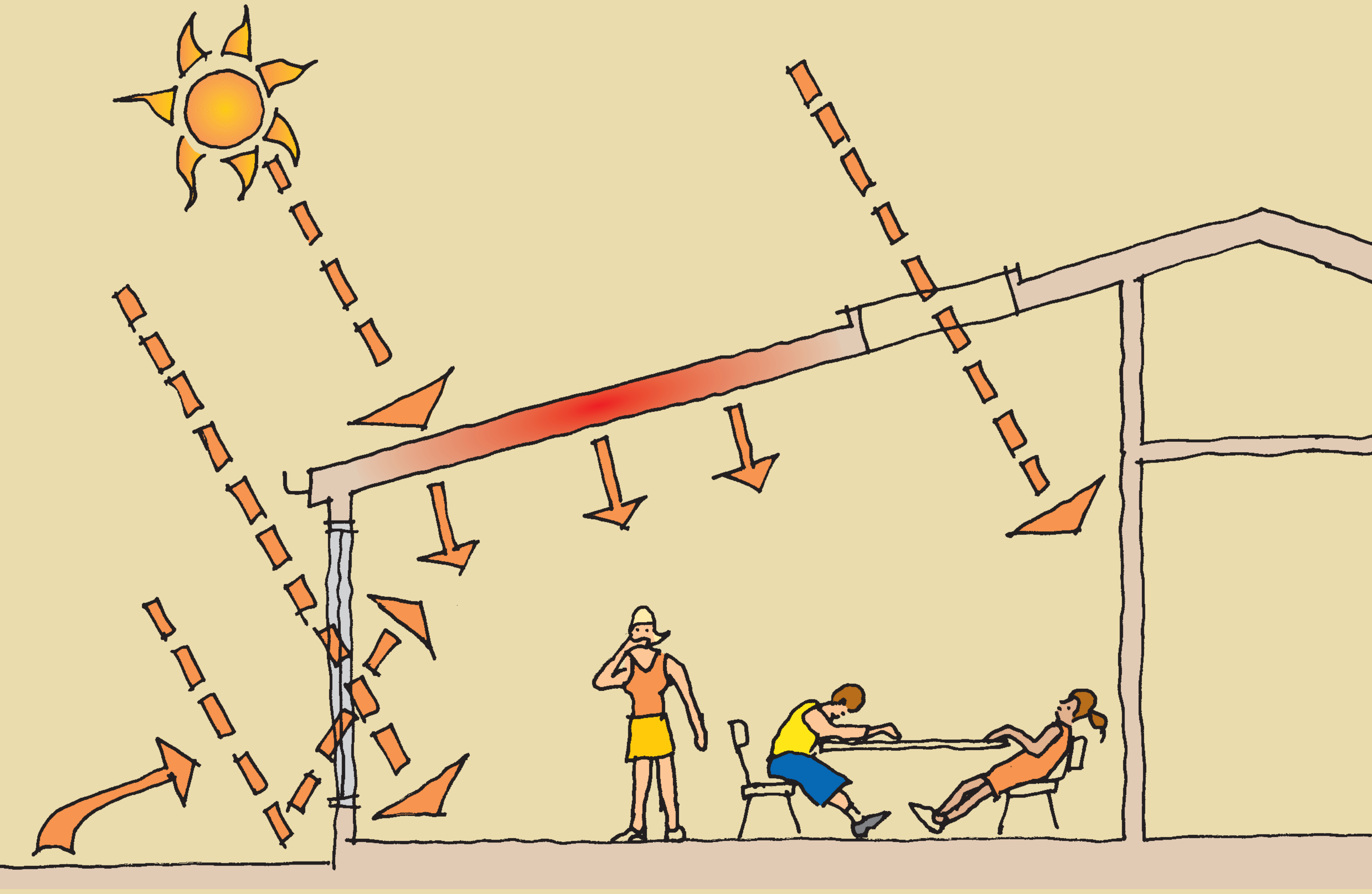
Designing Quality Learning Spaces: Heating & Insulation

Developed by BRANZ Ltd
for the Ministry of Education



BRANZ

MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

Introduction

The Ministry of Education has prepared a series of guidelines to help boards of trustees and principals to:

- assess the performance of existing teaching spaces
- be aware of the characteristics of quality learning spaces
- achieve the highest possible quality spaces.

This information is important because of the effect the teaching environment can have on student learning.

For this series, ‘environment’ refers to the quality of the learning environment which is affected by many physical factors, including:

- acoustics
- air quality and ventilation
- heating and insulation
- lighting
- interior design, function and aesthetics.

These factors interact with one another: achieving good natural lighting must be balanced against possible uncomfortable heat gain from the sun, and the need for natural ventilation can clash with outside noise control efforts. No single factor should be altered without assessing its effect on all the others – a holistic approach is essential.

It is also important to spend the available money well (both the initial outlay and long-term running and maintenance costs).

This series gives practical advice, but it cannot provide definitive answers for all circumstances. What ***Designing Quality Learning Spaces*** can do is give advice which should improve teaching spaces for both students and teachers.

Although the main objective is to guide boards of trustees and principals, the series should also be available for teachers, to help them understand what makes a good learning environment and how they can contribute to this, such as by ensuring windows are opened for good ventilation. The guides can also be given to professional designers as part of their brief.

While the specific designs and solutions chosen will vary between schools, all quality learning spaces have certain features in common:

- there is always a fresh air supply, which helps to prevent the build up of carbon dioxide levels, clears away pollutants, odours and excessive moisture, and improves comfort in warm weather by increasing air movement and removing heat
- there is a comfortable temperature regardless of outdoor conditions
- there is good lighting, preferably natural, without glare
- students can hear and understand the teacher from all parts of the room (and vice versa), teachers don’t need to raise their voices to be heard, and noise from outside doesn’t interfere with teaching.

In their design and layout, learning spaces should:

- allow the teacher to move about easily
- allow for a variety of teaching methods
- allow enough personal space for students
- let all the students see visual aids clearly
- provide work space for specialised activities
- cater for students with special education needs
- be safe and comfortable.

A quality learning space will have furniture which:

- allows learning and tasks to be carried out efficiently without fatigue
- helps protect students from injury owing to bad posture
- reduces the risk of distraction or fidgeting owing to discomfort.

Editorial Note

This guideline for heating and insulation is part of a series for boards of trustees, principals and teachers to help them understand the importance the internal environment plays in the design of quality learning spaces. It will also help boards of trustees brief consultants and tradespeople on their schools' requirements when planning alterations or maintenance. Other topics in the series include acoustics, ventilation and indoor air quality, lighting, and interior design.

The series is also designed to help boards assess their existing teaching spaces and includes practical steps to improve the quality of the learning environments in their schools.

Only when students and teachers are comfortable in their learning/teaching environments can their full potential be reached. Students can lose concentration and become drowsy in over-heated rooms or have difficulty doing simple tasks when cold. A comfortable teaching environment is good for everyone – students, teachers, principals and boards of trustees – as it helps to improve learning.

Achieving thermal comfort can use a significant portion of a school's operating costs so reducing this expenditure is important. Environmental factors are just as relevant and, in recent years, the need to reduce the adverse local and global impact of energy use has become more urgent. The New Zealand government is developing a National Energy Strategy to provide a long-term energy system that supports economic development and is environmentally responsible.

Schools can contribute by using environmentally sustainable fuel in efficient heating systems and having less energy demands. Energy use can be controlled by reducing heat loss through good insulation, using solar control to avoid over-heating and making sensible use of passive solar energy. This guideline explains these issues and gives practical advice on how energy efficiency can be improved.

A school with a positive energy policy can also use it as a practical teaching tool to raise student awareness about the social and ecological issues of energy use.

Glossary of Terms used for Heating & Insulation

EIFS	Exterior insulation and finish system
Glass wool	Masses of finely spun glass fibres resembling wool
Heat conductor	A material that readily conducts heat
Insulation	A material of low thermal conductivity used to reduce heat loss – typically glass wool, wool or polyester
kWh	Unit of electrical energy equal to the work done by one kilowatt in one hour
Skillion roof	A roof where the ceiling is fixed close to or near to the underside of the rafters
Solar heat gain	Heat from the sun which warms the inside of a building
Thermal mass	Dense materials which can store heat
Thermal resistance (R)	The measure of a material's ability to resist the transfer of heat
Wood wool slabs	A matrix of wood shavings and cement formed into a building board

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Overview

Comfort affects learning outcomes

The comfort of students and teachers depends on:

- good indoor air quality (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
- adequate ventilation (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
- appropriate thermal comfort resulting from an acceptable air temperature and relative humidity.

Air quality, ventilation and temperature are interdependent and must always be considered together. Adequate cooling for thermal comfort (whether active or passive) is closely related to heating and ventilation.

Students and teachers need to be comfortable in their learning/teaching environments to reach their full potential. Achieving personal thermal comfort for everyone is a difficult issue because it is so subjective. A space may be within the normal temperature comfort band, but high humidity may make the occupants feel thermally uncomfortable. Thermal comfort also depends on such factors as personal metabolism and the amount of physical activity underway.

Heating accounts for a large portion of a school's costs, so it is important to ensure heat is used efficiently and not wasted.

This section covers:

- heating
- solar gain
- heat loss and insulation.

Control is important

In a survey to understand what teachers and students considered were essential elements of good design for classrooms, teachers thought the ability to control room temperature was 'very important'.[1] Students felt having a comfortable temperature was a 'key issue'. Eighty-seven per cent of students rated having a classroom that is not too hot or too cold as 'vital' or 'very important'.

In the same survey, design consultants had no preference for local or central heating, saying it depended on the school and the space. They pointed out:

- central heating is not reliant on someone remembering to turn it on and off but the temperature level of individual rooms needs to be able to be adjusted
- local heating gives more control to the users.

Schools are not like houses

It is sometimes assumed that schools have similar heating requirements to houses because of their similar construction.

Heating requirements of schools are different to houses because:

Houses may be occupied by a few people all day and night all year round	Schools are mainly occupied by many people between 9.00 am and 3.00 pm five days a week (excluding possible community use)
If one room in your house becomes uncomfortable you can move to another room or part of the room	Students and teachers mostly stay in the same place in the same room
It is useful in houses to store solar heat until the cooler evening	School is out between 3.00 pm and 5.00 pm so stored heat would not be used unless the school is used for evening classes or community use

Heating accounts for a large portion of a school's energy costs.

Heating accounts for a large portion of a school's energy costs. For these reasons, passive solar design – by which a building stores excess heat during the day and releases it at night – is a useful consideration in houses more than in schools. Overnight heat release isn't required in schools, and collection of excess heat during the day can make teaching spaces uncomfortable.

Understanding Heating

Introduction

The purpose of heating and ventilation in a classroom is to provide indoor thermal comfort regardless of outside conditions. If a building is unoccupied and not affected by heat gain from the sun, the indoor temperature will be similar to that outside (Figure 1). However, when occupied, the indoor temperature is affected by heat from sources (Figures 2 and 3) such as:

- students' bodies
- lights
- computers
- solar gain.

Indoor temperature is affected by heat from students' bodies, lights, computers and solar gain.

FIGURE 1 The temperature in an unoccupied building.

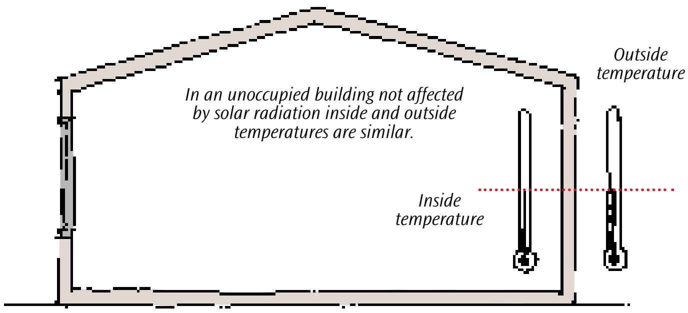


FIGURE 2 People and lighting contribute heat to the inside.

