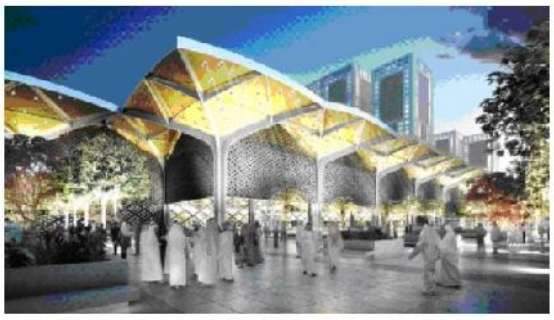
Global PCM based Building Services Application Examples

THE ROYAL WOLVERHAMPTON HOSPITAL, UK HOT & CHILLED WATER ENERGY STORAGE SYSTEM

As the hospital heating and cooling loads vary significantly a simple 20 m3 hot water TES tank is found to be the optimum solution providing **930 kWh (3,173 MBtu)** heating load shifting while a separate 30 m3 PCM tanks filled with **+10C (50F)** FlatICE containers provides **1,500 kWh (426 RT-h)** chilled water cooling load shifting capability which enabled the designers to reduce both heating and cooling equipment sizes as much as by half for a given conventional load profiles.



SAUDI ARABIAN HARAMAIN HIGH SPEED TRAIN STATIONS,JEDDAH / MAKKAH / MADHINA / KAEC, K.S.A. PCM ENERGY STORAGE SYSTEM

High speed trains serving between Jeddah & KAEC and Holly cities connected with local stations in each city but as the ambient temperatures during day time exceeding 55C (131F) levels as opposed to night time of 30C (86F) .

Hence, a simple **+10C (50F)** PCM energy storage using conventional 7C (45F) to charging the TES tanks **(Jeddah = 3,200 kWh (909 RT-h) / Madhina 3,200 kWh (909 RT-h) / KAEC 3,200 kWh (909 RT-h) / MAKKAH (10,000 kWh (2,840 RT-h).**

TES capability over night enables the designer shifting day peak loads to night time and effectively reducing the number of chillers required for the peak load.

Most importantly, by running the chillers at night time with far lower ambient conditions than day peak, one can reduce the actual power consumption as much as 35~45% in comparison with the conventional chiller day operation. Furthermore, in comparison with day very high operation conditions one can also increase the life of the chillers due to significantly reduced head pressures / temperatures and therefore reduced maintenance cost in the long run and of course significant improved reliability.

WESTERN SYDNEY UNIVERSITY, BULDING 24, SYSDNEY, AUSTRALIA PCM ENERGY STORAGE SYSTEM

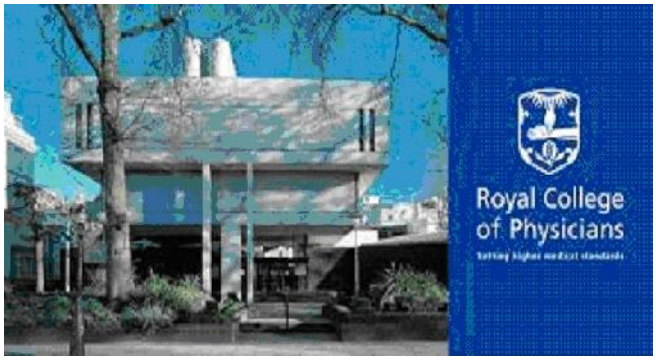
Considering a large swing between day and night temperature as well as a significant cost difference between peak and off-peak utility cost an addition of a 13 m3 (795 USG) tank filled with **+10C (50F)** FlatICE containers providing **550 kWh (156 RT-h)** load shifting capability offered the end user a flexibility, reduced running cost and further stand-by capability.

STONE 34 COMPLEX, SEATTLE, WA, USA PCM ENERGY STORAGE

This building is rewarded the LEED 2009 Platinum Ward and achieved 31/37 score and PCM energy storage using a 25 m3 (6,625 USG) tank filled with **+10C / 50F** FlatICE containers providing **1,250 kWh (355 RT-h)** load shifting capability for the operator provided a useful to achieve this high score.

STAOIL HQ, BERGEN, NORWAY CENTRAL COOLING PCM ENERGY STORAGE

Conventional chilled water system complimented using 30 m3 (~8,000USG) tank filled with **+8C (47F)** FlatICE containers providing **1,300 kWh (369 RT-h)** load shifting capability from peak periods to off-peak periods as well as providing a stand-by cooling capability without the need for a generator.



