SELECTING THERMAL STORAGE SYSTEMS FOR SCHOOLS

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ABSTRACT

Mesquite is a suburb located on the east side of Dallas with a population of approximately 120,000. The school district covers over 60 square miles with a student population of 25,000. The 34 schools consist of 25 elementary, 5 middle and 4 high schools, with one elementary under design. The school district facilities cover approximately 2.7 million square feet with an annual energy budget of $1.8 million (natural gas and electric).

Utility Rates:
Electric - Texas Utilities Company MS Rate $15/mo per meter + KWH charge. On peak monthly average (June 89 thru September 89) $.0676/KWH. Off peak monthly average (October 89 thru May 90) $.0481/KWH.

Natural Gas - Lone Star Gas Company - September 88 thru August 89 monthly average $4.41 MCF.

The outdoor design conditions of the Dallas, Texas area as taken from the ASHRAE Handbook 1985 Fundamentals Volume are: Summer - 100^{o} D.B. and 78^{o} W.B. and Winter - 18^{o} D.B.

ENERGY MANAGEMENT PROGRAM

During the early 1980's Mesquite Independent School District (MISD) adopted an energy-efficient design concept for new schools built in the district. The features of the energy-conscious design concept include:

1. The use of Direct Digital Control.
2. Less than 5% area is glass.
3. The average U value is .05 BTU/ft^{2} - hr - ^{o}F.
4. Thermal storage heating and cooling.
5. Variable speed drives on pumping and ventilation air handling units.
6. Closed circuit cooling towers.
7. Four pipe heating and cooling systems.
8. Hydropulse boilers for domestic hot water and space heating.
9. Heat recovery on walk-in freezers and refrigerators.
10. Occupancy sensors for lighting and HVAC control.
11. Electrical distribution system broken down into HVAC, lighting, and miscellaneous loads with each load submetered.
12. All the meters and submeters can be remotely read through the energy management system.
13. All exterior lighting is high pressure sodium.
14. All interior lighting is 34w fluorescent with energy efficient or electronic ballasts.
15. District Energy Management System.

Schools Occupied or Under Construction Using the MISD Design Concept

SCHOOL	SQUARE FEET	DATE OCCUPIED
Kimball E.S.	32,200	10/85
Kimball (Add)	9,991	9/88
Poteet(I & II)	114,642	6/86
Poteet(III)	78,600	9/88
A.C. New M.S.	93,780	8/87
Pirrung E.S.	36,065	9/87
Cannaday E.S.	45,438	9/88
Black E.S.(Add)	11,553	9/88
Austin E.S.	45,438	9/89
N.Mesquite HS	247,631	9/89
Pirrung (Add)	19,300	9/90
Moss E.S.(under design)		9/92

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Each of these schools utilize the following types of thermal storage:

Static Ice Builder:
- Kimball E.S.
- Pirrung E.S.

Chilled Water:
- Poteet H.S.
- North Mesquite H.S.

Dynamic Ice Harvester:
- AC New M.S.
- Cannaday E.S.
- Black E.S.
- Austin E.S.
- Moss E.S.

Cash Incentive Payments

The following cash incentive payments have been received, or will be received, from Texas Utilities Electric Company for Thermal Storage Projects since 1985:

SCHOOL	KW REDUCTION	AMOUNT
Kimball E.S.	71	$ 17,750
Poteet H.S. Phases I & II	210	52,250
AC New M.S.	184	64,400
Pirrung E.S.	76	26,600
Poteet H.S. Phase III	140	49,000
Kimball E.S. Phase II	20	7,000
Black E.S.	37	12,950
Cannaday E.S.	90	31,850
Austin E.S.	94	32,900
N. Mesquite H.S.	480	140,000
Total	1,402	$434,700

DR. RALPH H. POTEET HIGH SCHOOL

A project description of Poteet High School is that of a totally integrated energy conserving concept utilizing a weather impervious envelope, minimal internal loads, and highly efficient mechanical systems coupled with heating and cooling thermal storage to generate, store, and distribute thermal energy in the most efficient and cost effective manner.

By utilizing occupancy sensing equipment all elements of the energy consuming environmental comfort systems of the facility respond instantly to the utilization desires of its occupants never necessitating preplanning for equipment operation or seasonal operating mode selection. More importantly, all energy consuming equipment is automatically de-energized within a few minutes in the areas that occupants leave. The systems are so effective that a single individual can go to his or her office after hours without prior arrangements with total facility energy consumption only increasing proportionately.

A detailed listing of all the specific features are as follows:

I. Envelope

Less than 5% thermal glazing, average U value for walls and roof is 0.05 with vestibules on all entrances with radiant heating.

II. Electrical Systems & Equipment

A. Variable frequency drives on chiller, cooling tower fans, chilled water distribution pump and ventilation air unit.

B. High pressure sodium fixtures used on all exterior lighting.

C. Electrical distribution is divided according to function and submetered for HVAC loads, lighting loads, and process loads.

