District cooling gets hot

Utilities across the country are adopting cool storage methods, such as ice-storage and chilled-water tanks, as an economical and environmentally safe way to provide cooling for cities and towns. **By Robert S. Seeley**

The use of district cooling, in which cold water or steam is pumped to absorption chillers and then to buildings via a central community chiller plant, is growing strongly in the United States. In Chicago, San Diego, Pittsburgh, Baltimore, and elsewhere, independent district-energy companies and utilities are refurbishing neglected district-heating systems and adding district cooling, a technology first developed approximately 35 years ago.

District cooling offers both economical and environmental advantages. The method cuts electrical loads and operating costs when a building no longer runs its own chillers. "It eliminates the equipment, labor, materials, and operating hassles of on-site chillers, cooling towers, and associated equipment," said Mark Spurr, a district-cooling consultant with Resource Efficiency Inc. in St. Paul, Minn. "The building owner can operate with a smaller maintenance workforce." District cooling also gives building operators an alternative to replacing or modifying their chlorofluorocarbon-based chillers as that technology is being phased out.

The environmental benefits of district cooling are also significant. The average fossil-fuel or nuclear power plant operates at 30-percent efficiency, according to Thomas R. Casten, president and chief executive officer of Trigen Energy Corp. in White Plains, N.Y., which owns and operates 12 city district-energy systems and supplies district cooling in many of them. By applying cogeneration with district heating and cooling, Casten said, Trigen facilities can convert between 55 and 90 percent of their fuel to electricity, steam, hot water, and chilled water. At the same time, he added, Trigen facilities produce less than half the pollutants of conventional generation. "We compete with someone who makes electricity in a central plant and throws 70 percent of the energy away in the river or up the stack."

Robert S. Seeley is a technical writer who covers industrial and energy issues.

The rise of cogeneration and independent power during the past 15 years have created independent district-energy companies that have refurbished old utility district-heating systems. Since 1980, the number of district-cooling systems in the United States has grown from 59 to more than 100. Electric utilities, facing impending deregulation, are jumping into district cooling as a strategy to retain customers and sell off-peak electricity.

"These are exciting times, with the growth of new district-cooling systems and the expansion of existing systems," said John Fiegel, executive director of the International District Energy Association (IDEA) in Washington, D.C. "When district-cooling systems go in, we've seen almost exponential growth. Once a building's neighbors see it receiving reliable, efficient comfort, a district-cooling system grows fast."

Building owners are increasingly interested in outsourcing the heating, cooling, and energy-management parts of their operation to an expert in the field. "By signing a multiyear contract, the building owner gets round-the-clock expert cooling-system management that individual buildings can't match," said Casten.

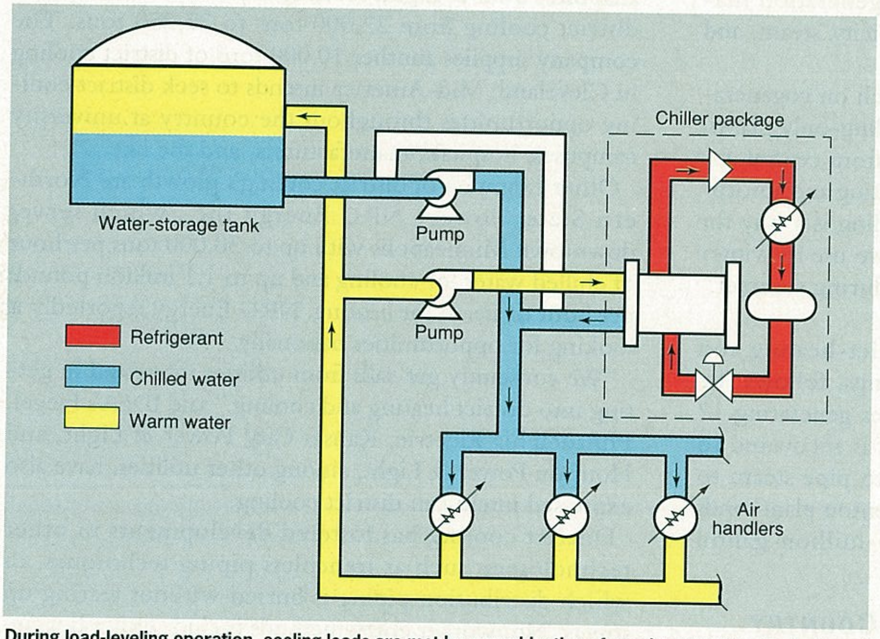
Ice-Storage and Chilled-Water Tanks

Advances in technologies such as cool storage (ice-storage and chilled-water tanks), trenchless piping, better meters and heat exchangers for district coolers, and pre-engineered connection packages between the district system and the building have also contributed to the growth of district cooling in the United States.