ROYAL PHYSCIAN HQ, LONDON, UK CHILLED WATER PCM ENERGY STORAGE , UK

As being in central London the only way to add any TES capacity was to build a 40m3 site built sectional pre-insulated rectangular tank which is filled with **8C (47F)** to compliment the existing chilled water circuit providing ~ **2,000 kWh (568 RT-h)** load shifting capability as well as increasing the cooling capability.

NETHERLAND CANCER INSTITUTE, AMSTERDAM, HOLLAND

Using FlatICE filled with **+8C (47F)** PCM in a 45 m3 (~12,000USG) tank chilled water circuit can shift the peak loads as much as **2,000 kWh (568 RT-h)** and provide a full stand-by capability in case any power failure as well as utilising the low night ambient and utility cost reduce significant annual running cost.

CLEANTECH-2 ZERO ENERGY BUILDING, SINGAPORE

State of the art Cleantech-2 building incorporates **+11.5C (52.7F)** PCM tank with a capacity of holding 28,000 FlatICE containers providing **7,200 kWh (2,000 RT-h)** energy storage capacity to shift the peak loads.

BERGEN AIRPORT, NORWAY-T3 ENERGY CENTRE TES APPLICATION

New Terminal 3 at Bergen Airport utilises 4 x 60 m3 TES tank filled with +**10C (50F)** PCM tanks providing **~10MWH (2,840 RT-h)** energy storage in order to shift the peak loads.

By and spread the cooling loads over 24 hours and effectively reduce the cooling machinery, peak power demand and annual running cost by storing excess capacity from the chillers at overnight lower ambient & low load conditions.

NATIONAL THEATRE, London, UK

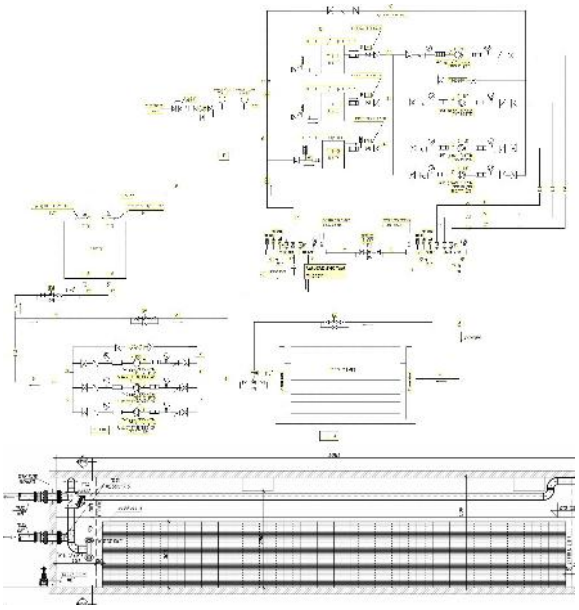
A CHP system installed to provide electricity and heating for the offices during day-time and excess heat is utilised to drive the Absorption chiller cooling system which charges the PCM based 8 Nos TES tanks filled with **+8ºC (47ºF)** PCM containers storing **2,000 kWh (568 Ton-hr)**
The stored waste heat cooling is used for the cooling of the theatre during evening shows, thereby eliminating the need for a very large chiller infrastructure.

TITANIUM COMMERCIAL BUILDING A/C APPLICATION, ISREAL

Like any commercial building whereby a large cooling demand required during day time but very little or no cooling demand over-night, Installed PCM Thermal Energy Storage (TES) offered a great opportunity to utilise the cooling machinery over-night using lower electricity rates as well as higher efficiencies due to lower night time ambient in Israel and effectively enabling to shift the peak loads.

Hence, PCM based TES offered not only an environmentally friendly design but also provided a significant operational running cost savings. Also having a static system a PCM energy storage system can be considered as a maintenance free system providing a stand-by capability in case of power cuts or any major machinery failures.

100 m3 (26,417 USG) Atmospheric rectangular tank loaded with 20,000 FlatICE filled with S9 **(+9C/49F)** PCM Providing **4.5 MWh (1,278 RT-h)** TES capacity.



Norwegian University of Life Sciences, Campus Ås SLP, K302, NORWAY

Thermal Energy Storage (TES) bridges the time gap between energy requirement and energy use. This PCM-TES campus installation near Oslo, Norway utilises the installed infrastructure and by spreading the load over a 24 hour period one can installed half the number of mechanical cooling machines for the same peak loads.

