Thermal energy storage technology – application in Renewable Energy and Energy Efficiency

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New Delhi; 03 February 2014

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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

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Thermal Energy

Thermal energy storage (TES) is a technology that stores thermal energy by heating or cooling a storage medium so that the stored energy can be used when desired for heating and cooling applications and power generation. In a typical building/industry around half of the energy consumed is in the form of thermal energy. Therefore, TES systems can help balance energy demand and supply on a daily, weekly and even seasonal basis.

Types of energy storage technologies

Energy can be stored in the following form:

1. Sensible heat storage – storing thermal energy by heating/cooling a storage material e.g. sand, water, molten salt, water, etc.
2. Latent heat storage – string thermal energy in a phase change materials (PCMs)
3. Thermo-chemical energy storage – uses chemical reactions to store and release thermal energy

Parameters for selecting TES material

Capacity: Energy stored in the system

Power: Rate at which the energy stored in the system can be dis/charged

Efficiency: Accounts for the energy loss during the storage period and the charging/discharging cycle;

Storage period: Period for which the energy can be stored

Dis/Charge: Time required to charge or discharge the system

Cost in capacity (Rs/kWh), power (Rs/kW): Depends on the capital and operation costs of the storage equipment and its life

Sensible heat storage

Storing thermal energy by heating/cooling a storage material e.g. sand/stone, water, molten salt, water, etc.

i. Heat storage in solids: Pebble bed storage, metals, etc.

ii. Heat storage in liquids: Water, etc.

Inexpensive and easy to use

Requires large volume because of low energy density

Requires appropriate design to discharge energy at constant temperature

Sensible heat storage: sub-ambient temperature

Use of low cost sensible heat storage inside a residential house insulated from surroundings - conduction from above

