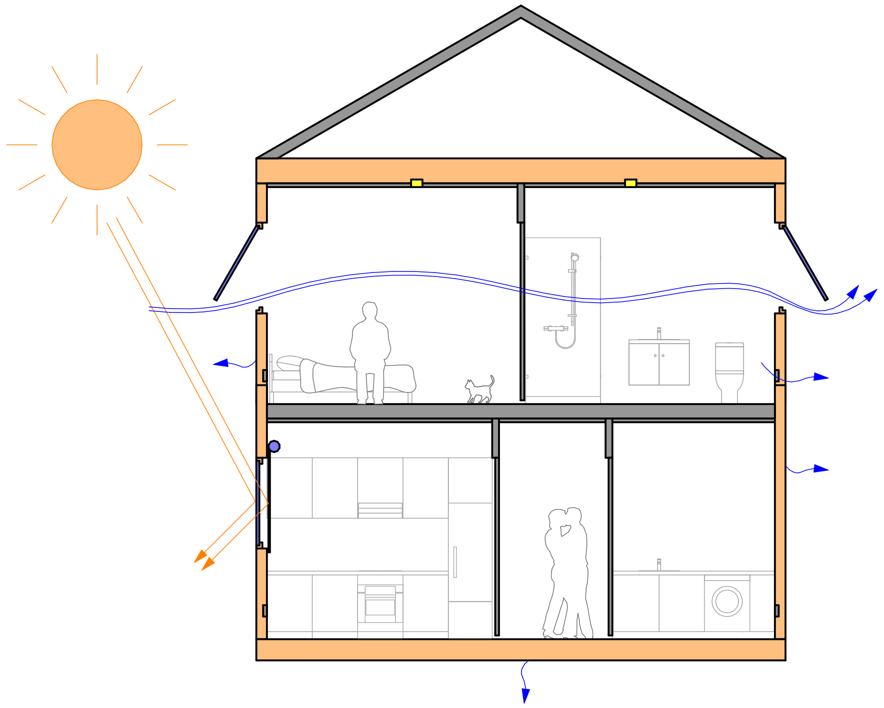
Sources of heat loss include
- Transmission heat loss through floor, wall, roof, and windows
- Natural ventilation
- Ventilation systems and uncontrolled air leakage

In this design guide, we will focus on some effective ways of reducing overheating.

1. Shading design
2. Glazing selection
3. Summer window ventilation



Heat gain sources

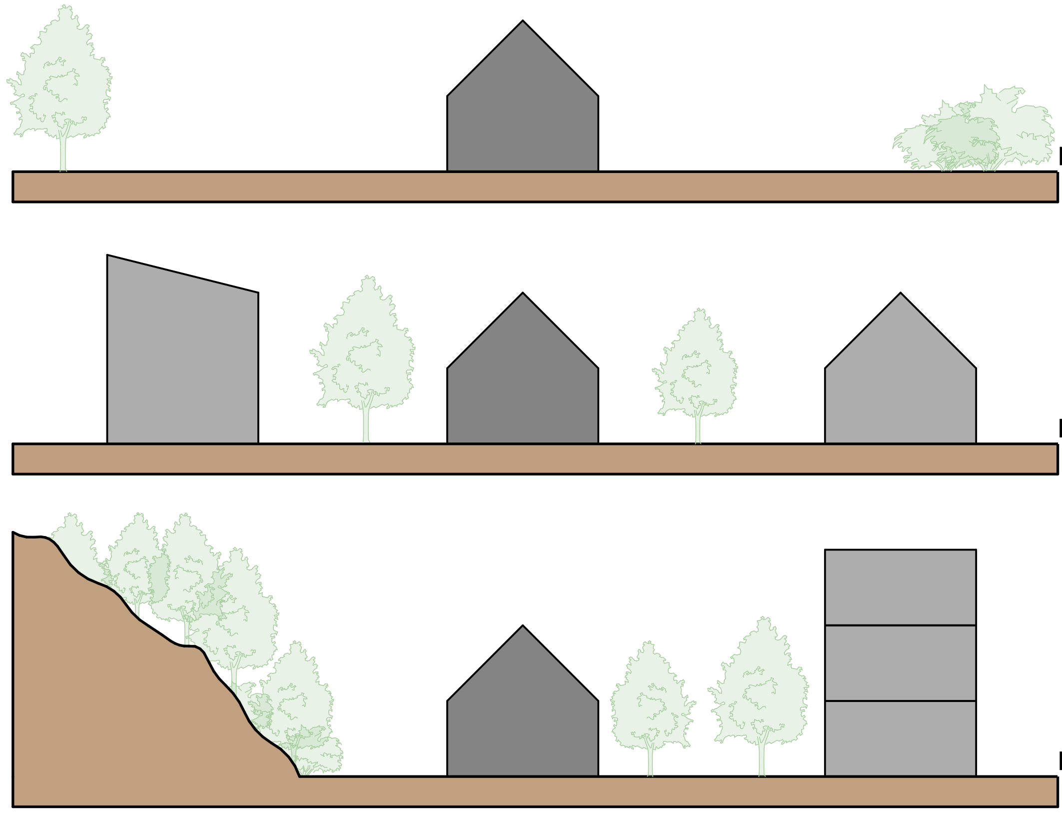


Heat loss sources

Shading - its importance and how to quantify it

Shading can have a significant impact on the performance of a building. We rely on certain levels of ‘free’ solar gain from the sun to reduce the amount of additional energy required to heat the building up. If there is something blocking the sun - a mountain, a tree line, a fence or a neighbouring building for example, we are getting less ‘free’ heat, so need to add more energy.

The other side of this is overheating - in summer we will likely need to reduce the amount of solar gain to prevent the building getting too much heat energy, which will result in overheating. To this end, correctly understanding the amount of shading related to the site is very important.



Lightly shaded site

Modestly shaded site

Heavily shaded site

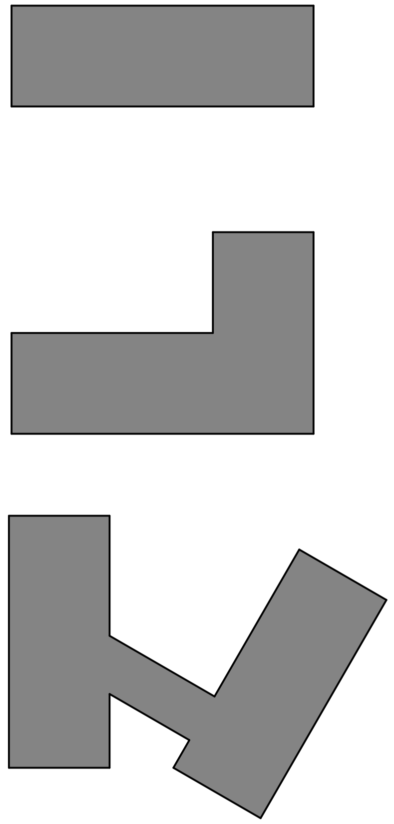
Site shading

Site shading generally refers to shadows cast by the surrounding terrain, neighbouring buildings, landscape features on the horizon. Urban plots will contend with neighbouring buildings, and future buildings around it, as well as fences, gardens, etc. Rural plots will likely have fewer buildings, but more forests, bush, mountains and hills.

We can assess this shading with a variety of tools:

- Site photos - scale trees, buildings and immediate surroundings
- Google Earth Pro - to find the horizon shading using a path
- Topographical surveys & council maps.

Using a combination of these we can usually make a reasonable approximation of the surrounding shading levels. However, with more complex sites it may be necessary to utilise other software to assess the shading - PHPP, DesignPH or dynamic modelling software for example.



No self-shading

Some self-shading

Major self-shading

Self-shading

Self shading generally refers to shadows cast by the building itself including, but not limited to, building form, wing walls, external shading screens, etc.

Note: Overhangs are technically a form of self-shading, although these are calculated separately in ECCHO. Overhangs are most effective to the north. Sun angles to the east and west are relatively lower, therefore overhangs are less effective.

Note: Fixed louvres and screens are calculated as part of self-shading.

Window treatment

Window treatment generally refers to blackout internal blinds and curtains. External blinds are generally excluded in Homestar due to the variety of the external blind types and fabric perforation. Window treatment can work well, but due to their reliance on occupant behaviour can’t be as relied upon, compared to an effective self-shading design. For this reason we only allow a slight improvement with the installation of the blinds. Any design that fails badly for overheating will not pass solely by the installation (or use) of blinds.