Like any other educational facility bulk of the peak load occurs once the buildings are occupied but after office hours this large peak load subsides significantly.

This campus PCM energy storage can be considered as a useful tool to spread the loads over 24 hours periods and thereby not only reduced the initial investment cost but also it offers reduced operational cost.

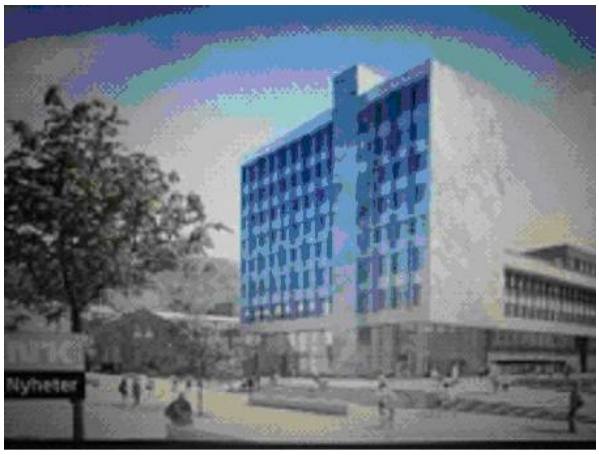
200 m3 (52,834 USG) pressurised 3 Nos tank buried and landscaped next to the building accommodating 40,000 FlatICE containers filled with +10C (50F) PCM Providing 9.0 MWh (2,560 RT-h) TES Capacity

WESTERN NORWAY UNIVERSITY, CAMPUS KRONSTAD, Bergen, NORWAY, LARGE SCALE DISTRICT COOLING APPLICATION

PCM energy storage spreads the loads over 24 hours periods and therefore a carefully balanced PCM energy storage not only reduces the initial investment cost but also it offers reduced operational cost.

Utilising the diversification for a large scale energy centres like University of Bergen, Norway PCM energy storage **12,000 kWh (3,000 Ton-hr)** using **+10C (50F)** PCM material acts as a buffer to handle large spikes, hence, steady overall operation for the system.

A video link of the system can be watched http://www.nrk.no/nett-tv/indeks/295683/



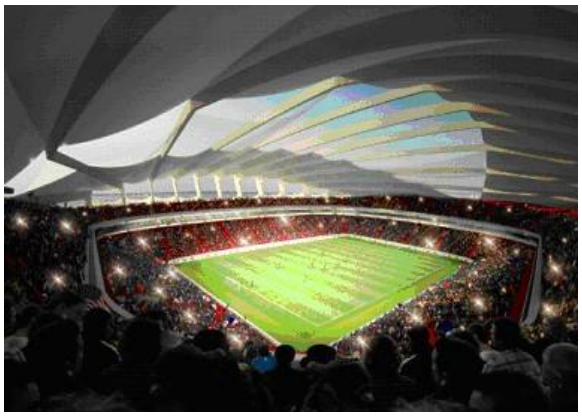
DOHA/QATAR FIFA 2022 WORLDCUP STADIUM PCM BASED SOLAR AIR CONDITIONING APPLICATION

Qatar's bid for FIFA 2022 Worldcup, a full scale demonstration stadium using only SUN to run air conditioning using PCM energy storage **5,000 kWh (1,420 Ton-hr).**

Using parabolic solar concentrators oil is heated to drive the absorption chiller which in return charged a large PCM tank filled with **+10F (50F)** FlatICE containers and later once the sun goes down this stored energy provided the cooling for the enclosed stadium as a totally off-grid system.

www.cibsejournal.com/search

www.worldfootballinsider.com/Story.aspx
thetechjournal.com/off-topic/qatars-2022-world-cup-stadium.xhtml



EIDOS, ITALY HEAT PUMP APPLICATION

Geothermal heat pump while heating the building, cooling side on the ground is wasted or vice versa. This Italian micro-chip factory required both heating & cooling all year round in order to control both temperatures and humidity. Utilising PCM based hot **1,200 kWh (4,095 MBtu)** using 46C (115F) PCM solution) and cold **900 kWh (256 RT-h)** using +10C (50F) PCM based TES solution on each side all the energy is stored above ground in TES tanks and therefore this new concept simultaneously can prove heating and cooling from a single central plant to control both the space temperature as well as humidity without wasting any energy with a COP of as much as 13 (EER=45)

GOSNEL CITY DISTRICT COOLING, AUSTRALIA

Large scale coolth PCM storage as part of the district chilled water circuit applied for a West Australian office / city centre complex.

