Z a f e r U R E

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e-mail: z.ure@pcmproducts.net

www.pcmproducts.net

THERMAL ENERGY STORAGE

“ Storing *High* or *Low* temperature energy for later use in order to bridge the time gap between energy availability and energy use “

WHY THERMAL ENERGY STORAGE ?

* Reduced Machinery Size
* Reduced Running Cost
* Improved System Operation
* Flexible System
* Environmental Benefits

THERMAL ENERGY STORAGE TECHNIQUES

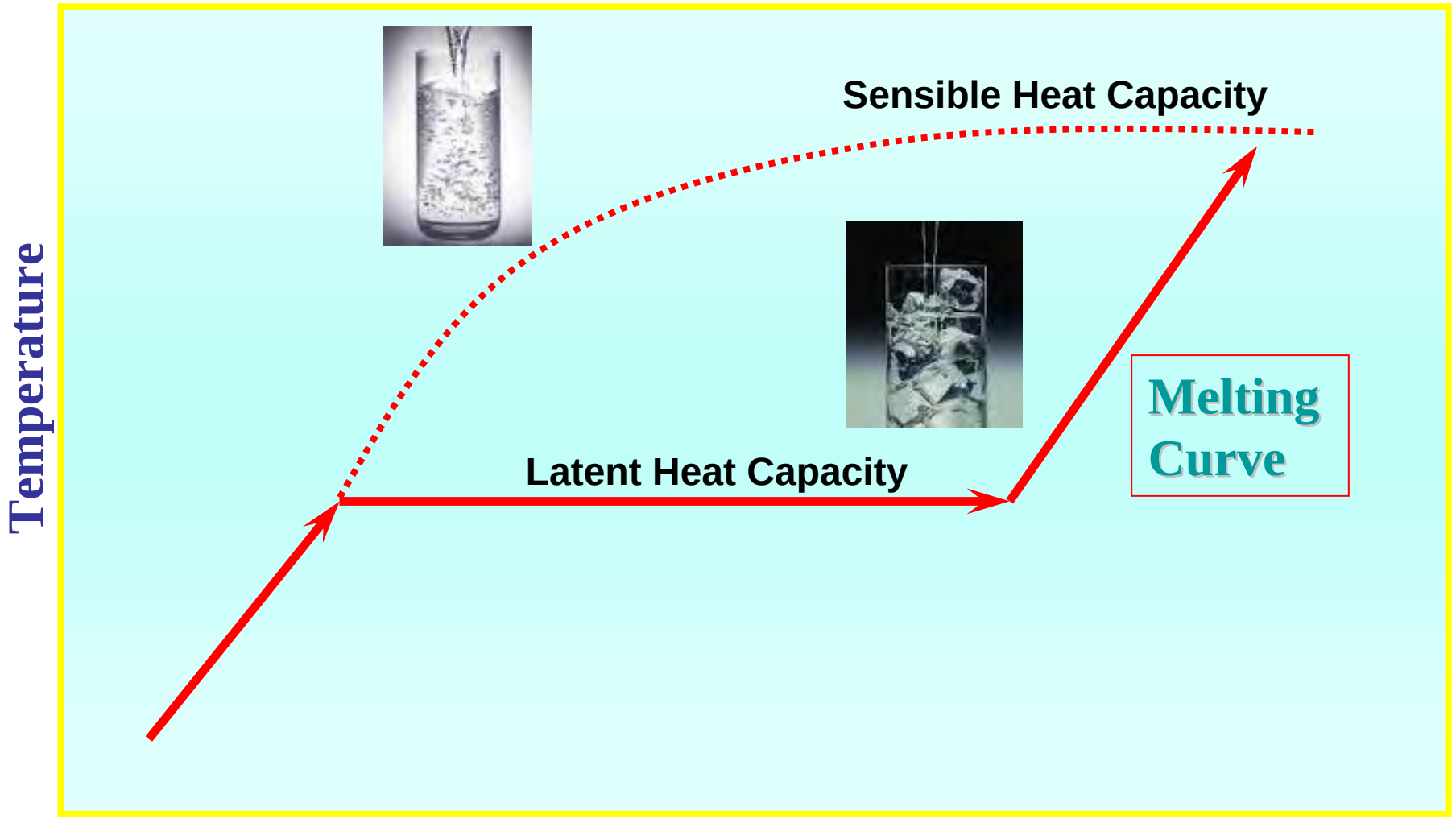
SENSIBLE TES

- Chilled / Hot Water
- Fabric TES

LATENT TES

- Ice TES
- Eutectic TES

SENSIBLE Vs LATENT HEAT OPERATION



THERMAL ENERGY STORAGE TECHNIQUES

SENSIBLE TES

- Chilled / Hot Water
- Fabric TES

4,500 ton-hour TES Tank, San Antonio, TX

Michael Young Building,
Open University,
Milton Keynes

CURRENT ICE PRODUCTION TECHNOLOGIES

STATIC ICE PRODUCTION

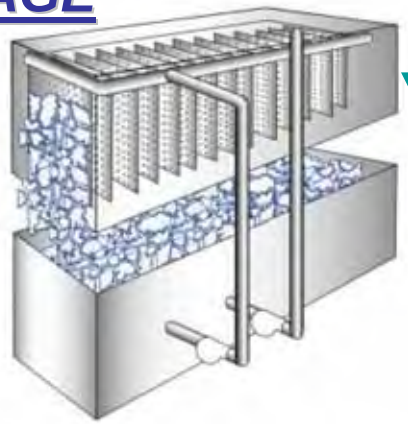
1) Ice Builders
2) Ice Banks
3) Encapsulated Ice Modules
    a) Balls
    b) Flat Containers

DYNAMIC ICE PRODUCTION

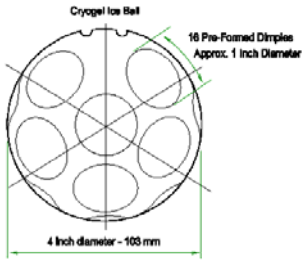
1) Plate Harvester
2) Tube Harvester
3) Flake Ice Machines
4) Binary Ice Machines

THERMAL ENERGY STORAGE TECHNIQUES

DYNAMIC ICE STORAGE



STATIC ICE STORAGE



LATENT TES

- **Ice TES**
- **Eutectic TES**

EUTECTIC MATERIAL
PHASE CHANGE MATERIAL (PCM)

Mixture of two or more chemicals (inorganic salts) having a freezing / melting temperature point which is higher or lower than those of water 0 C (32F).

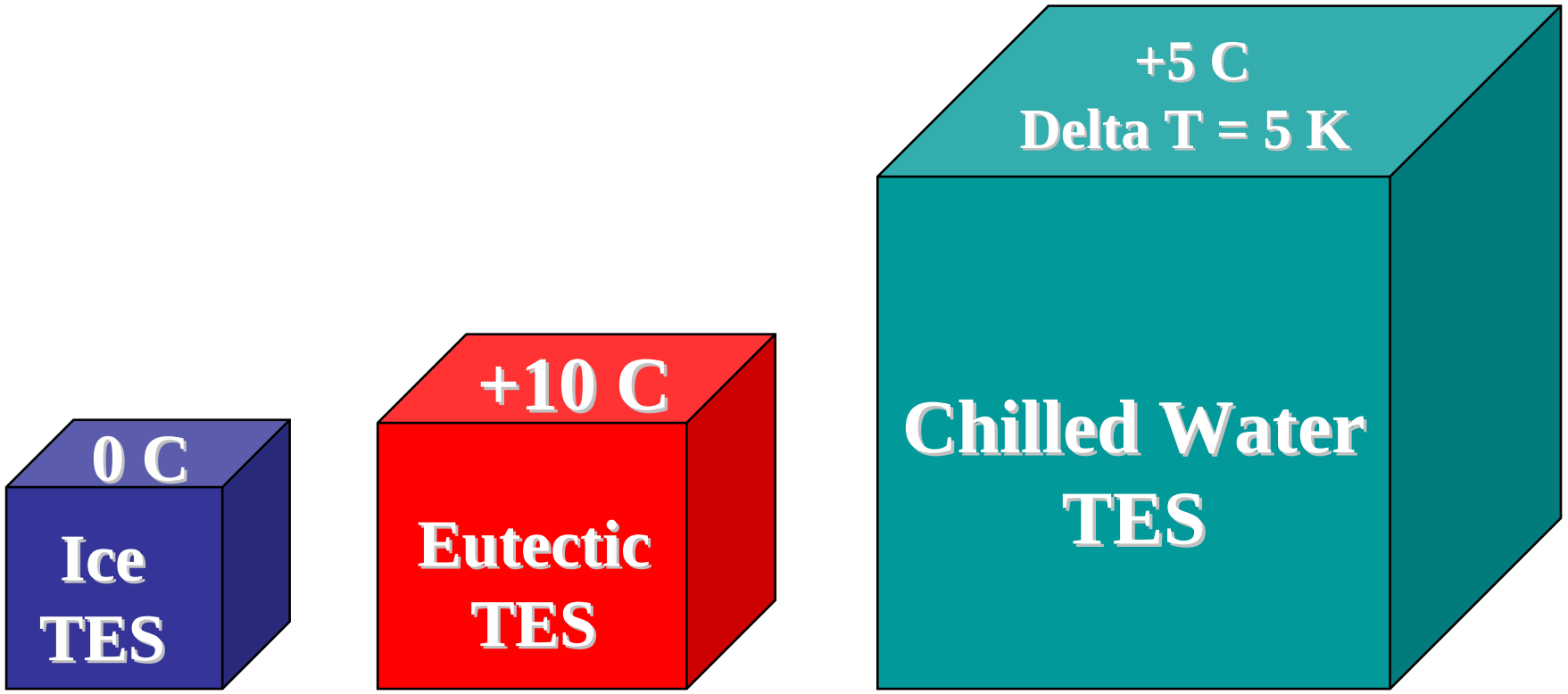
ORGANIC COMPOUNDS

- Wax
- Vegetable Oil
- Soya / Sugar

SALT-BASED SOLUTIONS

- Glauber's Salt
- Calcium Chloride
- Organic Salts

WHY EUTECTIC THERMAL ENERGY STORAGE?



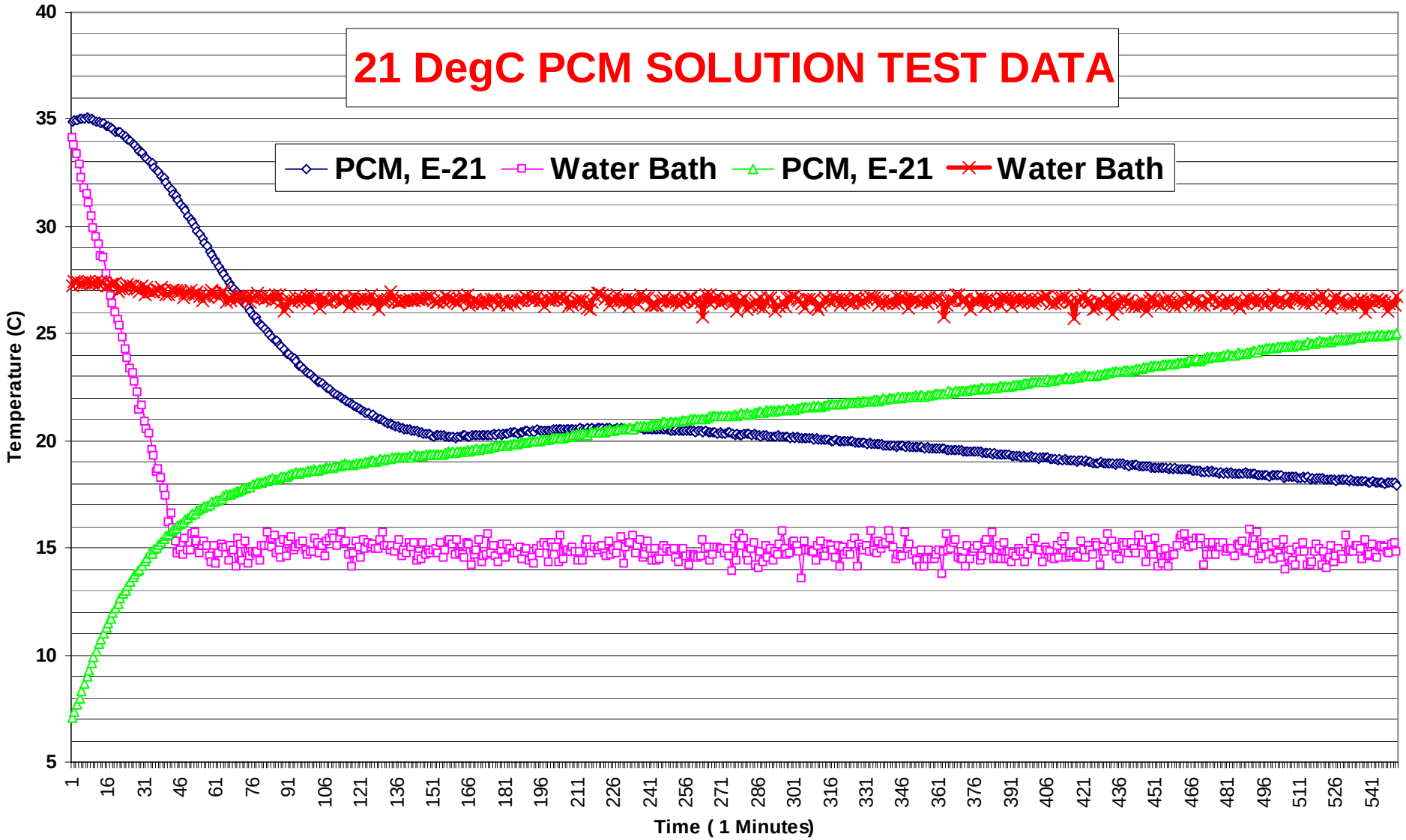
Ice TES	Eutectic TES	Chilled Water TES
335 kJ/kg	140 kJ/kg	4.18 kJ/kgK * 5 K (20.0 kJ/kg)
915 kg/m3	1470 kg/m3	1000 kg/m3
306 MJ/m3	206 MJ/m3	20 MJ/m3
1/15	**1/10**	**1**

COMMERCIALLY AVAILABLE PHASE CHANGE MATERIALS

PCM Type	Phase Change Temperature (C)	Phase Change Temperature (F)	Density (kg/m3)	Density (lb / ft3)	Latent Heat (kJ/kg)	Latent Heat (Btu / lb)	Latent Heat (MJ/m3)	Latent Heat (Btu / ft3)	Spec. Heat (kJ/kg K)
E117	117	243	1450	90.5	169	72.7	245	6,580	2.61
E89	89	192	1550	96.8	163	70.1	253	6,784	2.48
E58	58	136	1280	79.9	226	97.2	289	7,767	0.72
E48	48	118	1670	104.3	201	86.5	336	9,013	0.70
E32	32	90	1460	91.1	186	80.0	272	7,291	0.78
E30	30	86	1304	81.4	201	86.5	262	7,038	0.69
A28	28	82	789	49.3	245	105.4	193	5,190	2.22
E21	21	70	1480	92.4	150	64.5	222	5,961	0.68
E19	19	66	1484	92.6	146	62.8	216	5,817	0.68
E17	17	63	1487	92.8	143	61.5	213	5,709	0.67
E13	13	55	1489	93.0	140	60.2	208	5,597	0.67
E10	10	50	1519	94.8	140	60.2	213	5,710	0.66
A8	8	46	773	48.3	220	94.6	170	4,566	2.16
E8	8	46	1469	91.7	140	60.2	206	5,522	0.67
E7	7	45	1542	96.3	120	51.6	185	4,968	0.62
A4	4	39	766	47.8	227	97.6	174	4,669	2.18
WATER	*0*	32	*1000*	62.4	*335*	144.1	*335*	8,995	*4.186*

A - Alkine / Aliphatic Based Solution **E- Eutectic Based Solution**

PASSIVE COOLING PCM SOLUTION



PHASE CHANGE MATERIAL TYPES

PHASE CHANGE MATERIAL APPLICATIONS

A TYPICAL PASSIVE COOLING ELECTRONIC CHAMBER APPLICATION

ROOM (+45C)
MAX

DAY (+45C) PCM (+32C) DAY (+27C)

SHELTER COOLING

Date	Scale: NTS	
	Drawing No:	**C001**
Drawn	Project Name	
	PASSIVE COOLING APPLICATIONS	
Job No:		

EPS
ENVIRONMENTAL PROCESS SYSTEMS LTD.