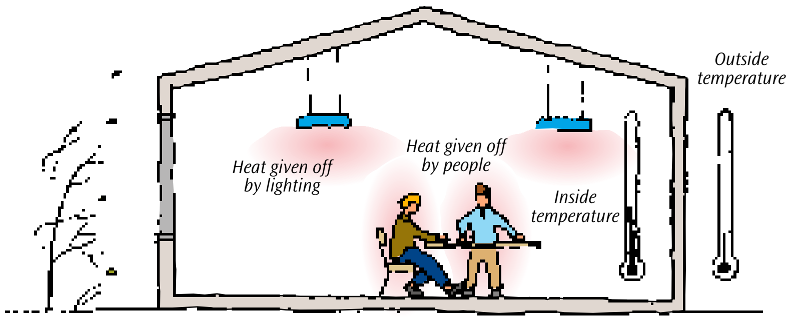
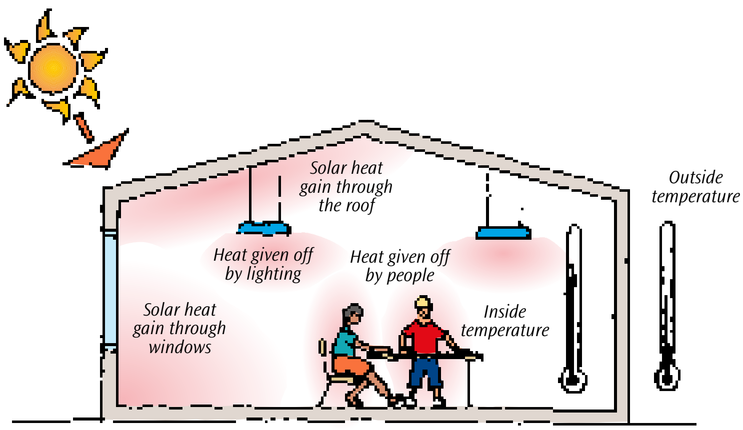


FIGURE 3 Solar heat gain in summer.

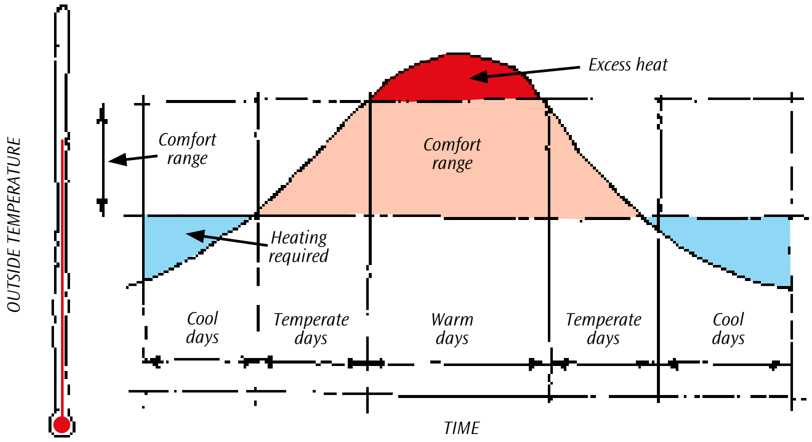


Depending on the outside temperature, for some of the time heat must be added or taken away to maintain indoor comfort. Figure 4 shows there are three conditions that will vary with the time of year, the climatic region and the design of the building:

- ***cool days*** – when the outside temperature is low the internal gains are not enough to maintain comfort and additional heat is needed
- ***warm days*** – when the outside temperature is high and room temperatures become uncomfortable unless heat is lost or cooling is added
- ***temperate days*** – when the outside and indoor temperatures balance to give comfortable conditions.[2]

The impact of climate change has been mentioned as a factor in design of learning spaces but for New Zealand this is not as likely to be as significant as the impact of the variable climate change that can already occur within a normal school day.

FIGURE 4 Pattern of Heating.



Temperature characteristics are design-related

The pattern of heating/cooling requirements illustrated in Figure 4 is a feature of the heat gain and heat loss characteristics of a building. These characteristics are design dependent, which means they can be altered by changing the building design features. The opposite is true, and spaces are sometimes used for activities or numbers of students they were not designed for, which can lead to overheating.

The aim, whether modifying an existing building or designing a new one, is to:

- achieve a balance which gives comfortable conditions without the need for heating for most of the time
- maintain natural ventilation without the need for cooling
- use natural daylight but control excessive heat from the sun.[2]

New Zealand climatic conditions need flexibility

Our climate has large variations:

- regionally
- from year to year
- from day to day
- during each day.

For this reason, flexibility is key in designing school heating for our conditions. Heating must be suitable for the region and be able to cope with fluctuations.

Flexibility is key in designing school heating for our conditions.

A well-designed building:

- will not store heat which cannot be got rid of when the outside temperature rises rapidly
- will not gain heat from the sun during hot weather
- can be heated quickly when the outside temperature drops suddenly
- can be cooled quickly by natural ventilation when the temperature rises suddenly
- can gain heat from the sun in cold weather.

Planning for comfort

To plan for heating comfort we need to decide what building design features are useful in maintaining the temperature on:

- cool days
- warm days
- temperate days.

Comfort on cold days

On cold days, or during winter in cold regions, three strategies are used to maintain comfort levels and reduce running costs:

- ***controlling heat loss by:***
  - appropriate thermal insulation (see Section 3)
  - continuous but controlled minimum ventilation (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
  - recovering heat lost through ventilation (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
  - appropriate window area
- ***using the sun's heat by:***
  - correct orientation of the building to use the heat from winter sun, but exclude summer sun to avoid overheating
  - suitable glazing to give adequate natural lighting without glare or excessive heat loss
- ***adding heating by:***
  - an efficient and flexible heating system that can respond to changing conditions
  - the teacher having control of heating.

How much extra heat is needed?

In an average New Zealand classroom with 30 students and adequate thermal insulation, the heat generated by the people can be the equivalent of a 3 kW heater. Electric lighting can add another 1 to 2 kW. If the required temperature inside is 20°C, and the outside temperature is 0°C, only a 4 kW heater would be able to cope with normal heat loss and keep the room at a comfortable temperature. In most of New Zealand 0°C outside is rare so a small amount of extra heat would be needed. A bigger heater that can be turned down when the room is warm will heat the room faster. A small heater would take too long to heat the room.

The classroom should be warm enough when the students arrive. Once they are in the room the heat they generate, and that generated by lights, may be sufficient to keep an insulated building warm with only a small amount of extra heating.

In schools with central heating which cannot be controlled by the teacher, it is not unusual for windows to be wide open at 9.30 am on a cold morning. This is the only way that the room can be cooled once the heat generated by students, lights and the heating system combine.[3]

On a cold morning in an inadequately insulated building, where the heating has not been turned on early enough, windows will be kept shut until the room temperature rises. This causes inadequate ventilation and carbon dioxide levels to rise above an acceptable level (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

What is a suitable temperature?

Air temperature that feels comfortable will vary according to the time of day, the outdoor temperature and the activities of the students. Classrooms should be maintained at 18–20°C. For other spaces see Section 4.

Classrooms should be maintained at 18–20°C.

How much of the sun's heat is needed?

Generally, it is preferable to avoid solar heat gain most of the year and to use it carefully in winter. Direct solar gain, even in winter, can cause overheating and thermal discomfort for students who are sitting in the sunny patch.

Comfort on warm days

On warm days and in warm summer weather excessive indoor temperatures must be prevented by:

- ***controlling the sun's heat by:***
  - having appropriate thermal insulation
  - having sufficient glazing to give adequate natural lighting without excessive heat gain
  - shading windows
  - using appropriate glazing
  - using natural shading from trees and artificial shading such as sails
  - correct orientation of new buildings to avoid direct sunlight during the hottest part of the day (excessive direct sunlight in existing buildings may be moderated by some external sunshades)
- ***passive cooling by:***
  - increasing ventilation and air movement (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
  - using the thermal mass of the building to even out the effects of outside temperature fluctuations
- ***active cooling by:***
  - air conditioning – but only where critical to the function of the space
  - using heat pump units.

Comfort on temperate days

When the outside temperature means it's comfortable for both teachers and students:

- ***control heat from the sun by:***
  - using the same measures as for hot and cold weather because these will also work on temperate days
- ***ventilate by:***
  - continuously replacing the air within the room via open windows or mechanical ventilation (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

Temperate days do not usually require heating or cooling and ventilation (whether active or passive) is the important factor.

Controlling solar gain

There are two conflicting aspects of solar gain:

- ***winter sun*** which can provide useful heat (but care is needed)
- ***summer sun*** which can cause overheating, so its entry through windows should be restricted, particularly in the late morning and afternoon.

The main disadvantage of naturally ventilated classrooms is the potential for overheating in hot weather. It is therefore very important to avoid excessive solar heat gains.

Many New Zealand classrooms gain too much heat from the sun (Figure 5) owing to:

- the high amount of direct sunshine entering through unshaded windows
- orientation – the room faces the wrong way
- inadequate thermal insulation in the roof and walls
- unshaded windows
- roof lights that allow too much direct sun
- landscaping that does not provide summer shading or too much shade in winter.

Many New Zealand classrooms gain too much heat from the sun.

FIGURE 5 Many New Zealand classrooms have too much solar heat gain.

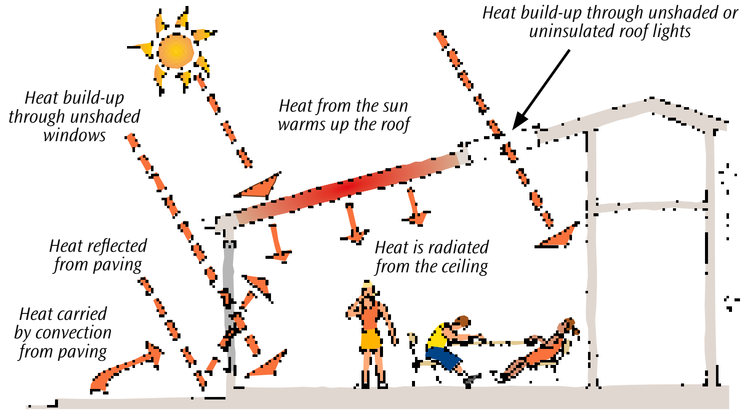
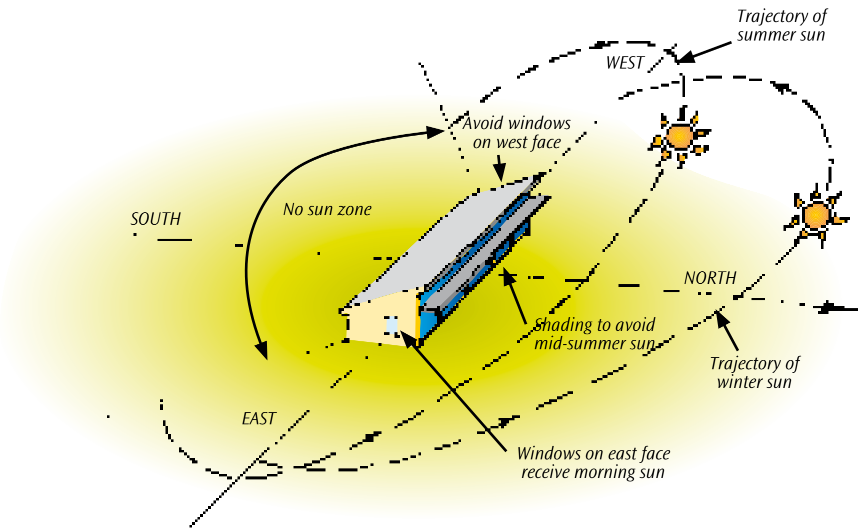


FIGURE 6 Orientation of classrooms for the sun.



Building orientation

Ideally, in new buildings, all classrooms should be positioned so their windows face within 20° of true north (Figure 6). With suitable sun-shading:

- summer sun is excluded to avoid unwanted heat build-up
- winter sun can help to keep the building warm.

Rooms with windows that face east will:

- have good morning light
- gain heat from the sun in the morning all year round – high solar heat gain in the morning can lead to higher temperatures throughout the day
- be cool in the afternoon and need more heating in winter.

Rooms with windows that face west:

- will be liable to get too hot in the afternoon all year round unless shaded
- will be difficult to shade late in the day
- should be avoided or have some shading provided.

Thermal insulation

When classrooms get too hot, especially older classrooms, it is most likely to be from solar gain through uninsulated walls and roofs or through large areas of glazing. The roof and walls absorb the sun's heat and transfer it inside. Good thermal insulation not only prevents heat loss, it reduces heat gains – it's a two-way deal (see Section 3).

Shading windows

Fixed solid overhang for shading

Windows can be shaded by a projection over the window which:

- is deep enough to stop direct sun from 21 September to 21 March between 10.00 am and 2.00 pm
- lets in winter sun.

Overhead sun-shades

Windows can be shaded and some light let in by:

- louvred shades
- perforated metal shades
- solar reflecting glass.

Vertical louvres

Shade windows facing east to north-east, or north-west to west with vertical louvres to cut out the low angles of the sun.

Landscaping

Hard paved areas can reflect heat through windows and can absorb heat which may be carried into classrooms by air movement.

Plants around the building (especially on the north and west sides and close to windows) will help reduce solar gain.

Carefully positioned deciduous trees can shade windows in summer and let the winter sun in.

