PASSIVE COOLING

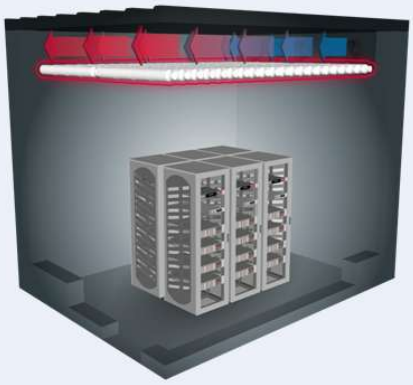


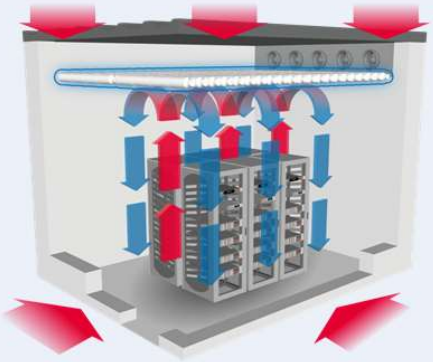












PCM

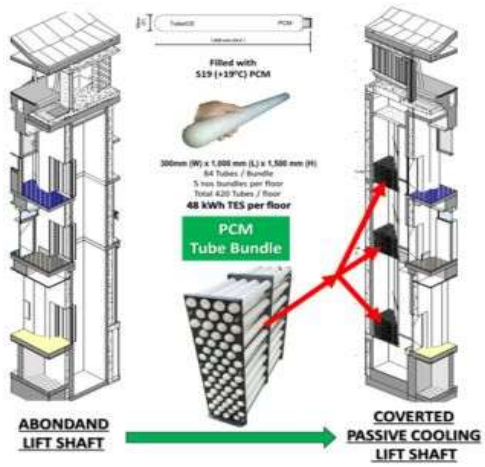
FREE COOLING APPLICATION UN AFRICA

UN ECONOMIC COMMISSION FOR AFRICA, Addis Ababa, ETHIOPIA

As part of the renovation programme an internal old lift shaft was no longer required and considering almost all year cooling demand it is decided that repurposed abundant lift shaft might be possible to convert for a free cooling using cooler air at night to freeze PCM (Phase Change Material) modules, which then provide cooling during the day to reduce the air conditioning load.

Passive cooling is provided by +19C (67F) hydrated salt based PCM material placed inside 50mm (2") x 1m (3ft) HDPE tube containers. 84 of these PCM tubes are placed within a staggered frames in order to form heat exchanger shape whereby the air can efficiently pass through the bundle.

Existing lift shaft acting like a ductwork forcing the air across these tube bundles and providing 48 kWh (14 RTh) TES capacity on each floor level. Total three floor installation providing 144 kWh(42RTh) passive cooling for the building simply storing the cooler night energy and bridge the gap between night and day time.





UNIVERSITY OF WESTMISTER, Cavendish Street Building, Passive Cooling, London, UK

As part of the drive to demonstrate passive cooling application University of Westminster in London incorporated PCM passive cooling modules within the top floor offices. Utilising the cooler night ambient by simply storing the cool energy within the PCM modules day cooling loads within the office area is absorbed by PCM modules without using any mechanical cooling machinery

During normal operation mode additional cooling as well as any latent loads i.e. humidity control loads are handled using a conventional VRV system if and when required. Same goes for the heating loads which is provided the same VRV heat pump units.

PCM based TES modules filled with +270C (800F) PCM encapsulated in 50mm (2") diameter x 1,000mm (40") HDPE TubeICE containers. Tubes are fixed at ceiling level using standard 50mm (2") pipe bracket system.



