Table of Contents

EXECUTIVE SUMMARY

****

An energy conservation study was performed for ************* in ******. The study objective was to obtain an overview of existing building energy consuming systems related to the lighting, Heating Ventilating and Air Conditioning (HVAC), building control, and Chiller systems, motor loads, process and office equipment. In order to determine the energy consumed by this building, daytime and nighttime walk-throughs were performed. Building occupants were questioned as to equipment and building usage schedules. Most building characteristics and systems were discussed.

Energy savings opportunities for ************* have been identified. They include HVAC retrofits/replacements, HVAC control system retrofits, chilled water system retrofits, power factor correction, lighting retrofits, and no/low cost opportunities.

Currently, the total energy consumed annually by the main hospital building is 10,305 MMBTU for electrical and 7,161 MMBTU for gas, for a total of 17,466 MMBTU at a cost of $163,956. For the 95,370 square foot facility, this equates to $1.72 per square foot and 183,140 BTU per square foot. Gas costs make up 21% of the total utility costs for the facility and 41% of the consumption. Electrical costs make up 79% of the total utility costs and 59% of the consumption.

The largest utility cost for the Hospital is electrical peak demand. Controlling peak electrical demand should be the number one goal of the Hospital. This can be accomplished by implementing a Hospital-wide Energy Management System (EMS) to provide electrical load shedding and control/sequence of HVAC equipment start-up (demand-side management).

The HVAC systems and associated heating/cooling water systems are thermostatically controlled and run continually. Several rooftop air-handling units provide building air conditioning by using direct expansion (DX) refrigeration cooling with heating provided by natural gas. Other areas are served by various air handling systems that have heating and cooling coils. Comfort cooling for the air handling systems comes from chilled water via chillers and hot water boilers provide heating.

There are some HVAC systems that have reached or are close to reaching the end of their useful life. They are high maintenance items that operate very inefficiently and are not effective in meeting the comfort heating or cooling requirements of patients or staff. In particular the patient care areas of the Hospital. Replacement and/or major renovation of these units through an energy retrofit project may be an attractive alternative, because these systems most likely will need to be replaced over the next 3-5 years. Yet, capitalization of these costs can be deferred through the energy savings generated.

Most building lighting uses fluorescent fixtures, but there are pockets where incandescent lighting exists. Lighting usage varies throughout the facility. And, daylighting opportunities exist for several areas of the Hospital.

There was a large equipment load observed in this building. From our walk-through, it became clear that HVAC is the major energy users.

If the hospital desires to move forward with an energy performance contract it can expect to achieve the following energy savings. The total energy consumption of the main Hospital facility can be reduced to 135,000 BTU per square foot or 26.3% and the cost per square foot can be reduced to $1.05 per square foot or 36.3%.

Potential annual savings were identified to be $63,613 while Total Estimated Cost (TEC) for the measures to achieve these savings were $665,367, which translates to a lifecycle payback of 10.5 years. TEC includes contingency, overhead, feasibility and engineering design costs, plus financing. Please see the next page for the Cost/Savings/Payback table.

Total Estimated Costs and Savings

****

	Continue w/ ESPC		Stop At Audit	
Initial Audit Function:				
Raw Labor Estimate	$ 7,500.00			$ 7,500.00
Fringe	$ 2,400.00		32.00%	$ 2,400.00
Overhead	$ -		0.00%	$ -
Total WES Cost	$ 9,900.00			$ 9,900.00
G&A	$ -		0.00%	$ -
Subtotal	$ 9,900.00			$ 9,900.00
WES Profit	$ -		0.00%	$ -
Total Client Cost	$ -		Subtotal	$ 9,900.00
Engineering and Design				
10% of Construction Costs	$ 39,227.87		7.00%	$ -
Retrofit Function:				
Construction Cost	$ 310,101.75			$ -
Overhead	$ 46,515.26			
Subtotal	$ 356,617.01			
Equipment/Supplies/Rentals	$ -			
Self-Performed Work	$ -			
Subtotal	$ 356,617.01			
G&A	$ 17,830.85			
Profit	$ 17,830.85			
Subtotal	$ 392,278.71			
Construction Management	$ 11,768.36		12.00%	$ -
Commissioning	$ 1,961.39			
Monitoring and Verification	$ 7,845.57			
Training	$ 3,922.79			
Total Retrofit Cost	$ 417,776.83		Subtotal	$ -
ENGR and CONSTRUCTION COST	$ 457,004.70		**TOTAL**	$ 9,900.00
FINANCE CHARGES @ 8%	$ 208,362.67			
TOTAL ESTIMATED PROJECT COST	**$ 665,367.37**			
TOTAL ESTIMATED SAVINGS	**$ 63,613.09**			
ESTIMATED PAYBACK	**10.46**			

SECTION I

INTRODUCTION

This energy study analyzes the energy consumption of *************. Data was gathered by walking through the facilities, reviewing utility bills, as well as, asking questions of the building occupants.

The Energy Conservation Opportunities (ECO's) and resultant savings described in this report reflect only those opportunities identified for the main *************. No peripheral properties are addressed as part of this report.

Energy Conservation Opportunities were developed to demonstrate energy and cost reduction initiatives that an Energy Service Company (ESCO) would be expected to perform.

Preliminary cost estimates for each ECO were prepared. Using the costs and benefits, the simple payback and life cycle cost analysis were calculated.

The Study is organized as follows:

- *Observations/Recommendations* succinctly summarizes the Energy Study's results.
- In the *Scope of Work*, the goals and requirements of the study are itemized.
- An overview of the existing building energy consuming systems is presented in *Existing Systems.*
- *Method of Analysis* presents an overview of the approach taken in this building energy audit.
- In *Energy Conservation Opportunities,* savings opportunities are listed.
- *Load Data* describes available data that documents energy consumption.
- *Utility rate schedules and changes* gives an explanation and breakdown of utility costs Estimate.
- *Appendices:*
  - Appendix A, Savings Calculations
  - Appendix B, Preliminary Cost Estimate
  - Appendix C, Summary Utility Cost
  - Appendix D, EMS Controls Point List
  - Appendix E, Audit Data
  - Appendix F, Products

SECTION II

OBSERVATIONS / RECOMMENDATIONS

The following Observations and Recommendations are based on the energy analysis that was performed for *************.

OBSERVATIONS

A. GENERAL

The Hospital has a very large electrical demand charge that includes a peak demand ratchet clause.

