INFOSHEET 2

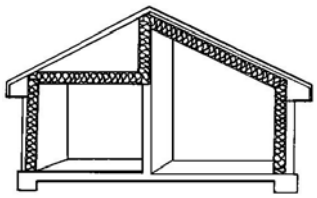
School cooling

Cooling can present a substantial energy cost to schools. Temperatures of 24°C to 27°C with less than 60% relative humidity give acceptable comfort in summer. Higher temperatures can be considered comfortable with air movement created by a breeze or a fan. Schools located in northern Victoria may need cooling systems to maintain a comfortable working environment.

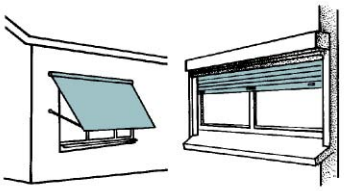
Careful consideration should be given to the use of natural and passive methods of cooling before the installation of electrically powered cooling systems in schools.
It is more efficient and effective to stop heat entering a building rather than having to remove heat to lower internal temperatures.
Heat entry into your school can be reduced by:

- Insulation to ceilings (and walls if possible);
- External shading to north, east and west windows.

As significant heat in summer enters through windows, external shading and insulation are important strategies in keeping schools cool.

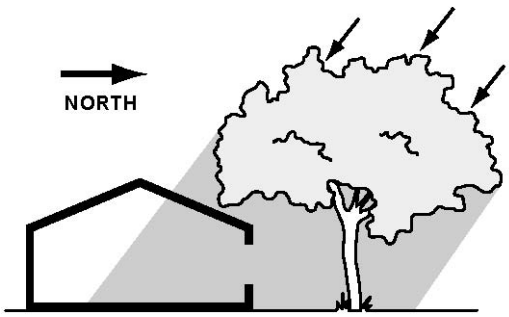


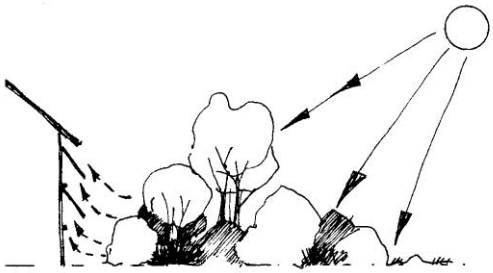
Insulation reduces heat transfer through walls and ceilings



Shading awnings and shutters reduce radiant heat passing through windows

As well as providing shade, trees and shrubs planted next to buildings provide a cooling effect through leaf transpiration. The leaves give up moisture, which evaporates and cools the air in the immediate area. Watering should be done in the evening to avoid leafscorch and mulching will help retain soil moisture.





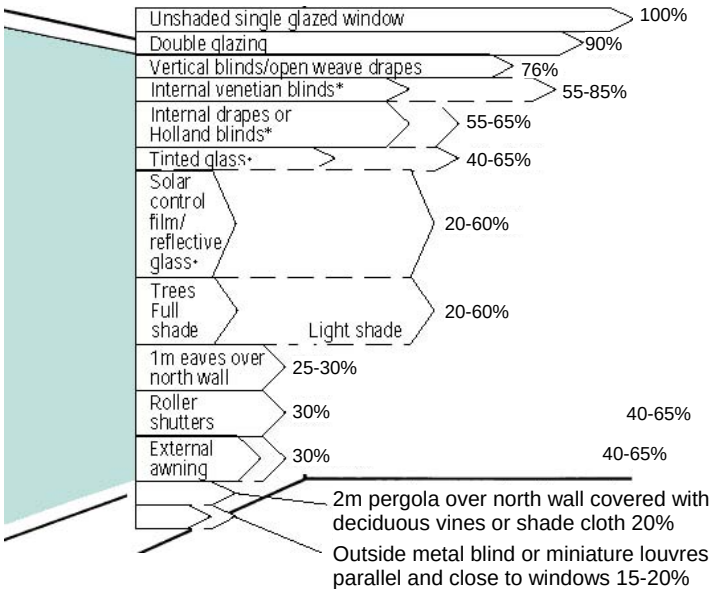
From School Cooling, Ministry of Education (Schools Division) Victoria, 1986. Reproduced with permission of the Department of Education, Employment and Training (DE&T).

