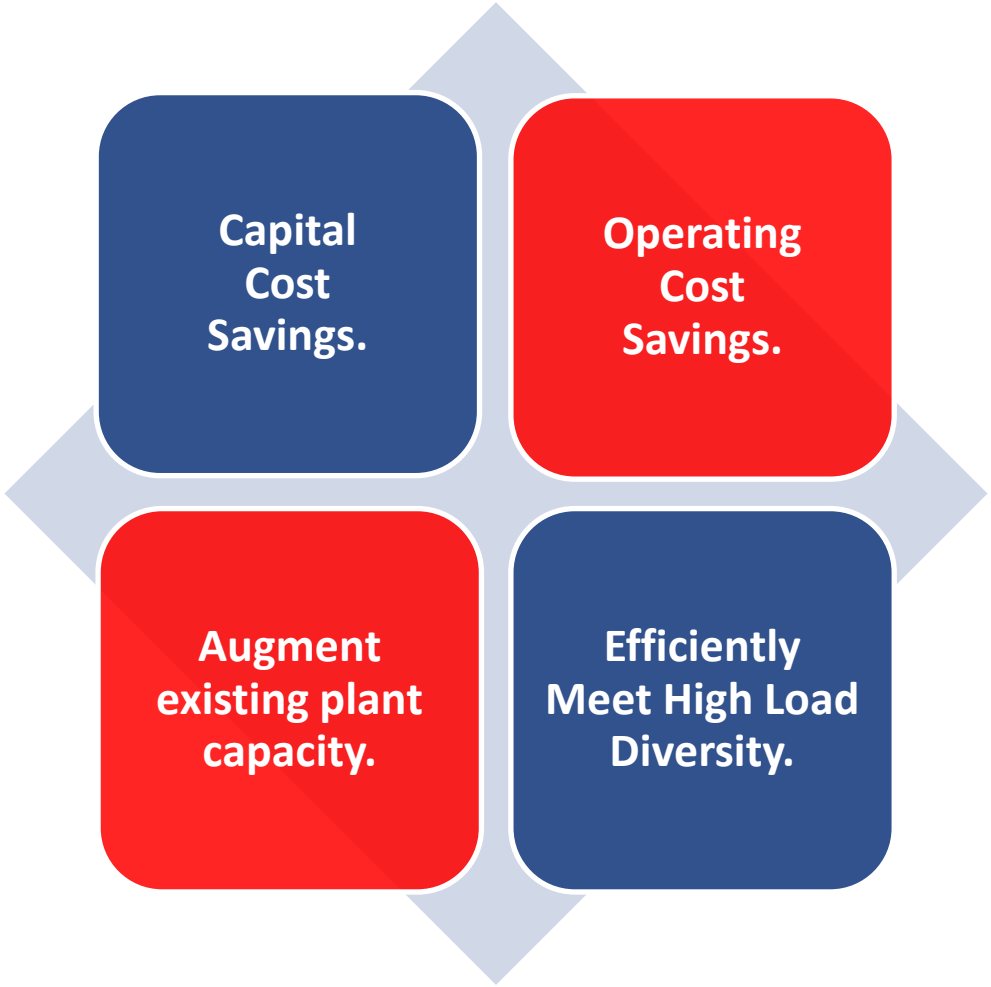
PLUSS®

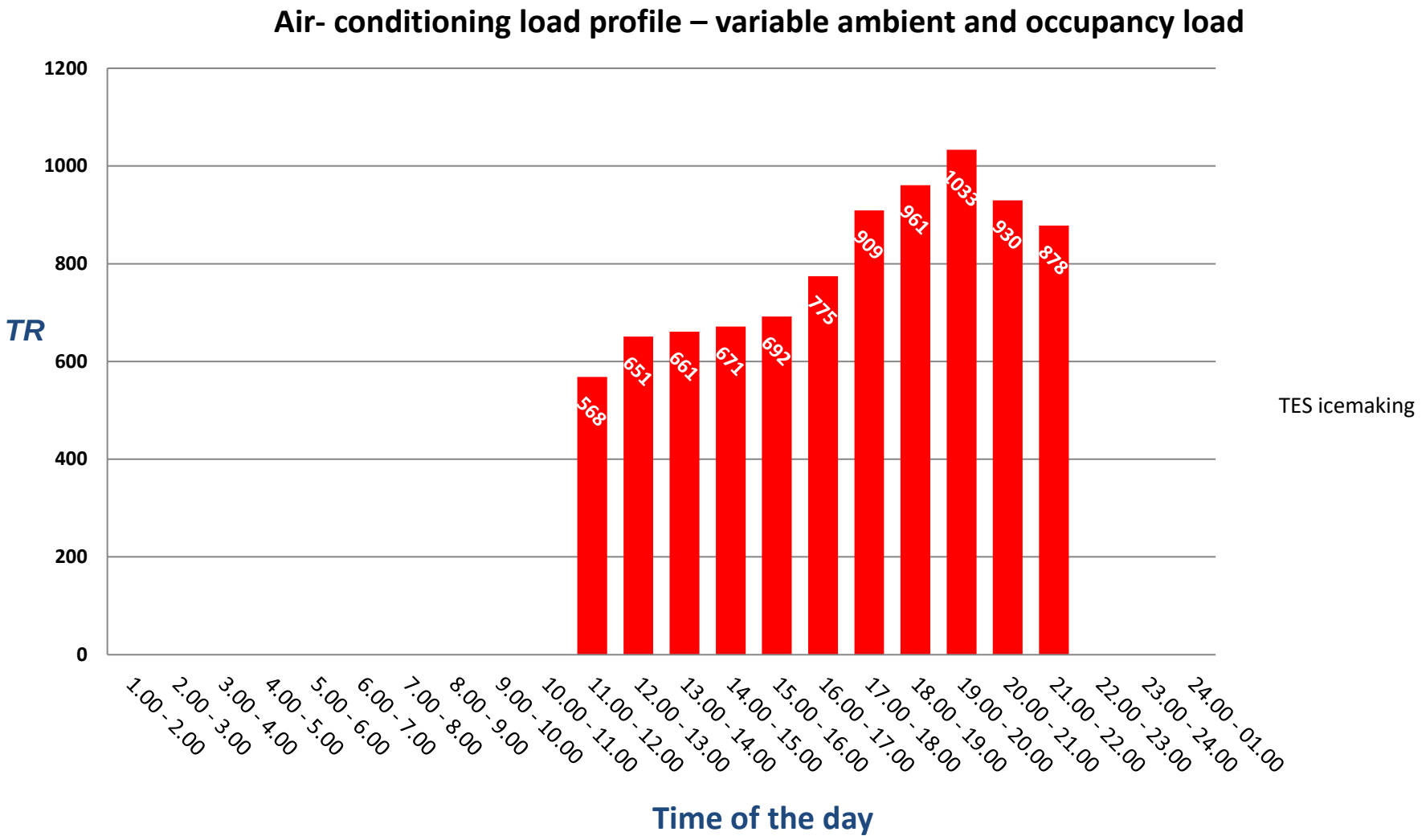
TECHNOLOGY FOR
A BETTER WORLD

Thermal Energy Storage System for Building and HVAC

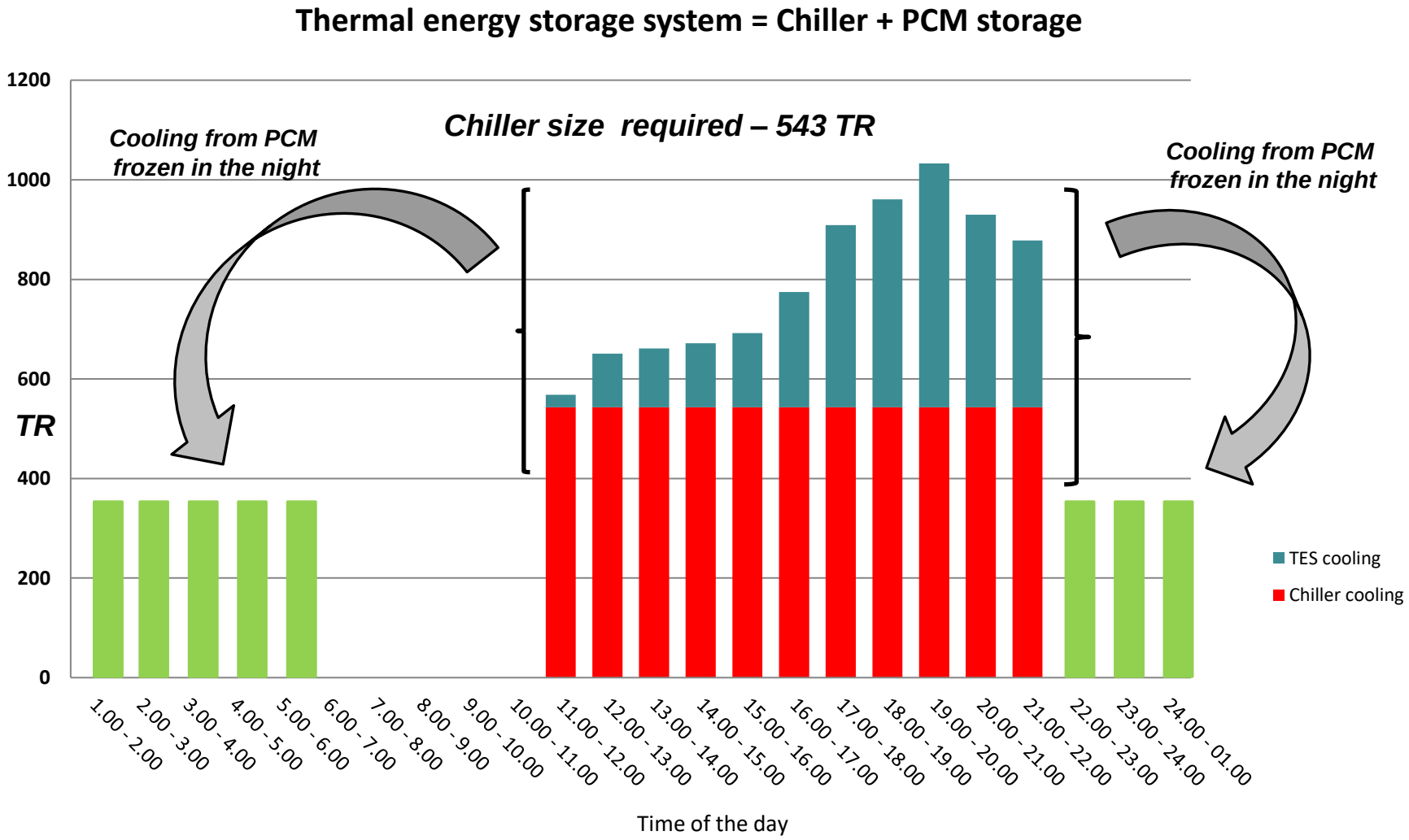
BENEFITS OF THERMAL STORAGE SYSTEM



BUILDING LOAD PROFILE (12 HR OPERATION)



