ENERGY EFFICIENCY IN HOSPITALS- A CASE STUDY

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Introduction

This case study is from a Hospital located in Kerala . This is a multi specialty hospital having 360 beds. The hospital has 50% above air conditioned area. The location is dry and humid.

Energy Performance

The historical energy consumption details has been evaluated for establishing the energy benchmarking.

This is an indicator towards the energy performance of the hospital. The managers need to know how the building performs with respect to energy in order to make the most effective management decisions.

KWh/ m^2 :110.05
KWh/ Bed : 4751.61

Benchmarking Indicators

Two indicators are used in hospitals

1. Annual energy consumption per square meter of hospitals building area, (KWh/m^2)
2. Annual energy consumption per inpatient bed in the hospital (KWh/Bed)

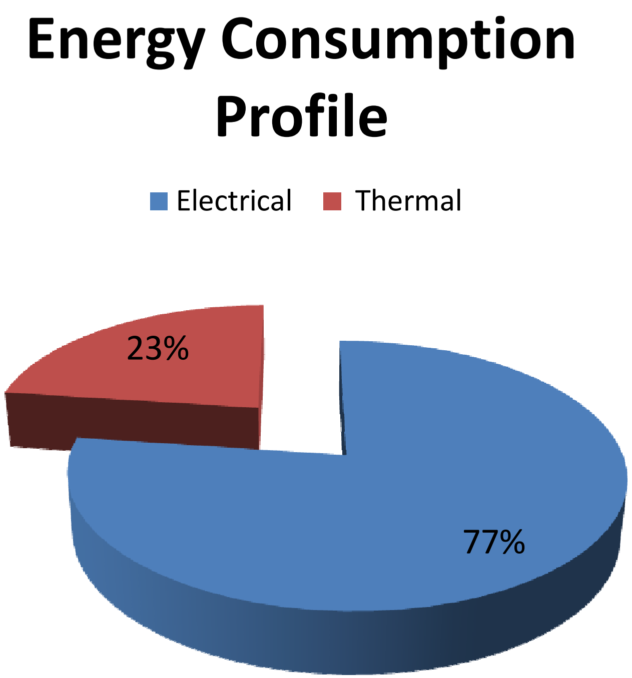
Benchmarking Approaches

1. Internal Benchmarking
   This approach is used to compare performance before and after retrofit measures have been implemented for energy saving
2. External Benchmarking
   used to set performance targets for the future by comparing energy performance of similar buildings against an established standard or baseline

Benchmarks

84 KWh/m^2
15181 KWh/Bed
(By Bureau of Energy Efficiency, Govt of India ECO-III project)

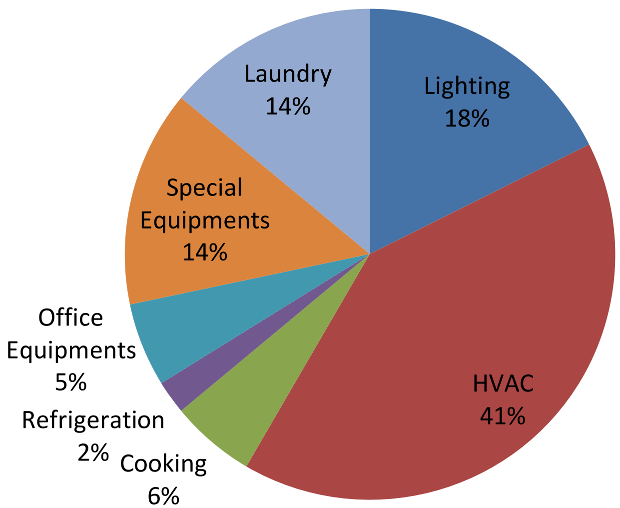
Energy Analysis



The hospital is depending on electricity grid supply for meeting its energy needs. A Diesel Generator is used as the power backup and it delivers is 3.5 KWh per Liter of HSD consuming. LPG is used for the hot water system for providing backup for solar water heater.

