Energy Management
in Healthcare Facilities

ENERGY IS LIFE
BEE
CONSERVE IT
Bureau of Energy Efficiency

British High Commission
New Delhi

ICF INTERNATIONAL

Energy Management

in Healthcare Facilities

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ENERGY IS LIFE ऊर्जा कार्यकुशलता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)
CONSERVE IT

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FORWARD

Energy Cunsumption in India is expected to more than double over the nex two decades as the country achieves economic growth that is both inclusive, as well as sustainable. However, concerns of energy, environmental and economic security demand that the stategies for inclusive and sustainable growth are built on a foundation of resource - use efficiency, including energy efficiency. The built environment is a key determinant of the nature and extant of growth; and its quality- Including energy efficiency - drive and influence how we live, work and play, and so, to a large extent, determine our energy use requirements. India, as a fast developing economy, needs to reassess and evaluate its energy consumption by employing a sector approach for its built environment.

This Guidebook for Managing Energy Use in Healthcare Sector focuses on the health care sector which is one of the largest contributors to energy use in the built environment. This book in addition to drawing on International experience and several energy audit studies, it is also based on existing healthcare sector energy consumption studies conducted in India. The studies indicate that healthcare facilities can effectively reduce 15-25% of energy use without impacting the quality or quantity of their energy intensive activities and in the process also benifit from cost savings and enhanced patient comfort.

This Guidebook, developed by ICF International with the help of funding support from Stategic Programme Fund; Low Carbon High Growth Programme managed by the British High Commission In India , makes a concerted attempt to support the growing healthcare industry in India in achieving improved energy performances. This guidebook aims to highlight several low cost and no cost enegy saving opportunities to create and Implement an energy management plan within the healthcare facilities. Topics include steps to develop and implement a management plan, to identify low and no cost energy saving opportunities, and to evaluate costs and paybacks.

I am sure that the users will find this Guidebook very useful, and that it would faclitate the process for achieving improved energy performances in healthcare sector facilities.

New Delhi, the 25th March, 2009

(Ajay Mathur)
Director General
Bureau of Energy Effiency, New Delhi

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ Save Energy for Benefit of Self and Nation
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Why Manage Energy Use

UNDERSTANDING THE INDIAN ENERGY CONTEXT

The India energy requirements are likely to grow at a much higher rate than the world growth rate of 2% also highlighted in fig 1. India has limited energy reserves and therefore it will need to increase its energy efficiency, in addition to revaluating its existing building stock. Existing buildings offer one of the greatest potentials in contributing to energy conservation and if not evaluated also provide the greatest challenge of being severe energy hogs. Healthcare sector is responsible for an extended building stock and a stepped approach to manage energy use in this sector will have a significant impact. This book highlights a methodology for implementing energy management in healthcare sector.

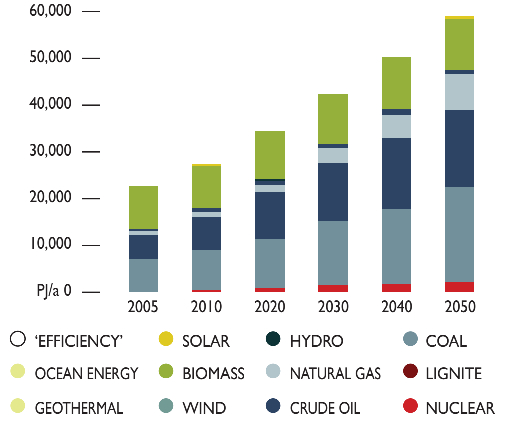

Figure 1 – Understanding the Indian Energy Consumption Scenario

WHY MANAGE ENERGY USE

Hospitals are complex, often sophisticated types of buildings, and therefore all engineering systems require special consideration because health care services are provided 24 hours a day, seven days a week, throughout the year. Every hospital is different in terms of its size, the services it provides, and the specialized functions it performs. They usually consist of large buildings, and careful control of their internal climate is necessary. They also require standby generators to ensure a continuous supply of power in emergencies. The typical hospital building is designed for long-term use and, in practice, is often used for longer periods than its builders ever intended. The actual lifetime is frequently over 50 years. During this period the building will be retrofitted and renovated many times. Reasons for this include the shorter life of technical equipment, the development of new types of equipment, new regulations, new energy-saving technologies and the ageing of the building itself. The intensive and extensive energy consumption of hospitals can be continuously optimized by implementing an energy management program.

HOW TO MANAGE ENERGY USE

Energy management helps improve your bottom line and holds down operating costs. There are numerous ways by which energy can be managed within your hospital. This guidebook aims to highlight several opportunities to create and implement an energy management plan within your hospital. The book has been structured to include and highlight the steps required to develop and implement a management plan, to identify energy opportunities and to evaluate costs and paybacks.

A successful energy management program should be cyclic as highlighted in figure 2. The process always starts with a commitment, followed by assessing and benchmarking existing performance, setting goals for improvement, creating and implementing an action plan to achieve these goals. The process should revisited after a defined period of time where the performance is reassessed and new goals are identified and implemented thereby continuously improving the energy performance of the facility and setting new benchmarks. The book attempts to capture this process by the following chapters.

Managing Energy Use in Your Hospitals

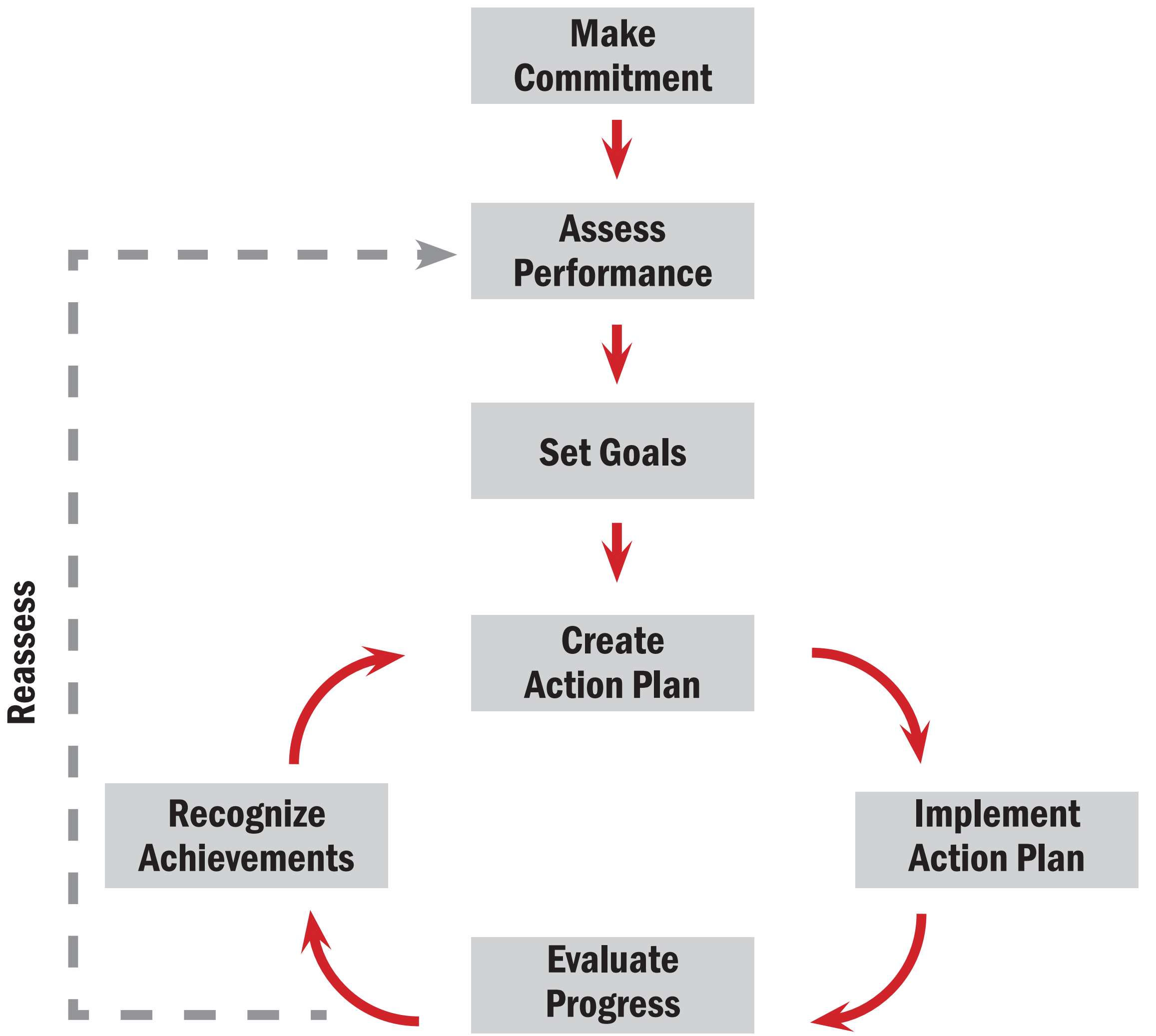

Figure 2 – Energy Management Cycle

Initiating an Energy Management Program

To effectively reduce energy consumption, maintain sound energy resource management and provide the appropriate physical facilities and equipment for health care requires that the institution develop an energy management program which has broad organizational status. Before any energy management program can be initiated and developed a dedicated staff team is required to ensure that accurate objectives are set and the right people are identified to implement the plan.

OBJECTIVES OF ENERGY MANAGEMENT PROGRAM

The objectives of such an energy management program could be:

- To aid in developing an atmosphere within the facility in which energy management and conservation are acceptable goals.
- To demonstrate the nature of sound energy resource management policies.
- To reduce energy waste and costs.
- To examine the impact on the facility of energy conservation measures.
- To examine the costs and benefits of implementing and incorporating energy conservation measures.
- To facilitate organizational wide input to the energy management program.
- To develop a program for ongoing facility maintenance.
- To ensure that the facilities and equipment provide the needed support to the health care mission of the facility.

To ensure that all measures are aligned to maintaining / providing comfort to all occupants. Energy Management dashboard in Fig 3 captures the proposed flow of events aligned with the defined objectives for implementing a management plan. The plan needs to be a closed loop type that is revisited and reassessed after a defined period of time.

Figure 3 also highlights how this book discusses the various steps translated into chapter. It is critical to understand that while these steps have been clearly identified they are not mutually exclusive and have overlaps, interconnections and synergies that need to be addressed.

1 Why Manage Energy Use	2 Intiate Energy Management	3 Determine Energy Efficiency	4 Conduct Energy Assessment	5 Energy Saving Opportunities	6 Implement Measures	7 Calculate Costs and Payback	8 Monitor Performance
Increase in energy costs Decrease in energy availability Increase occupant comfort Reduce environmental impacts	Define objectives Identify implementa-tion team Involve stakeholders	Determine the energy use Benchmark the energy use Develop metrics for comparison and reduction	Develop a comprehensive understanding of the building systems Walk through the building Interview stakeholders Collect energy performance data	Assess building energy consumption data Perform maintenance Identify and implement operation modifications Evaluate equipment replacement/ update Document energy savings over the baseline	Implement identified saving measures Incorporate into EMS Engage stakeholders	Establish annual utility savings Calculate payback on energy saving measure costs Identify intangible benefits	Develop interactive monitoring Benchmark monitoring data with past performance and best practice Reassess targets periodically

Figure 3 – Energy Management Dashboard

CRITICAL SUCCESS FACTORS

The following steps are the critical success factors of the energy management plan. Some of the recommended steps run parallel and integral to the process identified in the energy management dashboard. These steps/factors ensure that right people will implement the plan and achieve the objectives.