Pebble-bed storage under construction for indoor heating - residential house

Source: SolLad, ComSolar, GIZ

Sensible heat storage: mid-temperature storage

Temperatures can be achieved as high as 350 °C

Heat can be stored overnight. To continue the cycle, the following day

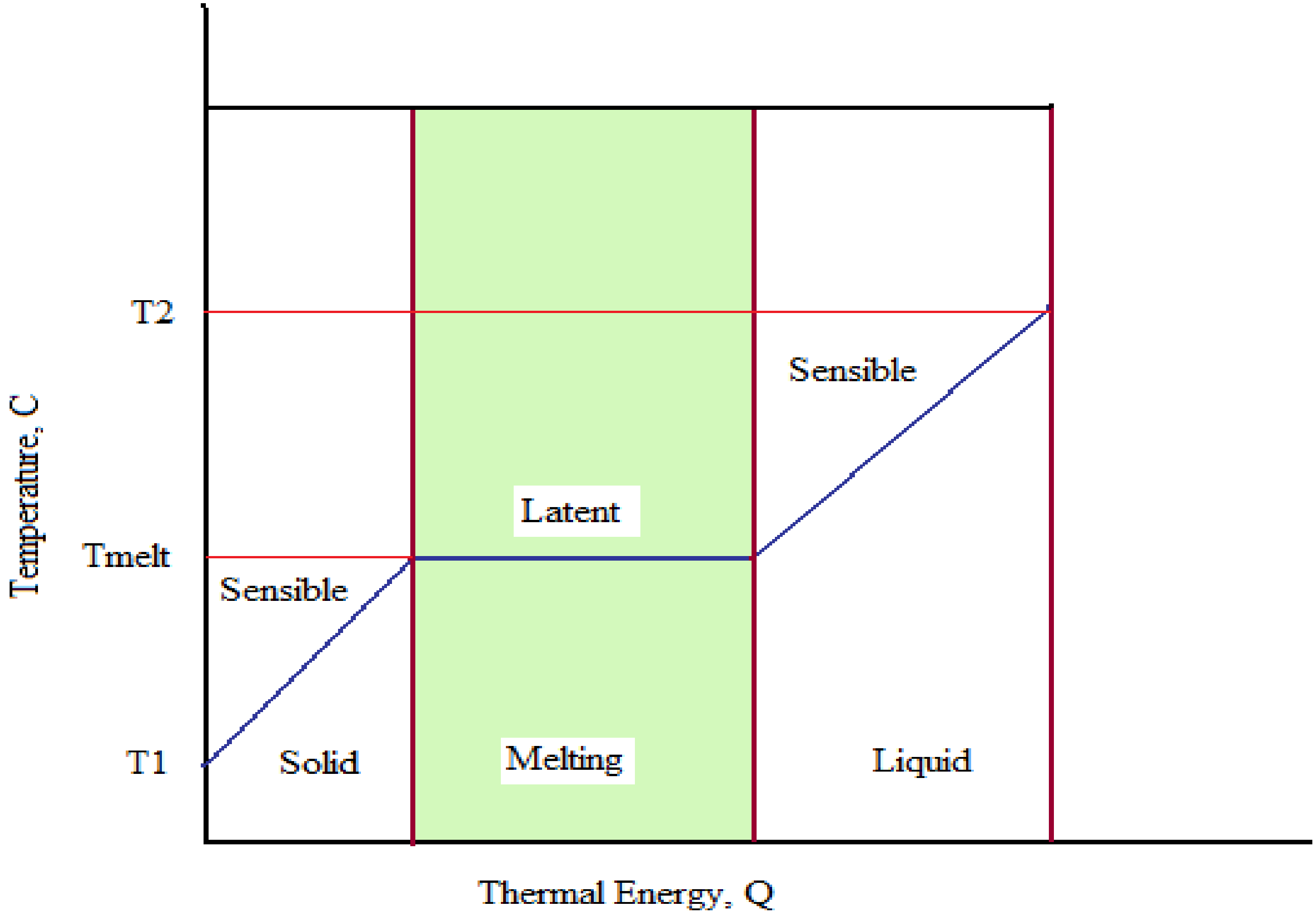
Source: IndiaOne, ComSolar, GIZ

Latent Heat Thermal Energy Storage