Accounting for shading in ECCHO

ECCHO has two inputs to help quantify the amount of shading on glazing, which are included in the dialogue for each window and door:

1. Overhang (calculated window by window)

The way to quantify overhangs is documented in Homestar v5 technical manual. Simply enter the "shading depth" and "shading height" of any soffits, balconies, etc above each unit according to the manual guidelines, so that the correct amount of overhang shading is calculated for each joinery unit.

2. A reduction factor for winter and summer as a percentage

This refers to the amount of sunlight that isn't prevented from reaching the building by surrounding buildings, trees, hills, etc.

The reduction factor default values are 80% for winter and 90% for summer. However these figures are quite approximate and don't allow for higher or lower levels of shading in different site contexts, or more complex building forms. Using these can result in less accurate heat gain and overheating results, which can lead to incorrect design decisions, e.g. an over reliance on natural ventilation or the incorrect choice of the type of low-e glass. If this happens, the end user comfort can be significantly impacted.

The following tables and worked example in this chapter aim to help Homestar professionals meet the overheating targets, and make better decisions on shading design.

To better estimate shading in ECCHO, we can break the single percentage down to three categories:

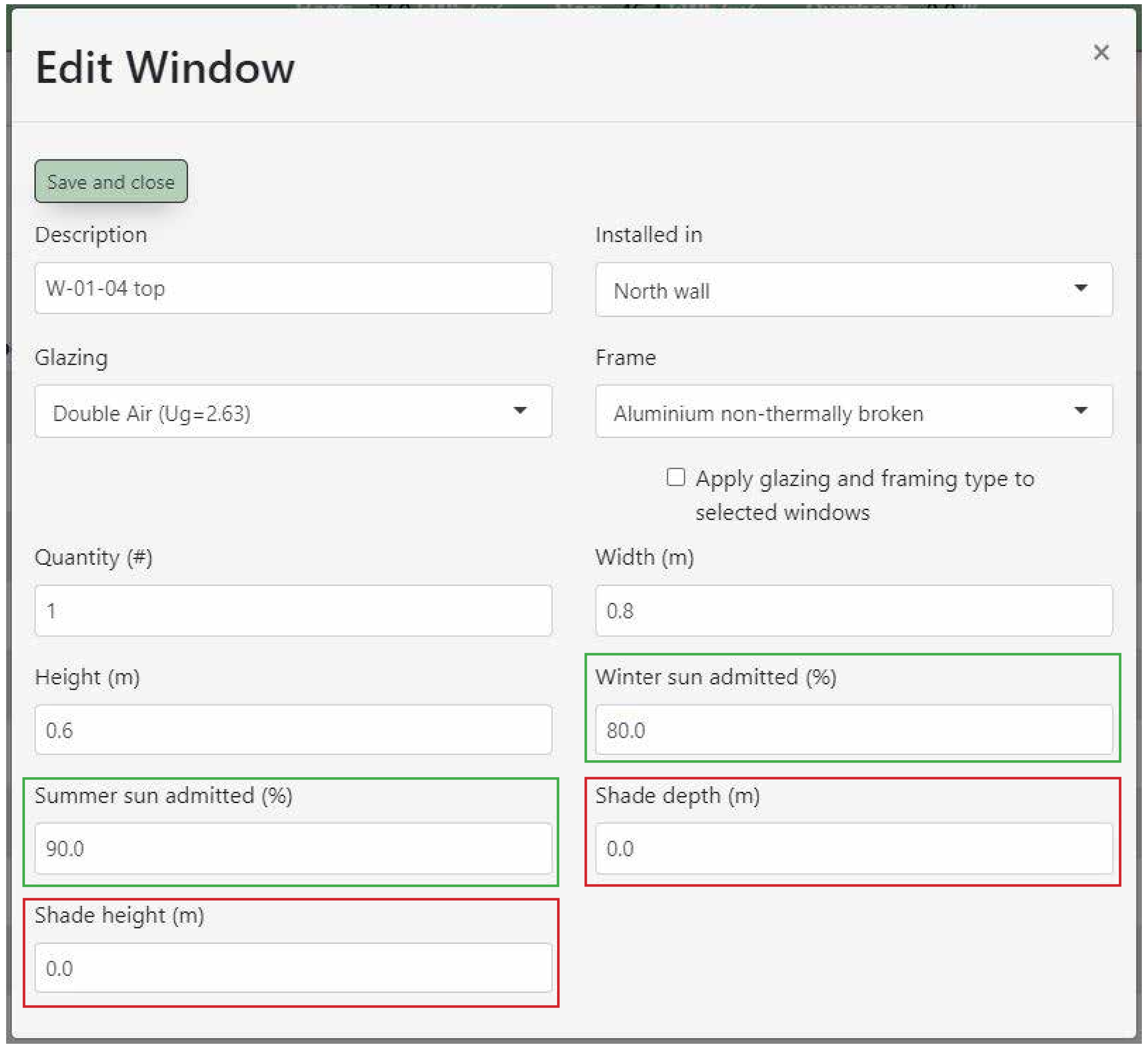
A: Site shading – terrain, neighbouring buildings, landscape feature
B: Self-shading - building form, wing walls, shading screen
C: Temporary shading (summer only) – Internal window treatment - including this is optional

We can then use these three categories to calculate more accurate shading percentages:

Winter sun admitted (%) = A% X B%

Summer sun admitted (%) = A% X B% *X C% (optional)*

The table on the following page provides percentages for each category.



The joinery input dialogue box from ECCHO

ECCHO shading percentage categories

Site shading					
Lightly shaded		Modestly shaded		Heavily shaded	
Winter	Summer	Winter	Summer	Winter	Summer
90%	100%	80%	90%	70%	80%
Typical cases: - Houses in an open field without large hill or dense bush around - Upper storey apartments with the surrounding building being the same height or lower		Typical cases: - Houses or multi-unit dwellings in a neighbourhood with similar types of housing next door. - Middle storey apartments with other 3-storey apartments across the street		Typical cases: - Single story house with 2-storey neighbouring buildings or established trees around. - Ground floor apartment with other 3-storey apartments across the street	
Note 1: Site shading generally has smaller impact in summer due to higher sun angle. Overhang, on the contrary, has greater impact in summer typically. Note 2: Typical site shading reduction factors are sourced from multiple PHPP energy models based on the 4 case study buildings in different site context.					

Self-shading		
Box form	L-shape form or similar	Complex form
100%	90%	80%
Typical case: - Houses or multi-unit dwellings that are simple, rectangular shape without additional shading screen. - Most apartment units	Typical cases: - Houses or multi-unit dwellings that are not in rectangular form. - Single sided apartment units with recessed balcony	Typical cases: - Houses with pavilions and links - Any building type with extensive use of shading screen
Note 1: Typical self-shading reduction factors are sourced from 3 DesignPH models, certified by Sustainable Engineering, to best reflect the average reduction factor for each level of complexity.		

Temporary shading (summer only)	
White outer facing internal blind or curtain on double low-e argon filled glazing	White outer facing internal blind or curtain on triple low-e argon filled glazing
60%	70%
Note 1: window treatment with other colours may not be quantified using ECCHO as the shading effect is largely dependent on the darkness. Note 2: window treatment must be installed and verified during Built Rating if temporary summer shading is included in ECCHO. Note 3: Typical temporary shading devices with insulated triple and double glazing are sourced from PHPP_10_EN_Manual and modified to provide conservative reduction factors.	

Worked example 1

Case study 02 is in a subdivision with similar houses as close as 4m to the rear, but further away on the front and sides.

There are some established trees but no dense woodland or bush. The house's attached garage mean the form is considered similar to an L shape. Internal blinds are proposed on the bedroom windows to block the full moon, or sun in daylight hours.