Identify a core team. This is the first step in initiating an energy management program. Identifying key staff members who will be involved in energy management activities and those responsible for overseeing the program is imperative for success. An effective team should include members from owner or management, the hospital staff, facility operations, engineering and someone who understands finance. A key group to have represented among the hospital staff is housekeeping. Commitment from top-level management and their involvement is vital to providing focus to energy management operations. Also, designate a mid level or upper level employee as "Energy Manager" to monitor energy saving activities and projects daily. Once the team is selected, plan and organize an introductory session to start laying the groundwork for the program.

Identify and set specific objectives. Identifying the program goals and objectives helps establish a standard of comparison for success and also lays the path toward achieving desired results. For example, if you want to save 25% over the next 1-3 years you should consider the following:

- Be clear about defining the 25% savings as reduced consumption of energy or as reduced cost?
- Set a baseline against which the savings will be measured
- Define strategies to achieve the 25% savings
- Prepare a budget for capital cost will be needed and calculate the payback
- Decide that how will the stakeholders be made aware of this initiative and involved?
- Establish a plan for measurements

Receive input from your team and plan workable goals and objectives to establish a baseline for your efforts. Use this phase to also identify related budget factors to achieve goals.

Develop a plan. Create an action plan to define the implementation of the pre-determined energy management goals and objectives. This plan will outline steps toward achieving desired results, delegate responsibilities, identify budget limitations and set targets for energy saving opportunities.

Communicate plan. Once the plan is established the success of the energy management program depends on the effectiveness of communicating it to the involved staff members and other individuals including patients etc. Use the plan to delegate responsibilities to key members. Ensure that the proposed energy management program is easy to understand and everyone shares the common goals and objectives of the program. Regular updates on program and visual tools to share progress are effective ways of building momentum within staff members.

Implement measures and monitor performance. Implementing measures identified and monitoring of measures and associated results is imperative for the program. Without regular monitoring of program it will be difficult to evaluate any savings. Follow up is also required to ensure that measures have been implemented properly.

Motivate staff members. The key to keeping people onboard with your energy management plan is having a reward and celebrating successes. Don't wait until the end of a two year program to announce results. Have regular milestones and incentives to meet them. Make people feel part of the program's success and it will take on a life of its own. Create an environment where people work together to get things done and enjoy the rewards of achieving success on a regular basis.

Figure 4 – Stakeholder Engagement

Determining
Efficiency Targets

Determining energy efficiency targets is the most critical step towards achieving energy savings. As hospitals have special and intensive energy use requirements, it is important to gather some initial data on the energy, which is then evaluated based on operations, occupancy, function and system. This initial study provides a very basic understanding of where the energy could be saved and this is then used to determine an initial energy efficiency target. It is important to note that the energy efficiency targets are often revisited during the energy management process as more detailed information becomes available.

WHERE IS ENERGY BEING USED

Figure 5 below highlights a typical hospital energy end use graph. Such a graph is a first step in determining efficiency targets and is critical in understanding where energy is being utilized within the hospital. Identifying areas of high and low energy use will help target key areas for improvement and also areas that will provide maximum returns. From the figure, it can be established that hospitals have an extensive energy demand for ventilation, equipment, sterilization, laundry and food preparation. On an average, Lighting (15 -20 percent) and water heating & HVAC (40-50 percent) are the largest parts of a typical hospital's energy bill. Both areas present opportunities for significant savings. Previous studies show that through an energy management plan a hospital could save from 20-40% of energy.

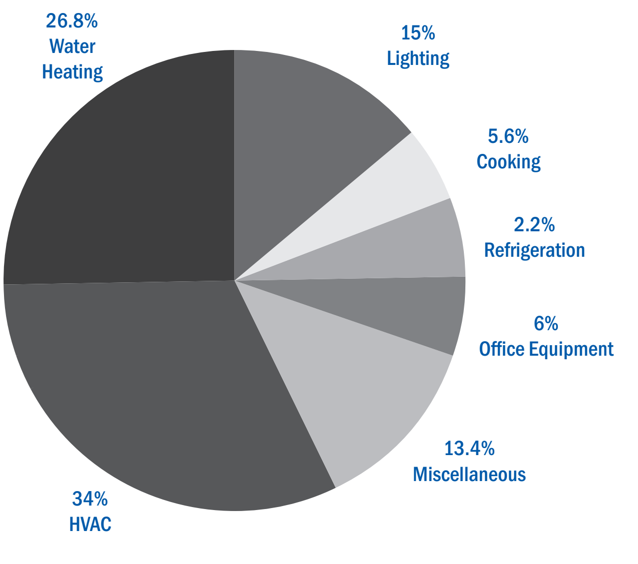

Figure 5 – Typical Energy use in Hospitals

Conducting Energy Assessments

An energy assessment is an essential component of a successful energy management program. This will help you identify the present energy use situation within the hospital and flag energy costs. Energy saving opportunities can be identified based on the initial assessment report. The assessment will also help to develop a baseline for future comparisons of program success by comparing energy use before program implementation and after, thereby implementing a feedback loop mechanism.

There are different approaches for conducting an energy assessment. The Hospitals can conduct either a basic walk-through energy assessment or a more detailed energy analysis audit. Hospitals also have the option of carrying out the assessment as a first step to identify existing energy saving opportunities and implement the results followed by a more detailed analysis audit to derive more detailed measures for savings including capital intensive energy saving opportunities.

This guide focuses on the walkthrough energy assessment process as a means for hospitals to delve immediately into saving energy and improving their bottom line through less capital intensive measures. Hospitals are encouraged if they desire to follow implementation of these measures with a more detailed audit to garner additional savings.

PERFORMING A WALK-THROUGH ASSESSMENT

A walk-through assessment is the easiest and least expensive means of identifying and evaluating energy use in a hospital. Since people have a major affect on how energy is used, this audit pays particular attention to identifying habits and procedures that can be adopted to use energy more efficiently.

The first step in this assessment is to examine energy use and associated costs across systems within your hospital. Utilize your operations and maintenance staff to assist in this process. Provided in the following pages are–

Data Collection – assist you with highlighting required information to initiate the assessment

Preventive Maintenance Checklist– is a more comprehensive checklist that will assist you with identification of energy saving improvements that can be easily implemented during the walk through. The checklist will also help in identifying issues that will be addressed later.

Use both these sheets while walking through your hospital and recording information on energy use.

Data Collection

The data must be complete and accurate because it will be used for analysis and goal setting. Consider the following when collecting energy use data:

- Determine appropriate level of detail — The level and scope of data collection will vary from organization to organization. Some may choose to collect data from sub meters on individual processes while others may only look at a utility bill.
- Account for all energy sources — Inventory all energy purchased and generated on-site (electricity, gas, steam, waste fuels) in physical units (kWh, mMBtu, Mcf, lbs of steam, etc.) and on a cost basis.
- Document all energy uses — For the sources identified above, assemble energy bills, meter readings, and other use data.

Energy data may reside in the accounting department, be held centrally or at each facility, or can be acquired by contacting the appropriate utilities or energy service providers. Gather at least two years of monthly data or a more frequent interval if available. Use the most recent data available. Collect facility and operational data — to be able to normalize and benchmark, it may be necessary to collect non-energy related data for all facilities and operations, such as building size, operating hours, etc.

Conducting Energy Assessments

Sample Data Collection Form

Building Location (city):

Number of heating degree days:

Number of cooling degree days:

Building Completion year:

Building Statistics

Building Area (sq. mt.):

Total Site Area (sq. mt.):

Air conditioned area (sq. mt.):

Number of permanent staff (FTE):

Number of Beds:

Occupancy (%)

Average:

Peak:

Fuel Used

Heating:

Cooling:

Water Heating:

Cooking:

Laundry:

Mechanical Systems

Primary heating source:

Size of heating system:

Primary cooling source:

Size of cooling system:

Primary type of air-conditioning system:

Energy Use

Monthly energy use for last year:

Electricity - Consumption in kWh (INR/kWh)

Demand in kW (INR/kW/month)

Natural Gas units* (INR/unit)

Heating Oil in gallons (INR/gallon)

LPG Gas – Cylinders (INR/cylinder)

Other units (INR/unit)

TOTAL INR Cost:

*units may be "therms" (100,000 Btu/therm) or "ccf" (hundred cubic feet) or "mcf" (thousand cubic feet)

Energy Cost

Utility bill by Month
(Indicating any time of use incentives etc)

Preventive Maintenance Checklist

The walk through assessment also provides an additional opportunity of initiating one of the first (the most apparent no cost mesure) measures of preventive maintenance. The preventive maintenance checklist below (From the Healthcare Energy Project Manual developed by the American Society of Healthcare Engineers) is a summary of some of the meaintenance mesure. This is not an exhaustive list but an evolving database. it is recommended that the identified energy management team members continuously update this by adding new measures and deleting the ones already in place.

1. **BUILDING ENVELOPE**

Windows and Skylights

- Replace broken or cracked window panes
- Replace worn weather stripping and caulking
- Replace defective sealing gaskets and cam latches

Doors

- Replace worn weather stripping and caulking

Exterior Surfaces

- Replace worn weather stripping, caulking, and gaskets at exterior joints and at openings for electrical conduits, piping through-the-wall units, and outside air louvers

Stairwells and Shafts

- Replace worn seals and weather stripping in stairwells on penthouse machine-room doors, in elevator shafts in vertical service shafts and on basement and roof equipment room doors when they are connected by a vertical shaft that serves the building

Conducting Energy Assessments

2. HVAC-AIR CONDITIONING EQUIPMENT

Refrigerant Circuit and Controls

- Inspect the moisture-liquid indicator to ensure that no moisture is in the system
- Check for and repair refrigerant and oil leaks around the shaft seal, sight glasses, valve bonnets, flanges, flare connections and the condenser assembly relief valve
- Check for and repair leaks at pipe joints on equipment, valves and instrumentation
- Check for and repair the source of oil spots on connections or under equipment
- Listen to the systems operate for a few minutes and determine the cause of any unusual sounds
- Check all gauges frequently to ensure that design conditions are being met
- Inspect the tension and alignment of all belts and adjust as needed
- Lubricate motor bearings and all moving parts
- Inspect the insulation on suction and liquid lines and replace as necessary

Compressor

- Check for unusual compressor operation, such as continuous running or frequent stopping and starting
- Listen to the compressor operate for a few minutes and determine the cause of any unusual sounds
- Check to see that the compressor and motor are securely fastened to the base
- Check all compressor joints for leakage
- Inspect instrumentation frequently to ensure that the operating oil pressure and temperature agree with manufacturer's specifications

Air-Cooled Condenser

- Check the fan belt drive and motor to ensure that they are properly aligned and lubricated
- Ensure that refrigerant piping connections to the condenser coil are tight. Check for leaks
- Clean the face of the condenser coil
- Determine if hot air is being bypassed from the fan outlet to the coil inlet

Evaporative Condenser

- Inspect piping joints and check for leaks
- Check for dirt on the coil surface
- Inspect the air inlet screen, spray nozzles, water distribution hoses, and the pump screen
- Check to see if the local water supply leaves surface deposits on the coil
- Follow the manufacturers guidelines for fan and pump maintenance

Water-Cooled Condenser

- Clean condenser shells and tubes

Chillers

- Inspect for clogging
- Keep water-side tubing clean and the refrigerant-side

Cooling Towers

- Conduct a chemical analysis to determine if solid concentrations are being maintained at acceptable levels
- Check the overflow pipe's clearance from the normal operating water level
- Listen to the fan and determine the cause of any unusual noise or vibration
- Inspect the V-belt and the alignment of the fan
- Follow the manufacturer's guide
- Check to see if the tower is clean
- Check to see if the intake strainer is clean
- Determine if air is bypassed from the tower outlet back to the inlet
- Inspect spray-filled and gravity-distributed towers for proper nozzle performance. Ensure that the nozzles are clean
- Inspect gravity-distributed towers for even water flow
- Monitor the effectiveness of any water-treatment programs

SELF-CONTAINED UNITS (SUCH AS WINDOW AND THROUGH-THE-WALL UNITS AND HEAT PUMP

- Clean evaporator and condenser coils
- Clean air intake louvers, filters, and controls
- Keep airflow from units unrestricted
- Replace worn caulking in openings between the units and windows or wall furnace
- Check the voltage to ensure that the unit is operating at full power
- Follow applicable maintenance guidelines for compressors, condensors and fans.