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Yaxley, Cambridgeshire,
PE7 3HS, UK
Tel.: +44(0)1733-243400
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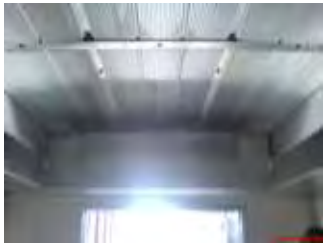
SHELTER COOLING

CEILING FITTINGS



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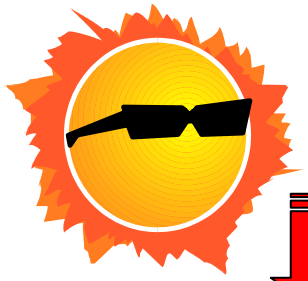
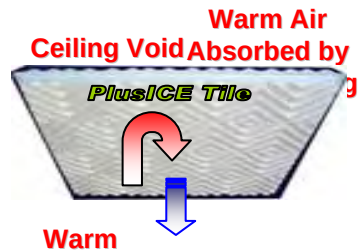
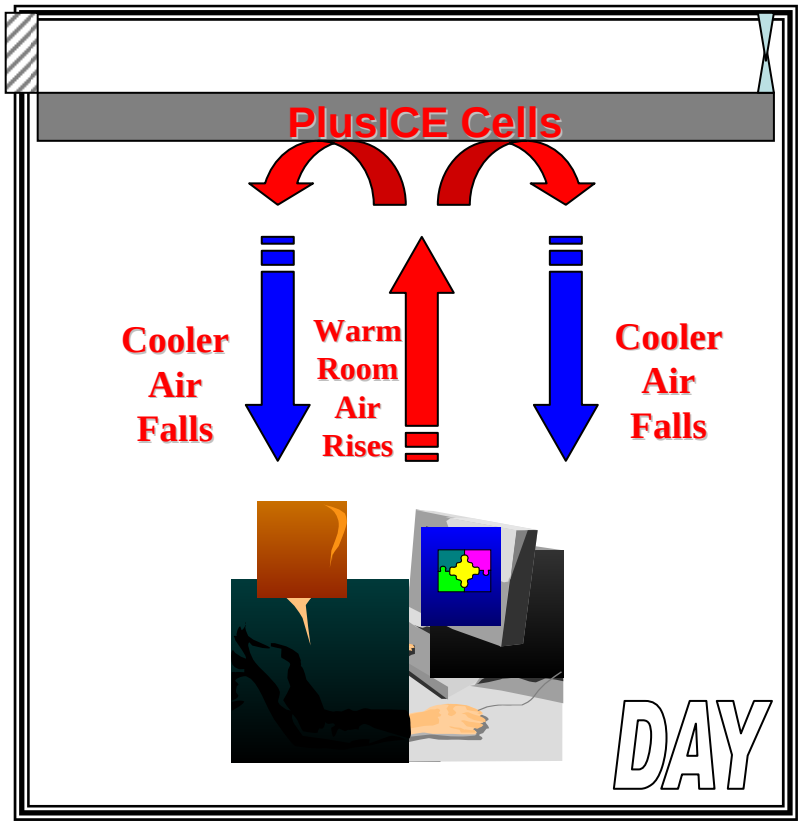
PASSIVE COOLING