- Winter % for all windows = 80% x 90% = 72%

- Summer % for bedroom windows = 90% x 90% x 60% = 48.6%
- Summer % for other windows = 90% x 90% = 81%

- Overhang = as per calculation window by window

Worked example 2

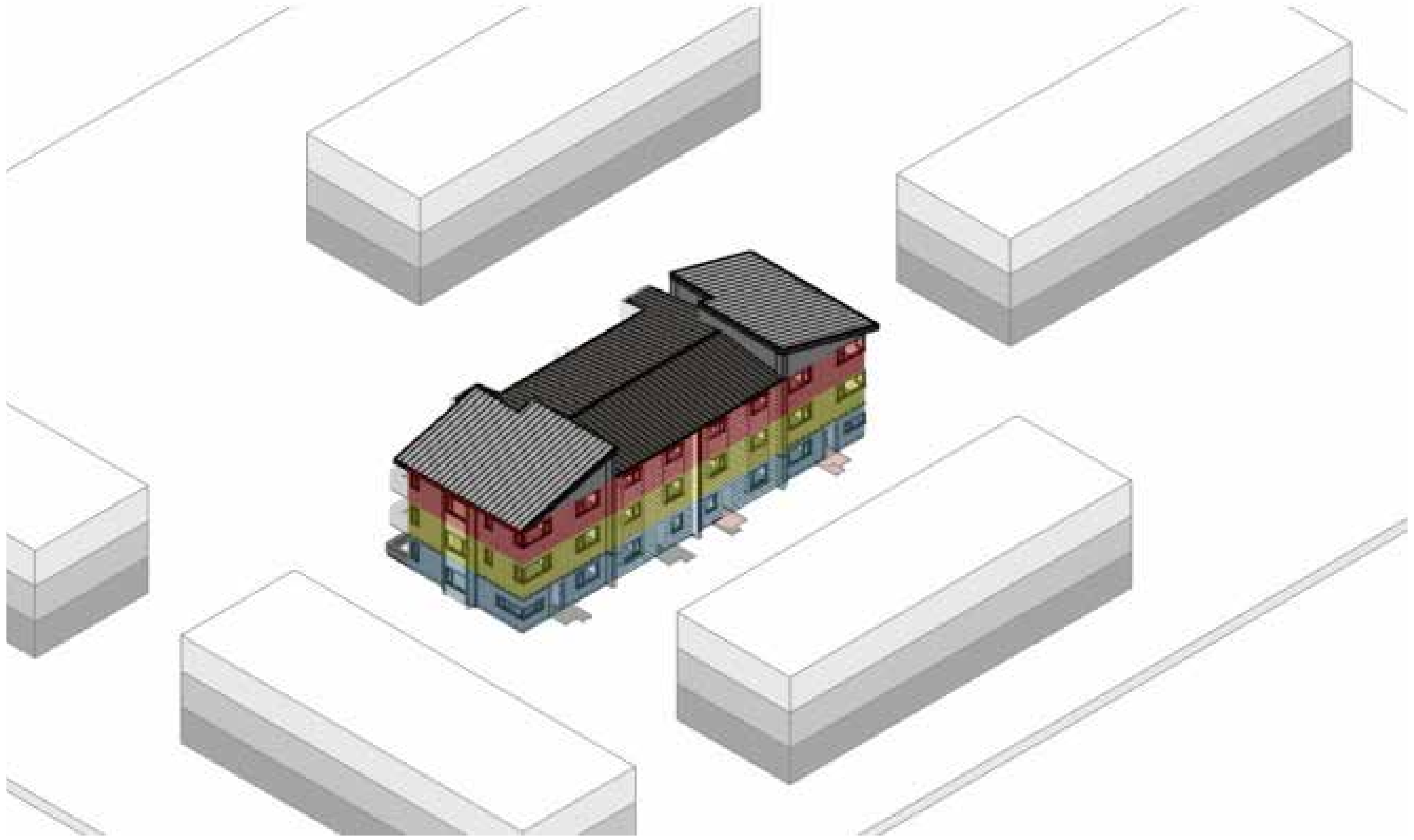
Case study 04 is in a new medium density zone, with other 3-storey walk-up apartments across the street, and across a large courtyard or car park.

Each apartment unit is considered as a rectangular shape with little to no self-shading effect on most windows. Internal blinds are proposed on all windows for privacy reasons.

- Winter % for ground level units = 70% x 100%=70%
- Winter % for first floor units = 80% x 100% = 80%
- Winter % for top floor units = 90% x 100% = 90%

- Summer % for ground level units = 80% x 100% x 0.6% = 48%
- Summer % for first floor units = 90% x 100% x 0.6% = 54%
- Summer % for top floor units = 100% x 100% x 0.6% = 60%

- Overhang = as per calculation window by window



Glass selection

Low-e coatings, edge spacer, filled gas

The glass in your windows can have a large impact on your overheating levels in summer. Low-E coating to the glass reduces solar gain from the outside and increases the reflection (preservation) of infrared (heat) from the inside. Despite Low-E glass always achieving better overall energy balance compared to conventional glazing, it does limit the solar gain in winter as well. This must be tested in ECCHO to help inform the optimal balance for it to passively enhance your summer and winter comfort.

Considerations for overall glazing performance:

g-value

- Higher g-value = more solar gain = good for winter but bad for summer.
- Also called the SGHC (Solar Heat Gain Coefficient) this is a shading factor that tells you how much total solar radiation the glass lets through. For example, a g-value of 0.57 will let through 57% of the solar radiation, while a g-value of 0.35 will only let through 35%.
- g-values are provided by the low-E coatings on the glass. This is a thin layer of silver or other low emissivity material, that reflects a percentage of the total solar radiation from the outside away and keeps a percentage of the total infrared from the inside within the space.
- The g-value is not tied to the amount of visible light the glass lets through (the VLT) however once you start getting to very low g-values the glass may start to appear darker.

U-value

- Higher U-value = lower R-value = less insulating = bad for both winter and summer
- This is the thermal performance of the glass and is a result of the space between panes, number of panes and the type of gas between the panes in double or triple glazing. Note: choosing a less insulating glass is NOT a good way to reduce overheating.

Filled gas

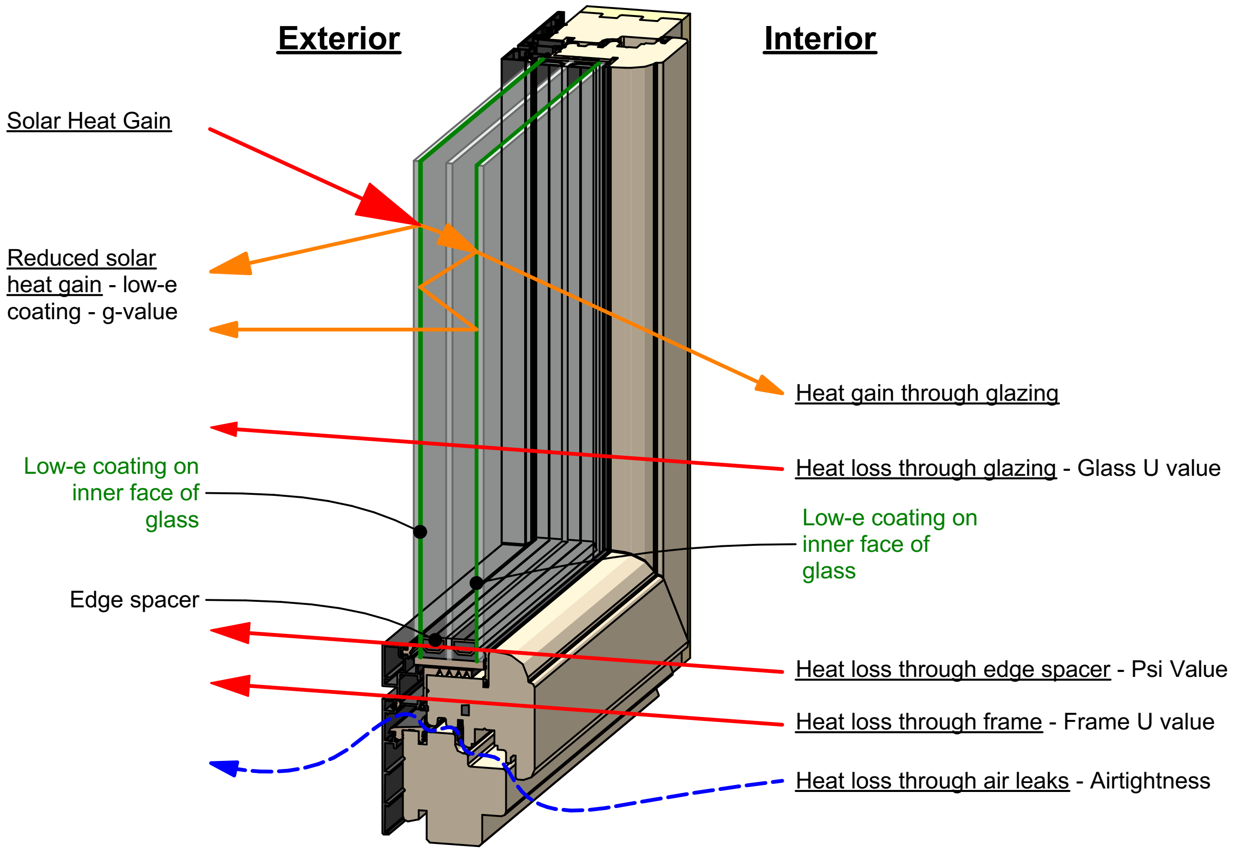
- Argon or Krypton filled glass = lower U-value = higher R-value = good for both winter and summer compared to conventional uncoated glass