Utilising the existing machinery the new extension cooling loads are covered by simply running the existing system over-night and store the surplus capacity in 80m3 (21,200 USG) site built rectangular tank filled with 12,500 FlatICE using +8C (47F) PCM solution providing **4,000 kWh (1,136 RT-h)** cooling capacity.

WATER-WATER COLT HEAT PUMP TES SYSTEM

Water based heat pump buffer system using +22C (68F) PCM to stabilise the water heat balance circuit. Normal practice is to use boiler and chiller to balance and keep this common circuit around 20~24C (68~72F) against over-heating and over-cooling. This process follows a 24 hour cycle and over a 24 hours period main circuit heated part of the day but later cooled and therefore chiller and boiler has to kick in respectively to balance the circuit.

A PCM tank as art of this circuit may eliminate the need for a chiller and boiler by absorbing excess heat and cold as a shock absorber and maintain the main circuit within the operational limits and not having boiler / chiller energy consumption PCM energy storage offers a significant reduction in running cost and environmentally friendly option.

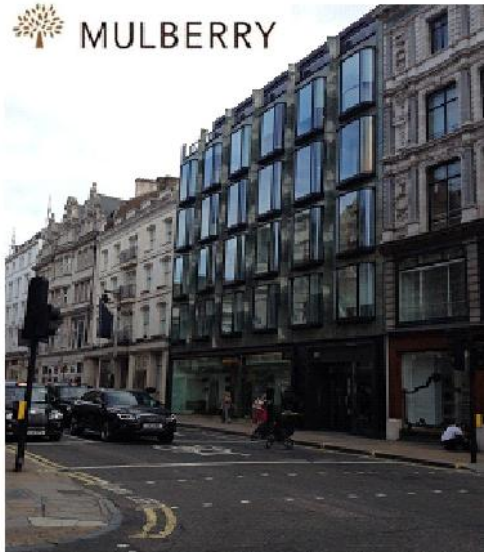
CHINA CHIPPING HQ, Felixstowe, UK

Building cooling load shifting achieved utilising 30 m3 rectangular pressurised tank containing FlatICE containers filled with S8 **(+8C/47F)** providing **422 kWh (120 RT-h)** TES capacity.

By simply running chillers over-night while no load and cooler night ambient conditions as well as almost 1/3 of the electric cost, this system annual running cost reduced significantly in comparison with a conventional design.

MULBERRY TES FOR AIR CONDITIONING, LONDON,UK

This two story showroom was in the centre of London and located in a listed building with very little external walls to fit sufficient number of air conditioning outdoor units.
Allowable outside wall space was just about the half of the total cooling load and by simply utilising half the size air conditioner over-night to charge the PCM modules the 50% of the day loads can be handled by using these stored energy. PCM modules not only provided the missing capacity but also enables the store utilising firstly free cooling more than half of the year and other times using low cost night time electricity, hence, reduce the overall running cost significantly.



WESTI

WESTERN SYDNEY, BUILDING 24 TES LOAD SHIFTING APPLICATION

As the bulk of the cooling load occurs during day time i.e. teaching periods any installed mechanical cooling is not used over-night while the ambient is low as well as lower the night time lower electricity rates are wasted. By simply installing S10 **(+10C/50F)** 2,500 FlatICE containers which provided approx. **550 kWh(156 RT-h)** the above disadvantages are eliminated.
Furthermore, by simply running the mechanical cooling machinery over 24 hours periods installation required only half the size cooling machinery thereby saving not only initial installation cost but over its life time maintenance cost.

GKG OFFICE BUILDING TES APPLICATION, DONGGUAN, CHINA

Electricity supply especially for the Industrial zones in China currently struggling in particular during lunch time periods. Hence, the power supply to buildings / factories is either cut or a few hours sold with excessive higher costs. By simply shutting down the air conditioning systems for a few hours during mid-day running cost related to the air condition systems can be reduced significantly. To this end, **+8ºC (47F)** PCM TES is installed and it enabled to shift **4,250 kWh / (1,200 RT-h)** energy by simply running the installed chiller over-night. It is estimated that TES investment return would be within 2~3 years.