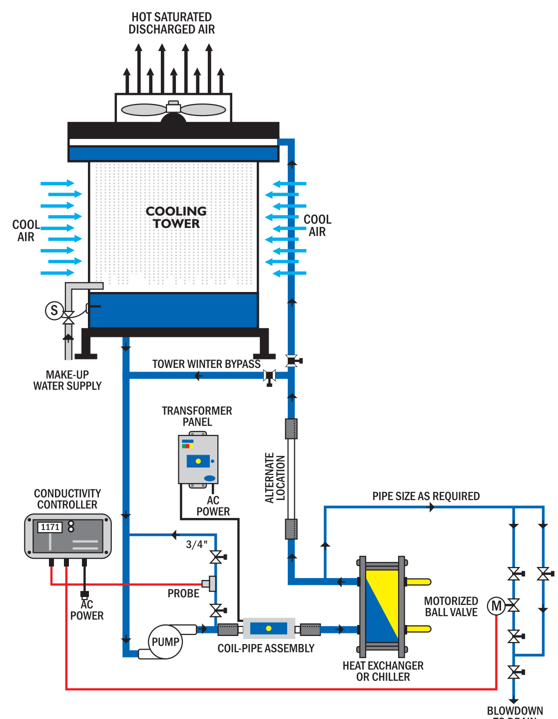

Figure 6 – Typical Cooling Tower Operation

3. HVAC- HEATING EQUIPMENT

Boilers

- Tune boilers at least annually
- Inspect boilers for scale deposits, accumulation of sediment, or boiler compounds on waterside surfaces. The rear of the boiler is the area most susceptible to scale
- Inspect the fire side of the furnace and tubes for deposits of soot, flash and slag. Pay particular attention to the fire side refractory surface. Check the temperature at the gas outlet. Adjust the air to fuel ratio for a clean burning fire
- Replace door gaskets that do not provide a tight seal
- Keep a daily log of pressure, temperature, firing rate, and other data. Look for variations as a Way to determine the need for tube and nozzle cleaning, pressure or linkage adjustments and related measures
- Keep stacks free of haze. Adjust the burner if necessary
- Tighten linkages when slippage or jerky movements are observed
- Observe the fire when the units shut down. If the fire does not cut off immediately, the solenoid calve may need to be repaired or replaced
- Clean nozzle or cut-offs on oil fired u nits as necessary
- Check the burner's firing period. If it is too long or too short controls may be faulty
- Check the boilers stack temperature. If it is too high, clean the tubes and adjust the fuel burner
- Clean mineral or corrosion build up on gas burners

Central Furnaces, Make-Up Air Heaters, and Unit Heaters

- Clean all heat exchange
- Inspect burner couplings and linkages
- Seal air links in casings as necessary
- Repair or replace insulation as necessary
- Follow the manufacturer's suggested guidelines for fan and motor maintenance

Radiators, Convectors, and Baseboard and Finned Tube Units

- Remove obstructions in front of all units whenever possible. Ensure that air movement in and out of the connector unit is unrestricted
- Be sure that air collected in the high points of hydroponic units is vented to enable hot water to circulate freely throughout the system
- Clean heat transfer surfaces in radiators, convectors, and baseboard and finned-tube units

Electric Heating

- Keep the heat transfer surfaces of all electric heating units clean and unobstructed
- Keep the air movement in and out of the units unobstructed
- Periodically inspect heating elements, controls, and fans
- Check reflectors on infrared heaters
- Determine if electric heating equipment is operating at the state voltage
- Check controls for proper operation.

4. HVAC – HUMIDIFICATION AND DEHUMIDIFICATION EQUIPMENTS

- Remove lint and dust from air dampers, fan parts, the spray changers and diffusers
- Check equipment for carryover.
- Follow the manufacturer's suggested guidelines for fan and motor maintenance

5. HVAC – AIR HANDLING EQUIPMENT

- Seal leaks in ductwork by taping or caulking and repair or replace ductwork insulation a necessary
- Check ductwork access openings for obstructions, such as loose hanging insulation (in lined ducts), loose turning vanes and accessories, and closed fire dampers. Adjust, repair or replace as necessary
- Inspect for buildup of water, condensation, or moisture on insulation and on equipment walls and floors of air handlers. Ensure drip pans and drains are kept clear and free running
- Inspect damper blades and linkages. Clean, oil, and adjust regularly
- Inspect air valves in dual-duct mixing boxes to ensure full seating and minimum air leakage
- Inspect mixing dampers for proper operation
- Clean or replace air filters regularly
- Clean air heating, cooling, and dehumidification coils regularly
- Seal leaks around the coils and casing
- Keep all room air outlets and inlets (diffusers, registers, grills) clean and unobstructed
- Inspect air washers and evaporative air-cooling equipment for proper operation. Clean damper blades and linkages. Inspect nozzles and clean as necessary
- Check electronic air cleaners for excessive accumulations on the ionizing and grounding plate section. Replace filter media as necessary. Follow the manufacturer's instructions whenever adjustments or maintenance are required
- Keep humidifier and dehumidifier air dampers, fan parts, spray changers, diffusers, controls, strainers, and eliminators free of dirt, lint, and other foreign particles

- Adjust variable air volume boxes so they operate precisely to prevent overheating or overcooling
- Follow the manufacturer's guidelines for fan maintenance

6. MOTORS, FANS, PUMPS, ENGINES AND TURBINES

Motors

- Check the alignment of the motor to the equipment it drives. Align and tighten as necessary
- Check for and repair loose connections and bad contacts regularly
- Determine the cause of excessive vibration and repair as necessary
- Clean motors regularly
- Lubricate the motor and drive bearings regularly
- Replace worn bearings
- Tighten belts and pulleys
- Check for overheating. If overheating is present, check for functional problems or inadequate ventilation and repair as necessary
- Balance three-phase power sources to motors
- Check for over voltage or low-voltage conditions and correct as necessary

Fans

- Check for excessive noise and vibration and correct as necessary
- Clean fan blades
- Inspect and lubricate bearings regularly
- Inspect drive belts for proper tension. Adjust or replace as necessary to ensure proper operation
- Keep inlet and discharge screens on fans free of dirt and debris

Pumps

- Check for packing wear and repack as necessary. Replace glandular packing with mechanical seals
- Inspect bearings and drive belts for wear and binding. Adjust, repair, or replace as necessary

Engines

- Follow the manufacturer's recommended maintenance procedures
- Check fuel consumption and compare it with the designed fuel consumption. If fuel consumption seems to be excessive, determine the cause and correct
- Record and check cooling-water temperatures daily. If they exceed the manufacturer's recommendations, check the temperature controls and correct as necessary

Turbines

- Follow the manufacturer's recommended maintenance procedures
- Record steam pressure and check turbine speed daily
- Check the oil level, packing and governor and throttle valve operation regularly and correct any problem as necessary

- Record and check the bearing temperatures and oil cooler temperatures. If they exceed the manufacturers recommendations, check the temperature controls and correct as necessary
- Check for vibration weekly and correct as necessary

7. HOT AND CHILLED WATER PIPING

- Inspect and test all controls for proper operation and leakage at joints. Adjust, repair, or replace as necessary
- Check flow measurement instrumentation for accuracy. Adjust, repair, or replace as necessary
- Repair or replace insulation as necessary. Replace any insulation damaged by water
- Determine the source of the water and correct
- Clean strainers regularly
- Inspect heating and cooling heat exchangers. Temperature differences may be an indication of air binding, clogged strainers, or excessive amounts of scale. Determine the cause of the condition and correct
- Remove clogs from vents.

8. STEAM PIPING

- Repair or replace insulation on all mains, risers, and branches as well as economizers and condensate receiver tanks as necessary
- Check the automatic temperature-control system and related control valves and accessory equipment to ensure they are regulating the system properly in the various zones
- Inspect zone shutoff valves and shut off steam going into unoccupied spaces
- Adjust, repair, or replace an y faulty steam traps
- Adjust, repair, or replace pressure-reducing and regulating valves and related equipment as necessary
- Adjust, repair, or replace condensate tank vents as necessary
- Check the accuracy of recording pressure gauges and thermometers
- Inspect the pump for satisfactory operation, particularly for leakage at packing glands
- Correct sluggish or uneven steam circulation
- Correct any excessive noise in the system, particularly water hammer
- Repair leaks in the vacuum return system

9. PNEUMATIC AIR COMPRESSOR FOR CONTROLS

- Repair any air leaks, particularly at connections
- Note compressor operation. If it seems to run excessively, there could be pressure loss at the controls or somewhere in the piping system. Determine the cause and correct
- Inspect the air pressure in the supply tank and pressure-regulator adjustment in the supply line for proper limits
- Check belt tension and alignment
- Clean or replace air compressor-intake filter pads as necessary
- Lubricate electric motor bearings according to the manufacturer's recommendations.

10. LIGHTING

- Wipe lamps clean at regular intervals. Lamps that are exposed to substantial amounts of dirt, dust, grease, or other contaminants should be cleaned more frequently than lamps in a relatively clean atmosphere
- Maintain luminare efficiency by properly cleaning the reflecting surfaces and shielding media
- Replace lens shielding that has yellowed or become hazy with a clear acrylic lens with good non-yellowing properties. A clear glass lens can be considered if it is compatible with the luminare and does not present a safety hazard
- Clean ceilings, walls, and floors frequently to improve reflective qualities
- If day lighting contributes to lighting, wash windows frequently to maintain illumination levels
- Replace all lamps used for area illumination after they have been in service for a substantial portion (approximately 70 percent) of their rated life, instead of simply replacing lamps one at a time as they burn out.

11. COMMERCIAL REFRIGERATION

- Clean display fixtures and cooler coils regularly. Be sure to shut off refrigeration before using water for cleaning
- Replace worn refrigeration seals
- Check all electrical circuits for power leaking to the ground
- Check all systems for the correct refrigerant charge to avoid excessive compressor operation
- Check all multi-shelf fixtures for inoperative fan motors.

Identifying
Energy Saving Opportunities

Hospitals are unique in design and size, and in the different specialized services they provide. Their plant operation systems must be designed and adjusted to meet the requirements of many different areas including surgical, clinical, laboratory, office, and patient care environments as well as space requirements found in large office buildings. These requirements are met through proper design and operation of the building and it s technical systems such as moisture barriers, thermal insulation, heating, ventilation and air conditioning (HVAC), and lighting.

When considering energy-saving measures, the need to control the indoor climate is the top priority. Once indoor climatic requirements are established, energy efficiency in creation of the environment becomes an increasingly important secondary requirement. The facility manager is challenged to accomplish any energy savings while dealing with many complicating factors, including:

- Scheduled maintenance cannot interfere with the 24-hour, 7 days per week (24/7) operation of the facility
- Large amounts of outside air are needed to dilute odors
- Ventilation is still required, even when critical spaces are not in use, to maintain pressure relationships and control the spread of infection

Identifying Energy saving opportunities is a key step of an energy management program, the opportunities should be identified in the following steps, the first and foremost focus should be to address all maintenance issues, second is focus should be to explore appropriate changes in the operations, third should be to look at system improvements, part and whole and the fourth and the last focus should be to evaluate replacement options. This flow of evaluation also aligns with the low and no cost measures first and then looks at capital investment.

