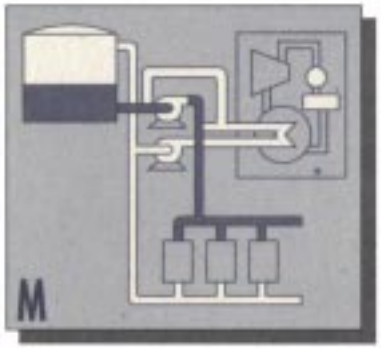

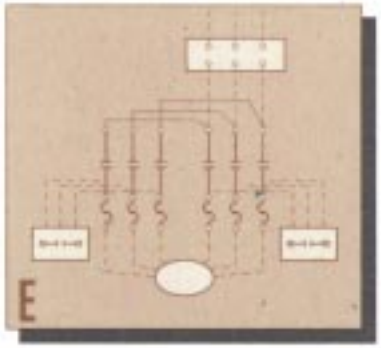

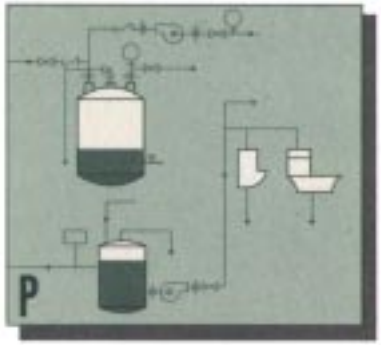

TEXAS DEPARTMENT OF MHMR

Terrell State Hospital

Terrell, Texas

Maintenance and Operations Report

Texas LoanSTAR Program

Maintenance Department

December 20, 1997

Terrell State Hospital - Administration Building

ACR ENGINEERING, INC.

Report Contents

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Print Report

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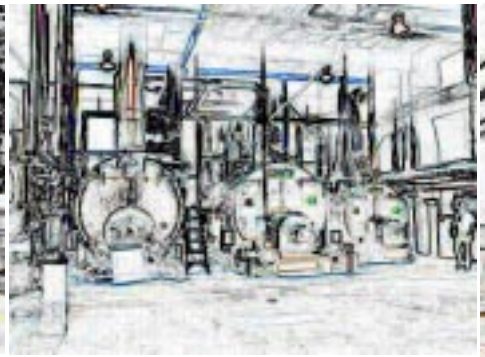
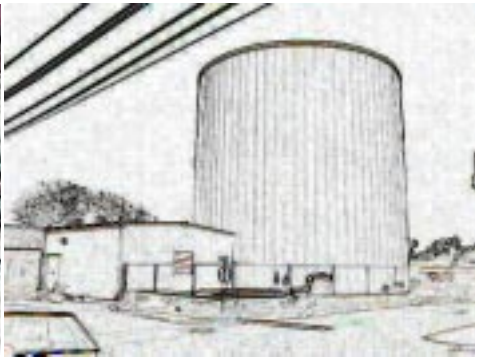
Terrell State Hospital's existing Energy Management Plan

Cover Page



Energy Savings



Thermal Storage System

INTRODUCTION

This report is not intended to be a "typical" O&M[1] report.

A typical O&M report addresses a "laundry list" of O&M's, usually directed towards specific pieces of equipment. It usually includes such things as fixing water leaks, plugging air leaks in air handlers, turning off specific equipment items when not needed, repairing broken equipment, caulking and weatherstripping windows and doors, etc. While this report does address many of these standard "laundry list" items, the main focus of the report is systemic administration, policy, and organizational issues. We believe the greatest potential for achieving energy savings at Terrell State Hospital will come from addressing these broader issues.

An "Operations And Maintenance" (O&M) item is typically defined as a work item which:

a) normally should be taken care of by maintenance staff as a routine part of their duties;
b) involves no or little out of pocket costs.

This definition leaves considerable room for interpretation. What is a "normal" part of the maintenance staff's duties? Do O&M's include items which take up a tremendous amount of the maintenance staff's time? How much money does a "little" cost encompass? For purposes of this report, we will interpret O&M measures in a broad rather than a narrow sense. We discuss some measures which are arguably not O&M's, and some which are clearly not O&M's, because we believe that the TSH administration should be aware of the full range of maintenance problems facing the hospital. Note that some listed O&M's have no direct dollar savings associated with them. These are items which, for example, should be implemented to provide backup control or monitoring for essential systems, or which will enable Maintenance to do their jobs more effectively and efficiently, etc.

We have divided this report into four sections:

ENERGY SAVINGS ACHIEVED TO DATE
Terrell State Hospital has recently completed energy efficiency projects under the State Of Texas LoanStar program. As the projects were quite extensive and expensive, it is important to evaluate the results in order to know how to proceed from here.

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ADMINISTRATIVE AND PROCEDURAL CHANGES
As stated, we believe there is very large potential for energy savings through administrative and procedural changes, and so we list this as a separate topic.

THERMAL STORAGE SYSTEM OPERATION
The thermal storage system, in operation at the hospital since July of this year, is granted its own section, since it plays an extremely important role in the effort to reduce energy costs, and failure to operate the system correctly can have disastrous consequences on energy costs.

INDIVIDUAL BUILDINGS O&M's
We end up the report with the "laundry" list of O&M items which were found by inspection of the buildings.

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ENERGY SAVINGS ACHIEVED TO DATE

In 1996, Terrell State Hospital (**TSH**) participated in the State of Texas LoanStar program, administered by the State Energy Conservation Office. An engineering analysis was performed for TSH energy-using systems, and a report was prepared which included cost / savings analyses for O&M projects and capitol expenditure projects. TSH then received a low interest loan for implementation of the energy efficiency measures identified in the LoanStar report.

The capitol expenditure projects which were implemented included the following:

1. Lighting Conversions	Old 40 watt fluorescent lamps were replaced with new 32 watt lamps; conventional magnetic core ballasts were replaced with electronic ballasts. Incandescent lamps in exit fixtures were replaced with LED lamps.
2. Electric Motor Conversions	High efficiency motors were installed in place of many standard efficiency motors.
3. Variable Speed Controllers	Variable speed drives were installed on certain air handlers and chilled water pumps.
4. Steam Trap Repair / Replacement	Most of the old steam traps on campus were replaced with new ones.
5. Piping Insulation	The majority of underground steam distribution piping had been uninsulated for several years; this piping was re-insulated.
6. Central Plant Boiler Replacement	Two new steam boilers replaced old steam boilers.
7. EMS Replacement & Extension	An extensive energy management system (EMS) was installed to control heating and air conditioning equipment automatically.
8. Convert AHU 'C' To 20% OA	Air handler C in M&S (Bldg. 673) was converted from a 100% outside air unit to one which brings in only 20% outside air.
9. New Chillers, Bldg. 686	New chillers and a new cooling tower were installed to replace old ones.

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10. Revise 4th Flr HVAC, Bldg. 673	The fourth floor M&S air handler was converted from a 100% outdoor air unit to one which recirculates air.
11. Convert DX Units To Chilled Water	Old direct expansion cooling units were converted to hydronic units in Buildings 537, 541, 682, 684, 691, and 725.
12. Thermal Storage	A 7,000 ton-hour thermal storage system was installed to reduce peak electrical demand.
13. Re-do Economizer Ductwork	Air handlers in Building 500 were converted so that their economizer dampers operated more effectively.

Work on these projects started in March 1996. Various stages of the project were completed throughout 1996 and 1997, with final completion of the last project, the thermal storage system, coming on-line in late June 1997.

TSH has seen significant reductions in energy costs since that time. On the following pages, we include graphs and spreadsheets comparing various energy parameters for the most recent twelve months versus the base year 1993-94 when the LoanStar report was done.

Nevertheless, energy and cost savings to date have fallen well short of projected savings. Savings estimated in the LoanStar report compared to actual savings are as follows:

Savings In	LoanStar Savings Estimate	Actual Savings [2]
Kwh/yr	4,908,013	2,746,080
MCF / yr	61,607	34,542
$ / yr	$515,149	$239,507

There are several reasons for the shortfall, some of which are discussed below.