Oman Across Ages Museum Free PCM Cooling, Muscat, Oman

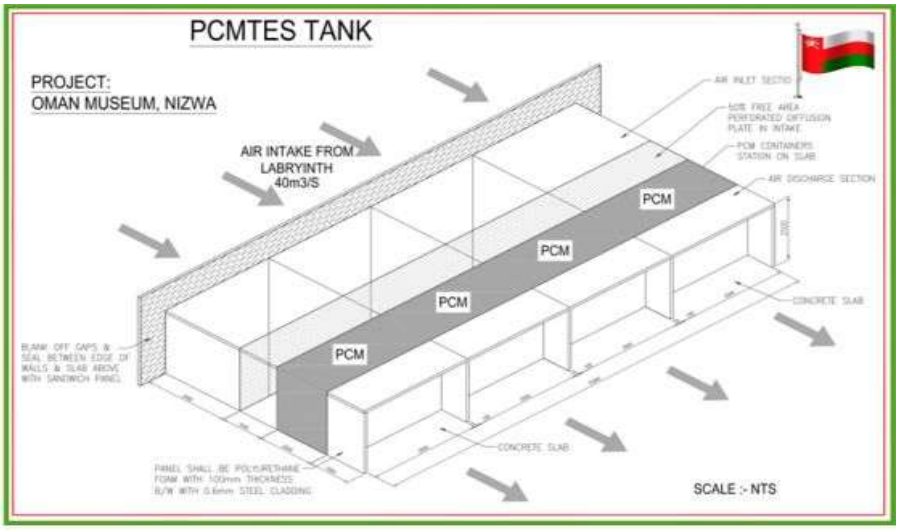
Yes even in the Middle East one can utilise free cooling by simply storing the cool night energy and utilising this FREE stored energy during day peak period in order to reduce the outside air-cooling demand during peak ambient conditions

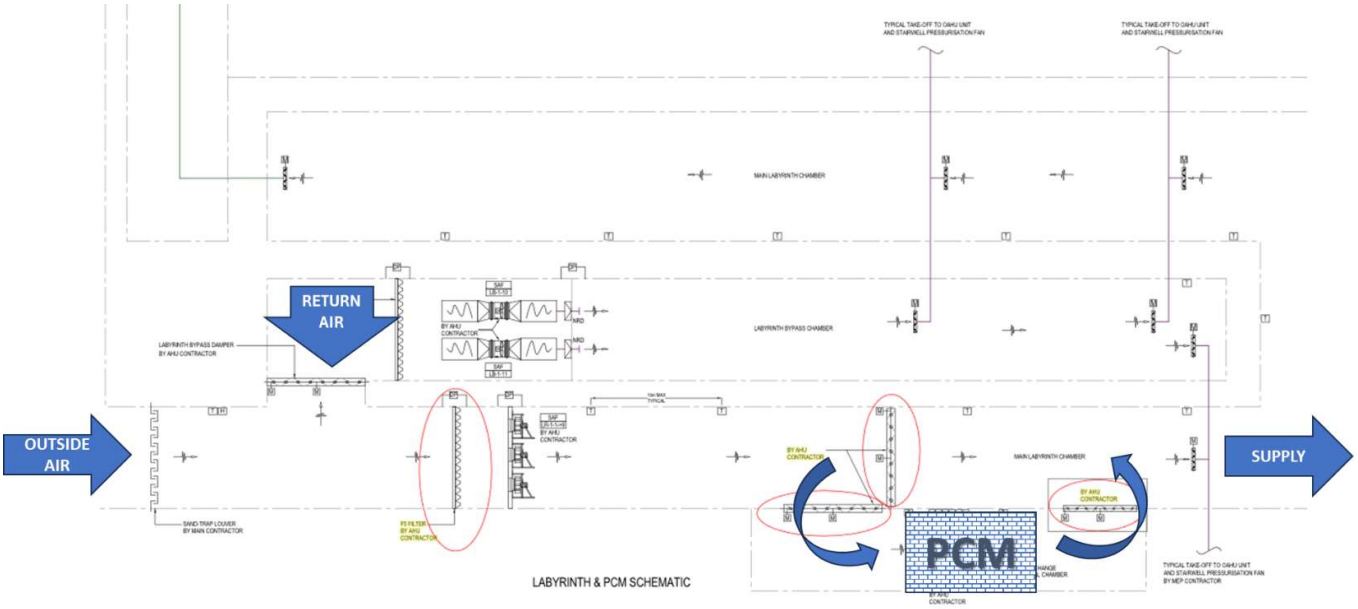
For this purpose, Oman Museum installation, a special tunnel built to accommodate the PCM containers whereby when the ambient air temperature is less than the PCM solution generally during night time, these containers freeze naturally by the surrounding cooler night ambient and later this stored energy in the form of latent heat can be released back to the air supply system during daytime to cool the incoming air for the outside air supply requirement for the museum. Almost the total daily sensible heat gains due to outside air supply can be absorbed by the passive cooling tunnel.