KEY SYSTEMS THAT INFLUENCE ENERGY USAGE

- The following systems have the most influence on energy usage:
- Temperature Control
- Thermal Insulation
- Ventilation
- Indoor Air Quality
- Lighting

TEMPERATURE CONTROL

Most clinical areas require a consistent temperature throughout the year. To maintain comfort levels for patients, the indoor temperature in hospitals is usually two to eight degrees F higher than for other building types. A typical temperature for patients' rooms is 72 degree s F, but may be much warmer, for example 79 degrees F, due to heat given off from patient care equipment in the room.

THERMAL INSULATION

State and local building regulations typically establish maximum U-values (coefficients of thermal transmittance) for the entire building envelope, including walls, foundations, roof, and windows.

VENTILATION

Hospital ventilation rates are established for infection control and comfort as compared to heat surplus (as in office and commercial buildings). Occupants and activities in the hospital contaminate indoor air so it must be renewed in order to eliminate odors, pollutants, and pathogens. Ventilation rates typically range from two to six air changes per hour (ACH) in patient rooms to 15 to 25 ACH in surgical suites. Installing carbon dioxide sensors are an essential component of controlling the quality and quantity of ventilation, especially essential in hospitals due to the heavy occupancy load.

Figure 7 – CO_2 Monitors

INDOOR AIR HUMIDITY CONTROL

The comfort range covers relative humidity of 30–60 percent, at temperatures normal for hospitals (72–78 degrees F). Strict humidity control is often only applied in rooms where conditions are more critical, such as in surgical suites, intensive-care units, and computer-intensive areas. In other areas it is common practice to allow humidity levels to fall outside the comfort range due to expansive operating costs (humidification), and initial costs (dehumidification). Humidity plays an important part in also avoiding infections.

Why Humidity is Important

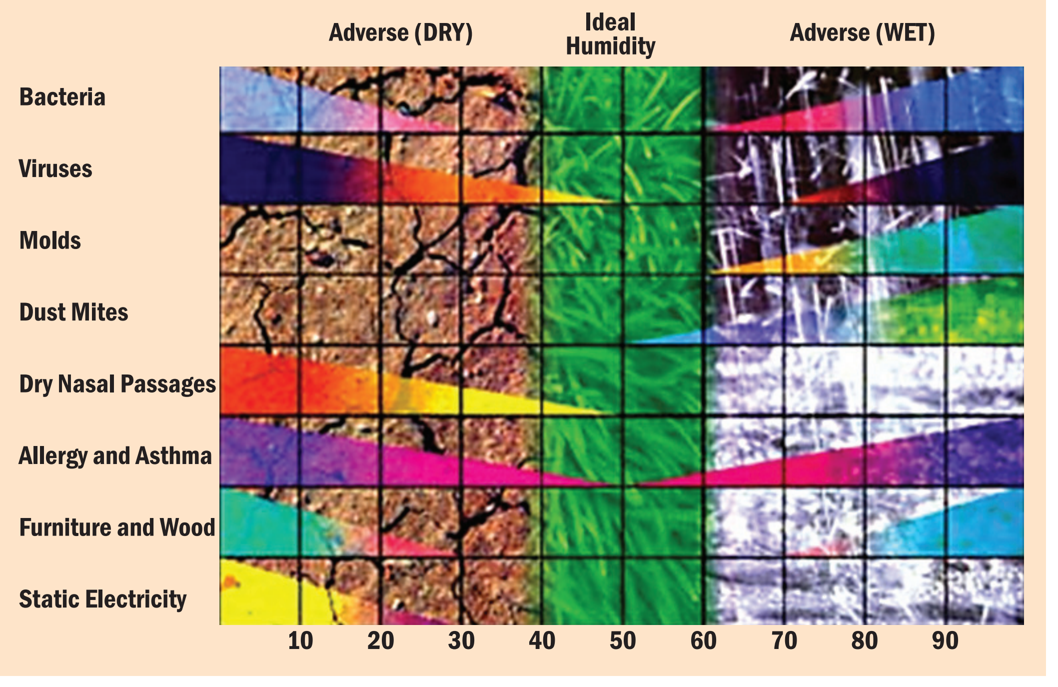

Figure 8 – Humidity Mapping

LIGHTING

Designs to realize the therapeutic impact of daylight often result in unwanted effects of glare and overheating. Having sunshades and blinds automatically controlled by sensors triggered by sunshine and wind best provides maximum utilization of daylight, but manual controls should always be available for individual adjustment. Hospitals also usually contain a substantial number of windowless rooms with artificial lighting as the only source of light.

Figure 9 – LED Signs

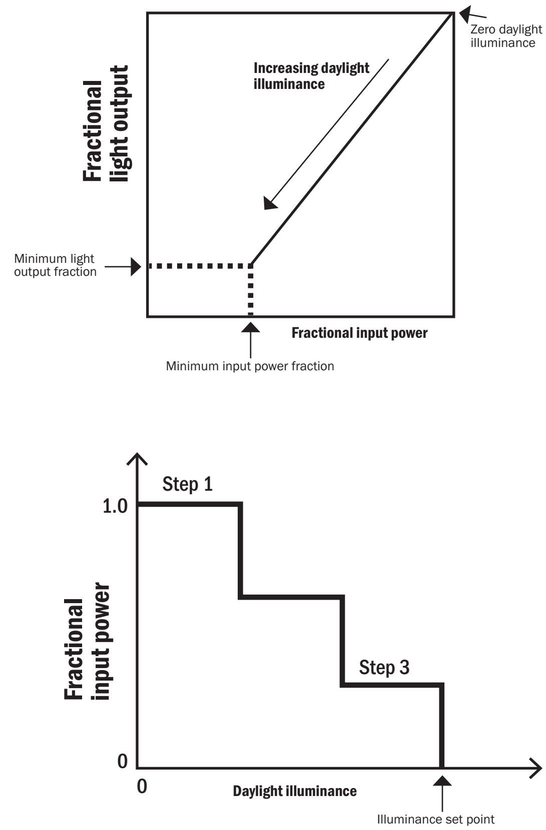

Figure 10 – Types of Photosensors

Simple measures to control the energy used in lighting are

- Reduce the supply voltage to lighting loads from 235 V/phase to 210V/phase using the energy saver. This will bring down the power consumption by about 5% without any significant reduction in lumen level.

- Install motion sensors and photo sensors in private offices of the management, staff, doctors and students, the sensors will reduce the wastages on lighting.
- Install timers in outside lighting as appropriate leaving the emergency access areas. Different timing should be set for summer and winter months. Also create zones using alternative lights, and have each zone turn on 30 minutes apart, and turn off 30 minutes apart, instead of all at once.
- Implement zoning of similar spaces such as the corridor and lobby lights in the hospital building with consulting doctor's offices which are not operational at night. The zoning will be supported with the use of timers to switch on and off the lights. It is important to note that the lights at extreme ends of corridors and the lights close to elevators should not be switched off for proper access.
- It is recommended to use LED exit signs. The use of incandescent bulbs in Exit signs consumes a minimum 40 Watts/hour and the life span of these bulbs is only 750 to 1000 hours. It is recommended that 5 Watt LED lights should be used for Exit signs. This will save 35 watts per hour for each sign. The life span of LED lights is 7500 to 10,000 hours. Although the initial cost is high (approx. INR 750-1000) but this can be recovered within a year's time.

HOSPITAL DESIGN AND RENOVATION

The typical hospital building is designed for long-term use; frequently over 50 years. Often it is used for longer periods than its designers ever intended. During this period the building is retrofitted and renovated many times. This nearly constant state of change both challenges previous system designs and offers opportunities for system upgrades to address new and existing energy issues.

Energy-efficiency measures are implemented most cost effectively when they are installed during new construction or retrofitting/ remodeling buildings, or when replacing old equipment. It is generally less expensive to introduce additional energy-saving measures when retrofitting work is already being carried out on a building than at times when the hospital is operating normally. By choosing installation times carefully, interference with normal hospital routines can be minimized, and capital expenditures may be substantially reduced. If an installation or item of equipment has to be replaced anyway, it is only the extra cost (the over-cost com pared to a conventional system) that needs to be taken into consideration when calculating the payback period for a new, more energy-efficient installation. In calculating payback period it is important to recognize the thermodynamic linkage between retrofit projects, such as the less heat that high-efficiency lighting generates compared to older lighting technologies. For example, reducing the heat generated by lighting will reduce the need for cooling.

ROUTINE OPERATION AND MAINTENANCE

Although many technical methods exist for improving energy efficiency, energy management plan should begin by considering the most fundamental measures. Often, improved maintenance and operation procedures, coupled with moderate investments, will provide immediate and continuing energy and cost savings.

No-cost opportunities, such as switching off equipment like lights and HVAC systems when rooms are unoccupied, are easy to identify and implement.

Depending on the hospital's energy practices, a simple walkthrough inspection may reveal areas where lighting and equipment are left on when unattended, or where lighting, ventilation, or other service levels can be reduced without detriment to comfort or health care. Unused areas and rooms to be unoccupied for longer periods of time should be closed off with blinds or shades drawn and climate control air reduced or eliminated.

Storage rooms should not be cooled unless it is necessary for protection of stored contents

Other simple measures include:

- Cleaning lamps and reflectors regularly
- Replacing lamps and filters at the

recommended time intervals

- Regularly checking for and repairing leaks
- Checking that thermostats and timers are accurate and correctly set
- Checking that automatic controls are functioning properly
- Keeping surfaces of radiators, convectors, baseboards, and finned-tube heater s clean for efficient operation

A basic maintenance function most facilities perform is a steam trap inspection program to prevent the escape of live steam from a distribution system. A leaking trap will allow steam to pass into the condensate system, wasting energy and creating noise. One can trend steam production with outside air temperature to help flag a possible problem in system performance.

A good starting place is to perform a mechanical and electrical assessment.

ROOF AND BUILDING ENVELOPE ENHANCEMENTS

Building enhancements include several measures such as insulation, weather stripping, double-paned windows, and energy-efficient window films. These films reflect heat in the summer to reduce cooling needs, insulate the glass in the winter to reduce heating needs, and are especially effective on single pane and clear glass with southern or western exposure.

Use temperature-sensing equipment (IR or thermal scanning) to detect air leaks around windows and doors.

Seal in place operable windows. If they cannot be permanently sealed, ensure that operable windows have sealing gaskets and cam latches that are in p roper working order.

Single pane windows with aluminum frames are a source of occupant discomfort and an energy hog. It is worth evaluating the payback

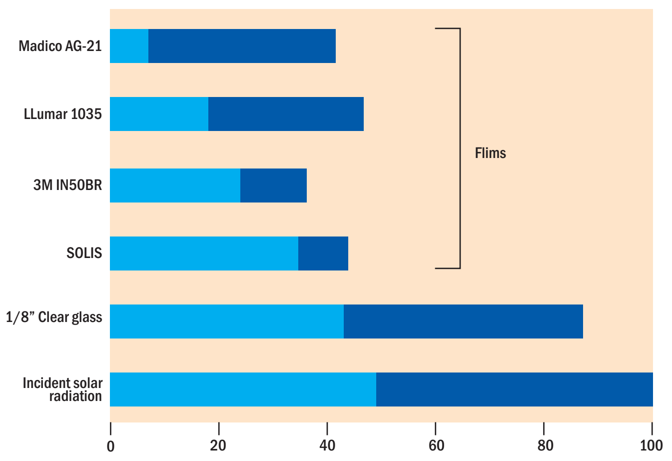

Figure 11 – Types of Window Flims

in up grades to double-pane glass with a thermal break, for example phased over three years.

Develop a roof management program to trace the age and condition of each roof and to schedule when to refurbish and replace. Perform annual roof inspections to detect moisture infiltration and caulking inspections to determine breaches in the building envelope. Pay particular attention to roof/parapet/ wall flashing, equipment and curb flashing, expansion joints, and the interface between concrete or stone slabs.