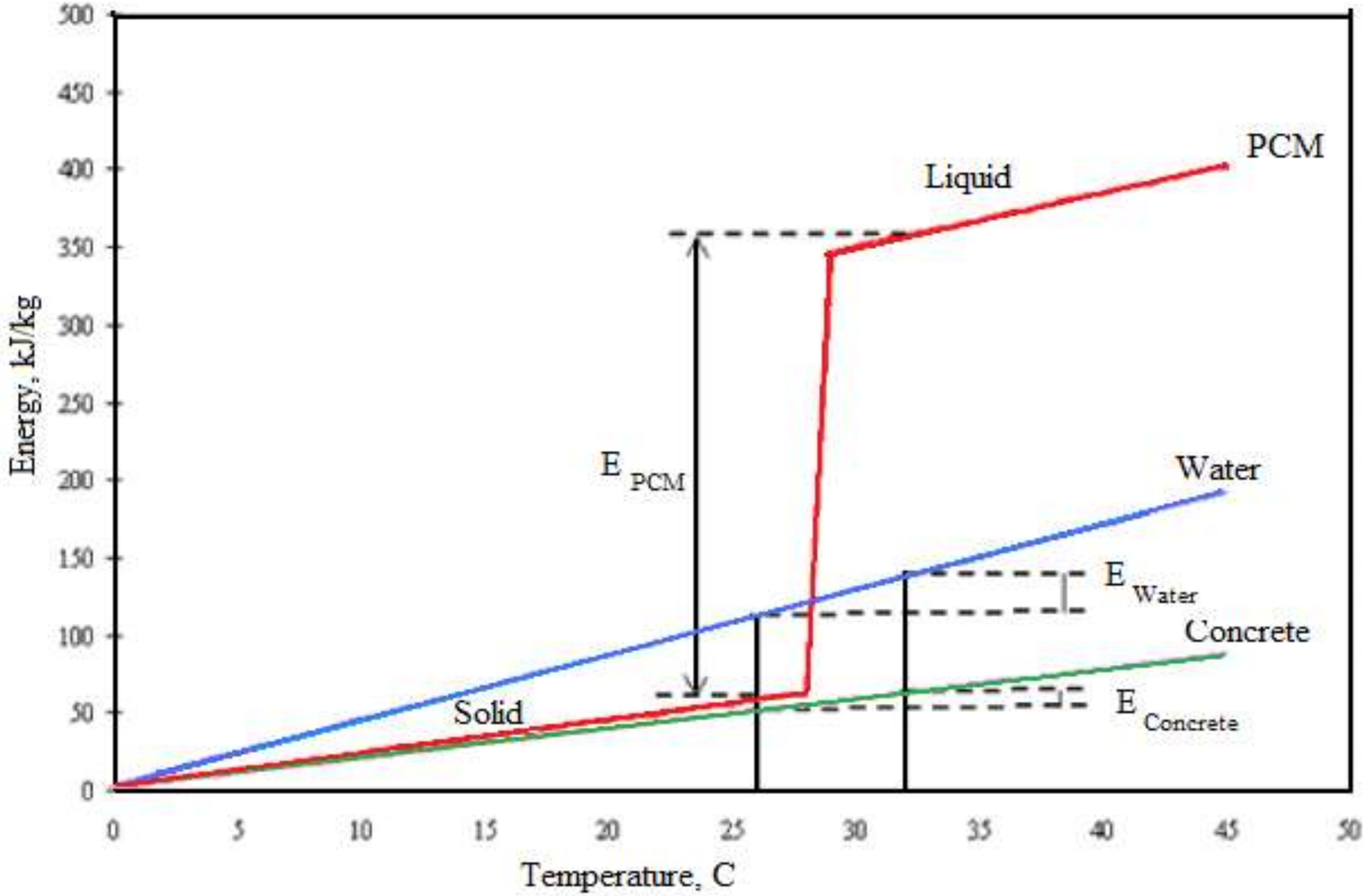
Phase Change Materials (PCMs) or Latent Heat Storage Materials offers a **higher storage capacity** compared with Sensible Heat Storage and at **constant temperature** as it is associated with the latent heat or the phase change of a material.

PCMs enables a target-oriented discharging temperature that is achieved by selecting an appropriate PCM