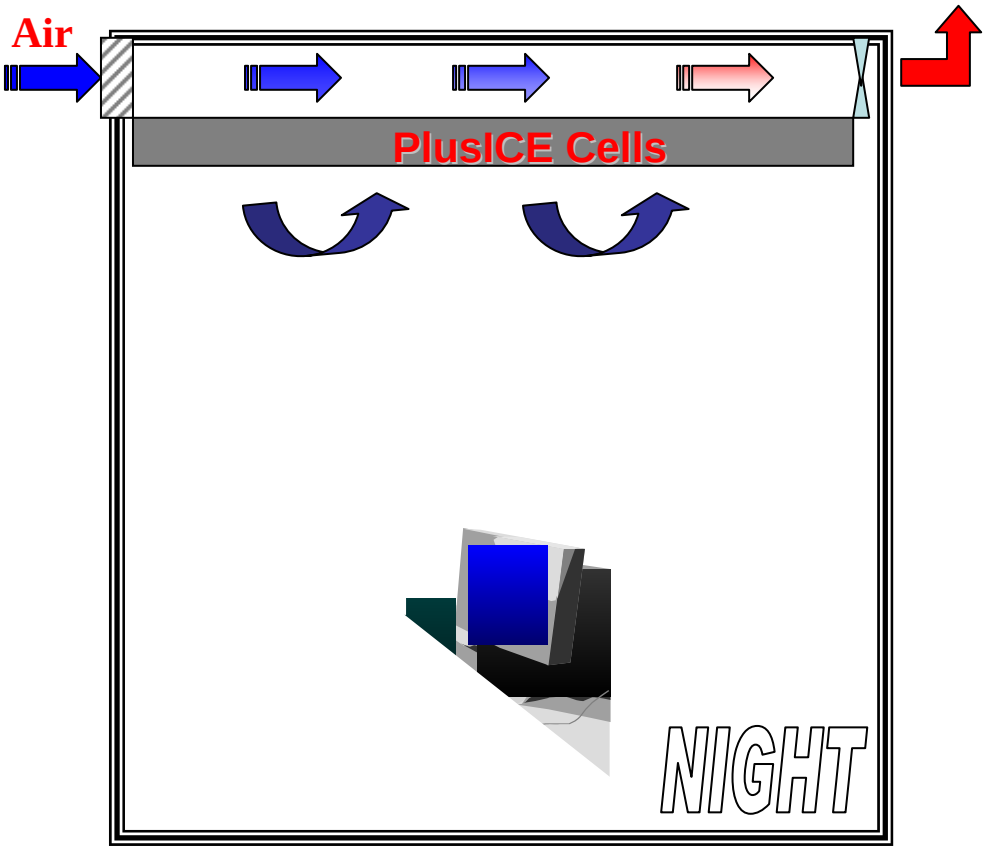


Solar Gains

Cool Outside Air



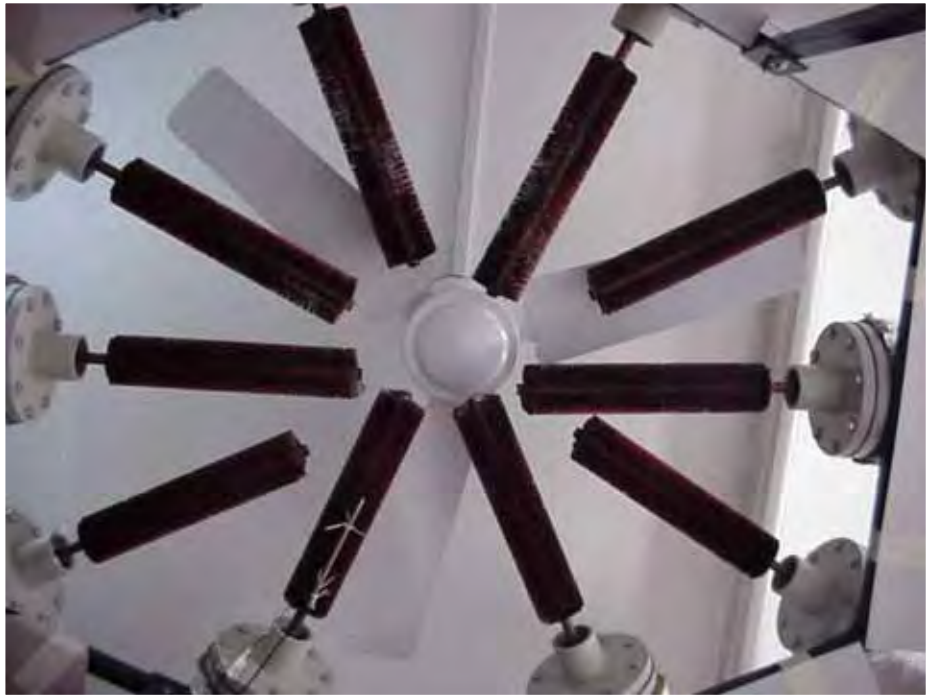


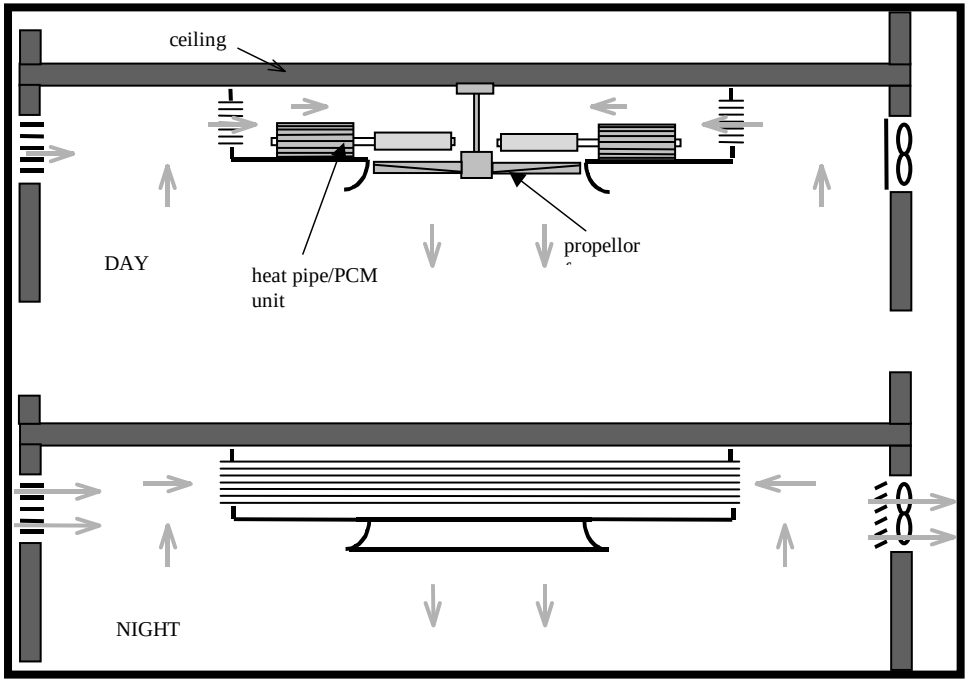


DISCHARGE PERIOD

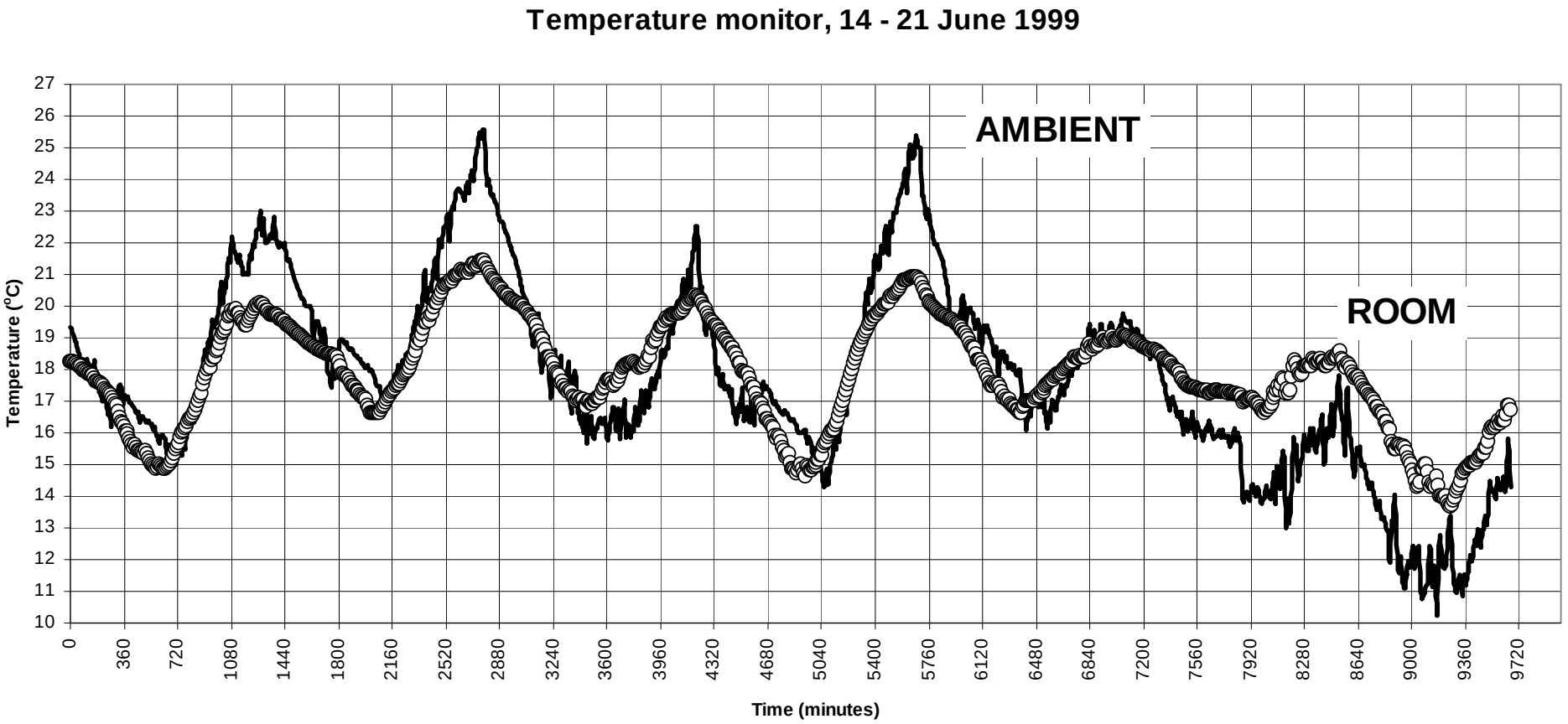
CHARGE PERIOD

Nottingham University Office Building PCM/ Heat Pipe Passive Cooling

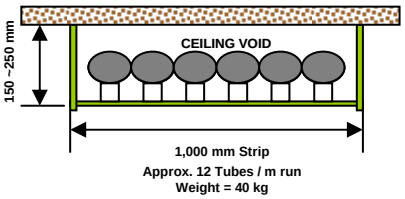


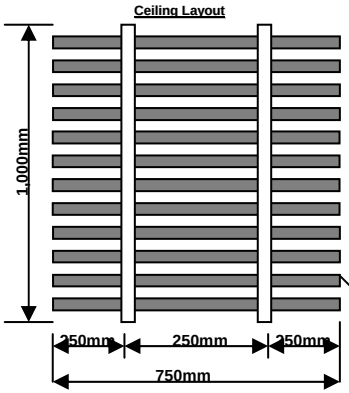


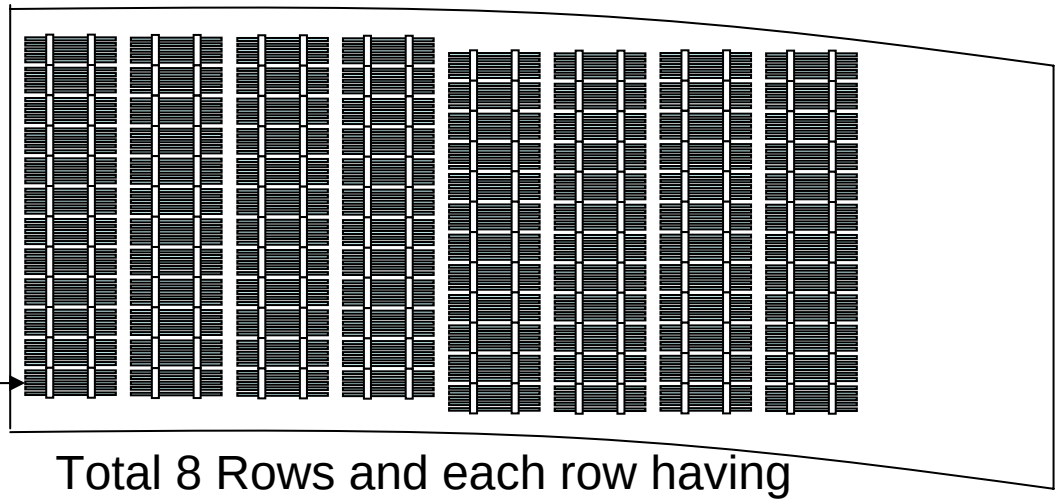
Nottingham University Office Building
PCM/ Heat Pipe Passive Cooling Operational Data



LECTURE THEATHER PASSIVE COOLING CELL INSTALLATION

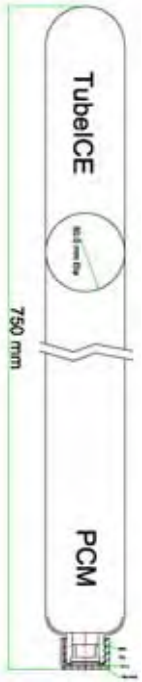


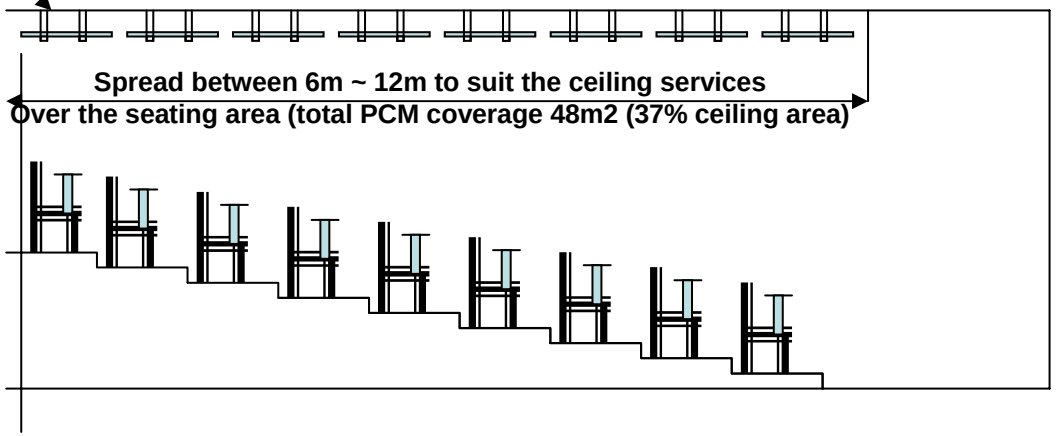




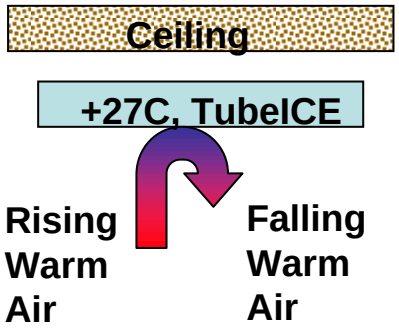
Total 8 Rows and each row having
96 TubeICE containers;
Total: 768 TubeICE containers

Tube ICE





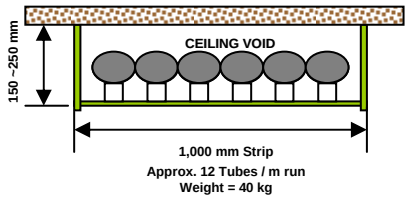
PASSIVE COOLING CONCEPT

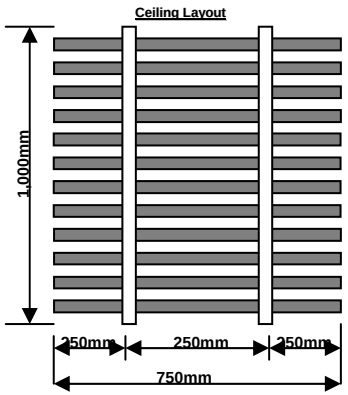


PCM

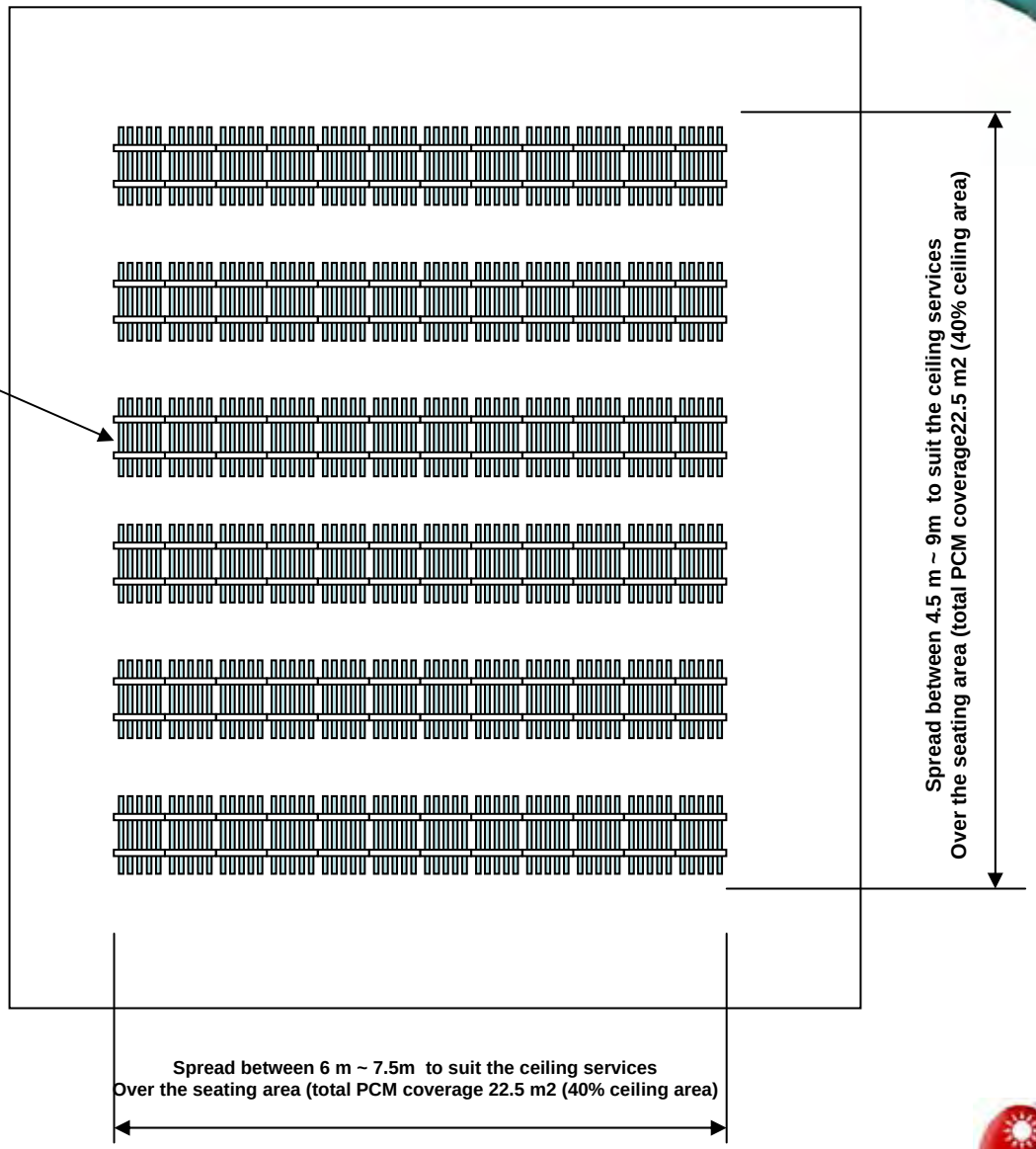
Lecture Theatre

CLASSROOM PASSIVE COOLING CELL INSTALLATION

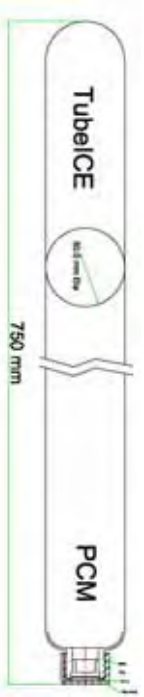




Total 6 Rows and each row having 60 TubeICE containers;
Total: 360 TubeICE containers

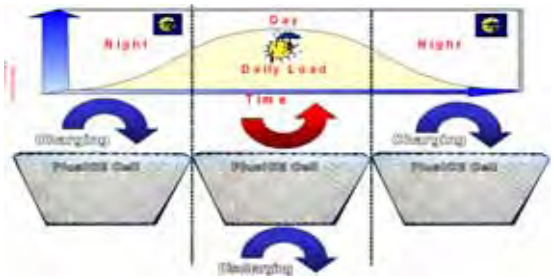


Tube ICE



PCM

Classroom



PCM

The Stevenage (UK) Passive Cooling Office Application

This office has a number of 'environmentally friendly' features which follow the principles of sustainability and Local Agenda '21'

Comfort Cooling:

- This office area is partially cooled during the summer months by using cool air at night to cool the structure of the building which is used to reduce the daytime temperature.
- The cooling capacity of the structure has been enhanced with the innovative use of a 'Phase Change Material'. This Phase Change Material which changes state at a predetermined temperature, is fitted to 48 steel plates which are positioned close to the concrete slab in the ceiling void.
- Air from the room is delivered via ceiling fans and flexible ducting to the centre of the plates and discharges back into the room via the ceiling void.
- The operating cycle of the system in summer is as follows:

  Night-time - Window fans bring cool air from east side of building and discharge warm air to west elevation.

  - Ceiling fans operate at high speed to cool structure and pcm panels.

  Daytime - (When temperature reaches preset level – 24ºC).

  - Ceiling fans operate at slow speed to circulate room air through pcm panel to stabilise the room temperature.

LCD Flat Screens:

- The LCD flat screen computer monitors installed in this office use less than a third of the energy of a traditional CRT monitor. They produce the same proportion less heat thus reducing the summertime overheating problems and a financial saving in energy cost.
- They allow desks of a shallower depth to be utilised with the consequential saving in materials and better utilisation of office space.
- LCD flat screens are very much less susceptible to glare and do not require inefficient highly defused light fittings to be installed.

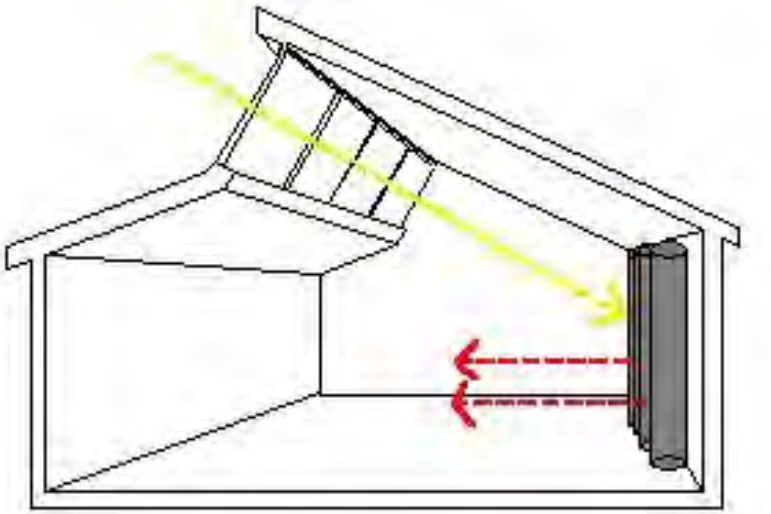
Solar Reflecting Blinds:

- The vertical blinds in this office are special highly efficient solar reflective blinds which reflect 73% of the solar radiation and reduce the solar heat gain by 94% thereby helping to reduce the summertime temperature.
- Note: Ensuring that the blinds on the east (bus station) side of the building are closed at night, will significantly reduce the effect of early morning sun.

