ACE
CONSULTING & ENGINEERING

THERMAL ENERGY STORAGE SYSTEM

FOR BETTER ENERGY MANAGEMENT

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WHY STORE ENERGY?

Thermal Energy Storage (TES) is a technical solution to air conditioning systems and industrial cooling, which reduces energy consumption and saves on initial capital and running costs. Rationalization of energy use is also a solution to the problem of reducing greenhouse gas emissions.

Standard cooling systems are designed for peak demand, even if this chiller capacity is used only for few hours per day, every year. Thermal Energy System allows using smaller capacity chillers. When demand is higher than chiller capacity, the storage provides deficit Energy for continuous operation at its maximum efficiency.

Thermal Energy system (TES) manages the cooling energy according to the requirement and stores energy during off peak hours. By using off peak electrical tariffs storage system saves on running costs. TES improves system consistency and offers a safer mode of operation for processes or back-up system.

Kehems offers to design Thermal Storage System (TES) for your air conditioning and industrial refrigeration requirements. Our experts will assist you in basic calculation, selection, optimization and commissioning of Thermal Storage System.

BENEFITS OF STORING ENERGY

To Reduce	To Increase	Environment Protection
-Chiller Size by 30-70%	-Cooling capacity from existing plant	-Reduction of Co2 emission
-Refrigerant charge	-Chiller annual efficiency	
-Size of heat rejection plant	-Smoothness of electrical load profile	
-Electrical demand	-Energy management	
-Plant room space	-System life expectancy	
-System maintenance costs	-The COP	
-System Operation costs	-Reliability of the system	
	-System control	

STORAGE APPLICATION

It is necessary to examine the available energy source when considering potential application for Thermal Storage.

Where cooling is generated by electricity, attractiveness is increased if off peak tariffs are available outside the cooling demand period.

In Industrial cooling and air conditioning systems, the process requirements do not permit large temperature differentials across the circuit. Thus sensible Energy Storage System is required. The high cost of chillers makes the reduction of installed capacity attractive.

Listed below are some typical applications for Thermal Energy Storage:

AIR CONDITIONING	PROCESS COOLING	BACK-UP
Airports	Bottling Plants	Computer Rooms
Banks	Chemical Industries	Clean Rooms
Cinemas/ Multiplexes	Cold Stores	Cold Storages
Commercial Complexes	Dairy industries	Operating/ Surgery Theaters
Conference centers	Food Processing	Television Studios
Departmental Stores	Pharmaceutical Industries	Telephone Exchanges
Hospitals		
Hotels		
Residential Complexes		
Shopping Malls		
Show Rooms		
Super Markets		

THERMAL ENERGY STORAGE SYSTEM

Thermal Energy Storage System is an efficient solution for optimizing air conditioning and refrigerant plants.

Uses of other components (Cooling towers, transformers etc.) are reduced in the same proportions and the servicing of equipment is simplified. Also it allows the use of low cost electricity.

Thermal Energy System is composed of a tank filled with "Nodules". The tank has upper manhole to allow the filling with nodules. A lower manhole allows emptying. Inside the tank two diffusers (inlet and outlet) spread the heat transfer fluid along the tank. The pressure drop through the tank is 2.5mWG.

The Thermal Energy Storage is determined by the phase change temperature and the volume. The quantity of energy stored for each type of nodule is proportional to the storage volume. The number of nodules in a system determines the heat exchange rate between the nodules and the heat transfer fluid.

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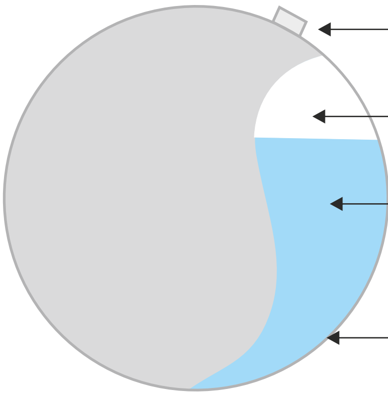
Kehems offers a range of temperatures from (-) 33°C to +27°C. The TES has been conceived for hydraulic applications. Please contact us for any other application requirement.