ENERGY EFFICIENT COOLING STRATEGIES

Minimise the heat entering buildings by:

- shading of north-facing windows with deciduous trees, shade cloth, external blinds or awnings;
- closing internal curtains or blinds during the day;
- fully or partially covering east and west-facing windows with notice boards or providing external shading;
- applying white gloss paint to metal roof surfaces. This can reduce internal summer temperatures by up to 4–5°C; and
- applying reflective films to windows to reduce glare and heat transfer. These films have the disadvantage of reducing natural light and solar heating in cooler months.

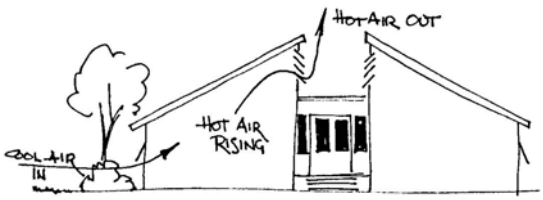
Effectiveness of various window treatments



** Effectiveness is reduced as the colour darkens.*
• Solar film, tinted glass and reflective glass of varying effectiveness is available. They significantly reduce light levels all year round.

Remove heat from rooms by:

- opening doors and windows when outside air is cooler in the morning to delay the need to switch on coolers;
- venting rooms at night with secure ceiling vents or high windows;
- utilising cross flow ventilation;
- using ceiling fans to increase air circulation. Running costs are only about 2 cents per hour; and
- many central heating fans can be operated during summer to increase room ventilation, or purge rooms of heat at night.



From School Cooling, Ministry of Education (Schools Division) Victoria, 1986. Reproduced with permission of Department of Education and Training.

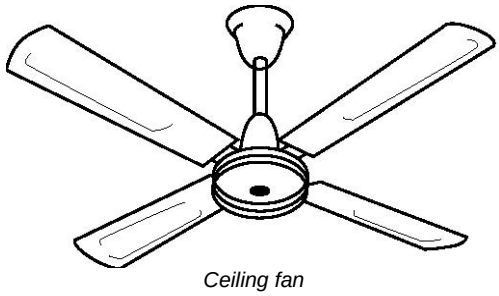
Where mechanical cooling is installed:

- set thermostat no lower than 25°C in summer (every extra 1°C adds 10% to energy consumption);
- rooms with refrigerative air conditioners should have doors and windows shut;
- open doors or windows to discharge air fromevaporative coolers;
- maintenance is important! Regularly clean filters on air conditioners and maintain drive belts and thermostats in good working condition;
- if the condenser coil of a refrigerative air conditioner is exposed to direct sunlight, provide shading and weather protection, but don't restrict movement of air around it;
- limit access to after hours use of air conditioning, particularly if the system is centralised serving the whole school. Arrange for the cleaners to begin work as soon as classes finish;
- evaporative cooling outlets should be closed off during cool weather; and
- power points supplying small room air conditioners can have a push button time delay switch fitted to ensure they are not inadvertently left running when not required.

MECHANICAL COOLING

Fans

Fans produce a cooling effect by moving air over the skin, encouraging moisture on the skin to evaporate which, in turn, causes the skin to cool. Although they do not reduce actual room temperatures or humidity levels, fans can often provide an adequate level of comfort and provide the cheapest method of cooling.



Ceiling fan

Ceiling fans should have a head clearance of 600–900 mm for safety. They can be suspended with down rods in areas with high ceilings. Note the following:

- the number of blades has no effect on cooling capability. Metal blades are best;
- units should be mounted clear of existing light fittings to avoid annoying flicker;
- they should have a reverse spin setting to assist with winter heating; and
- general classrooms require two ceiling fans.

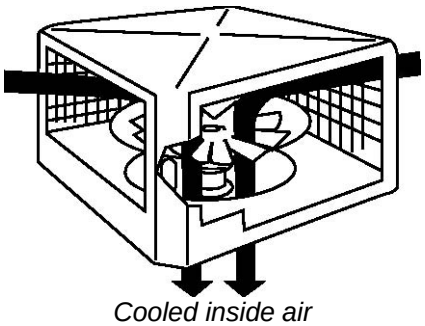
Purchase cost: $60–$200 each
Running cost: 2 cents* per hour
**Based on a assumed electricity tariff of peak rate 16c/kWh and natural gas tariff of 95c/MJ.*

AIR CONDITIONING

The installation of cooling systems can substantially increase energy costs for schools. There are two main options available to schools—evaporative cooling or refrigerative air conditioning. Schools should consider the issues below when considering these systems. Prior to installing cooling systems, careful consideration should be given to passive methods of cooling, especially shading and ventilation. Even if a school intends to pursue mechanical cooling, the adoption of passive cooling measures will reduce the energy use and operating cost of cooling or air conditioning systems. There are several important differences between evaporative and refrigerative systems including operation, performance, ventilation, running costs, and peak electrical demand.