- The ratchet clause means the Hospital is penalized throughout the year for high peak electrical demands experienced during the summer (See Section VIII).
- Many HVAC systems are nearing the end of the their useful life and need to be upgraded or replaced.
- Previous aggressive preventive maintenance measures have positively impacted utility consumption. The Hospital is encouraged to continue with these types of programs.
- The Energy study found many areas where ductwork should be re-installed or adjusted to reduce crimping and other air restriction (See Section IV (E), also).

Energy Management System With Direct Digital Control (EMS-DDC)

- The existing HVAC pneumatic controls are in fair to poor operating condition and need to be replaced and/or upgraded.

- The Hospital needs to move toward a Direct Digital Control system that links all building operating systems together for demand-side management, night setback, and more consistent occupant comfort.

- Factory training should be provided to all HVAC maintenance personnel for the new EMS-DDC system.

Free Cooling opportunities need to be maximized through the use of economizer sections on the HVAC units. All rooftop units have economizer sections on them that are currently not operational.

HVAC Systems

- The HVAC systems and associated heating/cooling water systems run continuously.
- Some of the rooftop units have reached the end of their useful life and should be replaced.
- The remaining rooftop units should be retrofitted with Evaporative Pre-Condenser Coils, which will improve the operating efficiency and reduce the maintenance costs for these units.
- All four chillers should be retrofitted with Evaporative Pre-Condenser Coils to improve operating efficiency and reduce maintenance costs.

Special HVAC Recommendations

- There are severe air distribution issues associated with the East Wing patient care area. In addition to upgrading the controls for this area, a new supply and return air system needs to be designed to relieve the air pressure problems. The new design will utilize a majority of the existing ductwork and equipment.
- The main air-handling system for the East Wing should be renovated. This includes a comprehensive cleaning of the air-to-air heat exchanger, coils, and pumps.
- The laboratory and medical records HVAC systems need to be redesigned to address the appropriate heating/cooling loads for these areas. Air pressure concerns and poor distribution were observed in both areas.
- The HVAC systems for the surgical and patient care areas should be brought up to current operating parameters recommended by the Association of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) Standards, JACHO requirements, and the American Healthcare Providers Association design requirements.
- It is strongly recommended that a complete “as-built” of the existing HVAC systems be completed and stringent document control of these records be enforced.

Power Factor Converter (S/R Controller)

- The Hospital was independently metered by the utility company approximately 1 year ago.
- The average power factor for the Hospital is 0.88 on a scale of 0 to 1.0. The closer to unity that the power factor can be corrected the better.
- It is strongly recommended that the Hospital install a power factor controller. An S/R controller will have a two-fold impact on the electrical energy consumption on this facility. On the one hand, it will have a 5% reduction on Kwh power use. Secondly, it will have a larger impact (estimated at greater than 10%) on the KW demand component of electrical consumption. See Appendix A for power factor saving calculations.

Lighting

- Most building lighting uses fluorescent fixtures.
- The Hospital maintenance staff has made good progress in the replacement of most T-12 fixtures in the facility. At the time of the audit, 438 fixtures, 62.5%, of the Hospital had been completed. No pre or post installation consumption data was available for these retrofits making it impossible for the Hospital to take credit for energy reductions.
- The remaining T-12 fixtures should be replaced and a lighting re-design should be considered to either reduce or improve lighting distribution in numerous locations throughout the Hospital.
- Light controllers should be installed throughout the Hospital. These systems will allow the lighting systems to go into the equivalent of a night setback similar to night setback scenario for the HVAC systems.
- The use of ambient light and motion sensors throughout the Hospital is highly recommended.
- Some incandescent lighting exists and should be replaced with compact fluorescent fixtures.
- Lighting usage varies throughout the facility.
  - Lighting in many areas remains on all the time.
  - Other area lighting is turned off when not in use, at night, and on weekends.
- No procedural or medical equipment lighting (e.g. surgery) was addressed as part of this report.
- Parking lot lighting was not addressed as part of this report.

Building Envelope

- The building envelope was visually examined and found to be in good to excellent shape.

RECOMMENDATIONS

- It is recommended that ************* proceed with a full engineering design and construction of the following ECO's:

  ECO#1 – EMS-DDC
  ECO#2 – HVAC Replacement and Renovations
  ECO#3 – Power Factor Controller
  ECO#4 – Lighting
  ECO#5 – No/Low Cost Opportunities

SECTION III

ENERGY AUDIT TASKS

The ************* Energy Audit included the following tasks/goals:

1. Perform an energy conservation audit to examine the operations and condition of the facility's mechanical and electrical systems, all other energy consuming equipment, utilities systems and metered data, and facility envelope.

2. Determine energy use profiles, facility operating schedules, operating schedules of energy consuming systems, and any other items that characterize current energy use for the existing facility.

3. Identify all ECO's that are life cycle cost effective. The criteria established by ************* for total project cost and payback period were $1.0 million and 10 years or less, respectively.

4. The ECOs shall be individually identified with independent cost and saving estimates. Then, they shall be combined to capture the benefits of all the ECOs for the entire project.

5. Calculate detailed cost savings.

6. Develop **<u>preliminary</u>** cost estimates for the various ECO's. These costs include engineering and design costs, construction, construction management, measurement and verification, and financing.

7. Identify a proposed Measurement and Verification protocol for the performance guarantee.

SECTION IV

EXISTING SYSTEMS

A. GENERAL

The Hospital was constructed in phases over the last several years with a blend of different construction types. The prevailing interior construction is typical steel stud and finished drywall. During the growth of the hospital much was made of the aesthetics of the building although some concern may have been given to patient and ************* partners comfort. Hospital additions in the last 15 years seem to have been of consistent type building envelop construction: typical steel stud, brick or CMU, insulation and dead air space with a finished drywall covering. The total R-value of the walls appears to be approximately R22.

The original part of the building housing ************* is constructed primarily of concrete masonry units (CMU) with both rough and smooth finish. The apparent *R value* of the original area is R11, well below the standard required to maintain desired space temperatures without the use of excessive amounts of energy.

Between remodeling, new-construction and upgrades, the lighting system has evolved over the years such that in many areas of the hospital light levels in common areas (hallways), far exceed light standards, thus using excess energy to meet the demand, while light levels at task areas (Desks) are far under the standards; a potential area of workman's compensation concern and energy losses.

