How TU Electric Helps its Customers Benefit from Thermal Cool Storage

THE RESULTS CENTER
IRT ENVIRONMENT

(Editor's Note: This article is abstracted from a report on thermal storage developments promulgated by TU Electric, an investor-owned, full-service electric utility which is the principal subsidiary of Texas Utilities Company. TU Electric leads the nation's utilities in the number of customers using thermal storage, with more than 205 systems developed to date.

FUNDAMENTALS OF THERMAL COOL STORAGE

Thermal cool storage relies on an inexpensive storage medium with a high specific or latent heat (such as water, ice, or eutectic salts) to store cooling produced during off-peak hours for use during peak hours. Refrigeration is provided by conventional chillers or industrial-grade ice-making units which charge the storage tanks during off-peak hours. On-peak cooling is provided by circulating chilled liquid from storage through the building's fan coils or a secondary heat exchanger. The two most common storage designs are chilled water storage and ice storage. Ice storage tanks have much smaller footprints and depths than chilled water tanks of the same cooling capacity.

System Design Options

There are a broad range of thermal cool storage system designs available. There are three basic types of chilled water storage tank systems: thermally stratified, diaphragm, and empty tank. Ice storage systems include ice building systems and ice harvesting systems. Ice building systems come in two types: ice-on-coil and brine systems. Ice harvesting systems also come in two basic types: dynamic ice harvesters and spray slush-ice systems.

Thermally stratified systems rely on the difference in buoyancy between warm and cold water to separate warm water to the top and cold water to the bottom of the storage tank. This system is the simplest and least expensive method of separating warm and chilled water. Because the difference in buoyancy between warm and chilled water is very slight, tank distribution manifolds and laterals must be designed to minimize the turbulence and mixing in the tank.

Diaphragm systems use a flexible rubberized cloth diaphragm to physically separate warm water and chilled water in the tank. Typically diaphragms divide the tank horizontally, and the diaphragm is usually attached to the tank wall at its mid-section and has enough slack to handle a fully chilled or fully warmed tank.

Empty tank systems use multiple tanks to segregate warm and chilled water. By drawing supply water from one tank and routing return water to another, both mixing and heat transfer between warm and chilled water are prevented. Such a system usually consists of three to ten tanks. Successive tanks are emptied as the bank of tanks is charged or discharged.

BACKGROUND:

Cool storage was first used commercially in the 1940s in buildings that only required cooling for limited portions of the day or week such as theaters, churches, and dairies. The goal of these applications was to downsize air conditioning and refrigeration equipment. As the price of air conditioning equipment dropped in the 1950s and 60s and central air conditioning became more popular, the primary incentive for employing cool storage shifted from equipment downsizing to energy cost savings and peak load management.

Thermal cool storage systems can be sized to shift all or part of the building's electrical demand for cooling from peak to off-peak hours. Storage sizing decisions are usually based on economic as opposed to technical factors. Thermal cool storage involves the use of conventional

HVAC equipment and a storage tank to shift the period of chiller operation in commercial buildings from peak to off-peak periods. By shifting electricity use to off-peak hours, cool storage benefits both utilities and their customers. Utilities improve load factors and off-peak sales, and customers lower their electric bills.

Thermal cool storage helps utilities reduce peak demand and fill load valleys, improving the utilization of baseload generating equipment, reducing reliance on peaking units, and improving load factors. By employing cool storage to stem peak demand growth, utilities can also defer capacity expansion costs.

Commercial electric rates typically reflect the utility's cost of generating power which at TU is highest during weekday afternoon peaks. Because conventional air conditioning uses power primarily during peak hours it is a major component of electricity costs. Use of cool storage allows commercial building owners to reduce peak demand and take advantage of the Time-of-Day rate option, thus significantly reducing utility bills.

As space cooling accounts for 30% of commercial sector electricity consumption and 44% of its summer peak demand, it is clear that potential savings from thermal cool storage are very high. High occupancy commercial buildings and other structures with large afternoon cooling "spikes" are the best candidate sites.

Cooling systems are typically measured in terms of "ton-hours" which is equal to the number of system tons times the number of hours that the system runs in a typical day. Thus a 3-ton chiller that runs 4 hours a day would require 12 ton-hours of storage. Thermal cool storage systems installed in a retrofit situation typically use the existing chiller. There are additional space requirements with a thermal cool storage system due to the storage tanks. A typical chilled water storage system requires 550 gallons per peak ton shifted, and ice systems typically use 1/4 the storage space of water storage systems. Chilled water storage systems tend to be tall and narrow, while ice systems are usually short and wide. (Note: A "ton" of cooling capacity—12,000 BTU/h or 3.516 thermal kW—is equivalent to the cooling effect obtained by melting a short ton (2,000 lb of ice in a 24-hour day, without warming the 32°F meltwater): it represents water's latent heat of fusion with no sensible heat added.)

