Air Conditioning with Thermal Energy Storage

An Online Continuing Education Course for Engineers

Course Number: HV-4005

Credit: 4 Hours / 4 PDH / 4 CPD

Air -conditioning with Thermal Energy Storage

Abstract

Thermal Energy Storage (TES) for space cooling, also known as cool storage, chill storage, or cool thermal storage, is a cost saving technique for allowing energy-intensive, electrically driven cooling equipment to be predominantly operated during off-peak hours when electricity rates are lower. TES may be considered as a useful tool to reduce the number of refrigeration machines by means of spreading the daytime load over 24 hours period. Hence, any type of TES systems can be considered as useful tool to reduce the overall environmental impact for a given cooling application.

There are many different types of cool storage systems representing different combinations of storage media, charging mechanisms, and discharging mechanisms. The basic media options are chilled water, ice, and eutectic salts. Chilled water uses rely solely on the sensible (i.e., no phase change or latent energy) heat capacity of water and the temperature difference between supply and return water streams going to and from the cooling load. Ice systems and eutectic salts use only latent heat associated w/ freezing and melting. The difference lies in the heat absorbing capacity.

This 4-hr course provides the overview of Thermal Storage Systems and is divided into 5 sections:

PART – I Overview of Thermal Energy Storage Systems

PART – II Chilled Water Storage Systems

PART – III Ice Thermal Storage Systems

PART – IV Selecting a Right System

PART – V District Cooling System

PART – I OVERVIEW OF THERMAL ENERGY STORAGE SYSTEMS

Thermal energy storage (TES) is a method by which cooling is produced and stored at one time period for use during a different time period. Air conditioning of buildings during summer daytime hours is the single largest contributor to electrical peak demand. Realistically, no building air conditioning system operates at 100% capacity for the entire daily cooling cycle. Air conditioning loads peak in the afternoon -- generally from 2 to 4 PM -- when ambient temperatures are highest, which put an increased demand for cooling and electricity.

Electricity is a commodity that can not be stored economically while it is transmitted through grid and is consumed as it is produced. The electricity generation (MW) depends on the downstream consumption, which is generally at peak (maximum) during afternoon and evening hours and low (lean) at nights and morning hours. While the utilities are committed to deliver the peak demand by increasing their generation capacity, during lean periods when the demand is low, the power plants are forced to operate at low load factor. The low load factor implies that the generating plant will produce below its capacity implying hit on their return on investment and bottom line profits.

Utility companies attempt to minimize the impact of excess and idle capacity through Demand Supply Management (DSM) – a tool to improve the plant load factor through incentive programs and keeping tariff rate structures that penalize customers' poor load factors or exceeding demand limits. Most commercial customers are charged not only for the amount of energy they use, but also for the peak amount of energy they demand. In some places, the local utility provides really attractive rates to customers during night to encourage the electricity use during lean periods.

Building services must be designed to provide sufficient flexibility for load shifting and energy usage control in order to achieve the most economical operation. A Thermal Energy Storage technique whereby “Storing Low Temperature energy for later use in order to bridge the time gap between energy availability and energy use " can be considered as a useful tool to achieve this aim.

Here’s how TES Works

The concept behind TES is simple. Water is cooled by chillers during off-peak* hours and stored in an insulated tank. This stored coolness is then used for space conditioning during hot afternoon hours, using only circulating pumps and fan energy in the process.

Electrical costs peak during the day when demand is at its highest and is significantly less during evening hours when demand decreases. TES is considered to be one of the most preferred demand side management technologies for shifting cooling electrical demand from peak daytime hours to off peak night hours.

Terms

DSM- Demand Supply Management is an effort by utility companies to ensure energy optimization by ensuring the power generating plant operates at most efficiently at high load factor all the time.

What is demand charge? : Demand charge is a tariff added to a customer electric bill that increases in proportion to maximum kilowatts used. Many commercial customers pay a monthly demand charge in addition to electric bill based on the largest amount of electricity used during any 30-minute period of the month. TES moves heavy energy usage off-peak, reducing your demand.

Off-Peak: A time period, defined by the utility, when the cost of providing power is relatively low, because the system demand for power is low. The off-peak period is often characterized by lower costs to the customer for energy costs, and either no or low demand charges.

On-Peak: A time period, defined by the utility, when the cost of providing power is high because the system demand for power is high. The on-peak period is typically characterized by higher costs to the customer for energy and/or demand charges.

Advantages of Thermal Energy Systems

Thermal storage systems offer building owners the potential for substantial cost savings by using off-peak electricity to produce chilled water or ice.

A thermal energy storage system benefits consumers primarily in three ways:

1. Load Shifting
2. Lower Capital Outlays
3. Efficiency in Operation

1) Load shifting

Load shifting is primarily the main reason to install a TES system.

- Since TES works during off-peak energy you can take advantage of electrical utilities lower time-of-use rate.

- TES benefits in lower operating costs by saving money on electric bills and avoiding ‘on-peak’ demand charges.
- TES benefits on reduced demand for electricity during the peak demand periods. Many utilities offer cash incentives and rebates for installing or converting to TES.