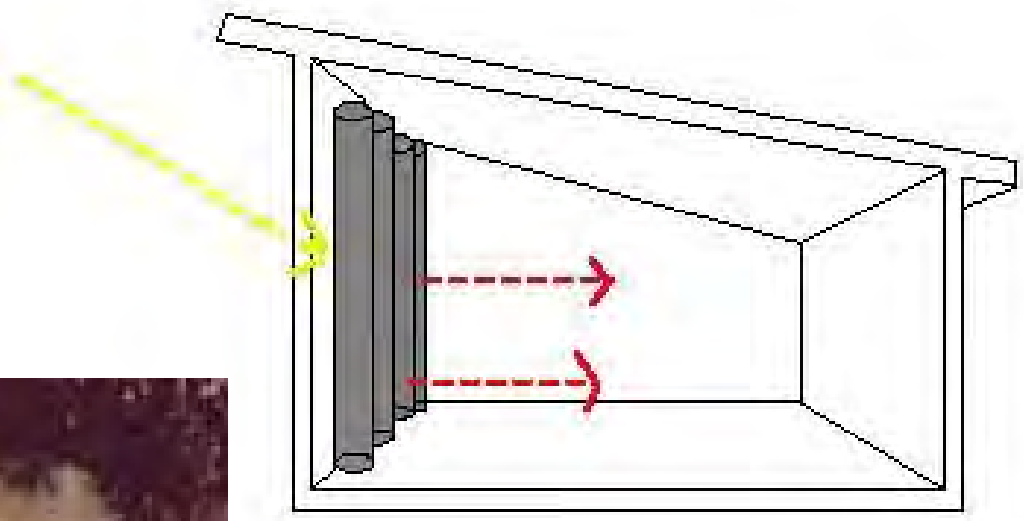
Solar and Occupancy Lighting Controls:

- The main lighting in this office is controlled by solar sensors which will turn the lighting off when sufficient daylight is available.
- The meeting room and office areas have occupancy and solar sensors to ensure that the lights are not on when the areas are not occupied.
- For night-time security/caretaking the two centre rows of lights will operate when anyone enters the area.

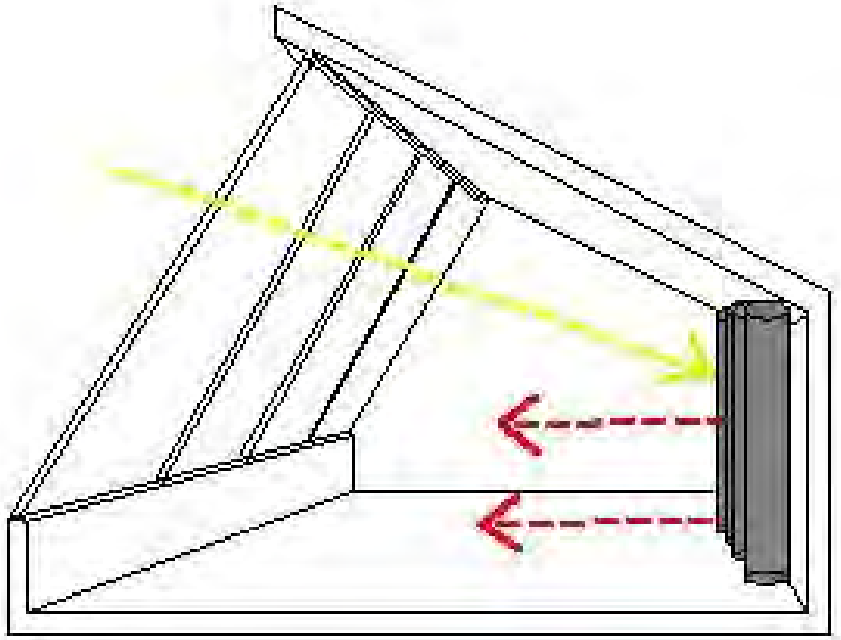
SOLAR SHIELDS



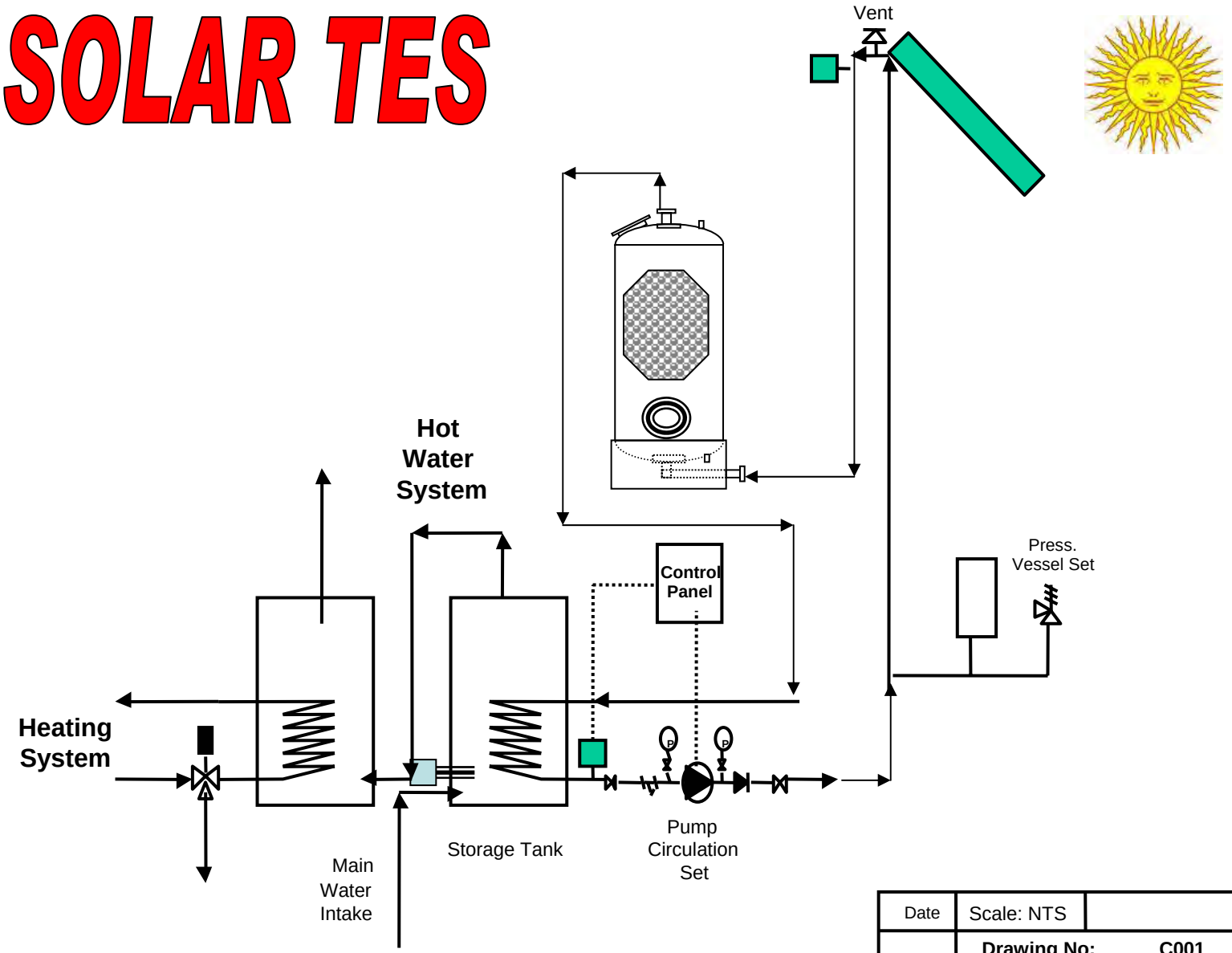
SOLAR TUBE



SOLAR TUBE



SOLAR TES



Date	Scale: NTS	
	Drawing No:	**C001**
Drawn	Project Name	
Z.URE	PlusICE Solar TES System	
Job No:		
01/04/016		

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COMMONWEALTH GAMES VILLAGE (AUSTRALIA)

LEGEND.

- Gate Valve.
- RPZD./Dual Check.
- Ball Valve.
- Pressure relief valve.
- Automatic Air-Vent.
- Check Valve / Non-Return.
- Balancing Valve.
- Automatic Filling Valve.
- Gas Valve.

MELBOURNE 2006

Total Water Management Solutions

Designed | Drawn | Checked | Approved

Job: Commonwealth Games.

Title: Typical Hot Water Schematic.

Scale

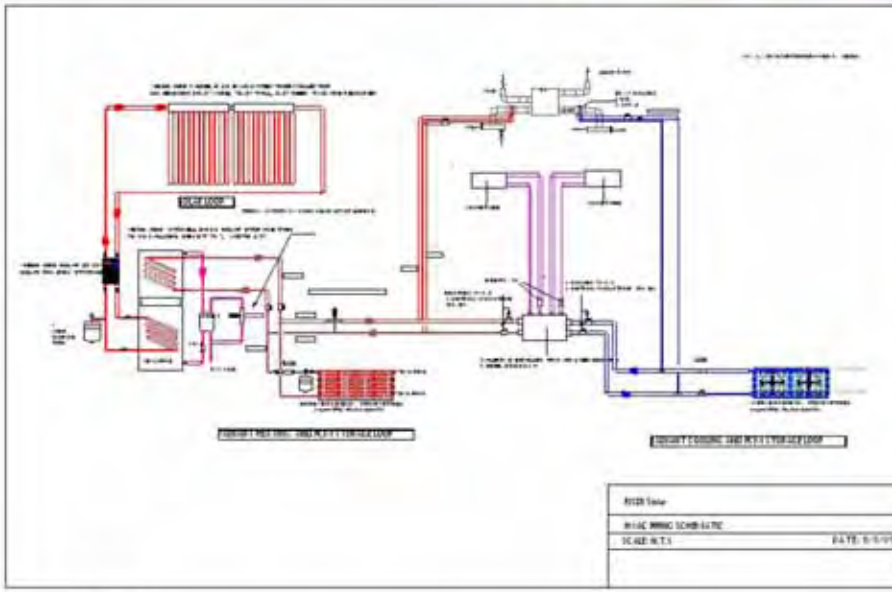
Drawing No.

Solar House Design

General;

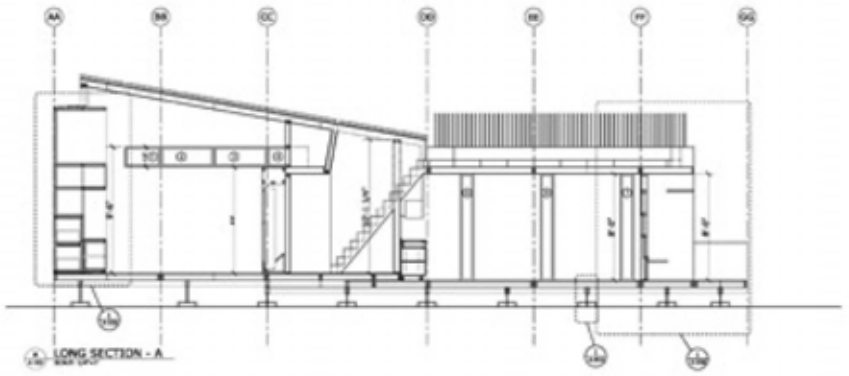
As part of the US solar decathlon competition, which required the minimum or no external energy usage domestic dwelling design, this new concept is designed around storing day-time solar energy for heating and hot water usage, and storing night-time cooling energy for day-time cooling requirements, so that both cooling and heating requirements can be met without using any external energy source.

The relevant schematic drawing of the system is a s follows;

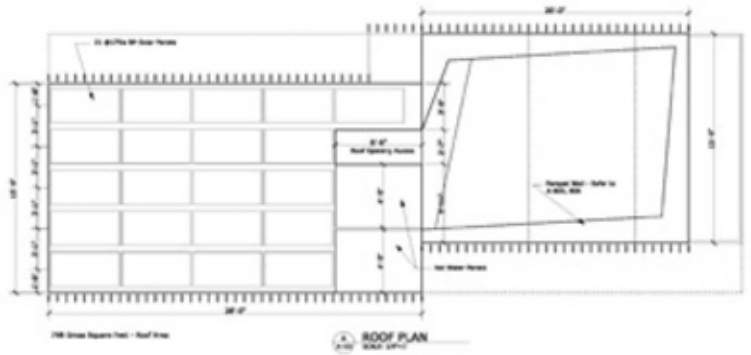


Heating Mode;

Hot water is produced utilising the Evacuated Tube Solar Collectors, and stored in the Solar storage tank. The tank has two purposes, domestic hot water and heating. The design takes heat from the domestic hot water and, through a heat exchanger, transfers the heat to the PCM heating box. Once the tank reaches temperature, whenever we have excess heat, heat is stored in the PCMs. At night or very cloudy weather, the system draws heat back off the PCMs and uses it to heat the house with Radiant Heating Ceiling panels. During the competition the system actually had no sun for 8 days, yet it was still possible to heat the house with just the PCMs on one "charge". Daily Temperature ranges were from 25.6 Deg C (78 Deg F) during the day to 12 2 Deg C (54 Deg F) at night.