External window shading

Windows facing between north-east and north-west	
Fixed projecting overhang above windows (Figure 7)	• cuts out mid-summer midday sun • will reduce amount of light let in by windows • usually constructed as part of building
Overhead sun-shades with fixed louvres in timber or metal (Figure 8, page 13)	• low-cost option in timber but will need maintenance • higher-cost option in galvanised steel or aluminium with less maintenance • will admit light • can be retrofitted
Overhead sun-shades with perforated durable metal screen and frame	• moderately high-cost option • can be visually distracting • amount of sun and light admitted will depend on size of perforations • can be retrofitted
Overhead sun-shades with solar glass and metal frame	• will need cleaning • will admit good light • may still contribute to glare and solar heat gain • can be retrofitted • high-cost option
Retractable awnings (Figure 10, page 13)	• low to moderate-cost option • will need maintenance • may not be suitable for windy locations • can be retrofitted • need someone to operate them at the appropriate time
Windows facing north-west to west	
Fixed vertical timber or metal louvres in front of windows (Figure 9, page 13)	• low-cost option in timber but will need maintenance • higher-cost option in galvanised steel or aluminium with less maintenance • will admit sun at some time of the day but will cut out the sun when needed if well designed • will admit light • may obstruct the view • can be retrofitted

Adjustable vertical metal louvres in front of windows	• will need maintenance and cleaning • can be adjusted to exclude sun at different times of year • highest-cost option
Landscaping	
Remove paving or tarseal and plant low garden in front of ground floor windows	• low cost • will reduce reflected and convected heat • needs maintenance and irrigation
Plant deciduous shade trees	• low cost • long time lag before it becomes effective • will reduce sun in summer • will allow winter sun to penetrate when leaves drop • needs leaf clear-up in autumn • may reduce daylight

FIGURE 9 Plan of vertical sunshading

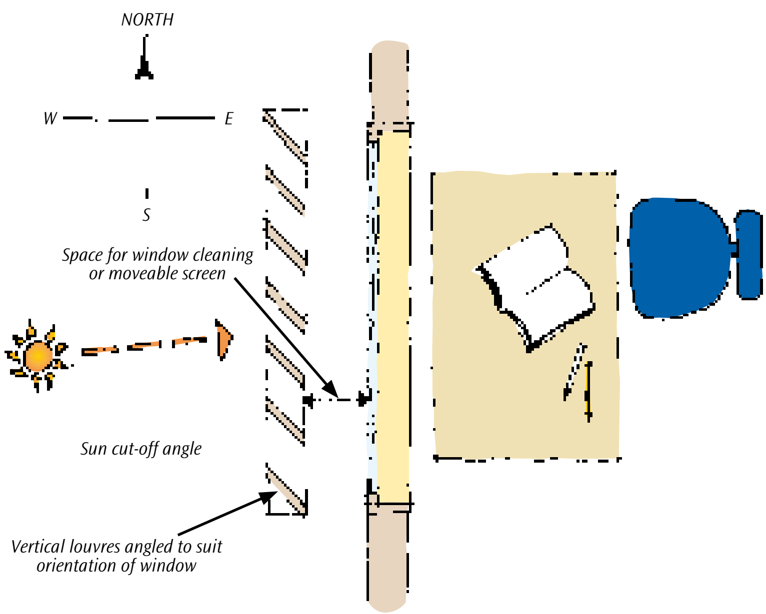


FIGURE 7 Shading windows by projecting overhang.

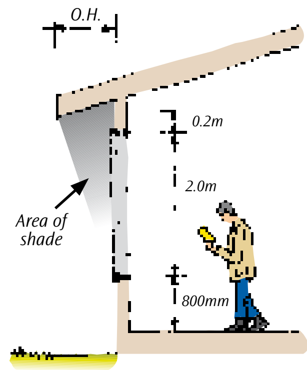


FIGURE 8 Horizontal sunscreen

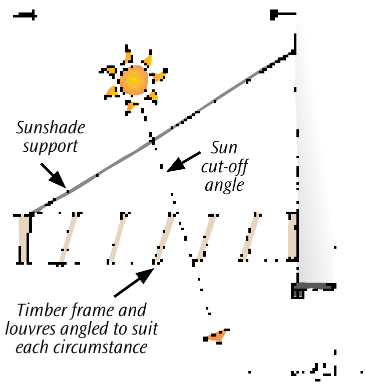
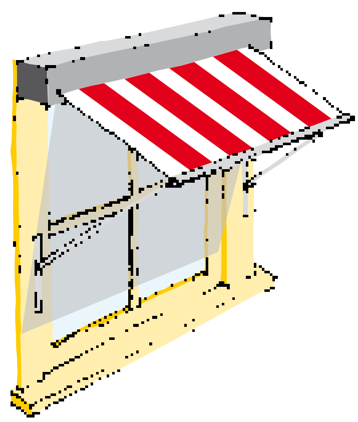


FIGURE 10 Retractable awning.



Solar control through glass

Apart from shading, the amount of heat entering a classroom through the windows can be reduced by:

- solar control glass which is fitted into the window frames
- solar films or coatings which can be applied to glass already there
- double glazing which reduces heat transfer only if solar control glass is incorporated in the unit (see Section 3).

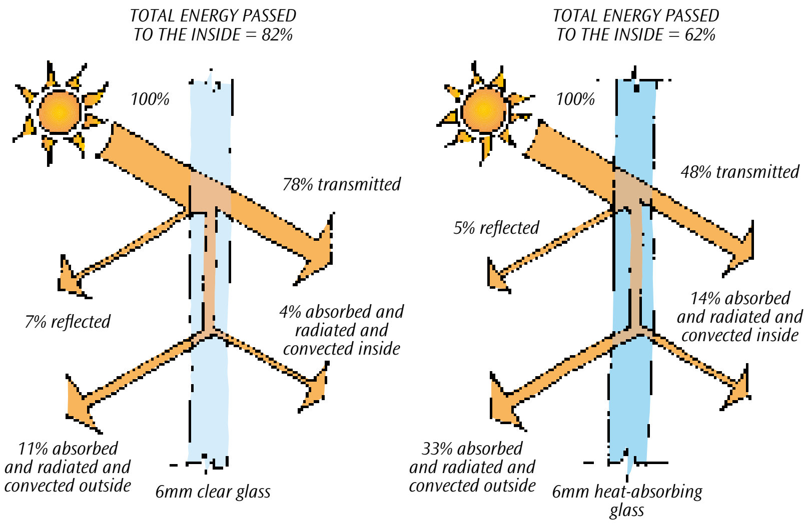
Both solar glass and coatings reduce light, and required daylight levels must be balanced against reduction in solar heat gain and glare.

Solar control glass is similar to clear glass, but its appearance and thermal performance is altered by tinting or by adding a reflective coating. It restricts the sun by:

- absorbing its energy and radiating most of it to the outside but some to the inside (heat absorbing glass – see Figure 11)
- reflecting most of the energy (reflective glass – see Figure 12).[6]

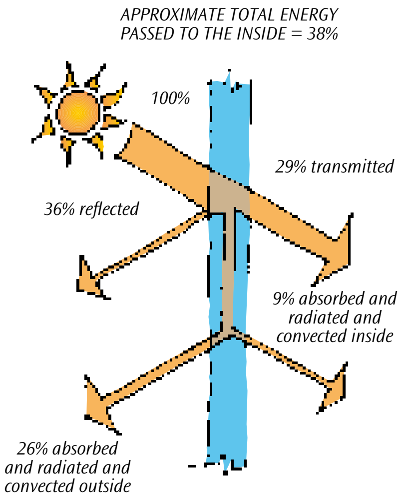
Solar films or coatings filter or reflect the sun's energy. There is a range of films available with varying properties.[5]

FIGURE 11 Heat transmittance of clear glass and heat-absorbing glass.



When choosing the product – glass and films are made for a wide range of purposes – it is important to decide what the requirements are and to establish clearly with the manufacturer which product will give the specified performance. An important consideration is the reduction in light transmittance. Glass and applied finishes must be installed and maintained as instructed by the manufacturer. The length of warranty for films should be checked. (Note the Ministry of Education has recently carried out a programme of installing a safety film over some glass windows that could be considered dangerous after an accident involving the death of a child. These windows may not be appropriate for further film treatment.)

FIGURE 12 Heat transmittance of reflective glass.



Reducing solar gain through the glass

Solar control glass	• wide range of glass available • reduces solar energy transmission • can help to reduce heat loss • moderately expensive option for new windows • expensive option to re-glaze windows • will reduce light – the energy performance must be balanced against the need for natural light • will change external appearance of building • will darken view looking out • can still contribute to thermal discomfort if not carefully selected
Solar film or applied coating	• lower-cost option but has limited life and needs care in use • wide range of films available • reduces solar energy transmission • will reduce light – the energy performance must be balanced against need for natural light • will change external appearance of building • will darken view looking out

Internal window shading

Internal shading is less effective at reducing solar heat gain. This is because the solar radiation has already come through the glass before it reaches the shading which absorbs it and releases it as heat into the room. However, internal shading is useful when the sun penetrates for only a short time and where heat build-up will not be a problem. Internal shading includes:

- venetian blinds
- vertical adjustable blinds
- roller blinds
- curtains.

Internal window shading

Curtains	• low to moderate-cost option (Refer to the ministry's *Fire Safety and Design Guidelines for Schools*) • small reduction in heat gain • useful where room must be darkened for projection • cut out most of the light when drawn • reduce ventilation when drawn
Venetian blinds and vertical blinds	• moderate-cost option • amount of light can be adjusted • adjustable up and down or by tilting the blades • allow a view to the outside • small reduction in heat gain • susceptible to damage through misuse • need cleaning • allow ventilation but can rattle in the wind
Roller blinds with light-admitting, UV-reducing fabric	• reduce the amount of light • darken the outlook • only adjustable up and down • small reduction in heat gain • can be motorised and fitted to high windows or roof lights • most expensive option

Thermal mass

What is thermal mass?

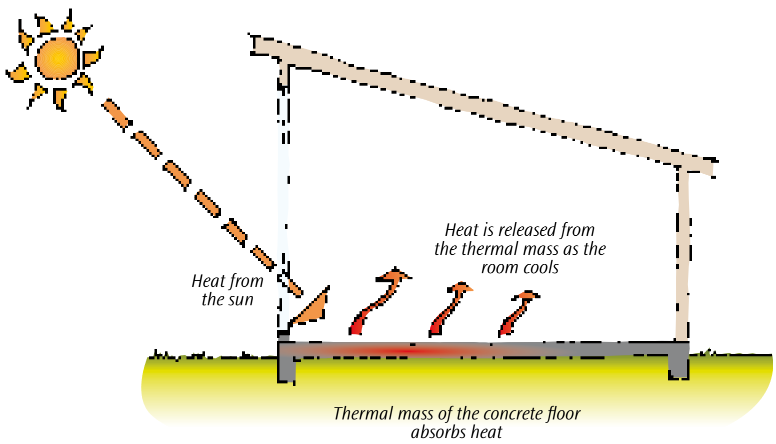
In building terms, 'mass' refers to dense (or heavy) materials such as concrete and brick. These materials can absorb more heat than lighter material such as wood or plasterboard (Figure 13). This capacity to store heat is referred to as 'thermal mass'.

Concrete and brick can absorb more heat than lighter materials.

Thermal mass and heating

During the day when the sun shines through a window it can slowly heat up concrete floors and walls (high thermal mass). In the evening as the room temperature drops, the stored heat is released and helps to warm the inside air. The thermal mass of the building can absorb unwanted solar heat during the day and release it at night.

FIGURE 13 Principles of using solar heat gain.



How does this affect schools?

In buildings occupied during the night, using thermal mass to store solar heat can be an advantage. However, if the students go home between 3.00 pm and 4.00 pm, and the school is lightly occupied, there is little advantage in collecting and storing solar heat.

On the other hand, if the school is to be used for evening classes or other community uses, designing for solar heat gain can substantially reduce heating costs. However, careful design is needed to avoid making the rooms too hot during the day.

Most New Zealand schools have timber floors and framing and are 'thermally light buildings'. Unless they have a high standard of insulation they will warm up quickly on hot days and cool down quickly on cold days. The trend with new schools is for concrete floors. Apart from economic and acoustic considerations, these floors help the building to keep cooler on hot days and stay warmer on cold days.

If the school is used in the evening, designing for solar heat gain can substantially reduce heating costs.

> SECTION 2
– Heating Systems

There are two basic systems for heating schools:

- central heating
- local heating.

Central heating

A central heating system is one where all the heat for a school is produced at one central plant. Fuels used include:

- coal
- oil
- gas
- electricity.

Some may use geothermal heat.