Some examples of light level discrepancies are:

- The volunteer desk light levels vary from 4 foot-candles (FC) to 100 FC's. The IES lighting handbook specification for administrative task areas is 50 FC. The varied lighting levels do not provide for sufficient or even lighting levels for the task at hand. This lack of proper lighting cannot only increase the difficulty of task performance, but, as evidenced by volunteer comments, worker dissatisfaction as well.

- Information Services (IS) lighting levels varied from 35 FC's to 97 FC's at workstations. Again, the lighting specification from the IES handbook is 50 FC's. The background lighting over non-workstation averaged 200 to 400 FC's. This disparity of lighting levels in IS, coupled with light placement, does not provide sufficient light levels at workstations for the task at hand, and current light placement increases the lighting glare on computer monitors making monitor use more difficult and bothersome to the user of the computer monitor and adding to the increased use of energy.

- The medical librarians desk is 104 FC's provided by two lighting fixtures each containing four florescent bulbs. The lighting specifications from the IES handbook for administrative task levels are 50 FC's. The lighting placement is above and to the rear of the main librarian task area. This lighting fixture placement, in combination with excess light levels, not only uses more energy than should be used, but causes increased computer monitor screen glare thus adding to user discomfort and increasing the difficulty of task accomplishment.

- The lighting levels of the main corridor connecting the East Wing patient care area with the west side of the hospital average 100 FC's. The IES specification for corridors is 20 FC's. Again, this higher than required lighting level (80 FC) adds to the energy expended to illuminate common corridors.

These are only a sampling of lighting level discrepancies discovered during the course of this audit. During the design and engineering phase of this project, each major area of the hospital should be properly designed for the areas specific lighting requirements as well as energy requirements of the facility.

Utility systems loads consist primarily of lighting and HVAC. Many computers and other devices add to building utility loads. There are a number of measures and means that are available to reduce the operating cost of these devices without significantly impacting hospital business routine.

The hospital has multiple and varied types of use. These range from 24-hour-a-day patient care areas to administrative areas and a cafeteria.

General Observations

- Building construction appears to be in good shape.
- HVAC units run continuously in the return air re-circulation mode and do not take advantage of free cooling opportunities; use of economizers to pull fresh air from outside the facility during the cool periods of the day or night operating hours.
- Lighting in hallways and restrooms is on all the time. Office lights are on most of the time and are not controlled.
- Cafeteria load is significant; three meals a day as well as call in orders, are prepared about 13 hours a day.

B. ENERGY EFFICIENT MEASURES

Some energy conservation measures have been taken during the past three to four years; a lighting lamp and ballast replacement program was initiated by plant operations to convert the high-energy using T12 lighting systems to energy efficient T8 fixtures with electronic ballast lighting systems. In addition, an aggressive and comprehensive utility system preventive maintenance (PM) program was initiated by plant operations. The PM program included items such as cleaning heating, ventilation and cooling coils, cleaning air-conditioning condensing coils and monitoring and adjusting equipment to operate within manufacturer parameters.

These measures not only cut utility usage as they were performed, but as the cost of energy escalated this past year, the energy savings measures undertaken by plant operations helped lessen the "Blow" of the rapidly escalating price of energy.

Based on the observations of this audit, it is in the best interest of ************* to improve on the existing PM program as well as maintaining a dynamic and aggressive energy conservation program. The consistently fluctuating cost of energy causes prediction of energy cost as a percentage of revenue to be difficult at best. However, based on historical data, the prospect of reduced energy cost by the utility provider(s) in the foreseeable future is not likely.

General Observations

The preventive maintenance program must be continually monitored to ensure scheduled items are completed as scheduled and that the level of effort given the maintenance task is such as to maintain equipment operating as designed with minimum energy expended.

C. BUILDING ENVELOPE

The exterior has two types of finish. The first is an exterior insulated finish system. This system consists of a rigid Styrofoam insulation with a plasticized stucco finish. The R-value of the wall system is directly proportional to the amount of the rigid Styrofoam applied.

The second type of finish is an exposed firebrick, which is installed on a many areas of the Hospital. The predominant insulation value is gained from the fiberglass insulation (commonly referred to as Batt insulation).

In general, windows are operable, double panes. The most notable area with operable windows is the East Wing Section of the Hospital. The opening and closing of these windows is used to control air temperature throughout the year, resulting in large energy losses from the heating, ventilation and cooling system.

Floor to floor (or roof deck) height is approximately 12 feet. There is a 2X4 grid lay-in ceiling throughout the Hospital with few exceptions. The most notable exception is in the Operating Rooms of the Surgery Wing, which have gypsum board (hard) ceilings. Floors are poured concrete with various floor coverings. Hallways utilize linoleum while offices use carpet.

There is a flat roof. Construction consists mostly of a single-ply membrane roof. Roof replacement has been a ongoing event. Average roof insulation value is R30.

D. LIGHTING

Although some task lighting is in existence, the major lighting design consists of fluorescent fixtures installed in lay-in ceilings. A mixture of high – energy using T12 lighting fixtures are intermingled with energy efficient T-8 fixtures throughout the facility. Most of these lighting systems utilize prismatic lens in distributing light. These prismatic lens are designed to distribute light throughout a work area and provide evenly distributed levels of lighting such that the light level in the corner of a room can possibly receive as much light and expended energy as a task area such as a desk, lab table or patient care area.

The T12 fluorescent lighting system generally consists of old style magnetic ballasts with T-12 lamps. ************* plant operations personal have been retrofitting these older systems with energy efficient T8 systems with electronic ballast.

Recessed incandescent light fixtures provide lobby lighting. Due to the close proximity of and abundance of windows in the lobby area, light readings were taken with a luminary light meter. The lobby lighting systems reading, as indicated in lums, were taken with the lights energized and with the lights not energized. There was no significant difference in light lums reading; a sure indication that these lights are not required to be energized during majority of the daylight hours. This lack of lighting difference further states the case for the increased us of light level sensors throughout the facility so that only the amount of light required for the task at hand is operating. We need to take full advantage of natural lighting systems in combination with motion sensors to further reduce the requirement for electricity.

Exit lights are a combination of incandescent and L.E.D.

Mechanical rooms had some incandescent lighting, these lights were found to be energized during each of our audit visits, both day and night visits.