Energy Analysis

Energy Consumption Profile



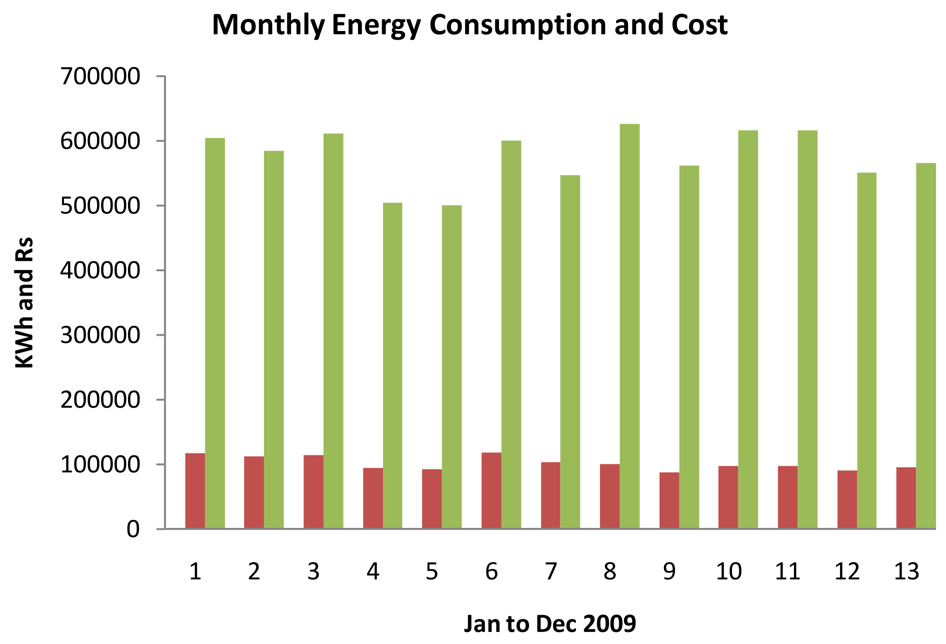
The figure above highlights the energy end use of the hospital. This is the indicator for preparing the implementation strategy for energy conservation and efficiency projects.

Lighting and Heating Ventilation and Air-conditioning (HVAC) contributes about 41% of the total energy consumed in the hospitals. Cooking, Office equipments, Special equipments, Refrigeration and others (including laundry and pumping) contributes the rest 59% of the total energy consumed

Energy saving opportunities are identified based on the share of each sector contributes.

- HVAC
- Lighting
- Laundry
- Hot water system
- Waste heat recovery

Energy Analysis



The figure shows the monthly electrical energy consumption in the hospital. This gives the data of January to December in the year of 2009

1. Heating ventilation and air conditioning (HVAC)

Space cooling and Heating

- Eliminating energy waste does not have to compromise patients comfort.
- Obtain feed back (from patients through staff)
- Check controls
- Zoning
- Keep the conditioned area in
- Keep systems clear and unobstructed
- Localize control
- Upgrade controls

Ventilation and Air conditioning

HVAC comfort conditions (NBC,2005 and ASHRAE hand book 2007 on HVAC)
Safety first- ventilation systems
Take advantage of Natural ventilation
Set a Temperature Dead Band
Maintain System components
Mixed mode systems.
Variable Speed Drives
Building energy management systems
Hot water generating systems
Water saving systems

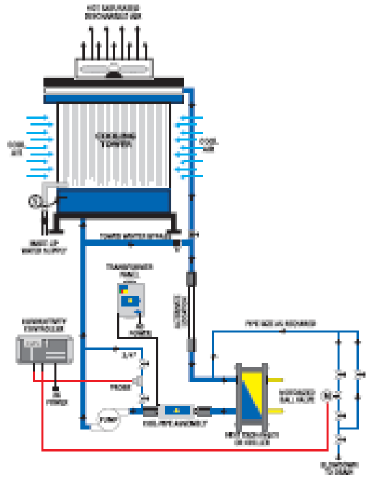
1.1 Energy saving in Cooling water pumping system