- Demand savings from thermal storage system for 1996-97 were gained only in four months of the year; for seven months, TSH was charged a high "ratchet"[3] demand charge. A full years demand savings will not be seen until July 1998.

- Even in the four months in which thermal storage system savings were gained, savings were not as high as they could have been. Under Texas Utility's thermal storage rate schedule, peak kW demand charges for an entire year are heavily influenced by peak kW attained in the months of June through September. July '97 was the TSH thermal storage system's first month of operation; On-Peak demand was reduced to 1731 kW. While this is a considerable improvement over the 2,542 kW which would have been charged without thermal storage, it was still not as low as it could be. Maintenance was still getting used to the system and working out operational bugs. Today they are able to keep On-Peak demand to no more than 1500 kW . Unfortunately, the 1731 kW is the amount which will be used in calculating billed kW at least until June of 1998. Until that time, savings will be diminished.

- Not all LoanStar projects were completed and in operation within the past twelve months. For example, the lighting retrofit was started late January 1997, but was not 100% completed until mid July. The main HVAC retrofit project was not completed until approximately mid 1997. Look at the graph of kWh savings on the following page. Quite clearly, kWh savings in January through March are small to non-existent .

- A great deal of savings will be gained when the energy management system has been fine-tuned and all its "bugs" have been worked out.

- The LoanStar report savings estimates assumed many O&M / policy issues would be implemented. To date, many of them have not been addressed.

We believe that the savings projected in the LoanStar are still achievable, given a dedicated effort by TSH.

Terrell State Hospital

	ELECTRICITY – 1993-94				GAS – 1993-94	
Month	Consumption kWh	Demand Metered kW	Demand Charged kW	Total Cost $	Consumption MCF	Cost $
Jan-94	992,160	1,822	2,477	$60,305.25	19,206	$48,936.70
Feb-94	865,440	2,110	2,477	$57,208.80	15,100	$39,630.30
Mar-94	929,520	1,980	2,477	$58,756.33	11,877	$30,510.38
Apr-94	988,200	2,318	2,477	$60,215.19	8,058	$20,115.59
May-94	1,204,200	2,509	2,509	$65,742.71	8,447	$22,211.97
Jun-94	1,416,240	3,031	3,031	$74,423.30	5,678	$12,921.70
Jul-94	1,758,600	3,006	3,006	$82,506.40	5,194	$10,394.45
Aug-94	1,511,280	2,977	2,977	$76,095.26	5,637	$12,689.00
Sep-93	1,657,440	3,024	3,024	$84,575.08	6,569	$18,818.26
Oct-93	1,393,560	2,898	2,898	$76,239.66	9,130	$28,469.32
Nov-93	1,122,120	2,549	2,549	$64,563.97	16,743	$42,250.30
Dec-93	984,240	2,185	2,477	$60,147.70	15,002	$42,284.73
TOTAL	14,823,000	30,409	32,379	$820,779.65	126,641	$329,232.70

	ELECTRICITY – 1996-97				GAS – 1996-97	
Month	Consumption kWh	Actual Peak kW	Billed Demand kW	Total Cost $	Consumption MCF	Cost $
Jan-97	938,160	1,951	2,192	$51,935.22	14,369	$61,018.38
Feb-97	844,920	2,095	2,192	$49,671.36	11,387	$31,838.62
Mar-97	785,880	1,987	2,192	$48,237.47	9,063	$18,659.67
Apr-97	854,280	2,059	2,192	$49,894.54	8,160	$16,594.18
May-97	851,400	2,174	2,192	$49,797.32	5,200	$12,350.48
Jun-97	1,166,400	2,542	2,542	$62,115.51	4,172	$10,434.25
Jul-97	1,241,280	2,542	1,934	$55,882.94	3,749	$9,047.89
Aug-97	1,279,800	2,736	1,982	$57,465.67	3,719	$9,388.17
Sep-97	1,240,200	2,621	1,954	$56,132.71	3,724	$10,666.73
Oct-97	1,117,080	2,470	1,916	$52,639.08	6,951	$16,176.62
Nov-96	925,920	2,038	2,192	$51,555.40	8,514	$25,557.89
Dec-96	831,600	1,814	2,192	$49,257.03	13,091	$54,187.34
TOTAL	12,076,920	27,029	25,672	$634,584.25	92,099	$275,920.22
SAVINGS	2,746,080	3,380	6,707	$186,195.40	34,542	$53,312.48
PCTG.	18.5%	11.1%	20.7%	22.7%	27.3%	16.2%

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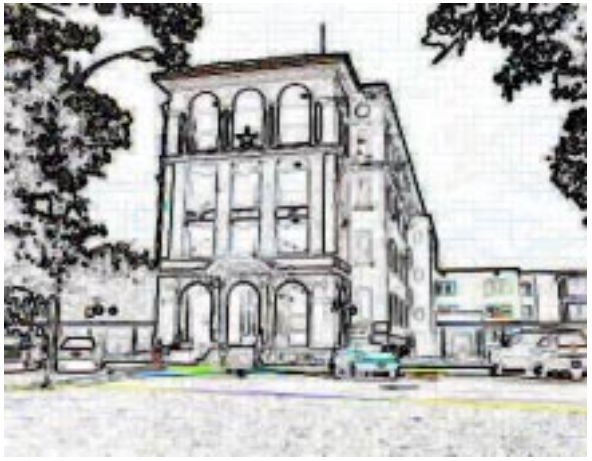
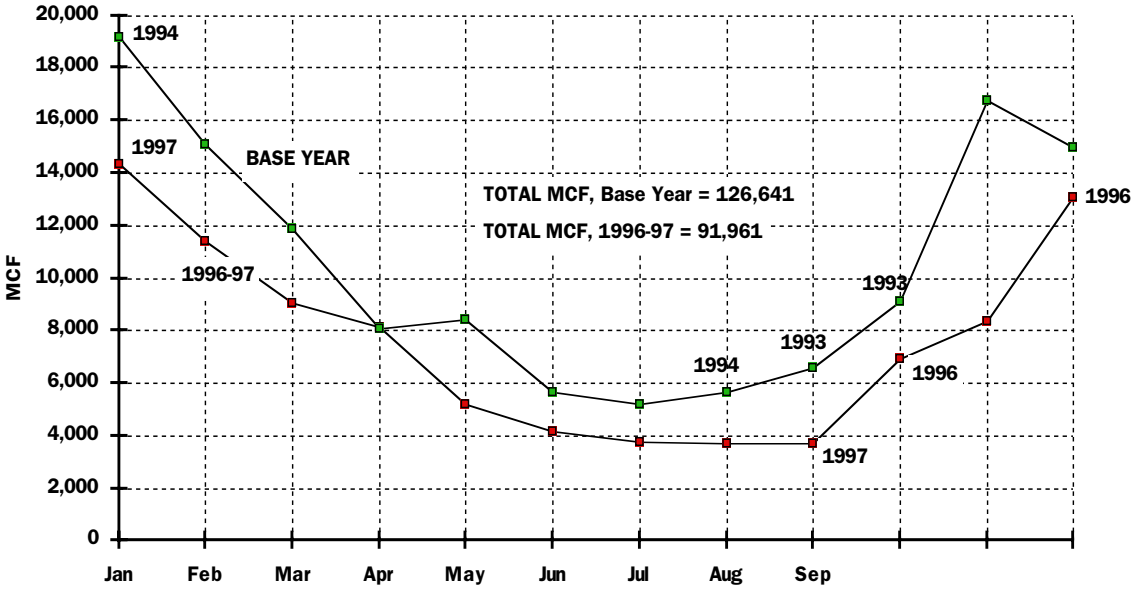
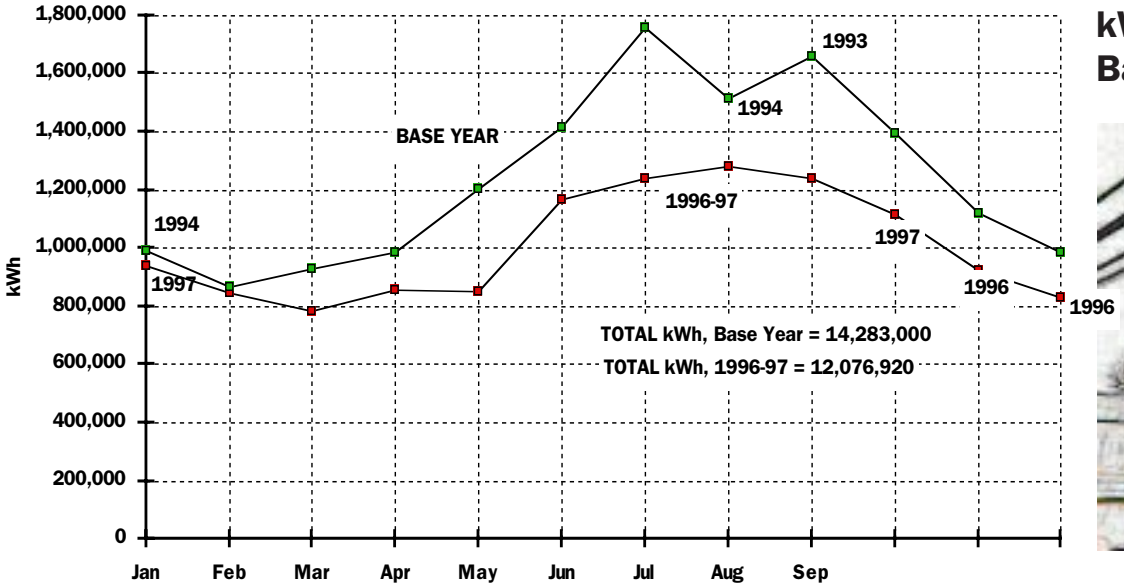
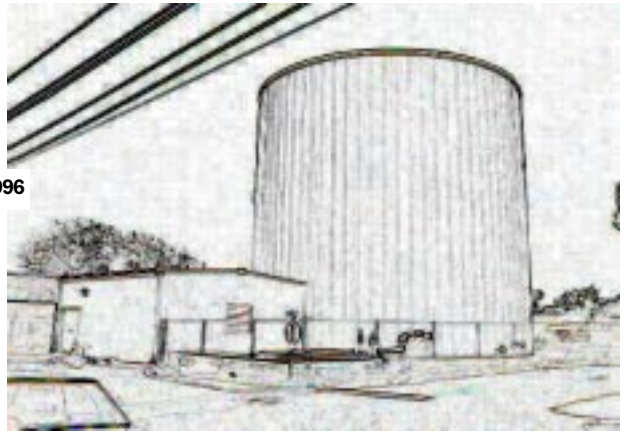
MCF Consumption
Base Year Vs. 1996-1997