LOAD PROFILE W. THERMAL STORAGE

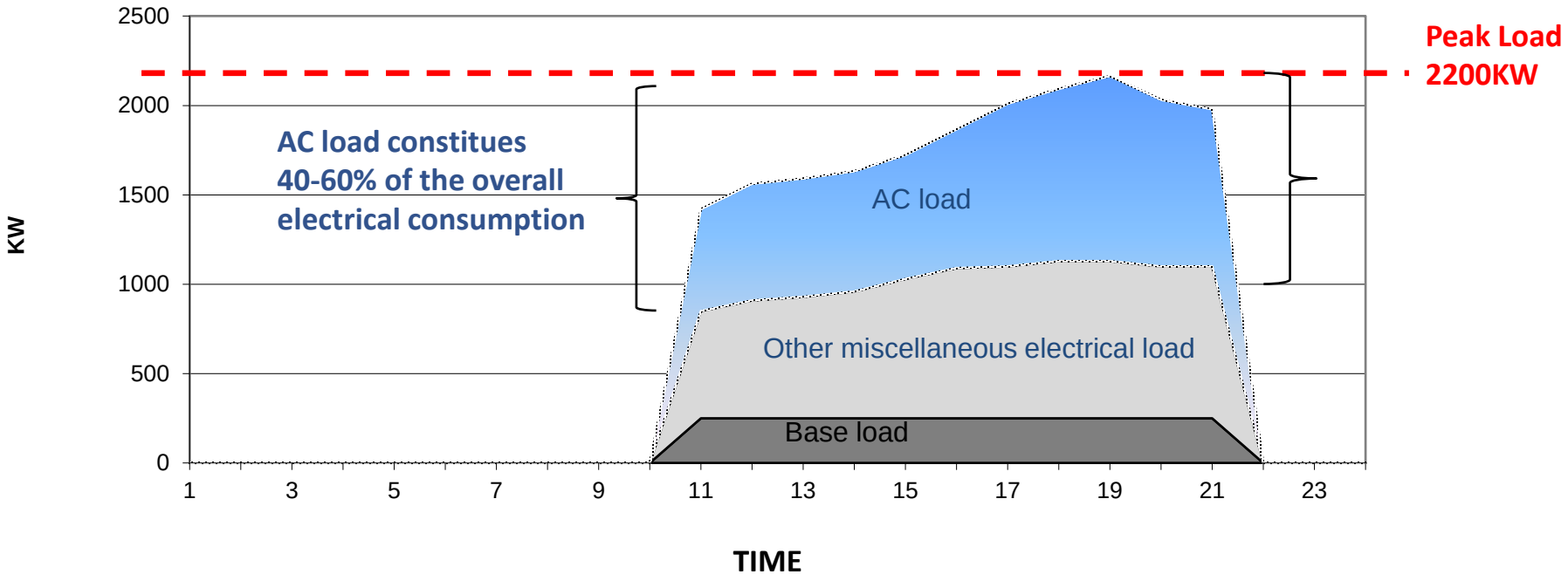


COMPARISON – HVAC ELECTRICAL LOAD

	Conventional system(kVA)	System with Thermal storage(kVA)
Chillers	963	489
Primary pumps	56	69
secondary pumps	111	109
condenser pumps	123	61
cooling tower	41	20
Total power (kVA)	**1294**	**748**

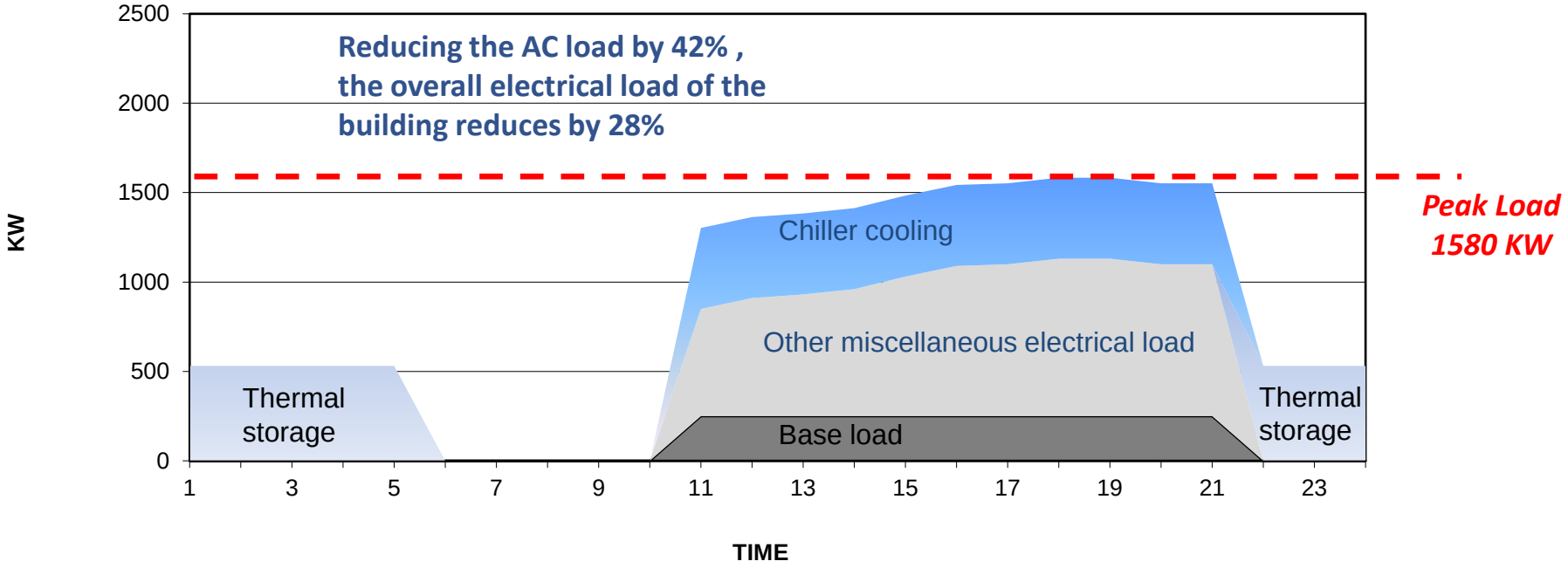
- **Reduction in the HVAC electrical load for system with thermal storage is 42%**
- **42% lesser electrical demand for HVAC**
- **42% lesser DG backup for HVAC**
- **lesser chiller, condenser pumps, cooling tower for HVAC**

ELECTRICAL LOAD PROFILE – CONVENTIONAL HVAC SYSTEM



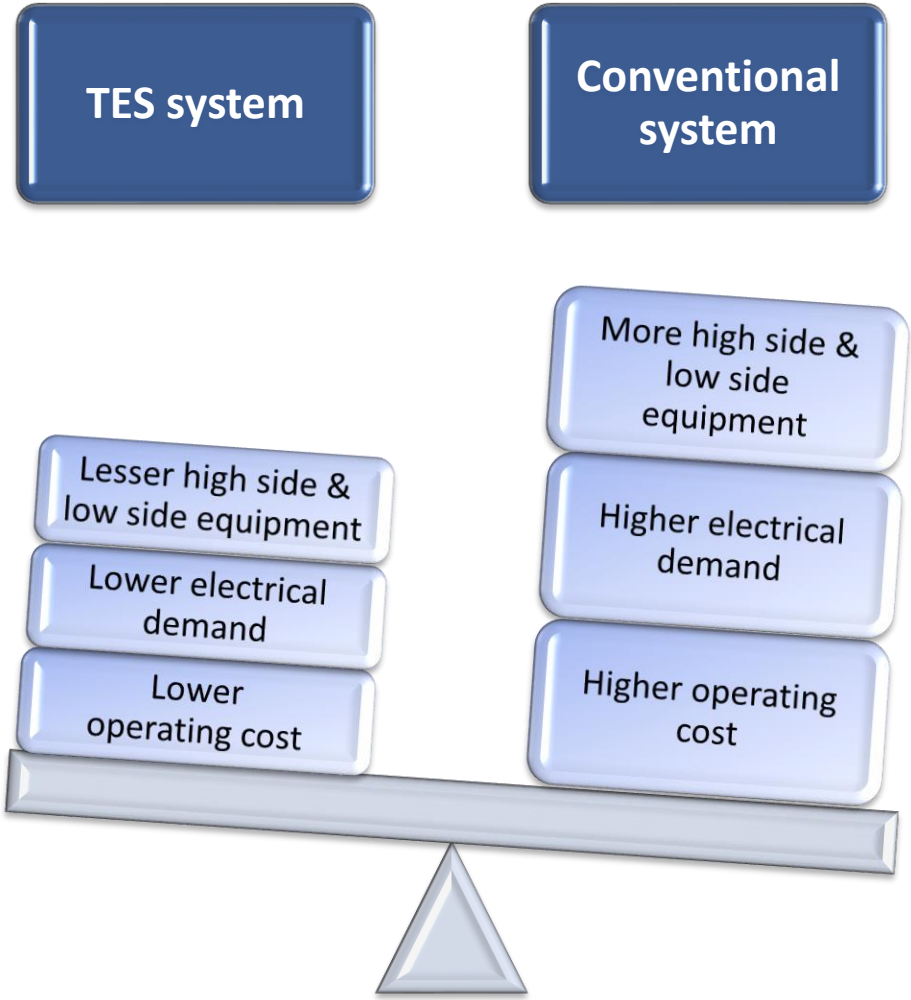
- Max. Electrical demand or mall =2200 KW / 0.8 = 2750kVA
- Transformer size for mall = 2200kW / (0.8 X 0.9) = 3055 kVA

ELECTRICAL LOAD PROFILE – HVAC SYSTEM WITH THERMAL STORAGE

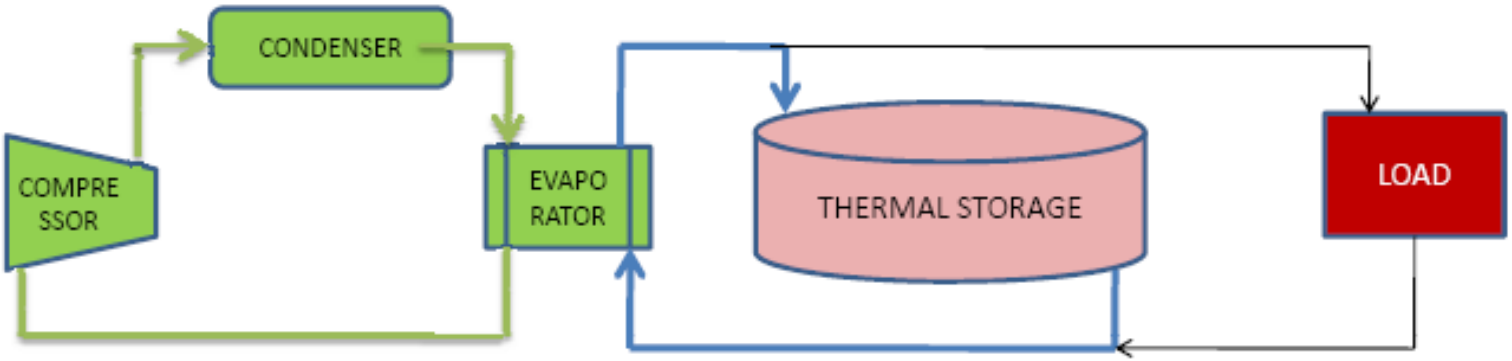


- Max Electrical demand for the mall = 1580KW / 0.8 = 1975 kVA
- Transformer size = 1580 / (0.8 x 0.9) = 2195 kVA
- 28% reduction in the overall electrical demand and transformer size