THE NODULES

The nodules are spherical with a diameter of 77mm (type SN), 78mm (type IN) or 98mm (type AC.00) - depending on the nodule type. The Polyolefin nodules contain Phase Change Material (PCM) and the mechanical and chemical characteristics of the nodule shell are adapted to the conditions encountered in air conditioning or Refrigeration systems.

Once filled with PCM the nodule plugs are sealed by ultrasonic welding to ensure perfect water tightness. The nodules are designed for higher service pressures up to 10 bars.

- Material: Blend of Polyolefins
-Chemically neutral towards heat transfer fluid.
-Thickness 1 mm: No migration of heat transfer fluid
-Blow moulded: No leakage
-Cap sealing by ultrasonic welding
-Air pocket for expansion: No stress on Nodule shell.



CHARACTERISTICS FOR 1 m^3 TES

					Heat Transfer PCM				
Nodule type	Phase change temp °C	Latent Heat Ql kW/m^3	Sensible Heat Solid Qss kWh/°C	Sensible Heat Liquid Qsl kWh/°C	Crystalisation Kvcr KW/°C	Fusion Kvfu KW/°C	Nodule Weight Kg	Toxicity Ld50 value in mg/kg a	Operating Temp. Limits °C
SN.33	-33.0	44.6	0.70	1.08	1.60	2.20	724	2,600	
SN.29	-28.9	39.3	0.80	1.15	1.60	2.20	681	1,200	-40°C
SN.26	-26.2	47.6	0.85	1.20	1.60	2.20	704	1200	TO
SN.21	-21.3	39.4	0.70	1.09	1.60	2.20	653	1,300	+60°C
SN.18	-18.3	47.5	0.90	1.24	1.60	2.20	706	2,700	
IN.15	-15.4	46.4	0.70	1.12	1.60	2.20	602	8,400	
IN.12	-11.7	47.7	0.75	1.09	1.60	2.20	620	5,000	-25°C
IN.10	-10.4	49.9	0.70	1.07	1.60	2.20	617	11,000	TO
IN.06	-05.5	44.6	0.75	1.10	1.60	2.20	625	18,000	+60°C
IN.03	-02.6	48.3	0.80	1.20	1.60	2.20	592	58,000	
IC.00	00.00	48.4	0.70	1.10	1.60	2.20	558	85,000	
AC.00	00.00	48.4	0.70	1.10	1.15	1.85	560	85,000	
IC.27	+27.0	44.5	0.86	1.04	1.15	1.85	867	2,500	

Allow a useful expansion volume of 5%.

THE STORAGE TANK

The horizontal cylindrical storage tank is manufactured in black steel. The tank shape is usually cylindrical in order to withstand service pressure higher than 3 bar. The test pressure varies between 4.5 to 10 bar.

The spherical shape allows an easy filling. The dimension of tank is calculated based on available space and thermal requirement. Tank can be horizontal or vertical, outside or inside buried or built on site according to site requirements.

Two connections are fitted on the manhole covers for filling, air bleed valves and manometers.

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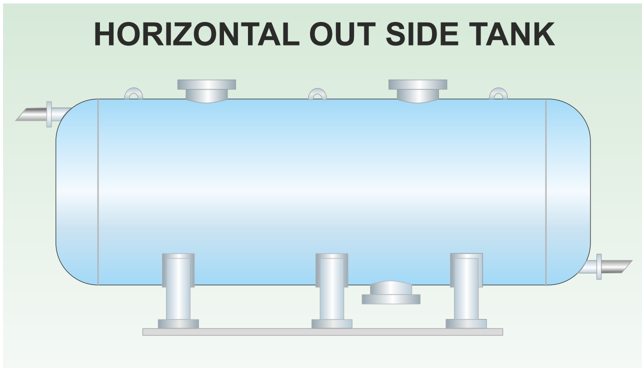
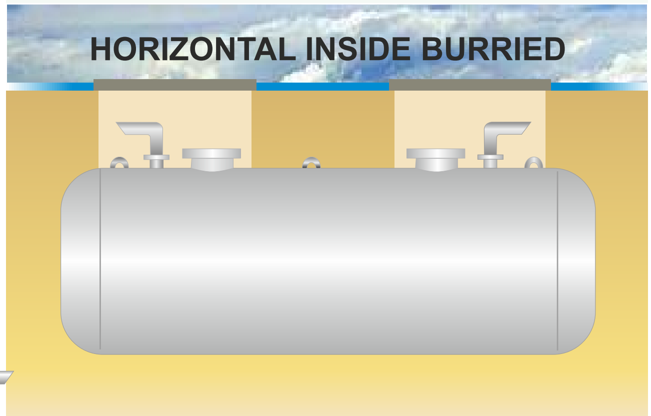
It is possible to use rectangular tanks (in steel or concrete).