VLT

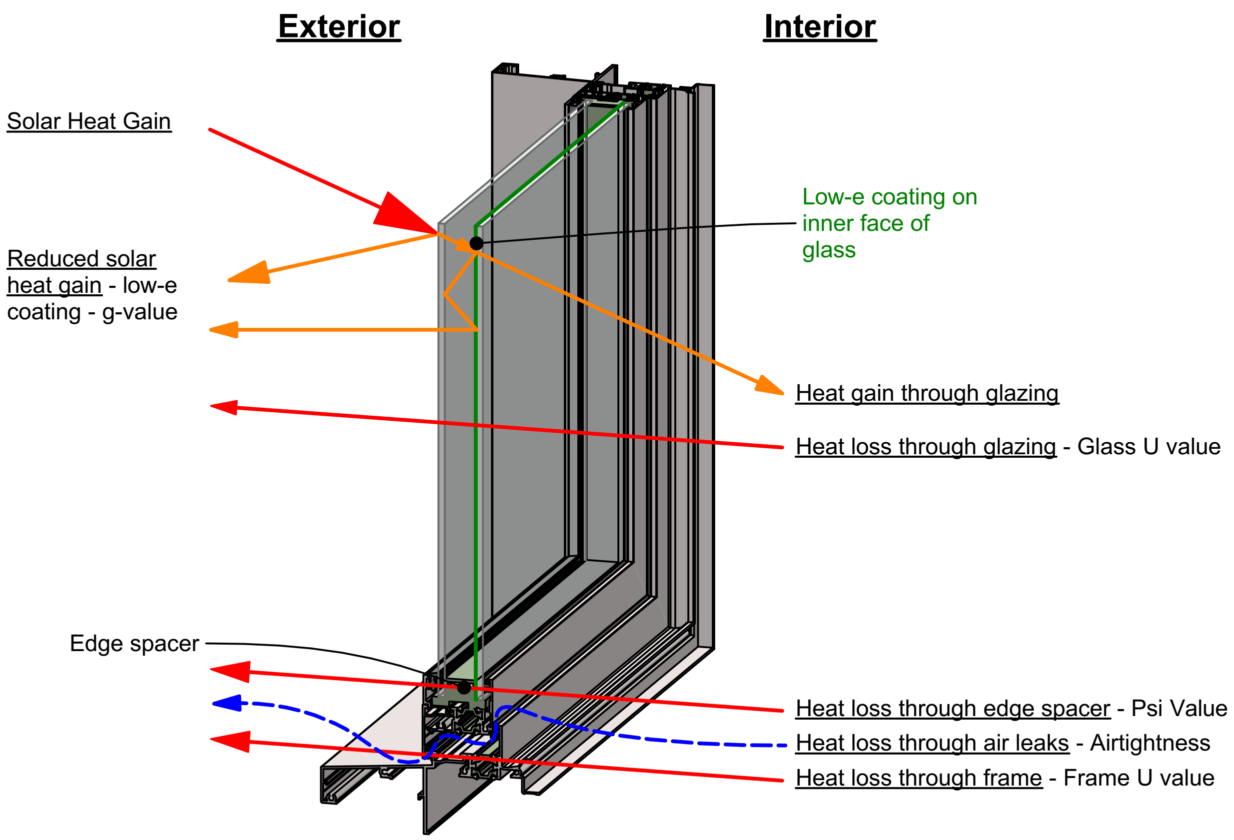
- Higher VLT = a visually brighter room
- The lower the value the less visible light will come through, although this is not proportional to the total solar radiation that comes through the glass, which is reflected by g-value.

Edge spacer and its psi value

- Aluminium spacer = higher heat loss = condensation around glazing edge.
- Warm edge spacer = less heat loss = reduced or no condensation around glazing edge.
- The psi value is a correction factor for the thermal bridge, or overlap between the frame, the glass and the edge spacer, to account for the heat loss at this junction.



Tilt/ turn timber window



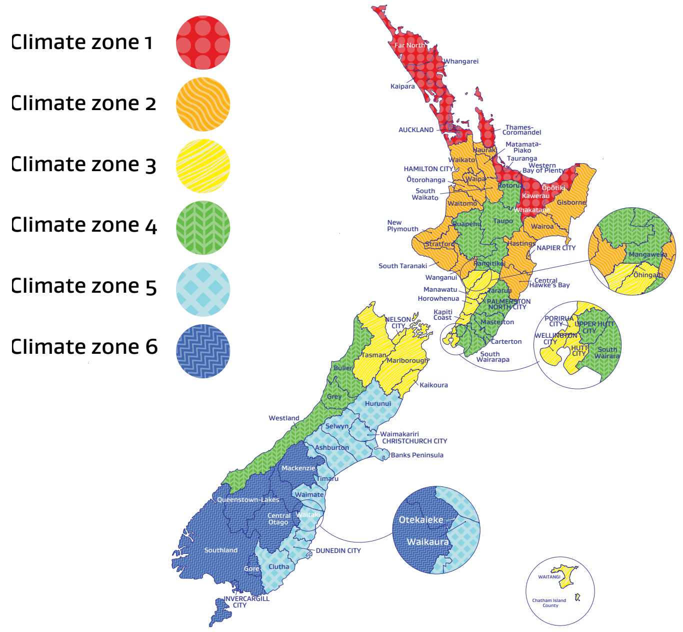
Awning aluminium window

Glass selection for each climate

The table below shows which glazing options can be used as a starting point for preliminary ECCHO models in selected climate zones. The default glazing options in ECCHO are consistent with Table E1.1.1 in H1/AS1, which makes it easy to combine the Homestar and compliance considerations together to streamline the process.

For Homestar projects with a good margin for both heating demand and overheating, the ECCHO default glazing options could be used rather than sourcing manufacturer specific data. However this will limit the chance of achieving the optimal energy balance in both summer and winter.

Obtaining specific glazing data from manufacturers, and testing these in ECCHO, will still be necessary for any project with a higher overheating potential, or if a specific low g-value glazing is proposed.



Type of glazing	ECCHO default equivelant	g-value	U_g (1)	Spacer type (2)	Example IGU(3), (4) (informative)	R_{window} (m^2·K/W) for different frames: Aluminium frame	Thermally broken aluminium frame	uPVC frame	Timber frame	Rule of thumb choices for prelimanary ECCHO model
Double pane	**Double Lowe Arg Best**	**0.57**	1.30	Thermally improved	Glass: Low E_3/Clear Gas: Argon	R0.35	R0.46	R0.63	R0.71	**HS6 for Climate Zone 1-3**
	Double Lowe Arg Exceptional	**0.54**	1.10	Thermally improved	Glass: Low E_4/Clear Gas: Argon	R0.37	R0.50	R0.69	R0.77	**HS6 for Climate Zone 4-6** **HS8 for Climate Zone 1-3**
	Double Lowe Krypton	**0.37**	0.90	Thermally improved	Glass: Low E_4/Clear Gas: Krypton	R0.40	R0.54	R0.76	R0.85	**May be triggered by overheating requirement in any climate**
Triple pane	**Triple Lowe Arg Best**	**0.47**	0.70	Thermally improved	Glass: Low E_3/Low E_3/ Clear Gas: Argon		R0.59	R0.86	R0.95	**HS8 for Climate Zone 4-6**
	Triple Lowe Arg Exceptional	**0.43**	0.60	Thermally improved	Glass: Low E_4/Low E_4/ Clear Gas: Argon		R0.62	R0.91	R1.01	

H1/AS1 glazing table and it's ECCHO/Homestar equivalent

Low E Xtreme Double Glazing

Low E Xtreme - Argon - Clear - Thermal Spacer

	Building Code Acceptable Solution H1/AS1 Schedule (see schedule notes) — Window System Material Type by Climate Zone				EN 673 Heat Loss & Condensation	EN410 Visibility			EN410 Heat Gain		
					Ug²	VLT³	VLR-E³	VLR-I³	SF³	SC³	LSG³·⁴
Make-up mm¹	Standard Aluminium	Thermal Break Aluminium	uPVC	Timber	U Value	Visible Light Transmission	External Reflectance	Internal Reflectance	Solar Factor (g)	Shading co-efficient	Selectivity
4-16-4	Zones 1-6 Stage One	Zones 5-6 Stage Two	Zones 5-6 Stage Two	Zones 5-6 Stage Two	1.0	75%	14%	14%	41%	0.47	1.87
4-18-4	Zones 1-6 Stage One	Zones 5-6 Stage Two	Zones 5-6 Stage Two	Zones 5-6 Stage Two	1.1	75%	13%	14%	40%	0.46	1.87

Edit glazing type

Save and close

Description: Metro Low-e Xtreme 4/16/4

$U_{glazing}$: 1.0

g value: 0.41

How to create your own glazing option in ECCHO based on glazing manufacturer's datasheet

Summer window ventilation and night purging

As discussed in the ventilation chapter, windows cannot be solely relied on to provide the minimum required ventilation. Nevertheless, they can be used to ensure user comfort and provide additional ventilation to mitigate overheating.