Evaporative coolers

Evaporative coolers draw warm outside air through a series of wet filter pads. As the water evaporates in this air stream, it is cooled and becomes more humid. Dust is also filtered. The cooled air is blown into the building, cooling rooms as it passes out through open windows, doors or vents.



Evaporative cooling

To work effectively, it is vital that rooms filled with evaporative coolers have adequate ventilation to exhaust air outside. They are an excellent cooling choice in most buildings, provided some doors and windows can be left open during school hours or adequate vents can be installed.
Evaporative coolers are significantly cheaper to operate than refrigerative air conditioning.

Performance limitations

The main disadvantage of evaporative cooling is its reduced performance during humid weather conditions. The higher the humidity level, the less evaporation takes place, and the less cooling can be provided by the system. In northern Victoria these days are rare, but in Melbourne the number of such days per year is usually between 5 and 10. However, the system should work well on most hot school days over summer.
On humid days it may be more appropriate to use evaporative systems in 'fan-only' mode, which provides a steady flow of air through the room. The air movement will still assist local cooling of the skin.
Evaporative systems are not as sensitive to the level of insulation because they continuously blow cooled air through the open doors and windows of a room.

Sizing

Evaporative coolers are rated according to the volume of air they can move through a room. This is usually quoted in litres/second or cubic metres/hour. An evaporative cooler should be able to change the whole volume of air enclosed in a room 35 times every hour.

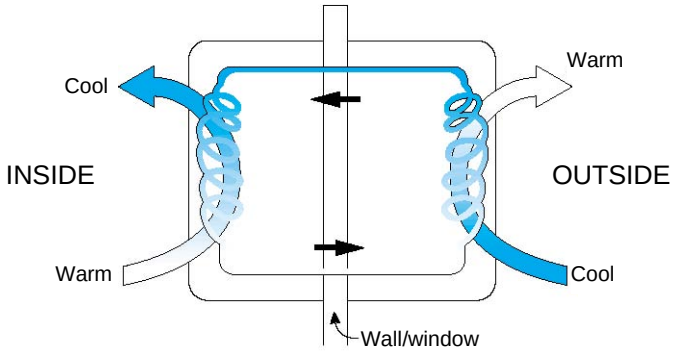
Installation

Evaporative coolers are usually installed on the roof and deliver cooled air directly into rooms through a dropper duct. Sometimes multiple ducts from a larger unit are used to cool more than one room.

Refrigerated air conditioning (ducted, split or room air conditioners)

Operation

Refrigerative air conditioners operate in a similar manner to a domestic refrigerator. Heat is transferred from the inside (cooler) of a building to the outside environment (warmer) via a refrigerant fluid. Energy is supplied (electricity) to drive this transfer. Domestic air conditioners use a compressor to circulate the refrigerant in pipes between the inside and the outside of the building.



Operation of refrigerative air conditioning

The resulting cooled and filtered inside air is recirculated through the room or building. Some units also provide a small amount of fresh air from outside into the building.
Refrigerated air conditioning is most suitable for buildings which are well sealed, and where the doors and windows can remain closed during school hours. Unlike evaporative cooling, air conditioners are unaffected by high humidity levels and allow a temperature to be thermostatically set.

Window mounted air conditioning

Domestic refrigerative air conditioners are usually built as all in one units which are mounted in windows and walls, or as split systems, in which the compressor is located separately to a cooling head that is usually mounted on a wall or ceiling inside the building. The compressor can be in a less obtrusive outside location, provides for quieter operation and is connected to the cooling head by insulated pipes.

Sizing

Refrigerative air conditioners are sized in kW according to the rate at which they can transfer heat. This rating of an air conditioner's cooling ability is usually 2 to 2.5 times the electrical power required for their operation. The correct size of an air conditioning system depends on many factors including: building construction, level of insulation, shading of windows, room size, number of people in the room and their activity and the presence of other heat generating sources such as computers and lights. A north-facing General Purpose Classroom measuring 7.2 m x 7.2 m with 25 students and three computers would require about 9 kW of cooling. It should be noted however that the largest domestic type air conditioner available is rated at about 7.5 kW.