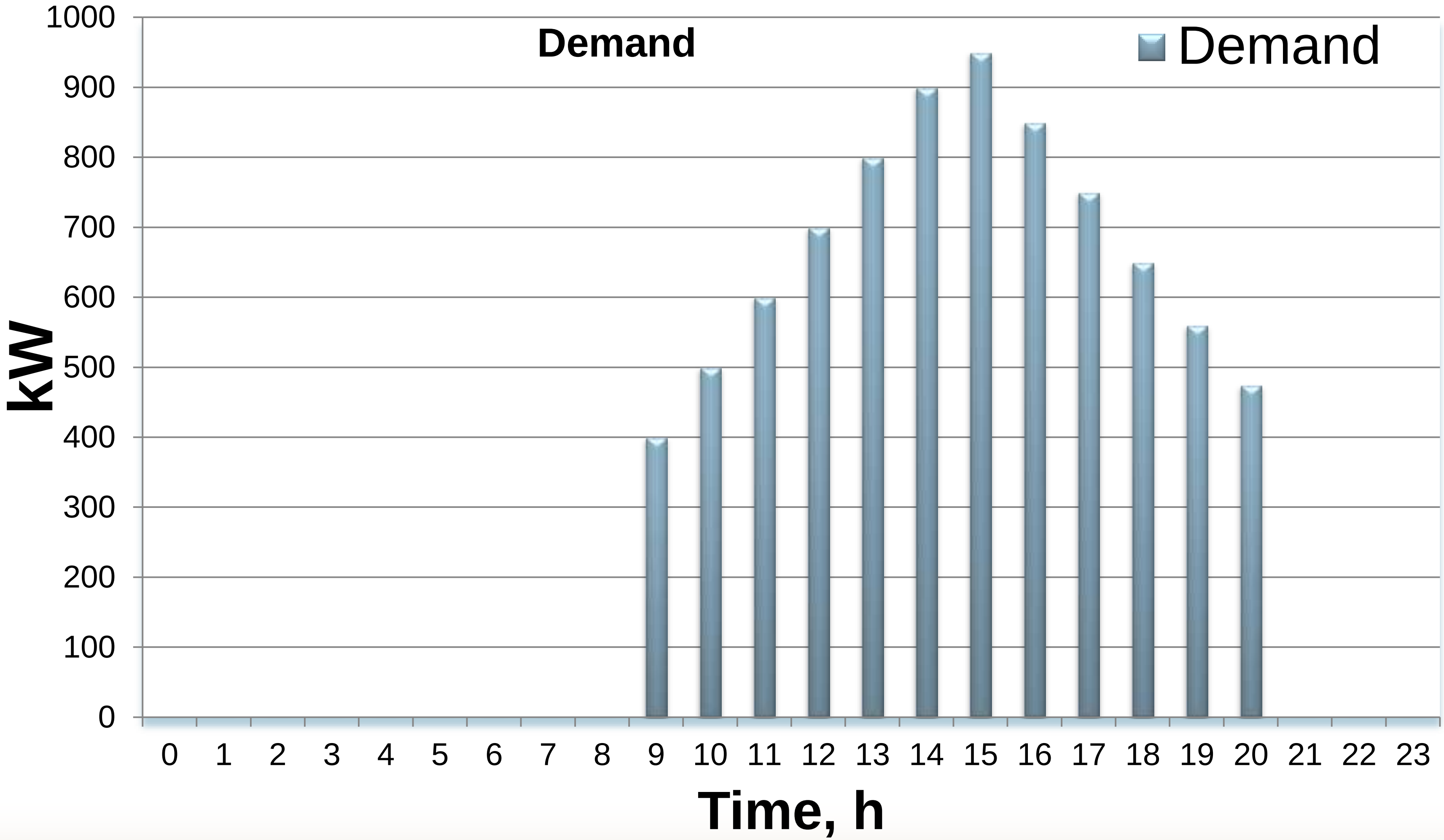
How Thermal Energy Storage work?