There are three pumps available to pump the cooling water to the cooling tower situated at the top floor of the old building and after cooling it is return to the chiller. At a time only one pump is in operation and the other two are kept as stand by. The butterfly valves used to control the flow in the lines, and it is found at the time of inspection that all the valves are damaged and the flow is not controlled over the cooling water line.
The damaged valves thus allows the water to cross flow in to the other lines connected to the two stand by pumps. This causes energy wastage. This pump is working almost 24hr a day. If the valves were repaired or replaced with good quality gate valve or ball valve, 12% of the total energy consumed can be saved.

Energy Saving Proposal-1.1 Energy Saving in Cooling Water System-1	
Investment required (in Rs)	10000.00
Annual Energy Consumed (KWh)	96360.00
Annual energy Cost (in Rs)	546361.20
Energy Saved annually (in KWh)	11563.20
Energy Cost Saved (in Rs)	65563.34
Simple Pay Back (in Months)	1.83

The maintenance of the valves and other controls shall be done regularly. There was no maintenance has been done in these valves after installation, as per the information from the floor staff. Butterfly valves are not good to operate these type of system and it is better to go for ball valve or gate valve. The maintenance of the system can be included in the AMC of the AC system.

1.2 Energy saving in Cooling Tower



There are two cooling towers available. At a time one cooling tower fan is operating but the line is bypassed to the both cooling towers.

The energy conservation opportunities available are

- ✓If the cooling tower may bring down to the ground level the energy can be saved in the cooling water pumping system.
- ✓And also the heat gain to the cooling tower can increase the range of the cooling tower and thus increase the efficiency of the cooling tower
- ✓This proposal can be considered as a long term project.

Energy Saving Proposal-1.2 Energy Saving in Cooling Tower	
Investment required (in Rs)(Approx)	500000.00
Annual Energy Consumed (KWh)	96360.00
Annual energy Cost (in Rs)	546361.20
Energy Saved (in KWh)	67452.00
Energy Cost Saved (in Rs)	382452.84
Simple Pay Back (in Months)	15.69

1.3 Energy saving in Air Conditioning System

Patients Comfort : It is important to have an effective cooling and heating systems to keep patients and staff comfortable. Setting appropriate temperatures, ensuring that cooling and heating equipment and controls are operated and managed correctly can help reducing energy costs up to 30%.

Recommended temperatures for specific areas in hospitals

Room type	Temperature °C	Relative Humidity
Operation Theaters	17-27	45- 55 %
Recovery Rooms	24-26	45- 55 %
Patients Rooms	24-26	45- 55 %

Source: National Building Code (2005)

Obtain Feedback: Encourage staff to report any areas that are tool cold or hot. This feed back will help maintenance personals to work efficiently. In order to maintain appropriate internal temperatures, the thermostat settings shall be in accordance with the activity taking place in the area. The NBC (2005) recommendations may followed.

Zoning: Hospital have areas with different time and temperature requirements such as in waiting areas or private rooms . That is why the system is provided with air handling units (AHUs). Zoning results in increased comfort for patients and staff , and saves money as well as energy.

Keep the Conditioned air isolated: Opening through doors, windows allows heat gain in to the conditioned area. The thermostat then sense a temperature increase and automatically switch the cooling , which is unnecessary. The heat gain through single glazed windows are very high and in the double glazed windows the heat gain is very low.

Safety first Ventilation Systems: The use of ventilation for infection control is important so always seek professional advices before any alterations. Ventilation systems for clinical areas in hospitals has a critical aspect, they need use full fresh air with no recirculation.