During the day in summer when the exterior temperature is high and the air often humid, we don't really want to open windows and bring this in. However, they can be used to provide air movement which creates a feeling of reduced heat, and in the evenings and night when the exterior temperature drops, we can use open windows for 'night purging', that is, removing excess heat that has built up during the day.

When utilising openable windows as a strategy to reduce overheating, only units that can be fixed in an open position and avoid the rain coming in can be included in the calculation, as per clause 1.2.3 of G4/AS1. In most cases, doors cannot be included in this area, as while they may be utilised by occupants, they are not weatherproof when open, cannot usually be fixed open, and are a security risk if left open overnight or during unoccupied times. One of the few exceptions is doors to a fully recessed balcony on the upper floors of an apartment. This must be agreed with NZGBC on a case by case basis.

When designing openable windows, consideration should be given around location and security - will they provide cross ventilation; are there some low and some high; can high level windows be included, as they can be left open with fewer security risks? As per the diagrams on the right, achieving code compliance can also limit the amount of openable area available, depending on the requirements of F4/AS1 section 2.0.

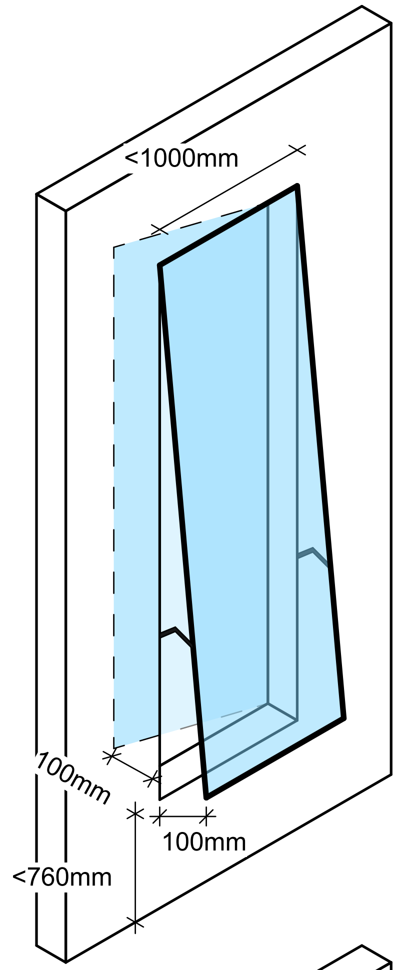
1.2 Natural ventilation – General

COMMENT:

1. The net openable area of windows or doors is measured on the face dimensions of the *building element* concerned.
2. Fixing in an open position of doors and windows used for ventilation is necessary to avoid injury or damage from sudden closure in the event of strong winds or other forces.
3. Keeping water from entering the *building* must be considered for compliance with NZBC Clause E2 External Moisture.

1.2.3 Openable *building elements* shall be constructed in a way that allows them to remain fixed in the open position as a means of ventilation during normal occupancy of the *building*.

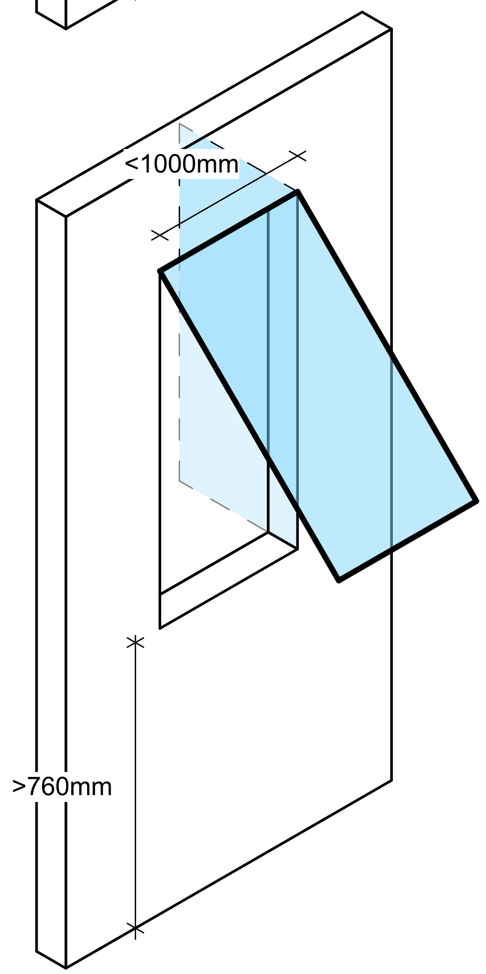
Paragraph from G4/AS1 section 1.2

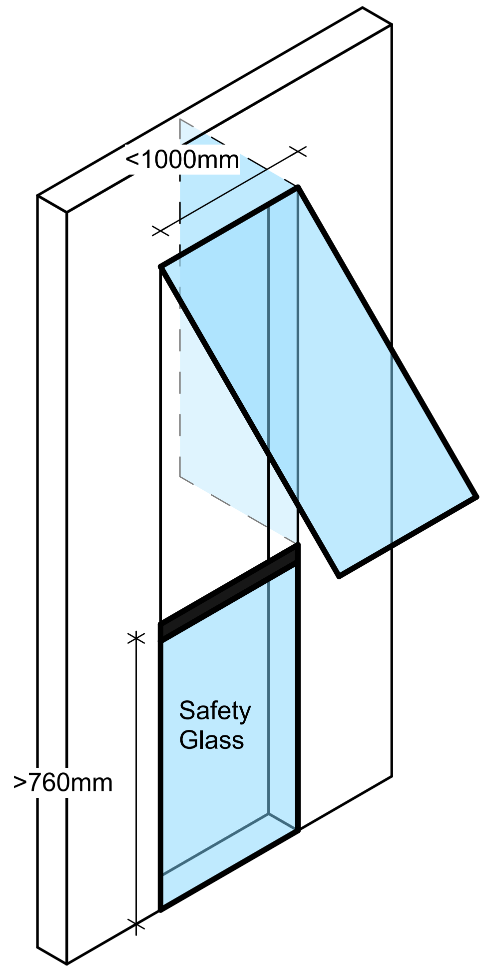


1.
Window sill height <760mm.
Maximum width 1000mm.
Maximum of 100mm opening, limited by restrictors to prevent safety from falling.

2.
Window sill height >760mm.
Maximum width 1000mm.
Whole window can be fully open for natural ventilation.

2.
Window sill height <760mm but transom level is > 760mm.
Maximum width 1000mm.
Upper sash can be fully open for natural ventilation.





Different building types also have different opportunities and issues that will impact the effectiveness of natural ventilation.

Single storey detached houses

These are easier to achieve sufficient summer ventilation, because most windows can be fully opened during occupied hours. They also usually benefit from more cross ventilation and stack effect scenarios.

Two storey multi unit dwellings

These typically face some challenges for the upper level rooms as hot air rises, and the ability of natural ventilation through windows can be limited by the restrictor stays. The window configuration strategies on the previous page can help improve natural ventilation rates and reduce overheating.

