

Strata-Therm®

Stratified Water Thermal Energy Storage

CB&I Storage Tank Solutions

mcdermott.com

MCDERMOTT





Tank is partially underground

Our Unique Approach

We focus on delivering cost-effective customer solutions through our unique, true EPC approach – designing and building projects turnkey, self performing the work from concept to commissioning and providing a lump sum price for the project. Since the 1970s, CB&I Storage Tank Solutions has completed hundreds of thermal energy storage projects safely, on time, and with the highest quality standards.

Many customers draw upon our vast knowledge and extensive construction experience early in a project's development, allowing us to provide input, recommendations and project-specific solutions that deliver maximum long-term value.

Throughout our organization, every employee is committed to setting a leading example in all areas of Quality, Health, Safety, Environment and Security (QHSES). Taking the Lead with QHSES is a company-wide initiative that brings a single, united QHSES culture to our diverse workforce. We encourage our partners,subcontractors and clients to join us in the pursuit of outstanding QHSES performance.

We are focused on delivering customer solutions.

For any storage solution we can provide:

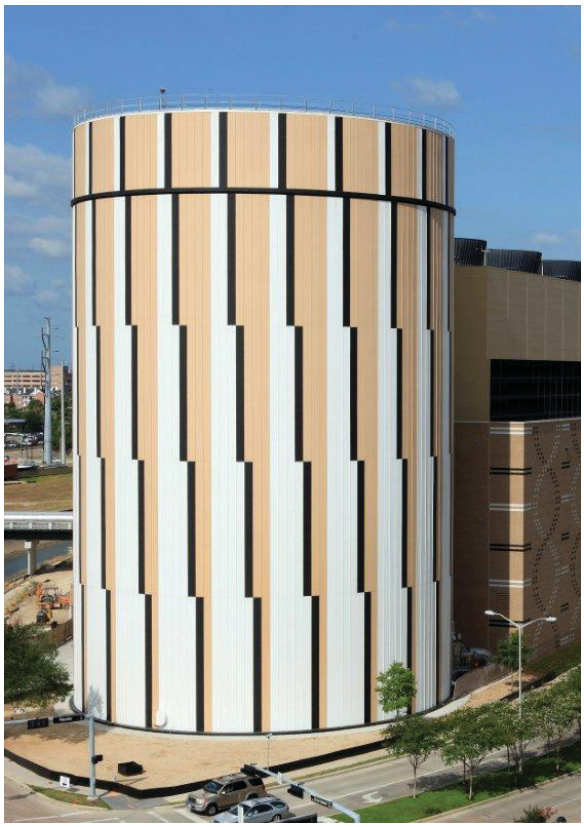
- Concept definition
- Sizing recommendations
- Budgetary assistance
- Design and detail engineering
- Procurement
- Fabrication
- Field construction
- Project management
- Inspection and testing
- Commissioning
- Startup

Thermal Energy Storage (TES)

Cost effective

TES is a capital cost saving solution for many large air-conditioning and process cooling systems. For new construction, retrofit expansions and chiller plant rehabilitation, TES reduces the necessary installed chiller plant capacity. In nearly all cases, TES reduces the daily operating costs of the facilities in which it is installed.



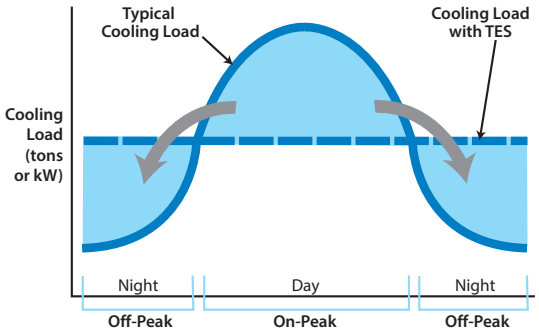


Energy efficient

TES is an energy cost savings solution for large air-conditioning and process cooling systems. TES minimizes electricity costs by shifting cooling production from high-cost, on-peak periods to low-cost, off-peak periods.

TES technologies for cool storage include chilled water (CHW) and low temperature fluid (LTF), in which thermal energy is stored as a temperature change in the storage medium. Choosing the best technology for an application is based upon several factors including desired system operating temperatures, available space, existing cooling equipment, capital costs and other factors, such as efficiency, simplicity and reliability.

Potential shift of cooling load



A Pioneer and Leader in TES

Since the inception of the industry in the 1970s, we have designed and constructed more chilled water TES systems than any other company in the world. Hundreds of our TES systems are in use today providing energy efficient solutions in a variety of countries and climates. We have provided systems ranging from 400 ton-hours to 269,000 ton-hours, including the world's largest (17.6 million gallons) at 160,000 ton-hours, shifting 20,000 tons with a single tank.