Design is based on having four identical chambers 2.5m(8') (W) x 2.0m (61/2') (L) x 2.5m (8') (H) filled with 10 wide x 58 high self-stacking HDPE PCM containers filled with 32C (90F) PCM solution.

Total 4 chambers accommodate 9,280 FlatICE filled with S32 (+32C/ F) PCM solution providing 2.0 MWh (595 RT-h) TES capacity.







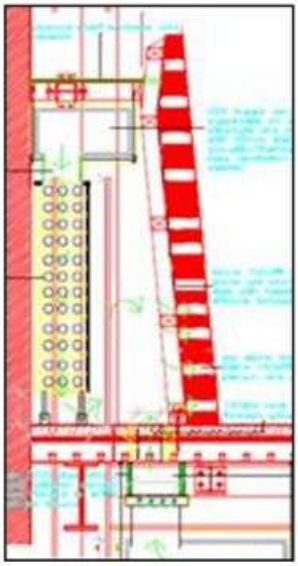
MULBERRY SHOP, BOND STREET, LONDON, UK

The building housing the Mulberry shop in central London Bond Street is a listed building with significant restrictions on any alterations and therefore it offered very little space for the external air conditioning machinery

Bulk of the cooling load is based on lights and people inside the shop and therefore 60~70% of the base load is fixed all year round irrespective of seasons.

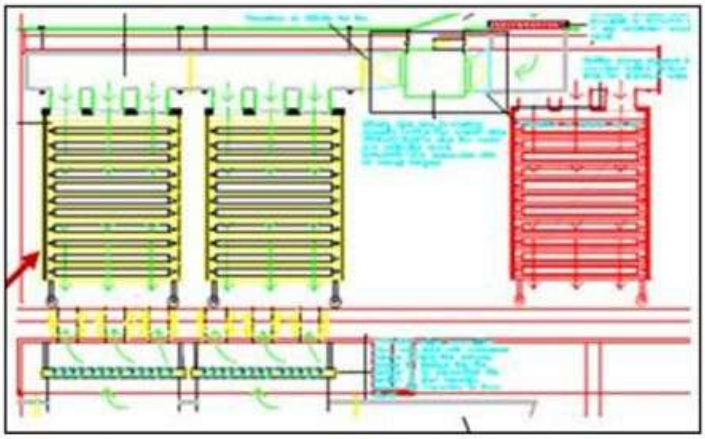
As this is a listed building with very high restriction and limited outdoor walls to install condensing units, contractors could only able to install just about 50% of the outdoor units required for the full air conditioning units. A/C system is based on split direct expansion systems and therefore only option looked like utilising the maximum amount of A/C split kits and run them runover-night or alternatively using free cooling if ambient permits (almost 6~8 months of the year) to charge the 22C (72F) PCM tube bundles and in return this stored energy can be used to top up the required missing cooling loads during day.















Linton College Passive Cooling, UK

Although schools in the UK may require cooling for only a few days of the year but the current regulations dictate to keep the upper limit below an acceptable limit. This over-heating may occur south facing classrooms.
Conventional mechanical cooling might solve this issue but cost associated with not only installation but also ongoing maintenance services cannot be accommodated with the school budgets.
The cooler night ambient is used to store cool energy within the PCM passive cooling modules placed within the false ceiling area and this stored energy enables the day cooling loads / solar gains within the classroom is absorbed by PCM modules without using any mechanical cooling machinery.
+250C (770F) PCM encapsulated in 50mm (2″) diameter x 1,000mm (40″) HDPE Tube containers. Tubes are fixed at ceiling level using standard 50mm (2″) pipe bracket system behind the false ceiling panels. Solid ceiling panels are replaced with egg crate panels allowing air to escape to the ceiling void whereby tubes act like a heat sponge...