Lights are generally left on continuously in hallways, restrooms, the library and all common areas. Lighting in office and administration spaces is operating from approximately 7am to 6pm five days a week, whether the office is occupied or not. During the audit, many lighting systems were on in unoccupied office spaces as late as midnight and at times were found on as late as 5am, or until turned off by security. Although difficult to quantify, this uncontrolled and needless use of lighting energy in unoccupied office spaces is creating a drain on the system and costing the Hospital money.

No occupancy or ambient light sensors were found. Occupancy sensors would give ************* more manageable control of the amount of energy used in lighting as well as control times that lighting systems are actually utilized effectively.

Lighting Observations

- A large amount of lighting remains on continuously.
- A few incandescent light fixtures, including some incandescent exit lights, were found to still exist. Incandescent lighting should not be used.
- Appropriate light lenses should be installed to control light distribution in offices, hallways, etc.
- Overhead lighting is utilized to provide the required lighting levels without taking into account the available ambient light.

E. HVAC SYSTEM

The major focus of capital improvements for ************* is the replacement or upgrade of aged equipment at no out of pocket expenses to our partners at *************. The replacement of the mechanical systems is at the top of the list of capital improvements as the majority of the rooftop units have reached the end of their useful life. The cost of both operation and maintenance of these older units is becoming cost prohibitive; drawing manpower and dollars from other improvement projects as well as requiring additional staffing levels to maintain these units.

Heating Ventilation and Air Conditioning (HVAC) is provided by a combination of air handler chilled water air-conditioning systems with heating and cooling coils and rooftop mounted heating and cooling units. The source of chilled water for much of the hospital cooling system is provided via a few centrally located chiller units. Heating is provided via three Weil /McLain boilers and rooftop mounted gas fired heating systems in combination with some gas fired unit boilers.

Throughout the hospital, the mechanical systems run continuously. There were several different HVAC systems observed during the audit walkthrough. These systems ranged from the make-up air unit serving the kitchen area to the central station Air Handler with Variable Volume zone control in the East Wing. Only the most significant of the systems will be discussed below. These consist of the East Wing, Operating Rooms, and all the packaged rooftop units.

The air-conditioning system providing air to the East Wing patient area has been particularly problematic over the years. Conversations with ************* partners as well as patients indicate a high level of dissatisfaction with the current heating, ventilation and cooling system. Complaints of the area being to hot or to cold are commonplace. Although the East Wing Patient Care heating, ventilation and cooling system problems have a variety of causes, the principle cause is rooted in design.

The current HVAC system for the East Wing draws 100% outside air and the air is routinely conditioned two times prior to being discharged into a patient or ************* partner room or work station. The heating/cooling sequence is as follows:

- The incoming air passes through a single pass counter flow heat exchanger (where it should be pre-conditioned by the exhaust air from the East Wing through indirect contact). During the audit, this pre-heat exchanger was observed to be blocked to the point of complete ineffectiveness, thus requires the heating, ventilation and cooling system to expend more energy to condition the in-coming to desired patient / partner areas.

- Then the air passes through a cooling coil, typically set to discharge air at 55 degrees F.

- The AHU then sends this air to one of three zones serving the East Wing. Each zone has a tube-type hot water heating coil that will reheat the 55 degree F air if its zone is calling for heat. If one of the three master thermostats in the East Wing is calling for heat, the air that has been chilled down to 55 degrees F is now heated up to set point (100 degrees F was observed during the audit), and then discharged to the applicable section of the patient / partners area. Thus placing cooled, then heated air to the entire section of the unit, even though all of the patient rooms may not have a requirement for heated or cooled air.

- The air is then distributed to the East Wing via ducting where the air is discharged to each room via step down diffusers. There are three air duct trunks providing conditioned air to the East Wing. Each section of the East Wing is fed from a duct dedicated to a section of the unit. One duct line is dedicated to the east section (patient care) of the unit, one duct line is dedicated to the center section (nursing station and doctors dictation) of the unit with a third duct dedicated to the west section of the unit (patient care).

- The air exits the East Wing by a fan exhaust system. This is a once through system with no return air.

- Patient rooms as well as nursing stations and physician dictation area temperatures are controlled by two methods:

- A thermostat controls each patient room temperature. This thermostat controls a damper, which opens and closes to allow air at a set temperature (either hot or cold) to enter the room. The temperature of the in-coming air is heated or cooled based on the set point of the master thermostat located outside the room. The amount of air provided to a space is, controlled by the room thermostat. Routinely, the room (patient) will actually have a need for cooling or heating but will not receive cool/heated air because the master thermostat sets the zone heating/cooling requirement and maybe be in the opposite operating made of what the patient is requiring.

- Each of the sections of the patient care unit (east-west-center) is controlled by a master thermostat to maintain air temperatures to that particular section of the East Wing patient care area. This master thermostat can prevent air movement in a room as well as prevent the room from attaining a temperature desired by ************* partners or patient.

Air volume and velocity readings of the room supply and exhaust system indicate that the supply air levels are operating at the minimum level required with the room exhaust system not operating at a level sufficient enough to draw air from the room. This lack of exhaust air movement from the room results in a high level of static air backpressure in the room. This high static backpressure in the patient care room prevents the incoming air from sufficiently circulating in the room resulting in wide temperature differences in the room as well as the feeling of "stale air". Not only will this lack of air movement cause temperature air differences in areas, this lack of air movement may adversely affect infection control and be a root cause of in door air quality issues as well as a possible site for hospital-bourne infections.

The growth of the hospital has pushed the current utility systems to their limits. In some areas of the hospital, the heating, ventilation and cooling system that was in place and utilized for a specific and particular area and application was also used to accommodate building expansions and increased heating, ventilation and cooling demands. This growth of current utility systems has lead to some areas of the hospital experiencing periods of high or low temperatures while other areas within the same area experience the opposite temperature effect. Large differences in airflow velocities as well as large temperatures differences are commonplace

The operating room systems currently run continuously on 100% outside air. They do not have time or temperature setback thermostat; they run at a manual set point 24 hours a day seven days a week. These units are configured for thermostatic control, but rely heavily on user awareness and physician desires to turn down or turn up the thermostat. These units were observed at 1:00am on two occasions to be cooling unoccupied space to thermostatically set temperature of 70 degrees F. While these units run continuously on 100% outside air there are no code or regulatory requirements that require this operating configuration.

