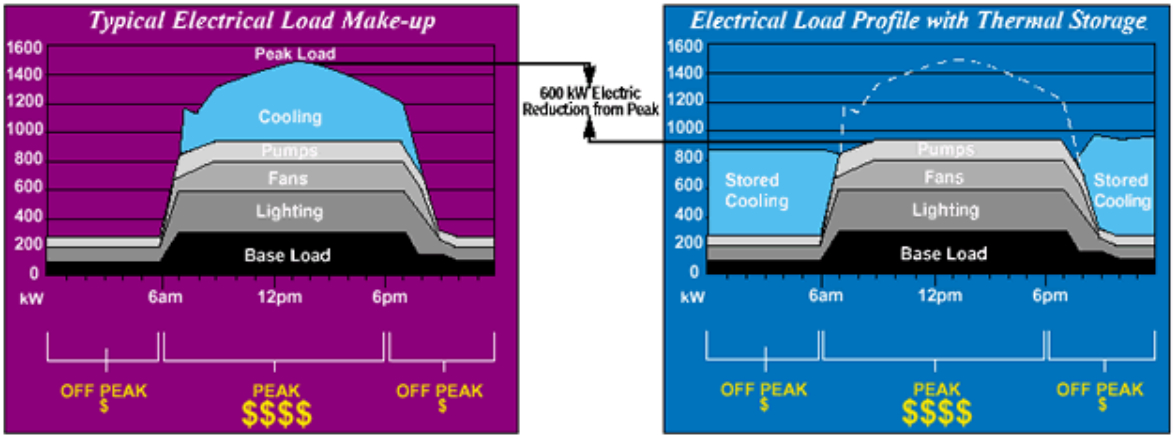
While You Were Sleeping: Thermal Energy Storage (TES)

Key Points

- Savings are realized by shifting the electrical load from day-time to night-time, when electricity is more plentiful and less expensive.
- Factory assembled modular ice making systems for Thermal Energy Storage (TES) have become economically viable in the last decade.
- TES is most attractive when the average cooling load is significantly less than the peak cooling load.

Thermal energy storage (TES) can be used to provide cooling capacity by extracting heat from a storage medium, such as ice or chilled water, during off-peak power times. Typically, a cool storage system uses refrigeration equipment at night to create a reservoir of cold material. Source energy consumption and emissions are typically less for night-time generation. Source energy savings average 14% for ice storage and about 20% for water storage according to Doug Reindell of the University of Wisconsin. During the day, the reservoir is tapped to provide cooling capacity. The two charts below (courtesy of CALMAC Manufacturing Corporation) show how cooling load is shifted from peak to non-peak times with a resultant 600 kW drop in peak demand (1,500 kW to 900 kW). At a demand charge of $8.00/kW, that saves $4,800 per month. Additional savings are possible if time-of-use rates result in a lower $/kWh energy charge during off-peak hours.



A TES application that shifts the entire load to off-peak hours is known as a Full Storage system and is driven by electric rates and rebates. Full Storage TES represents only about 5% of installations. Typically, when more cooling capacity is needed or when a chiller needs to be replaced, a smaller chiller combined with TES is added to complete a Partial Storage system. In this case, a much smaller chiller runs during both peak and off-peak hours with help from stored cooling during peak hours. This allows the chiller size to be decreased by 50 to 60% or more than normal. For instance, a normally 400-ton chiller outputting 3,000 ton-hours per day might be replaced by a 160-ton chiller producing 1,600 ton-hours during a 10-hour peak time period and 1,400 ton-hours during a 14-hour off-peak period.

As an example, Credit Suisse, an investment banking and financial services company, was recognized by New York State and City officials for installing New York City's largest ice-storage-based air-conditioning system. The system uses a modular product called IceBank, and is projected to lower the facility's peak energy usage by 900 kW. The savings are realized by shifting the electrical load from day-time to night-time, when electricity is more plentiful and less expensive.

Other case studies include the following:

- CBS Television City—Los Angeles, CA
- Marriott—San Francisco, CA
- Miami International Airport—Miami, FL
- Hospitals in CA, OK, FL, KY, MI, OH, NH, NC
- Schools in FL, MI, TX
- Federal Office Building—Chicago, IL
- Fossil Ridge High School—LEED Silver certified NC and 2008 ASHRAE Award Winner, Fort Collins, CO
- The University of Arizona
- Grossmont Hospital—La Mesa, CA

Ice and water are the two most popular options for cool storage media, and there are many variations of these systems. Ice is popular because it can absorb eight times the thermal energy of chilled water. For the ice systems alone, choices have to be made in how the ice is made and stored (ice on coil—internal melt, ice on coil—external melt, or encapsulated ice), how the ice bank is discharged, and how cold is transported to the load (slurry systems versus brine or glycol transfer).

Factory assembled modular ice making systems for TES have become economically viable in the last decade. Businesses such as office buildings, hospitals, shopping malls, churches, schools, and hotels are implementing TES. The economics are driven by several factors, including the lower night-time temperatures that allow refrigeration equipment to operate more efficiently than during the day, reducing energy consumption. Also, a Partial Storage system can enable the main chiller to be 40% to 50% smaller than conventional HVAC systems, because the chiller works in conjunction with the TES system during on-peak day-time hours. Downsizing the chiller means lower capital equipment costs. And, by using off-peak electricity to store energy for use during peak hours, day-time peaks of power consumption are reduced.

The DOE, in its article "Thermal Energy Storage for Space Cooling," suggests that TES can be especially attractive if the following conditions apply:

- Electricity energy charges vary significantly during the course of a day.
- Electricity demand charges are high or ratcheted.
- The average cooling load is significantly less than the peak cooling load.
- The electric utility offers other incentives (besides the rate structure) for installing cool storage.
- An existing cooling system is expanded.
- There is new construction.
- Older cooling equipment needs replacing.
- Cold air distribution benefits can be captured.

Suppliers of TES systems include Baltimore Aircoil Company, Calmac, Cryogel, EVAPCO Inc., FAFCO, Ice Energy, and others. Cryogel's approach involves "ice balls," which are plastic balls filled with water and frozen. This is a slightly different concept than the other ice generating techniques, but the company claims more than 18 million ice balls are shipped to various applications. In addition, the DOE describes an ice storage air conditioning module (called IceBear), engineered to upgrade existing air-conditioning equipment into TES systems.

Additional Information

Keeping It Cool with Thermal Energy Storage