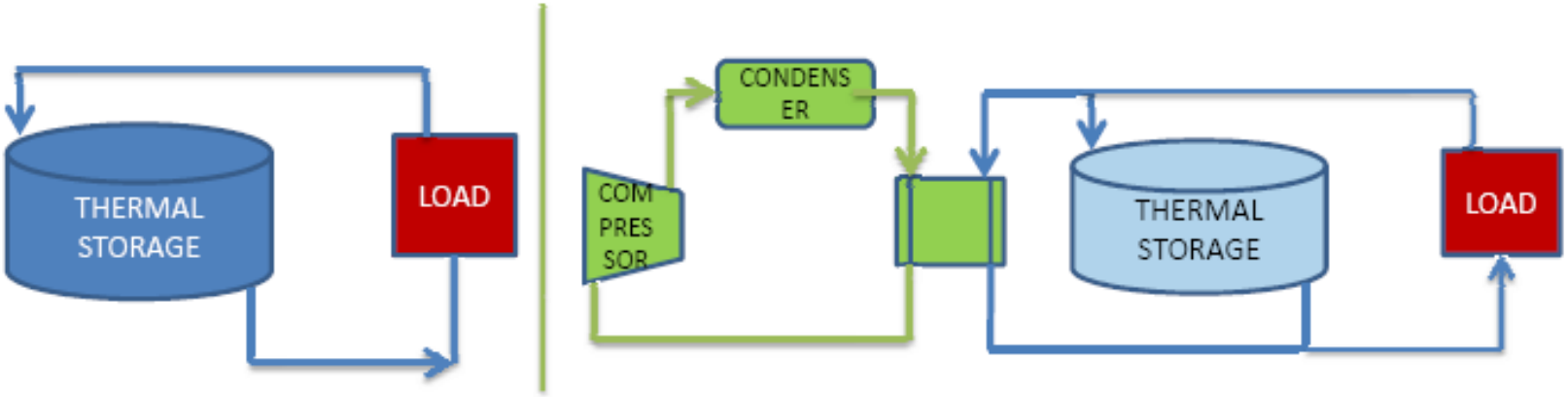
LIFE CYCLE COST



SIMPLIFIED THERMAL STORAGE CONCEPT

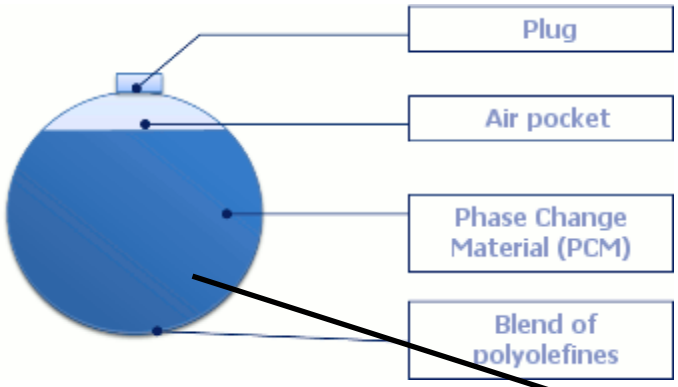


CHARGING IN OFF PEAK HOURS

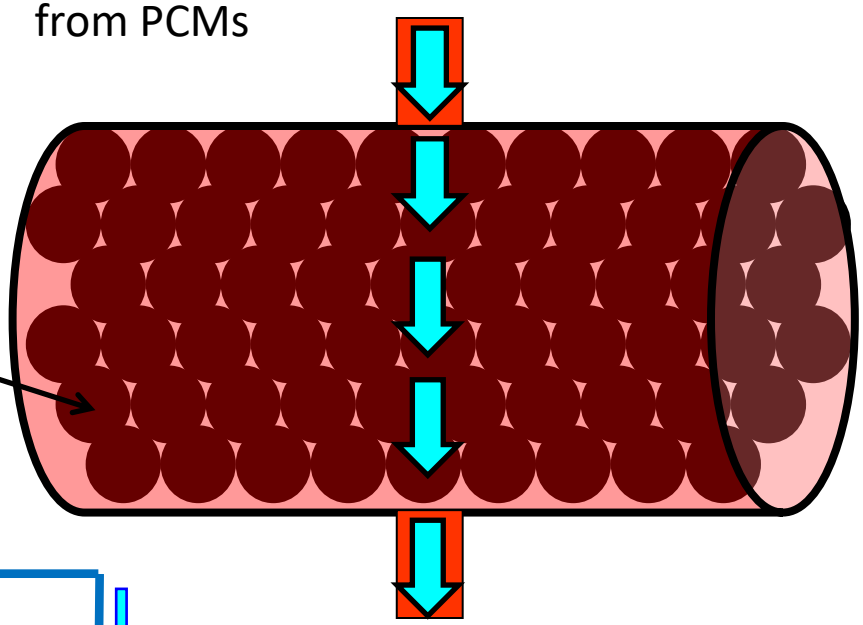


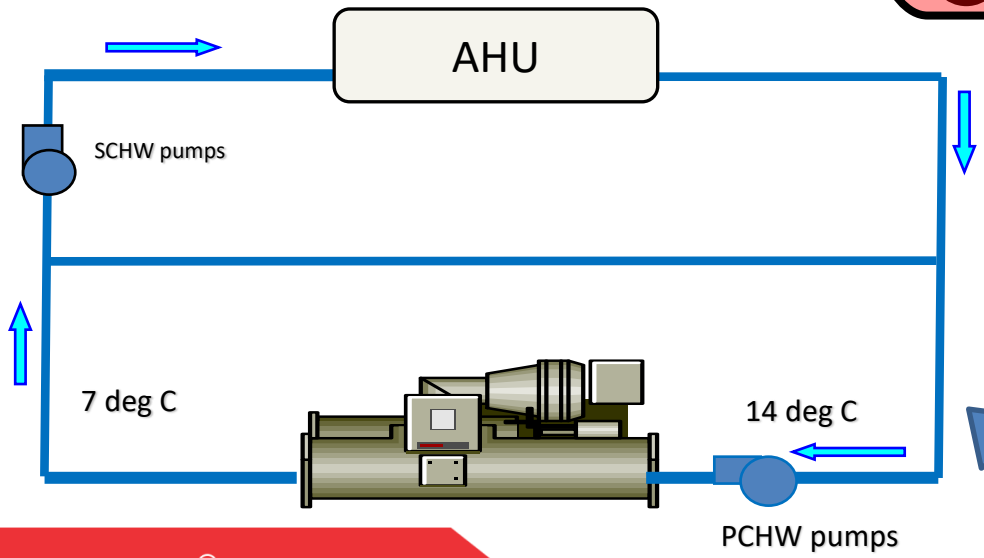
DISCHARGING DURING PEAK TARIFF / LOADS

SIMPLIFIED THERMAL STORAGE CONCEPT



Chilled water circulates through the thermal energy storage(TES) tank absorbing energy from PCMs

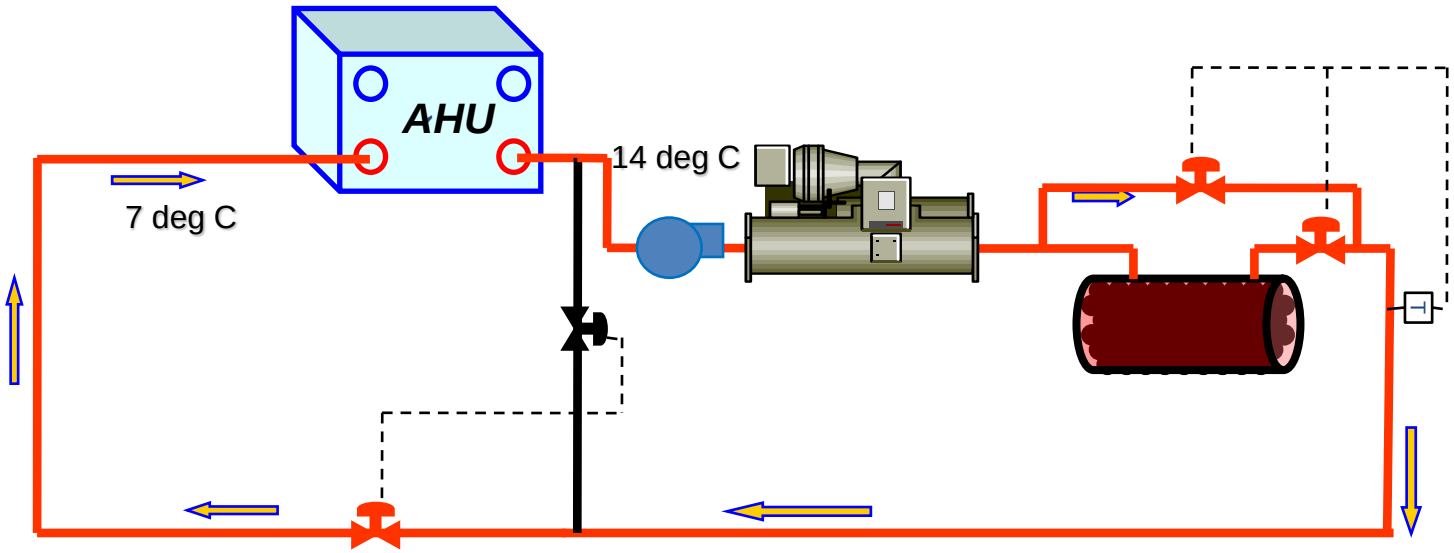




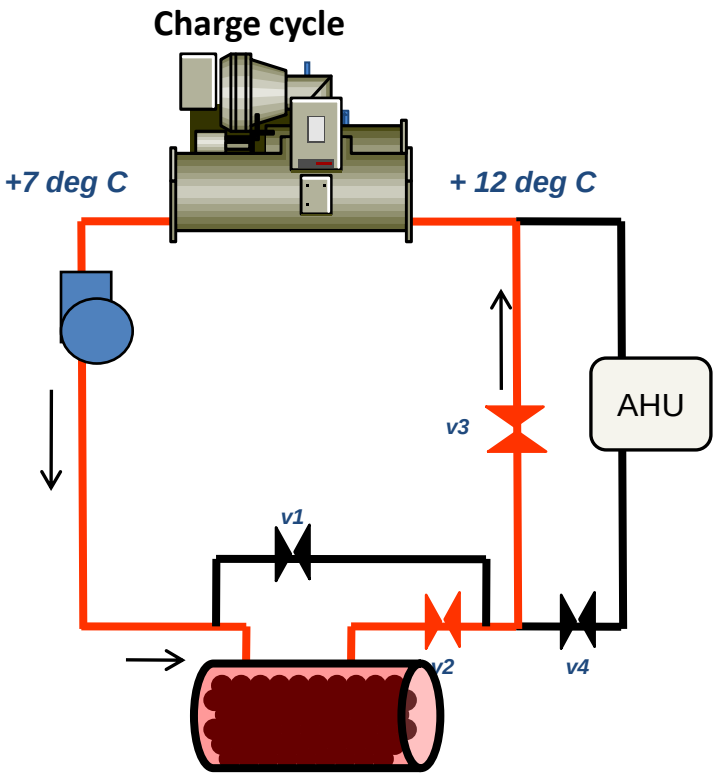
TES tank is integrated in the existing chilled water pipeline