Performance limitations

The main disadvantage with refrigerative air conditioning is high energy use, operating cost and greenhouse gas emissions. If sized correctly to meet cooling loads, purchase price will also be high. Refrigerative systems are also less effective in poorly sealed rooms. This is because cool air continually leaks out of the room and is replaced by fresh hot air, increasing the demand on the system. Generally, schools are not as well sealed as homes or offices, because of the type of construction and the movement of people. Every time a class enters or leaves a room, most of the cool air can be lost. The refrigerative system will then have to start from scratch to cool the room down again. These systems therefore often operate continuously at peak capacity.
Poor insulation also greatly increases the load on a refrigerative air conditioning system. Just as a poorly insulated fridge is expensive to run, a poorly insulated room is expensive to cool.

Peak electrical demand

Refrigerative systems can double the peak electrical load of each classroom. The electrical load of a typical classroom is 2 to 3 kW (lights and some PCs), which is similar to the electrical power demand of a refrigerative system (3 kW).
If considering installing cooling to most classrooms in the school, an assessment should be made to ensure the electrical wiring in the building has the capacity to supply the necessary power for all units. An upgrade of electrical capacity within school buildings or of the school's main supply can be very expensive.

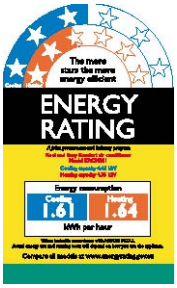
Noise

An air conditioner can be a noisy and annoying appliance, particularly if you are installing the system close to neighbouring buildings. Most air conditioners sold in Australia now have a noise (dB) rating label on them.

Reverse-cycle units

Reverse-cycle systems provide both heating and cooling from the one unit. As they are only marginally more expensive to purchase than cooling-only units, they can be considered when looking to both heat and cool school rooms.

ENERGY RATING LABELS



The energy efficiency of refrigerative air conditioners sold in Victoria is reflected in a compulsory energy star rating labelling scheme for units up to 7.5 kW cooling capacity (ducted systems are not rated). The more stars shown on the label, the more energy efficient the unit. The label also gives an estimate of the annual electricity consumption, when installed in a house.

Your supplier should be able to provide you with information on the efficiency of various units. If not, full information ion the rating is available at www.energyrating.gov.au.
High efficiency units may cost more, but can easily pay for themselves over a few years through lower running costs.

COMPARING THE OPTIONS

Running costs

For a typical classroom of light timber construction (LTC), evaporative systems operate at about 1/5 the cost of domestic refrigerative systems. This is because evaporative systems only need a fan and a small water pump, while refrigerative systems have the much higher load of compressing the refrigerant gas.
The table below summarises the sizing and estimated daily operating costs of each type of cooling.

Maintenance

All cooling systems require regular maintenance. Evaporative coolers need the filter pads cleaned and mechanical parts such as fans and pumps checked and lubricated before each cooling season. If not fitted with automatic internal dampers that close in Winter, evaporative units should have external covers fitted during the post-season service.

	Evaporative Cooling		**Refrigerative air conditioning**	
	Size	Running cost $/day*	Size (cooling load)	Operating cost $/day
LTC room (7.2m x 7.2m)	1750 l/s	$0.60 ($0.46)**	1 x 7.5 kW	$3.35
LTC room (7.2m x 8.4m)	2000 l/s	$0.60 ($0.60)	2 x 5.09 kW	$4.00
Multipurpose room (275m	9350 l/s	$3.45	Estimated at 34kW	$14.10

** Assumes 7 hours per day operation at an electricity tariff of $0.16/kWh*
*** Cost in brackets is if one larger unit supplies two rooms*

Refrigerative air conditioners require regular maintenance to optimise performance however they are considered less maintenance intensive than evaporative cooling units. Servicing usually involves cleaning or replacing filters, mechanical checks and topping up refrigerant if necessary.

Noise

Evaporative systems are slightly noisier than split-system refrigerative units, but quieter than typical wall or window mounted air conditioners.

Ventilation

Adequate ventilation is important for maintaining health and alertness. However, refrigerative systems rely on a room being fully sealed for best performance. Higher ventilation rates will make refrigerative air conditioners more expensive to operate. In comparison, evaporative systems rely on a room being fully ventilated for best performance as these units continually blow 100% fresh, cool air into the room. Some manufacturers of evaporative coolers also promote the health benefits of these units filtering dust and pollen from the air.