GKG PRECISION MACHINE CO.,ITD.

SOMACIS GRAPHICS TES INSTALLATION, DONGGUAN, CHINA

As China struggles to provide sufficient power the drive the fast expansion of manufacturing plants generally power supply to buildings / factories are either cut or a few hours at peak periods sold at a premium price. Hence, most of the factories installs generator to avoid these a few hours during mid-day running cost related to the air condition systems.
To this end, **+8ºC (47F)** PCM TES is installed and it enabled to shift **4,250 kWh (1,200 RT-h)** energy by simply running the installed chiller over-night. It is estimated that TES investment return would be within 2~3 years.

TTI-TECHTRONIC INDUSTRIES FACTORY TES APPLICATION, DONGGUAN, CHINA

A large production plant in China struggles no only with the high electricity costs during mid-days but also due to unreliable power supply had the find a solution either buying more generators or install a TES and utilise the existing chillers to storage thermal energy.
Based on the return on investment as well as being a maintenance free system an **+8ºC (47F)** PCM TES offered the best economical solution and therefore they installed **4,250 kWh (1,200 RT-h)** TES system.
As PCM energy storage system is static and no moving parts it offers a very reliable and cost effective option to shift the loads from peak periods to off-peak periods.

DEKRA-HQ in Stuttgart/GERMANY OFFICE BUILDING TES

Although having 62,000 m2 office areas, this building had very limited space for any TES.
Therefore in stead of a simple large chilled water storage, latent heat storage is selected using a **16m³ ,600 kWh (170 RT-h)** PCM storage tank filled with **+15C (59F)** was installed in parallel to a small chilled water storage of the same size.
Based on normal than larger DeltaT for the water circulation the installed PCM system still provided 4 times energy storage capability higher than that of chilled water storage of the same size.

FEDERAL CENTER SOUTH, Seattle, USA, US GENERAL ADIMINISTRATION BUILDING

We are proud to be part of the Federal Center South “American Recovery and Reinvestment Act (ARRA)” funded project. It is also part of the U.S. General Services Administration’s (GSA) Design Excellence program. The Center currently house the Seattle headquarter of U.S. Army Corp of Engineers.

Cooling load shifting is achieved by utilising TES tanks filled with 4,500 FlatICE using **+13ºC (55ºF)** PCM **1,050 kWh (300 Ton-hr)** PCM Energy Storage.

The building achieved LEED PLATINUM certification from the U.S. Green Building Council. The building earned an ENERGY STAR score of 98.

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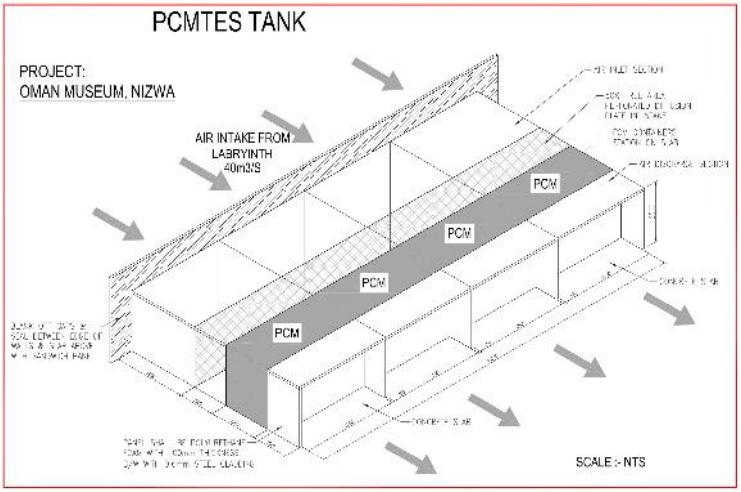
BANK SOUTH PASIFIC DATA CENTRE PAPUE NEW GUINE