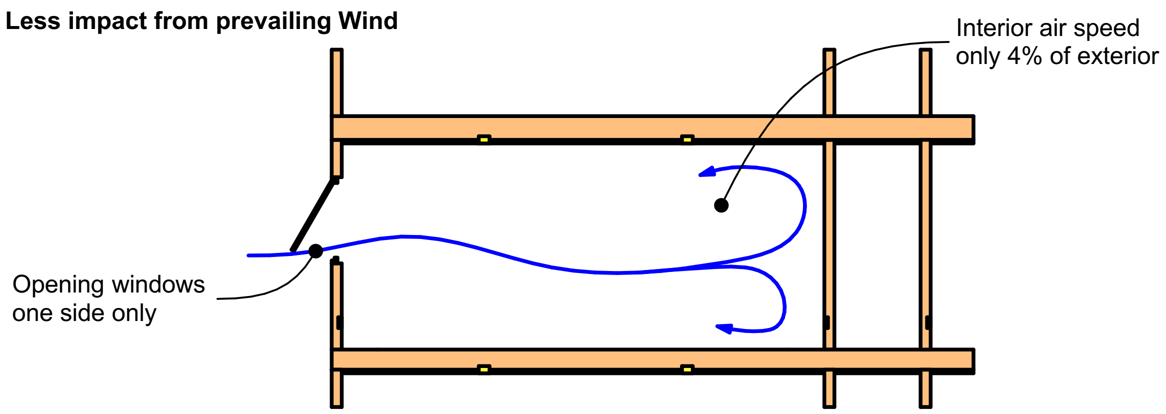
Three storey walk-up apartments

These tend to face greater challenges, especially when it comes to complying with the maximum overheating percentage for the “summer worst case unit”. This is due to less potential for site shading on upper stories to reduce solar gain in summer.

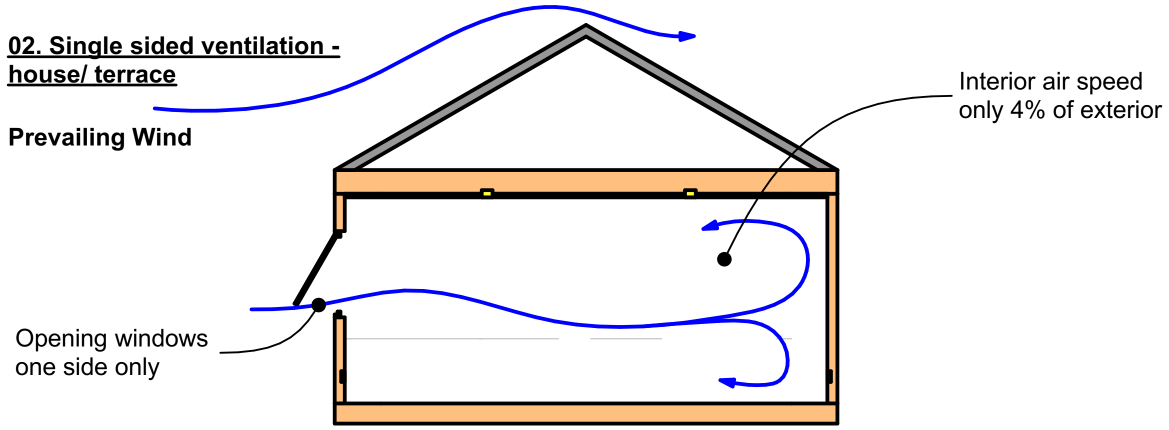
Take case study 04 as an example: the top level north facing apartment has limited shading, plenty of solar gain, but limited heat loss due to the compact form factor. Without changing the design, both careful glazing selection, potentially exterior shading, and a good natural ventilation strategy will likely be needed to ensure overheating levels are minimised.

With apartments there may also be more units where cross ventilation isn’t possible, further reducing the effectiveness of using openable windows to reduce overheating.

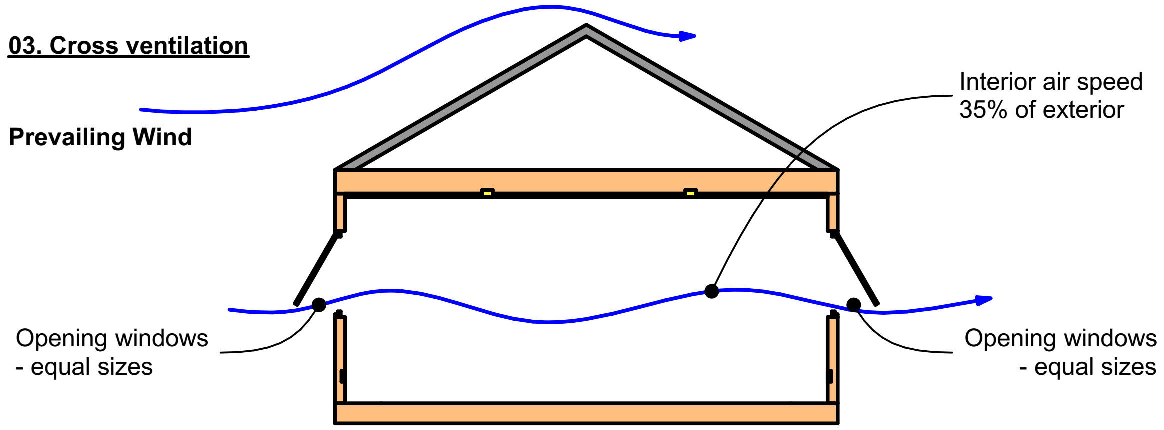
01. Single sided ventilation - apartment



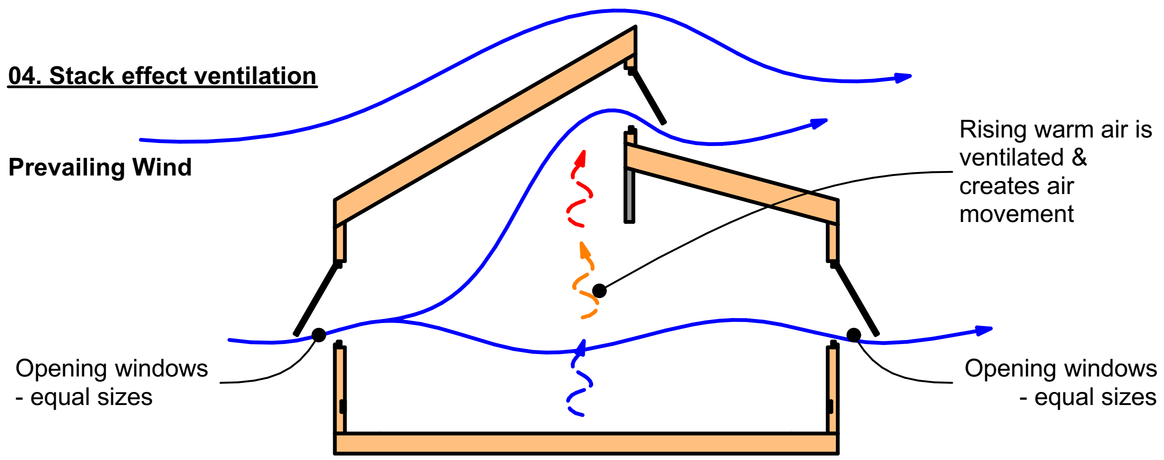
02. Single sided ventilation - house/ terrace



03. Cross ventilation



04. Stack effect ventilation



Overheating - other impacts

There are a range of other elements that can impact overheating in a building, which aren't expressly included in ECCHO and Homestar at this stage, but should be considered:

Climate change and heat island effect

- In our warming world, higher exterior temperatures are almost a given. When assessing the current levels of overheating based on historic climate data, bear in mind these will likely increase over time.
- In urban environments with lots of buildings, footpaths, roads, etc, the ambient air temperature will be higher than if the building was surrounded by trees and grass. This is hard to quantify but we need to bear in mind.

