Mechanical Breadth

Introduction

For the mechanical breadth work, an in-depth analysis will be performed on the integration of a Thermal Energy Storage (TES) system. A TES system dramatically reduces energy costs while protecting the environment by allowing energy-intensive cooling equipment to be operated during off-peak hours when electricity rates are the least expensive, while still providing a cool and very comfortable environment for occupants. Also, by using a TES system a building's load factor will be increased which can lead to the building owner negotiating lower energy prices with electric generation providers. Because of the reduction of peak electrical demand, an energy plant can produce more power at higher efficiencies and potentially avoid an expansion to the plant. It has also been shown that by producing more power during off-peak hours, an energy plant can create less greenhouse-gas emissions because of the increased efficiencies at off-peak hours. Even though medical facilities require air conditioning continuously for 24 hours a day, they are still great candidates for a TES system mainly because of the significant energy-cost reductions.

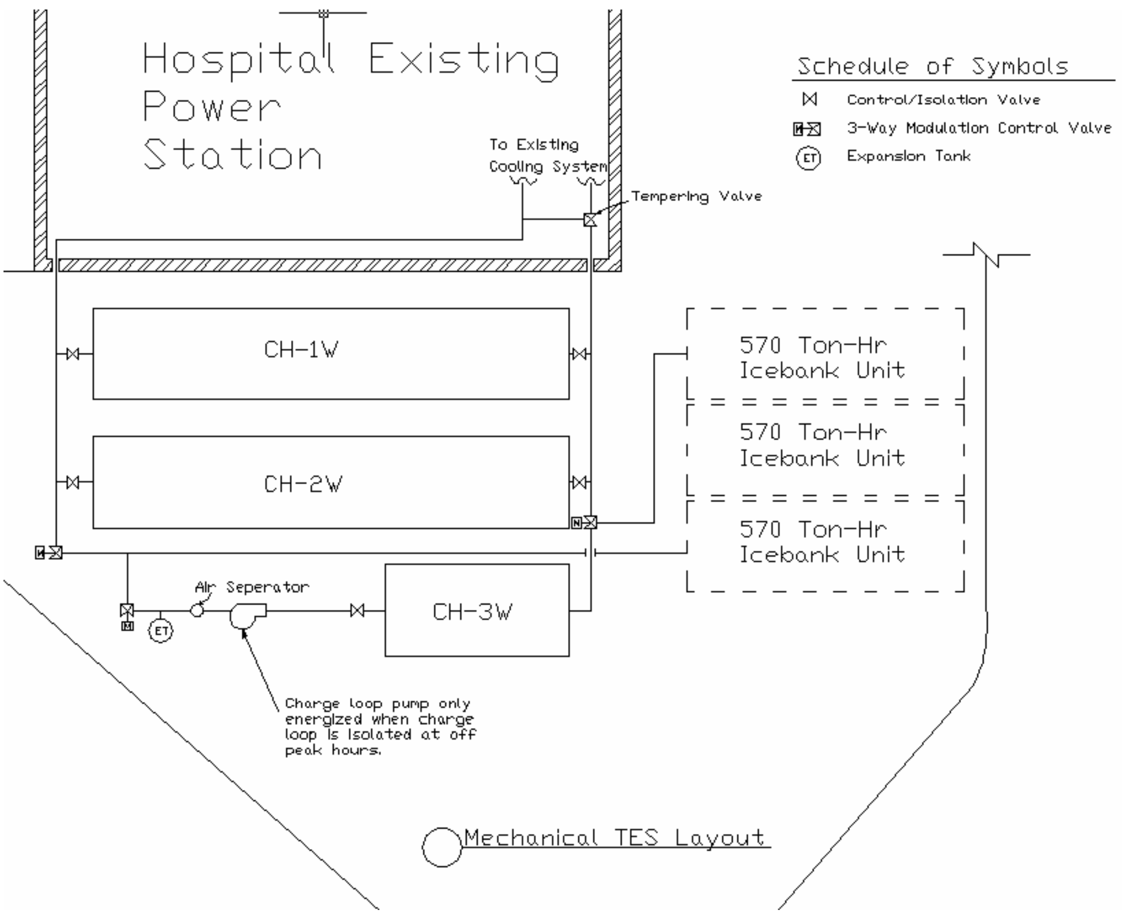
Design Concept

A TES system uses a standard chiller at night to produce solid ice during off-peak hours. The ice produced is then stored in a modular ice tank which is an insulated, polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. These ice tanks will then provide the cooling for the next day. First the system must be sized by finding the optimal amount of Ton-Hrs that can be shifted to off-peak hours. For this medical application, a partial storage system is optional, where a smaller chiller is turned on during off-peak hours in conjunction with the rest of the cooling system to charge the ice storage tanks. At night, the chiller will run water containing 25% ethylene glycol through the heat exchanger, which will extract the heat until about 95% of the water in the tanks is frozen solid. The next day the small chiller will be turned off and the stored ice will cool the water/ethylene glycol solution, along with the still running chillers, to the desired temperature by using modulating valves. By now you have to be thinking that these ice banks are probably huge, and will take up a lot of real-estate. Actually, ice banks are compact factory-made modular units that have no moving parts and no corrodible materials. Ice tanks can be located indoors or outdoors and can even be stacked or buried to save space.

