AIR CONDITIONING – M1

Eco-efficiency opportunities for Queensland manufacturers

Hot tips and cool ideas to save energy and money!

Air conditioning units or systems are often used by manufacturers for employee and customer comfort, and to improve productivity. In some processes, air conditioning may also be essential to control an enclosed area's temperature, humidity, or even cleanliness (hygiene).

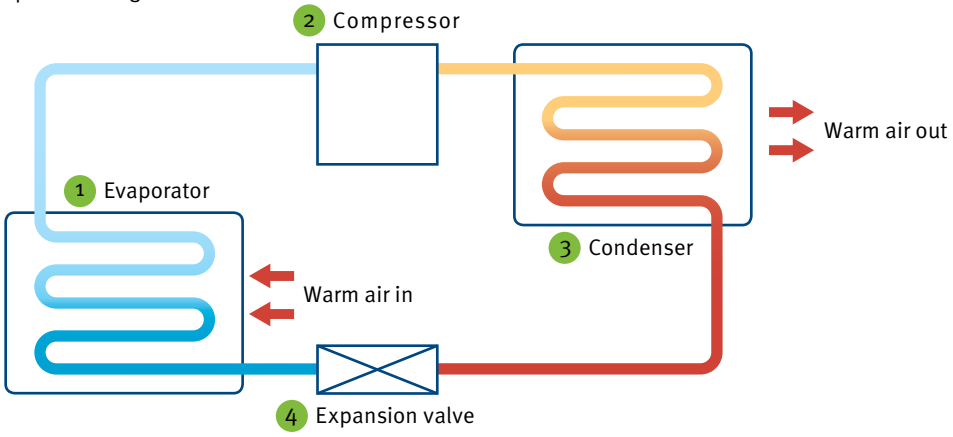
There are many environmental and commercial advantages in ensuring air conditioning systems are well designed and being operated and maintained as efficiently as possible. Each unit or system can consume large amounts of energy, typically generated from electricity produced by burning coal. Not only is the use of non renewable fossil fuels unsustainable but the generation of this energy also emits greenhouse gases which contribute to climate change.

In addition, the refrigerant used in air conditioners may contain synthetic greenhouse gases called hydrofluorocarbons. If not properly managed, these refrigerants can leak out of poorly sealed systems or enter the atmosphere during the point of disposal.

Make sure air conditioning units or systems are well designed, operated efficiently, regularly cleaned and maintained and that energy is not being wasted due to draughts, poor ventilation or inadequate insulation.

Types of air conditioning systems and heat pumps

Air conditioning systems can be use for space cooling or, in the case of reverse cycle systems, space heating.



A basic cooling system uses refrigerant in the **evaporator (1)** to absorb the heat from the air conditioned space. A **compressor (2)** increases the pressure of the warm refrigerant before it is circulated to the **condenser (3)** where the heat is released to the outside air or water flowing over the condenser. Once the refrigerant has rejected its heat it flows back through an **expansion valve (4)** and becomes a cold low pressure gas. The gas runs back into the evaporator completing the cycle.

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In reverse cycle systems (also called heat pumps) the refrigerant cycle is reversed and the heat is extracted from the outside air, even mid winter, and released into the air conditioned space. As three or more units of heat can be generated for every unit of electricity, reverse cycle air conditioning systems can use as little as one-third the electricity of heaters that have an electric element.[1] Geo-exchange heat pumps absorb heat from the ground or ground water rather than air and can be even more efficient, removing between three to five units of heat for every unit of electricity consumed.[2]

In some cases the refrigerant cools or heats water in a heat exchanger. The chilled or hot water is then pumped to coils in air handling units mounted on ceilings, floors or walls that heat or cool air flowing over these coils.

There are several types of systems including:

- **single unit**
- **packaged split system** that typically have a compressor and heat exchanger located outside with lines joining them to a number of air handling units. Split systems are typically quieter indoors than single units but more expensive.
- **packaged ducted systems** have the compressor, condenser and evaporator located outside, usually on the roof, and air is ducted to outlets.
- **central plant systems** have multiple packaged units, often grouped in one plant room with the condenser mounted on the roof. The condensers can be air or water cooled (using cooling towers). Central plant systems are usually only economic for industrial buildings wanting 100 kW cooling capacity or more.[3] For more information on cooling towers refer to the fact sheet on Cooling tower efficiency (F8).

Audits of existing air conditioning systems can help to identify efficiency opportunities.

Designing an energy efficient system

Businesses with significant cooling or heating requirements should seek the advice of a qualified air conditioning contractor. Businesses with existing large air conditioning systems may also benefit from a professional audit to help them identify possible efficiency improvements.