Colour of the cladding and roofing

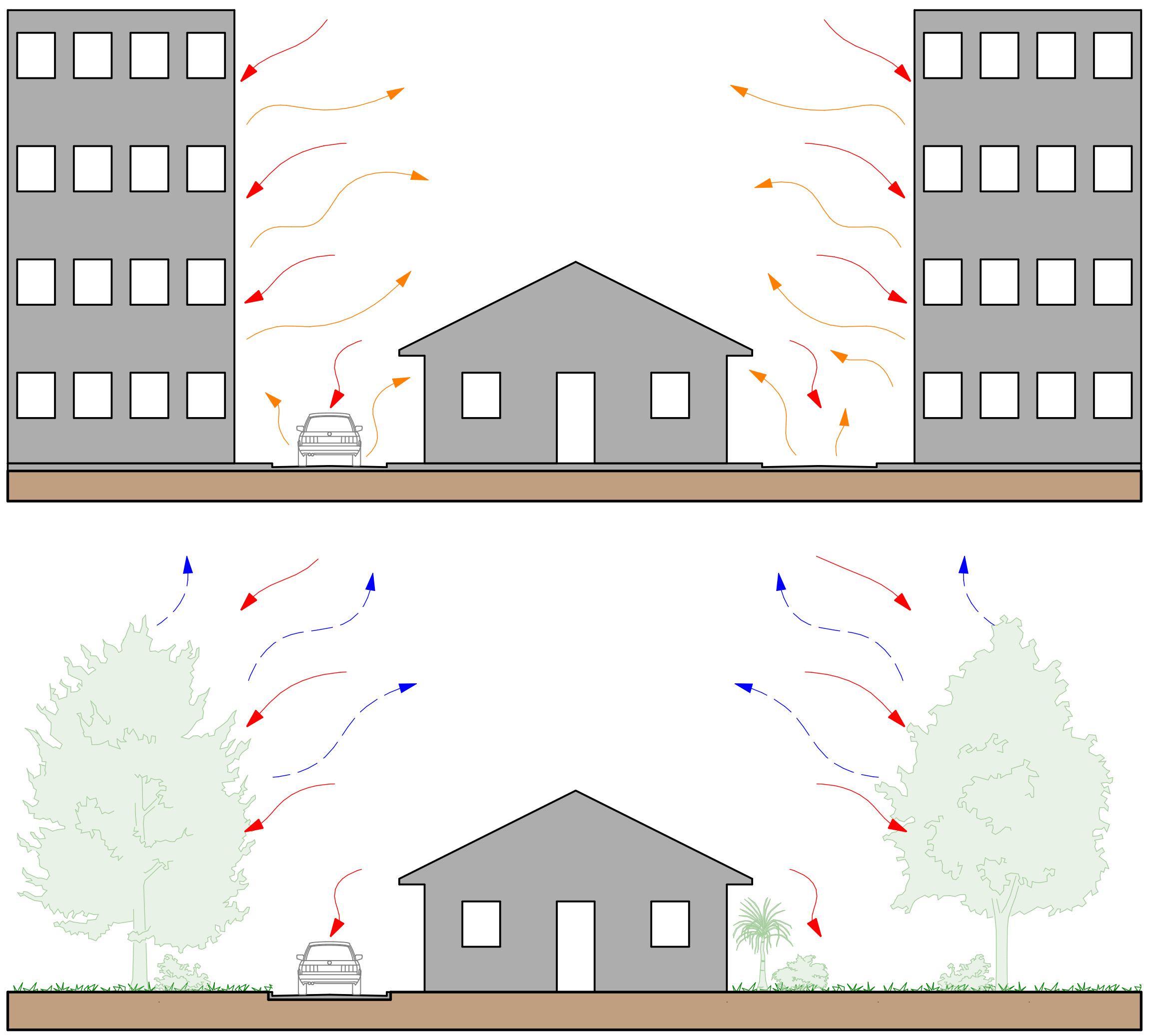
- Light coloured cladding and roofing will absorb less sun than dark cladding, so a light grey roof will result in less heat gain than a black roof for example.
- Cladding and roofing colour has less impact on a well-insulated building - the amount of ceiling/ roof insulation can help to mitigate heat transfer from a dark coloured roof.
- Overhangs can mitigate the amount of sun that will reach dark claddings and reduce heat gain.

Internal heat gains

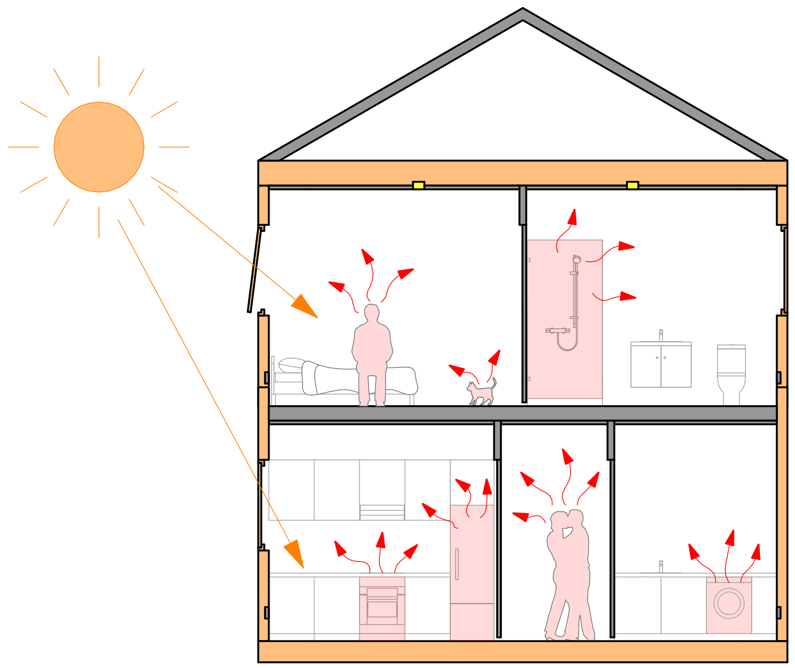
- This refers to the heat generated within the building from appliances, cooking, showering and the occupants themselves. ECCHO makes an assumption for these based on the assumed occupancy, which is based on the floor area of the building.
- This can be hard to quantify, but if the designed occupancy load is higher than ECCHO default, e.g. more people live there than the assumed amount, we can investigate further in ECCHO by using custom occupancy values.

Active Cooling

- Overheating can be managed by providing active cooling, from a heat pump for example. However, the design of the system must be assessed. A single room heat pump will usually be in the main living space, so will likely not be able to cool the bedrooms sufficiently.
- A ducted heat pump system will provide the best cooling effectiveness for relatively low power use, but will likely attract a higher system and installation cost.
- In some cases, air movement can mitigate the user experience of lower levels of overheating. This can be provided by ceiling fans for example.



Heat island effect



Heat gain sources

MVHR bypass

- Most balanced mechanical ventilation systems, which include heat recovery, also include a ‘summer bypass’. This means that during summer when you don’t need to retain excess heat, the air will bypass the heat exchanger so no heat is recovered.
- This can help remove excess heat during the night, but during the day in summer when the exterior air temperature is higher, the incoming air temperature will still be warm.

Thermal mass

- Relying on thermal mass to reduce overheating is not recommended. Thermal mass can work in principle, but it requires precise window sizing and whole-year shading design analysis in BIM model. Without this level of analysis, thermal mass often absorbs too much heat during summer days and causes overheating in the evening. In winter, thermal mass often receives insufficient heat and makes heating the room harder.
- Materials with higher thermal mass such as concrete tend to be highly heat conductive. When thermal mass is part of the thermal envelope, it must be fully insulated. Without continuous insulation, thermal mass would act like a leaky battery and can compromise thermal performance throughout the year.
- Thermal mass within a well insulated thermal envelope and that does not receive direct sunlight has better potential to ease temperature fluctuation in both winter and summer with no knock on effect.