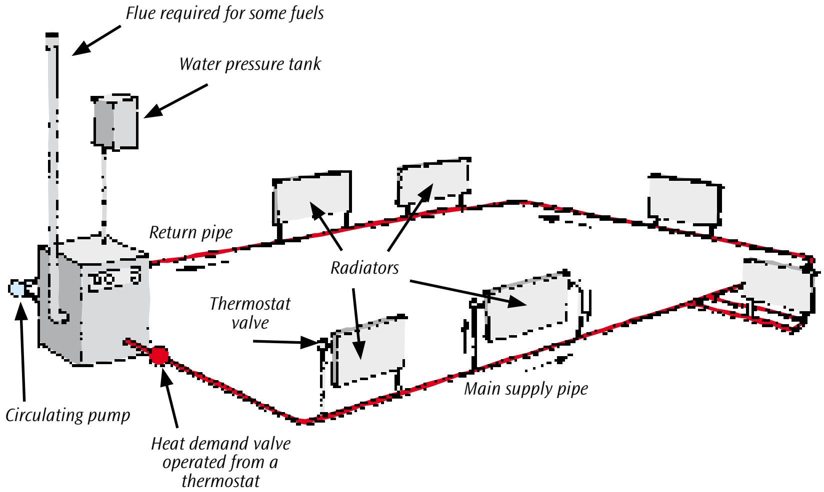
Hot water systems

Low pressure water is heated and circulated through pipes to:

- hot water radiators
- hot water pipes embedded in the floor
- fan heaters – which heat and recirculate indoor air
- air handling units – which temper outside air.

The water is returned to the central heating furnace and re-heated (Figure 14).

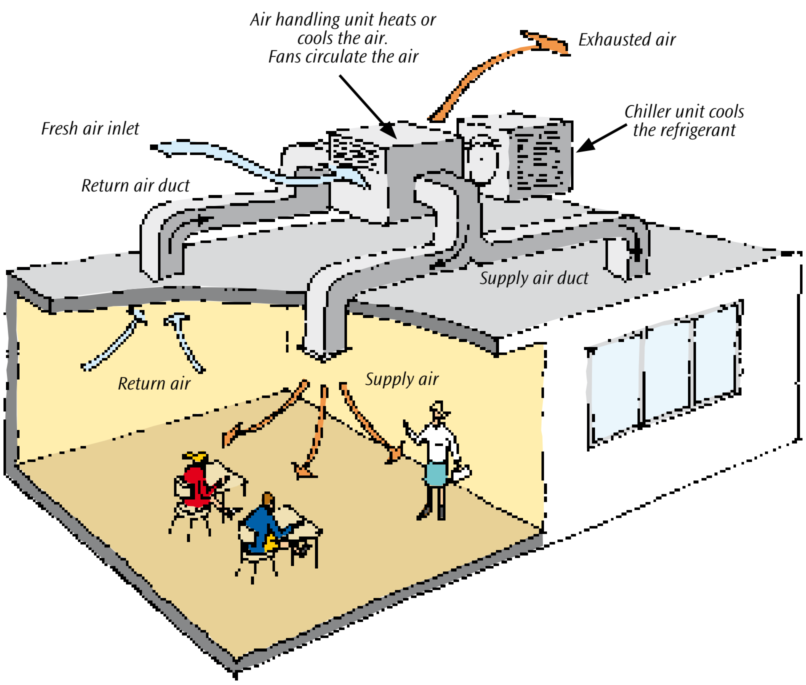
FIGURE 14 Diagram of a central heating system (Single Pipe).



Heating, ventilating and air conditioning systems (HVAC)

Air handling systems supply warm air ducted from a central plant and can control its temperature, humidity and cleanliness. Air is returned to the plant and heat is recovered from the exhaust air. In cold weather additional heat can be added. In warm weather the air supply can be cooled and the humidity controlled by condensing out moisture (Figure 15).

FIGURE 15 Cut-away diagram of a heating, ventilating and air conditioning system.



Air handling systems:

- provide constant ventilation and can vary the flow based on occupancy and temperature
- can heat or cool the air
- can control humidity if cooling is provided
- can filter the air
- are very expensive to install
- are expensive to run and maintain, but if a heat recovery system is installed running costs are reduced
- must be designed by an expert consultant.

Heat recovery ventilation systems supply outside air but warm it with heat recovered from the exhaust air (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

Controls for radiator heating systems with a central plant

Central heating systems are usually centrally controlled, but individual room control via thermostats may be provided in some systems. The heating is set to come on in the morning and turn off at night.

Some individual hot water radiators have thermostats or valves which can adjust individual room temperatures. These valves are tempting for students to fiddle with. In many older systems they probably no longer work or have been removed. Often radiators have a simple on/off valve.

Some systems may have thermostatic controls fitted which will adjust the temperature for all rooms with a similar aspect on the same hot water circuit.

Older control systems are time-based and not sensitive to individual room temperatures or to fluctuations in outside temperature. If the room temperature rises, and the system is on, the only way to cool it down is to open the windows.

Central heating maintenance and efficiency

The management of a central heating system and its control needs specialised knowledge.

A suitably qualified consulting engineer will be able to carry out an investigation of your system and advise on:

- its efficiency and what can be done to improve it
- additional controls that can be installed to:
  - improve heating efficiency
  - give more control over individual room temperatures
- how heat loss can be reduced
- system compliance with local authority outdoor air quality standards.

The management of a central heating system and its control needs specialised knowledge.

Local heating

Local heating is stand-alone heating in each classroom.

Heaters for classrooms

The heating requirements of a school are influenced by the:

- climate of the region
- construction and design of the rooms to be heated
- level of thermal insulation of the building
- size of the building envelope
- amount of outdoor air supply – whether actively or passively supplied.

The choice of fuel will be based on:

- availability in the region
- comparative annual cost
- suitability and convenience
- environmental impact.

The selection of heaters will depend on their:

- capacity to satisfy the heating requirements of the room
- thermal efficiency
- adequacy of the controls
- safety
- robustness and suitability for school conditions
- capital cost
- life expectancy.

Advice should be sought from an experienced heating expert who is familiar with local conditions.

How do heaters work?

Heat is delivered by either convection or radiation or a combination of both.

Convection heaters: (Figure 16)

- distribute the heat evenly around the room by warming the air
- can heat a classroom fairly quickly but take more time to heat large spaces
- are not suitable for spaces with high ceilings
- are economical to run.

Convection heaters warm the air, so if windows are left open for passive ventilation there can be large heat losses (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

Radiant heaters: (Figure 17)

- radiant heaters only heat the objects or people on which the radiation falls; they do not heat the air
- they are suitable for large spaces such as gyms and halls where it is more economic to heat the occupants than the large air volume
- may be more expensive to run than convectors unless correctly sized and controlled
- some people do not like the heat on their heads from ceiling fixed heaters – this applies more to lower ceilings.

Convection heaters warm the air; radiant heaters heat objects or people.

FIGURE 16 Principles of a convector heater.

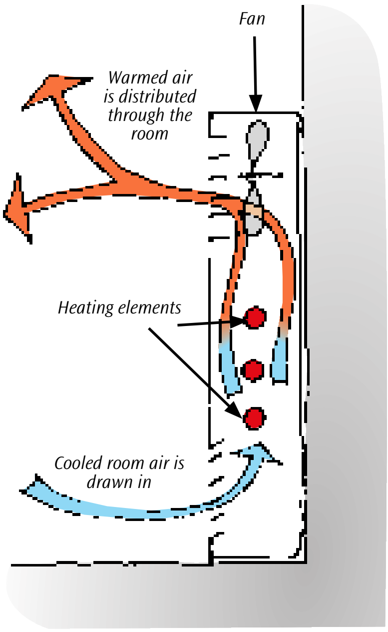
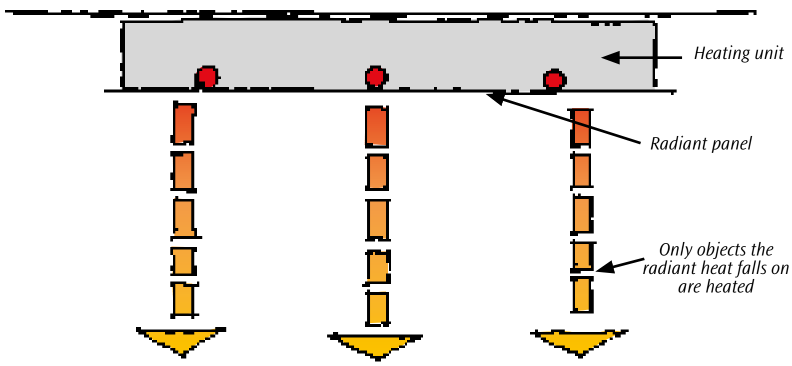


FIGURE 17 Radiant heat.



Heat pumps: are a type of fan-assisted convector heater. An outside unit collects heat from the outside air and transfers it to an inside unit that heats the room. Most heat pumps are reversible and can cool the air when required. Because they extract 'free' heat from the air, heat pumps are very efficient and produce 200–400% as much heat as the energy they use. They are more expensive to install and their efficiency is less where temperatures fall towards and below freezing.

Heat pumps are very efficient and produce 200–400% as much heat as the energy they use.

There are two basic heat pump systems:

- ***split systems*** that heat or cool the air within a room (Figure 18). They do not ventilate, so separate provision must be made for fresh air
- ***ducted systems*** where the heat is transferred to air that is ducted to one or more rooms. For economy, the warm/cool air in the room is re-circulated and some new fresh air introduced for ventilation (Figure 19).

Storage heaters: (or night store heaters) are permanently installed heaters filled with heavy heat-retaining materials (such as fire bricks). The material is heated during off-peak periods (usually at night) by electricity at low off-peak rates and released slowly during the day. The disadvantage is that if the day temperature is unusually warm, the heater stays warm, which may mean the room becomes too hot (Figure 20).

Storage heaters release heat slowly during the day, but may be too warm if the day is also warm.

FIGURE 18 Split system heat pump.

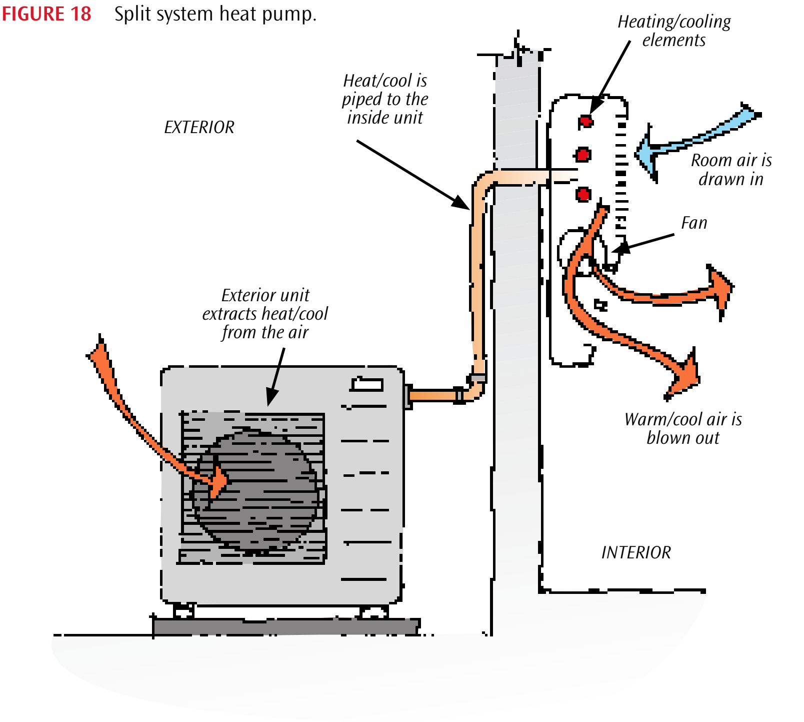


FIGURE 19 Heat pump and ducted air system.

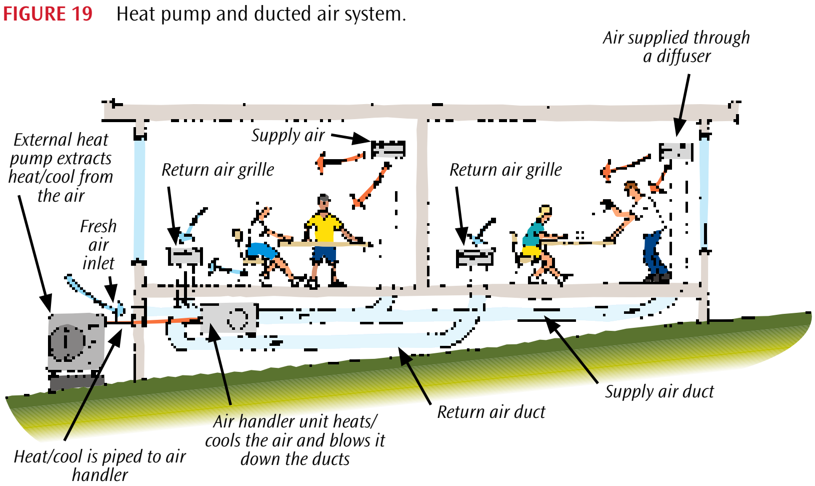
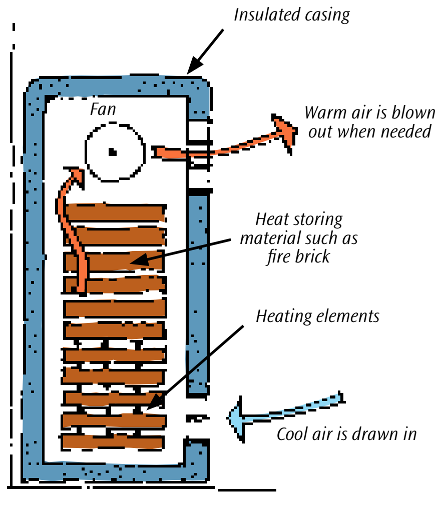


FIGURE 20 Storage heater.