kWh Consumption
Base Year Vs. 1996-1997



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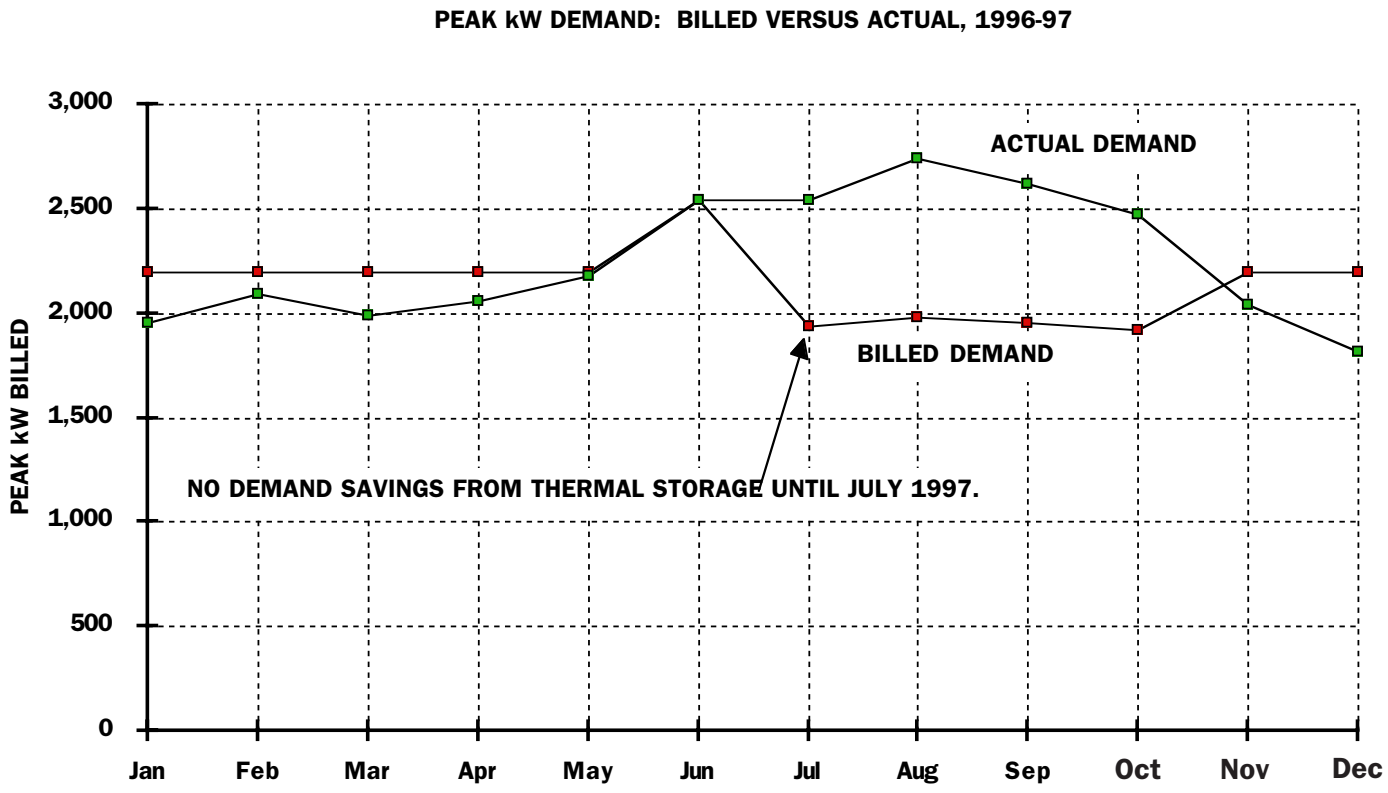

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ADMINISTRATIVE AND PROCEDURAL CHANGES

1. Implement An Energy Management Plan

- Implement a comprehensive Energy Management Plan for Terrell State Hospital, one that addresses operations issues as specifically as possible.

It is essential that the TSH administration set firm policies, procedures, and standards for operating and maintaining equipment and buildings in an energy efficient manner so that the maintenance personnel can keep energy operating costs to a minimum. This in no way means that clients or staff will suffer discomfort. Energy policies will of course be in keeping with generally recognized standards of comfort and with common sense.

To date, there are no firm energy management policies and standards set by TSH administration that the maintenance staff can fall back on. A document called the "Energy Management Plan For Terrell State Hospital" has been produced by TSH, a copy of which is included in the appendix of this report. This document is an admirable statement of goals and philosophy, and is an excellent first start. However, the document is general in nature. We recommend that the Plan be elaborated upon to include very specific policies. For examples, the report should address the following specific items[7] :

- **Temperature Setpoint Policy**

  Any time a group of individuals congregate in a conditioned space, some will be too warm, some too cool, and some will be perfectly comfortable. There is no single set of space conditions which will make all persons comfortable. Maintenance staffs the world over are painfully aware of this fact. It is not unusual for them to receive complaints that a space is too hot within the same hour of receiving a complaint that the same space is too cold. Once it is accepted that not all persons will have their personal comfort conditions met, then a temperature setpoint policy can be set based upon generally recognized standards of comfort.