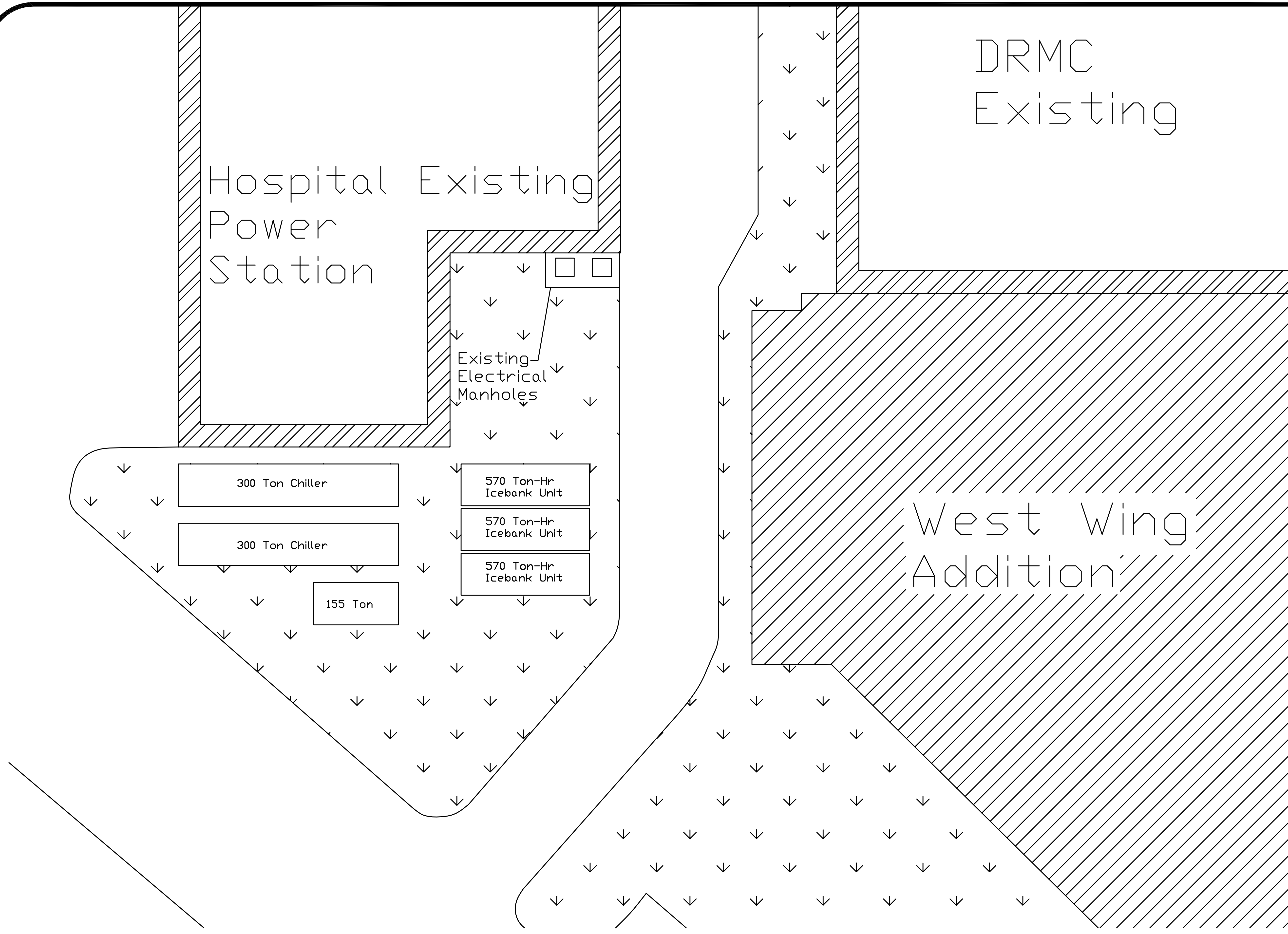
Design

Design Ton-Hrs = 8904
On-Peak Hours/Day = 12 hours
Chiller Capacity = 8904/12 = 742 Tons
Off-Peak Capacity = 600Tons
    Two 300 Ton chillers will be run at off and on-peak hours.
Available Charge Tonnage = 724-600 = 142 Tons
    One 155 Ton chiller will be run during off-peak hours.
Ton-Hr's Charged = 12 x 142 = 1704 Ton-Hrs
    Need three 570 Ton-Hr Icebank units for charge loop.

Mechanical Cooling Redesign



* See Appendix for Cutsheets*



SITE PLAN
Scale: 1/8" = 1'

General Notes

No.	Revision/Issue	Date

Firm Name and Address
Ben Ardary
Architectural Eng.
Penn. State University
State College, PA

Project Name and Address
DRMC
West Wing Addition
100 Hospital Ave.
DuBois, PA

Project: THESIS
Date: 4/2/2005
Scale: 1/8"=1'
Sheet: E-C1

Charge Loop Design:

Charge Loop Makeup

25% Ethelene Glycol

ρ (Glycol) = 1096.78 Kg/m^3

75% Water

ρ (Water) = 1000 Kg/m^3

ρ (Total) = 1024.195 Kg/m^3 = 63.9 Lb/ft^3

Cp= $63.9\frac{Btu}{kgR}$

Heat Transfer = 142 Tons x (12000Btu/hr)/1 Ton = 1704000 Btu/hr

Flow Rate = $\dot{V} = \frac{\dot{Q}(Btu/hr)}{\rho(lb/ft^3)Cp(Btu/kgR)\Delta T(R)} = \frac{1704000}{63.9*0.91*6} = 4884\frac{ft^3}{hr}$

$= 4884\frac{ft^3}{hr}*.12\frac{gpm}{cfh}$ **=586.08gpm**

Charge pump designed to run required gpm.

Use an 1150 R.P.M. close coupled centrifugal pump.

Pump will be run at 60 hertz.

See Appendix for Charge Loop Component Cutsheets

Sequence of Operation for Charge Loop

Associated 3-way motor valves and pump should be wired to internal time clock controlled by the BAS system. Off-peak time will be programmed to the time clock as well as on-peak return time. When the time clock reads off-peak start time, 3-way motor valves shall modulate to isolate the charge loop. Once loop is fully isolated, pump and chiller should energize. Loop will run for all 12 hours of off-peak time. When time clock reads off-peak, stop time pump and chiller shall deenergize. Once pump and chiller have fully deenergized, associated 3-way modulation valves shall modulate back to discharge position. When valves are in discharge position, ice storage units shall work in parallel with the two 300 Ton units to meet building cooling load. At part load conditions the tempering valve shall modulate to adjust water supply temperature.