SIMPLIFIED THERMAL STORAGE CONCEPT

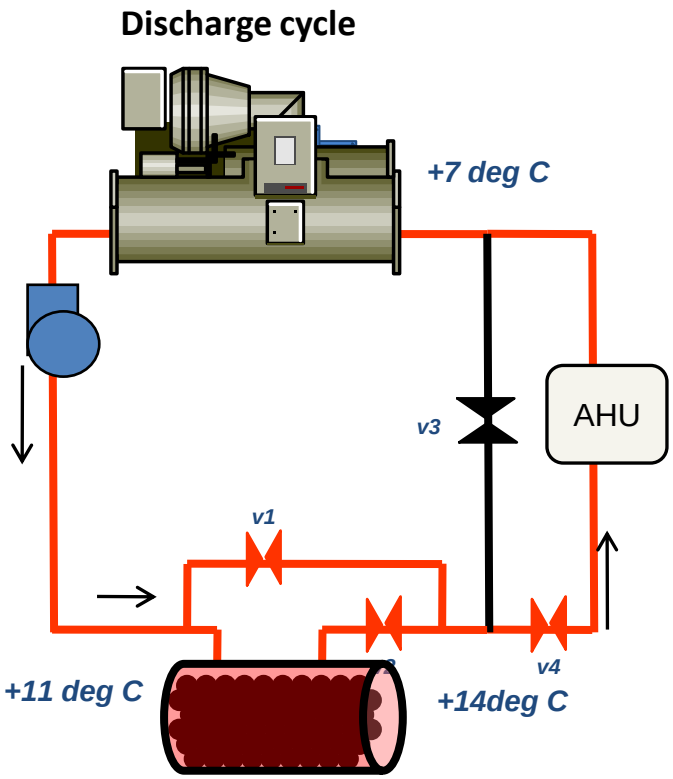
Chilled water system Integrated with TES



SIMPLIFIED THERMAL STORAGE CONCEPT



Valve v1 - off
Valve v2 - on
Valve v3 - on
Valve v4 - off



Valve v1 - modulating
Valve v2 - modulating
Valve v3 - modulating
Valve v4 - modulating

ACTUAL IMPLEMENTATION – CASE STUDY

Miesen Plaza, Dublin

- PCM used - +11 deg C
- Stores latent energy which is used to pre-cool the return chilled water temperature.
- Utilizes off-peak tariff to run the chillers at night – 50% lower than day time tariff.
- The +11 deg C latent storage consumes 30% less energy than ice storage
- This building did get **Special low energy award LEED platinum V4 – one of only 178 buildings in the world.**

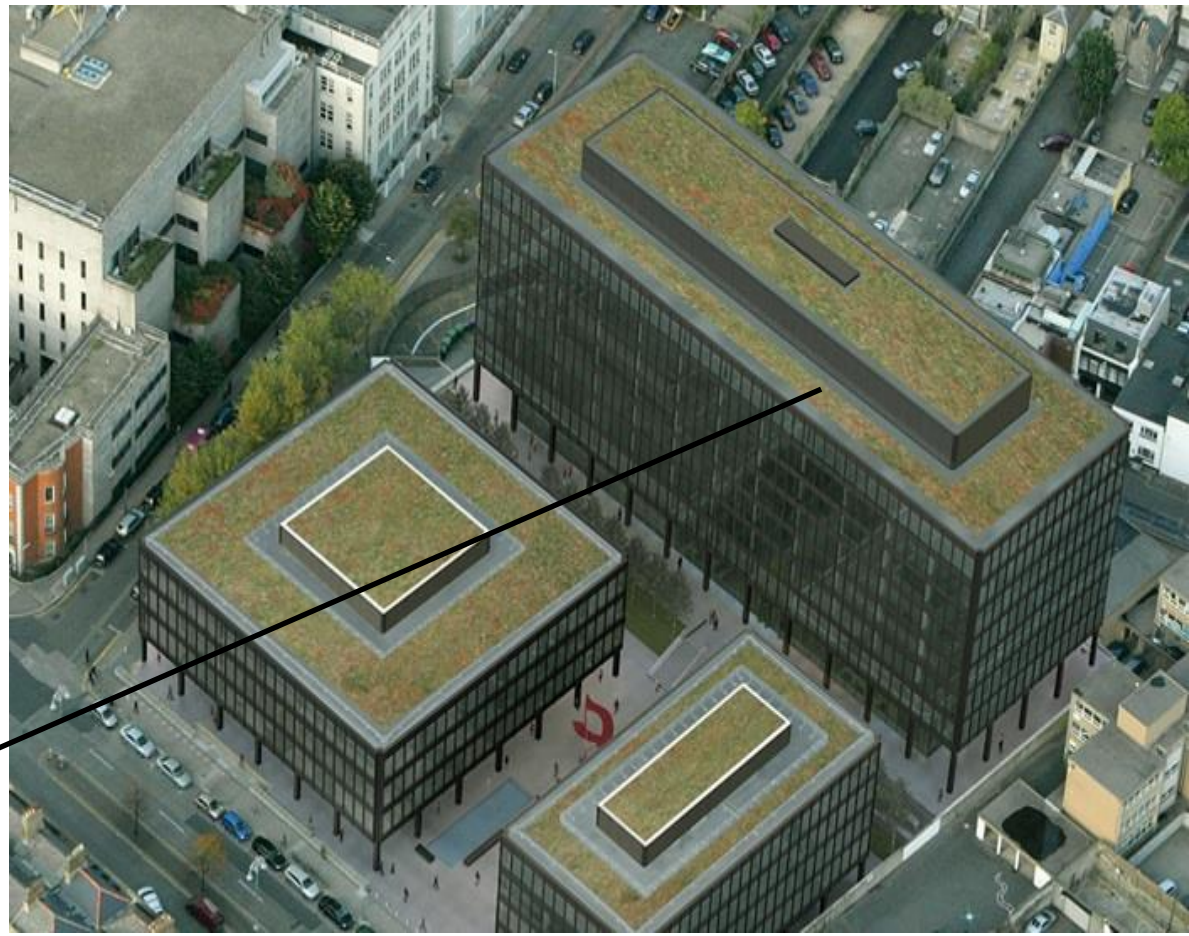
Overview of the air-conditioning design plan

- The buildings are designed for a waterside-controlled four pipe fan coil system for cooling. The high-efficiency water **cooled chillers and thermal storage** at basement level will generate chilled water (CHW) in Block 1.

- Blocks 2 and 3 will have independent air-cooled chiller system

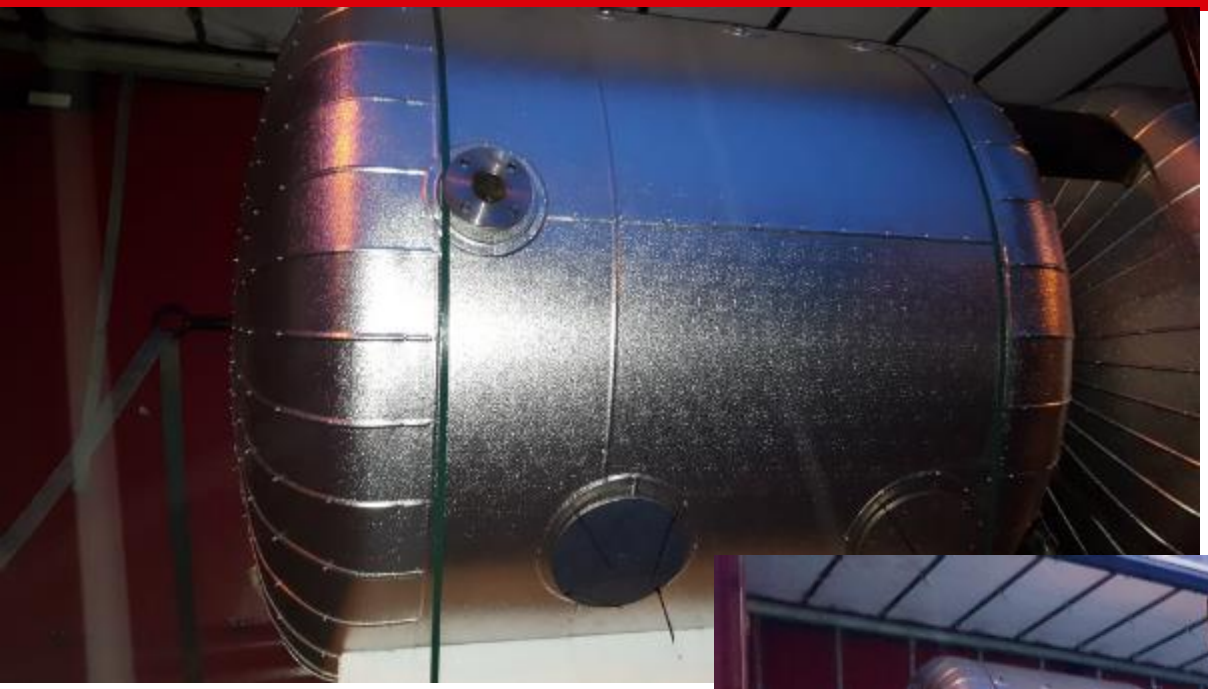
- Block1 total Floor area 18,557 sq.ft

- The building consists of G +7 floors with area totaling to 1,43,086 sq.ft



Block1 – Installed with TES system

Overview of the air-conditioning design plan



- PUF insulated TES tanks
- Modular in design
- Customized as per project requirement

Cold Storage Warehouse - Thermal mass to reduce energy consumption

- Reduces energy consumption during the peak load hours as the TES system provides the cooling energy for extra load during the day.
- PCM placed on top of racks is in direct contact of the cool air.
- The TES solution can be implemented for any warehouse of various temperature ranges.
- Electricity Consumption reduced by 20% + Reduced Carbon Footprint in the environment.