  Human comfort depends upon a number of factors. Environmental factors include dry bulb temperature, humidity, radiant temperature, velocity of air. Human factors include body metabolism, clothing, psychological factors, gender, age, and how active the person is (or recently was). Numerous studies have been undertaken concerning requirements for human comfort. The American Society Of Heating And Air Conditioning (ASHRAE) is considered the ultimate authority among **HVAC**[8] engineers. ASHRAE lists a range of conditions at which most people indicate they are comfortable[9] . These conditions are

winter: 68˚F to 74˚F
summer: 72˚F to 79˚F

We recommend that the following temperature setpoint policy be established for Terrell State Hospital for normal occupied spaces (i.e. excepting those areas which have special requirements for clients):

winter: 70˚F to 71˚F
summer: 75˚F to 76˚F

For those persons who find it too cold in winter, recommend additional clothing. For those who find it too warm in summer, recommend the use of a small personal fan.

- **Night Temperature Setback Policy**

Temperature during nighttime hours need not be the same as for daytime occupied spaces.

For unoccupied spaces, employ temperature setbacks[10] as follows:

winter: 55˚F
summer: 94˚F

For occupied spaces where people are sleeping, employ temperature setbacks as follows:

winter: 60˚F to 63˚F
summer: 77˚F to 79˚F

A narrower temperature range is required for drug storage areas[11]. Employ the following night / weekend setbacks:

winter: 60˚F
summer: 85˚F

- **Eliminate Electric Space Heater Use**

We recommend that the use of personal electric space heaters be prohibited. In fact, there exists an MHMR-wide directive from the 1970's prohibiting the use of personal electric space heaters. We know of at least one other campus where any such heaters found are confiscated. Today's energy management plan from MHMR/Central Office does not

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specifically mention electric space heaters, but individual campuses have the latitude to set their own policies concerning them.

The use of such heaters present at least two problems which should be avoided. One, the space heaters often are plugged into electrical circuits which are not large enough to handle the heater plus the other electrical equipment served by the circuit. TSH maintenance personnel indicated that quite frequently they are called out to reset circuit breakers that have been tripped due to staff use of personal space heaters. This is a waste of the maintenance person's time. Two, electric resistance space heating is very expensive as compared to steam heat, which is the predominant form of heat on the TSH campus. (Even worse than using them in winter, many persons use them in summer!)

There are other alternatives to electric space heaters. One, small electric foot warmer pads are available which warm the feet but use a lot less electrical energy. As an alternative to banning the heaters, set a maximum wattage that can be used so that the circuit breaker tripping problem will be greatly reduced.

Publicize well the space heater prohibition several weeks before implementing the policy. Note also that the maintenance staff will have to do a good job of maintaining space temperatures within recognized comfort zones. It will be hard to justify denying someone use of their space heater if room temperature is a drafty 65˚F.

- **Building Use Policy**

Do not schedule any building for only very sparse occupancy. Rearrange building occupancy patterns so that buildings are fully utilized. Do not allow cooling or heating of a very sparsely occupied building except to prevent freeze damage.

- **Janitors Operations**

Janitors can play an important role in reducing energy waste. First and foremost, janitors should be instructed in proper operation of lighting systems. After normal working hours, all lights should be OFF with the following exceptions:

hallways
rooms in which janitors are actually working
occupied areas

In addition, HVAC equipment should be turned off and setback temperatures implemented immediately after normally scheduled occupancy hours. Normal daytime occupancy temperatures in an entire building should not be maintained for the sake of a small janitorial crew. This is standard operating practice for most institutional facilities. It is normally the

case that the building stays relatively comfortable for several hours after HVAC is turned off, so this should not be a major inconvenience for the janitorial staff.

- **Food Service Equipment Operation**

Remote food service areas have their own food warmers, which are often electrically heated. As a rule, kitchen staff turns on all such heaters at the same time. As a result, there is a large inrush of electrical current in the late morning hours. This may or may not result in a new peak demand being set; only a more detailed study can determine this. However, there is no use taking the chance. Kitchen staff should be instructed to turn heaters on over five minute intervals. As an alternative, they could be placed under control of a sequential timer.

- **Staff Education**

The existing "Energy Management Plan For Terrell State Hospital" calls for TSH to "develop and implement an energy awareness training program for staff". This should be a high priority item. Staff can have a tremendous impact on energy costs at TSH. Furthermore, training in energy efficiency matters will enable the staff and maintenance personnel to work together more smoothly in achieving the common goal of reduced energy bills.

Lights left on, unoccupied area

We recommend that operation of lighting systems be high on the education agenda. Staff needs to be informed that fluorescent lights need to be turned off whenever a room is empty for as little as five to ten minutes. Lights in areas which are frequently unoccupied should be left off completely, or rewired such that the great majority of lights can be turned off, leaving only one or two fixtures for minimal lighting.

Thermostat operating principles should also be high on the list. Staff should be instructed that adjusting the thermostat setpoint to its very coldest position (usually around 55˚F) will not cause a room to cool off any faster. If a room cannot be maintained at comfort conditions with a normal thermostat setting, it is an indication of more fundamental problems in the HVAC system, and the maintenance staff should be notified. If the thermostat is moved to its coldest setting, the probability is high that it will be left there when staff leaves for the day, and energy will be wasted in overcooling. Educate staff on the need for space temperature setpoint policies.

Inform staff of the prohibition of electric space heater operation, as discussed above.

- **Energy Savings Goals**

  The existing "Energy Management Plan For Terrell State Hospital" calls for TSH to "reduce energy consumption by 15% per square foot of conditioned space for FY 98 compared to a 1990 energy use baseline". This goal has very likely already been surpassed due to energy measures undertaken within the past year and a half. We do not have 1990 energy bills, but TSH has seen a reduction of 18.5% in electricity use and 27.4% reduction in gas usage compared to 1993-94 bills. Reduction in dollars for electricity and gas fell by 22.7% and 16.2%, respectively, for a total overall reduction of 20.8% in dollar costs. We recommend the goal be adjusted to reflect the savings already gained, i.e. use fiscal year 1996-97 as the new base year. A worthy and achievable goal is to further decrease energy use by another 20% as compared to this most recent twelve month period.

The specific policies and standards listed above are not by any means a complete list. Include as many additional items as you feel are necessary and prudent.

We have included a sample Energy Management Plan, attached at the end of this report, which can be used as a starting point in developing one specifically for TSH.

Estimated Savings: $20,000/yr

2. Maintenance Personnel Work Load

- Increase resources available to maintenance staff to perform necessary maintenance tasks.

The maintenance staff at TSH has been steadily whittled down over the years. A few years ago there were fourteen HVAC workers; now there are five. The square footage of buildings to maintain and the amount of work to do has remained approximately the same. The end result is that normal maintenance items end up being neglected for lack of time. For examples, air handler coils are no longer cleaned on a regular basis, nor are filters changed regularly. Just taking care of these two items could take the full time services of one or two workers. There are none to spare for this work. The morale of the maintenance staff cannot but help be hurt by the feeling of always having more work to do than time to do it.

We recommend the hiring of additional HVAC maintenance personnel. With just a few more such personnel, there should be a noticeable improvement in reliability of HVAC operation and how quickly repair work takes place.

We have not listed the cleaning of air handler coils and changing filters as a separate O&M item, but include a discussion of the issue under this section "Maintenance Personnel Work Load", since we do not see how the situation can appreciably

improve unless Maintenance is given sufficient resources to carry out the work. It has always been unwise to neglect coils cleaning and filter changing, as clean coils and filters directly impact air quality. However, in this day and age, it is even more important to keep coils and filters in good condition. Air quality issues have attracted tremendous interest among HVAC professionals these past few years, probably more than any other single issue. A variety of diseases and discomforts, including headaches, nausea, dizziness, and allergies, have been traced directly to dirty air handling systems. In addition, our society has become much more litigious this past decade. Institutions are frequently sued by building occupants for failure to provide healthy indoor environments. One lawsuit by a disgruntled staff member or client, whether justified or not, could end up costing TSH hundreds of thousands of dollars. Finally, having a clean, fresh smelling indoor environment is a positive feature that will sell Terrell State Hospital to clients and their families. If TSH is to compete with other private institutions in keeping a client base, a pleasing environment is a must.

Dirty air handler coils

Estimated Savings: NA

3. <u>Copy Utility Bills To Maintenance Department</u>

- Provide copies of utility bills to the maintenance department immediately after receiving them each month.