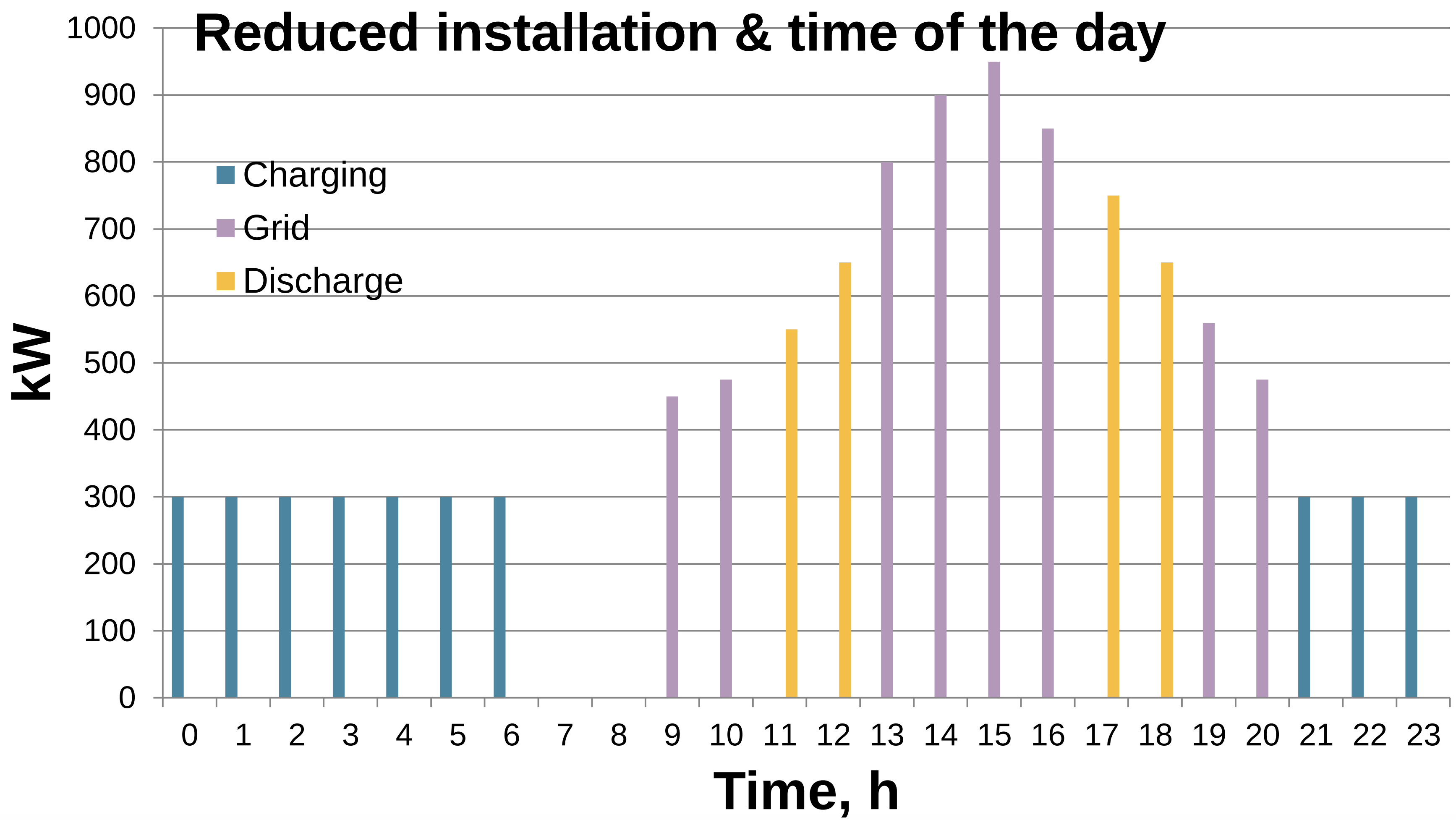
Energy stored as function of temperature