Under-floor heating: consists of embedded heating elements which heat a concrete floor. There are two methods of heating the floor:

- electric heating cables
- pipes carrying hot water, usually heated by a boiler or heat pump.

A heated concrete floor gives an even spread of heat and is comfortable for young students who sit on or near floor level.

Under-floor heating has the disadvantage that it may not respond quickly to rapid changes in temperature and:

- if the day temperature is unusually warm, the stored heat is not wanted and may cause the room to get too hot
- if the day temperature is unexpectedly low and the floor has not been heated early enough, there will be a long delay before heat can be provided.

Flues for gas burners

Gas burns comparatively cleanly, forming carbon dioxide and water. However, as combustion is not always complete, small amounts of carbon monoxide, nitrogen dioxide and sometimes formaldehyde may also be produced. Unflued (portable) gas heaters are unsuitable for schools.[10]

All gas burning heaters in classrooms must have either a:

- full-height flue discharging at high level (Figure 21)
- fan-operated or balanced flue which can discharge through the wall at low level (Figure 22).

FIGURE 21 Full-height flue.

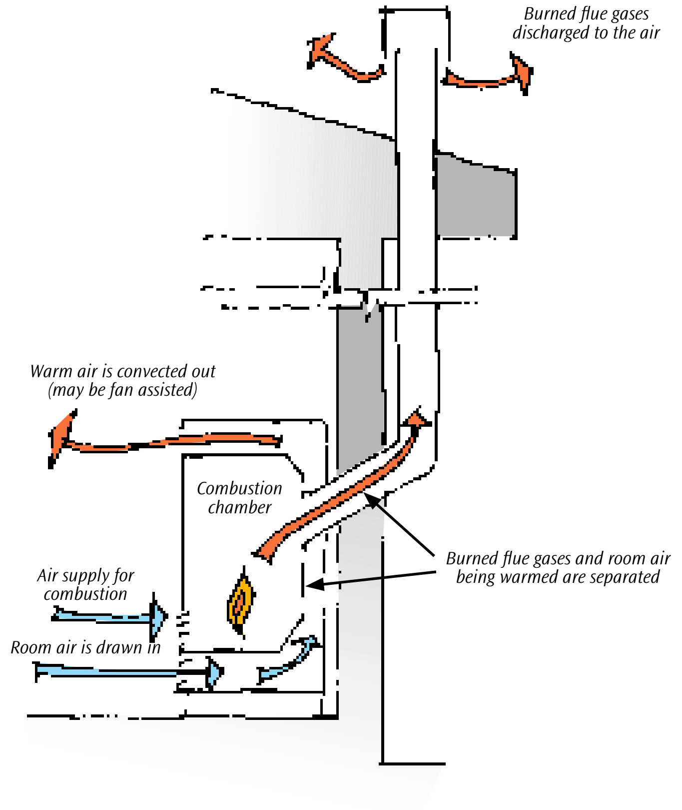
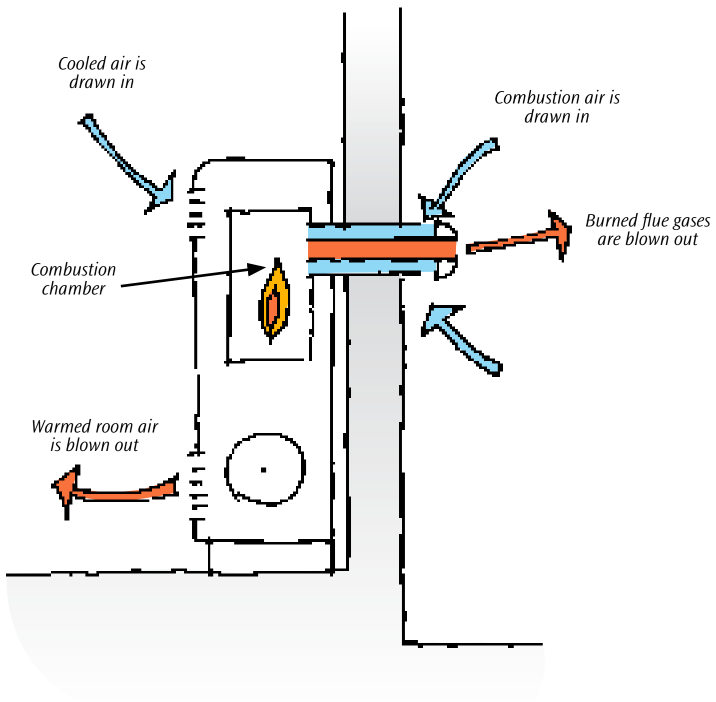


FIGURE 22 Fan operated or balanced low-level flue system.



All gas heaters in classrooms must have flues.

Controls for heaters

Most heaters have built-in thermostat and heat-output controls that can be switched on and off by the teacher. Controls in classrooms should preferably be robust so they won't be damaged by students.

Electric heaters can be remotely controlled by a:

- central timer that turns the power on in the morning and switches it off in the evening
- thermostat located in the room that switches off all heaters in that room when a set temperature is reached.

These systems need their own wiring.

Safety

Convector and radiant heaters in schools should:

- be permanently fixed in place, not portable
- have a safe touch temperature
- be robust enough not to be damaged by students
- have lockable controls so that students can't fiddle with them
- not have things put on top of them.

Selecting local heating:

Solid fuel

Not a suitable choice for new schools but it may be the form of heating for some existing schools. Note the potential impact of the National Environmental Standards on this form of heating.

Wood or coal	• fuel inconvenient to store • labour intensive • inadequate controls • generally unsuitable for schools • air pollution issues

Solid fuel heaters

Open fires	• only 15% efficiency
	• cost per unit (kWh) high
	• safety issues
	  – fire
	  – potential burns from hot surfaces

Modern closed wood burners	• 70% efficiency
	• cost per unit competitive
	• give rapid warm-up
	• high initial cost
	• safety issues
	  – fire
	  – potential burns from hot surfaces

Gas

Piped gas	• convenient fuel
	• availability
	  – widely in the North Island
	  – some areas of the South Island
	• cost per unit competitive

Bottled gas	• widely available • convenient fuel • cost per unit competitive

Gas heaters

Heaters without a flue	• should not be used in schools (see *Guidelines for Ventilation and Indoor Air Quality*)

Gas heaters

Convection heaters with: • flue or balanced flue • fan-assisted convection • remote controls • lockable controls • built-in thermostat	• safe – low temperature casing • can heat room quickly • can maintain an even temperature • heat input can be stopped instantly • competitive running cost • higher initial cost compared with electric heating • needs gas piping • needs electrical supply • high heat loss when used with passive ventilation • can be retrofitted
Radiant heaters – with or without flues	• generally unsuitable for use in schools – safety issues with open flame heaters – air quality issues with unflued heaters

Electricity

Electricity	• convenient fuel • widely available • capital cost per unit competitive

Electric heaters

Convection heaters with: • fan-assisted convection • remote controls • built-in thermostat	• safety – check casing temperature • can heat room quickly • can maintain an even temperature • heat input can be stopped instantly • low initial cost • high running cost • high heat loss when used with passive ventilation • can be retrofitted
Storage heaters with: • fan-assisted convection • built-in thermostat	• off-peak rates may be available • safety – check casing temperature • can heat room quickly • lack of flexibility – once heat is in the heater it cannot be dissipated on a warm day – may be acceptable in very cold areas • high installation cost • can be retrofitted
Radiant heaters with exposed elements – fixed low down	• generally unsuitable for schools – do not distribute heat evenly – safety issues – do not warm the room quickly

Radiant heaters – ceiling mounted or fixed high up	• suitable for heating large spaces • suitable for technology rooms • can provide heat to specific work areas • heat input can be stopped instantly • does not directly heat the air so heat lost when the room is not in use will be minimised • low installation cost • may have higher running cost
Central hot water heating with radiators	• can use a range of fuels • single plant installation to switch on or off • good control needs careful design • minimum maintenance • medium installation cost
Hot water under-floor heating from a central plant	• can use a range of fuels • single plant installation to switch on or off • gives good all round temperature • gives warmth at low level • may be acceptable in very cold areas • high installation cost • can only be installed into a new concrete floor
Heat pump – split system with: • reverse cycle capability • filters • remote control	• safe • can heat/cool the room quickly • heat input can be stopped instantly • can maintain an even temperature • very economical running cost • can be used as a dehumidifier • is not a ventilation system – separate ventilation is necessary • makes some noise • high installation cost • can be retrofitted
Heat pump – ducted air system with: • reverse cycle capability • filters • remote control	• safe • can heat/cool the room quickly – it is, in effect, an air conditioning system • heat input can be stopped instantly • can maintain an even temperature • is a ventilation system • very economical running cost • can be used as a dehumidifier • can be used to heat several rooms • can be retrofitted where there is floor or roof space for ducting • very high installation cost

> SECTION 3 – Insulation

Overview

What is insulation?

Insulation in this section is thermal insulation that resists the passage of heat. Every part of a building structure has some thermal resistance, but most need more to be effective.

The benefits of good insulation

The benefits of good insulation in a school are:

- better comfort levels by reducing heat loss through the structure
- interior surfaces are warmer, which reduces condensation (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
- less condensation means less likelihood of mould (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
- lower heat gain in summer
- reduced heating and cooling costs.

How insulation works

Insulating materials work by either:

- trapping air
- reflecting heat.

Insulation either traps air or reflects heat.

Insulation that traps air

Air is a poor conductor of heat and bulk insulation materials trap minute pockets of still air, which provides thermal resistance. Typical bulk insulation materials are:

- loose fill such as macerated paper, cellulose fibre, mineral fibre, sheep's wool and glass wool
- segments (batts) or rolls of glass wool, sheep's wool and polyester
- polystyrene and polyurethane boards
- wood wool slabs.

Insulation that reflects heat

Shiny materials such as metal foils reflect heat so that it doesn't pass through them easily. Materials such as aluminium foil are especially suited to reducing downward heat flows and are used in floors. To be effective, reflective insulation must have at least 20 mm space in front of it.

Insulating windows

Double glazing or insulated glazing units can have a significant effect on:

- heat loss
- condensation

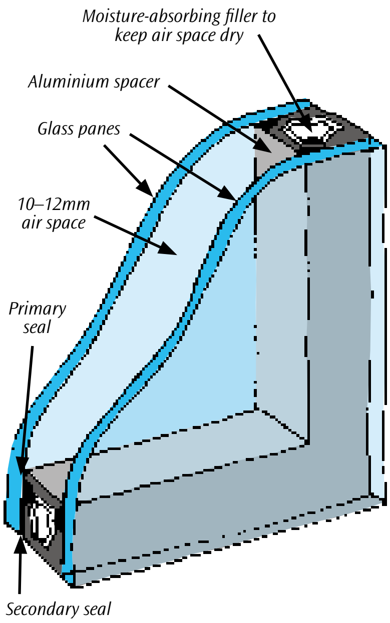
and will have some effect on:

- solar gain if they incorporate tinted or reflective glass
- noise transfer.

Double-glazed windows significantly reduce heat loss and condensation.

The most common type of double-glazing is made of two sheets of clear glass spaced apart by an aluminium hollow bar which is sealed to both sheets (Figure 23). The space between the sheets is normally filled with dry air, but some units have a partial vacuum or are gas filled to improve performance. Many types of tinted, reflective or laminated glass may be used in insulated glazing units.

FIGURE 23 Typical insulated glazing unit construction



It is important to decide what your requirement is and to establish clearly with the manufacturer which product will give the performance you're looking for.[8]

How is insulation measured?

The ability of a material to resist heat transfer is its ‘thermal resistance’ (R). The higher the R-value the greater the amount of insulation. R-values can be given for building elements, such as a wall, by adding the thermal resistance values of all the materials and the air gaps between them.

Table 1 shows the thermal resistance of some common materials and approximate R-values.