Capital costs

The cost of fitting cooling systems to school classrooms is site dependent, however information from schools that have recently installed either cooler are summarised below.

	EVAPORATIVE COOLING	WINDOW AIR CON.	SPLIT AIR CON.
Purchase cost/room	$2200–$3000	$1500–$1800	$2200–$3000
Improvement in conditions	very good	good/ very good	very good
Noise level	low/satisfactory	satisfactory	low
Operating cost	low	high	high

Using larger units that cool two or three rooms lowers the cost of evaporative units provided minimal duct work is required. In general, if more ducting is required the cost increases. The cheapest capital cost is provided by installing window mounted refrigerated units however these have some performance limitations and often higher levels of noise.

Recommendation

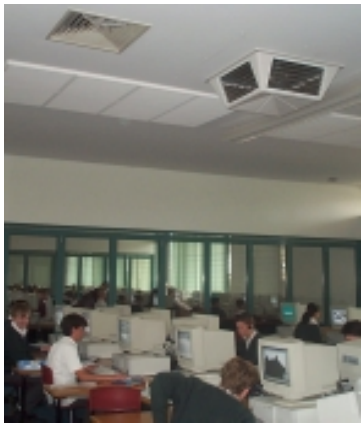
The installation of either evaporative cooling or refrigerative air conditioning will provide a dramatic improvement in classroom conditions on hot days. The *Building Quality Standards Handbook* produced by the Facilities Division of the Victorian Department of Education and Training (page 74), recommends evaporative cooling as being applicable to general purpose classrooms, music, art/craft, science/home economics and technical studies rooms. In general evaporative systems will keep most people happy most of the time, with approximately 20% of the running costs of refrigerative systems. Evaporative coolers also enhance classroom ventilation. For these reasons, the use of evaporative systems for most school applications is favoured.

CALLING FOR TENDERS FOR AN EVAPORATIVE COOLING SYSTEM

The main points to specify for an evaporative refrigerative air conditioning or evaporative cooling is

- Celdek filter pads—have longer life and better hygiene than natural products
- centrifugal fan—are quieter than axial fans
- control options e.g. a time switch that controls the delay between switching the pump and fan
- warranty—5 years rather than 2 years

The school will also need to contract out regular maintenance, which is discussed below.



Evaporative cooling can be used in computer rooms

Other considerations affecting evaporative cooling

Computers and IT equipment

The *Building standards quality handbook* (Section 4.8.1) states that evaporative cooling is 'generally not applicable' to computer rooms, but also states that the information 'should be used as a guide only'. Reference guides for current personal computers typically specify an operating temperature range of 10°C to 35°C, and a relative humidity range of 8% to 90%. This suggests that modern PCs are perfectly capable of coping with evaporative cooling.

Ducting

Evaporative coolers installed directly on top of each classroom require no ducting. These units feed fresh cool air straight down into the room. While complex ducting can be expensive in some installations it can be cheaper to specify a larger cooler to meet the needs of 2 or 3 rooms and install short ducts to direct airflow into two rooms. Where ducts are used, cooling will be maximised if they are kept as short as possible, shaded from direct sun or well insulated.

Air leakage over winter

It is very important to ensure that during winter hot air cannot 'leak' out of rooms via the evaporative cooler. As the units are situated where the hot air collects (on the ceiling), hot air loss can be responsible for a significant increase in heating costs. This should be minimised by using air tight shutters or dampers or having a service contract that specifies each cooler be sealed for the winter. Any sealing mechanisms (such as an airtight cover) should be removed during pre-season servicing.

Vandalism

Vandalism can greatly increase maintenance costs. Evaporative coolers are typically mounted on the roofs of buildings, and are supplied with water and electricity. Consideration should be given to protecting the copper water pipes from leverage, puncture, or compression.

Water temperature and supply

The temperature of the water supplied to an evaporative cooler affects the performance of the system. Cooler water will create cooler air. Water pipes should therefore have minimal contact with a hot roof and preferably shaded from direct sunlight or insulated.
For schools with a limited supply, water consumption may be a consideration.

ENERGY PRICING

All operating cost quoted in these info sheets are based on a standard school day and are approximate only. The operating costs are based on an assumed peak electricity tariff of $0.16/kWh , natural gas tariff of $0.95/MJ and a LPG prince of $0.70/litre. Schools should check with their electricity and gas retailer for tariffs applicable to their particular schools.