We were informed by the maintenance department that utility bills are paid by the TSH accounting staff, and copies of the bills are not forwarded to maintenance. It is very important that maintenance be given copies of utility bills as soon as they are received. Maintenance needs to be able to compare bills to previous years and keep track of progress of energy efficiency measures. Further, electric companies often make billing mistakes. We know of institutions where overbilling (or underbilling) in the amount of many thousands of dollars has taken place. The maintenance department should set up a procedure for tracking bills and confirming their accuracy.

Estimated Savings: NA

4. Energy Management System Operation And Training

- Provide additional training for the operator of the energy management system.

EMS operator David Wilhite

A new energy management system (**EMS**) operator has recently been employed at TSH. In a change from the past, the new EMS operator has been given the EMS operation as his sole responsibility, whereas the previous operator was given vast responsibility for HVAC maintenance operations as well.

TSH should be commended for this change. Operation of the EMS is — and will remain for at least the next year or more — a full time job. There are countless issues to resolve in fine tuning the EMS (some of these will be discussed later in the report), and these take time. Furthermore, the thermal storage system is under direct control of the EMS. Proper operation of this system is essential. Any operating malfunctions can result in scores of thousands of dollars in electric bills for TSH. Having an EMS operator who is continually in touch with the system's operation is therefore essential.

We recommend that the EMS operator be given an intensive training course from CSI, the manufacturer of the controls system now in use at TSH. The more thoroughly he understands the EMS and how it controls equipment, the more capable will he be in optimizing efficiency and achieving energy savings.

Estimated Savings: NA

5. Laptop Computer

- Provide a laptop computer to facilitate problem troubleshooting with air conditioning equipment.

When the TSH energy management system was installed, no laptop computer was specified. This was done purposefully at the time, though in retrospect it would have been a good idea to have the laptop. Typically when an energy management system is installed, provision of a laptop computer is also specified as part of the job. A laptop computer is valuable in helping the maintenance staff troubleshoot problems. The maintenance person carries the laptop to the piece of equipment

which is causing a problem. He plugs it in to a data access port, and can then read a variety of data which helps him to discover what the problem may be. For example, at an air handler he may read supply and return air temperatures, chilled water supply temperature, position of the chilled and hot water valves, space temperature, and position of dampers.

We recommend a single laptop computer be provided to Maintenance.

Estimated Savings: NA

THERMAL STORAGE SYSTEM OPERATION

1. Alarm Notice For Thermal Storage

- Provide an additional terminal for the energy management system in the boiler operator's room so that problems with thermal storage system operation can be detected immediately.

TSH's 7000 ton-hour thermal storage system

The importance of proper operation of the thermal storage system was mentioned above. Further explanation of why proper operation of the thermal storage system is so important is in order.

Electric companies charge their larger customers for "peak demand". Measured in terms of kW, peak demand represents the single highest amount of electricity use for any 15 minute time period in a month. TSH hit a maximum monthly peak demand of 3,031 kW in June 1994, and a minimum peak demand of 1,822 kW in January 1994. TSH is charged each month $12.66 for each kW of peak demand; thus $38,372 was paid for peak demand in June 1994.

Nearly all electric utility companies have a "ratchet" clause in their rate structures. TSH has such a clause. The ratchet ensures that the customer gets billed for a minimum peak demand in low usage months, regardless of the actual peak kW they attain. TSH's ratchet is 80%. The ratchet is structured so that TSH is always billed for at least 80% of the highest kW attained in the months June - September. For example, using the 1994 demands cited above, an 80% ratchet applied to the 3,031 kW in June equals 2,425 kW. Despite the fact that TSH only used 1,822 kW in January, the hospital was billed for 2,425 kW because of the ratchet clause. This added $7,634 to the electric bill for January 1994!

The purpose of the thermal storage system is to reduce peak demand during the months of June through September when demand is typically the highest. For example, peak demand in the months since the thermal storage system became opera-

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tional is typically 1,500 kW, versus the approximately 3,000 kW prior to its operation. However, the ratchet clause is still in effect with the new thermal storage system electric rate. If for some reason the thermal storage system fails to operate, and peak demand reaches 3,000 kW instead of the now typical 1,500 kW, a new high peak demand will be set which will cause higher ratcheted electric bills for twelve months to follow. The importance of proper thermal storage system operation is clearly illustrated by this example.

The thermal storage system "recharges" itself at night. No one is on campus with access to a monitoring system to confirm that the thermal storage is being recharged as required. However, there is an boiler room operator on site twenty-four hours per day. We recommend an additional EMS monitor be located at the boiler room operator station so that the operator can keep track of thermal storage system recharge, and immediately inform maintenance personnel should any problems occur.

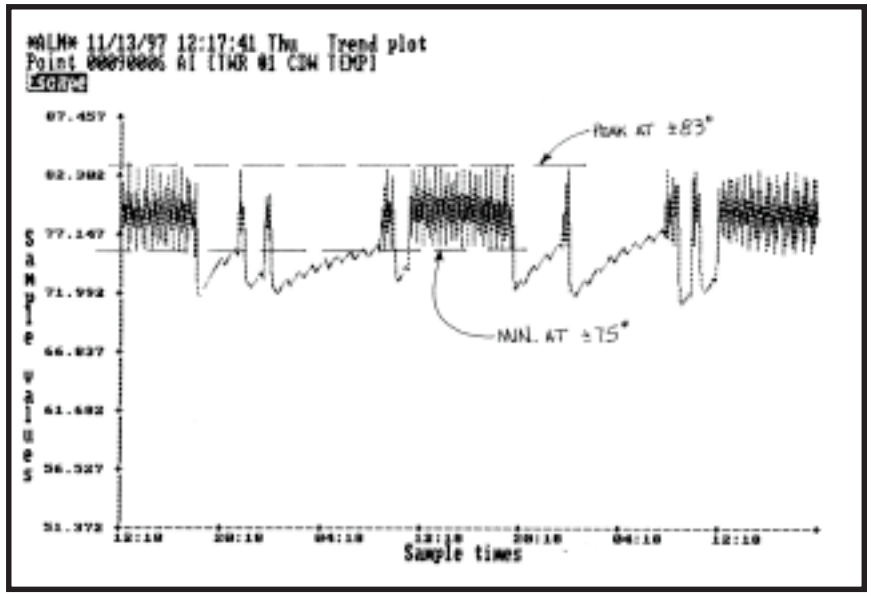
Estimated Savings: NA

2. Condenser Water Temperature Control / Carrier Chiller Interface Panel

- Provide an interface panel at the Building 686 chillers to allow the energy management system to read information directly from the chiller panels.

The energy management system (EMS) has taken over control of the cooling tower to provide condenser water to the chillers at the desired temperature. The algorithm performing this control routine is performing very badly. The accompanying graph illustrates the problem. Condenser water temperature swings rapidly and wildly over a range of about 9 degrees. The algorithm should be capable of maintaining condenser water within a degree.

We have been in contact with the EMS manufacturer, CSI, several times about this problem. They have not remedied it yet. We recommend that regular and increasingly intense pressure be brought to bear on CSI until they give this problem the attention it deserves, and resolve it.



Trend graph of condenser water temperature, Building 686

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It is an absolute certainty that the energy management system has several errors of this type "hidden" within its code that remain to be discovered by TSH staff. CSI should be held strictly accountable for remedying all such programming errors discovered.

An additional problem with condenser water temperature control is that the condenser water temperature sensors for the energy management system are not located in the same spot as the sensors of the Carrier chillers. As a result, Carrier's sensors consistently show an approximately 4˚F difference from those of the EMS. To remedy this problem, purchase an interface card which will allow the EMS to connect directly to the chiller control panel, and read the identical information which the Carrier chiller is seeing.