PCM Tubes


PCM Tubes




Class Room

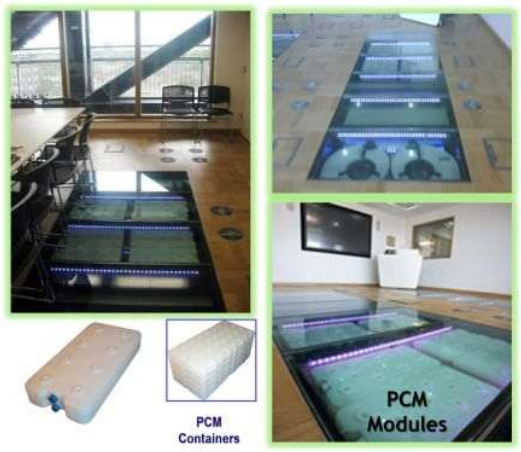
Pendle Vale College Passive Cooling, UK

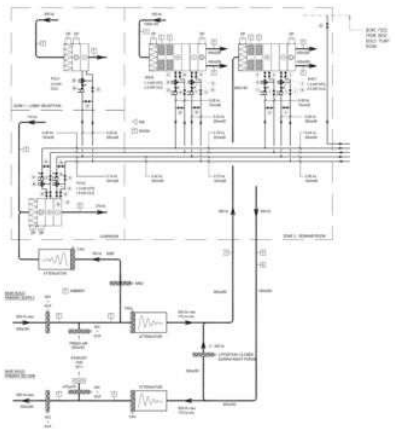
Although schools in the UK may require cooling for only a few days of the year but the current regulations dictate to keep



CENTRE FOR RENEWABLE ENERGY IN BUILDINGS (CEREB) PASSIVE AHU COOLING SOUTHBANK UNIVERSITY, LONDON, UK

As part of the drive to demonstrate passive cooling application Southbank University is incorporated PCM modules within the AHU sets. By simply over-night freezing i.e. storing the cool energy in PCM modules day cooling loads within the meeting room are absorbed without using any mechanical cooling machinery. During normal operation mode additional cooling as well as any latent loads i.e. humidity control loads are handled using a conventional chilled water circuit. Same goes for the heating which is provided via AHU coils supplied from the central heating circuit.
PCM based TES modules filled with +210C (700F) PCM encapsulated in 500mm (20") x 250mm (10") x 32mm (1 ¼") rectangular HDPE FlatICE containers.





Sir John Laing Building, Free Cooling, Coventry University, UK

1,590 TubeICE filled with +27C (81F) PCM solution placed within the existing false ceiling area providing 230 kWh (65 RT-h) free cooling by simply freezing over-night and absorb the heat loads during day-time.
Passive cooling takes advantage of the naturally occurring temperature swing caused by day & night. The excess coolth available in the night can be stored in the PCM, which is then released during the day, absorbing internal and solar heat gains. Once the TubeICE containers are filled with PCM they weigh between 2~3 kg (4.4~6.6 lbs) each depending on PCM type and by simply using standard 50mm (2") pipe brackets they can be suspended from the ceiling area to act like a heat absorbing sponge to soak up the rising heat within the enclosure.

Although it is possible to apply 12 TubeICE per m2 (~1 TubeICE / ft2) within the ceiling area but as the same area is also used for other services, the practical limit for the passive cooling modules free area could be anywhere between 40~70% of the ceiling area.
Using conventional bracket systems it is possible to hang 12 TubeICE containers per m2 ceiling area and the overall total weight could be in the region of 40kg and in return these tubes can provide anywhere between 1.7 ~2.2 kWh/m2 (0.046~0.057 TRh/ft2) energy depending on the PCM type.

