

Appendix D: Alternative Cooling Technologies (ACT)

General

Singapore has a hot and humid climate and the use of conventional air-conditioning methods in such a climate requires intense amount of energy. Since the inception of BCA Green Mark Scheme in 2005 and efforts of 3 Green Building Masterplans in 2006, 2009 and 2013, various Alternative Cooling Technologies (ACT) have been researched and developed to provide similar thermal comfort conditions and comparable Indoor Air Quality (IAQ) as conventional systems while using significantly lesser energy.

Acceptable Solutions as Alternative Cooling Technologies

Examples of Alternative Cooling Technologies are:

- a) Passive Displacement Cooling (PDC) Systems
- b) Hybrid Cooling Systems
- c) Decoupling of Latent and Sensible Cooling Systems

The adoption of above technologies in projects will be able to gain credits based on size of adoption under Part 5 Advanced Green Efforts as well as credits under Part 2 Building Energy Performance through direct and indirect improvement in performance and reduction in energy consumption. The use of ACT should not compromise thermal comfort and IAQ. The ACT are expected to have energy savings from 10% to 40% depending on degree of applications, building functions and application scenarios. The above list is non-exhaustive and other Alternate Cooling Technologies that intend to gain similar credit will require review by BCA Green Mark team.

Passive Displacement Cooling (PDC) Systems

Description

Uses natural convection of heat transfer to move the cooled air without mechanical fans and thus reduced energy uses.

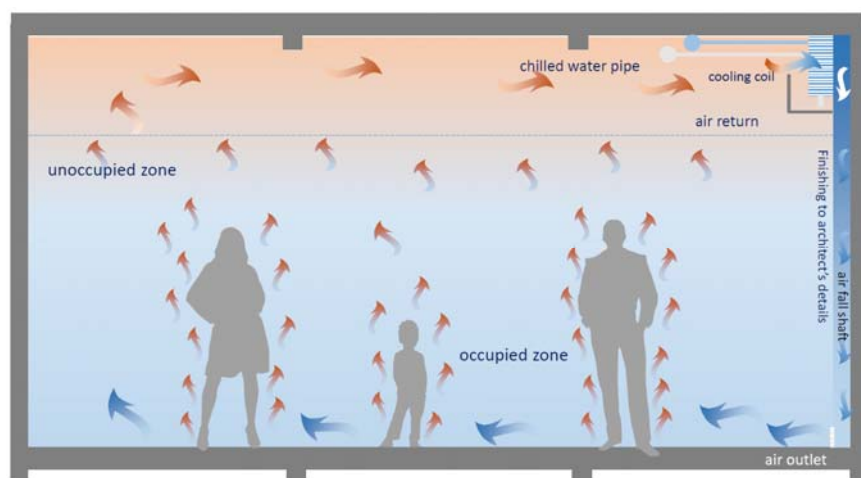


Figure D1: Schematic for Passive Displacement Cooling (PDC) Systems [Copyright ©. Used with permission.]

Hybrid cooling Systems

Description

Other than cooling through lower air temperature and lower humidity, cooling effect can be achieved through convection and evaporation processes from occupants' bodies with increased air speed. Within threshold limit, occupants feel cooler with higher air movement without the need to cool the air further. There are various ways to increase air movement such as desk, pedestal, wall-mounted, and ceiling fans. Electrical fans can be effectively used to increase air movement indoors and effectively cool down occupants to ensure that occupants are in thermal neutrality with the indoor environment even at higher set-point temperatures.

Elevating air speed compliments with air conditioning systems and it only requires a fraction of the energy needed to cool down the air temperature for achieving an equivalent thermal comfort condition. The higher the cooling temperature setpoint, the higher the energy saving. Every 1 °C increase in the cooling temperature set-point is estimated to reduce ACMV energy consumption by roughly 10%.

The air movement generated by specific fans, at different speed settings, can be obtained from the manufacturer's documentation. For ceiling fans, the data should comply with ASHRAE Standard 216. Project teams would need to ensure thermal comfort is achieved, by checking design with comfort tool with reference to ASHRAE Standard 55.