The rooftop units run continuously. They have a maximum Seasonal Energy Efficiency Rating (SEER) of 10 or less. The SEER is the rating that correlates the amount of input energy required to provide the required cooling to a space. The higher the SEER rating the more efficiently the unit performs. Due to the age of the equipment, it is quite possible that all of these units are operating well below their maximum SEER, which increases the energy demands for each unit. Also, the rooftop units have capability to provide free cooling for their respective zones through the use of an economizer system installed on every single unit. The audit results determined that every roof top unit economizer was inoperable and was unable to provide free cooling under any conditions.

The chilled water systems consist of four chillers serving various parts of the hospital. The only seasonal chiller is the Carrier Unit, serving Respiratory Therapy, Occupational Health, and parts of the Surgery Wing. This unit operates approximately 6 months out of the year. The other three chillers serving the MRI, E/R, and East Wing operate year-round. The East Wing and E/R chillers are aged equipment and approaching the end of their useful life.

The three Weil-McLain hot water boilers and two Burnham hot water boilers provide hot water for space heating. The hot water boilers located in the west side mechanical room and the ICU mechanical rooms provide hot water to various heating systems. These boilers, installed in 1968 and 1991 respectively, are gas fired direct heating boilers. Non- chemically treated water from the city water system enters the boilers where the water and is heated to set point, it is then distributed to the heating system. These boilers run 24 hours and day seven days a week 52 weeks a year. A temperature sensor in the water outlet stream controls the final temperature out put without regard to outside air temperatures; this leads to increased fuel usage because the boiler is continuously maintaining a boiler set point, not a space temperature.

Please see Appendix A for the summary cost savings associated with the HVAC systems.

HVAC SYSTEM OBSERVATIONS

- Systems appear to be in fair operating condition considering their age.
- Systems run continuously
- Originally, the systems were adequately sized to cool the space, but as they get older, their capacity diminishes. Plus, the occupancy and use of many of the spaces has changed over the years, making it difficult for the aging units to meet the new demands.

F. CONTROLS

The control system is a pneumatic system, which is basically a system that uses compressed air to control the operation of valves, dampers, and other mechanical controlled devices.

Without exception, the systems run 24 hours per day 7 days per week.

Pneumatic controls are used to control the HVAC equipment and are available to control the VAV boxes and zone reheat coils. In general, thermostats located throughout the building each individually control a VAV box or a zone on the AHU and all flow control valves. CONTROL SYSTEM OBSERVATIONS

- Pneumatic controls require frequent adjustment to keep within tolerance. However, this system can be re-enabled to provide zone control on the multi-zone systems.
- EMS-DDC controls capabilities can be more fully utilized with the existing rooftop units, chillers, AHU's and potentially be expanded to include the smaller HVAC systems.

G. EQUIPMENT LOAD

- Typical office type equipment is located throughout the Hospital. This equipment includes computers, printers, fax machines, copy machines, and scanners.
- There was a large equipment load observed in this building.

EQUIPMENT OBSERVATIONS

- Over 60% of the computers and printers are left on continuously.

H. COMPRESSED AIR

- Compressed air represents a minor building load. It is used primarily for control air in the pneumatic controls.

SECTION V

METHOD OF ANALYSIS

This energy audit of the ************* was conducted to determine existing energy usage and opportunities for reducing that usage through various building and equipment modifications. These are identified by Energy Conservation Opportunities – ECO's. The method of analysis described below indicates the methodology used.

A. SURVEY

In order to determine the energy consumed by each facility, day and night time walk-throughs were performed to observe and list energy consuming items as well as building envelope energy related components for tabulation during the survey of this building.

All systems and operations were surveyed for everything that may affect energy consumption. This includes physical characteristics, lighting, HVAC systems, process equipment, and office equipment. Building occupants were questioned as to equipment usage schedules. Lighting and equipment schedules, very important components of energy usage, were determined by asking employees and personal observation.

Night-time observations were conducted by *WASTREN Energy Services* to determine if any unusual energy demands exist.

Independent electrical metering data was used to determine the power factor. This is useful in assessing the need for any power factor corrections that may be made. Power factor reflects how efficiently a facility uses electricity. Power factor compares the amount of useful work that is extracted from the total amount of electrical energy supplied. A power factor of 1.00 or unity means that all of the power consumed by a facility goes to produce useful work.

B. UTILITY BILLS

Utility bill data was compiled, analyzed and utilized to determine the current conditions and the potential of reducing utility costs through energy conservation projects. It was determined that the hospital is being charged for demand energy though a ratchet clause. This technique, used by the utility provides, penalizes the hospital through the year for high seasonal loads, which usually occur during the summer.

C. INTERVIEWS

The plant personnel were interviewed to learn as much about the building as possible. Building characteristics and systems were discussed. Changes, problems, current plans, envisioned improvements and questions were all discussed in order to develop a sound understanding of the existing building and verify that potential ECO's could be implemented.

Observations: In walking through the building during the energy survey, major energy users appeared to be: lighting, motor loads, and, HVAC units. Many of these did not have any methods of control and are left on continuously.

D. MEASUREMENT AND VERIFICATION

Measurement and Verification for the performance contract will be based on a one-time guarantee using actual 2000 utility consumption data per square foot of the building data.

There are several contributing factors to this one-time guarantee.

There were several data gaps associated with gathering of equipment information. This included: equipment technical data sheets were unavailable or incomplete, nameplate data was missing or unreadable, "as-built" drawings are outdated and inaccurate for several areas of the Hospital.

An additional change was the number of light fixtures that have been replaced or retrofitted. This number is substantially greater than originally stated. The impacts, both positive and negative, of the light retrofit cannot be evaluated accurately at this time. Only those light fixtures that remain to be upgraded will be discussed in this report.

The one-time verification will be conducted 60 days after construction has been completed and the work has been commissioned on a date that is agreeable to both parties.

SECTION VI

ENERGY CONSERVATION OPPORTUNITIES

ECO#1 – Energy Management System with Direct Digital Control

This ECO addresses the effect of installing an EMS-DDC for the HVAC systems. Features include turning off building HVAC equipment during unoccupied times with freeze protection override, night setback to a cooler temperature in the winter and warmer temperature in the summer via the thermostat schedule, shutting off outside air during unoccupied times, and use of economizers for free cooling. Variable frequency drives (VFD's), where applicable, are also modeled. VFD's adjust the speed of motors and pumps, depending on system demand.

In order to make sure that the building has sufficient outside air during occupancy, morning warm-up/cool-down control programs turn on the HVAC equipment prior to occupancy to ensure that the buildings have adequate outside air and are at the proper occupancy temperatures.