Coventry University	John Laing Building, Coventry, UK		
	Pre	Post	Saving
Boilers energy (MWh)	418.8	399.3	11.35%
Total system energy (MWh)	448.8	428.9	10.58%
Total nat. gas (MWh)	418.8	399.3	11.35%
Total electricity (MWh)	30.1	30.1	0.00%
Total Carbon Emissions (Kgco2)	106,064	101,614	9.67%
Total energy (MWh)	448.8	428.9	10.58%
Total energy (MWh/m2)	0.123	0.117	10.58%
Total energy (KWh/m2)	122.6	117.2	10.58%







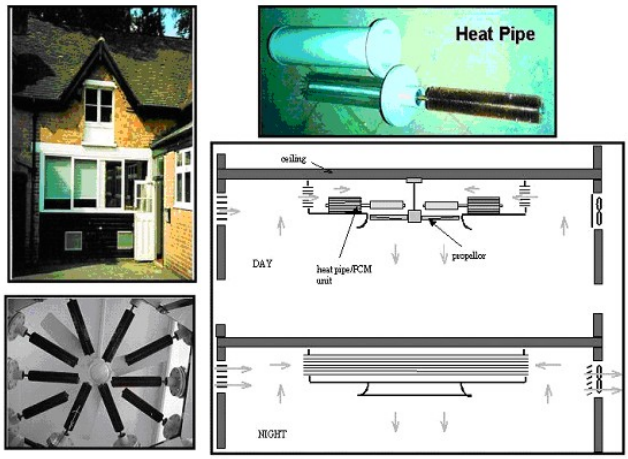


Passive Cooling Building Services Applications, Nottingham, UK

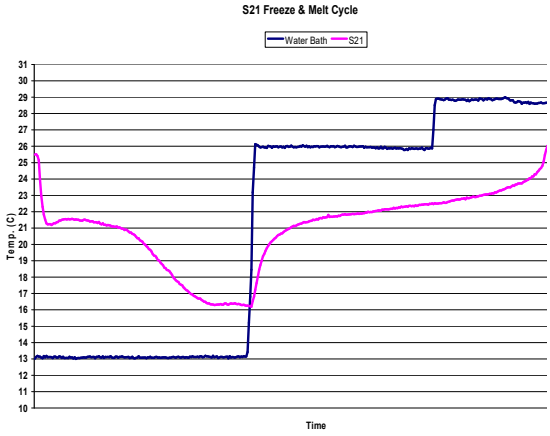
A small scale 10.8 m2 (116 ft2), 27m3 (953ft3) standard UK office complete with all the conventional internal heat gain is selected near Nottingham, UK and this office is fitted with Passive Cooling heat pipe beams as illustrated below filled with 21°C (70°F) PCM Eutectic solutions. The relevant freezing and melting curves for this specific PCM solution is also below.

This test site at Nottingham, UK operated for a whole year with full data logging and a typical peak daily operational data recorded as illustrated in Figure 4.1.3.