2. Lower Capital Outlays:

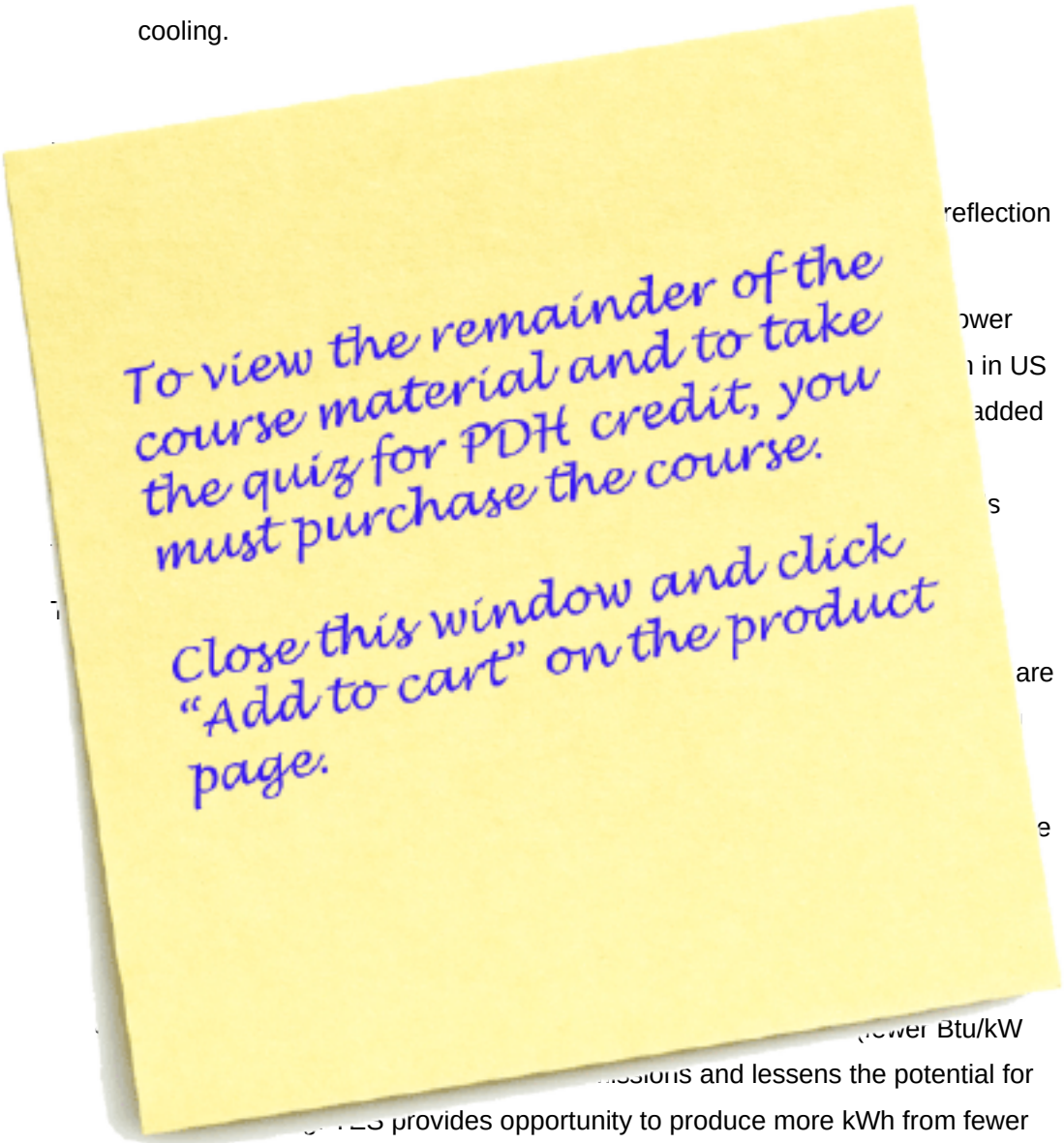
- Capital costs incurred are comparable to conventional air-conditioning system, with cost saved by using a small refrigeration plant. Storage systems let chillers operate at full load all night instead of operating at full or part load during the day. Depending on the system configuration, the chiller may be smaller than would be required for direct cooling, allowing smaller auxiliaries such as cooling-tower fans, condenser water pumps, or condenser fans. TES tanks allow a reduction of chiller capacity requirements. This is true for both new construction and system expansions. Lower equipment requirements translate to reduce maintenance needs.
- A TES system takes up less space and, when designed in conjunction with an air distribution system and installed during a building's construction phase, requires smaller ducts and fan motors. This can reduce spacing between floors and save you money.
- Optional fire protection advantages
  TES tanks are full at all times, availing a massive supply of water in case of fire. Engineers can design a tank to fulfill the dual service of cooling and fire protection. This however need permission of local fire authority and should meet the requirements of NFPA.

3. Efficiency in Operation:

- Conventional systems only operate at partial operating conditions most of the time. In contrast, the chiller used in a TES system operates at full-load conditions for a shorter period of time while the system is being charged. The equipment's operating efficiency increases. TES system chillers always either run in its full efficiency or not at all. In other words the chiller operation is not dependent on the varying load profile of the building.
- Additionally, because the stored cooling equipment typically operates at night when outdoor air temperatures are cooler, heat rejection is improved. The condenser always sees low ambient dry and wet bulb temperatures. The net

effect is usually a net decrease in kWh consumption; by anywhere from a few percent to a few tens of percent.

- TES system provides operational flexibility because the reserved storage capacity ensures enough buffers for varying loads of minimum and maximum demand. Chillers can be stopped during normal working hours for maintenance and service while the ice stored during off-peak period supplies cooling.



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ES provides opportunity to produce more kWh from fewer kW of operating capacity.

- Since thermal storage is displacing on-peak demand, less generating capacity must be maintained in reserve. This means the electric suppliers need not have to bring additional, more costly generating equipment on line to handle this increased demand.