Table 1. Typical R-values of some common insulating and building materials

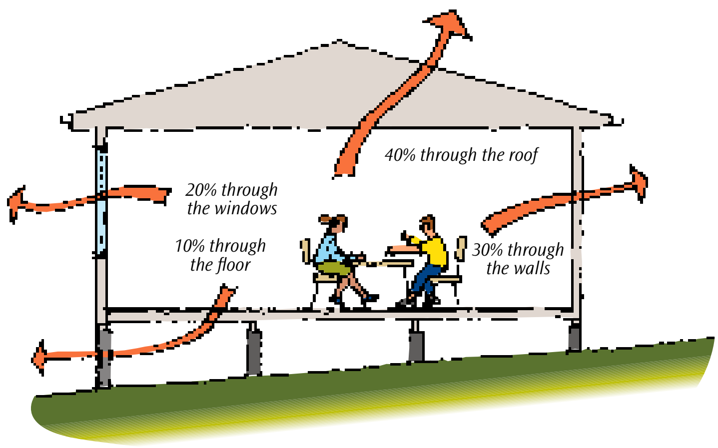
Materials	Thickness (mm)	R-value
Insulating materials		
Fibreglass insulation (values and thicknesses vary with different manufacturers)	50 75 100	1.3 1.8 2.0 to 2.2
Polyester	100 120	1.6 2.2
Wool	90 120	1.7 2.2
Macerated paper loose fill	100	2.2
Mineral fibre loose fill	100	2.2
Expanded polystyrene board: Class S Class H	40 40	0.9 1.1
Extruded polystyrene board	40	1.4
Wall cladding materials		
Weatherboards	19	0.14 to 0.16
Fibre-cement sheet	9	0.04
Plywood	12.5	0.09
Steel or aluminium cladding		Nil
Concrete	100	0.06
Bricks	70	0.05
Concrete blocks	100	0.13
Plasterboard	9.5	0.04
Soft board	12	0.22
Window glazing (aluminium frame)		
Clear glass	4	0.15
Double-glazing each pane 4 mm 12 mm air gap between	20	0.26
Flooring		
Particleboard	20	0.13
Cork tile	3	0.05
PVC sheet		0.01
Carpet and underlay		0.4

How is heat lost?

In a typical uninsulated classroom (Figure 24) heat is lost from the:

- roof 40%
- walls 30%
- windows 20%
- floor 10%.

FIGURE 24 Typical heat losses from an uninsulated classroom.



How much insulation is necessary?

New buildings and additions

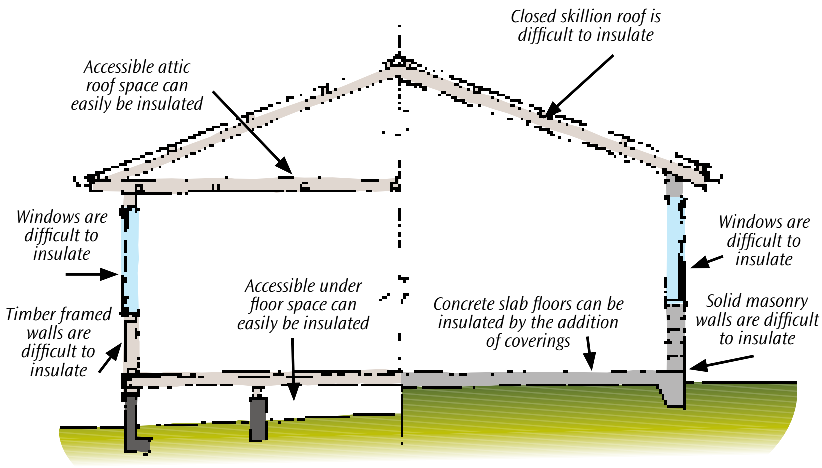
In new buildings and additions insulation should be installed to the recommendations set out in Section 6.

Existing buildings

Most thermal insulation is built into the building structure. Fitting insulation into existing buildings (apart from attic roof spaces) is difficult and expensive (Figure 25). Thermal insulation should be retro-fitted to existing buildings when:

- comfort conditions cannot be achieved in classrooms because of heat loss or gain
- alterations, refurbishments or repairs make it possible.

FIGURE 25 Retro-fitting insulation to existing classrooms.



Where is insulation most effective when upgrading?

Roofs and ceilings

Because it is the area where most heat is lost or gained, roof insulation is very effective. In cold regions, insulation of roofs should be considered even when it means a new ceiling.

Look to fit roof insulation when:

- there is an accessible attic roof space
- the roof cladding must be replaced
- the ceiling lining needs replacing
- a new ceiling is installed beneath the existing one for acoustic reasons.

Roof insulation is very effective.

Walls

While they account for a high proportion of total heat loss, it is difficult and expensive to insulate existing walls. Insulation can be installed when the:

- outside cladding must be replaced
- inside lining needs replacing.

Insulation can be added as an additional layer to the outside or inside of walls, but this is expensive.

Windows

Double-glazing is not likely to be a cost-effective option, except:

- in colder regions
- where it is required for acoustic reasons (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality or Acoustics*)
- if condensation is a problem.

Ground floors

Heat loss through ground floors is relatively small, but because younger students often sit on or near them, fitting insulation will make it warmer. Insulation can be fitted to timber floors where there is enough space to work. The best solution for classrooms with existing concrete floors is to fit carpet with rubber waffle underlay, or cork tiles (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

Improving insulation

Fully accessible attic roof spaces

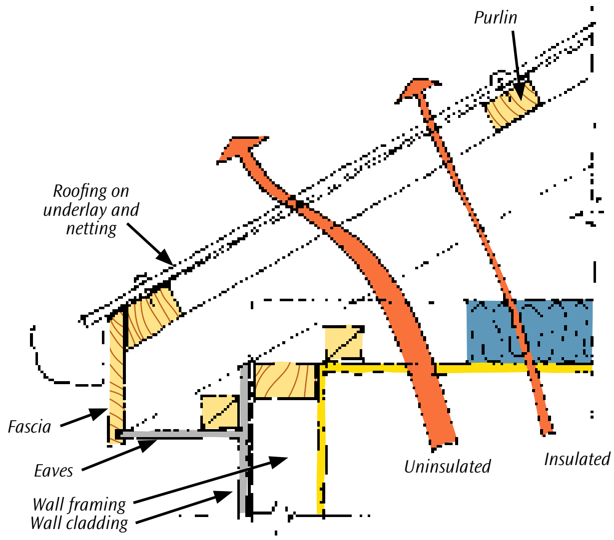
For uninsulated roof spaces in all regions fit:

- 150 mm glass wool, wool, polyester – blanket or segments or
- 150 mm macerated paper, mineral fibre, blown wool – loose fill

(Figure 26)

- cost-effective
- will reduce heat loss
- will reduce solar heat gain
- must fit tight between or overlay the joists
- must be no gaps
- must have correct coverage

FIGURE 26 Adding insulation to an uninsulated attic roof.



In roofs in cold regions with up to 75 mm of existing insulation fit an additional:

- 50 or 75 mm glass wool, wool, polyester blanket over the joists

- cost-effective
- will improve insulation performance

Attic roof spaces with restricted access

For uninsulated roof spaces install:

- 150 mm macerated paper, mineral fibre, blown wool – loose fill

- cost-effective
- will reduce heat loss
- will reduce solar heat gain
- can be blown into inaccessible corners

Uninsulated skillion roofs

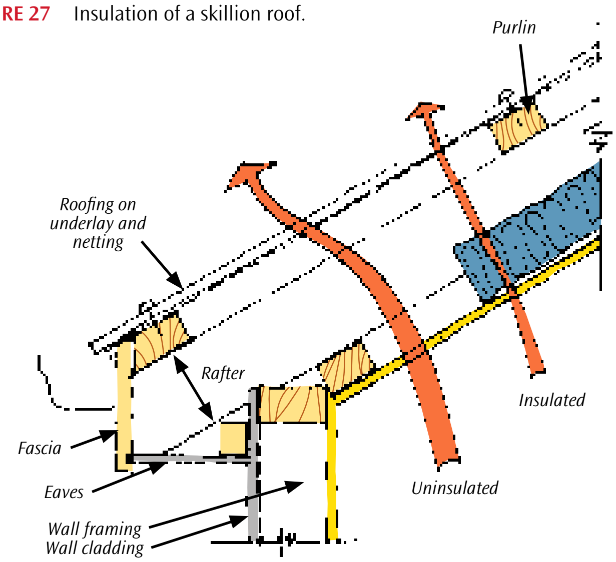
When replacing the roofing remove roof underlay and netting and fit:

- up to 150 mm glass wool, wool, polyester – segments

Replace roof underlay and netting before fixing new roofing (Figure 27)

- expensive but cost-effective, particularly in cold regions
- will reduce heat loss
- will reduce solar heat gain
- must fit tight between roofing timber
- must be no gaps
- must be 25 mm gap between insulation and building wrap

FIGURE 27 Insulation of a skillion roof.



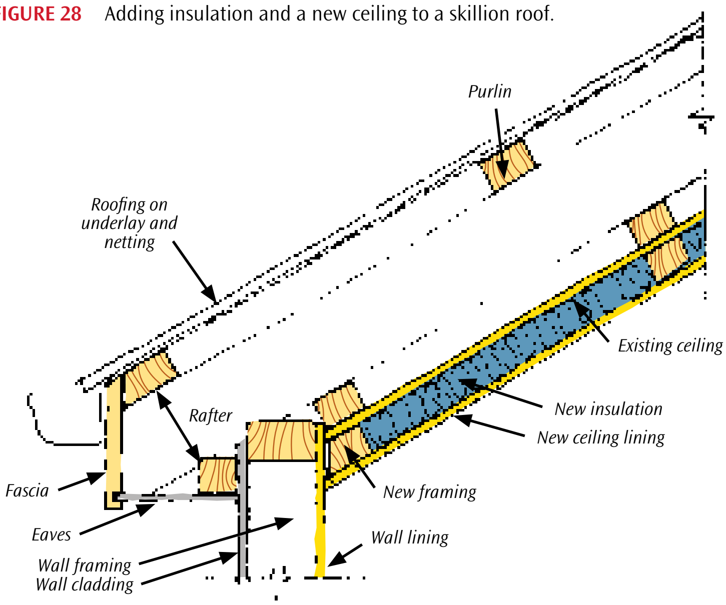
When replacing the ceiling lining, fit:

- up to 150 mm glass wool, wool, polyester – segments

- cost-effective
- will reduce heat loss
- will reduce solar heat gain
- must fit tight between roofing timber
- must be no gaps
- must be 25 mm gap between insulation and building wrap

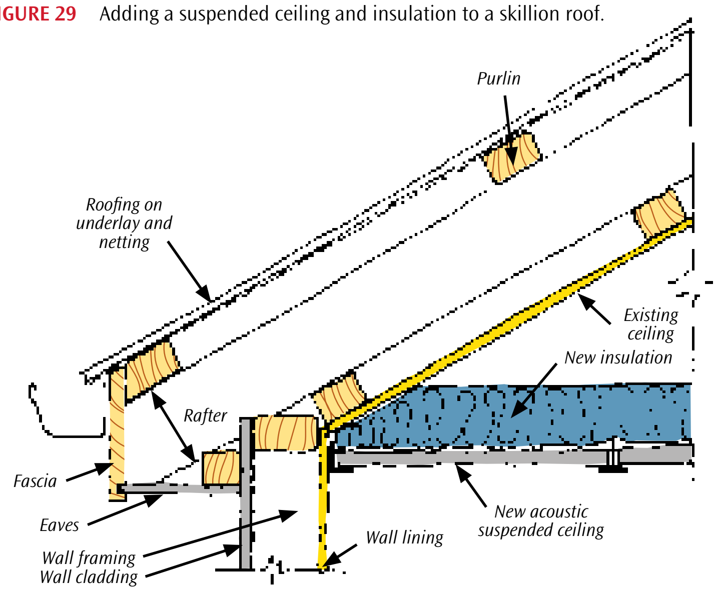
Construct new packed-down ceiling below the existing one with 50 mm glass wool, wool, or polyester segments (Figure 28)	• will reduce heat loss • will reduce solar heat gain • must fit tight between roofing timber • must be no gaps • expensive option

FIGURE 28 Adding insulation and a new ceiling to a skillion roof.



Construct new suspended ceiling below the existing one with 100–150 mm glass wool, wool, or polyester insulation (Figure 29)	• most effective way to reduce heat loss • will reduce solar heat gain • must be no gaps • can be combined with acoustic treatment (see *Designing Quality Learning Spaces – Acoustics*) • most expensive option

FIGURE 29 Adding a suspended ceiling and insulation to a skillion roof.



Walls

Replace outside cladding to timber-framed walls and install insulation (Figure 30)	• will reduce heat loss • will reduce solar heat gain • low-cost option if cladding is due for replacement – otherwise expensive
Add Exterior Insulation and Finish System (EIFS) existing cladding (Figure 31)	• will reduce heat loss • will reduce solar heat gain • needs care around windows and doors • useful option where external cladding is in poor condition and needs upgrading • expensive option
Replace internal lining and install insulation	• will reduce heat loss • will reduce solar heat gain • low-cost option if internal linings are due for replacement
Add framing to inside of timber-framed walls, install insulation and fit new lining (Figure 32)	• will reduce floor area • needs careful detailing around windows, doors and skirtings • insulation gains will depend on new framing thickness • expensive option
Add EIFS on the outside of block walls (Figure 33)	• may upgrade general appearance • will reduce heat loss • will reduce solar heat gain • needs care around windows and doors • expensive option

FIGURE 30 Adding insulation by preparing the external cladding.