1.3 Energy saving in Air Conditioning System

Air changes: Ventilation is required not just combat heat gains from lighting , staff , patients and special equipments but, more importantly, to provide high air change rates in the operation theaters and on the wards to help eliminate airborne bacteria. The air changes recommended by National Building code is given in the table.

Upgrade control: Existing systems have old, inefficient time and temperature controls. Upgrading them is worth while as pay back is so very quick. The AHU control may be upgraded with the control over chilled water flow also. The present situation is the chilled water flow is still their even if AHU is not working.

Keep systems clear and unobstructed: Regular cleaning of filters are very important to improve the cooling. This ensures better circulation of air into the space and reduces energy required to meet the cooling demand.

National Building Code, 2005	
Function Space	Minimum Total Air Change per Hour
Sterilization	15 - 25
Wards	6 - 8

Check Controls: Damaged thermostats, thermostat setting is maximum, cooling in the un occupied areas because timers and thermostats are not set correctly. Regular check of controls is very important. Install simple time switches in smaller places like consulting rooms. It is important to review time settings every month or check the correctness. Patients welfare comes first, so seek further guidance before turning the air temperature settings up and down.

Natural Ventilation: Natural ventilation and cooling relies on natural airflow between openings on opposite sides of a room or building, or rising warm air being replaced with air sucked in through windows or vents. The quality of air out side shall be checked before letting in.

1.3 Energy saving in Air Conditioning System

Maintain system Components: There is no proper preventive maintenance schedule following in the hospital.. Energy consumption in HVAC will increase substantially if regular maintenance is not under taken. Dirty or faulty fans, air filters, air ducts and components directly affect system efficiency and increase running costs and risk of break down. The performance of the system maintenance activities shall be reviewed , and always consult a maintenance specialist.

Myth: Turning air conditioning temperature as low as they can go, cools the building more quickly

Reality: The temperature drops at the same rate but then overshoots, using more energy than necessary and creating discomfort for staff and patients. If controls are not coordinated, the temperature could even go low enough for the heating system to be switched on. Both systems then operate at the same time.

Remedy: Set thermostats correctly and educate staff to dispel this myth. As a last resort, protect thermostats to prevent tampering, where possible

Energy Saving Proposal-1.3 Energy Saving in Air Conditioning System	
Investment required (in Rs)(Approx)	450000.00
Annual Energy Consumed (KWh)	5905830.24
Annual energy Cost (in Rs)	33486057.46
Energy Saved (in KWh)(3%)	177174.91
Energy Cost Saved (in Rs)	1004581.72
Simple Pay Back (in Months)	5.38

1.4 Energy saving by Installing VFD in Chilling Water System

Chiller water pumping system is running 24 hrs a day. There are 3 chilling water pumps available and running one at a time and the other will be at stand by mode. The chilled water pump draws 8.16 KW. The operating speed of the pump is not changing with respect to the demand at the user end. There are 8 AHUs (Air handling units) and number of FCUs fan coil units , operating individually at the private rooms and consultant rooms. During inspection it is found that the air-conditioning is an option to the patients. If they opt for it the technician will activate the system by operating the FCU and set the temperature at the FCU it self. There is no option for the patients to control the temperature in side. It is found that some times the air conditioning in near 50% of the rooms are turned off. This load variation is not affecting in the Chiller pump. The solenoid valve installed in the FCU will cut only the chilled water flow to the coil in the FCU. A variable frequency drive can save energy in the chilled water pumping system by controlling the speed of the chiller pump as per the pressure required. The private room allocation may be planned like all the non AC rooms will be provided in the old block were the AC is operated individually will save substantial amount of energy.