Purchase an efficient system

The efficiency of air conditioning systems is measured by a co-efficient of performance (COP). Package commercial units usually have a COP between 2.5 and 4 but can be as high as 5.[4]

Air conditioning units are also star rated according to their efficiency (for more information visit www.energyrating.gov.au).

Note that some air conditioners now have a variable speed drive on the compressor's motor. While their star rating at rated capacity is not as high as conventional air conditioners, they are more efficient at part load operations. These should be considered for systems which need to operate for long periods. They are typically more expensive to purchase but the energy savings generally give a short payback period.[5]

Size air conditioner to suit cooling load

Undersized air conditioner systems will not achieve the heating or cooling required while oversized systems will result in not only larger capital and maintenance costs but also excessive energy consumption and thus higher running costs.

To accurately estimate the cooling or heating load before choosing a system, carefully consider the following:

- function of the cooled or heated air e.g. to maintain humidity levels, employee comfort and productivity
- size of the space to be air conditioned

1 Sustainable Energy Authority Victoria (SEAV), 2004, Reverse Cycle Air Conditioning www.sustainability.vic.gov.au/resources/documents/Reverse_cycle_AC.pdf
2 SEAV, 2004, Choosing a cooling system www.sustainability.vic.gov.au/resources/documents/choosing_a_cooling_system.pdf
3 SEAV, 2004, Refrigerated Air Conditioning Systems www.seav.vic.gov.au/manufacturing/sustainable_manufacturing/resource.asp?action=show_resource&resourcetype=2&resourceid=21
4 SEAV, 2004, HVAC Tips www.sv.sustainability.vic.gov.au/manufacturing/sustainable_manufacturing/resource.asp?action=show_resource&resourcetype=2&resourceid=46
5 Australian Department of the Environment, Water, Heritage and the Arts, 2007, Tips for Choosing an Efficient Air Conditioner www.energyrating.gov.au/acl.html

- building design e.g. aspect, existing thermal insulation, ventilation and level of shading
- number of people, heat generating equipment and lighting in the space
- when and for how long the space will be used
- external climatic conditions.

Zone air conditioning

Ducted air conditioning systems should be zoned to ensure air conditioning is only operating at the required temperatures and in areas that are in use. In older systems this can be achieved by closing vents in some areas and leaving them fully open in other areas. Where possible, reduce air conditioning or at least humidification (control over the amount of water vapour in the air) in non-critical areas.

Energy controls

Energy controls allow air conditioning systems to be operated more efficiently. They should include the ability to:

- shutdown air to unoccupied spaces
- program a timer and thermostat controls. If the thermostats are often tampered with consider remote controllers.
- choose economy settings so the air conditioner can use outside air when the external temperature is cooler than the required internal temperature.
- adjust multi speed fans to save energy and enable better cooling e.g. slower air movement in humid conditions allows more moisture to be removed.
- adjust and rotate louvers to help optimise air flow within an enclosed space
- adjust variable speed drives on motors.

AIR CONDITIONING AND LIGHTING IMPROVEMENTS[6]

Arnott's biscuit processing plant in New South Wales saved $14,000 per year by adjusting air conditioning schedules, installing occupancy detectors, including delay push buttons in some areas and photoelectric sensors in the manufacturing area, and reduced office lamps by 30 per cent to suit occupancy. The payback period was two years.

Insulated ducting

It is beneficial to insulate hot and cold air ducts, especially those in un-air conditioned spaces such as in the ceiling. The higher the R (resistance) value of insulation the longer it takes heat to cross the insulation barrier. In some cases a U value may be used which measures the transfer of heat through the material rather than the resistance to heat transfer.

Draft proof the building

Drafts and air leaks into and out of the building increase the amount of energy required for cooling or heating. Seal any leaks along window and door frames and other room penetrations such as electrical outlets or mounted air conditioners.

Insulate the roof, walls and floor

Insulation is one of the most effective ways to save energy. It can help keep heat in during winter and lets heat out in summer. Bulk insulation traps pockets of air within its structure while reflective insulation reflects radiant heat away.

Reduce the loss of air conditioned air and solar gain through windows

While windows allow access to natural light and help to keep the indoor environment well ventilated they can also be a source of unwanted cool or heated air loss. Similarly, they can significantly add to the heating or cooling load of a building by allowing the transfers of external cold or hot air inside. Single pane windows provide poor insulation. Consider installing multiple window panes (glazing) to put a seal of air or gas between the panes of glass that can act as an insulator.

6 NSW Government, Department of Energy, Utilities and Sustainability, "Arnott's saves big bikkies" www.deus.nsw.gov.au/Publications/Arnotts.pdf

Another alternative is to cover the window with a reflective pane or solar screen however this can reduce visual light transmittance and impair views. An alternative is transparent low-emissivity (low-e) coatings that reflect heat while allowing light wavelengths to transfer through the glass. Windows should be well sealed.