III. Mechanical Systems & Equipment

A. Chilled Water Storage Tank - 280,000 gallon concrete vertical stratification without separation. Temperature measurement at six equally spaced elevations. Charged by chiller or hydronic vent cycle.

B. Hot Water Storage Tank - Concrete lined steel 17,000 gallon with four headers arranged for dual temperature storage.

C. Chiller - Variable frequency drive, 196 ton rated at 38° F. Sized for full site development peak day load.

D. Boilers - Pulse fired high efficiency units sized for continuous operation at peak requirement. 440,000 BTU/HR output.

E. Closed Circuit Cooling Tower - Operates in three modes. Rejects heat from chiller, generates cooling effect for facility directly or indirectly through charging of chilled water storage tanks.

F. Distribution Pumping - Variable frequency drive heating and cooling pumps controlled to maintain proper differential across system load elements. Hot water pump operates below 70° F during occupancy periods or for facility warm up cycle. Chilled water pump operates during occupancy or cool down cycle. System differential set points varied according to supply water temperatures and outside air conditions.

G. Ventilation - Variable frequency drive unit providing air to only the occupied rooms. Provides supplemental cooling anytime outside air is below 55° F. Supply temperature drops to 40° F before heating coil is controlled to maintain that minimum temperature. Gym and auditorium dampers are controlled for supplemental cooling. All ventilation is set for 5 CFM per occupant minimum.

H. Air Units/Fan & Coil Units - Units start automatically when area served is occupied.

I. DDC Control System - Controls equipment, provides system operation information, generates historical data files for meter readings and selected system points.

The greatest innovation of this project is its ability to utilize existing technology to enable the school district to efficiently cope with the current rising energy costs. The project is a 193,242 square foot high school containing classrooms, a gymnasium and a fieldhouse. The electrical systems feature high efficiency motors and variable frequency drives on the chiller, cooling tower fans, distribution pumps, and the ventilation air units. The majority of the interior lighting uses 34 watt lamps and high efficiency ballasts. Occupancy sensors control the lighting and air conditioning units for most areas.

Both the cooling load and hot water requirements are satisfied from storage systems. The chilled water storage tank uses stratification and low velocity headers to store and utilize 280,000 gallons, which represents 130 percent of the maximum daily cooling load. The hot water storage tank has dual storage at 190° F and 120° F, the upper-level is filled from the boilers, while the bottom-level is filled by waste heat recovery from kitchen refrigeration units. The chiller is sized to recharge the storage tank during a 16 hour full-load period from 8 p.m. to 12 noon. To increase efficiency, a VFD for the chiller compressor takes advantage of lower night-time condensing temperatures rather than part-load conditions. A closed circuit cooling tower is used to reject condenser heat or to provide hydronic free cooling directly to the storage tank.

A School Built in Phases

The school complex consists of Phases I and II which have been occupied since June 1986, and Phase III which has been occupied

since September 1988. The future plans for the site are two more additions (Phases IV and V) when required by the area student census.

Phase I - 114,642 sq. ft. - two story academic wing, major mechanical equipment room, and hot and chilled water above ground thermal storage tanks.

Phase II - Gymnasium and Athletic Complex.

Phase III - 73,600 sq. ft. - Kitchen, Cafeteria, Library and Vocational Wing.

Future Phases - Approx. 112,000 sq. ft.:

Phase IV - Auditorium, Band and Choral Facility and New Administration Area.

Phase V - Two Story Academic Wing

When all five phases are complete the complex will be approximately 300,000 square feet. The major mechanical equipment and the thermal storage tanks were designed for the complete facility (300,000 sq. ft.) and installed under the Phase I project.

COMPARISON OF ENERGY COSTS FOR POTEET HIGH SCHOOL AND THE SCHOOL DISTRICT'S THREE OTHER HIGH SCHOOLS

(Data for comparison from electric & natural gas bills 9/88 - 8/89)

SCHOOL	BTU* SQ.FT/YR	$ SQ. FT/YR	SAVINGS COST	SAVINGS BTU
Poteet	40,029	.46	--	--
NMHS	56,491	.55	16%	29%
WMHS	57,948	.68	32%	31%
MHS	78,146	.77	40%	49%
Three H.S. Average	64,212	.67	31%	38%

*Site BTU Consumption Data was used in calculations.

MESQUITE INDEPENDENT SCHOOL DISTRICT HIGH SCHOOL HVAC SYSTEMS

POTEET - Occupied 9/88 - 193,242 sq. ft. Four pipe hot water and chilled water thermal storage system.

NORTH MESQUITE - Occupied 9/69 - 262,915 sq. ft. Area cooling and ventilating air handling units with room electric reheat.

WEST MESQUITE - Occupied 8/76 - 190,214 sq. ft. Two pipe hot/chilled water system with room diverting boxes (an early version of VAV boxes).

MESQUITE - Occupied 9/63 - 230,609 sq. ft. Two pipe hot/chilled water system.

ECONOMIC IMPACT

The concepts utilized in Poteet High School have unlimited transferability to all educational facilities. Since this facility can operate on an energy budget at least 30% below existing schools the economic impact is felt by all taxpayers in the school district.