I was told that Carrier told TSH staff that their chiller cannot operate with condenser water cooler than 80˚F, and that cooler condenser water contributed to the problem of the chillers (in building 686) tripping off line. This is in direct conflict with Carrier literature and with what Carrier salespeople and service directors say. Under certain conditions, the chiller should be able to operate with condenser water around 66˚F. Terry Lee of the Shreveport office indicates that there should be no problem at all operating with 75˚F entering condenser water. The project specifications for the energy management system called for varying condenser water temperature according to outdoor air temperature, but at no time would it be less than 75˚F. I suspect the chiller tripping was related to other problems (for example, the poor control range, as discussed above; Mr. Lee believes this to be the problem also). Once the control algorithm is fixed, try changing the condenser water setpoint control back to the way it was originally: 75˚F condenser water at 55˚F outdoor air, 85˚F water at 95˚F outdoor air, and linear in between.

Estimated Savings: $500 / yr

3. Maintain 55˚F Return Chilled Water To Storage Tank

- Change all chilled water return setpoints under energy management system control to 55˚F.

The thermal storage tank was designed to provide 7,000 ton-hours with a delta T of 55˚F / 40˚F. In order to extract the full 7,000 ton-hours of cooling out of the thermal storage tank, it is necessary that chilled water return to the tank be maintained as close to the design 55˚F as possible. In order to achieve 55˚F return water, variable speed drives on secondary pumps in each building modulate their speed higher or lower to increase or decrease flow through air handler coils.

While on site, we inspected the control settings for return chilled water temperature for several buildings. The setpoints were 50˚F or 51˚F for several of the buildings. We recommend TSH review the setpoints for all buildings on the chilled water loop to ensure they are set at no lower than 55˚F.

Savings for this change are virtually impossible to estimate. Some small savings will be gained by allowing the chilled water pumps to operate at lower speed. However, the major benefit will come by increasing the thermal storage system capacity to its design level. If this is not done, it is probable that supplemental cooling from a chiller will be required during On-Peak electrical demand periods, which will increase electric bills needlessly. Indeed, during last year's hottest months, one chiller was kept on-line to provide supplemental cooling during times when the thermal system should have been providing all cooling required (see discussion under building 673 below).

Estimated Savings: NA

4. Optimal Operation Of Thermal Storage

- Operate the thermal storage system throughout the day in such a manner that peak demand is minimized in Off-Peak months of October through May.

The operating sequence for the thermal storage tank, as described in LoanStar project specifications, called for operating the thermal storage system in winter so as to minimize peak kW during the entire day, not just in the noon to 8 PM on-peak window. To explain how this will save money, a discussion of TSH's electric rate as relates to billing demand is required.

TU Electric defines the following demand-related terms:

On-Peak kW: the highest demand attained in the time period noon to 8 PM, but only in the months of June - September.
Annual kW: the highest demand attained at any time, day or night, in any time of the year.
Contract kW: a minimal contractual kW that TU Electric will bill TSH, no matter how many kW the facility uses; TSH's contract kW is now 2800 kW.

TSH is billed demand as follows:

a) Billed Demand is the smaller of
1) current month kW
2) On-Peak kW + 0.25 x (current month kW - On-Peak kW)

except that

b) Billed Demand is NEVER smaller than the highest of

1) 0.8 x On-Peak kW
2) 0.5 x Contract kW
3) 0.5 x Annual kW

Take the months January, July, and August 1997 to illustrate billed demand calculations.

Month	Actual Peak kW	Billed kW	On-Peak kW
January '97	1,951	2,192	NA
July '97	2,542	1,934	1,731
August '97	2,736	1,982	1,583

The On-Peak kW for this year is 1,731 kW, set in July.

The Annual kW is 2,736 kW, set in August.

The absolute minimum kW TSH will be billed, from b) above, is the highest of:

1) 0.8 x On-Peak kW = 0.8 x 1,731 kW = 1,385 kW
2) 0.5 x Contract kW = 0.5 x 2,800 kW = 1,400 kW
3) 0.5 x Annual kW = 0.5 x 2,736 kW = 1,368 kW

In other words, TSH will always be billed for at least 1,400 kW, regardless of any other circumstances.

Now assume the thermal storage system in January 1998 continues to be operated in the current manner, i.e. the chillers will operate up until noon and then again after 8 PM. Again assume demand peaks at 1,951 kW. The billed kW will be, as per a) above, the smaller of

1) current month kW = 1,951 kW
2) On-Peak kW + 0.25 x (current month kW - On-Peak kW)
   = 1,731 kW + 0.25 x (1,951 - 1,731) kW = 1,786 kW

Therefore peak billed kW = 1,786 kW[12] .

Now suppose that the thermal storage system had been operated in such a manner that during the month of January, kW demand at no time during the month exceeded 1500 kW. The billed kW will be the smaller of

1) current month kW = 1,500 kW
2) On-Peak kW + 0.25 x (current month kW - On-Peak kW)
   = 1,731 kW + 0.25 x (1,500 - 1,731) kW = 1,731 kW + 0 kW = 1,731 kW

Therefore peak billed kW = 1,500 kW.

This illustrates the point that during the months October through May, TSH's billed demand costs will be smaller if demand is kept at a minimum throughout the entire day, not just during the noon to 8 PM window, which really has critical importance only for the months June through September. In the month illustrated above, January, billed kW would be reduced by 286 kW, worth $3,621.

The original LoanStar project specifications called for thermal storage programming to achieve this minimum billed kW. Calculation are made each hour, projecting required ton-hours of cooling versus those available in the tank, in order that as few chillers as possible (zero, it is hoped) need operate. We suspect that in the months November through April, TSH can operate to maintain demand kW at no higher than 1500 at all times of the day, if the thermal storage tank is used judiciously.

Note that all the above discussion is based upon 1500 kW as a peak. This figure is one that TSH has set internally as a goal. There is no reason why 1500 kW is a sacrosanct number. We recommend that you set 1400 kW as a goal instead[13]. In June - September, the 1400 kW goal would apply only during the time from noon to 8 PM. In all remaining months, the 1400 kW goal would apply throughout the day. This figure may not be achievable for all the remaining eight months, but the lower the kW attained, the lower TSH electric bills will be. The savings listed below assumes, conservatively, that TSH achieves only 1600 kW demand in the months November - April, and 1750 kW in October and May.

Estimated Savings: $48,000/yr

INDIVIDUAL BUILDINGS O&M's

1. Building 518

- Repair air handler damper problems.

We discovered a number of problems in air handler rooms in building 518. These are listed below:

- On AHUs 006 and 007, the outside air dampers have been disconnected.
- There is a space heater in the main mechanical room. I looked for several minutes, but could find no control thermostat, only a manual on/off switch. If there indeed is no thermostat, install one.
- All lights in the air handler mechanical room (AHU-003[?] — close to the main mechanical room) were left on all day long. Judging from the furniture arrangement and newspaper, it appeared as though some staff member is using the room as a break room. Staff should be instructed to turn out the lights whenever they leave a mechanical room. If the problem persists, install a motion sensor or a solid state timer with a "flicker" feature[14] .
- For air handlers -003 and -004, neither the minimum nor maximum outside air dampers would move when unit turned off. The dampers for -004 appear to be in the 100% closed position.

Disconnected outdoor air damper

Estimated Savings: $250 / yr

2. Building 537

- Change after-hours building occupancy patterns.

Building 537 is another building which at times is sparsely occupied. After normal working hours, nurses infrequently use the building as a base of operations. Two air handlers and a chilled water pump must operate through the night to condition the building in case a nurse should show up. We recommend an alternate work space be provided for the nurses in a more fully occupied building.

Estimated Savings: $750

3. Building 545

BOILER OPERATING PRESSURE

- Reduce boiler operating pressure when possible.

Boilers in the central boiler plant operate at 120 psig; this high pressure is required in order that the laundry be supplied with sufficient steam. However, when the laundry is not in operation, steam pressure could be lowered without negative impact on the ability to provide all other campus steam needs (e.g. space heating, domestic hot water heating, sterilizing, etc.). When the laundry is not in operation, reduce boiler operating pressure. Experiment to find the minimum pressure that can be supplied without deleterious effect.

Estimated Savings: $600 / yr

The boiler plant

CONDENSATE RETURN PROBLEMS

- Repair or replace condensate system components to improve condensate return to the boiler room.