Additional proven strategies from facility managers include:

- Add vestibules at main entrances to eliminate infiltration through heavy traffic areas.
- Check elevator shaft louvers. These should be changed to operating louvers to prevent a stack effect from drawing negative pressure on the building.
- Be sure the total building is under positive pressure. Negative pressure in the building wastes energy from air infiltrating through open doors and cracks. In addition, moisture can come in that can damage the building and create conditions where mold and mildew can grow in wall cavities.

BOILERS AND HOT WATER SYSTEMS

By monitoring multiple points on steam systems, facility managers can detect performance reductions that slowly occur over a period of years. Scale reduces the efficiency of the boiler and can lead to overheating and cracking of tube ends. Inspect boilers for scale deposits, accumulation of sediment, or boiler compounds on waterside surfaces.

Good water treatment is essential to maintain peak performance and also extends boiler life and helps avoid costly repairs. A proper chemical treatment program ensures clean surfaces and good thermal exchange on boiler tubes. Make periodic inspections o f burner adjustments to ensure the proper fuel-to-air mix. Observe the burners when the boilers shut down to determine if any solenoid valves leak.

Operating efficiency falls off significantly with decreasing load. Most boilers achieve maximum efficiency only when running at their rated output. It is important to evaluate part load performance conditions. Evaluate boiler load characteristics to optimize operation for the staging and warm-up of boilers. Often boiler plants are over designed for the occasional worst-case conditions. Current designs incorporate modular boilers (small independent boilers) to stage on loads. Modular boiler system will increase seasonal efficiency as fluctuations of load are met by firing more or fewer boilers to come on in stages in order to make the operation energy efficient. Smaller boilers have low thermal inertia (low heat up and cool down losses) when running at maximum or off.

The boiler combustion efficiency is reduced by

- energy losses in the flue gas during operation - either by unburned fuel with the excess of fuel or by heating more air than necessary with the excess of air
- radiation and convection loss from the exterior surface of the boiler during constant or intermittent operation

The energy loss due to radiation and convection will increase with intermittent operation and reduced combustion time as expressed in the diagram below:

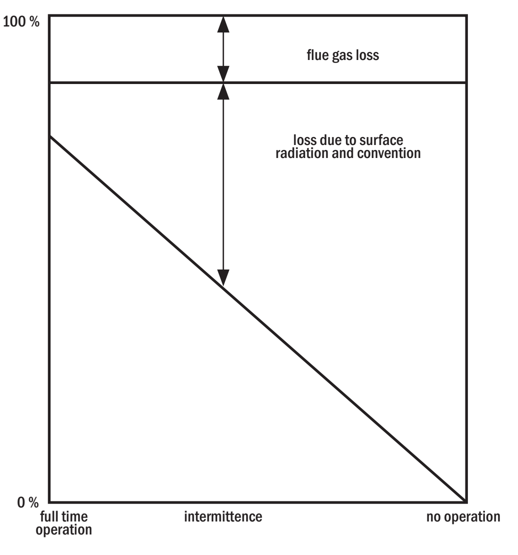

Figure 12 – Boiler part Load Operations
(engineeingtoolbox.com)

To increase energy efficiency of hot water systems, install a flue gas and air heat recovery system to preheat domestic hot water. Install instantaneous hot water heaters instead of storing hot water in tanks.

CHILLERS

Centrifugal chillers are the power monsters in the mechanical system room. The energy used by chillers is one of the largest operating costs in a facility. Energy efficiency of chillers has been improved significantly. All chiller manufactures have been working to increase the efficiency of their units, and the control technology has had a major impact. The new control systems are microprocessor-based and can perform control functions, which were not possible with electromechanical systems. Chiller controls can now be interfaced with energy management systems to match the chiller operation with building needs.

Operating efficiency falls off significantly with decreasing load. As with boilers, it is important to evaluate part-load performance conditions for chillers.

Energy management plan should include monitoring the actual performance for an individual chiller. Monitoring actual flow through a chiller is essential to determining the performance of the unit. Flow can be monitored relatively inexpensively using an ultrasonic flow-measuring device. These devices are accurate when properly installed. When coupled with the entering and leaving temperatures and power consumption of the chiller, the actual performance can be continuously monitored. Also, accurate chiller efficiency could help determine optimum operating sequences for multiple chiller systems.

Another area where flow measurement should be monitored is in the secondary chilled water loop. Comparing this flow to outside conditions could help determine if a variable-speed pumping system is tracking with changes in outside air temperatures.

Numerous variable-speed pumping systems do not perform properly because pressure differential sensors that control the system are not located properly or functioning as designed. By monitoring the flow at different conditions, one can determine if the system is truly working as a variable system.

Chiller design and operational issues include:

- Designs should incorporate chiller usage to take advantage of the most favorable electrical rates
- Energy Management Systems should coordinate the operation of the chillers, pumps, and cooling towers
- Multiple chiller operation requires computer software to coordinate chilled water production
- Chillers should be operated by electric consumption (full-load rated amps)
- The electric operating curve needs to be programmed into a computer for efficient chiller operation

- Future chilled water loads need to be anticipated for size (tonnage) of chillers
- Resetting chilled water temperature during intermediate seasons to reduce chiller energy consumption.
- Adding dedicated chillers for operating rooms and computer equipment rooms such as MRI and CT Scan. Often these areas require lower chilled water temperature. By using dedicated chillers for these areas, the main chillers can be set so that chilled water has a higher leaving temperature.
- Using double-bundle heat exchangers for new chillers to preheat domestic hot water or to provide reheat hot water during intermediate and summer seasons.

COOLING TOWER OPERATION EXPENSES

Cooling tower operating expenses can be as much as 40 percent of chilled water production costs. Evaluate the condenser needs of the chiller(s) to determine when (or if) the tower is needed.

- Specify variable speed drives so cooling fans can cycle and run at speeds to match heat rejection
- Specify the water treatment program and equipment to reduce chemical and labor maintenance expenses
- Make sure the cooling tower is connected to a chiller management program for efficient operation

One can also explore strategies specific to regional conditions:

- such as to run ground water (43–45 degree F water) through a closed loop system and then re-inject the water t back into the well, which served as a heat sink,
- use a smaller chiller or multiple DX units for equipment-intense areas with special cooling loads such as data processing, cardiac catheterization lab, MRI, and CT Scan through the use of winter air via the economizer mode on all ducted ventilation systems.
- a water-heat reclamation system from cooling tower water during cold weather. This hospital uses a plate-frame exchanger to produce chilled water for small air-handling units that serve interior spaces.

VARIABLE FREQUENCY DRIVES

A large energy cost savings is associated with controlling the fan speed on large air-handling units (AHUs) that typically operate 24/7. Often, internal temperature and humidity conditions within clinical areas are maintained by modulating the chilled water control valve on each AHU according to the highest demand for cooling as signaled by room temperature sensors. Reheat energy is provided to zones requiring less cooling in the form of hot water generated from steam. Typically, AHUs incorporate a humidity sensor in the return air stream to override the temperature sensors should the mean relative humidity rise. These conditions create a situation of over-cooling and re-heating.

Variable frequency drives (VFDs) vary the power delivered to a motor so that it runs only when needed and at the minimum speed required. Installing VFDs on each supply and return air fan motor (10 hp and greater) within each AHU reduces the air quantity over the cooling coil of each AHU. The sensible cooling load reduction on the space results in energy cost savings associated with the elimination of over-cooling and re-heating as well as significant electricity cost savings from the reduced electrical load of each supply and return air fan.

Temperature sensors in each zone and outside air-measuring devices are installed enabling the accurate measurement and control of fresh air to each AHU.

Specifying and installing VFDs designed for the highest possible load, on many of the AHUs, pumps, and cooling tower fan motors allow the motors to better match the load imposed upon them.

VENTILATION

The AHUs in a hospital have maximum turn around period and this replacement period can be use to include an economizer mode in the specifications to take advantage of "free cooling" when outside air temperatures are below 50 degrees F and also evaluate the applicability of an energy recovery system. Through greater use of outside air (below 50 degrees F) chillers are unloaded and often close chilled water valves to AHUs. In dry climates or when the relative humidity outside is low (or if other forms of dehumidification are used) this may not be a problem, but it could be critical for moisture-sensitive areas such as operating rooms.

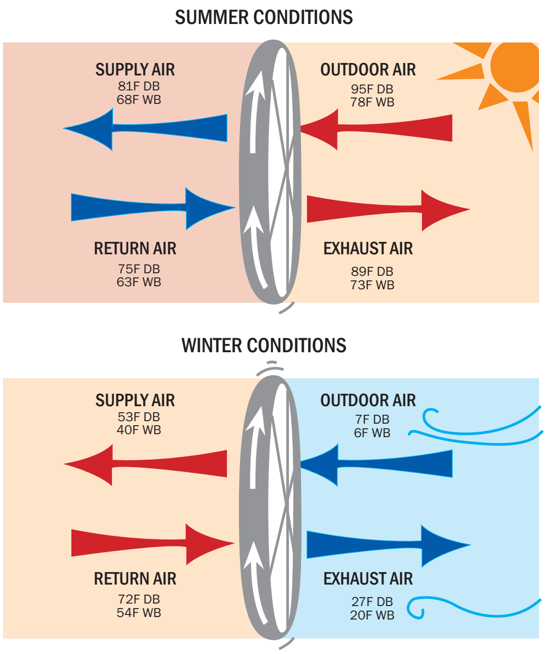

Figure 13 – Energy recovery system

In addition to adding an economizer mode, specifications packages often included VFDs for areas that can be throttled back like office space and surgical suites. Several facilities use the energy management system to determine when the facility should switch the HVAC systems to an economizer cycle.

If an AHU replacement had not occurred, the need to perform cleaning and repairs to older AHUs can be stressed, particularly to cooling coils, coil control valves, and air dampers, making existing AHU more efficient. These improvements not only reduce energy usage, but also improve performance from a user's standpoint.

- Excessive ventilation can also create a huge impact on energy use. Following strategies outline some ways of minimizing this:
- Investigate hours of operation of exhaust fans, cooking hood, laboratory hoods, and exhausts
- Install zone dampers and motion detectors to reduce airflow in unoccupied spaces
- Reduce airflow to nonessential areas during periods of low activity
- Mechanical retrofit ductwork in areas where 24-hour temperature monitoring and control is essential
- Change filters more frequently to reduce total static pressure on air-handling systems.
- Provide interlocks between exhaust fans and laboratories, and kitchens with outside dampers to balance makeup air and exhaust air. Significant savings can be achieved by shutting down exhaust hoods when not in use with a corresponding reduction in outside makeup air.
- Provide un-tempered air to kitchen range hood exhaust to prevent conditioned air from being exhausted from other spaces in the building through the kitchen.
- Rework 100 percent of outside air systems to return air to the AHU. If this is not feasible, use a heat wheel to recover both sensible and latent heat if the exhaust and supply ducts are in close proximity to each other.
- On AHUs equipped with an outside air economizer, use enthalpy controllers rather than setting changeover at designated outside air temperature. Enthalpy controllers measure humidity and temperature of the return air and outside air so that changeover is based on the total energy content rather than temperature alone.

MISCELLANEOUS

- Identify water-cooled condensers to upgrade to heat exchangers or air-cooled condensers.
- Trace the condensate path to ensure that there are return lines and that the condensate does not go down the drain. Condensate reuse reduces chemical usage.
- Identify liquid ring pumps and upgrade them to rotary vane vacuum pumps.
- Consider ground irrigation strategies such as irrigation of only presentation areas and the use of vegetation that requires little watering.
- Perform an audit of water (and related chemical treatment usage)—focus on high water-use areas.