Glossary

Air and vapour control layer (AVCL)	This is a layer designed to control the air and vapour flow through a building assembly. Examples include specialist membranes and taped plywood or oriented strand board (OSB).
Air changes	The number of times that the total air volume in a home is completely removed and replaced with outdoor air, usually expressed per hour.
Airtightness	An assessment of the amount of unintended air leaks in the building envelope. Homestar uses the envelope area (Air permeability qE50 from ISO9972) as a reference for airtightness: m3 of air loss per m2 of envelope per hour @ 50pa pressure.
Annual electricity demand	'Delivered' energy includes everything associated with operational energy - excludes plug loads/appliances. It takes into account efficiency of any systems (e.g. demand might be 30 kWh/m²/yr, but using a heat pump with COP=3 means delivered energy is only 10 kWh/m²/yr).
Annual space heating demand/ heat demand	The amount of energy required to keep the building interior at a specified temperature.
Balanced ventilation	A balanced pressure ventilation system uses two fans to bring in the same amount of air as it removes. This ensures there is no pressure on the building envelope so no air is pushed or pulled through the building fabric.
Building performance	In the context of this guide this refers to the overall energy efficiency, user comfort and long-term durability of a building.
Climate zone	Designation of areas within New Zealand that share similar climatic characteristics.
CLT	Cross laminated timber - a form of mass timber construction.
Cold roof	Conventional New Zealand roof build-up where the structure of the roof (e.g. the rafters) is outside the thermal envelope.
Conditioned floor area (CFA)	Space within the thermal envelope of the dwelling that could maintain a temperature band of between 20-25°C for 365 days of the year. Refer to the Homestar Technical Manual for more details.
Continuous extract ventilation	Whole-dwelling ventilation system that extracts air continuously at a low rate.
Decentralised ventilation	A ventilation system that uses several fans in different locations to deliver and remove air in a building.
Ducted ventilation	A ventilation system that uses ducts to deliver and remove air in a building, with a single central fan unit.
ECCHO	The Homestar® energy analysis tool, ECCHO (Energy and Carbon Calculator for Homes), is a web app that allows users to calculate the heating and cooling demand, energy consumption, overheating risk, and carbon emissions of a home.
Embodied carbon	Embodied carbon is the carbon dioxide (CO_2) emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure.
Energy balance	The assessment of the amount of energy lost through the thermal envelope vs the amount of energy gained, with the difference made up by heating or cooling to maintain a balance.
Energy/ thermal modelling	Energy modelling of buildings is a process that uses computer software to simulate how a building will consume energy based on its design, materials, and systems.
EPD	Environmental Product Declaration, used to determine the environmental footprint of a product following life cycle assessment, verified independently.
Form factor	The ratio of total external surface area of the thermal envelope (including the floor slab area) to the conditioned floor area. Typically, a large building will have a lower form factor than a smaller one. A simpler shape will also have a lower form factor than a more complex shape. The lower the number, the less insulation needed in the same climate (everything else being equal).
Frequency of overheating	The amount of time in a year the interior spends at 25ºC or above. Note this can assume night and window ventilation, so if the building is modelled with more ventilation than used in practice it may overheat more than predicted.
fRsi	Temperature factor. Value between 0 and 1 that expresses how cold the inside surface of a junction is likely to get. The lower the number the higher the risk of mould. Numerically this is the difference between the interior surface temperature and the exterior air temperature, divided by the average temperature difference between interior and exterior.
g-value	Fraction of solar heat energy that enters a building compared to that which hits the outside of the glazing unit. Roughly equivalent to Solar Heat Gain Coefficient (SHGC) which is sometimes published instead for glazing units.
Heat loss area	The exterior area of the building that is between interior heated space and the exterior air, through which heat is lost - generally the walls, floor, roof and windows of a building. If a building is joined to another building, the adjoining area is not a heat loss area as it is attached to another heated space.
HECC	The Homestar Embodied Carbon Calculator developed by BRANZ for NZGBC, an easy to use tool for estimating the embodied carbon content of a typical home.
HPCDH	The High Performance Construction Details Handbook, a document that covers a wide range of typical thermal bridges, assemblies and build-ups used in New Zealand, produced by Passive House Institute New Zealand, BRANZ and Jason Quinn.
HVAC	Heating, ventilation, and air conditioning systems.
Hygrothermal modelling	Hygrothermal modelling uses a computer program to model the long-term effects of heat and moisture within and through parts of a building and assesses interstitial condensation risks.
Internal heat gain	The heating in a building from its occupants and the use of appliances within the thermal envelope.
kgCO²-e/m²	Kilgograms of carbon dioxide equivalent per square metre (of the home). A measurement of embodied carbon.
kWh	Kilowatt hour, a unit of energy. A 2kW portable heater on for one hour would use 2kWh (2000Wh) of energy. 1kWh = 3.6MJ (megajoules). A 1m² window in direct sunlight allows approximately 1kW of energy into the home.
kWh/m²/year (sometimes abbreviated to kWh/m²)	Kilowatt hours per m² per year. Measures the space heating demand compared with the usable or conditioned floor area (CFA in Homestar® v5, measured externally of the insulation; ICA or internal conditioned area in v4.1, measured internally of the insulation).

Life cycle assessment	Life cycle assessment (LCA) calculates the environmental footprint of a product or service over its lifecycle. LCA tools include HECC (for embodied energy only - see above), the BRANZ LCAquick tool and ETOOL LCD.
Low-e coatings	Low emissivity coating, most commonly on glass surfaces between double or triple pane windows. Low emissivity coatings reduce heat transfer by lowering the level of infrared radiation transmission. They achieve this by reflecting IR radiation and work best if there is both a physical gap and the coating is not covered with dirt or condensation (which is why they are commonly used in the sealed environment between glass panes). There are many types of low-e coatings and the thermal performance can vary significantly between them.
Mandatory minimum	Each Homestar® star band has a set of mandatory minimums that must be met. These dictate the performance levels we are aiming to achieve in each climate zone with each typology.
Mechanical ventilation with heat recovery (MVHR)	Also known as heat (or in some applications, energy) recovery ventilation or comfort ventilation. A whole-house ventilation system that exchanges heat between the exhaust air and the supply air. Fresh air is typically delivered to living areas (e.g. living room and bedrooms) and extracted from kitchens and bathrooms. MVHR units do not necessarily supply additional heat into the supplied air. However, a supply duct radiator, heat pump or electric coil can be used to add heat or coolth to the new air before or after it leaves the MVHR unit.
Negative pressure ventilation	A mechanical ventilation system that uses fans to remove the air within the building and de-pressurize it, pulling make up air into the building through trickle vents and open windows.
Positive pressure ventilation	A mechanical ventilation system that uses fans to push air into the building, pressurizing it. The air is then forced out of the building through any gap it can find. Positive pressure systems are not acceptable at any Homestar level.
psi value	Measure of heat loss ('thermal bridging') within a junction of two thermal elements, measured in W/mK. Represents the rate at which heat passes through a junction per metre per Kelvin temperature difference [W/m/K]: for example, the junction between two walls forming an external corner. The length of the junction (ie height of the corner) is multiplied by the psi value to calculate the heat loss coefficient for that corner.
R-value (m2K/W)	Thermal resistance rating used to determine a material or assembly's ability to resist heat flow.
S/V	Surface to volume ratio - an assessment of the compactness of the building form.
Service cavity	A service cavity is a secondary cavity (that may or may not be insulated) usually to the inside of the structural elements and the AVCL (air and vapour control layer). It contains the wiring, plumbing etc to keep penetrations of the AVCL to a minimum. The service cavity is usually but not necessarily insulated. Commonly, the AVCL is tested for air leakage before insulating the service cavity or installing the interior finish.
Shading factor	A measure of how much solar heat gain enters through a window compared to an unshaded window.
Structural Insulated Panel (SIP)	A panellised off-site construction building system. The panels consist of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB). The panels are cut to size in the factory and are delivered to site.
Thermal bridge	A location in the thermal envelope where the uniform thermal resistance is changed by higher conductivity materials or geometry change.
Thermal conductivity	A material's ability to transmit heat is measured by the thermal conductivity (or lambda value). Unlike R-value, the thermal conductivity of a material remains the same irrespective of the thickness of the material.
Thermal envelope	The surfaces that enclose the building's conditioned spaces, which may or may not include garages. This includes the floor area to the exterior. For tools such as ECCHO and PHPP, external dimensions are used. This means from the bottom of the insulation below the concrete slab to the top of the insulation in the ceiling.
Thermal mass	The ability of a body of material to absorb, store and subsequently release heat (due to its specific heat capacity and its mass).
Transmission heat loss	The loss of heat energy via the building components of the house.
Upfront carbon	The carbon emitted in the production phase of products and materials, from mining and processing of natural resources, transport to processing sites, and the manufacturing phases, before any construction begins.
U-value (W/m²K)	Thermal conductance, the inverse of thermal resistance (R-value). Describes the heat flow per m² of an assembly per degree Kelvin.
Ug-value	U-value at the centre of a pane of glass. Note that this is not the U-value of an entire window (Uw) which must be calculated to include the balances of losses through the glass and frame.
VLT	Visible light transmission. VLT is expressed as the percentage of light allowed through the glass.
Waffle pod	A structural slab system that is made up of concrete ribs with plastic or polystyrene pods between, and a concrete slab on top.
Warm roof	A roof build up where the insulation is on the exterior of the structure.
WRB	Water resistive barrier. This is typically the flexible wall underlay but this can be the top layer of a rigid air barrier product used under the ventilated rain-screen cladding. Used to designate the control layer in the building assembly that is intended to stop rainwater entry.