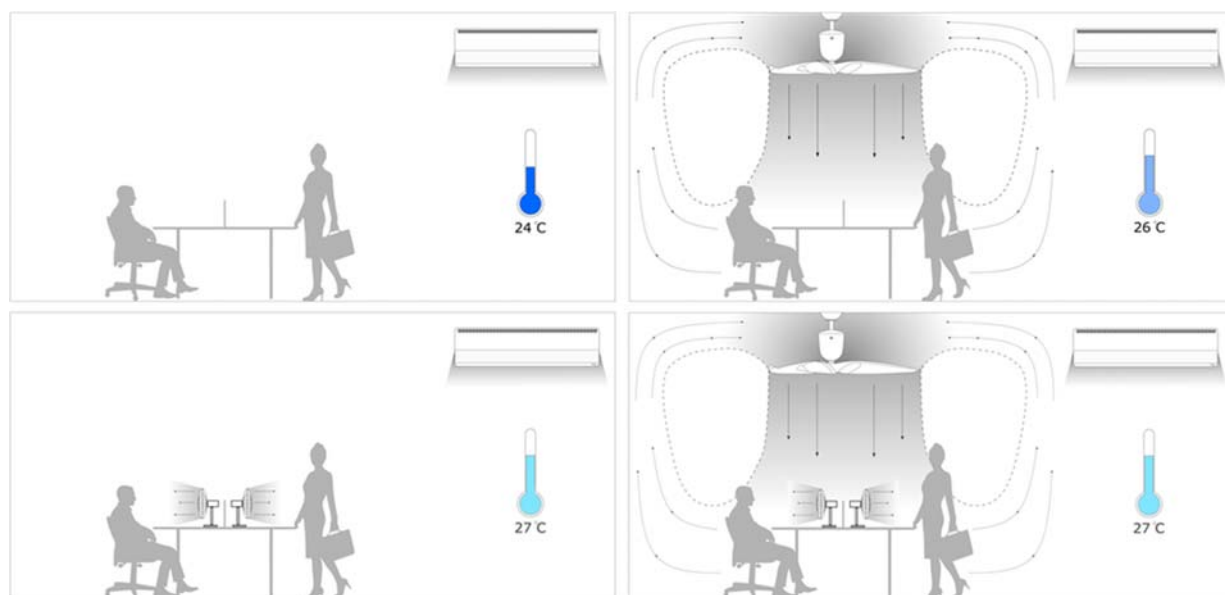


Figure D2: Schematic for Hybrid Cooling Systems (for illustration purpose only) [Copyright ©. Used with permission.]
Comparison of equivalent thermal comfort conditions.

For occupants involved in sedentary activities and wearing standard office attire, the same thermal comfort conditions can be achieved either by having lower space temperature, or by increasing air speed with elevated space temperature.

Decoupling of Latent and Sensible Cooling Systems

Description

Separate system to handle sensible load (through the use of radiant ceiling panels, chilled beam, underfloor slab etc.) and latent load (through the use of dedicated outdoor air system). There are many variants to this concept which comprises of direct or indirect cooling of air with chilled water pipes in spaces. All or most of latent load are handled at fresh air supply to allow chilled water pipes to handle mostly or only sensible load in spaces.

Radiant cooling through use of ceiling panels, metal chilled ceiling or comparable

The system operates primarily on the radiation principle and handles sensible cooling of the space. It is operated in combination with a heat recovery mechanical ventilation system to supply fresh air, cover latent loads by maintaining space dew point and if required, the remaining sensible load.

Metal chilled ceilings ceiling system is characterised by a variety of application and design options. It is used primarily in office and administration buildings, retail outlets, in rooms for seminars and conferences, as well as in clean rooms and hospitals. Some common variants are closed ceilings, island design, canopies or peripheral zones.

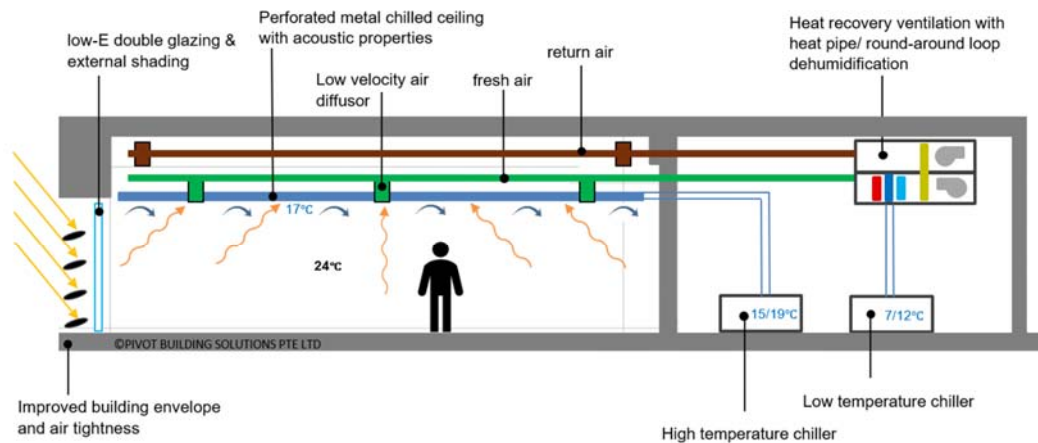


Figure D3: Schematic for perforated metal chilled ceilings with heat recovery ventilation with heat pipe dehumidification. [Copyright ©. Used with permission.]

Chilled beams

Chilled beams typically involves having metal chilled beams in occupant space and it is best suited for applications with high sensible heat ratio and low fresh air demand in hot and humid climate. Chilled beams are broadly classified as passive and active chilled beams. The former requires distinct load distribution with suitable space height to allow natural convection to bring hotter air to be cooled by chilled beams located near the ceiling. The latter makes use of small fan systems to bring about air movement toward the chilled beams. In applications where minor latent loads are involved, drain pans can be coupled into the system.

Underfloor cooling through the use of slab or comparable

A chilled slab system typically utilises the concrete's or screed's thermal mass by embedding pipes, such as polyethylene cross-linked pipes (PE-Xa), carrying chilled water to cool space's slab/wall. The embedded pipes activate the concrete or screed to temporary store and discharge thermal loads. In this way, activated ceilings, floors or walls contribute primarily to the sensible cooling of the building by removing convective, conductive, short and long wave radiation cooling loads.

Chilled slab systems in tropical climates are recommended to couple with heat recovery ventilation systems in fresh air supply, to remove latent loads before mixing with space air to control space's dew point. This application is recommended for base cooling, direct solar load removal and air stratification in building with high floor to ceiling height.