Two internal headers (top and bottom) are designed to generate maximum heat transfer efficiency. The heat exchange between the nodules and the system is achieved by circulating the heat transfer fluidthrough the tanks.

The dimensions of standard tanks are given in the table below.





EXAMPLE OF TANK CHARACTERISTICS

Consult us for alternative dimensions

Volume in m^3	External Diameter D mm	Total Length without Flanges L mm	External Surface to be insulated m^2	Inlet and outlet flanges ES mm	Number of Cradles	Empty weight PE 4.5 bars Kg	Heat transfer Fluid volume m^3
2	950	2980	10	40	2	660	0.77
5	1250	4280	18	50	2	1050	1.94
10	1600	5240	29	80	2	1890	3.88
15	1900	5610	37	100	2	2540	5.82
20	1900	7400	47	125	3	3200	7.77
30	2200	8285	61	150	3	4580	11.64
50	2500	10640	89	175	4	6860	19.40
70	3000	10425	106	200	4	8400	27.16
100	3000	14770	147	250	6	11700	38.80

Standard pressure drop 2.5mWG at nominal flow rate.

OPERATION PRINCIPLE OF THE TES

HYDRAULIC LAY-OUTS TO SUIT YOUR APPLICATION

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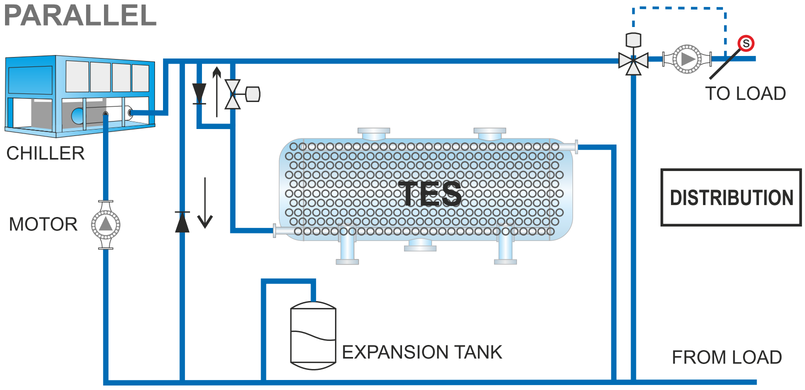
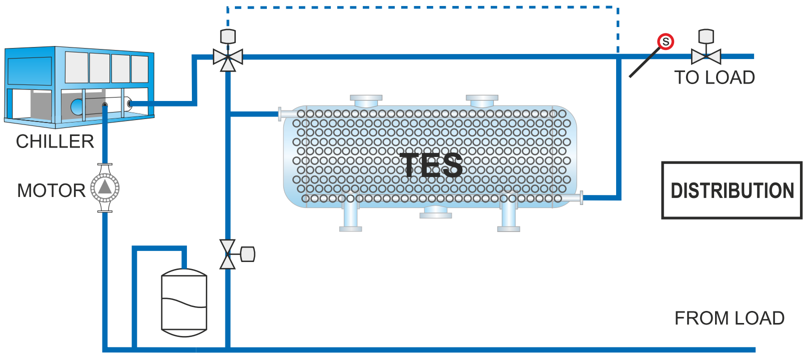
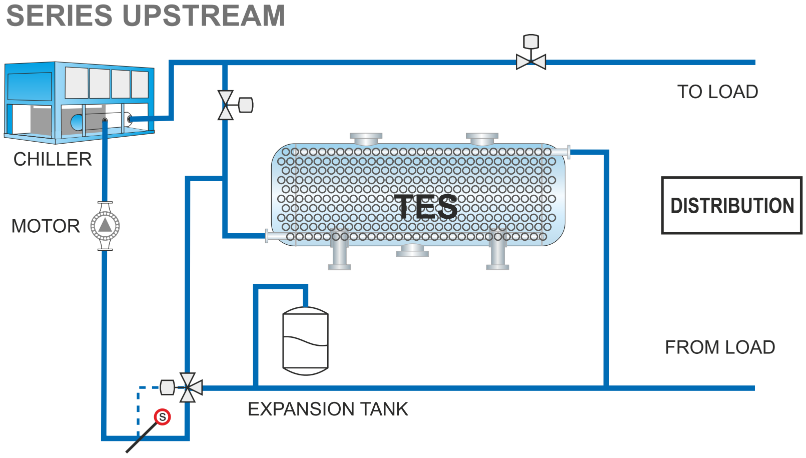
PARALLEL