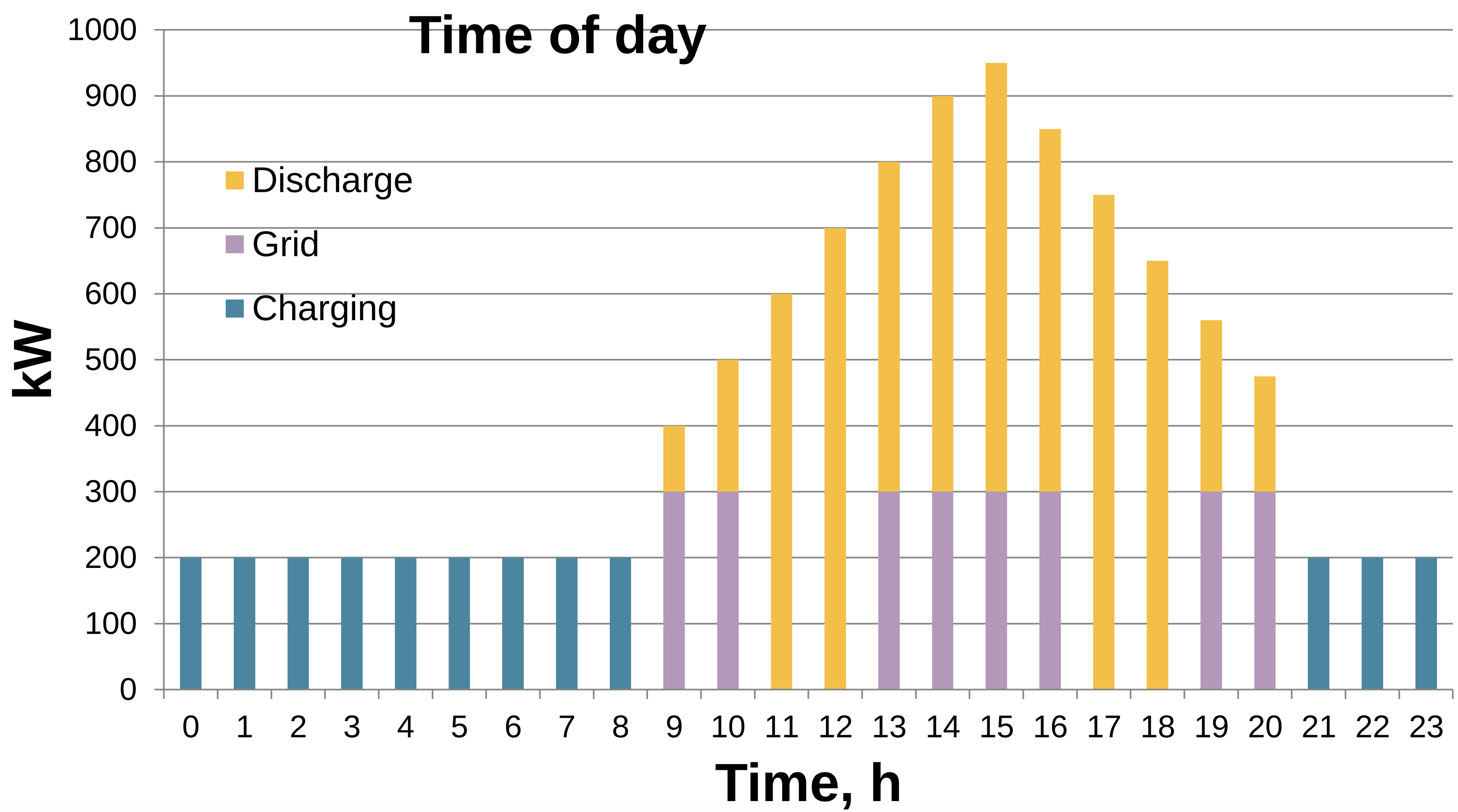
Demand pattern of a typical load



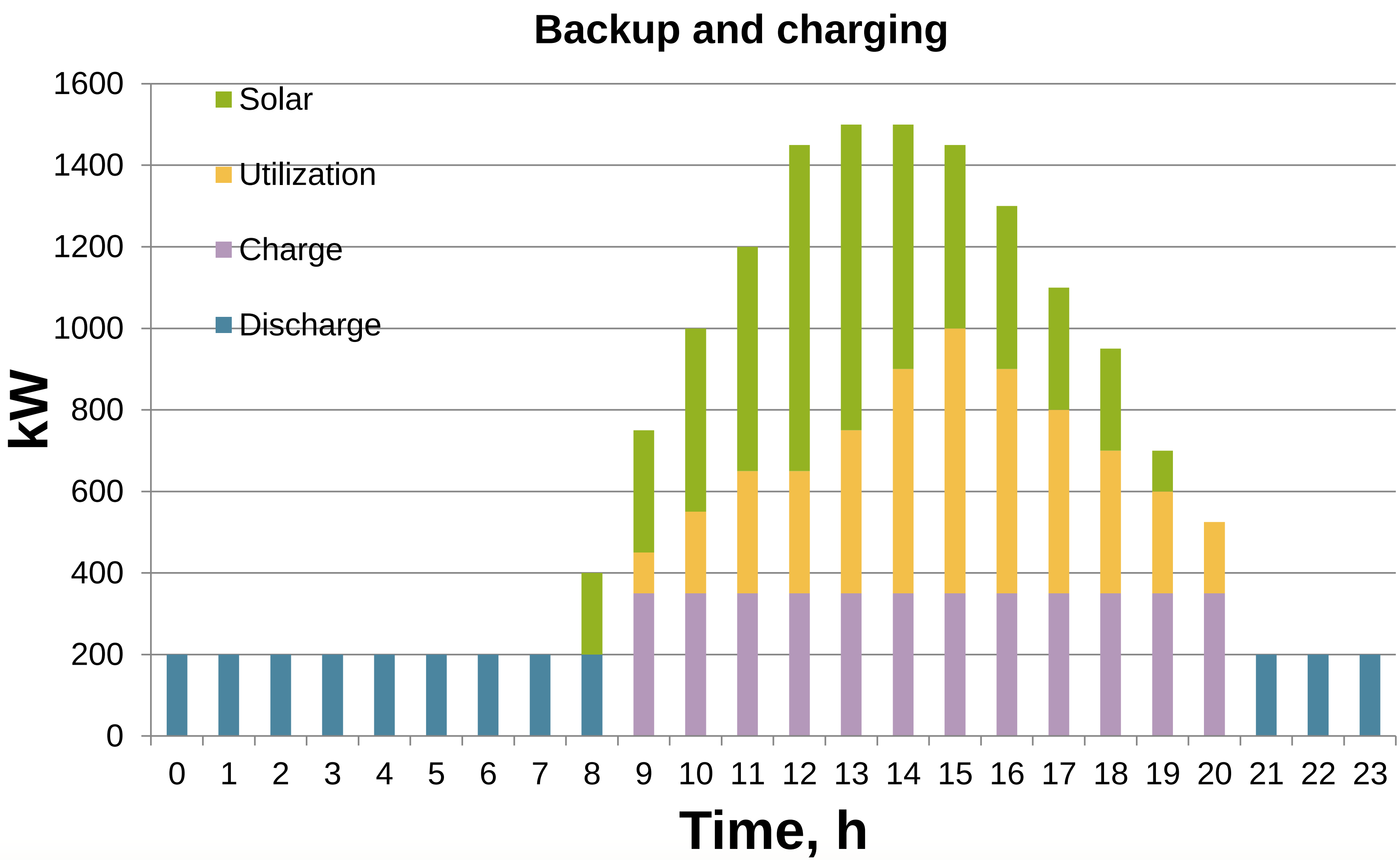
Storage utilization during Time of Day



Storage utilization during Time of Day



TES using 24 hours operation of CST



TES through chemical reactions

Absorption technology – absorption of water/NH_3 by LiBr/water in a vapour absorption machine. The machine can be driven by high grade heat from solar thermal/waste heat from conventional power generation.

Adsorption technology - Adhesion of a substance on surface of another solid/liquid can be used to store heat and cold. Such as adsorption of water vapour on silica-gel or zeolites (i.e. micro-porous crystalline alumino-silicates). Works at as low as 70-80 °C. This also helps control humidity. Zeolites are useful in WHR and also to convert heat into cold i.e. dessicant cooling

Metal Hydrates - Storage of energy in the form of metal hydrates at ~300 °C

Few application of TES in Solar Energy and Energy Efficiency

PCM storage can be used in the following types of applications:

1. CSP plants – operation during night
2. Thermal power plants – collection of heat for productive use
3. District heating and cooling
4. Trigeneration – storing heat for use during peak hours
5. Air conditioning
6. Industrial process heat
7. Cold storage, cold chain, and so on

Comparison of storage materials

Storage type	Energy density kWh/t	Power MW	Efficiency %	Period	Cost Rs/kWh
Sensible (water)	10-50	0.001-10	50-90	days – month	10 - 100
PCM	5-150	0.001-1	75-90	hours - month	100 - 500
Thermo-chemical storage	120-250	0.01-1	75-100	Hour - day	100 - 8000

Advantages of using thermal energy storage

Reduced	Increased	Challenges
Peak demand, size of equipment	Overall efficiency, utilization factor	Selection of suitable material
Primary energy consumption	Reliability,	Integration with existing system
Electricity demand charges and energy costs	Better control of the system	Optimization of the system
Supply and distribution system	Backup and easy switching peak and non-peak	Heat transfer during charging-discharging
Refrigerant use	Share of RE	
CO_2, So_x, NO_x emissions	Huge financial savings	
Low noise	Use off peak electricity	

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