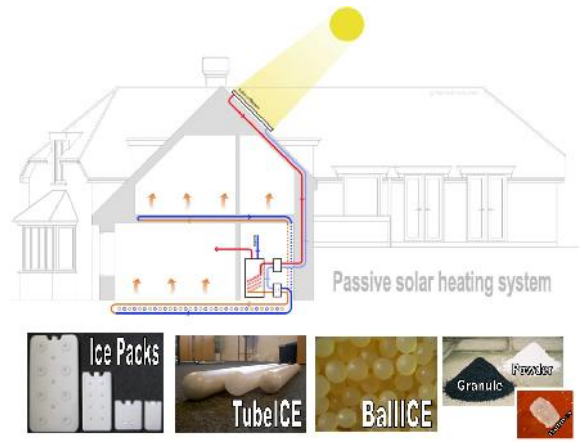
As the cooling load having large peaks it was vital to shift the loads and spread over 24 hours period. To this end 12 m3 tank containing FlatICE containers filled with S8 **(+8C/47F)** providing **420 kWh (120 RT-h)** TES capacity.
By simply running chillers over-night while the load is less than day peaks as well as cooler night ambient conditions installed system had almost half the conventional chiller capacity with lower running costs. Furthermore, TES tanks also acts as a stand-by facility in case of any power / mechanical failures which is considered a very attractive additional benefit for the data centre facility.

PASSIVE COOLING / HEATING APPLICATIONS

Oman Across Ages Museum, Muscat, Oman

Considering **55C (130F)** peak day time ambient temperature vs. **28C (82F)** night time ambient condition if one can store that cool night energy and utilising this FREE stored energy during day peak period one can reduce the outside air cooling demand during peak ambient conditions significantly.
For this purpose a special tunnel built to accommodate the PCM containers whereby when the surrounding 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.
As the outside air intake is crucial for public spaces like museums by simply storing cool night energy the overall cooling demand can be reduced significantly especially locations whereby the day time ambient reaches as high as 55C (130F) anywhere in the Middle East.
Each chamber 2.5m(8') (W) x 2.0m (61/2') (L) x 2.5m (8') (H) filled with 10 wide x 58 high FlatICE stack.
Total 4 chambers accommodate 9,280 FlatICE filled with **S32 (+32C/ F**) PCM solution providing **2.0 MWh (595 RT-h)** TES capacity.





SOLAR DRIVEN UNDERFLOOR HEATING, London, UK

An average solar collector in the UK may provide a few weeks of the full hot water requirement (above 65C (155F)) but even in winter these vacuum collector can provide water temperatures well above 30C (86F) in return can easily melt PCM encapsulated in HDPE containers having **27F (81F)** PCM buried next to the under floor heating pipes receive hot water from the solar collectors.

5 Nos well insulated houses' sole heating in London was provided by solar collector and without any additional heating houses coped with even cold snaps and provided energy free and very economical with short pay back solution.

MULBERRY SHOP A/C , London, UK

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UNIVERSITY OF WESTMINSTER

UNIVERSITY OF WESTMINESTER, CAVINDISH STREET BUILDING PASSIVE COOLING APPLICATION

Over night, PCM tubes fitted within the ceiling area freeze naturally by the surrounding cooler night ambient and later this stored energy in the form of latent heat is released back to the system during daytime to absorb the internal heat gains.

As the heat tends to rise and using the temperature strafication within the room rising heat melts the tubes and cooler airdrops back to occupied space and the PCM filled tubes acts like a heat sponge and soak up the heat during daytime.

COVENTRY UNIVERSITY, JOHN LAING BUILDING PASSIVE COOLING APPLICATION

Passive cooling by means of utilising the over night cool energy which is stored within the PCM tubes by freezing naturally by the surrounding cooler night ambient and later this stored energy in the form of latent heat is released back to the system during daytime to absorb the internal heat gains from offices and large open lecture area.

Large office area was facing south and had over heating issues and by simply adding the PCM energy storage the building mass is increased and day time especially on sunny days indoor conditions significantly improved by means of free PCM cooling.