Cool storage has been a prime innovation. Chilled-water tanks and ice-storage tank systems have proliferated over the last 10 to 15 years. In ice storage, chillers freeze the ice at night in modular tanks about 7 feet tall and 6 feet in diameter. During the day, the melting ice provides cooling. Both methods run their chillers at night, taking advantage of off-peak electricity rates. The Electric Power Research Institute in Palo Alto, Calif., estimates that cool storage has shifted peak cooling loads by more than 300 megawatts in the United States through 1992.

Chilled-water tanks and ice-storage tanks enable building owners to downsize their central chiller plants and meet average loads rather than peak ones. "You partly offset the cost of thermal storage with the cost savings for investing in lower chiller capacity and cooling towers," said John S. Andrepont, director of IDEA and manager of product development for CBI Walker in Aurora, Ill., a company that builds chilled-water-storage tanks. Both storage techniques operate on low-cost electricity to run chillers at night, off-peak.

For example, Chrysler's Technical Development Center in Auburn Hills, Mich., installed a 68,000-ton-hour chilled-water tank and saved $3.6 million by reducing its installed chiller capacity from 17,700 tons to 11,400 tons. In operating costs, by taking advantage of off-peak electricity rates, the center saves nearly $1 million yearly in demand charges.



During load-leveling operation, cooling loads are met by a combination of supply water from the bottom of storage and from a reduced-capacity chiller plant, thus minimizing the chiller plant's size and capital cost.

There are differences between the two storage systems. Ice storage, Andrepont said, fits best in tight downtown areas because it allows smaller storage volume. "Ice stores energy as latent heat instead of sensible heat, so you extract more energy in a given unit volume, permitting a smaller storage volume." Water requires four to six times the storage volume of equivalent ice storage.

But on a large scale for multiple buildings, chilled-water storage costs less per ton than ice storage because it stores the cold in one big tank as opposed to ice storage's modular equipment, according to Andrepont. Chilled-water storage also incurs lower operating costs because chillers operate at a higher temperature. "Typical water-storage temperatures are compatible with conventional chiller temperatures, making it easier to retrofit to existing chiller capacity," he said. "Ice storage, on the other hand, needs low-temperature chillers."

Low-Temperature Storage

CBI Walker is innovating with low-temperature chilled-water storage, which shrinks the footprint of large water-storage tanks. At Chicago's McCormick Place Exhibition and Convention Center, Trigen-Peoples Energy Co.—a joint venture between Trigen Energy and Peoples Energy Corp., the gas utility in Chicago—commissioned CBI Walker for the largest chilled-water-storage and lowest-temperature tank ever built: 8.5 million gallons and a 123,000-ton-hour capacity. It will provide cooling for the new South Hall, scheduled to open in September.

The McCormick Place tank boasts two firsts. Whereas water-storage tanks usually hold freshwater, the McCormick Place tank contains CBI Walker's noncorrosive brine solution, which enables the tank to meet the low-temperature air distribution (34°F) required by the new South Hall. Typical water-storage tanks stratify to a water temperature of 39°F, the point of maximum water density. Stratification means cold supply water lies in the bottom of the tank, and warmer return water lies on top, separated by a 2- to 3-foot thermocline.

"By using noncorrosive brine, we can change the relationship between density and temperature to store the supply water at the bottom of the tank at 30°F," Andrepont said. Trigen-Peoples runs the 30°F water through four heat exchangers, each of which can handle 5,000 gallons per minute, to keep a water-glycol solution circulating at 34°F to the air handlers in the new building. The large supply-to-return temperature differential helps reduce the tank's footprint to 127 feet in diameter and 90 feet high.

CBI Walker also increased the temperature stratification and thermal capacity by its proprietary design of tank internals, which introduce the water in and out of the tank. "The design allows us to put water into the tank and remove it without mixing the water, so the lower-density warm return floats on top of the higher-density cold supply water," Andrepont said. "The design minimizes turbulence that otherwise can mix the two temperature regions."

Earlier stratification attempts—such as erecting multiple tanks or separating the two thermal layers with a mem-