ENERGY SAVING MEASURES

In addition to indetifying project energy saving measures, it is also important to study and review best practices locally and internationally. Some good resources for this review are even of energy efficiency, American Society for healthcare enegineers, green guidlines for healthcare.

The following graphs summarize the results derived from HEP (Healthcare Energy Project) survey instrument and EPA energy star benchmarking tool. The results were categorized by top, middle and bottom performers with respect to the energy use intensity (i.e. top performers had the least energy use intensity and were the most successful in implementing energy efficiency measures). The graphs highlight a cross board of critical energy efficiency measures that were implemented, these graphs also align with our research of hospitals at a pan India level.

The measures have been highlighted from no cost - low cost to equipment replacement options.

Operations

- Building Automation System (BAS) to optimize system performance including day/night schedules, chiller setpoints, chiller staging and chiller plant peak demand limiting, reset schedules (AHU discharge air, hot water). Monitor boilers, hot water systems, secondary chilled water loop flow, exterior lighting control and temperature schedule per room
- Economizer cycling on air handling units
- Routine operations such as pre-heat and pre-cool building, exclude heating/ cooling of unused spaces, turn off equipment
- Water usage reduction and conservation, implement rain water harvesting, cooling tower makeup water reuse
- Education on energy practices and conservation
- Staging number of chillers and boilers to meet load demand
- VAV operation
- Metering of electric usage and power factor, peak demand limiting
- Hot water system regulation and instantaneous hot water heaters
- Eliminating bleed water and chemical usage from cooling towers

Maintenance

- Routine maintenance (boiler cleaning and water treatment, clean cooling towers to maximize condenser performance, chilled predictive maintenance, cooking equipment check, annual roof inspections, utilize zone maintenance for daily checks on lighting and clean light fixtures)
- Boiler and chiller efficiency testing and tuning
- Thermostat calibration
- Filter changes

Upgrades

- Lighting retrofits including high efficiency CFLs and LED exist signs
- VFD (Variable Frequency Drive) on pumps and motors
- Replacing aging and broken motors
- Steam plant upgrade
- Cooling tower upgrade
- Heat recovery on 100% outside air handling units
- Rehab all AHU, dampers and fliters
- Window films

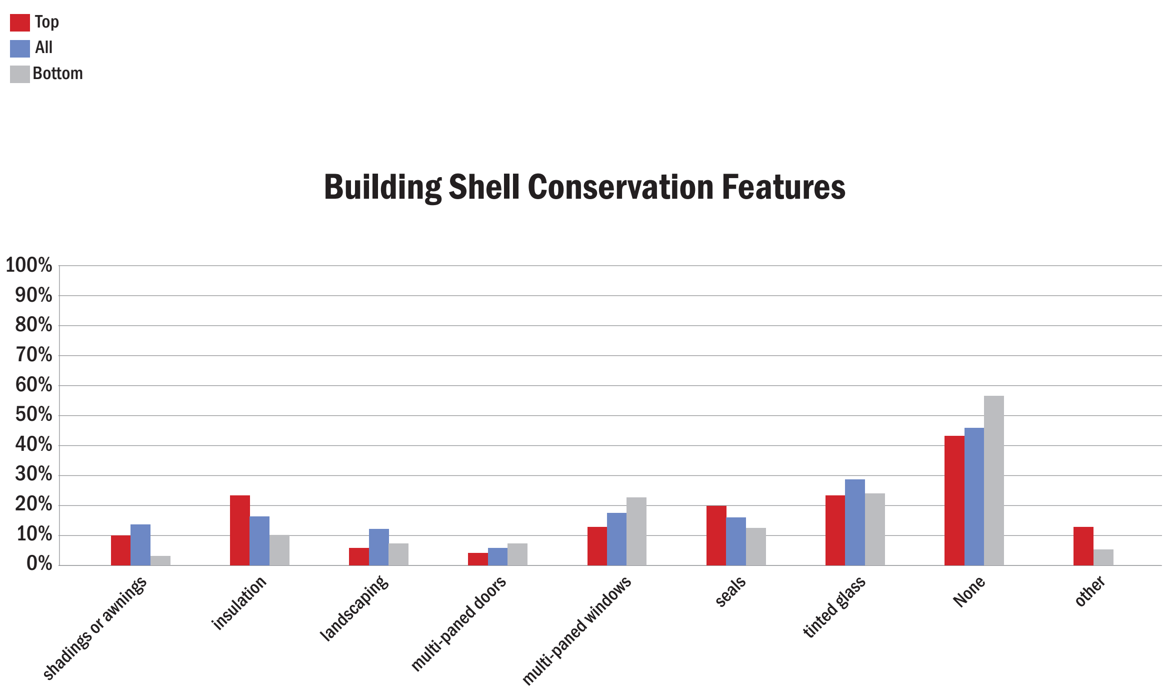

Figure 14 – Building Shell Conservation Features

Lighting Conservation Features

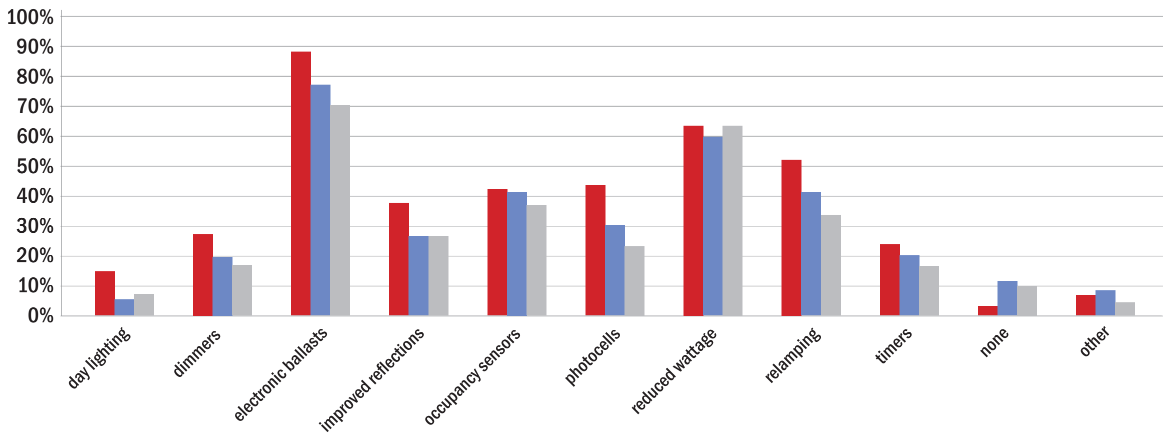

Figure 15 – Lighting Conservation Features

HVAC Conservation Features

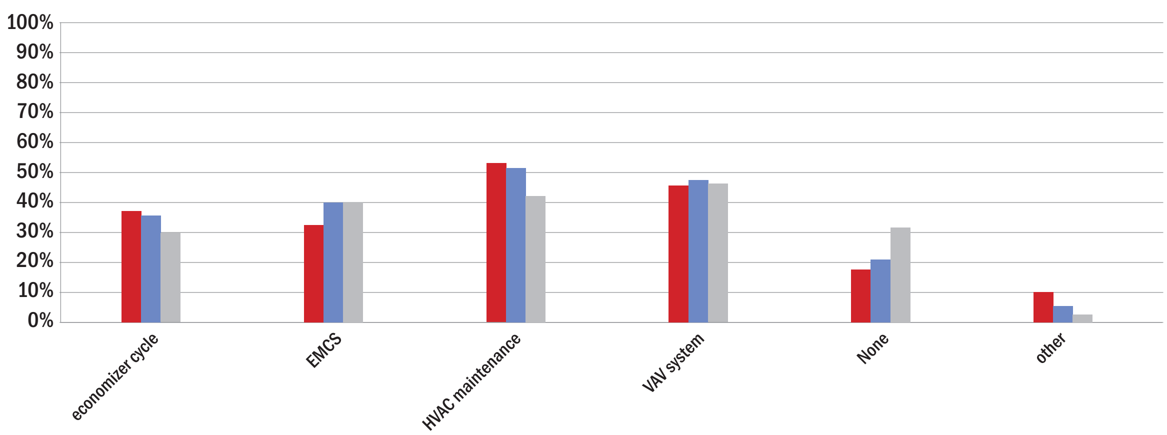

Figure 16 – HVAC Conservation Features

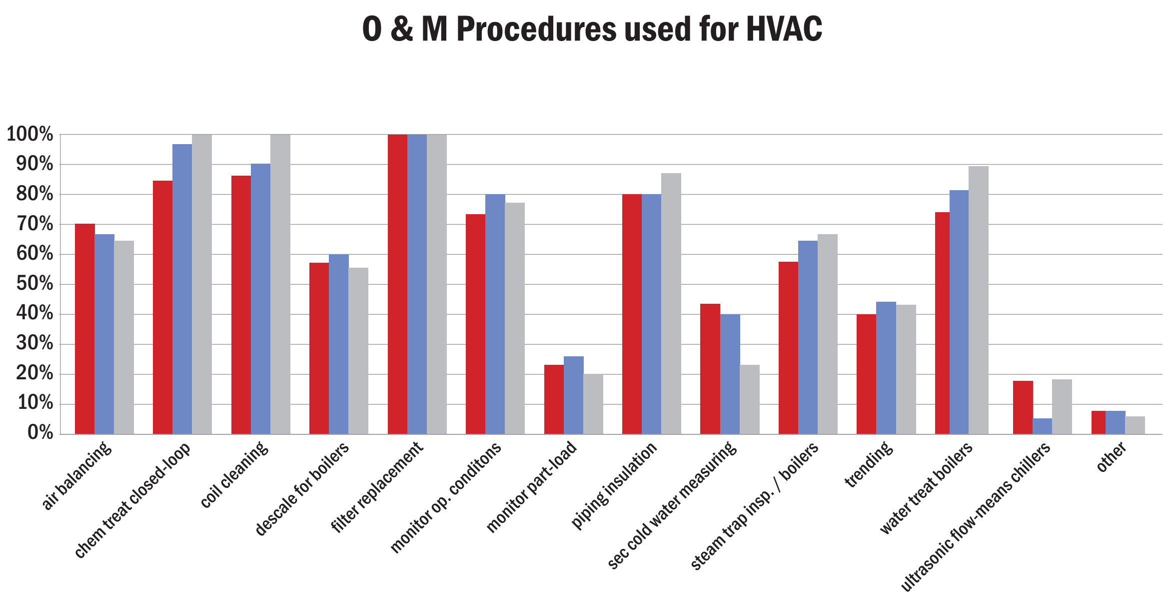

Figure 17 – O&M Procedures used for HVAC

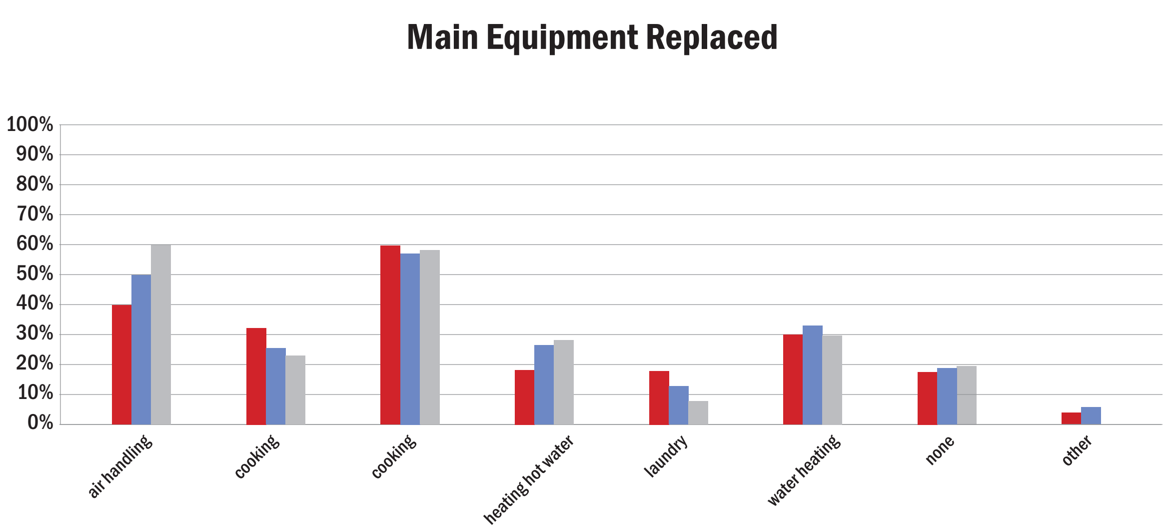

Figure 18 – Equipment Replaced

Identifying Energy Saving Opportunities

STAKEHOLDER PARTICIPATION

In addition to implementing energy efficiency measures, occupant involvement and behavioral changes are important to ensure that the measures will be implemented and sustained for long term. It is critical to involve the stakeholders in this process from the start of launching the program, through the progress and till the result. The stakeholders could be involved using

There potential options have been proposed to engage and facilitate stakeholder participation through the process:

Short-term campaign: A limited-term campaign of less than one year is useful when testing approaches and activities specific to a particular department/area/ space. Short campaigns may also be useful for educational efforts. For example, say a department includes an economizer cycle in their dedicated ventilation system. A short-term campaign may be useful to emphasize the benefits and steps of economizer cycle. Short-term campaigns may also be useful periodically as personnel change. For example, if the population of stakeholders has significantly changed over two years, a short campaign could be run every two years to reemphasize and motivate energy efficiency.