The entire mechanical system for the Hospital requires an Energy Management System to optimize; control, operation, and, most importantly, patient and staff comfort. The EMS will resolve the current condition of heating/cooling unoccupied space, lack of night setback for unoccupied space, dueling thermostats, and hot/cold complaints by patients and staff. The EMS will also improve the ability of the plant operations staff to forecast maintenance activities more accurately as well as improve troubleshooting capability on corrective maintenance. The EMS provides all this through the use of a computer-based system called "LonWorks". LonWorks is non-proprietary software that will allow the EMS to interface with those existing control systems that are working and communicate with any additional control systems that may be installed at a future date.

Of greatest importance, the EMS will allow the Hospital to have control over its very high electrical peak demand and demand load. The Hospital currently pays 62% of their electrical bill in demand charges. The demand charges are set up under a ratchet clause that, in essence, penalizes the Hospital for an entire year based on its high electrical requirement for cooling purposes during the summer. This ratchet clause adds literally thousands of dollars to the Hospitals electrical bill annually.

The installation and operation of an EMS will allow the Hospital to pre-program equipment start-up times and allow the plant operations to control load shedding during times of peak electrical use. All this means cost savings to the Hospital.

Training of both maintenance and building personnel will be required in order that they know how to both operate the EMS-DDC and change it, as conditions require.

Fans

Existing operation:	24 hours per day, 7 days per week
After retrofit - Summer most units:	4:00 am to 10:00 pm, M-F, off (or turned down) otherwise, off weekends
After retrofit - Winter most units:	4:00 am to 10:00 pm, M-F, cycle as required otherwise. Maximize free cooling with economizers.

VFD's: Provide VFD's on the following HVAC units: East Wing supply and exhaust fans, ICU, E/R, Pre-OP AHU's supply, return, and/or ventilation air fans. Also provide VFD's on pump motors.

HVAC Existing operation:	Static pressure and CFM are running at maximum regardless of zone load
After operation - CFM:	90% of maximum during occupied times, 75% otherwise
After operation - Static Pressure:	90% of maximum during occupied times, 75% otherwise
Pump Existing operation:	The chilled pumps run continuously. Heating pumps run continuously during the heating season and intermittently during the cooling season.
After operation:	Install 3-way valve at the end of the chilled water and heating water distribution systems and cycle pumps on and off with demand for heating/cooling. Otherwise, pump(s) are off.

ECO#2 – HVAC REPLACEMENT AND RENOVATIONS

This ECO will be completed in conjunction with the installation of the EMS-DDC for a combined savings that will have a positive effect on the overall operation of the HVAC systems.

The systems run continuously. The East Wing is designed to provide heating/cooling throughout the year through the utilization of a 100% outside system that uses a Variable Volume and Temperature (VVT) configuration. The system is configured into three zones - the east, west, and center zones. Return air is a major concern of the East Wing in that it is under designed and creates a large static pressure differential buildup which greatly increases the energy required to run the fan system to provide enough air to the space while overcoming the increased pressure load.

East Wing
The correction for the problem with the existing VVT configuration would be a simple re-design of the return air system to create the proper return airflow to maintain the fan system at its optimum efficiency. The second fix would include the re-design of the existing controls system from a VVT type to a Variable Air Volume System with zone re-heat. The Hospital will be able to utilize the existing VAV boxes and install the modified controls, hot water coils,

and by-pass valves right into the existing system. The new system will allow room-to-room temperature control for maximum patient comfort with separate control systems for the interior spaces. The temperature control system will no longer work based on a temperature-averaging scenario, but rather chilled air from the central station air handler at 55 F and allow each patient room thermostat to determine the heating or cooling requirement for the space. If the space is unoccupied, the VAV system will be dampered down to reduce airflow requirement on the entire system, thus, reducing the energy draw on the fan. The central fan will be retrofitted with a variable frequency drive so that when less air is required less air will be provided.

There are two major energy retrofits being considered for the rooftop units. They are the installation of evaporative pre-condenser units on the newer rooftop units and the replacement of older rooftop systems with higher seasonal energy efficiency rating (SEER) units that will save approximately 53% of electrical consumption per unit per year.

The operating room systems currently run continuously on 100% outside air. They are not currently configured to go into a setback mode. The major upgrades to these systems involve the installation of new units with night setback controls through the use of the proposed EMS. Additionally, the systems should be re-designed allow for appropriate air flow requirements in accordance with building codes and the latest acceptable industry standards for operating rooms. At no time will the recommendations being considered here be in violation of the minimum JACHO, health care regulations, life safety, or mechanical design requirements.

The evaporative pre-condenser systems will allow the air temperature moving across the condensing coil to be dropped from 105° F to 85° F, which will reduce the electrical draw requirements of the compressors an average of 11%. The one drawback on this system is that will require a higher level of preventive maintenance. Even factoring in the increased maintenance activity this retrofit is strongly recommended for implementation.

Most ENERGY SAVER Evaporative Precooler Systems are designed, engineered, and manufactured to attach directly to the condenser section of air conditioning or refrigeration equipment and utilize the airflow of the existing fan(s) for operation. The precooler unit is typically designed not to exceed 500 feet per minute face velocity at any time.

Evaporative Precoolers rely entirely on the evaporation of water for operation. As water moves downward through the media, drawn by the air velocity of the condenser fan, some of the water evaporates. This evaporation cools the air before it reaches the condenser coil. The condenser unit of the air conditioning system operates more efficiently than otherwise possible when temperatures exceed 80° dry bulb.

The media is cross-fluted and slopes at angles of 45 degrees towards the entering air face of the media and 15 degrees toward the leaving air face. The design of the media directs the water to flow towards the entering air face of the media, thereby preventing water carryover onto the condenser coil. This water flow also tends to minimize the collection of dust and other debris, which attempts to enter the air face of the evaporative media.

The chilled water systems should also be retrofitted with evaporative coils. Using the same principle described above to reduce the air temperature moving across the condensing coil, this will reduce the operating costs of the systems by an average of 11 percent.