UNIVERSITY OF WESTMINESTER, CAVINDISH STREET BUILDING PASSIVE COOLING APPLICATION

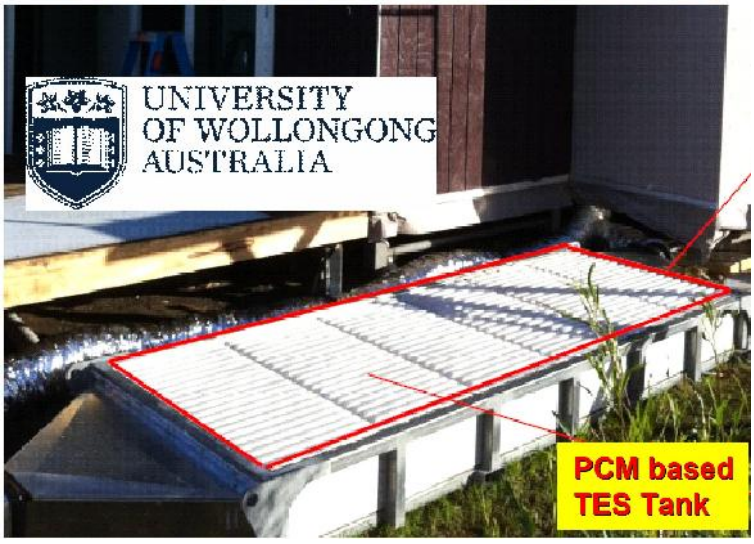
Over night, PCM tubes fitted within the ceiling area freeze naturally by the surrounding cooler night ambient and later this stored energy in the form of latent heat is released back to the system during daytime to absorb the internal heat gains. As the heat tends to rise and using the temperature strafication within the room rising heat melts the tubes and cooler airdrops back to occupied space and the PCM filled tubes acts like a heat sponge and soak up the heat during daytime.

Winner of the Solar Decathlon China 2013

For the Solar Decathlon competition 2013 (China), a PCM thermal energy storage (TES) unit with 21C (72F) Flat ICE are utilised as part of the HVAC system. The HVAC system consists with Photovoltaic thermal (PVT) collectors, PCM TES, and heat pump.

In winter, the PVT collectors generates hot air during the daytime, and then the hot air used for direct indoor space heating or store in the PCM TES for night-time use.

In summer, the PVT collectors generate cool air by sky radiative cooling, and then facilitate the indoor space cooling. Due to the intermittency of solar radiation and night-time coolness, the PCM TES play an important to make full use of the sustainable energy to reduce the indoor air conditioning power consumption. 21C (72F) PCM ideal to store either heat or coolness to achieve optimum free energy usage.



SOLAR HOUSE, USA

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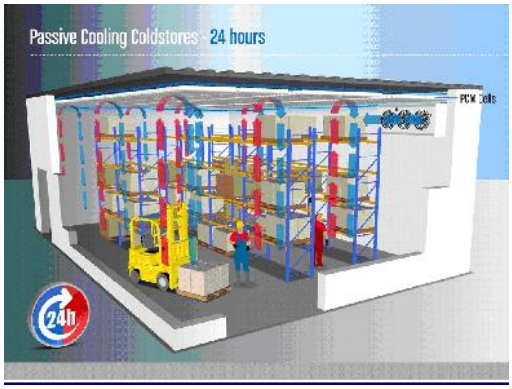
SHELTER & CONTROL PANEL PASSIVE COOLING APPLICATIONS

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).

As the night ambient temperatures over night 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.



COLD STORE LOAD SHIFTING

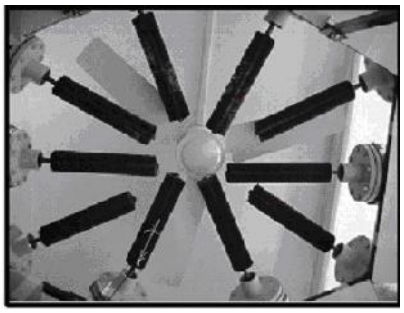
By placing the Eutectic products within the cold store one can create a TES facility whereby the excess refrigeration capacity during off-peak periods and lower ambient conditions over-night can be utilised to shift the peak load.

Eutectic TES can either be installed as part of the cold store fabric for example hanging TubeICE on ceiling/walls or alternatively containers like FlatICE can be placed on pallets and stored with the shelves or alternatively using ice packs / pouches Eutectic TES can be incorporated as part of the packaging / palleting.

By simply running the refrigeration machinery over night-time cooler ambient periods, one can save as much as ***15~25%*** electricity consumption due to higher efficiencies of the refrigeration machinery at lower ambient condition as illustrated in this graph.

Reduced actual kWh electricity consumption coupled with the possible cheap off-peak electricity costs may reduce the overall cold store annual running cost by as much as ***30~50*** depending on the region.

NOTTINGHAM PASSIVE COOLING,UK



Passive ceiling heat pipe + PCM comfort cooling application in the UK. Using standard ceiling fans and PCM+Heat Pipe arrangement provided a hybrid 22C (71F) PCM based dynamic passive cooling. Over-night exposed fin section of the PCM+Heat Pipe acts as condenser while the other side froze the PCM and during day-time the same exposed section reversed and acts as evaporator and provide cool downward air for cooling.