The maintenance staff estimates that only about 50% of the steam that is distributed out to campus buildings actually returns to the boiler room as condensate. In other words, nearly half of the energy output of the steam boilers is completely wasted.

There are many specific reasons why condensate return is so low, but generically speaking it can be summarized as old equipment: old condensate piping that has corroded so badly that the pipe walls crumble, rusted out condensate return tanks which spill condensate on the floor, steam traps that pass steam which ends up being blown to the atmosphere, leaking condensate pumps, leaking valves, steam heating coils with leaks, etc.

A 50% condensate return rate is definitely not good, but unfortunately not unusual. Many steam plants around the nation are so old or poorly maintained that return rates of 50% or less are common. The problem is usually not addressed until it becomes unbearable. So long as the maintenance staff is able to keep providing space heat and hot water, the money to fix

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the underlying problems is usually not budgeted. The reason is simple: it is much less financially painful to continue paying a few thousand dollars a month in higher energy costs than it is to pay $100,000 all at once to fix the problems.

The nineties are times of intense budgetary constraints. Maintenance departments have taken budgetary cuts as hard or harder than any other departments, and one cannot perform adequate maintenance with inadequate levels of staff and money. At TSH, Maintenance does not have the manpower or time to devote to tracking down and fixing the problems with condensate return systems, as was discussed early in this report, nor do they have the spare money to hire someone to do it. While one cannot with any degree of accuracy put a dollar cost on resolving the condensate return problems without a detailed study, a $75,000 to $100,000 figure would not be surprising.

Estimated Savings: $5,000 / yr

VARIABLE FREQUENCY DRIVE (VFD) SAFETY SHUT DOWN

- Have the VFD manufacturer confirm the drives' safety shutdown for single phasing.

TSH maintenance staff indicated that a VFD on the main loop chilled water pump (by the thermal storage tank) single phased recently, but did not shut down. Specifications call for variable frequency drives (VFD) to have "single phase fault protection". Verify with the manufacturer that this safety function exists and is programmed correctly.

Estimated Savings: NA

4. Building 650

OUTSIDE AIR INTAKE

- Place dampers under automatic control.

Outside air intake for air handlers in Building 650 comes in through manually set dampers through exterior walls (see accompanying photo). The dampers are typically 100% closed, on the assumption that sufficient air infiltrates into the building even with the dampers in the closed position.

Outdoor intake, Building 650

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Ideally, the outside air dampers should be automatically controlled. At a minimum, this would involve the addition of a damper actuator and pneumatic controls; or the addition of a damper and DDC controls from the energy management system. As introducing automatic control would be costly, it would not qualify as an O&M measure. However, we recommend that each outside air damper be reevaluated individually, and opened when necessary. Some of the areas in the building may need the additional outside air. We noticed at least one area in which there were noticeable objectionable odors.

No savings are estimated for this O&M, since opening outside air dampers will end up causing higher rather than lower energy costs. However, this measure should help produce a healthier and more pleasing environment for clients.

Estimated Savings: NA

REINSULATE CHILLED WATER PIPING

- Insulate chilled water piping that is currently uninsulated.

Insulation was removed from chilled water pipe in building 650 several years ago as part of an asbestos abatement project. Money was not appropriated for reinsulating the pipe. In addition to reducing energy losses, the main purpose of chilled water piping insulation is to eliminate water condensation on the cold pipe surfaces. A great deal of water condenses on building 650 piping in summer months because of the lack of insulation. The accompanying photograph was taken on a cold day when chilled water was not being pumped, yet the effects of chilled water puddling on the floor can clearly be seen. Dirt accumulates, and mold grows on the continuously damp floor. Water seeps down through the floor pipe penetrations, ruining ceiling tiles in lower floors.

Uninsulated pipe causes water problems

This measure should perhaps be classified as a capitol retrofit measure rather than an O&M measure, since it will cost a considerable amount of money[15]. Nevertheless, we list it as an O&M for two reasons: one, to indicate to TSH management the extent and nature of the problem; and two, because it is possible the work may end up being done piecemeal by TSH maintenance staff if adequate funding is not made available to do the job all at once. It is obviously preferable to contract the job out to a professional insulating company, since the TSH maintenance staff does not have the time, manpower, or equipment to do the work within any reasonable period of time.

Estimated Savings: $75 / yr

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REINSULATE STEAM PIPING

- Insulate steam piping that is currently uninsulated.

As above, a great deal of steam piping insulation was also abated and not replaced. Reinsulate this piping.

Estimated Savings: $300 / yr

Uninsulated steam pipe

AIR HANDLER WORK SPACE

- Increase work space around air handlers.

Many air handler mechanical rooms of buildings 650 and 651 are extremely small. One side of the air handler is butted up against one side wall. The other side of the air handler is but one or two feet from the opposite side wall, but all this space is taken up with a maze of chilled water and steam piping. Note the accompanying photograph which clearly illustrates how little space is available around the air handler. This is an extremely undesirable state of affairs. It is extremely difficult for maintenance personnel to work on these air handlers. It is a major ordeal even to squeeze back through the piping maze to get to the back side of the unit; one has to twist and contort one's body and crawl on hands and knees. Taking tools along on this odyssey is an impossibility; usually the maintenance man has to have another man with him to hand the tools back once he has reached the back side of the unit. Since this process is an extremely inconvenient and uncomfortable ordeal, any normal human being will tend to avoid it as whenever possible. As a result, these air handlers almost certainly do not receive the maintenance attention that they should. Furthermore, when maintenance work is finally performed on them, it probably takes three times as long to get the work done, using two workers, as it would if there were adequate work space.

Crowded air handler room

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We point out also that current building and safety codes call for a minimum of 30 inches of space around air handlers and other HVAC equipment. It is true that the Building 650 air handlers were installed before the codes were in effect, and TXMHMR is not legally required to follow the codes anyhow. Nevertheless, the codes have been written for good reason, and MHMR policy is to try to meet code requirements whenever possible.

We recommend knocking out the side wall around those units where air handler rooms are extremely small. If another wall is constructed to enclose the air handler room, leave at four feet clear space from the edge of piping to the wall.

Estimated Savings: NA

LEAKING STEAM VALVES

- Repair leaking steam valves.

Old steam valve

The days I was on site were fairly cold, and all heating systems were operating. I noticed several spaces in the building which were much warmer than setpoint. I inspected air handlers at three of these spaces to determine what the problem might be.

- AHU C1- east: The valve steam does move up and down, but I could clearly hear steam passing through the valve when it was supposed to be completely shut.
- AHU A1- east: inlet pipe surface temperature = 232˚F, outlet pipe surface temperature = 233˚F, outlet from steam trap = 210˚F; the steam trap thus appears not to be functioning properly[16] , and the steam valve is passing considerable steam when it should not be.
- AHU A1-west: Hot deck temperature setpoint = 50˚F, actual hot deck temperature = 173˚F, steam valve commanded to be 0% open by energy management system; clearly the valve is passing steam.

Most of the valves which are causing problems are quite old (approximately 28 years old in the case of building 650). These valves should be replaced. This is not strictly an O&M item, as the cost of replacing the valves will be substantial[17] . However, we list it in this report 1) in case TSH does end up having to do the work with their own staff and with funds from their

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normal maintenance budget, and 2) in order that the TSH administration be made aware that this is a very real problem with consequences for energy costs and client comfort. For example, on the day of my inspection, the rooms were getting so warm that hot calls were coming in to maintenance. A great deal of energy waste took place in overheating the rooms. Then, in order to cool them back down to comfort levels, maintenance turned on the cooling system! Simultaneous heating and cooling of a space is the most energy wasteful practice that exists.

Estimated Savings: $750 / yr

5. Building 673

OPERATION OF BASEMENT CHILLER

- Fine tune control / pump operations so that operation of the 673 chillers is never required during On-Peak hours.