IMPLEMENTATION

Marketing Cool Storage—TU Electric

During the late 1970s the utility recognized the need to address the increasing air conditioning load of commercial buildings. Thermal cool storage was seen as a promising means of flattening commercial air conditioning load shapes. However, initial efforts to interest builders in this technology encountered obstacles, and only a few new buildings included thermal cool storage in their cooling designs. While there were no utility cash incentives in place for thermal cool storage systems, commercial customers received lower electric bills based on their ability to reduce summer peak demand. Cheaper operating and maintenance costs and system efficiencies were the primary reasons for installation of the systems.

In 1980 two buildings under construction in Dallas utilized thermal cool storage systems. In addition to these two buildings, two other commercial buildings installed thermal cool storage systems before TU's incentive program was available. Thermal cool storage seemed to be the perfect solution to the utility's load management challenges in this particular sector and the technology has become more widely used throughout TU's service territory due in large part to the company's marketing efforts.

In 1981 the company realized that offering financial incentives would eliminate many barriers to installation of thermal cool storage systems. These barriers included a high initial system cost, a long payback period, and the large physical size of a thermal cool storage system compared to a standard system. The first thermal cool storage incentive was offered to InterFirst Plaza in Dallas. At the time it was to be the largest (1.8 million square feet) and tallest (72 stories) office building in Dallas. The incentive package included a one-time payment of $150/kW of summer peak demand savings along with a time-of-use demand charge with on-peak hours of noon to 8:00 pm. These incentives became the standard for the Thermal Cool Storage program.

To increase awareness of the program, presentations were made to architects, engineers, developers, and contractors. During 1982 and 1983, utility representatives made more than 180 presentations to 1,400 people. In 1983, of the commercial square footage with 300 kW demand or more, the thermal cool storage market share of new construction was 18%. By 1984 this figure reached 32%. From 1982-1988 approximately half of the installations were for new buildings, the other half for retrofits. After 1988 approximately 85% of the installations have been for retrofits.

Marketing Today

TU Electric focuses on marketing the concept and benefits of thermal cool storage and like most utilities that promote energy-efficient technologies through their DSM programs, TU does not sell any thermal cool storage equipment. For customers who are interested in thermal cool storage, equipment manufacturers present formal proposals that include costs and equipment options. The final decision on choice of equipment is up to the customer.

Marketing efforts are geared toward the three predominant parties in the thermal storage decision making process: the developers/owners, engineers, and architects. All three groups must be approached differently because they look at thermal storage from different perspectives. The developer is interested in the cost and payback of the system. The engineer is interested in the technical possibilities and consequences of thermal storage along with equipment options. The architect must be convinced that thermal storage is a worthwhile project enhancement that can be designed into the building.

TU field representatives market the program to customers and to trade allies (architects, engineers, equipment manufacturers and distributors) who are counted upon to help inform customers of the program. TU field representatives market thermal cool storage by explaining the benefits of thermal cool storage and customer incentives that TU offers.

TU also provides customer building audits which include an analysis of various HVAC system types along with system estimated operating costs. TU reps will help the customer determine the payback on a system's cost. Because thermal cool storage is not a widespread technology, TU tries to make several informative contacts with customers to encourage participation.

For new construction, effective marketing of thermal cool storage requires that TU initiate discussions as early in the design process of the targeted project as possible. While some potential customers are identified using Dodge data reports which track new residential and nonresidential construction on a city-by-city basis, some contacts are initiated by the developers/owners themselves. Many contacts for new construction projects are the result of the company's ongoing relationships with architects and engineers.

TU provides interested customers with a folder containing fact sheets and brochures that briefly explain all commercial & industrial cash incentive programs. TU will also arrange for interested customers to make on-site visits to thermal storage installations. Trade allies are informed about the programs through audio/visual presentations as well as program brochures. Periodically, TU sponsors technical training for HVAC dealers, thermal storage system operators, and architects and engineers.

DELIVERY

TU Electric pays case incentives to qualifying customers to help offset high initial capital expenditures (including associated labor costs) required for the permanent installation of thermal cool storage systems. These systems provide space and/or process cooling during on-peak periods (noon-8 p.m., weekdays, June through September).