Buildings HVAC – Adding Thermal Mass to reduce heat losses

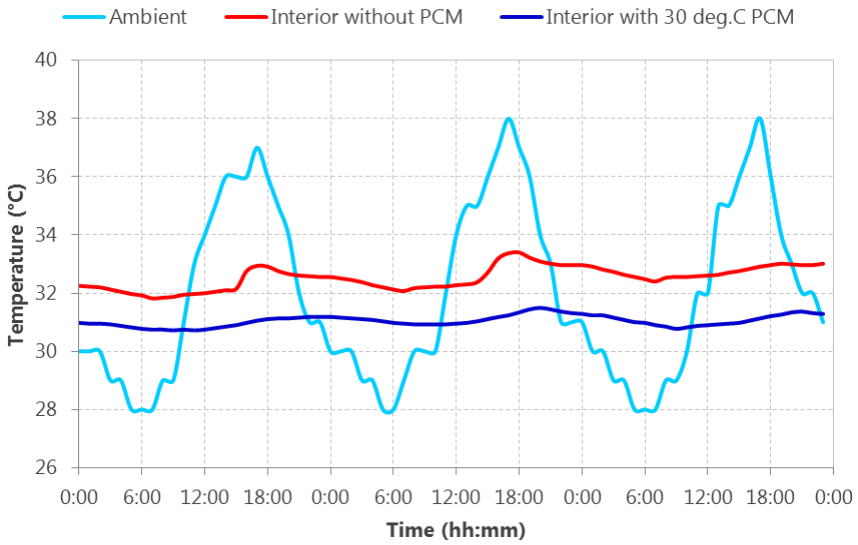
- Thermal energy storage can be recharged using **freecooling** at night.
- During the day the absorbed energy reduces load on the active system.

Buildings HVAC – Adding Thermal Mass to reduce heat losses

BUILDING : CEPT, Ahmedabad, India

Important Features

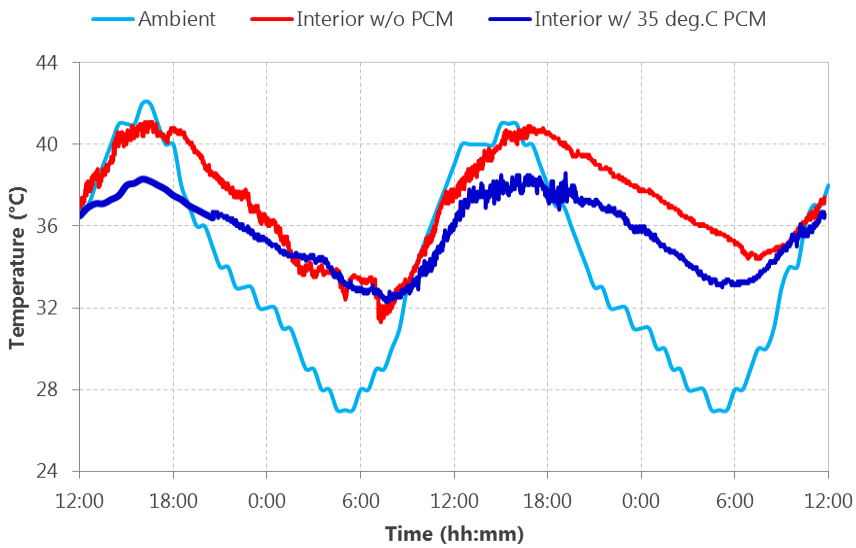
- PCM in the ceiling of a building.
- 0.5 cm thick tile in 3m x 3m ceiling
- PCM Used savE® FS 30
- Peak temperature during the afternoon reduced from 33°C to 31°C



BUILDING : DTDC Courier Service, Gurgaon, India

Important Features

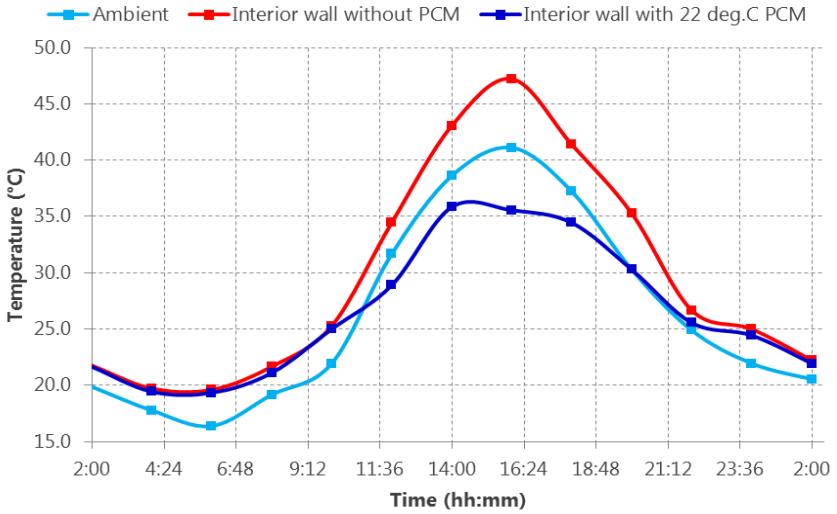
- PCM in the ceiling of a building.
- 0.5 cm thick tile in a 4m x 3m ceiling
- PCM Used savE® FS 35
- Peak temperature during the afternoon reduced from 41°C to 37°C



BUILDING: Greenhouse, North Carolina, USA

Important Features

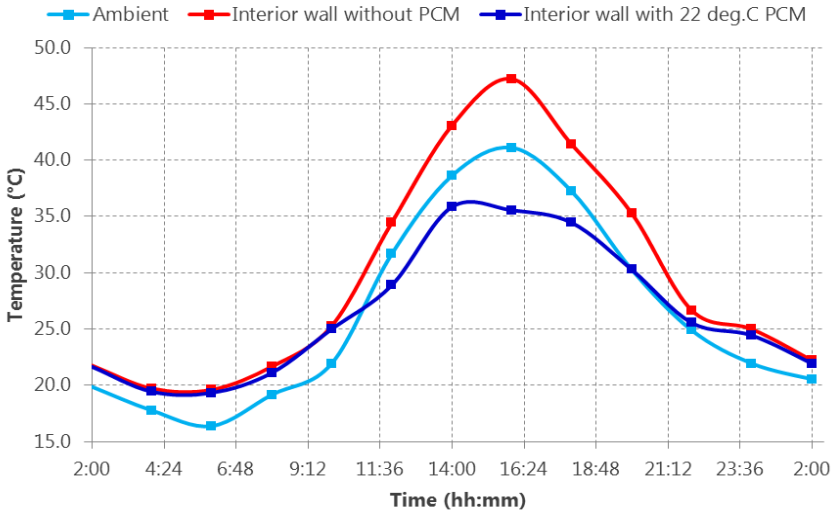
- PCM was implemented in the walls of the greenhouse as a PCM curtain
- 1 cm thick curtain in with PCM encapsulated in PVC tubes
- PCM Used savE® HS22
- The afternoon peak temperature reduced from 47°C to 35.5°C



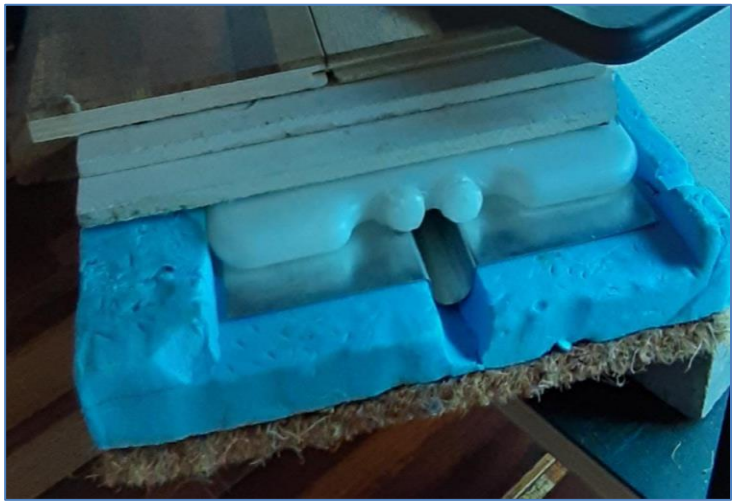
BUILDING: Telecom Shelter, Delhi, India

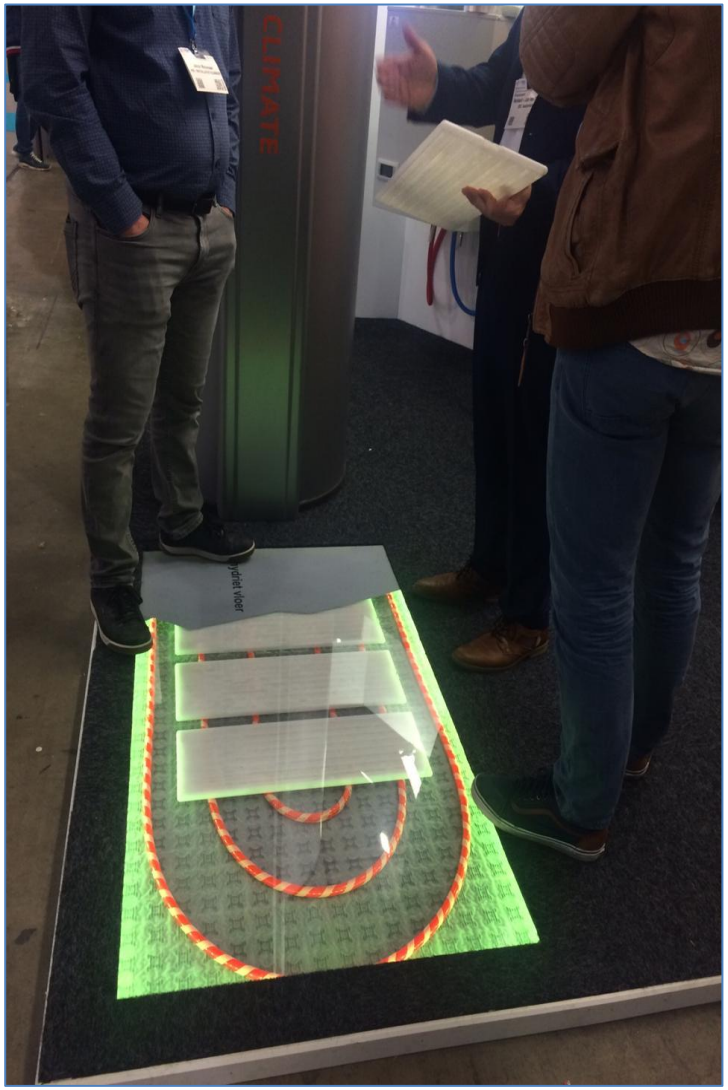
Important Features

- PCM was implemented in the walls of the greenhouse as a PCM curtain
- PCM occupied 2% of the total telecom shelter space volume. The PCM tiles were 1 cm thick.
- PCM Used savE® HS22
- Saving on diesel cost for the generator & HVAC running cost
- 8 hour of cold backup without any additional power source or maintenance;