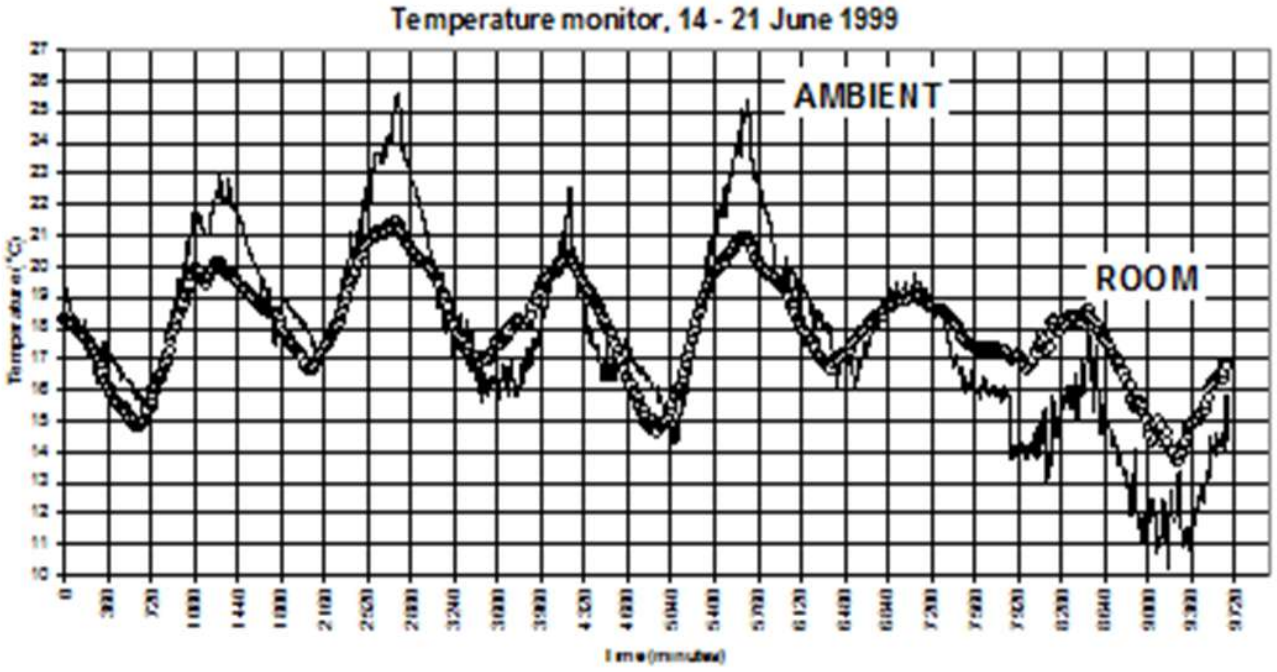
The recorded data proved that the system coped well with the average office internal gains throughout the year without running a single refrigeration machinery by simple utilising colder night-time air to charge these beams and release back the stored energy during peak day periods.



Office Passive Cooling Heat Pipe Design



21°C (70°F) **PCM Freezing and Melting Curve**

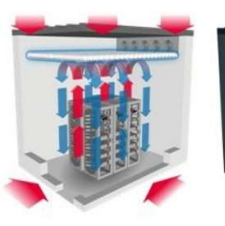


Passive Cooling Daily Operational Data

SHELTER PASSIVE COOLING APPLICATIONS;

Although, passive cooling applications are restricted in hot climate conditions for human comfort applications but PCM based passive cooling benefits can be widely applied anywhere in the World including Middle East for non-office (i.e. unoccupied) areas to cool the electronic chambers / control panels / lift shafts as they could tolerate space temperatures as high as 45 ºC (115 ºF) and as the night ambient temperatures overnight time remains less than the space temperature, it allows cool night energy to charge the PCM. This concept is widely applied for electronic chamber cooling for remote location whereby the lack of electricity eliminated the mechanical air conditioning and a typical cooling system as illustrated in Figure 4.2.1.

These systems even operate in hot countries and desert environments like the Middle East due to higher space temperature requirements in comparison with Office Cooling. A PCM solution of 32ºC (90 ºF) is sufficient to maintain the room temperature below 45ºC (115ºF) by simply using the temperature swing between day and night time as illustrated in Figure 4.2.2 for shelter passive cooling applications.



Shelter Passive Cooling Concept



Shelter passive cooling applications.



CONTROL BOX PASSIVE COOLING APPLICATIONS;

Many of the control boxes tend to have lots of electronics which generates fair bit if heat and in a sealed control, boxes this heat generated by the electronics as well as possible ambient / solar gains accumulates and the indoor temperature of these control panels may well exceed the maximum allowable temperatures of electronic components.

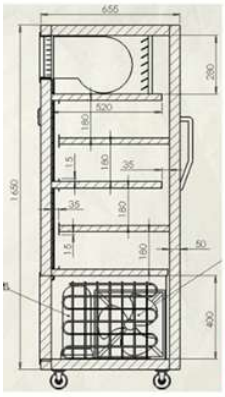
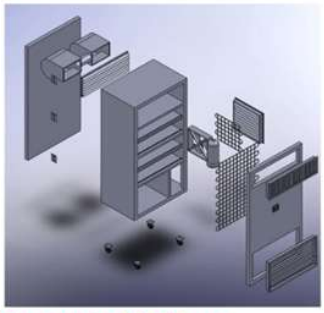
If one place 27~34 ^{0}C (81~93^{0}F) PCM modules inside the control boxes they would freeze over-night due to lower ambient conditions and during day-time they act like a heat sponge soaking up both internal / external heat gains and therefore keep the internal temperatures below the upper limits.