Kickoff campaign: A campaign can also be used to "jump start" a longer-term emphasis. Used in this way, the campaign raises awareness and attention to start a more sustained effort. A kickoff campaign attempts to attract widespread attention. If resources are available, a festival or other celebratory event could be held, prizes could be given out, a competition could be announced, a high-profile speaker could be brought in, and local media could be invited to cover it. The sustained effort, lower key, would continue with continued reporting of results and reminders.

Ongoing effort: The ultimate goal of any energy-efficiency effort is to sustain long-term change. A long-term effort focused on permanent behavior change is most effective when facility managers/energy management program implementers are personally committed to and accountable for energy savings, when methods exist to measure energy use for individual departments/spaces/areas, when financial incentives and disincentives are directly tied to individual energy use, and when a longer-term effort is preceded by a test campaign (as described above).

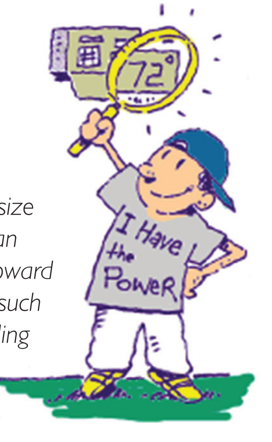

Figure 19 – Emphasize the actions that can contribute the most toward energy conservation such as heating and cooling

Figure 20 – Interactive monitoring display

The user behavior is a significant determinant of the impact that an energy efficiency program can have; while engineering advances permit increased efficiency of operation, the user's decisions and habits ultimately have a major effect on the energy or other resources used. There is thus a need to change users' behavior in such a manner that the need for the energy efficiency program is understood and the users take pride in achieving savings.

Implementing An **Energy Management System**

ENERGY MANAGEMENT SYSTEMS

Energy savings often occur as a result of changes to the operation of the steam and chilled - water generation systems, revised management practices for the steam and chilled-water distribution system, and modifications to building equipment operation schedules.

ENERGY MANAGEMENT CONTROL SYSTEMS (EMCS), AS PART OF A BUILDING AUTOMATION SYSTEM

(BAS) or as a separate system, are installed to control energy-consuming equipment from a central location. These systems enable one to schedule the hours of use of energy related services (such as HVAC), and make equipment adjustments, such as temperature control for different parts of a facility and for buildings that are spread over a large geographic area.

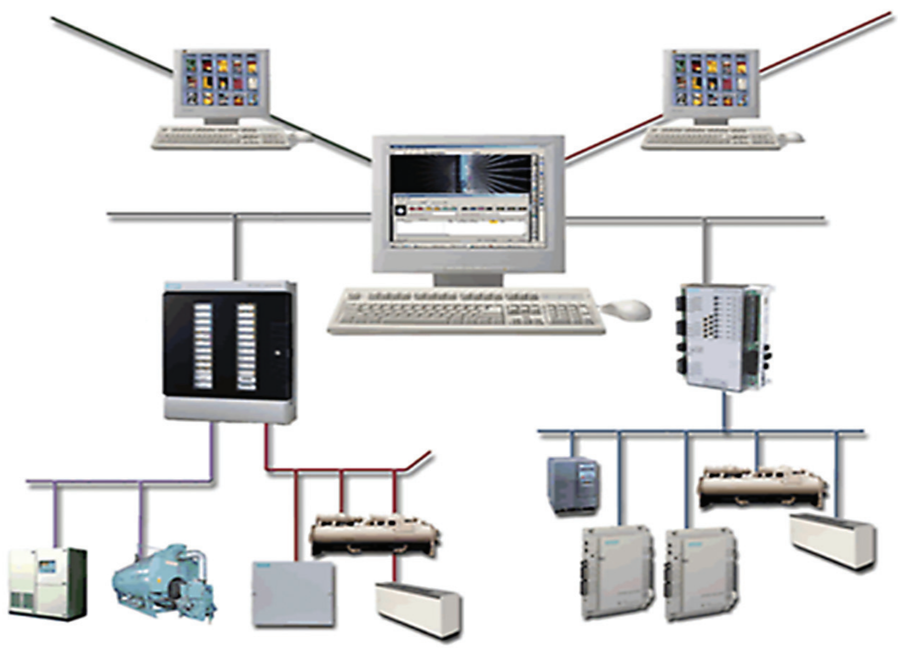

Figure 21 – EMCS Interface

For many years this dedicated networking technology has allowed dynamic improvements in HVAC system operational efficiency to existing equipment.

The efficiencies of centralized computer control allow one to invest more time in troubleshooting and maintaining equipment, rather then performing manual equipment control. Use of an EMCS allowed changes to operating procedures, duty cycling, and the re-balancing of mechanical systems.

Examples of system control measures performed by the EMCS for improved equipment efficiency and control accuracy include:

- Equipment outside air lockout
- An enthalpy sensor to initiate an economizer cycle
- Supply air temperature reset
- Chilled water temperature reset
- Condenser water temperature reset
- Hot water temperature reset
- Scheduled start/stop for fans and pumps
- Chilled water plant optimization or staging of chiller compressors
- Electric preheat control
- Optimum start/stop
- Controlled warm-up
- Two-speed fans
- System time of day control
- Night setback
- Optimized start time for peak shaving
- Custom designed fan control sequences to maintain proper pressure relationship between patient rooms and corridors
- Control of the building electrical load to eliminate excessive peaks
- Zone temperature monitoring and improved control of zone dampers and VFDs
- Controls to alter set points, such as the use of outside air temperatures to reset hot water temperature

An energy management system (EMS) can save 10% to 40% on electric bills. An EMS in your hospital can enhance your existing operations by allowing you to control various aspects of your energy use including lighting, and HVAC from a central point, reducing error intensity caused by manual operation of these services. It has been noted the EMS' have been proven to deliver 2 to 5 year paybacks.

EMS' are categorized primarily into 3 levels

LEVEL – I EMC SYSTEMS:

These systems are essentially electronic time clocks that perform a single function and are usually located on or in close proximity to the equipment being controlled. The control functions include:

- On and off time,
- Automatic temperature set-back/set-up,
- Dry bulb economizer,
- Enthalpy controllers,
- Single and multi-zone systems,
- Chiller energy management controllers.

LEVEL – II EMC SYSTEMS:

These systems generally provide remote control and perform more than one function typified by duty-cycling and optimized start-stop. Some of the better applications include:

- Demand controllers (to reduce peak electrical demand),
- Multi-load system programmers (to schedule multiple chillers on and off line),
- Multifunction programmable controllers.

LEVEL III EMC SYSTEMS:

These are the central building control systems with the fancy control screen graphics. The central console monitors and analyzes remote data logging equipment. These systems are usually appropriate only when the hospital comprises many buildings or floors in a high-rise with a central plant and several remote mechanical equipment rooms.

Typical optimizing functions include, but are not limited to:

- Economizer cycle,
- Hot/cold deck temperature reset,
- Discharge air temperature reset,
- Chilled water reset,
- Outside air schedule reset,
- Start/stop optimization,
- Air distribution optimization,
- Chiller plant optimization and demand control,
- Boiler plant optimization.

SOME IMPORTANT TIPS TO CONSIDER BEFORE SELECTING AN EMS

- Do not select an over complicated EMS. There are many types available in the market so first understand your system needs before selecting the EMS model
- You might already have an EMS in place. If so, appraise the effectiveness of the current system and analyze how well the existing energy systems will integrate into a new EMS.
- Will your employees be able to operate the system effectively?

After determining the type of EMS required for your hospital, consider the following recommendations for purchasing the system:

- Request bids from several vendors.
- Obtain a detailed list of the services and hardware provided.
- Determine what training your employees will need.
- Insure that service and operational support will be readily available.
- Talk with someone from another facility similar to yours who has installed the system.

ENERGY MANAGEMENT USING EMS

Energy bills can form the basis for monthly reminders to department heads and other staff of the importance of energy management. Achievements can be tracked and unexplained changes can be surfaced for early investigation and intervention.

More advanced tracking of performance may include 24 hour plots of hourly energy use. These “day plots”, developed with the help of EMS, show the pattern associated with system start up, parasitic power (when the building is less occupied), and peaks associated with heating and cooling loads. This view of how dynamic energy use is over the course of a day allows engineers to understand the events that drive energy use and when the peaks and valleys occur. If done seasonally—that is, summer, winter, and swing seasons—these day plots can reveal important differences caused by climate and weather. It is recommended that day plots be developed using the EMS, or, if necessary, using sub-metering equipment or manual readings off the utility meter. If this approach can be automated within the EMS, daily viewing will reveal shifts in patterns that inform operations. If effort is required to generate day plots, weekly, monthly, or seasonal plots are recommended. The more frequently these day plots are reviewed to assess change over time, the more value they have as a diagnostic and strategic tool for continuous performance improvement.

Calculating Costs And Payback

Evaluation and calculating costs and payback period form the lifeline for an energy management program. Cost savings are a driving factor behind the longevity and success of the program. Associated savings can be used to improve the program or re-invested within the school for enhancing other services. For example, cost savings are invested in additional facilities for the school. Understanding the payback period also helps school administrative authorities assess the viability of the measures to be implemented.

Please note that the payback option is primarily used as a basic calculation for each measure implemented. Determining cost effectiveness of large investments over time would require a life cycle cost or monthly flow calculations.

There are many ways associated with calculating costs and payback period. This guidebook focuses on the **"simple payback"** method, which is one of the least complicated ways to evaluate the value.