SERIES DOWNSTREAM



SERIES UPSTREAM



DESIGN

The operating cycle is divided into two distinct modes: Charge and Discharge - during which the nodules remain virtually at a constant temperature.

The Charge mode: The store is charged by crystallization of the salts contained within the nodules.

The Discharge mode: The stored energy is released by fusion of the salts contained in the nodules.

Running Principle: During the charge and discharge cycle the temperature of the heat transfer fluid passing through the TES should vary as little as possible relative to the temperature at the end of the release mode. Distribution flow temperature is normally constant.

HYDRAULIC LAY-OUT

The storage system may be used in parallel or in series with the chiller.

The decision whether to use parallel or series configuration depends primarily on the temperature difference across the distribution circuit. With a temperature difference of 5°C or 6°C (i.e. 5°C/10°C or 6°C/12°C) it is possible to use the TES in parallel so that the evaporator and TES operate on the same temperatures.

If temperature difference of 8°C to 12°C or more are permitted (i.e. As in low temperature distribution systems) the TES and evaporator can be configured in series. In this case the TES and the evaporator each produce a proportion of the temperature differential. This permits the evaporator to work at a reasonable temperature differential.

For example with a distribution circuit temperature difference of 4°C/12°C the TES and the evaporator will each produce 4°C of cooling and satisfy 50% of the maximum load demand. With the series configuration there are two possibilities: TES Downstream or TES Upstream.