Typical applications

- Universities and colleges
- District energy utilities
- Primary and secondary schools
- Hospitals and medical centers
- Convention, sports and entertainment centers
- Power plant combustion turbine inlet air cooling
- Manufacturing and other industrial facilities
- Thermal process systems
- Data processing centers
- Defense facilities
- Airports



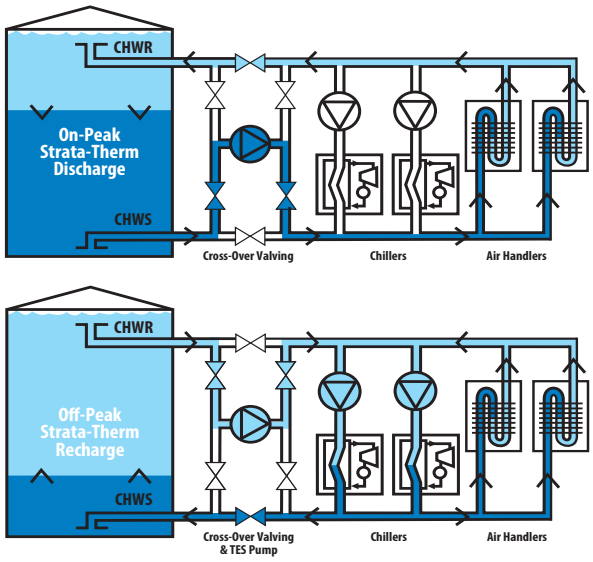


The Strata-Therm® Advantage

Strata-Therm thermal energy storage uses thermal stratification to separate low density warm (return) water above high density cool (supply) water in a single, economical tank. During peak cooling periods, typically in the afternoon, cool supply water is withdrawn from the bottom of the Strata-Therm tank, used directly in the cooling loop and returned as warm water to the top of the tank. During off-peak periods, typically at night, warm water is withdrawn from the top of the tank, then cooled using low-cost energy and returned to the bottom of the tank.

The advantages of a Strata-Therm system compared with conventional technologies include:

- Reduced capital and operating costs
- Improved reliability and flexibility
- Increased cooling efficiency using less expensive energy
- Reduced need for central plant generating capacity
- Expanded capabilities for simultaneous storage of fire protection water, cooling tower make-up water, or alternatively, stratified hot water
- Increased equipment utilization rates
- Ability to capitalize on electricity grid spikes associated with intermittent renewables such as wind and solar
- Superior maturity, performance and cost versus other energy storage technologies



Documented capital and operating cost savings

Application	Capacity (ton-hrs)	Capital Cost Savings	Operating Cost Savings
University Campus, Wash.	17,750	$1-2,000,000	$260,000/yr
Corporate R & D Center, Mich.	68,000	$3,600,000	$1,000,000/yr
District Cooling System, Fla.	160,000	$5,000,000	$500,000/yr





TES System Benefits

Economical and efficient

- Provides low installation costs utilizing above ground steel tank construction
- Minimizes the capacity and cost of chiller plant
- Typically coupled to centrifugal water chillers operating at conventional evaporator temperatures
- Can reduce annualized kWh/ton-hr by 5-10%

Highly reliable

- Has no moving parts and minimal maintenance downtime
- Provides long-term performance and zero leakage using all-welded steel tank construction
- Utilizes robust corrosion-resistant radial plate diffuser
- Employs only all-welded steel pipe – no plastic pipe

Flexible

- Compatible with virtually any type of water chiller
- Provides partial (i.e., load leveling) or full (i.e., load shifting) storage, maximizing demand side management options
- Stores optional patented SoCool® low temperature stratification fluid for stratified TES below 39º F
- Suitable for new and retrofit installations

Sample Sizes						
TES Capacity (ton-hrs) at Temp. Difference		Shell Height: 32 feet	48 feet	64 feet	96 feet	
		Soil Capacity: 2,000 psf	3,000 psf	4,000 psf	6,000 psf	
15º F Delta T (typical of chilled water)	**20º F Delta T (typical of SoCool fluid)**	**Volume (US Gal)**	**Diameter (feet)**			
1,000	1,700	120,000	25	20	–	–
2,000	3,400	230,000	35	28	24	–
3,000	5,000	350,000	43	34	30	–
4,000	6,700	470,000	50	40	34	28
6,000	10,100	680,000	61	49	42	34
8,000	13,400	880,000	71	56	48	39
10,000	16,800	1,100,000	79	63	54	44
15,000	25,300	1,650,000	96	77	66	53
20,000	33,600	2,050,000	111	89	76	62
25,000	41,800	2,750,000	124	99	85	69
30,000	50,700	3,250,000	136	109	93	75
40,000	66,700	4,400,000	157	125	108	87
50,000	83,600	5,500,000	176	140	120	97
62,500	105,000	6,900,000	196	157	134	109
75,000	126,000	8,100,000	215	172	147	119
100,000	168,000	10,800,000	248	198	170	137
125,000	210,000	13,600,000	277	221	190	153