Energy Analysis

The energy analysis assumes that the existing system would require energy equal to the amount used if all chillers were run at full load all year at off and on-peak hours. On-peak hours are Monday through Friday 8am till 8 pm and the rest are considered off-peak hours. Analysis will be on a per year basis.

Chiller Power Requirements:

CH-1W & CH-2W

P = Rated Amps x Voltage x Power Factor

P = 583A x 480V x .9 = 251.86 KW

CH-3W

P = 310A x 480V x .9 = 133.92 KW

KWH/year Without TES System:
Off-Peak
Total KW = [(2 x 251.86) + 133.92 = 637.64 KW
KWH/year = (637.64 KW x 12hr/day x 365day/year) + (637.64KW x 12hr/day x 2 day/wk x 52 wk/year) = **3,588,640 KWH/year**
On-Peak
KWH/year = 637.64KW x12hr/day x 5day/wk x 52 wk/year = **1,989,440 KWH/year**

KWH/year With TES System:
Off-Peak
Even though weekend rates are considered off-peak hours Chiller CH-3W will still cycle on and off every 12 hours.
All Chillers On
Total KW = 637.64 KW
Chiller CH-3W Off
Total KW = 2 x 251.86 KW = 503.72 KW
KWH/year = (637.64 KW x 12hr/day x 365day/year) x (503.72 KW x 12hr/day x 2 day/wk x 52 wk/year) = **3,421,510 KWH/year**

On-Peak
Chiller CH-3W Off
Total KW = 2 x 251.86 KW = 503.72 KW
KWH/year = 503.72KW x 12hr/day x 5day/wk x 52 wk/year = **1,571,610 KWH/year**

% Reduction in KW/year:
Without TES System = 5,578,080 KWH/year
With TES System = 4,993,120 KWH/year
% Reduction = (5,578,080 – 4,993,120)/5,578,080 **= 10.49 %**

Saving Due to Reduction in KW/Year:
Savings calculated from utilities generation and distribution charges.

DRMC's Utility Rage Structure – Penelec General Primary
Billed KW = $9.74/KW
ONKWH Charge = $0.004108/KWH
OFFKWH Charge = $0.00335/KWH

Without TES System
Generation Charge
Off-Peak = $0.0335/KWH x 3,588,640 KWH/year = **$120,219.00/year**
On-Peak = $0.0401/KWH x 1,989,440 KWH/year = **$79,776.50/year**
Distribution Charge
Off/On-Peak= $0.00011/KWH x 5,578,080 KWH/year = **$613.59/year**

With TES System
Generation Charge
Off-Peak = $0.0335/KWH x 3,421,510 KWH/year = **$114,621.00/year**
On-Peak = $0.0401/KWH x 1,571,610 KWH/year = **$63,021.60/year**
Distribution Charge
Off/On-Peak= $0.00011/KWH x 4,993,120 KWH/year = **$549.24/year**

Savings:
Total without TES System = $200,609/year
Total with TES System = $ 178,192/year
Savings = $22,417

Refer to Construction Management breadth for payback period for TES System.

Conclusion:

It was found that a TES system is an effective way for a hospital application to save a considerable amount on their electric bills. For this particular application a 155 Ton chiller was able to be turned off during on-peak hours. During these on-peak hours the glycol solution is diverted from the 155 Ton chiller through the Icebanks which pick up the lost cooling load. This particular TES system could reduce the amount of KWH used by the hospital by 10.49% and save the hospital owner about $22,500 dollars a year on his/her electric bills. The real question that needs to be considered now is whether the amount saved on electric bills is enough to cover the cost of the additional TES system. This question will be analyzed and answered in the Construction Management section of the report.