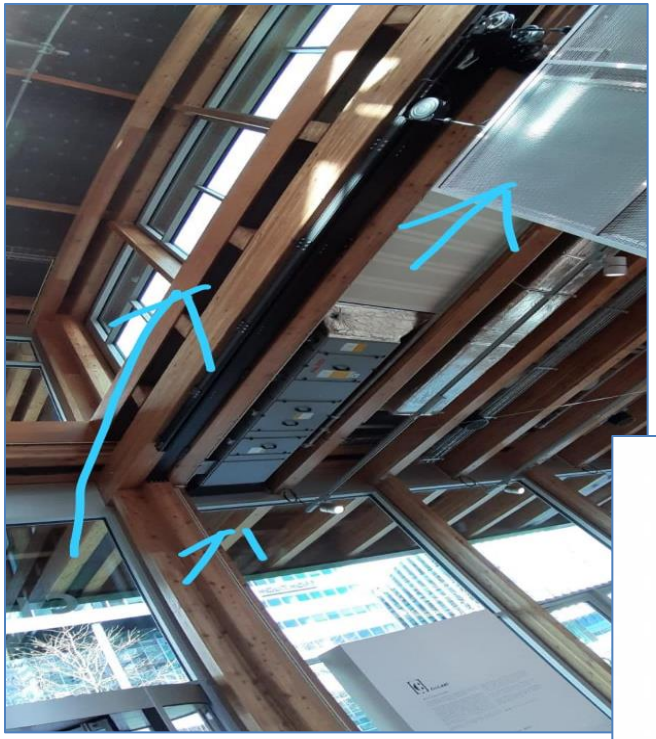


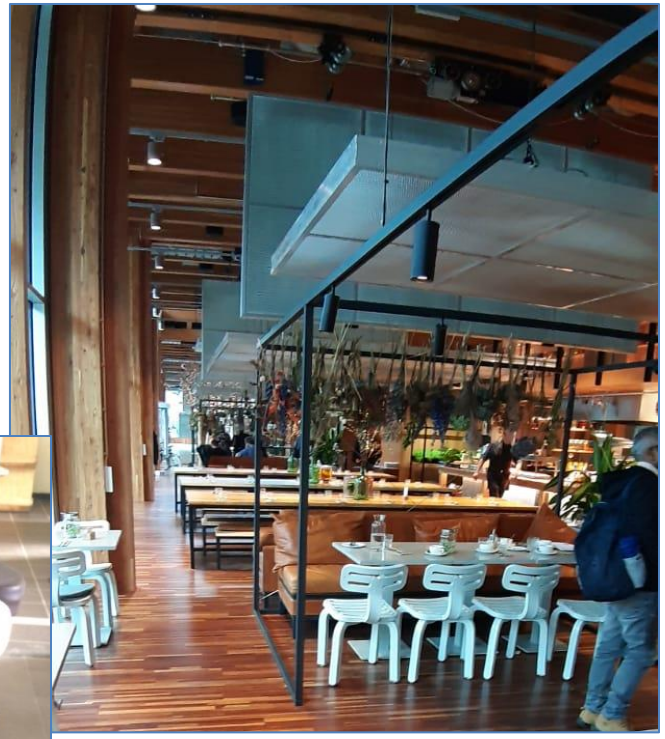
BUILDING: Under floor heating, Netherlands





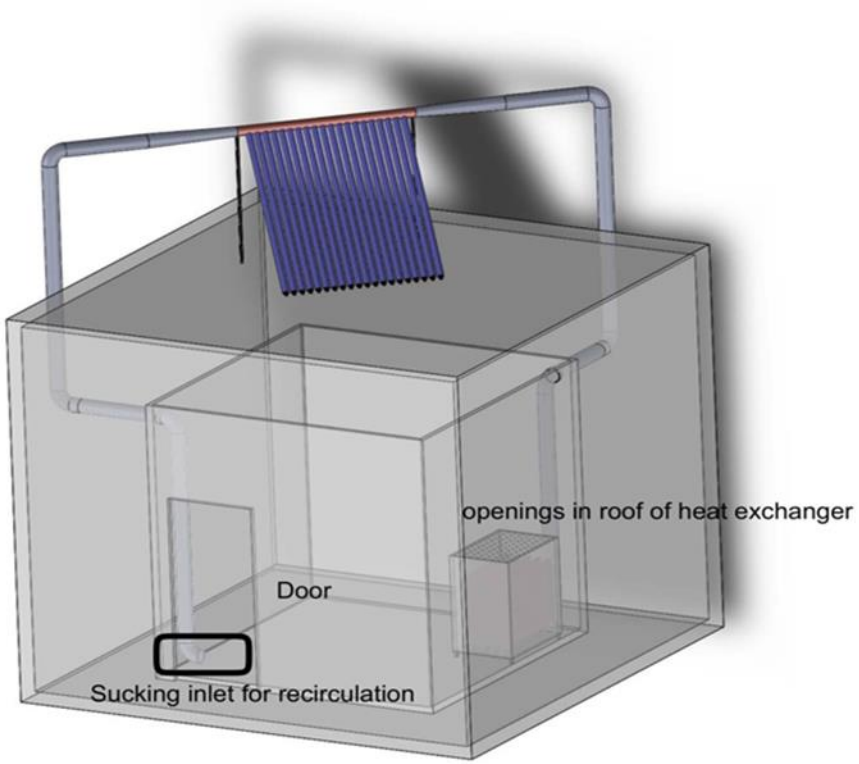
BUILDING: Passive Air-conditioning, Netherlands