Photo courtesy of DFW International Airport





SoCool® Low Temperature Thermal Stratification Fluid

Our patented SoCool fluid is used in place of plain water in a Strata-Therm TES tank to provide stratified storage and delivery temperatures colder than 39.40º F, the temperature of maximum density for plain water. This innovative fluid is an aqueous solution containing additives. When applied to air conditioning and process cooling systems, SoCool fluid can maximize the capacity or reduce the size of the TES tank, distribution pumps, piping and air handlers, while providing proven benefits of stratified TES. In addition, SoCool fluid provides long-term corrosion inhibition and microbiological control.

Some TES systems incorporate SoCool fluid from the very beginning, but many systems also are dual specified for future conversion from chilled water to SoCool fluid service.

TES for Emergency Cooling

Mission critical facilities, such as data centers, have become an important part of our information infrastructure. Safeguarding the data-storing servers is of the utmost importance. In emergency situations, TES is a reliable safeguard to protect against data loss associated with the failure of sensitive server equipment during cooling or power outages.

High powered servers often rely on chilled water systems to provide the significant amount of cooling required to keep their electronics from overheating. Server failure can occur within minutes after an unexpected power interruption or defunct chiller plant equipment, causing critical data loss. A TES system can take over as a reliable chilled water supply in the event of such an emergency, providing high discharge, short duration cooling until back-up power can be brought online. When sized accordingly, emergency cooling TES tanks can also serve as a source of emergency make-up water for cooling towers or even provide traditional load shifting where desirable.

TES and Combustion Turbine Inlet Air Cooling Systems

Turbine Inlet Cooling (TIC) systems are a proven, low capital cost technology that can boost summer peaking capacity of Combustion Turbines (CTs) by as much as 15-30% with heat rate improvements of 5% or more. When the ambient air temperature rises, CT output can decrease dramatically at the same time that electric power demand is highest. Cooling the inlet air allows the turbine to operate at or above rated capacity, but this introduces significant parasitic losses to the cooling equipment.

When TES is integrated into the chilled water TIC system, net capital cost can be dramatically reduced, while the parasitic losses can be shifted. The result is a crucial boost to electrical output to the grid at peak times. During these peak times, chilled water is removed from the tank and sent to the inlet air heat exchanger while warm water is returned to storage (requiring pumping power only). During night-time off peak periods, warm water is pumped from the TES tank to the cooling equipment and cycled back to the tank until recharge is complete.







Power-Therm™ Combustion Turbine Inlet Air Cooling System

In the power industry, our Power-Therm is a TES solution that provides low capital cost summer peaking capacity for open cycle combustion turbines (CTs) or on-peak enhancement of intermediate and base-load CT combined cycle (CTCC) power plants.

Global Capabilities

We are globally recognized and respected for having the resources to deliver thermal energy storage solutions anywhere in the world. Our operations are locally based, with dozens of offices worldwide having ready access to our integrated team of engineering, procurement, fabrication, construction and safety personnel.

Understanding governmental policies, labor requirements and the logistics of operating in various locations has contributed to the success of many of our projects. Localized knowledge has given us the ability to amass the most extensive and proven experience for TES tank projects. With numerous repeat customers, including many household names, and a wide variety of aesthetic treatment options, we are confident in our ability to provide our customers with the best TES system to suit their needs.

Proven Performance

Having designed and built hundreds of TES systems, including some of the world's largest capacity tanks, we have established a proven track record as an innovative leader in the global TES market. Our experience, technical capabilities and worldwide construction resources enable us to offer a wide range of TES storage solutions and superior results to our customers.

Those superior results are the end product of our business model – designing what we build and building what we design. We are competitive in providing the lowest total installed cost to our clients through our commitment to performing the turn-key scope required to deliver these energy-saving systems.



McDermott is a premier, fully-integrated provider of technology, engineering and construction solutions to the energy industry. For more than a century, customers have trusted McDermott to design and build end-to-end infrastructure and technology solutions to transport and process oil and gas into the products the world needs today. Our proprietary technologies, integrated expertise and comprehensive solutions deliver certainty, innovation and added value to offshore, subsea and downstream energy projects around the world.

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