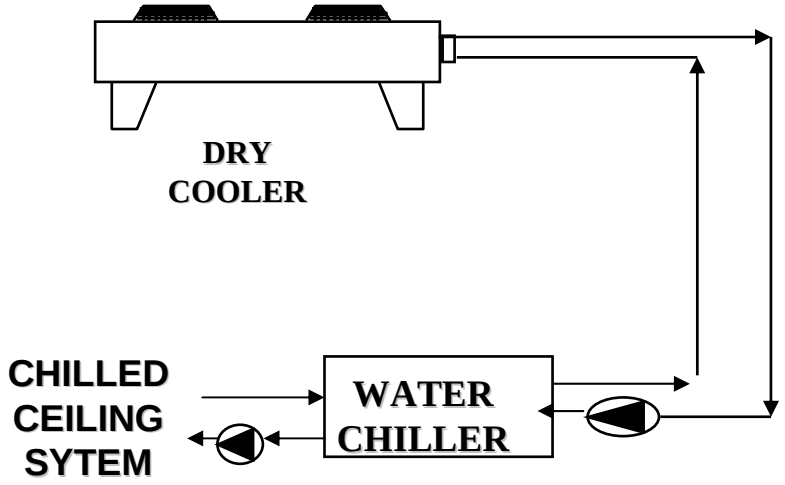


Cross Section

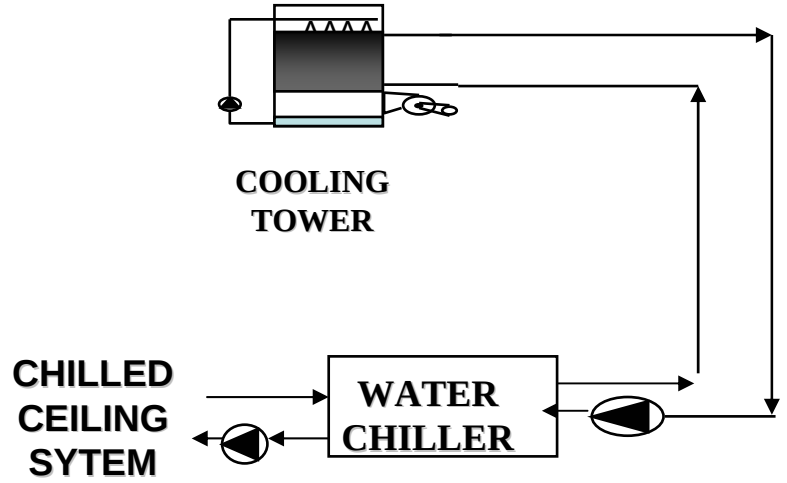


Plan

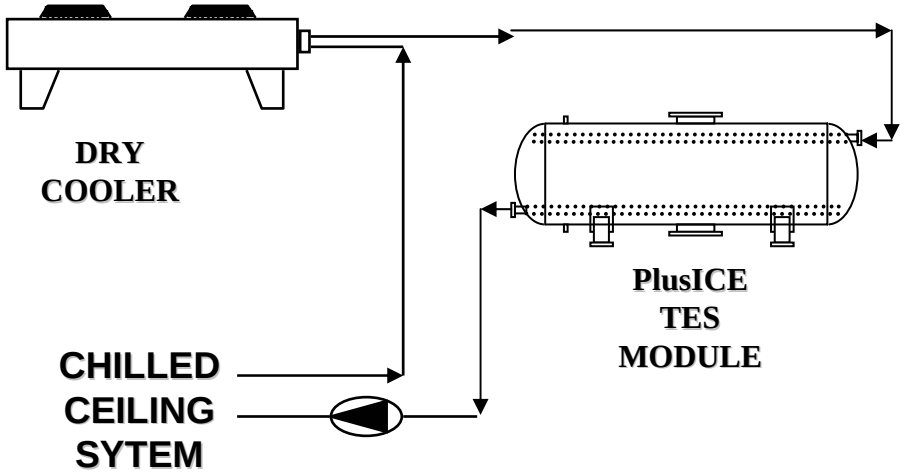
FREE COOLING CONCEPT



A) DRY COOLER SYSTEM



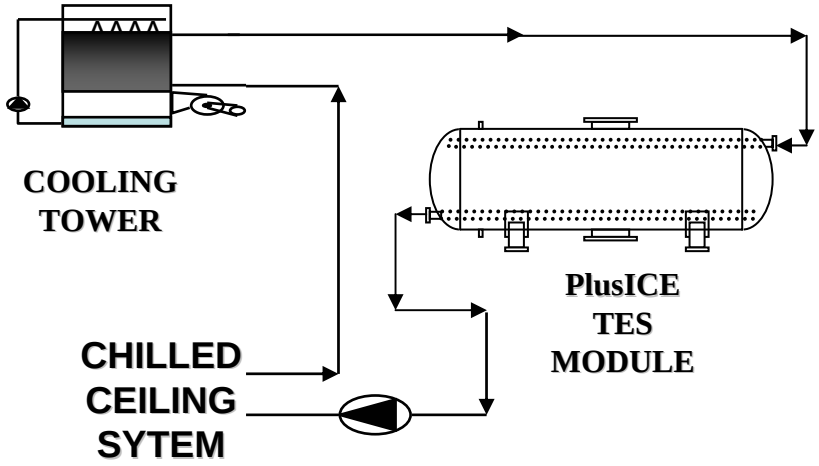
B) COOLING TOWER SYSTEM



C) DRY COOLER

+

PlusICE TES SYSTEM



D) COOLING TOWER

+

PlusICE TES SYSTEM

MELBOURNE CITY COUNCIL OFFICE (CH2)

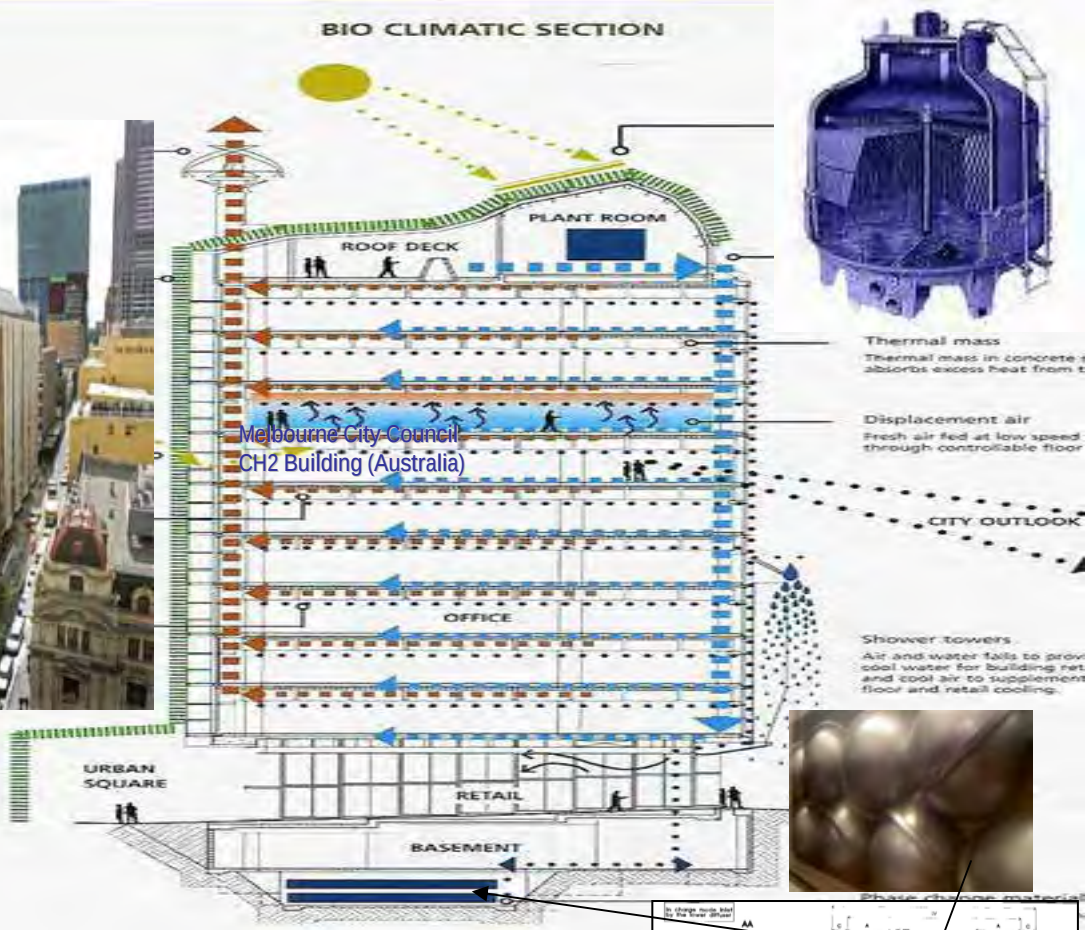
CH_2 has been designed to reflect the planet's ecology, which is an immensely complex system of interrelated components. Just as it is impossible to assess the role of any part of this ecology without reference to the whole, CH_2 comprises many parts that work together to heat, cool, power and water the building, creating a harmonious environment.

For example, in nature, dark colours absorb heat and hot air rises. Accordingly CH_2's north façade will comprise 10 dark-coloured air extraction ducts that absorb heat from the sun, helping stale air inside rise up and out of the building.

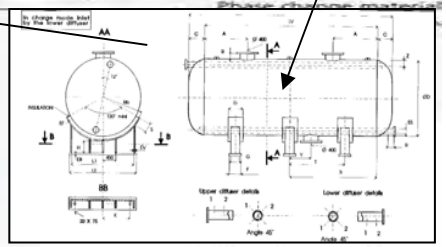
The south façade will comprise light-coloured ducts that draw in fresh air from the roof and distribute it down through the building. Staff will be able to control the flow of this 100 per cent fresh air to their work spaces by floor vents. Louvres made from recycled timber will shade the west façade. Energy from photovoltaic roof panels will power the louvres, which will move according to the position of the sun. Together these features combine to create a controlled and healthy climate.

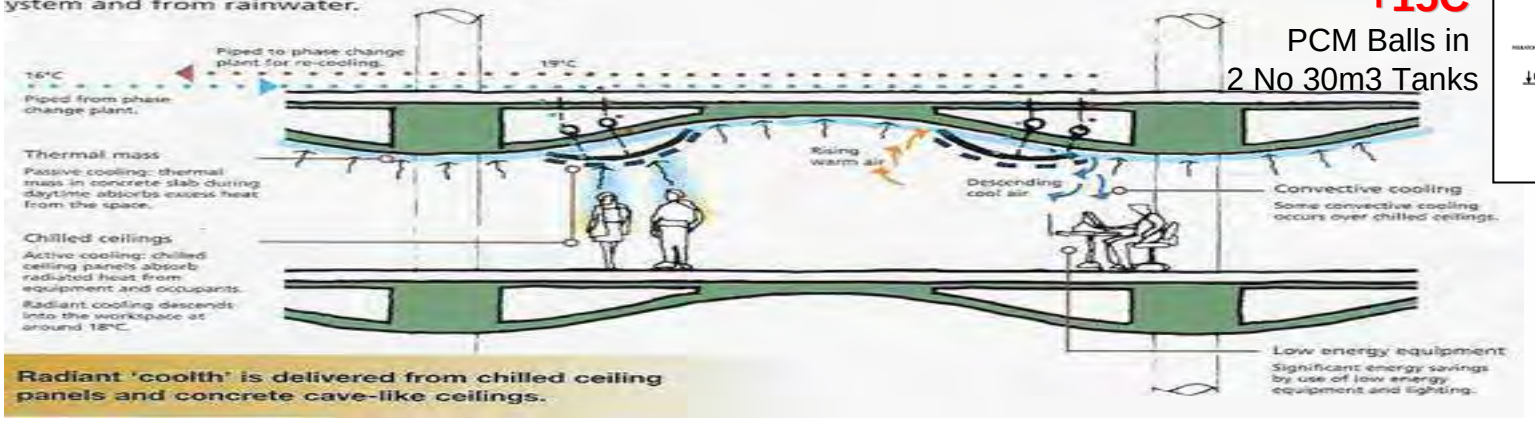
About 100,000 litres of black (toilet) water a day will be extracted from the sewer in Little Collins St. A city sewer usually holds 95 per cent water, a burden on the system and a waste of water. The sewage, along with any generated on site, will be put through a Multi-Water Treatment Plant that will filter out the water and send solids back to the sewer. The extracted water will be treated through a micro-filtration system to create A-grade clean water suitable for all non-drinking uses.

Some of the recovered water will supply CH_2's water cooling, plant watering and toilet flushing needs. The rest will be used in other council buildings, city fountains and plants. More water will be saved through recycling water from the fire-safety sprinkler system and from rainwater.



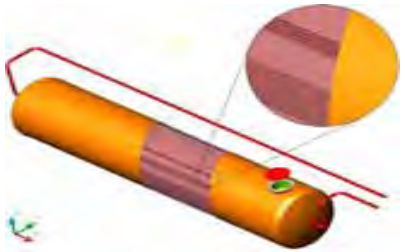
+15C
PCM Balls in
2 No 30m3 Tanks

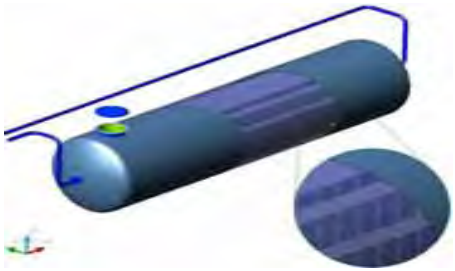




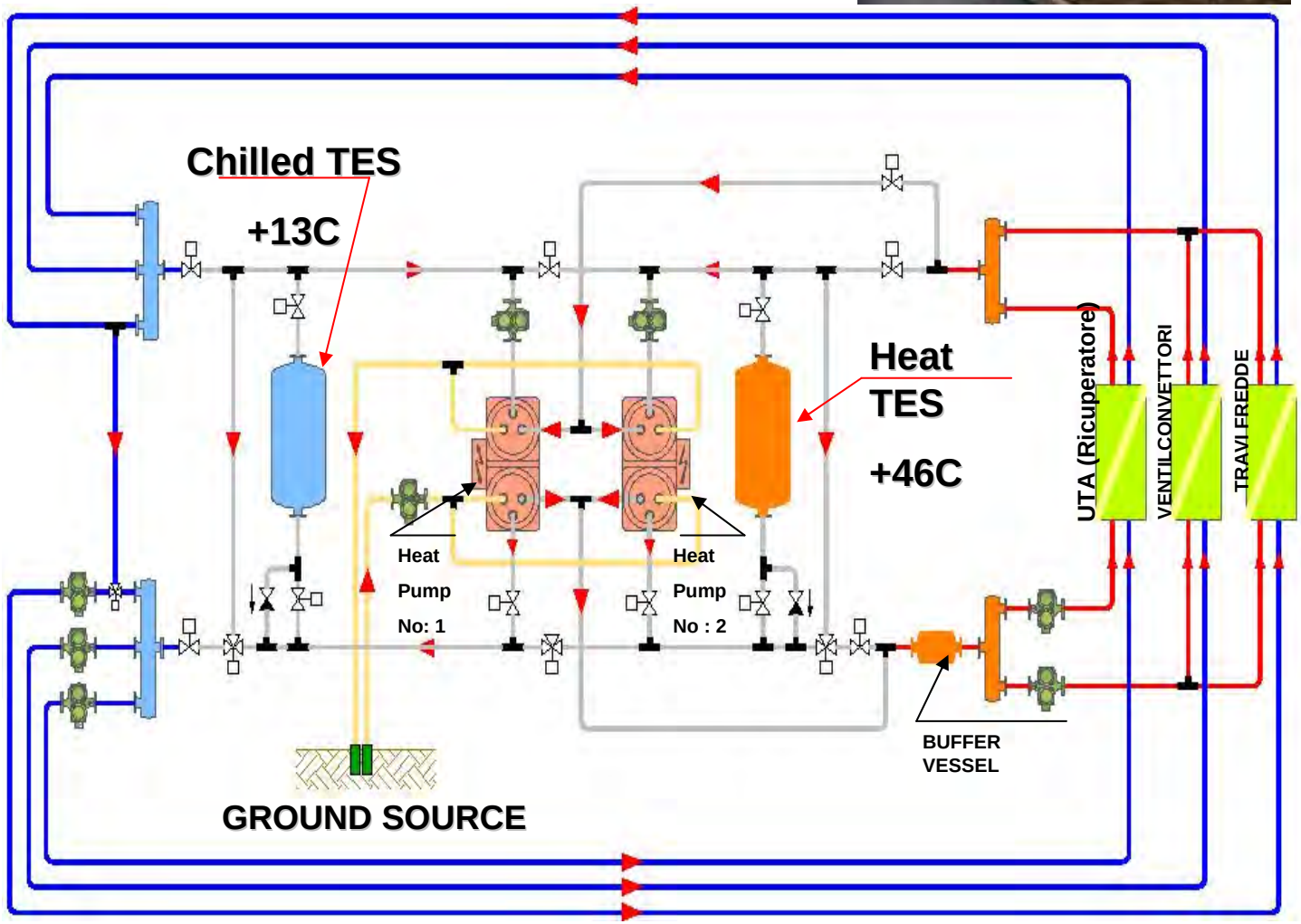
Radiant 'coolth' is delivered from chilled ceiling panels and concrete cave-like ceilings.