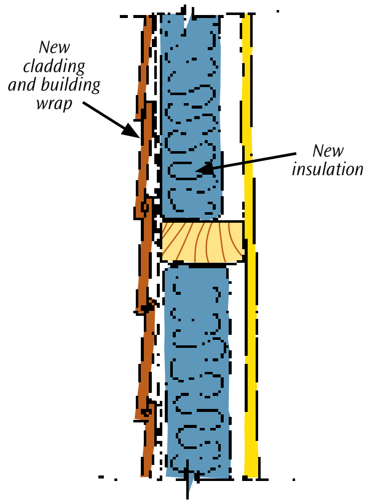


FIGURE 31 Adding insulation to the outside.

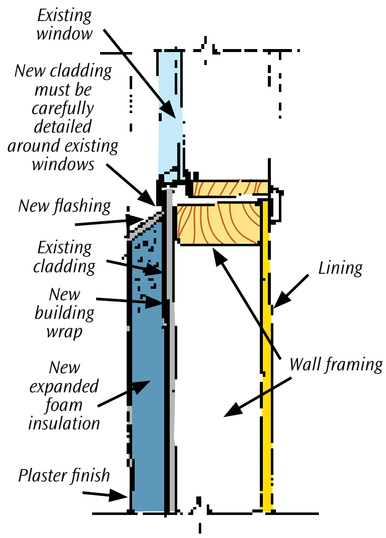


FIGURE 33 Adding insulation to the outside of concrete block walls.

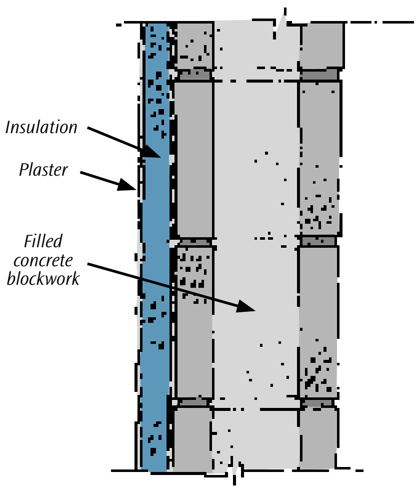
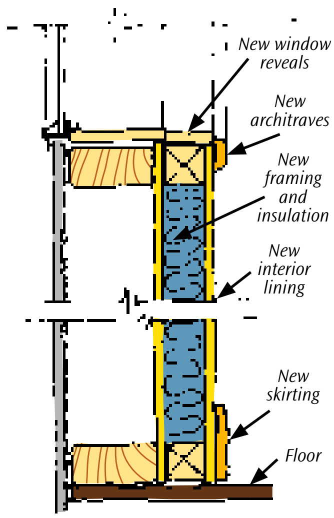


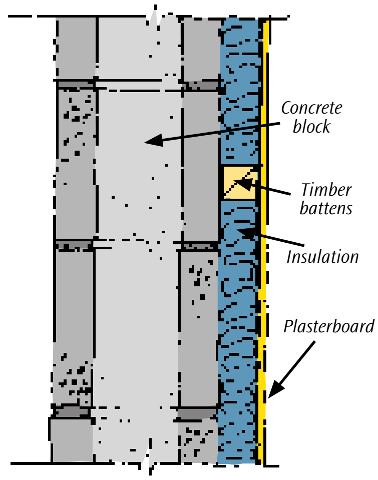
FIGURE 32 Adding insulation to the inside.



Add framing to inside of masonry block walls, install insulation and fit new lining (Figure 34)

- needs careful detailing around windows, doors and skirtings
- insulation gains will depend on new framing thickness
- very expensive option
- will reduce floor area

FIGURE 34 Adding insulation to the inside of concrete block walls.



Windows

Re-glaze with insulated glazing units

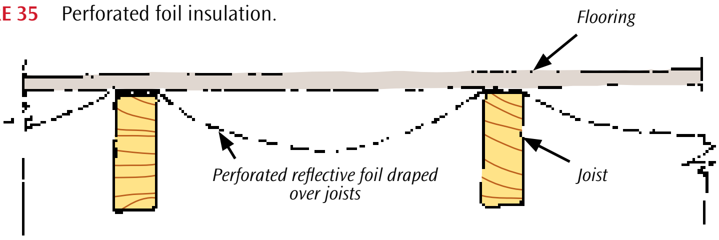
- in very cold regions will also reduce condensation
- will reduce heat loss
- unlikely to be cost-effective in warm regions
- expensive option

Timber floors

Standard insulation is perforated aluminium foil draped between timber joists (Figure 35)

- minimum recommended insulation

FIGURE 35 Perforated foil insulation.

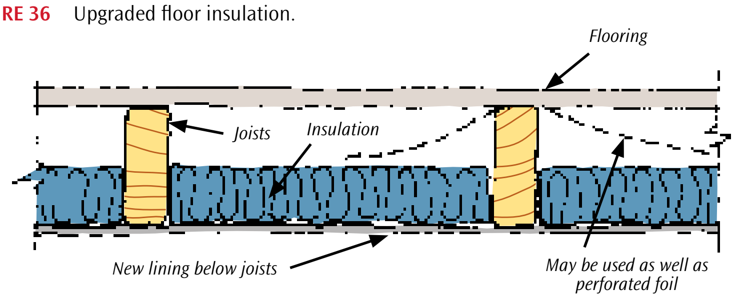


Add foil to underside of joists

- low cost
- will bring floor insulation up to minimum standard

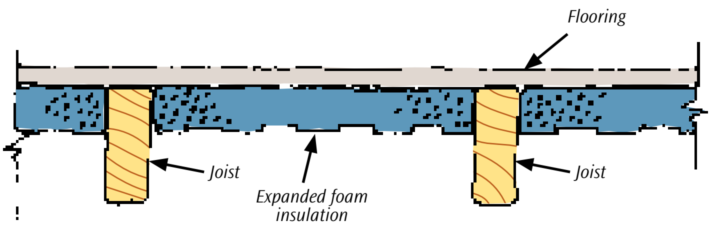
Add bulk insulation and lining to underside of joists (Figure 36)	• moderate cost • essential where the underside of the floor is exposed • will reduce heat loss and increase comfort

FIGURE 36 Upgraded floor insulation.



Add expanded foam insulation between joists (Figure 37)	• moderate cost • essential where the underside of the floor is exposed • will reduce heat loss and increase comfort

FIGURE 37 Upgraded floor insulation.



> SECTION 4
– Specialist Teaching Spaces

Specialist help

All areas under this heading have special requirements. It is important to seek advice from an experienced heating expert who is familiar with local conditions.

Computer rooms

Requirements are similar to classrooms, but the heat output of the machines must be considered.

Multi-purpose halls

Multi-purpose halls have many functions with a wide range of often conflicting acoustic, heating, ventilating and lighting requirements. (see other guidelines in this series *Designing Quality Learning Spaces – Acoustics, Lighting or Ventilation and Indoor Air Quality*).

Heating may be required for:

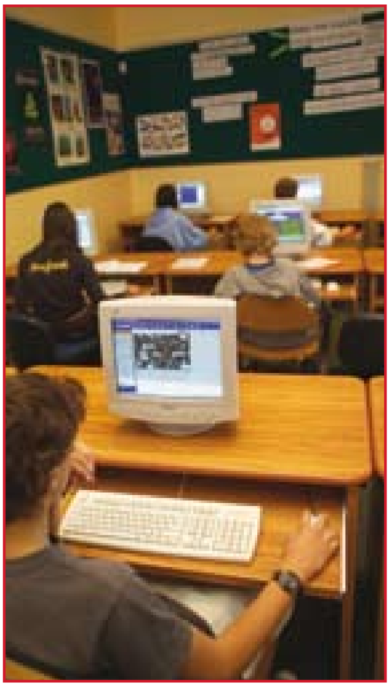
- large inactive groups at assembly, prize-giving and recitals
- large active groups for gym or dancing
- small active or inactive groups for teaching and rehearsals.

To cope with diverse conditions multi-purpose halls must have flexibility:

- radiant heating may be suitable and economic where the space is used intermittently
- convector heaters may be suitable for smaller halls which are used throughout the day
- a combination of convector and radiant heaters may give flexibility.

Suitable temperatures may be:

- 18–20°C if the hall is used for continual teaching purposes
- 14–16°C where the hall is used intermittently and has radiant heating
- 12–14°C if the hall is only used for physical activity and has radiant heating.



Considerations for multi-purpose halls:

Radiant heating	• low installation cost • will heat the occupants immediately without overheating the air • a lower temperature will be suitable if there is only intermittent use • may have high running cost
Convection heating	• low installation cost • low running cost • will take a long time to heat the large volume of air • a large amount of heat in the warmed air will be wasted if the room is only used intermittently • will maintain good comfort levels if the room is in continuous use
Heater layout	• must be coordinated to suit other functions such as drama lighting

Gyms

Owing to the high activity and heat generated by students in a gym, temperatures can be lower than in other teaching spaces and good ventilation is very important (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

Rather than heating all the air, it may be better to use radiant heating, which keeps everyone comfortable without heating the air. The need to avoid condensation, which can be a safety issue on flooring, is important.

Suitable air temperatures are:

- 12–14°C for radiant heating
- 17–18°C for convection heating

Considerations for gyms include:

Radiant heating	• heat lost through ventilation will be minimised • heat lost when the room is not in use will be minimised • low installation cost • may have higher running cost
Convection heating	• low installation cost • will take a long time to heat the large volume of air • warmed air will be lost through ventilation • a large amount of heat in the warmed air will be wasted when room is not in use • low running cost may be offset by heat wastage
Heaters	• must be robust to withstand impact from balls and equipment or be suitably protected • should be placed where impact damage is least likely (eg, high up) • should not be able to collect dust or shuttlecocks
Controls	• should clearly indicate when the heating is on • should be lockable

It may be better to use radiant heating in gyms.

Libraries

The heating requirement for libraries is similar to classrooms. There is little physical activity, so the temperature should be on the high side and the heat should be evenly spread.

Suitable temperatures are in the 18–20°C range.

Considerations for heating libraries include:

Convector heaters	• will maintain a steady temperature • may be placed high up to avoid book shelves • low running cost • low installation cost
Radiant heaters	• low installation cost • may not be as comfortable as convection heaters • check suitability for books • higher running cost may be offset if there is only intermittent use
Air conditioning (HVAC)	• consider using HVAC where: – audio visual projection is used regularly – there are large numbers of computers • high installation cost • high running cost • need to control noise levels
Under-floor heating	• an effective option, particularly in primary schools • warm for students sitting on the floor • leaves the walls free

Music Rooms

Generally the heating requirements for music rooms are the same as for classrooms. In some cases the acoustic requirements of music rooms (see *Designing Quality Learning Spaces – Acoustics*) may call for special solutions to heating and ventilation. The need to either contain the noise within music rooms, or prevent noise entering from outside, may limit the scope for natural ventilation and require air conditioning (HVAC). If the rooms have no windows and active ventilation this will reduce the need for cooling and simplify noise control.

Suitable temperatures are in the 18–20°C range.

Considerations for heating music rooms include:

Convector heaters	• will maintain a steady temperature • must have low noise output • low running cost • low installation cost
Radiant heaters	• low installation cost • may not be as comfortable as convection heaters • are quiet • higher running cost may be offset if there is only intermittent use
Air conditioning (HVAC)	• consider using HVAC where windows must be kept closed to exclude outside noise • high installation cost • high running cost • check noise level

Design, Art and Technology rooms

Although students are fairly active in design, art and technology rooms the temperatures need to be high enough so they are warm enough to operate machinery safely.

Suitable temperatures are:

- 16–18°C for materials and food technology
- 18°C for design, art and technology rooms.

Technology rooms need to be warm enough so students can operate machinery safely.

The additional heat output from computers, cooking and soldering, etc must be considered but may be offset by the extract requirements (*Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*).

Considerations for design, art and technology rooms include:

Convector heaters	• low installation cost • low running cost • will maintain a steady temperature • may take up usable wall space • consider industrial-type heaters fixed high up • additional heat input will be needed where heat is lost through extract units • tend to recirculate dust in the air • have an electric element so consider safety issues
Radiant heaters	• can be positioned to keep students warm at specific work places • lower air temperature will minimise heat loss from extract units • low installation cost

> SECTION 5
– Students with Special Education Needs

Schools for all people

Temperature requirements

The heating needs of some students, especially those who have less control over their mobility or body temperature, may be different than for other children in a classroom.

The standard of heating recommended in this guideline will be satisfactory for most students with special education needs. Some exceptions might be students who:

- need a warmer background temperature because they:
  - are confined to a wheelchair or have physical difficulties that limit their activity
  - have a sight impairment that restricts their movements

Planning ahead

Making provision for students with special education needs must be an integral part of a school's policies and practices. This provision must be considered at all stages of planning and construction of new buildings and refurbishments. Schools should take account of both existing and future students likely to attend the school. Generally, planning and design which makes provision for students with disabilities benefits all students and teachers.