ECO#3 – POWER FACTOR CONVERTER (SR Controller)

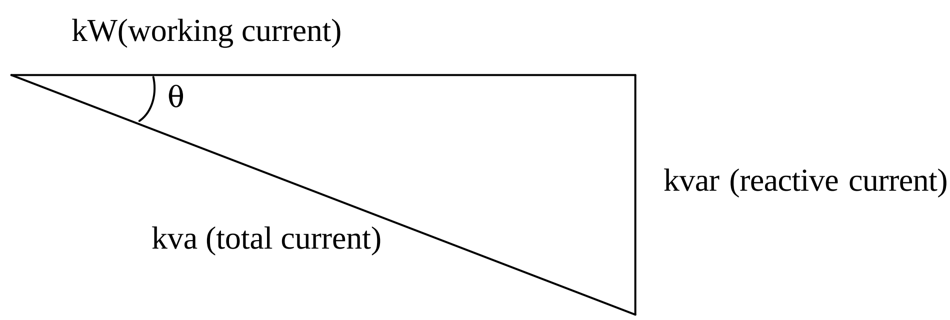
It is strongly recommended that ************* install a power factor converter on their main transformer. An SR controller will have a two-fold impact on the electrical energy consumption on these facilities. On the one hand, it will have at least a 5% reduction on Kwh energy use for each of the stores. Secondly, it will have a large impact (estimated at greater than 20%) on the Kwh demand component of electrical consumption.

The power factor is important because it imposes costs on a utility that are not recovered with demand and energy charges. Customers with high inductive loads, like *****, are more likely to be charged for a poor power factor. They create greater power factor problems for a utility because of the equipment they use. They are also more likely to be able to correct the problem.

Unless some way of billing for a low power factor is incorporated into a rate schedule, a company with a low power factor would be the same as a company with a high power factor. Most utilities do build in a power factor penalty for industrial users. However, the way of varies widely.

Power factor is the ratio of actual (real) power being used in a circuit, expressed in watts or kilowatts, to the apparent power drawn from the power line, expressed in volt-amperes or kilovolt-amperes.

A look at the triangle the Figure below shows that as the power factor is improved, kva is reduced, providing a motivation for power factor improvement.



θ = Phase angle = measure of net amount of inductive reactance in circuit
Cos θ = PF = ratio of *real power* to *apparent power*

$$\textbf{Billed Demand} = \textbf{Actual Demand} \times \frac{\textbf{Base Power Factor}}{\textbf{Actual power Factor}}$$

This way, if the actual power factor is lower than the base power factor, the billed demand is increased. If the actual power factor is higher than the base power factor, some utilities will allow the fraction to stay, thereby providing a reward instead of a penalty. Some will run the calculation only if actual power factor is below base power factor.

The demand or consumption-billing schedule is changed according to the power factor. Some utilities will change the schedule for both demand and consumption according to the power factor.

ECO#4 – LIGHTING RETROFIT

A lighting retrofit has been going on in the facility for the last 2-3 years and T-12 lamps with magnetic ballasts are being replaced with electronic ballasts and T-8 lamps. This ECO is a continuation of that project.

In addition, this ECO recommends the installation of ambient light sensors near the exterior window where lighting levels are higher than recommended during the day. In the cafeteria, it connects cafeteria seating area lights to light switches. There are a large number of incandescent lights in the building that will be replaced with compact fluorescent lamps with self-contained ballasts under this ECO. With light level readings varying from DOE/IES recommended lighting levels, it is recommended that areas be relamped as necessary to achieve those recommended lighting levels.

Exit signs using incandescent lights are replaced with exit signs using LEDS.

From the late night walk through, it appears that approximately half the lights in the building operate continuously, while the remaining lights operate throughout the workday and are turned off after night building cleaning. The lights that were observed during the night walk through were serving the East Wing Area, Emergency Room, Intensive Care Unit, Laboratory, main and surgical hallways. The only area on a light controller is the East Wing Area.

This ECO is strongly recommended for implementation in all the areas of the Hospital.

ECO#5 – NO/LOW COST OPPORTUNITIES

This ECO calls for the installation of vending misers on all machine located at the Hospital.

VendingMiser™ represents a technological breakthrough in intelligent and economical control of vending machines, which significantly reduces energy consumption without compromising the vended product.

Utilizing a custom passive infrared sensor, VendingMiser™ powers down a vending machine when the area surrounding it is unoccupied and automatically repowers the vending machine when the area is reoccupied.

Additionally, VendingMiser™ monitors the ambient temperature while the vending machine is powered down. Using this information, VendingMiser™ automatically powers up the vending machine at appropriate intervals, independent of occupancy, to ensure that the vended product stays cold.

VendingMiser™ also monitors electrical current used by the vending machine. This ensures that VendingMiser™ will never power down a vending machine while the compressor is running, so a high head pressure start never occurs. In addition, the current sensor also ensures that every time the vending machine is powered up, the cooling cycle is run to completion before again powering down the vending machine. This unique process also ensures a cold vended product.

The Monitor and LaserMiser™ essentially shut off monitors and printers when not in use will sacrifice nothing in convenience and will save energy. Similar to newer ENERGY STAR® computers and printers, and the Monitor and LaserMiser™ turn off the monitor and laser printer after a period of inactivity of five minutes (adjustable). Monitors can be reactivated by one keystroke on the keyboard. The LaserMiser™ acts like new printers by receiving data sent to the printer, storing it, turning the printer on, and sending the data to the printer when it is ready to print.

Currently, many printers, monitors, and Central Processing Units (CPUs) are left on continuously. Others are turned on when employees arrive in the morning and off when they leave at night. Some printers serve more than one employee and these are left on continuously. Other printers and computers act as servers and these are left on continuously. Monitors could always be turned off, even if the CPU is left on, when the employee is away from his desk for a meeting or lunch or any other reason. Printers could be left off whenever they are not in use.

The night walk through found many computers left on continually. However, it was not possible to enter some office and observations through the window frequently did not reveal whether computers and printers were left energized. During the audit, random occupants were asked about equipment schedules (usage patters).

A few printers are left on 24 hours per day because they are network printers. These will be considered for a network printer laser miser, which performs in the same manner as the laser miser. However, it allows placement of the printer card in the network printer LaserMiser™ so that when queried by the computer network, the printer can respond that it's connected to the system even though it's turned off.

It was assumed that a monitor, on average, would be turned off approximately 50% of the current estimated nine-hour day.

Interactive cooling load reductions will be calculated based on the equipment energy reduction, which no longer needs to be cooled.

An alternate to the monitor miser and LaserMiser™ utilizes occupancy sensors connected to an outlet strip. Electrical load not required to be on when the occupant is not present can be connected to this plug strip. After the occupant has left the area for more than five minutes (adjustable), the plug strip turns off those loads. Examples of this include under counter lights, printers and monitors. Advantages primarily relate to lesser cost affecting (turning off) more load. Disadvantages include monitors and printers remaining on while not in use during the time that an occupant is present.