Internal curtains and blinds with pelmets and external shades or vegetation can also help to insulate buildings. Ensure staff keep windows and doors closed and consider self closing doors if necessary.

Operate the system efficiently

Set thermostats for optimal energy savings

Temperatures around 24–25°C in summer and 17-19°C in winter are comfortable settings for employees.

Every 1°C increase in temperature set point will increase energy use by 15% in winter.

Every 1°C decrease in temperature set point will increase energy use by 10% in summer.[7]

TURNING UP THE TEMPERATURE AND THE SAVINGS

Bradken Foundry in Ipswich trialled increasing the set point of the summer air conditioning temperature within its office buildings from 22 °C to 24 °C. Staff were not affected by the change and the initiative was rolled out in all air conditioned buildings on the site. This simple housekeeping opportunity now saves Bradken 32.9 MWh per annum or approximately $3,300 for no capital outlay.

Turn off heat equipment

Turn off heat generating equipment and lighting when not needed to reduce cooling requirements.

Check for air leaks from the system

Air leaks in ducts reduce the cooling and heating capacity of the system and increases energy use. In addition leaks allow contaminants such as dust and pollen to be drawn directly into the system and distributed through the workplace.

Operate air conditioners only when needed

Timers can be used to turn off heating and cooling systems to ensure they are not left on when the building or room is not in use. Investigate when heating and cooling systems can be turned off. This is often at least a couple of hours prior to the close of business.

Regularly clean and maintain air conditioning systems

All air conditioning systems require regular maintenance. Maintenance should include:

- cleaning evaporator and condenser coils of dirt and debris that may block the flow of air
- clearing away any vegetation around the condenser that may also obstruct air flow
- cleaning the fins in the condenser and straighten if necessary
- vacuuming the air vents

Make sure qualified technicians:

- check refrigerant levels. If levels are low the technician may need to use a leak detector to locate the leak. Make sure no refrigerant is allowed to escape to the atmosphere during repairs. Once fixed, the system should be recharged. An air conditioning system's performance is most efficient when the refrigerant charge matches the manufacturer's specifications.
- measure the air flow over the evaporator coils
- check air ducts and seal any leaks

Keep the air vents clean so that the air flow is not obstructed.

7 SEAV, 2004, HVAC Tips **www.sv.sustainability.vic.gov.au/manufacturing/sustainable_manufacturing/resource.asp?action=show_resource&resourcetype=2&resourceid=46**

- check oil and belts of motor
- check accuracy of the thermostats
- check electric control sequence and electric terminals.[8]

Cooling and heating alternatives

Evaporative coolers

Evaporative coolers draw outside air through a wet pad. The damp cooler air is blown into the building forcing the hot inside air out vents or windows. Unlike air conditioners evaporative coolers add humidity to the air and thus work better in hot dry climates. They cost considerably more to install and maintain but can use up to four times less electricity to operate. They do not use a refrigerant however they can consume a considerable amount of water.[9]

Fans

Fans cool by creating air movement which evaporates moisture from the skin. Reversible fans can also be used with heating to circulate warm air that has risen to the ceiling and distribute it more effectively. They can be used in conjunction with air conditioning with the cooling effect of moving air compensating for as much as 4°C.[10]

Natural ventilation (passive cooling)

The aim of natural ventilation is to replace warm air inside a building with cooler air from outside using natural differences in pressure and temperature. The effect of the moving air again evaporates moisture from the skin and cools.

The interior of buildings can be designed to take advantage of natural convection flows. For example a lower window might be opened to draw in more dense cool air while a higher one allows less dense warm air to escape. Natural ventilation might also take advantage of wind pressures and allow cool air from the windward side to enter the building and pass out the other side. In this case the outlet on the opposite side of the building should be sized larger than the opening to increase air speed.

Clear paths will allow direct air flow which increases the air speed and cooling effect.

If natural ventilation is not sufficient due to the design, aspect or location of the building's design, warm air can be drawn out using ceiling mounted exhaust fans and then released through eave vents. Cool outside air can then be drawn in through windows.

Remember a completely airtight building with air conditioning is unhealthy as a certain level of ventilation is required to remove contaminants, odours, water and carbon dioxide. If possible provide windows that can be opened and locate exhaust fans near sources of contaminants or odours.

This series of fact sheets provides examples and suggestions to the modern manufacturer on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website **www.ecoefficiency.com.au** for more ideas and case studies.

8 US Department of Energy, 1999, Energy Efficient Air Conditioning **www.nrel.gov/docs/fy99osti/17467.pdf**
9 California Energy Commission, 2006, Evaporative Cooling, **www.consumerenergycenter.org/home/heating_cooling/evaporative.html**
10 Engineering Extension, 2001, Space Heating and Cooling, **www.engext.ksu.edu/ees/henergy/space/air.html#fans**

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