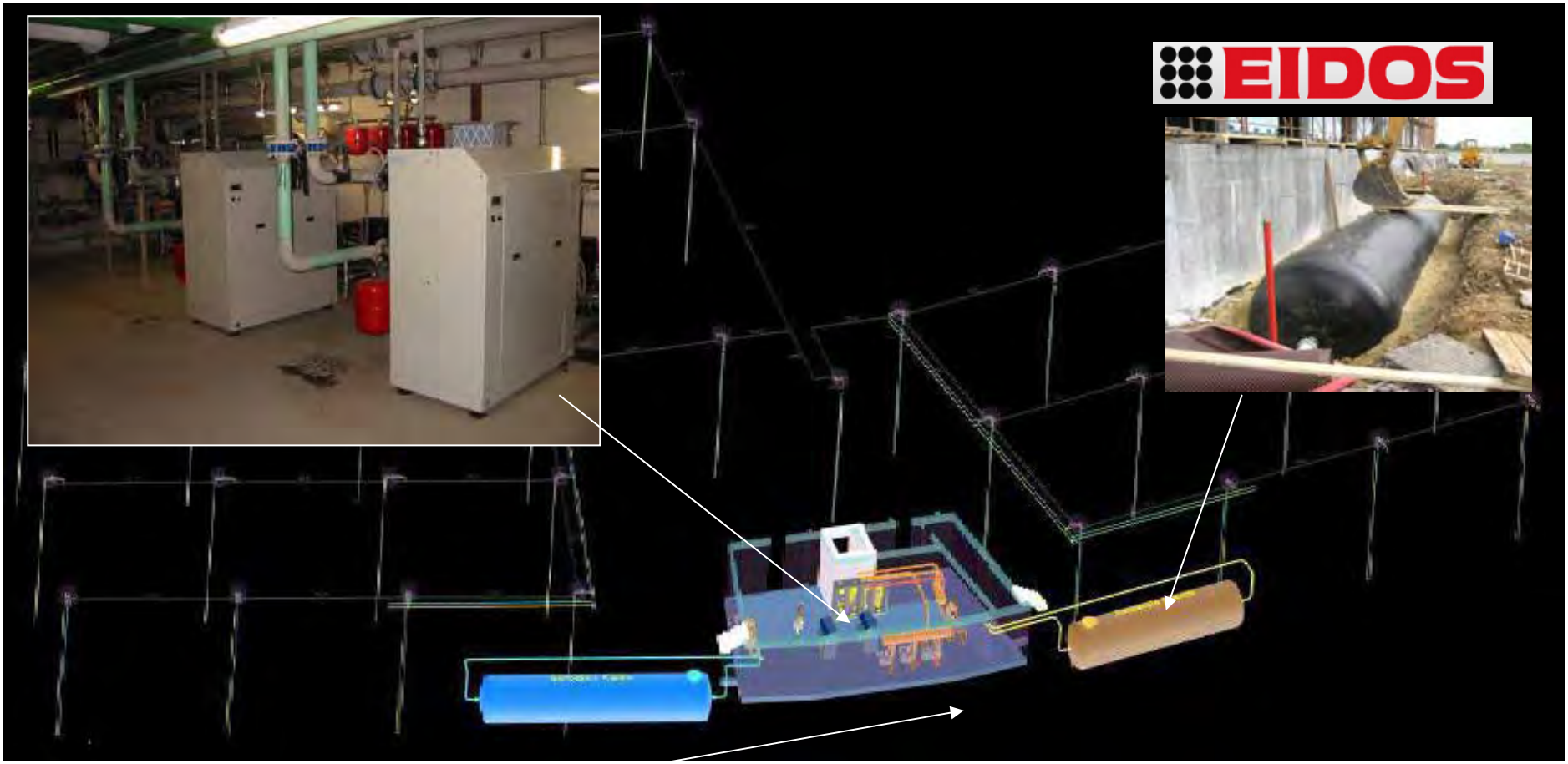
HEAT PUMP TES APPLICATION, Turin, ITALY



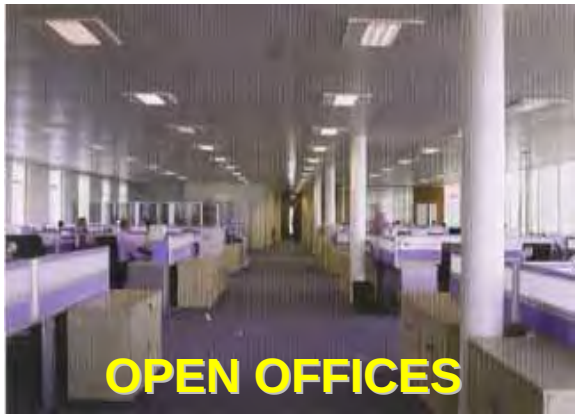


EIDOS

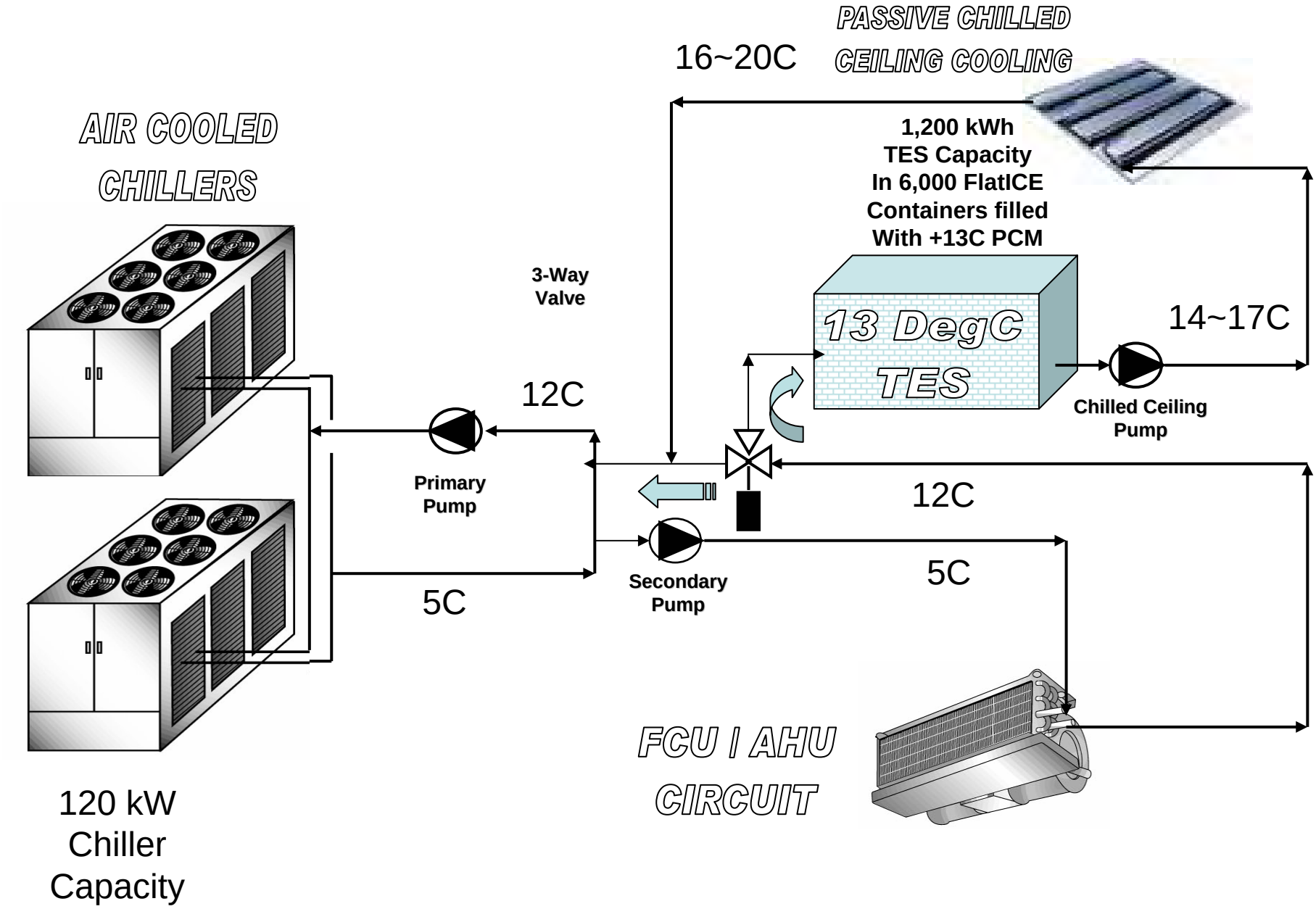



EIDOS

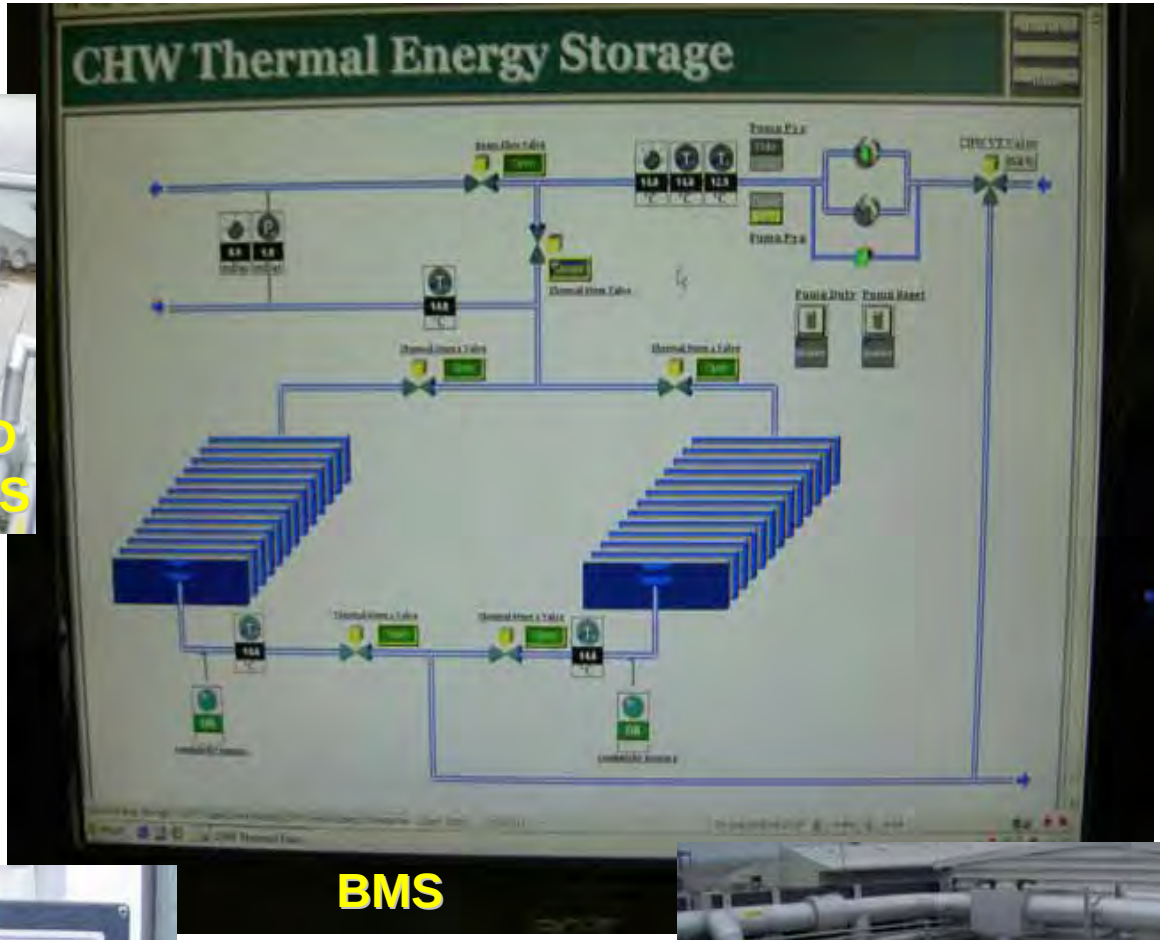
CHINA SHIPPING HQ FELIXSTOWE UK



CHINA SHIPPING BUILDING, Felixstowe, UK

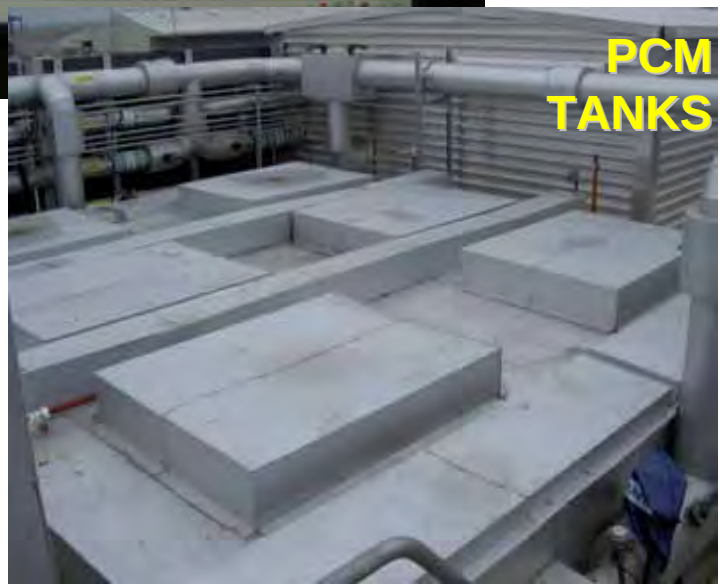


AIR COOLED CHILLERS



BMS

CONDUCTIVITY TRANSDUCERS



PCM TANKS

CHINA SHIPPING BUILDING, Felixstowe, UK

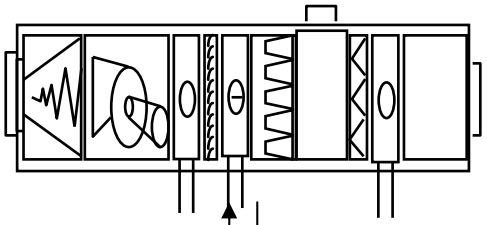
Chilled Ceiling Arrangement

PCM

UK Ground Source Heat Pump FlatICE Application

PCM

FlatICE Containers



Building Load

GROUND SOURCE

Solar System

Chilled Water Circuit

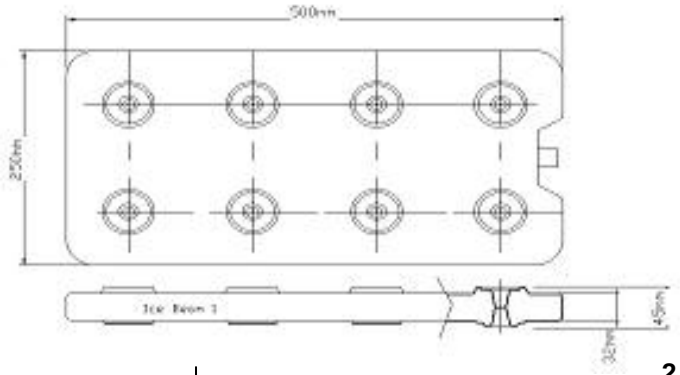
+45C (TES)