Thermal Energy Storage System

CASE STUDIES

Zydus Pharmaceutical, Ahmedabad

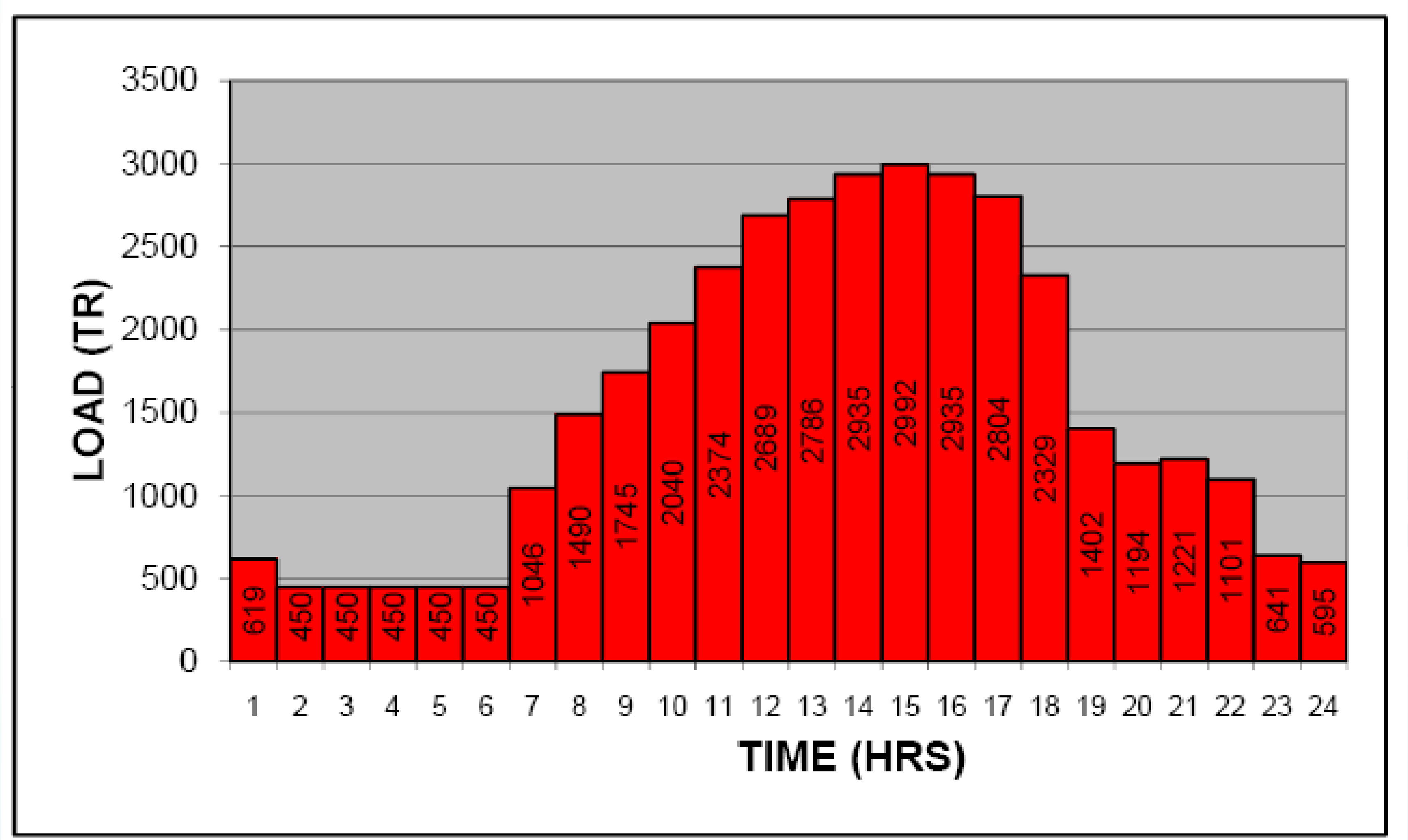
- **HIGH SIDE SYSTEM PREVAILING PRIOR TO THE INSTALLATION OF STORAGE SYSTEM.**

- 700 TR Capacities each Water Cooled Centrifugal Chillers, 3 Nos.
- 700 TR Capacity Vapour Absorption Chiller, 1 No.

The System was installed with Hot and Cold well with corresponding Primary and Secondary Chilled Water Pumps.

On the Condenser Water side sufficient capacity of Cooling Towers was installed.

• **COOLING LOAD PROFILE CONSIDERING FUTURE LOADS**



- **HIGH SIDE ITEMS ADDED ON:**
  - Brine Screw Chillers with dual set point: 240 TR x 3 Nos. (for operation up to -6ºC).
  - Thermal Storage System : 6340 TR-HR.
  - PHE : 531 TR X 2 Nos.

- **SAVINGS ENVISAGED AT THE DESIGN STAGE**

For the peak load of about 3000 TR with all the future expansions following savings were estimated in Energy and Maximum Demand recurring costs and Capital Costs at the design stage.

- Saving in Electrical Installation Cost for switch over to **33 KV from present 11 KV connection.**
- Savings in Operating Costs including Energy Cost and Maximum Demand Charges: **$ 149,000/ Year**

•SAVINGS BEING ACCRUED AFTER EXECUTION

Subsequent to the design stage the existing electrical loads increased and 2 Nos. 700 TR Centrifugal Chillers started operating on Diesel Generator Sets continuously during the day time.

After the installation and commissioning of Thermal Energy Storage System one Chiller of 700 TR is being regularly stopped for 6 Hours per day.