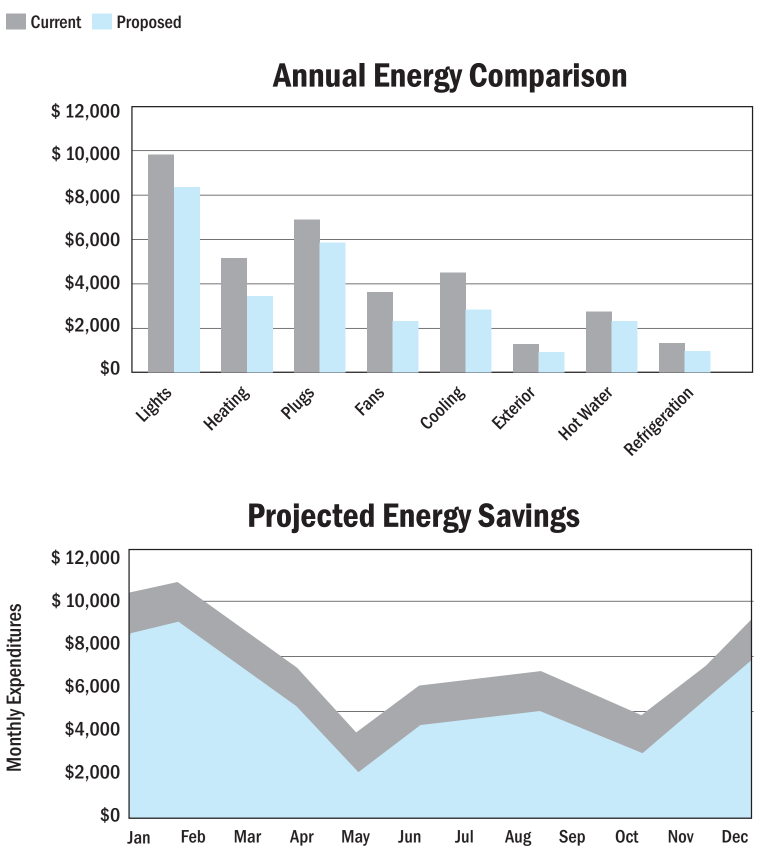

Figure 22 – Evaluating the Energy Savings

Simple Payback Method

The following calculation method and calculator has been adapted from the energy management guide "Managing Energy in Your Hotel". The calculator can be modified to include variables specific to your school.

The simple payback method involves calculating the simple payback by dividing the cost of the improvement by the annual energy savings. The result is the number of years to payback the investment from the energy savings.

This method comprises of a basic calculation and is utilized primarily for low investment measures. It doesn't take into account the time value of money, energy cost changes, tax effects if any, nor the expected life of the equipment. Please note that to make the ratio as accurate as possible, remember to subtract any rebates from the initial cost of the measure and deduct any required operating costs from the annual energy savings.

$$\textbf{Simple Payback} = \frac{\text{Cost of Measure (minus any rebates)}}{\text{Annual Energy Savings (minus any operating expenses)}}$$

Example: If installing a time clock costs INR 2,000 and saves INR 4,000 annually on energy costs, it has a 0.5 years or 6 months payback.

$$\textbf{Payback} = \frac{\text{INR 2,000}}{\text{INR 4,000/year}} = \frac{1}{2}\ \text{years}$$

ELECTRIC ENERGY IMPROVEMENT PAYBACK CALCULATOR

Cost For Implementing Measures

Cost of Materials INR ______________________ ,

Cost of Labor INR ______________________ ,

Cost of Training INR ______________________ ,

Total Cost of Energy Saving Measures INR ______________________ (A)

Electric Usage Savings

Complete the following calculations for each measure determine your total Rupee savings and compute your payback.

Details	Old	New
(B) Watts		
(C) Hours/day		
(D) Watt-Hours/day (Multiply B & C)		
(E) Days/year		
(F) Watt-Hours/year (Multiply D & E)		
(G) Total Kilo-watt-hour (kWh)/year (F/1000)		
(H) Annual kWh Savings [(G – Old) – (G – New)]		

Annual Electricity Cost Savings

Annual kWh Savings INR ______________________ (H)

Times Electricity Cost/kWh x INR ______________________

Total Energy Savings INR ______________________ (I)

Less any incremental O & M Costs INR ______________________ (J)

Total Savings INR ______________________ (K)

Simple Payback In Years

$$\text{Simple Payback} = \frac{\text{Total Cost of Energy Saving Measure}}{\text{Total Savings}}$$

Monitoring
Performance

As described earlier in the book, a successful energy management program needs to be a cyclic approach, where energy efficiency targets are continuously reassessed and the benchmarks are made more stringent for each cycle to improve performance, save energy and implement new innovative measure. For a successful cyclic energy management approach it is essential that the energy performance is continuously monitored, it builds on the principle "you cannot manage what you don't measure".

Monitoring uses energy information as a basis, which is translated into measurable and comparable metrics either by the use of an EMS system with inbuild capability, a statistical software (such as Microsoft Excel) or by manually sorting through the information. Monitoring can also be used as a format to engage stakeholders by coupling it with a graphical software, where real time information is displayed. Graphics provide a more comprehensive format of understanding and comparing the information.

Bureau of Energy Efficiency has highlighted the Cumulative Sum approach for Energy Monitoring and Targeting. The Cumulative Sum (CUSUM) represents the difference between the base line (expected or standard consumption) and the actual consumption points over the base line period of time.

This useful technique not only provides a trend line, it also calculates savings/losses to date and shows when the performance changes.

A typical CUSUM graph follows a trend and shows the random fluctuation of energy consumption and should oscillate around zero (standard or expected consumption). This trend will continue until something happens to alter the pattern of consumption such as the effect of an energy saving measure or, conversely, a worsening in energy efficiency (poor control, housekeeping or maintenance).

CUSUM chart (see Figure 23) for a generic company is shown. The CUSUM chart shows what is really happening to the energy performance. The formula derived from the 1999 data was used to calculate the expected or standard energy consumption.

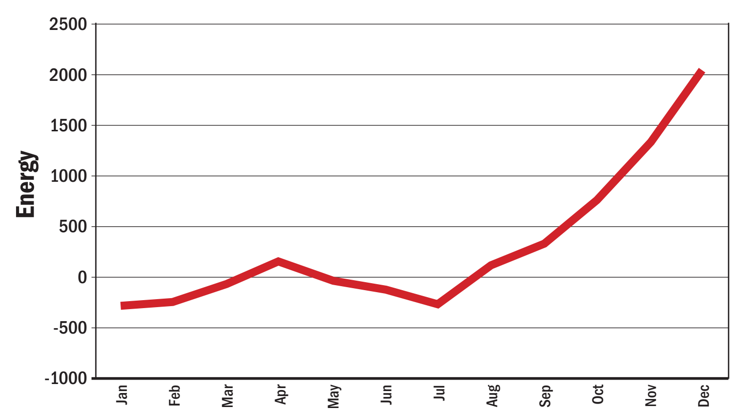

Figure 23 – CUSUM Chart

Monitoring Performance

From the chart, it can be seen that starting from year 2000, performance is better than standard. Performance then declined (line going up) until April, and then it started to improve until July. However, from July onwards, there is a marked, ongoing decline in performance – line going up.

When looking at CUSUM chart, the changes in direction of the line indicate events that have relevance to the energy consumption pattern. Clearly, site knowledge is needed to interpret better what they are. For this sample company since we know that there were no planned changes in the energy system, the change in performance can be attributed to poor control, housekeeping or maintenance. (BEE Energy Monitoring & Targeting Chapter)

The two benchmarks that are essential while monitoring performance in the Healthcare sector are

- Best Practice- a comparison to established practices that are considered optimal performing in the healthcare sector
- Past Performance- a comparison of current versus historical performance

Glossary

AIR HANDLING UNIT (AHU):
Equipment that distributes conditioned air.

AMBIENT TEMPERATURE:
Outside air temperature.

BALLAST:
A device used with fluorescent and other types of gaseous discharge lamps to aid starting and limit current flow and to provide voltage control at proper design levels. Can be magnetic or electronic.

BRITISH THERMAL UNIT (BTU):

Equal to the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit. One Btu is about equal to the amount of heat given off by a wooden match.

BUILDING ENVELOPE:
The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior.

CAULKING:
A flexible material used to seal up cracks or spaces in a structure.

COEFFICIENT OF UTILIZATION:
The ratio of lumens on a work plane to lumens emitted by lamps.

COMFORT ZONE:
Average: The range of effective temperatures over which the majority (50 percent or more) of adults feel comfortable. Extreme: The range of effective temperatures over which one or more adults feel comfortable.

CONVERSION FACTORS:
1 Watt = 3.413 Btu/hr

1 kW = 3,413 Btu/hr

746 Watts = 1 HP (Motor)

1 Gal. Oil = 140,000 Btu

1 Lb. Coal = 12,500 Btu

1 Therm of Natural Gas = 100,000 Btu

1 Cu. ft. of Natural Gas = 1,000 Btu

1 Cu. ft. of Propane Gas = 2,500 Btu

1 Lb. of Propane Gas = 21,500 Btu

1 Ton refrigeration = 12,000 Btu/1 hr

DEGREE DAY:
The degree day value for any given day is the difference between 65˚F and the mean daily temperature. Example: for a mean daily temperature of 50˚F, the degree days are 65 minus 50 or 15 degree days.

ENERGY AUDIT:
Any survey of a building, business or complex that reviews energy-using equipment or behavior.

ENERGY CONSERVATION MEASURE (ECM):
A permanent change made to a conditioned building after completion of operation and maintenance measures which will result in energy savings.

ENERGY EFFICIENCY RATIO (EER):
The ratio of net cooling capacity in Btu/hr to total rate of electric input in watts under designated operating conditions.

FOOT CANDLES (FC):
Energy of light at a distance of 1 ft. from a standard (sperm oil) candle.

GLAZING:
Another term for glass in windows.

HORSEPOWER (HP):
British unit of power, 1 HP = 746 W or 42.408 Btu per minute.

INSULATION:
A material used to minimize heat losses from a given space.

KILOWATT HOUR (KWH):
A unit of energy equal to that expended by one kilowatt in one hour = 3,414 site Btus and 11,600 source Btus.

INFILTRATION:
The process by which outdoor air leaks into a building by natural forces through cracks around doors and windows, etc. (usually undesirable). Usually caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

LUMEN:
Unit of light energy or output (luminous flux).

MAKEUP AIR:
Outdoor air that is brought into a building to compensate for air removed by exhaust fans or other methods.

MULTIZONE SYSTEM:
An HVAC system that heats and cools several zones each with different load requirements from a single, central unit. A thermostat in each zone controls dampers at the unit that mix the hot and cold air to meet the varying load requirements of the zone involved.

PHOTO CELL:
A device sensitive to light which is now commonly used to turn on and off the lights at dusk and dawn.

PNEUMATIC:
Operated by air pressure.

POWER:
Power is the time rate of doing work. In connection with the

transmission of energy of all types, power refers to the rate at which

energy is transmitted. In customary units it is measured in watts (W),

British Thermal Units per hour (Btu/hr), or Horsepower (HP).

REFRIGERATION, TON OF:
Equivalent to the removal of heat at a rate of 200 Btu per minute, 12,000 Btu/hour, or 288,000 Btu/day.

RESISTANCE (R-VALUE):
Term used to measure insulation material resistance to the flow of heat in units of square feet per hour.

RETROFIT:
The improvement of existing buildings to make them more energy efficient.

SETBACK:
Reducing the level of heat required from the conditioning system to the lowest practical point especially during periods where the room activities or occupation allows.

SIMPLE PAYBACK (SPB):
Time required for an investment to pay for itself. The cost of the retrofit measure divided by the annual energy cost savings in Rs/year.

SINGLE ZONE SYSTEM:
An HVAC system that supplies one level of heating or cooling to a zone or area controlled by one thermostat. The system may be installed within or remote from the space it serves, either with or without air distribution ductwork.

THERMAL BARRIER:
A strip of nonconducting material, such as wood, vinyl, or foam rubber, separating the inside and outside surfaces to stop conduction of heat or cold to the outside.

VENTILATION:
The process of supplying or removing air, by natural or mechanical means to or from any place. Such air may or may not have been conditioned.

WEATHERSTRIPPING:
Metal, plastic or felt strips designed to seal between windows and door frames to prevent air infiltration.

ZONE:
A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

* Note – Glossary adapted from "Managing Energy in Your Hotel"

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