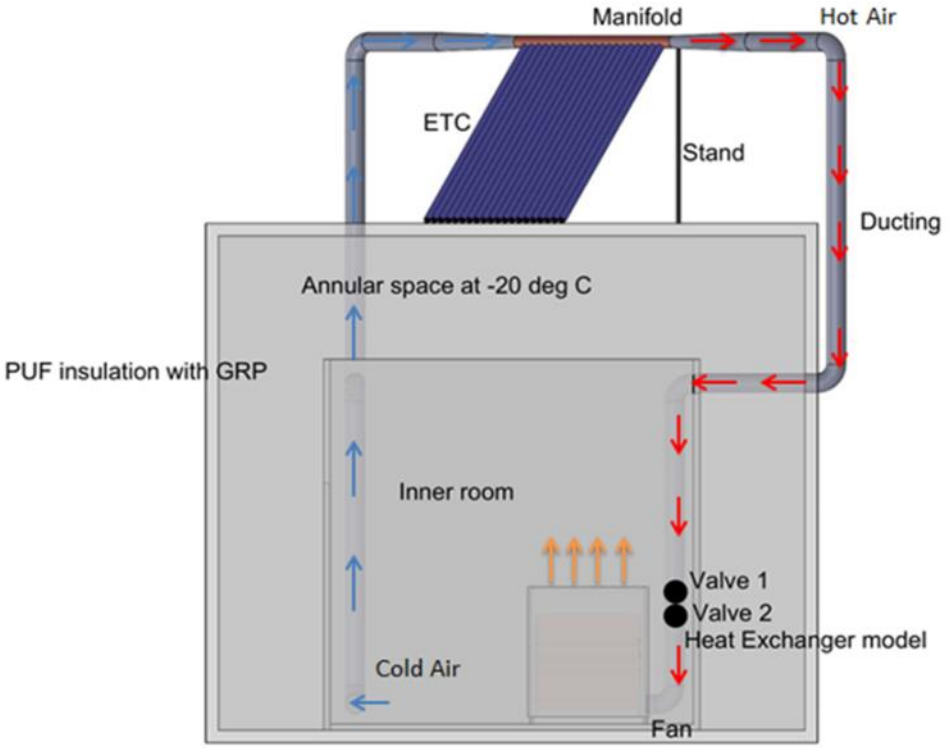




BUILDING: Space Heating

Working Principle

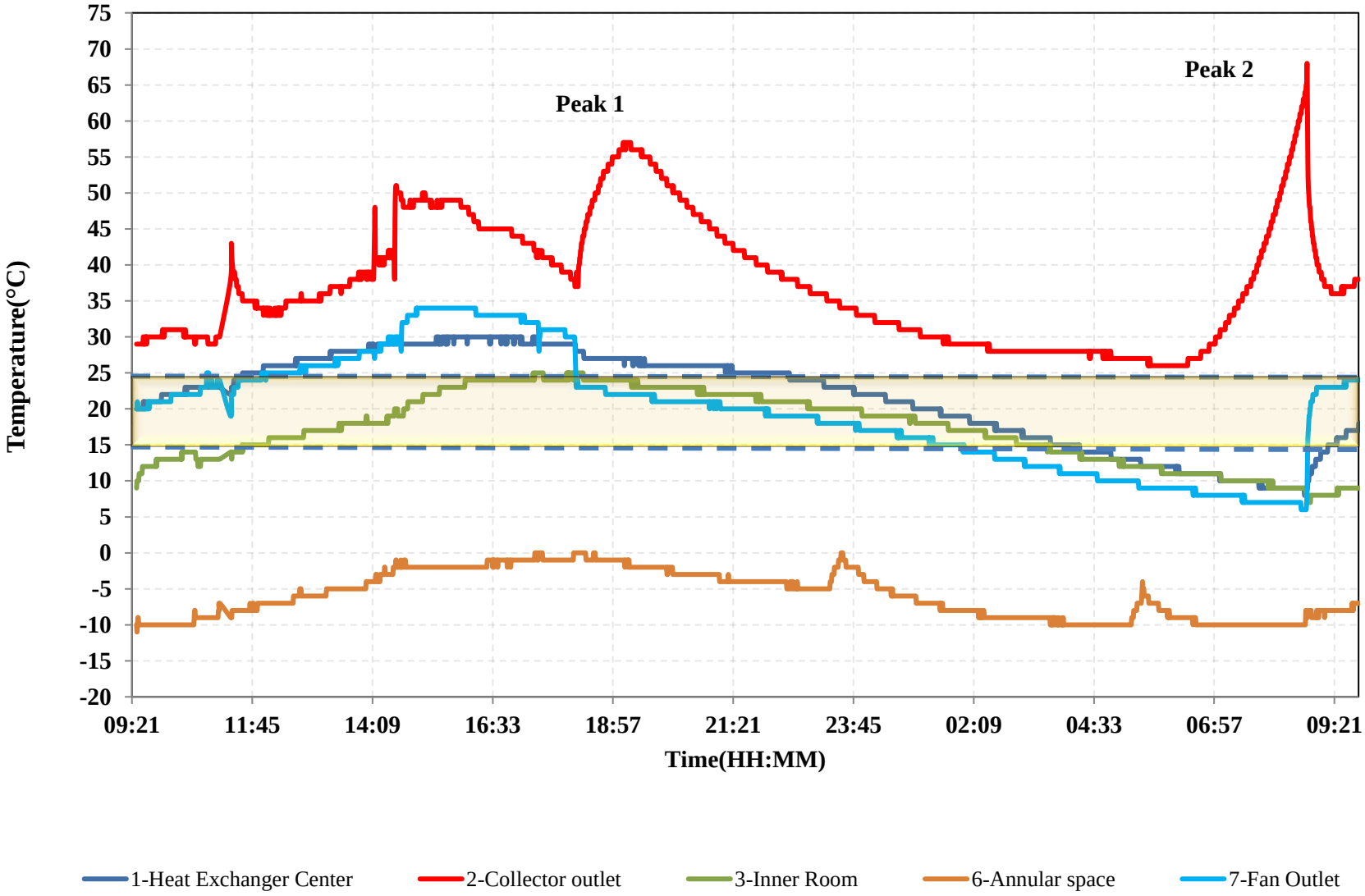




Heat Exchanger

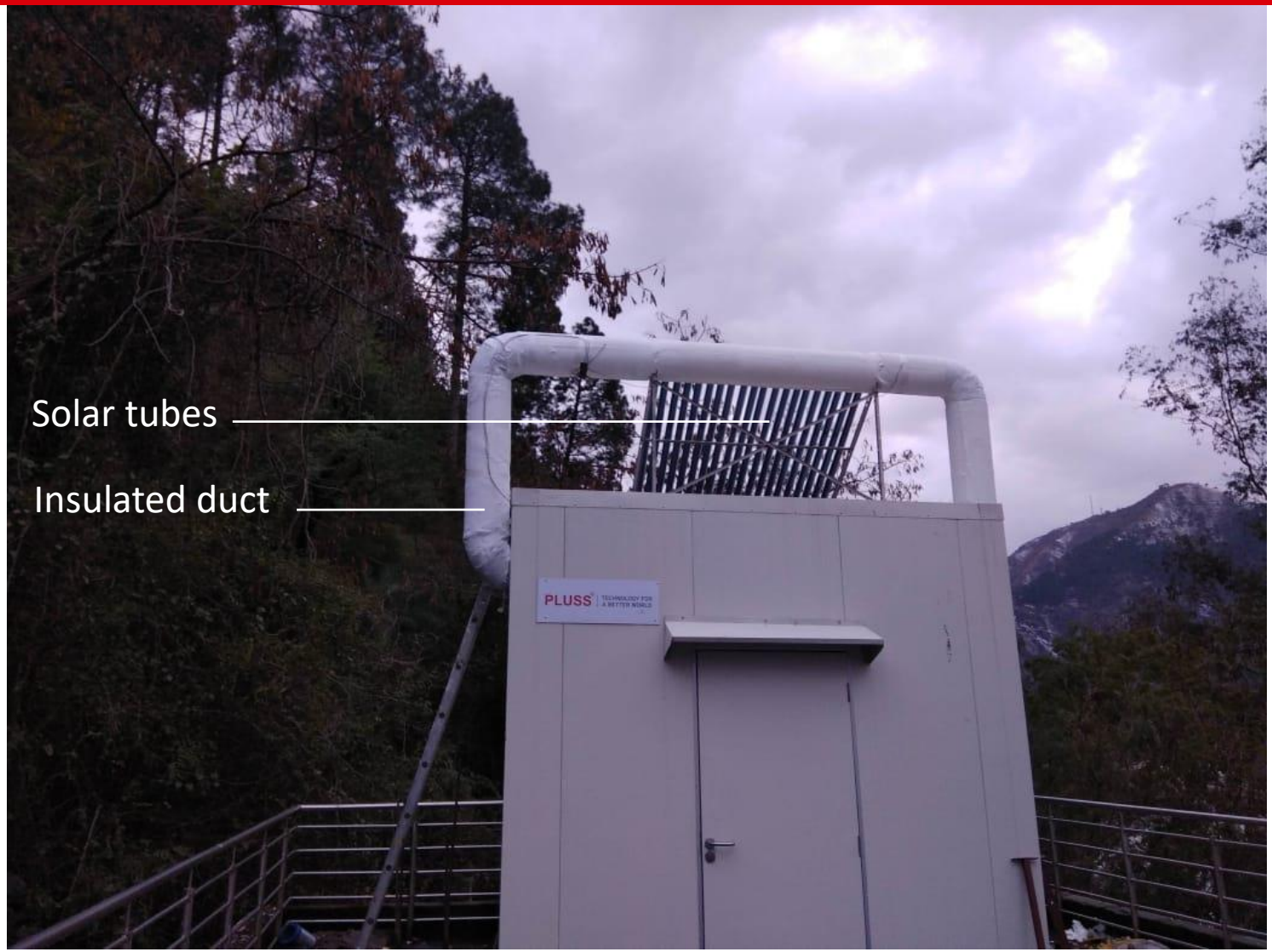
Figure 12(a) PCM air HX closed view (b) Stacking of the HDPE extruded panels inside HX open view

Results

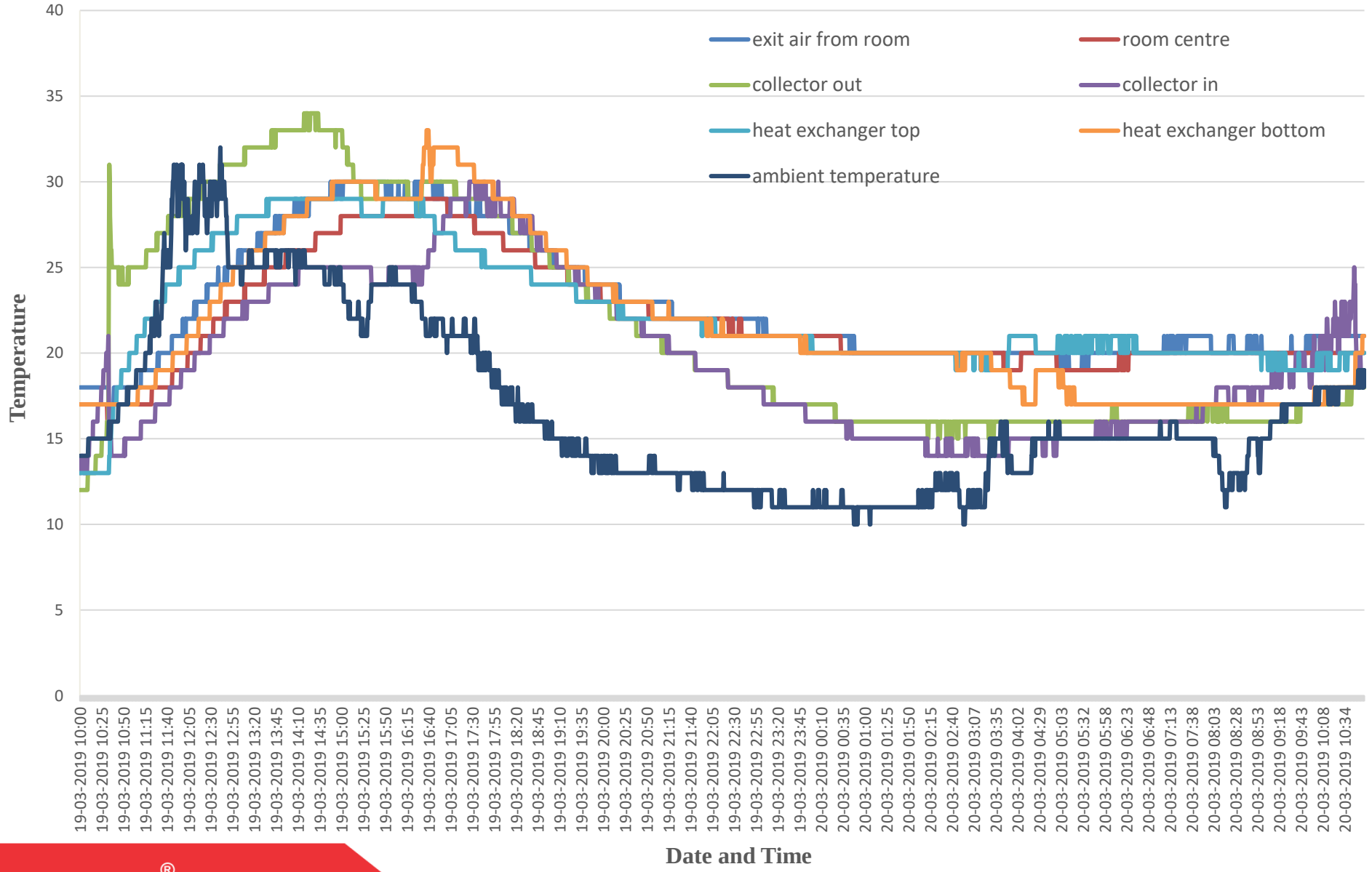

Peak 1
Peak 2
Temperature(°C)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
09:21
11:45
14:09
16:33
18:57
21:21
23:45
02:09
04:33
06:57
09:21
Time(HH:MM)
1-Heat Exchanger Center
2-Collector outlet
3-Inner Room
6-Annular space
7-Fan Outlet

Solar Air Heater – Installed at IIT Mandi

Solar Air Heater – Installed at IIT Mandi



Results (April ‘19)– Installed at IIT Mandi



Projects -

No.	Name of Project	Name of Partner	Location of Project	Capacity Installed with PCM	Application	Value of Project from PLUSS, USD	Impact
1	Miesian Plaza	Crystal Air (https://www.crystalair.ie/)	Lower Baggot Street Lower, Dublin, 2, Ireland	120 TRh (60,000 balls)	Integrated with Chiller	~ 62,000	10% chiller capacity reduction, 15% reduction in operating cost. *Special low energy award LEED platinum V4 – one of only 178 buildings in the world.*
2	Park Plaza		Dublin	252 TRh (1,26,000 balls)	Integrated with Chiller	~ 1,32,500	10% chiller capacity reduction, 15% reduction in operating cost
3	Hanging Gardens		19 Henry St, Limerick, V94 N125, Ireland	138 TRh (69,000 balls)	Integrated with Chiller	~ 71,000	10% chiller capacity reduction, 15% reduction in operating cost
4	ESB Office		Dublin	532 TRh (approx. 2,66,000 balls)	Integrated with Chiller	~ 2,85,000	10% chiller capacity reduction, 15% reduction in operating cost

Projects -

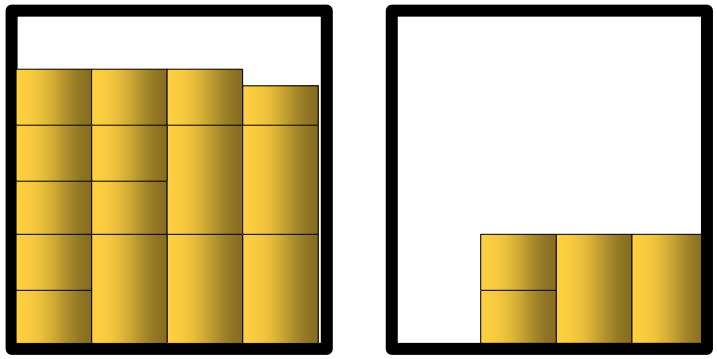
No.	Name of Project	Name of Partner	Location of Project	Capacity Installed with PCM	Application	Value of Project from PLUSS, USD	Impact
5	Undisclosed	Global E System (https://www.global-e-systems.com/en/)	Undisclosed	180 TRh (13,552 kgs)	Passive cooling	~ 35,000	15% reduction in operating cost
6	Heat Pump	Stash Energy (https://stash.energy/)	Canada	110 TRh (~ 3,800 tabs)	Integrated with heater	~ 34,000	Up to 50% reduction in operating cost
7	Undisclosed	Swastech India and Manifold	Arunachal Pradesh	77 TRh (~ 1,800 tabs)	Integrated with solar thermal	~ 23,000	Zero carbon emission (for Army shelter)