- Electrical Energy Consumption of 700 TR Chiller per Hour : 360 KWH
- Electrical Energy Consumption of 700 TR Chiller 6 Hours : 2160 KWH
- Differential Electrical Energy costs with Diesel Generator : $ 0.26 / KWH
- Savings in Electrical Energy Costs due to Stoppage of 700 TR: $ 552/- Per day.
  Chiller operation on D. G. set (552 X 0.26)
- Saving per month considering 25 working days : (552 X 25)
- Estimated yearly savings : approx. $165,600

National Stock Exchange, Mumbai
5000 TRH STL with existing system

National Stock Exchange, Mumbai

OPERATION OF AIRCONDITIONING PLANT BEFORE MODIFICATION

- Installation of 350 TR x 4 Nos. and 200TR x 1 No. Screw Chillers.
- Average Chiller Operation during
- Day time between 9 AM to 8 PM : 350 TR x 3 Nos. Chillers
- Average Chiller Operation during
- Night time between 8 PM to 9 AM : 200 TR x 1 No. Chiller

OPERATION OF AIRCONDITIONING PLANT POST MODIFICATION

- Average Chiller Operation during
  Day time between 9 AM to 8 PM : 350 TR x 1 No. Chiller, 4800 TR-HR STL
- Average Operation during Night time
  For load meeting : 200 TR x 1 No. Chiller
  For charging of STL : 350 TR x 2 Nos. Chillers

Savings in Maximum Demand

Month	Demand Savings (KVA)
January	616
February	616
March	924
April	924
May	616
June	616
July	616
August	924
September	924
October	924
November	616
December	616
TOTAL	**8932**

Electrical Energy Cost

	Monthly Consumption for Charging of Storage System during Night time	: 120,000 KWH
I.	Units shifted from 12:00 -18:00 Period to 22:00 – 06:00 Period	: 81, 600 KWH
	Savings in Energy Costs (81,600 x $ 0.02/Unit)	**: $ 1632**
II.	Units shifted from 09:00 -12:00 Period to 22:00 – 06:00 Period	: 38, 400 KWH
	Savings in Energy Costs (38,400 x $ 0.03/unit)	**: $ 1152**
	MONTHLY TOD SAVINGS	**: $ 2784**
	YEARLY TOD SAVINGS	**: $ 33,408**

My Home Abhra Apartment, Hyderabad

My Home Abhra Apartment, Hyderabad

My Home Abhra is a residential apartment in Hyderabad.

There are 5 towers in the complex, total no of flats is 396.

Total Connected load was calculated : 4824 TR

System details:

Details	Conventional System	System Installed	Savings
Chiller Load	3400 TR	900 TR + 3000 TR-HR (STL)	2500 TR
Total Connected Load	4400 KVA	1165 KVA	3235 KVA
DG Capacity	5200 KVA	1400 KVA	3800 KVA

Also, the space in each flat has been freed for the use of the occupant as the centralized system has been taken in the basement.

•SAVINGS BEING ACCRUED PRESENTLY

Subsequent to the design stage the existing electrical loads increased and 2 Nos. 700 TR Centrifugal Chillers started operating on Diesel Generator Sets continuously during the day time.

After the installation and commissioning of Thermal Energy Storage System one Chiller of 700 TR is being regularly stopped for 6 Hours per day.

- Electrical Energy Consumption of 700 TR Chiller per Hour: 360 KWH
- Electrical Energy Consumption of 700 TR Chiller 6 Hours : 2160 KWH
- Differential Electrical Energy costs with Diesel Generator : $ 0.19 / KWH
- Savings in Electrical Energy Costs due to Stoppage of 700 TR Chiller operation on D. G. set : $ 410.4/day. (2160 X 0.19)
- Saving per month considering 25 working days : **$ 10,260/-** (410.4 X 25)
- Estimated yearly savings : approx. **$ 123,120**

REFERENCES

Asia World Expo , Hong Kong

2826 TR Chillers +

18000 TRH Storage

Petronas Tower, Kuala Lumpur

6600 TR Chillers +

43000 TRH Storage

Tidel Park, Chennai

3000 TR Chillers +

24000 TRH Storage

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