Creative problem-solving

Owing to the need to cater for various heat requirements, careful thought and some creative ways of resolving problems may be called for including:

- installing a heating system able to respond quickly to changing outside conditions and students' needs
- ensuring sedentary students spend most of their time in areas of the room that are warmer in cold weather
- placing students with attention difficulties in cooler areas
- installing a small, high level or ceiling-mounted radiant heater to give additional heat to students who need it
- using fans to give additional cooling to students who need it
- having blinds or shades to avoid unwanted solar heat
- ensuring students with special education needs are dressed appropriately.

The heating needs of some students, especially those who have less control over their mobility or body temperature, may be different than for other children in a classroom.

> SECTION 6
– Planning New Buildings and Extensions – Statutory Requirements for Heating and Insulation

Ensuring comfort conditions and economic heating

Where new buildings or substantial alterations are planned, an architect will be appointed. Where alterations or additions are planned one of the early design tasks will be to appoint a heating consultant to assess if the existing heating system:

- has enough capacity to heat additional spaces
- has sufficient remaining life
- is efficient.

Principals and boards of trustees should be aware of important considerations for heating and they need to have a basic understanding of the design and building processes.

To achieve comfort conditions for all year round, and to ensure that project money is well spent, boards should monitor heating plans throughout the design and building process.

Boards of trustees should understand that:

- heating schools is not like heating houses
- designing to suit the regional climate is important
- correct orientation of the building is a prime factor
- a high standard of heat insulation will help to ensure comfort conditions and reduce running costs
- controlling solar gain is critical in all regions
- the correct choice of heating system will have a long-lasting beneficial effect on comfort and economy
- making it possible for teachers to control heating will make a more comfortable and productive school
- achieving comfortable learning/teaching conditions is a holistic process – design, ventilation, air quality, heating and lighting must be considered as a total entity and cannot be separated.

Teachers and educators should understand that:

- comfort conditions in teaching spaces are important for health and general wellbeing
- a comfortable environment is a good learning environment.

Architects and heating consultants should understand the:

- heating requirements for schools
- specific climate of the site
- climatic, technical and practical elements of heating
- importance of comfort conditions for health and well-being
- holistic nature of design, ventilation, air quality, heating and lighting
- requirements of students with special education needs.

Monitoring the design process

Key principles

Principles that can be applied at the appropriate stages are set out in the Ministry of Education *Property Management Handbook*.

At the initial assessment stage

Ensure that a survey is carried out to establish:

- local climatic year-round conditions
- sun angles and shading for all times of the year
- the incidence of extreme temperatures
- prevailing winds and wind strengths.

Ensure the architect is fully briefed on the:

- statutory requirements New Zealand Building Code (NZBC)
- Ministry of Education requirements
- recommendations in this publication
- need for a computer model to show the energy requirements and thermal comfort performance of the proposed design.

At the design stage

Ask the architect:

- how the local climate affects heating
- to explain the computer model of the energy requirements of the design
- how solar gain will be used to advantage in winter and minimised in summer
- to explain the life-cycle costing of the heating system
- about the advantages of the particular heating system that has been chosen
- the impact any changes will have on the existing heating system if this is a remodel or an additional building
- how the temperature of teaching spaces can be adjusted if they become too hot or cold
- the standard of proposals for insulation and its effect on running costs.

Answering these questions may involve some calculations and technical explanations which you are not expected to understand. The important point is that you ensure the architect has:

- given sufficient thought to these issues
- designed accordingly
- provided specific information on how a good outcome will be achieved.

At practical completion

Require the architect to:

- demonstrate by temperature monitoring and recording that the design requirements have been met
- show that running costs approximate to the design model.

The New Zealand Building Code (NZBC)

The NZBC contains two Clauses, E3 *Internal Moisture* and H1 *Energy Efficiency*, which influence the use of insulation in buildings:

***E3*[11]**
Performance E3.3.1

An adequate combination of thermal resistance, ventilation and space temperature must be provided to all habitable spaces, bathrooms, laundries and other spaces where moisture may be generated or may accumulate.

H1
Performance H1.3.1

The building envelope enclosing spaces where the temperature or humidity (or both) are modified must be constructed to:

a) provide adequate thermal resistance; and

b) limit uncontrollable air flow.

Performance H1.3.2

Buildings must be constructed to ensure that the Building Performance Index (BPI) does not exceed:

a) 0.13 kWh in a warm location; and

b) 0.12 kWh in a cool location.

E3.3.1 and H1.3.2 apply only to residential buildings and H1.3.1 is not specific.

Apart from the general intent and guidance in these clauses, the NZBC has no specific requirements for insulation of schools.

Insulation recommendations for schools

When insulation should be installed

Owing to the lack of guidance in the current NZBC, and the importance of insulation to health and running costs, a high standard of thermal insulation should be installed in all new school buildings.

Minimum standard of insulation

These guidelines recommend insulation be installed to the following minimum standards:

- for small, single or two storey school buildings use NZS 4218 *Energy Efficiency – Small Building Envelope*[12] (Note: this standard is intended for buildings under 300 m^2 but this recommendation is to use it for small, single or two storey school buildings which may exceed 300m^2.)
- for large schools over two storeys use NZS 4243 *Energy Efficiency – Large Buildings.*[13]

Better or best practice

These standards are minimum standards and, where possible, you should aim for a higher level of thermal insulation. BRANZ *House Insulation Guide*[7] is a useful tool that can be applied to most school buildings in the 'small' category. It is easy to use and gives you options of:

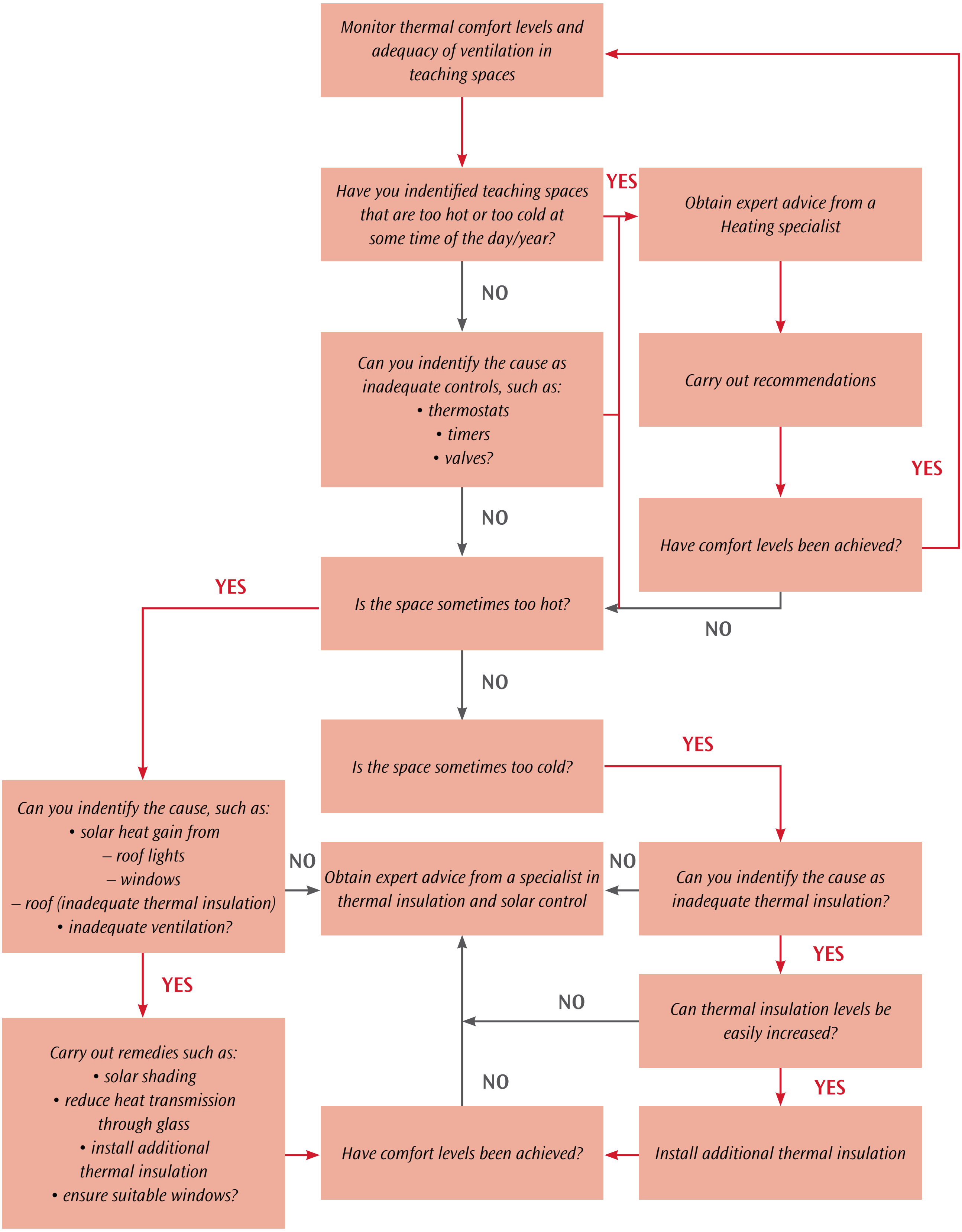
- minimum standards to NZS 4218
- better practice
- best practice.

These guidelines recommend using the BRANZ *House Insulation Guide* 'better practice' as a minimum and 'best practice' where possible.

> APPENDICES

– Flow diagram for Heating and Insulation Assessment
– Heating and Insulation Survey Form
– End Notes

Flow diagram for Heating and Insulation Assessment



Heating and Insulation Survey Form

Use this Survey Form to help you assess the suitability of heating and insulation in your classrooms.

1. Do students and teachers complain of being cold only in the early part of the morning?

Yes ☐ No ☐

Comment: check that:

- the heating is turned on early enough to pre-heat the classrooms
- the heater output is adequate
- the heaters and thermostats work.

2. Do students and teachers complain of feeling cold all day in winter?

Yes ☐ No ☐

Comment: this indicates that:

- the capacity of the heating system is inadequate
- thermal insulation is inadequate.

Check that the heaters and thermostats work and have sufficient output to heat the room. Also investigate the state of thermal insulation and consider upgrading where possible (see Section 3).

3. Do students and teachers find that the temperature is comfortable early on a winter morning, but complain of being too hot later in the morning?

Yes ☐ No ☐

Comment: this may be because once the room is warmed the heaters are still on. Check that:

- thermostats are working
- if there are no controls consider fitting either:
  - a thermostatic control
  - a simple on/off control.

4. Is the room hot in some parts and cold in others?

Yes ☐ No ☐

Comment: heat may not be circulating properly or may be confined to particular areas. Consider:

- installing a ceiling fan (see *Designing Quality Learning Spaces – Ventilation and Indoor Air Quality*)
- using fan-assisted convector heaters
- using radiant heaters in the cold spots.

5. Are there parts of the room that are uncomfortable when the sun comes in?

Yes ☐ No ☐

Comment: consider fitting:

- blinds
- solar shading
- solar control film or solar control glass to the windows.

6. Does the whole room become too hot in summer?

Yes ☐ No ☐

Comment: the likely cause is solar heat gain. Consider:

- improving the standard of insulation
- removing or shading any roof lights
- fitting solar shading where necessary
- installing solar control film or solar control glass to windows where necessary.

7. Is there uncomfortable heat build-up from equipment such as computers?

Yes ☐ No ☐

Comment:

- improve ventilation
- ensure there are adequate temperature controls.

8. Do you consider your school's annual heating bill to be unusually high?

Yes ☐ No ☐

Comment: employ an experienced heating consultant to carry out an audit to identify ways to improve comfort and efficiency.

End Notes

1 ***Best Practice in Classroom Design***

Report prepared for the Ministry of Education

AC Nielsen

Wellington, NZ

2 ***Design of Educational Buildings***

Samos Yannas

Environmental and Energy Studies Programme

AA Graduate School

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3 ***Energy and Comfort Feature – In the Hot Seat***

Michael Donn

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BRANZ Ltd

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4 ***Use and Control of Solar Gain***

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5 ***Windows – Films and Coatings***

Bulletin 421

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8 ***Insulated Glazing Units***

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10 ***Safety Reminder on Unflued Gas Heaters***

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11 ***New Zealand Building Code***

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Approved Document – H1

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12 ***Energy Efficiency – Housing and Small Buildings Envelope***

New Zealand Standard 4218

Standards NZ

Wellington, NZ

13 ***Energy Efficiency – Large Buildings***

New Zealand Standard 4243

Standards NZ

Wellington, NZ

Notes

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ISBN: 0-478-13621-8
WEB ISBN: 0-478-13626-9