SAMPLE SAVINGS

Computer/printer – daytime only	
Hours/day used (M-F):	10
Watts per computer (w/monitor) – existing:	500
%used – computer (w/monitor) – after:	75 (Simulates monitor off 50% of time)
Watts per printer – existing:	225
%used – printer –after:	15 (Simulates printer off 85% of time)

Computer/printer – 24 hour	
Hours/day used (7day):	24
Watts per computer – (w/monitor) – existing:	500
%used – computer (w/monitor) – after - workday	75 (Simulates printer off 50% of time)
%used – computer (w/ monitor) – after – night:	50 (Simulates printer off 100% of time)
Watts per printer – existing:	225
% used – printer – after:	15 (Simulates printer off 85% of time)

Close coordination with the Hospital's *Information Services Department* will be integral to making this ECO a success. Our goal is at no time to hinder employee use of equipment or productivity.

SECTION VII

UTILITY RATE SCHEDULES AND CHARGES

A. GENERAL

The Hospital is currently being charged for its electric utility consumption under the rate schedule of Secondary General (SG). This rate schedule includes major energy use charges of $0.01652/KWH and a demand charge of $12.55/KW. There are service charges and taxes that contribute to the overall utility costs, as well.

The Hospital is also being charged for demand through a technique known as a Ratchet Clause. The ratchet clause usually works such that the billed demand for any month is a percentage (usually greater than 70%) of the highest maximum demand of the previous 11 months or the actual demand, whichever is greater. This can be a real a problem for the Hospital due to its large seasonal peaking nature. In the Hospitals case, the peak electric demand is set in August during a heavy air conditioning period that the Hospital in effect pays for a full year. The impact of ratchet clauses can be significant, but often a company never realizes this has occurred.

An analysis of the electric utility bills for the year 2000 shows that the Hospital is, indeed, paying a percentage of the ratchet clause for the balance of the year because peak demand set in August is so high.

In 2000, ************* paid approximately $131,000 in electric utility bills for its Main Building. The 2001 data was added to the 2000 data to determine if monthly trends show an increase or decrease in use for the first part of 2001. The data was then averaged into a monthly cost.

Electric:

- Energy: $51,392 for 3,020,245 KWH or $0.0171/KWH
- Demand: $84,775 for a 519.85 monthly demand average, $12.55/KW
- Taxes and Credits: $3,788.98 annually or 2.7% of total Charges
- Combined Electric Charges: $139,956 for 3,020,245 KWH or $0.04656

The Hospital currently purchases its natural gas from *********. It appears that **** is a natural gas broker that purchases their commodity from a private source. The Hospital has realized a cost increase on their gas charges over the last 13 months from $2.96129 per MMBTU in January 2000 to $9.30658 per MMBTU in January 2001. This equates to a 214% increase. This trend is consistent with the cost increases taking place across the ****** and is expected to continue for the foreseeable future.

Natural Gas:

- Gas Charge: $30,172 for 7,161 MMBTU or $3.731/MMBTU
- Transmission Charge: $2,150 for 6,979 MMBTU or $.03248/MMBTU
- Capacity Charge: $2,437 for 689 MMBTU or $3.5369/MMBTU
- Meter Charge: $1,905 annually or 5.06% of total Charges
- Taxes: $1,002 annually or 2.66% of total Charges
- Combined Gas Charges: $37,665 for 7,161 MMBTU or $5.08715 average cost per MMBTU.

SECTION VIII

COST AND SAVINGS ESTIMATES

Cost savings were estimated for each operating system modification that is being recommended. The savings are based on the best available data for the time of use, operating parameters, equipment technical data sheets, and engineering calculations.

Costs for each ECO were estimated based on the requirements to accomplish the recommended modifications, renovations, or replacement of existing equipment and operations.

Total Estimated Cost (TEC) for the ECOs includes material and labor costs, all engineering design costs, overhead, and costs contingency costs.

Each ECO is broken down by its individual cost and saving estimates. The total project cost includes the project financing information. Project financing information includes: finance charges, subcontractor mark-ups, construction management fees, and measurement and verification charges.

Please see the Cost Estimates on the next page(s) for details.

APPENDICES

Appendix A, Savings Calculations
Appendix B, Preliminary Cost Estimate
Appendix C, Summary Utility Cost
Appendix D, EMS Controls Point List
Appendix E, Audit Data
Appendix F, Products

Appendix A–Savings Calculations

Appendix B–Preliminary Cost Estimate

Appendix C–Summary Utility Costs

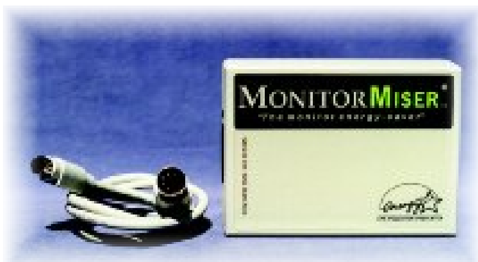
Appendix D–EMS Controls Point List

Appendix E–Audit Data

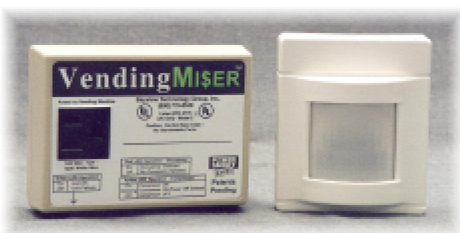
Appendix F–Products

Energy Star® Products

Office Mi$er is an occupancy based power controller for personal or modular offices, copiers, snack machines, personal heaters, etc. Any type of plug load that can be shut based only on occupancy.



Monitor Mi$er Plus is a hardware only, bulletproof, simple to install computer monitor power controller. Unlike software based solutions, this one works every time, with any operating system.



Vending Mi$er will reduce the power consumption of a cold drink ending machine by an average of 47%, with no impact on sales or drinks!

Laser Mi$er will shut down those idle, power hungry laser printers. It is software transparent, a simple plug-and-play installation, and capable of handling any laser printer with a parallel or serial connection.

Appendix A, Savings Calculations
Appendix B, Preliminary Cost Estimate
Appendix C, Summary Utility Cost
Appendix D, EMS Controls Point List
Appendix E, Audit Data
Appendix F, Products