Cold Storage Warehouse - Thermal Energy Storage Solution

Challenges - coldrooms/cold warehouse

1. Part Load Utility

Higher Holding Costs - Lower Margins

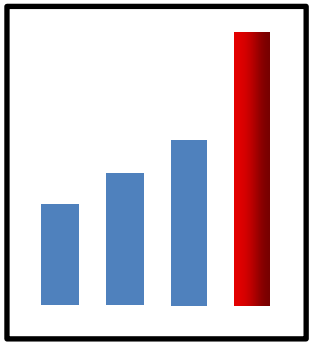


2. Diesel Consumption

Higher Costs and Environmental Impact

3. High power consumption

Higher Operating Costs - Lower Margins



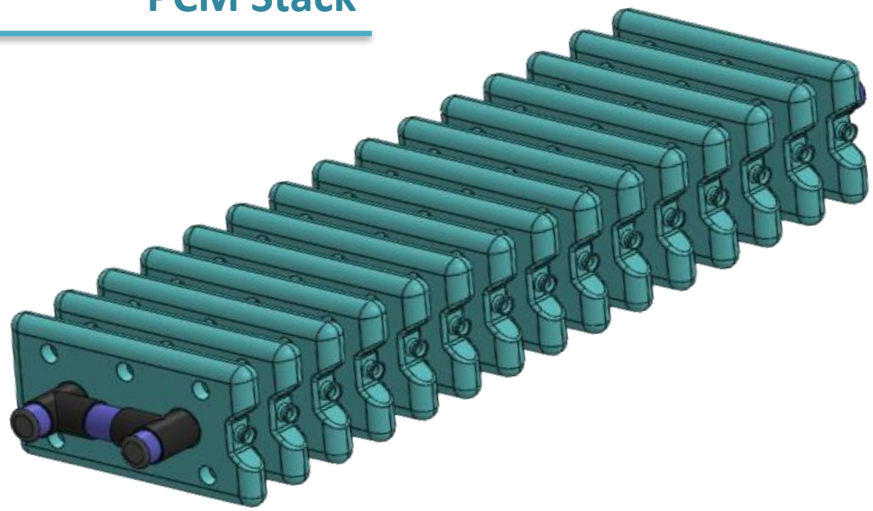
4. Product Spoilage

Cost of Penalty - Loss of business

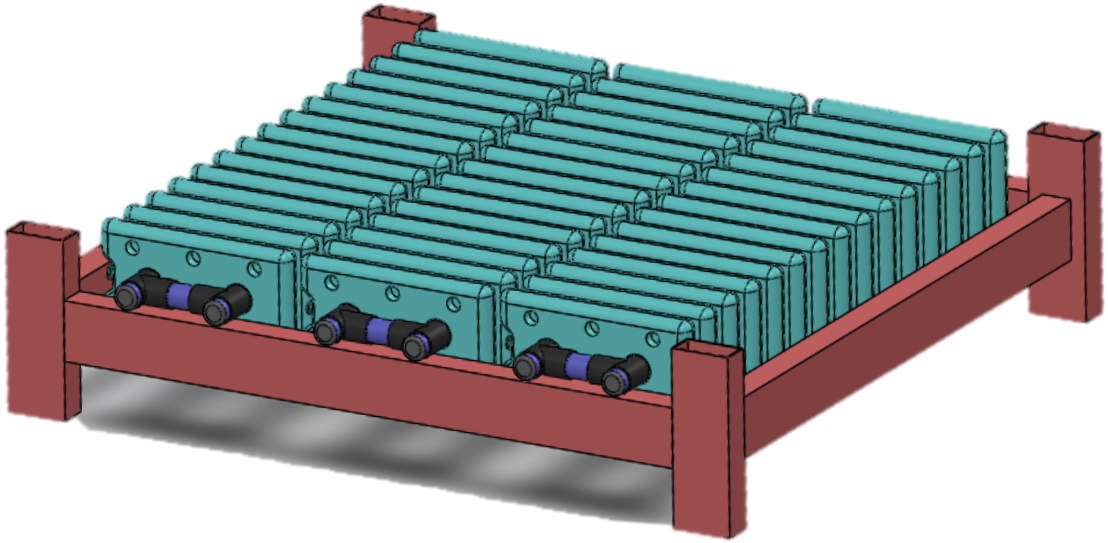
Cold Storage Warehouse: Passive TES Solution

- PLUSS offers an innovative cold warehouse TES based solution for power consumption reduction and temperature backup in the absence of power. Thus, reducing diesel consumption through DG set.

PCM Stack



PCM Module



ABOUT Cold Warehouse TES Solution

- Reduces energy consumption during the peak load hours as the thermal energy storage system provides the cooling energy for extra load during the day.
- PCM in blow molded containers is placed on top of the racks/ near the ceiling where there is direct contact of the cool air with the PCM. The modular design of the PCM stacks allows it to be installed into cold warehouse with any standard sized pallet.
- PCM containers are kept with minimal gap between two panels so as to provide maximum energy density per unit area of the warehouse along with effective charging.
- The thermal energy storage solution can be implemented for any warehouse of various temperature ranges.

ADVANTAGES OVER CONVENTIONAL SYSTEMS

- **No Food Spoilage** due to power failure
- **No Diesel consumption** for running cooling systems
- Electricity Consumption **↓ 10%**
- Better **temperature stability**
- **Reduced Carbon Footprint**

Cold Storage Warehouse: Active TES Solution

- Not exceeding 5 MT
- First mile connectivity

Small Capacity

Solar Powered

- Renewable source
- 24x7 off-grid storage and preservation

Self Sustaina-ble

- Farmer owned & operated
- Self sustainable within 1st year of operation

No Batteries

- Use PCM technology
- Stored energy utilized in the night

Technical Advantages

Enables…

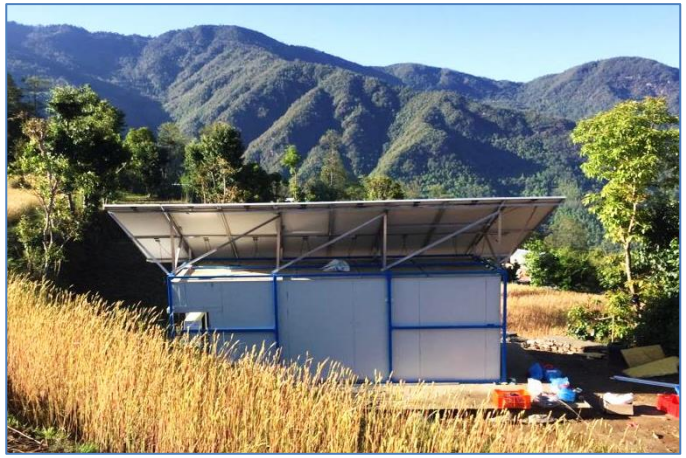
- **Uninterrupted operation** during power outage
- **100% grid free** system and renewable based power supply for cold storage
- **No battery** required
- **Reduces cost** of refrigeration for the farmers
- **Prevents problems** like diesel pilferage, stolen batteries et al.
- Consolidation and scheduling the transport of products to optimize payload of shipments
- **Allows accurate scheduling** of the working between PCM and the Solar PV based refrigeration unit.

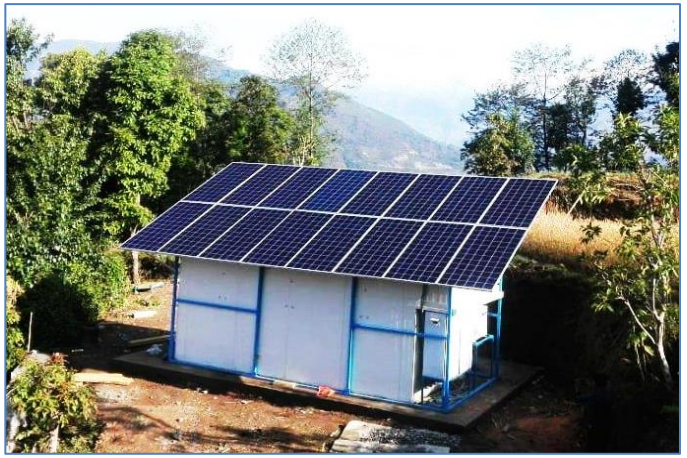
ThermoTab™*active* plates containing PCM for storage of cold energy

Installed Cold room at Mirge Village, Nepal

PCM based solar micro cold room operation

Installed Cold room at Jungu Village, Nepal





PCM based solar micro cold room operation

Approach, Environmental and Social advantages

6 hours Solar

18 hours PCM

- **Reduces food loss** due to spoilage.
- **15 to 20 days of storage** post harvest.
- Controlled temperature storage also **improves fruit/flower/veg quality.**
- **Better pricing** for farmers produce by storing and selling at the right time.
- **Increases farmers income** and encourages **entrepreneurship**.
- N**o pollutant emission** and **portable**.
- Not require a heavy duty battery - **reduces maintenance cost.**
- **Creates awareness** among small-scale farmers on the benefits of storing their fruits and vegetables in a temperature controlled environment.

…. Self sustainable and self replicable model

Possible Applications:-

Heat battery enables,

- 50 -75% Reduction in the boiler volume
- Utilization of residual/waste heat
- Instantaneous source of hot water

Stores extra heat generated from heat pump

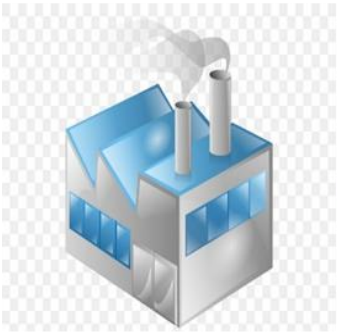
Possible Applications:-

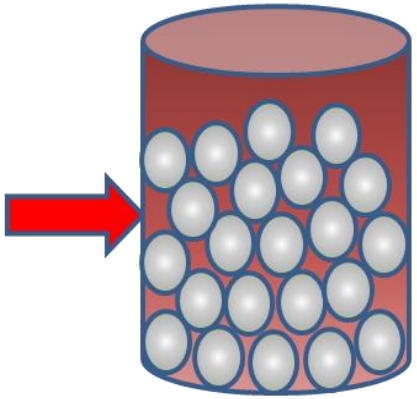
Heat battery enables,

- Storage of excess heat during peak
- Stabilization of the temperature

Intermittent availability of process heat

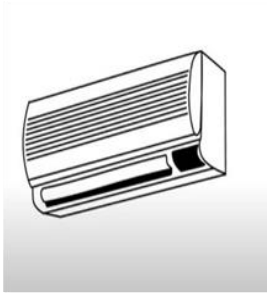
Constant supply from TES tank





Heat Battery

VAM Chiller



Cooling load

PLUSStainability
/ plʌsteɪnəˈbɪlɪti/
noun

the ability to maintain the optimal rate or level to meet the needs of the present without compromising the needs of future generations, the PLUSS way.

THANK YOU