As the PCM modules require no power supply and no moving parts they are considered as a maintenance free system and in particular explosion proof locations like oil rigs / Petrochem installation PCM based passive cooling concept offers an ideal solution.

PCM passive cooling modules can be manufactured in any size / shape to fit any existing retrofit or new control panel designs.



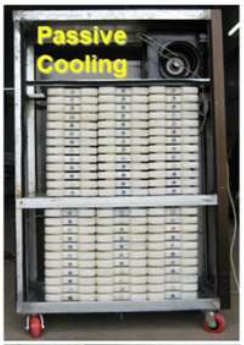


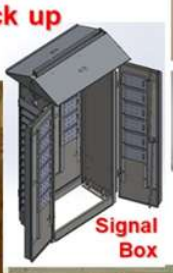







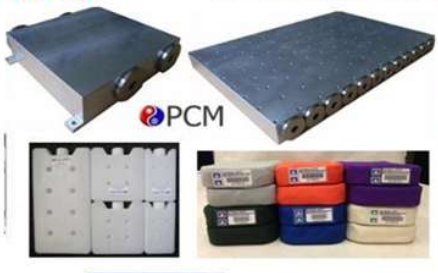










IT ROOMS BACK-UP COOLING

As majority of the large office-based companies tend to have a central IT room and requires constant cooling even during weekends. This requirement is becoming a problematic for high rise buildings whereby any small dedicated units like mini-splits / cassette type air conditioning units are near impossible to install and therefore the owners end up running the whole air conditioning for a few tenants / owners occupying a few floors. This operating cost a significant operational cost for each client using this service over weekend.
A small PCM based TES modules like the shown below having PCM modules filled with 22~25^{0}C (70~77^{0}F) PCM solution can be charged during normal operation and the stored energy can be utilised a passive cooling for the IT rooms over the weekends 48 hours by simple operating a small fan to circulate the air over the PCM modules. Apart from weekend cooling this system can also be used an emergency cooling in case of any power failure utilising a simple DC fan with battery back.



GREEN HOUSE PASSIVE COOLING APPLICATIONS;

As the name "Green House" gives a clear idea for the over-heating issues during day-time for any greenhouse installation. Solar gains gradually build up heat within the space and over-heating occurs during day-time but equally over-night cold ambient drags the space well below the lower limits of the plants.
By simply adding thermal mass in the form of PCM modules having 23~27^{0}C (F) energy absorbing capability for the day-time excess heat energy and once charged i.e. PCM melted by this heat, in return this stored energy becomes a radiant heating source for the space. Thermal mass provided by PCM modules lower the day-time temperature as well as raise the night-time temperatures and therefore keep the greenhouse well within the desirable plant conditions without the use of any external energy source.
Hence, PCM based greenhouse thermal stabilisation not only provides a very economical operation of the greenhouses but by reducing the energy consumption it makes greenhouses far more environmentally friendly option.



Positive Temperature Eutectic Solutions (PETES APPLICATIONS);

PETES applications between +4°C (39ºF) and +117°C (242ºF) can be charged using free cooling or conventional water chillers or by any free energy source and therefore offers many cost-effective energy management concepts for both New and Retrofit type process cooling / heating load shifting applications.

Passive cooling can be provided in two forms namely Passive or Active systems.

In passive system, design is based on utilising natural convection and density differences between warm and cooler air. These systems tend to be energy free design and relies on natural movements of the air circulation.

In dynamic systems air is forced over the PCM modules if and when required. Although this mechanical air movement requires power but it provides a full control of when to charge and discharge as opposed to static system only driving factor tends to be temperature different between the PCM and surrounding air.

Typical application examples of both systems are highlighted in the following graph.



Passive Cooling Building Services Applications