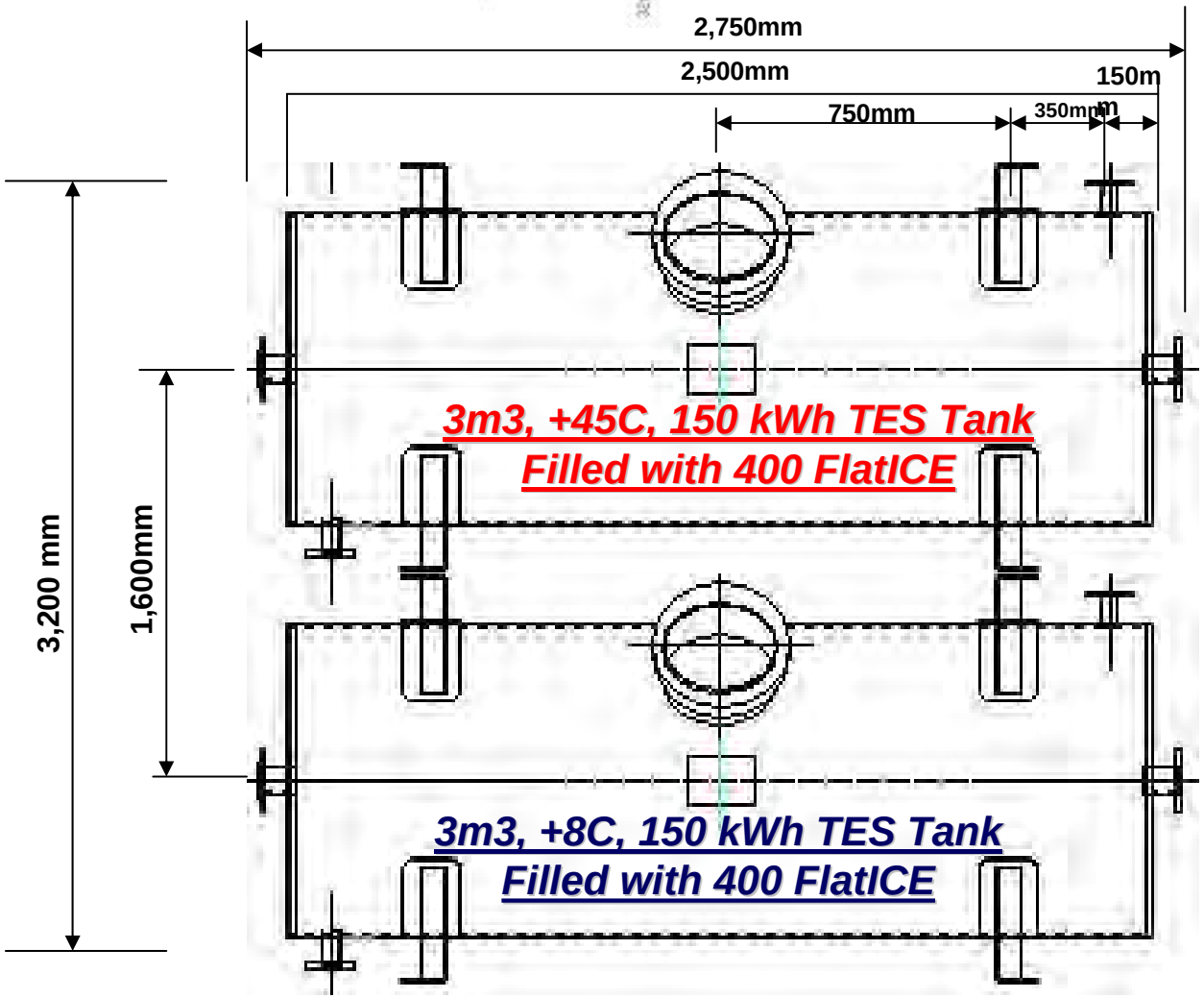
+8C (TES)

Hot Water Tank

FlatICE Containers


PCM

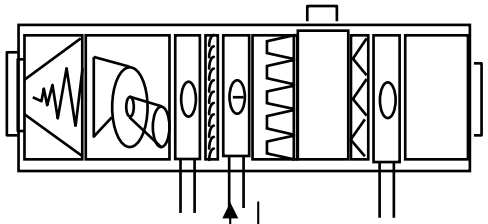

500mm
250mm
45mm
35mm


2,750mm
2,500mm
150mm
750mm
350mm
3,200 mm
1,600mm
3m3, +45C, 150 kWh TES Tank
Filled with 400 FlatICE
3m3, +8C, 150 kWh TES Tank
Filled with 400 FlatICE

Lancashire
County Council

Shuttleworth College
Lancs, UK
Heat Pump
FlatICE Application

Schematic Layout



Building Load

Chilled
Water
Circuit

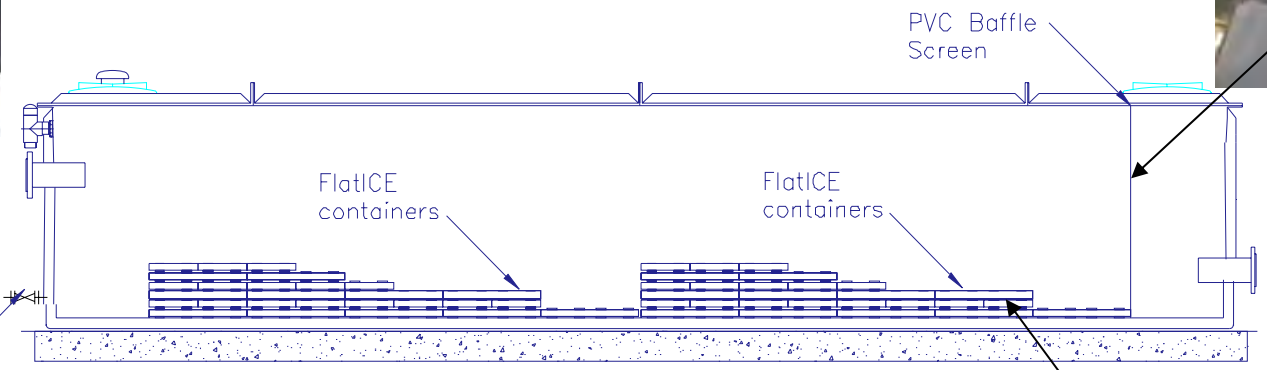
Solar
System

+45C
(TES)

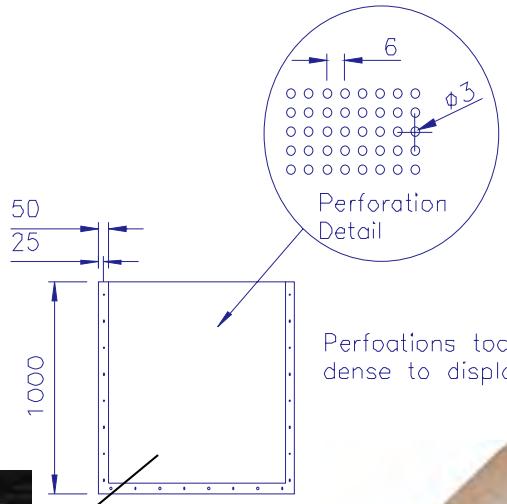
+8C
(TES)

Hot Water
Tank

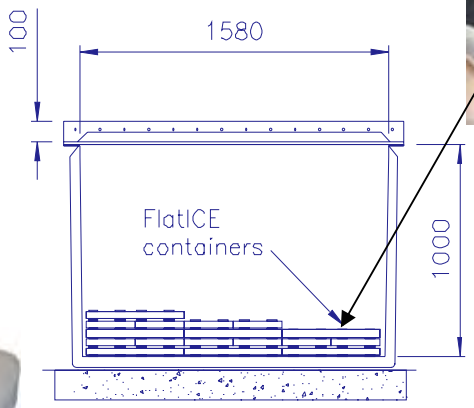
Rectangular Tank Design



SECTION F–F



PVC BAFFLE



SECTION E–E

FlatICE Containers

Lancashire
County Council

Burnley School
Lancs, UK
Heat Pump
BallICE
Application

Schematic Layout

Building Load

Chilled Water Circuit

Solar System

+45C (TES)

+8C (TES)

Hot Water Tank

Heat Pump

BallICE

HEAT STORAGE

6m3, +45C 300 kWh TES Tank filled with 33,000 BallICE

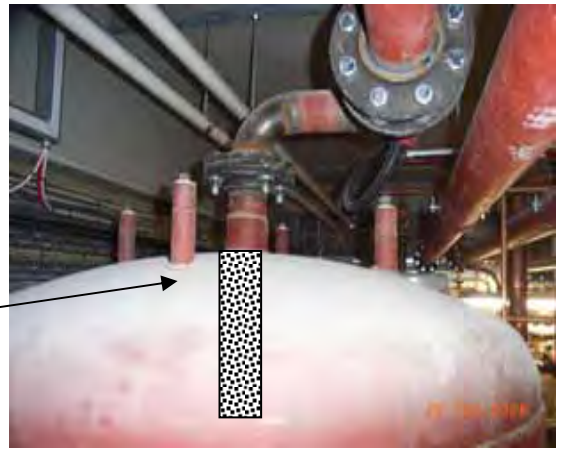
CHILLED WATER STORAGE

6m3, +8C 300 kWh TES Tank filled with 33,000 BallICE

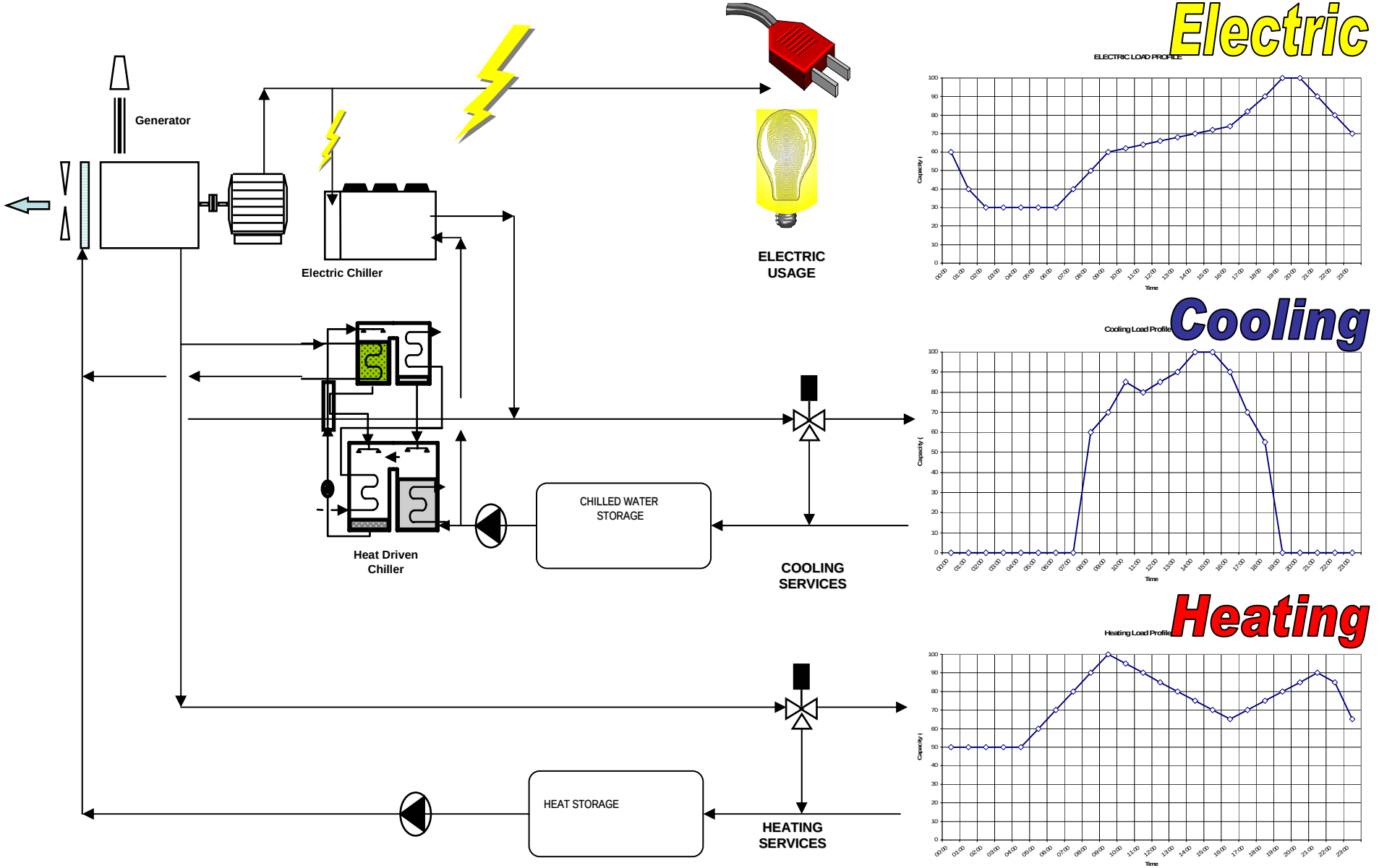
Outlet

BallICE Storage Tank

Inlet



COGENERATION THERMAL ENERGY STORAGE



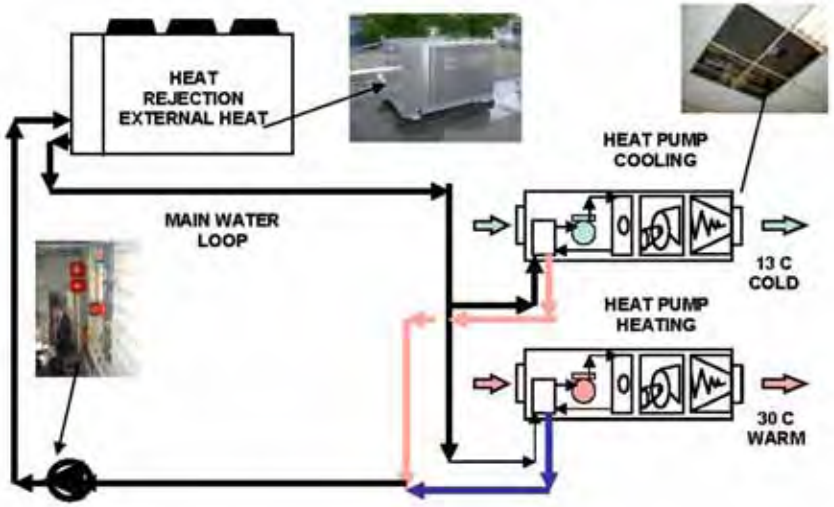
COLT-CALORIS - WATER SOURCE HEAT PUMP SYSTEM