We were told that, during this past cooling season, the chiller in the basement of building 673 had to be turned on during peak cooling hours in order that sufficient cooling be provided for M&S building 673. If sufficient capacity exists in the thermal storage tank (which is impacted by return water temperature to the tank, as described in the previous O&M), it should not be necessary to operate this chiller. The secondary chilled water pump in 673 basement is more than large enough to provide all the chilled water needed by buildings 673 and 500. If insufficient flow is being provided to these buildings, there may be something wrong with the pump speed control algorithm; or perhaps the chiller isolation valves are not closing or are leaking significant amounts of water. Investigate this issue fully with the goal of eliminating all chiller operation during On-Peak electrical hours. Even though TSH has set a departmental goal of 1500 kW peak demand during On-Peak electrical hours, there is no reason why On-Peak demand cannot be reduced even further through elimination of all chiller operation in On-Peak periods. This should be the ultimate goal.

Savings are not listed below, because they are already included in the “Optimal Operation Of Thermal Storage” section above.

Estimated Savings: NA

CONDITIONING OF 4TH FLOOR SURGERY AREA

- Do not condition the fourth floor surgery area except when scheduled to be in use.

The fourth floor surgery suite in building 673 is used very infrequently (about twice a week for a couple of hours each time). One of the measures implemented under the LoanStar project was to install a separate air handler for the surgery suites. The objective was to discontinue conditioning the surgery suite when it was unoccupied. The EMS operator was to have turned the surgery air handler on a few hours before the regularly scheduled operating hours, and maintain only minimal conditioning (i.e. enough to prevent freeze problems or extremely hot indoor temperatures) in all other hours of the week. Instead, maintenance personnel was informed by doctors that the surgery suite should be conditioned continuously, 24 hours per day, 7 days per week. This negated most of the savings projected to be gained from the installation of the new surgery air handler.

This problem was pointed out to Beatrice Butler during a pre-O&M report meeting at TSH. She immediately sent a memo to the surgery staff that the surgery suites would be conditioned only during scheduled times of use.

Estimated Savings: $1,000 / yr

CONDITIONING OF REMAINDER OF 4TH FLOOR

- Do not condition the fourth floor except when scheduled to be in use.

In the numerous visits made to building 673 over the course of more than a year and a half, I have never seen the fourth floor occupied except when there were people working in the surgery suite. Nevertheless, the entire fourth floor is conditioned continuously to 73˚F (cooling mode). We recommend temperature setpoints be changed to 80˚F in summer, and 65˚F in winter. Change setpoints to 74˚F / 72˚F (summer / winter) during the same hours that the surgery suite is scheduled to be in use.

Estimated Savings: $550 / yr

LEAKING STEAM VALVES

- Repair or replace leaking steam valves.

This issue was discussed fully under Building 650 above. On the day I was on site, a number of spaces in building 673 were also being overheated. I did not inspect the air handlers involved, but strongly suspect the problem is the same: leaking steam valves.

Estimated Savings: $200

6. <u>Building 684</u>

CONDITIONING OF UNOCCUPIED CHAPEL

- Setback chapel temperatures at all times when it is not in use.

The chapel in building 684 is most often empty of people, yet it is conditioned throughout the day. When we inspected it, chapel space temperature was 74˚F.

We expect building 684 occupants may object to the air conditioning system being turned off for the chapel, since it is possible that the space may be used on an unpredictable timetable. However, we recommend that chapel temperature be maintained at 79˚F in summer and 68˚F in winter during normal occupied hours; cycle the fan serving the chapel to maintain this temperature, and verify that hydronic valves close when the unit cycles off. If there is a regular schedule for chapel use, building 684 occupants can call this in to the EMS operator, who can program the system to change space temperature setpoint for the specific hours of use. Should any unscheduled use of the chapel take place, the 79˚F / 68˚F setpoints will not be uncomfortable to occupants unless they remain in the space a long time, in which case they should have informed the EMS operator in advance.

Estimated Savings: $400

CHAPEL LIGHTS OPERATION

- Do not leave lights on in empty chapel.

The lights in the chapel were observed to be operating even though the chapel was unoccupied. Building 684 occupants should be informed to leave the lights off unless there is someone actually using the space.

Estimated Savings: $35 / yr

Chapel lights left on

CONFERENCE ROOM LIGHTS OPERATION

- Do not leave lights on in empty conference room.

Likewise, all lights in the conference room at the back of the building were left on while the room was unoccupied. There are twenty 2-lamp fixtures in this room, accounting for a 1.2 kW electric load. This is a significant load. Again, inform building 684 occupants that all lights should be left off in unoccupied spaces.

This conference room would be an ideal space for motion sensors. Installation of motion sensors would be a capitol cost measure rather than an O&M, but our guess is that it's better than even odds that the building occupants will not do a good job of keeping these lights off. Have maintenance personnel make informal inspections whenever they are in the area to see how well these lights are being kept off. If it does not appear the 684 staff is doing an adequate job, install ceiling-mounted motion sensors.

Estimated Savings: $60 /yr

7. Building 725

BUILDING OCCUPANCY

- Vacate Building 725 completely rather than allowing two or three rooms to be occupied and conditioned.

Earlier in this report, we discussed the issue of arranging occupancy patterns so that no building is sparsely and/or infrequently occupied. Building 725 is one such building that is sparsely and/or infrequently occupied. A very few auditors occupy one very small section of the building. An air handler and a chilled water pump must be kept on to condition about one-sixth of the building floor area for the approximately two occupied offices. In addition, we noticed many hallway and other lights had been left on by person or persons unknown.

Hall lights left on

We recommend the auditors be given some other work space in a more fully occupied building, and that the building be fully shut down. Then turn off all lighting systems and HVAC equipment serving the building. Allow only heating systems to operate to prevent freeze damage.

Estimated Savings: $250/yr

8. All Buildings With Chilled Water

- Repair chilled water system leaks.

David Wilhite of the TSH maintenance staff estimates that there are at least thirty old chilled water valves which are leaking water. This wastes the energy used to chill the water, and it also adds to the water and sewage bills. Once again, the maintenance staff is aware of the problem, but repairing or replacing the valves is a job which simply cannot be done with available manpower and money. These valves likely will be fixed only in the event of a catastrophic valve failure when they absolutely *have* to be fixed.

Estimated Savings: $250/yr

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FOOTNOTES

1 "Operations and Maintenance".

2 Based upon months of November 1996 through October 1997.

3 See discussion of ratchet clause below under the section "Thermal Storage System Operation".

4 And even this 1500 kW amount can be improved upon. See discussion under the section "Thermal Storage System Operation" to follow.

5 The lower kWh usage in Nov/Dec '96 versus '93 is most likely accounted for by less cooling system operation. Nov/Dec 1993 was much colder than Nov/Dec 1996 (890 versus 791 heating degree-days, respectively).

6 As an example, thermostat setpoints have not been changed. Other such items are discussed in the body of this report.

7 Specific examples of deficiencies at TSH with respect to some of these issues are discussed later in this report.

8 Heating, Ventilating, and Air Conditioning.

9 As listed in ASHRAE Standard 55, the comfort conditions range is that in which "80% of sedentary or slightly active persons find the environment thermally acceptable".

10 I.e., the air handler or other HVAC system will not be allowed to operate in winter until space temperature falls below 55˚F, and in summer until space temperature rises above 94˚F.

11 We have been informed by pharmacists at other MHMR campuses that the allowable temperature range for the drugs is from 59˚F to 86˚F.

12 Note that TSH was actually billed 2,192 kW in January 1997; this is because the thermal storage rate had not gone into effect yet.

13 Recall it will do no good to reduce kW below 1400 because of the stipulation that billed kW will never be less than half of the 2800 contract kW.

14 The "flicker" feature causes lights to flicker about a minute before they turn off, giving room occupants ample time to reset the lights to On again.

15 A bid for about $50,000 was received for this work in November of 1996.

16 This is a new steam trap! We recommend you double check that the trap is not working. If indeed it is not, address its repair under warranty.

17 A 1.5" valve alone could cost $150 in materials. TSH maintenance staff has the expertise to install the valves, but as discussed earlier, they do not have the time or manpower to do so. This means the job needs to be contracted out, at a cost of probably another $100 per valve, and perhaps more because there are no unions on either side of the existing valves, making it much more difficult to remove existing valves and install the new ones.

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