Both new and retrofitted buildings qualify for program incentives. Furthermore, partial storage systems that are expended to take additional load off-peak receive incentives based on the added kW shifted. In instances where a thermal storage system is intentionally oversized to account for planned future expansion, the customer is eligible for the full cash incentives only upon completion of the expansion.

In 1993, TU Electric's thermal cool storage program offered $250/kW for the first 1,000 kW of shifted demand plus $125/kW for all remaining kW shifted. Incentive payments for 1993 were limited to either the above-mentioned incentive schedule or the customer's capital investment minus one year's estimated electric bill savings, whichever was lower.

Qualifying customers must have a payback exceeding one year. Incentive payments are based on shifted demand to off-peak hours. In addition to cash incentives, thermal storage customers may realize additional savings by taking advantage of the Time-of-Day rate option. The Time-of-Day rate option is available to customers who shift electricity use from on-peak hours to off-peak hours.

Currently TU Electric is not planning on providing upfront financing for this program to help customers with high initial system costs. Plans are in the works for other nonresidential and residential programs to include financing mechanisms. It is evident that some potential customers have been discouraged from installing thermal cool storage systems because of their high initial cost. Although TU does not provide equipment loans, some equipment installers do.

Before incentive payments are made, a TU representative verifies the installation of equipment along with the cost of installation. After verification, one half of the incentive payment is made. The remaining incentive payment is made after the end of an entire on-peak (June through September) operating season. The second payment is adjustable, based on the actual kW savings compared to the originally projected kW savings.

Control of the actual operating hours is left up to customers, but customers must follow TU guidelines in order to be eligible for the Time-of-Day rate option.

The actual installation process is rather complex as the building load must be analyzed before thermal cool storage equipment can be sized and installed. It is much easier to analyze building load for new buildings, with the process taking about two weeks. Analyzing load size for existing buildings may take as long as six weeks if no building plans are available and field measurements are required. After load size is determined the equipment manufacturer begins the design process for the thermal cool storage system. Installed systems can either be packaged or custom, although the large majority are custom. The actual installation of the tanks and complete storage system can take anywhere from a few months to an entire year. The size of the systems installed through the TU program ranges from 20 ton-hours to 25,739 ton-hours, with systems averaging between 3,000 and 4,000 ton-hours.

For customers who participate in the Thermal Cool Storage program, TU also offers a Thermal Storage Pilot program which has been in effect since 1992 and is not retroactive to existing thermal storage installations. This program targets commercial and industrial customers. In 1993 the pilot program offered an additional $50/kW for all kW shifted to customers who agreed to operate their thermal storage system on a prearranged schedule on an annual basis. Actual operation of the equipment is determined by the customer's annual internal cooling requirements. During the on-peak months (June through September) the system will be operated in accordance with the Time-of-Day rate option. During the off-peak months (October through May) part or all of the system charging will occur between midnight and 6:00 a.m.

CASE STUDY: TEXAS INSTRUMENTS

Texas Instruments (TI), one of TU Electric's major industrial customers, wanted to reduce the operating costs of a 4,200-ton cooling system located at a 1.1 million square foot Electro-Optics manufacturing facility. TU recommended thermal cool storage as the most cost-effective technology. After TU convinced Texas Instruments of the operating efficiency of such a system, TI installed a 24,500 ton-hour naturally stratified cylindrical chilled water storage system. Installation of the system as a retrofit project took 9-1/2 months.

This thermal cool storage system allows TI to reduce its peak demand by 2.9 MW. The system cost Texas Instruments $1.6 million and annual energy bill savings were projected to be $240,000. With the $610,500 incentive paid by TU Electric, TI calculates a simple payback of four years.

"During its first year of operation, the system was 100% reliable, and its performance and savings exceeded our expectations," said Don Fiorino, Texas Instruments.

ABOUT IRT/THE RESULTS CENTER

This report on Thermal Cool Storage is abstracted from a profile developed by the Results Center, which is part of IRT Environment, Basalt, Colorado. The profile is one of a series on the most effective energy efficiency programs in North America; they are intended to provide a thorough understanding of the unique elements of successful utility activities.

Through the Results Center's profiles, utilities have access to detailed information on a variety of planning, design, and implementation activities. The Results Center was formed in 1992 to publish profiles on highly successful energy-efficient efforts. Contact Ted Flanagan, c/o IRT Environment, P.O. Box 2239, Basalt, CO 81621, USA. (970) 927-3155; Fax (970) 927-9428.