Complete System:

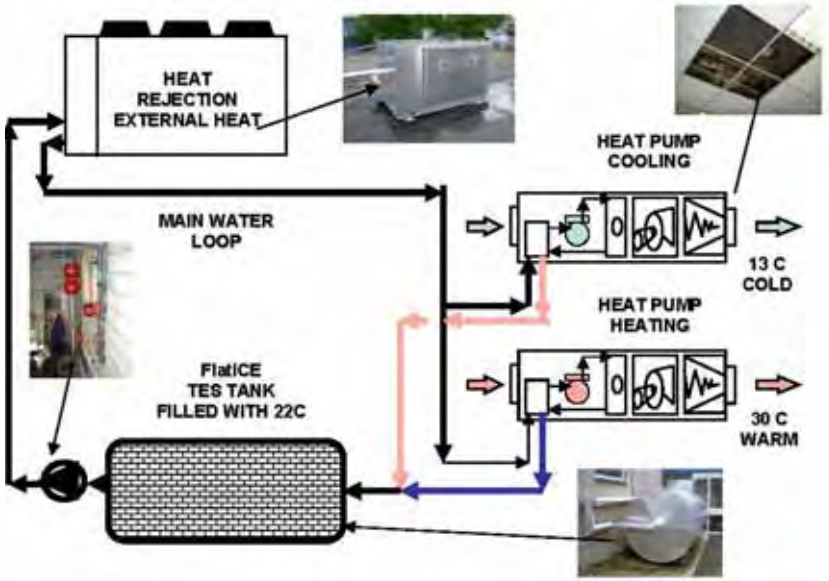
The system shall be capable of providing the relevant duties scheduled whilst operating with a water loop temperature between 15°C to 30°C with an optimum efficiency being achieved between 20°C to 25°C. The water loop temperature shall be maintained via a centrally positioned reverse-cycle water source heat pump.

The water loop energy transfer system shall use no insulation for the plastic pipe supplied and installed by the services contractor.

A standard Caloris Water Source Heat Pump system is illustrated in the following schematic drawing



In order to overcome the unnecessary running ,hence, waste of energy of the external heat pump a buffer vessel using FlatICE containers are incorporated to optimise the use of the excess energy from individual indoor unit in the following fashion;



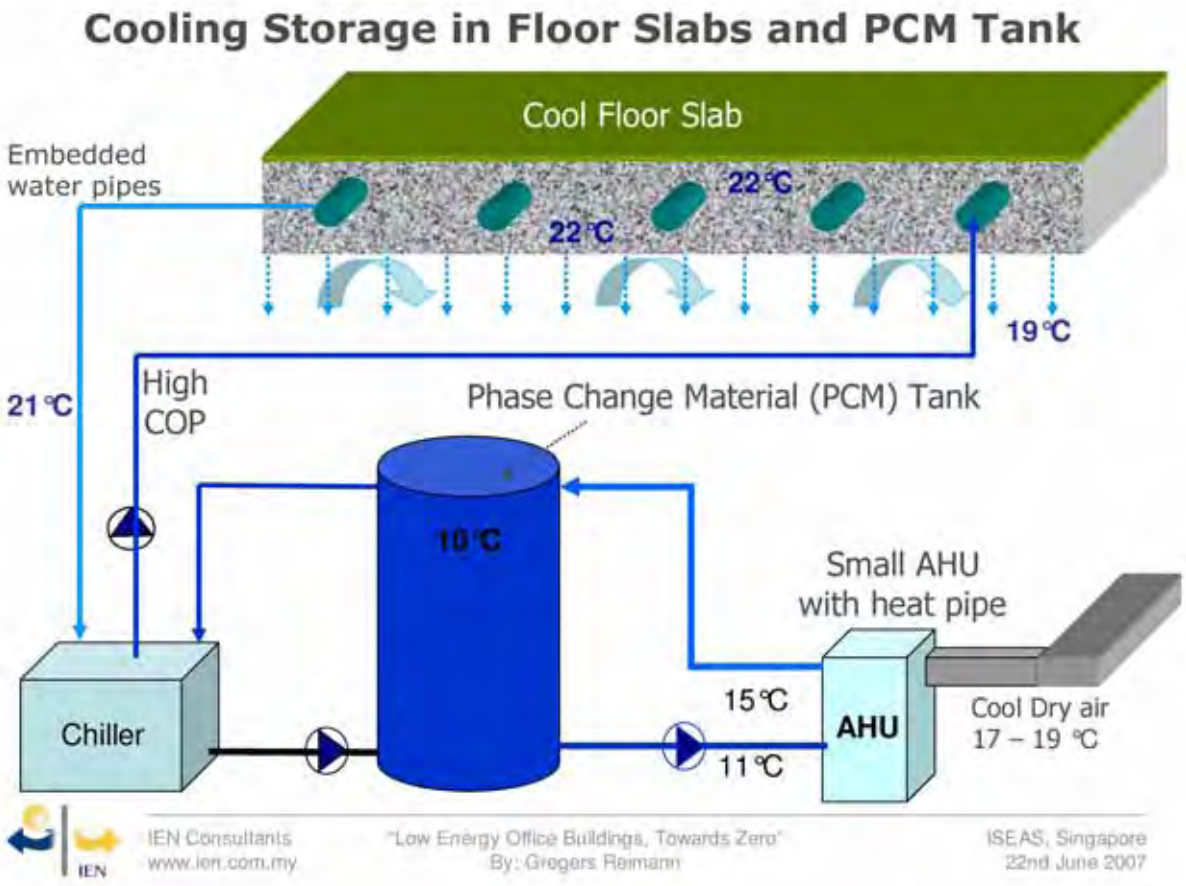
.ocal Heat Pump Unit:

'he local Colt-Caloris unit shall be completely self contained. Each unit shall comprise a thermal and coustic lined galvanised steel chassis up to 2mm thick, enclosing the following items. Double inlet entrifugal type recirculating air fan / fans, directly coupled to a 3 speed electric motor of the permanent plit capacitor type with sealed for life bearings and thermal overload protection built in as standard.

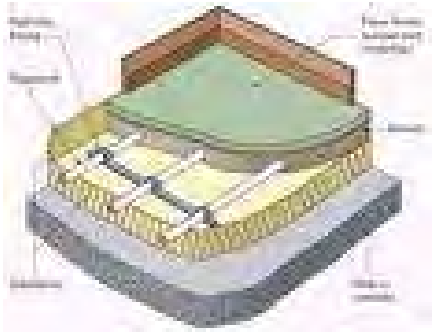
ir to refrigerant heat exchanger (air coil) constructed from 32-row (8 x 4) grooved copper tubes with nechanically bonded aluminium fins and expansion through capillary. Water to refrigerant heat xchanger (water coil) constructed from copper with special finned and grooved spiral shell-in-tube to efrigerant heat exchanger. Horizontal rotary type refrigerant compressor supported on anti-vibration nountings designed to minimise vibration.

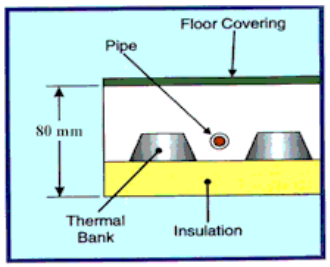
COLT HEAD OFFICE (HOLLAND)
FlatICE TES - WATER SOURCE HEAT PUMP SYSTEM

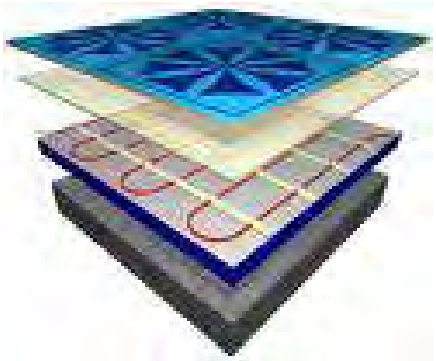
Zero Energy Office (ZEO) Building Pusat Tenaga Malaysia

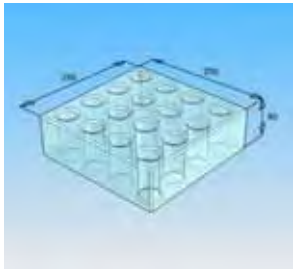


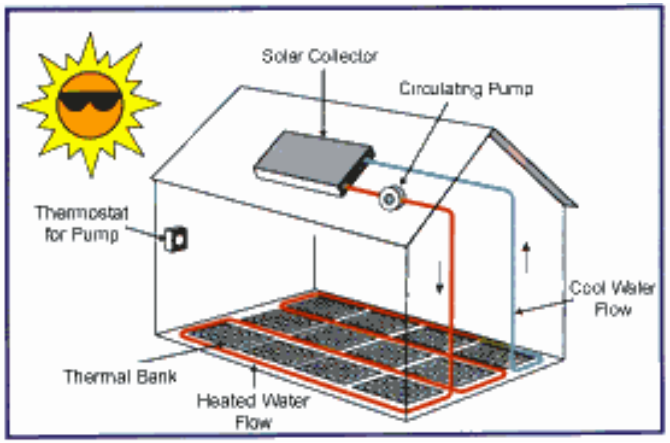
UNDERFLOOR / FABRIC TES CONCEPT

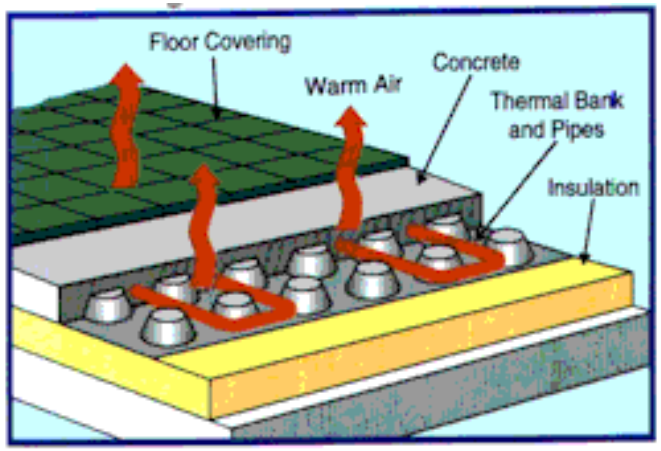




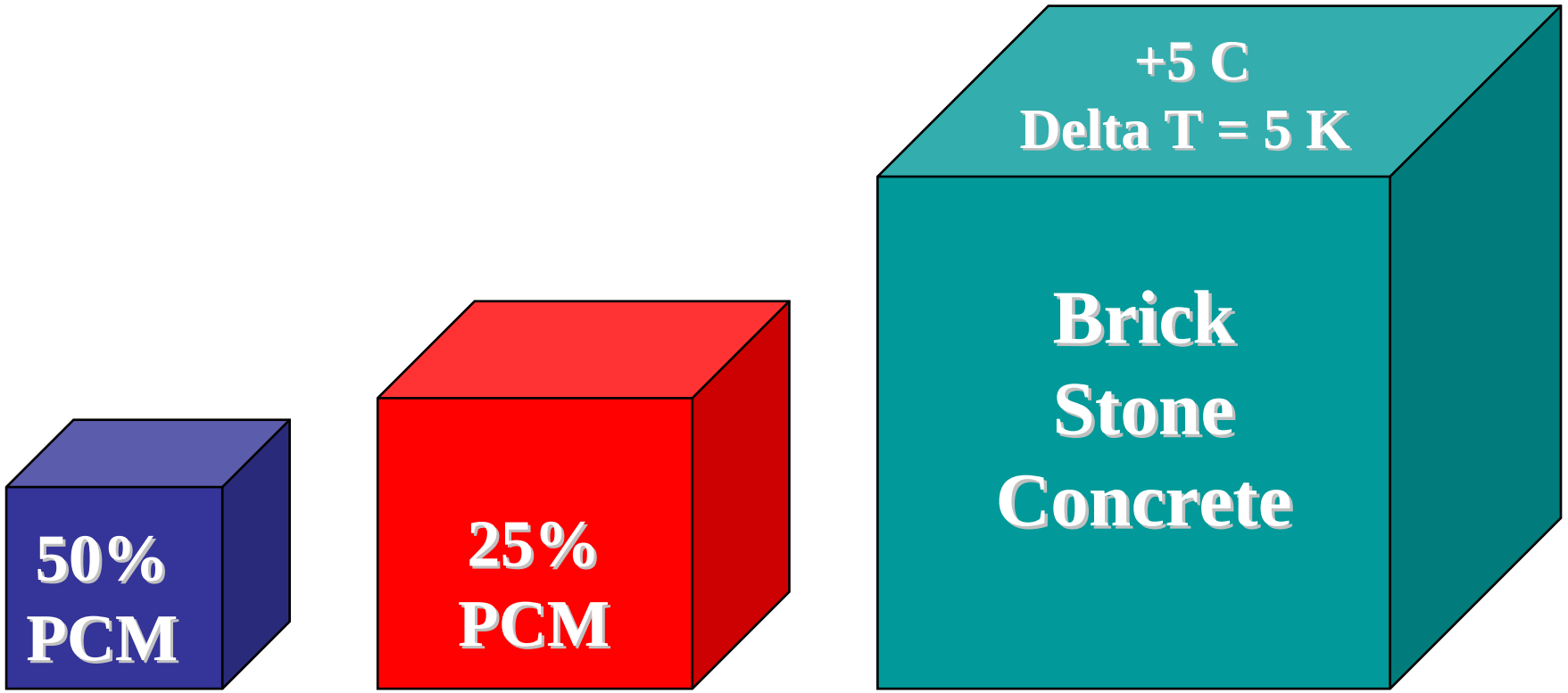








WHY PCM FABRIC ENERGY STORAGE?



50% PCM	25% PCM	Brick Stone Concrete
200 kJ/kg	200 kJ/kg	0.8 kJ/kgK * 5 K (4.0 kJ/kg)
1,280 kg/m3	1,170 kg/m3	1,060 kg/m3
128.5 MJ/m3	59.2 MJ/m3	4.24 MJ/m3
1/30	1/14	1

CONCLUSION

1) Utilise any WASTE & FREE energy.

***2) Search* for optimum combination.**

3) Diversify energy consumption.

4) Consider alternative / emerging technologies.

5) First Cost Vs Life Cycle Cost.

6) Use appropriate technology for application.