Energy Saving Proposal-1.4 Installation of VFD in Chilled water system	
Investment required (in Rs)(Approx)	75000.00
Annual Energy Consumed (KWh)	71481.60
Annual energy Cost (in Rs)	405300.67
Energy Saved (in KWh)	21444.48
Energy Cost Saved (in Rs)	121590.20
Simple Pay Back (in Months)	7.40

2.1 Energy Saving in Lighting System

Energy Saving Proposal-2.1 Installation of T5 in place of Existing T-12 lamps	
Investment required (in Rs)(Approx)	72250.00
Annual Energy Consumed (KWh)	51311.70
Annual energy Cost (in Rs)	290937.34
Energy Saved (in KWh)	20524.68
Energy Cost Saved Annualy(in Rs)	116374.94
Simple Pay Back (in Months)	7.45

Energy Saving Proposal-2.2 Energy saving in Lighting with best practices	
Investment required (in Rs)(Approx)	72250.00
Annual Energy Consumed (KWh)	211265.47
Annual energy Cost (in Rs)	1197875.23
Energy Saved (in KWh)	10563.27
Energy Cost Saved Annually(in Rs)	59893.76
Simple Pay Back (in Months)	14.48

Tip: Always make the most of natural day light. Research indicates that increased daylight in patient rooms may ease post-surgical pain, decrease the use of pain medication and reduce the length of stay in the hospital (ECO III project)

3. Laundry

Laundry facilities are extremely energy intensive. 14% of the total energy is consumed for the operation of laundry. The opportunities to reduce the energy consumption is very high.

Actions suggested:

•Stop using electrical heaters in washing machines and dryers. Use steam based one.

•Water recovery by recycling the rinse water from washer extractors is a proven means of reducing water usage.

•Total water recovery has to be considered and shall be investigated

•Heat recovery from other sections and solar energy via heat exchanger or waste heat boiler is a standard practice and can be used on all machines

•Consider combined heat and power (CHP) or Cogeneration systems, which might be viable for the hospital that incorporate a laundry.

Installation of a Hybrid hot water generating system for laundry.

❑ Water recovery system

❑Waste heat recovery system

❑Installation of solar water heater

❑LPG,Solar, Biogas Hybrid system for Hot water

❑Heat recovery from dryer waste heat

❑Installation of hot water boiler for the hybrid system

3.1 Energy saving in Laundry (Hot water generation from Heat recovery)

Heat Water recovery sources

- Incinerator
- Laundry Dryer exhaust.
- Solar water heater
- Water recycling.

Primary fuel

- LPG or FO or LNG.

Stand by

- Electricity

The laundry is now drawing 68KW load at its normal operation. Out of it 90% of the total load is going to be heat energy in the washing machines and dryers. The operating temperature of this equipments are 60 to 70 ^{0}C average. This is a very low heat value produced by using electricity. From the investigation from the sources where waste heat is generate it is found that from the waste heat generated from the hospital itself the laundry heat requirement can met. From the incinerator the flue gas temperature measured is 210^{0}C. Average feed in to the incinerator is 170Kg/day and operating for 5 hrs per day. There a good potential to install solar hot water on the top of the laundry itself. There is waste heat available with the dryer exhaust which is at 65^{0}C. It is possible to bring all these waste heat to operate a waste heat boiler and generate steam to operate laundry and may possible to transport it to other requirements.

Energy Saving Proposal-3.1 Waste heat utilisation in Laundry	
Investment required (in Rs)(Approx)	1200000.00
Annual Energy Consumed (KWh)	173740.00
Annual energy Cost (in Rs)	985105.80
Energy Saved (in KWh)	156366.00
Energy Cost Saved Annualy(in Rs)	886595.22
Simple Pay Back (in Months)	16.24

4 General Recommendations

- **Biogas plant**
  - Feed from canteen waste
  - Gas can be used to hybrid system
- **Solar Water heaters**
  - Feed water preheating to the hot water boiler
  - Can be installed in two packages
    - For laundry
    - For other requirements
  - Feed water for sterilization and other surgical requirements
- **Waste heat recovery**
  - From Incinerator having flue gas temperature of 210 degree Celsius.
  - From dryer exhaust
- **Rain water harvesting**
  - Use for Distilled water
  - Supplement to drinking water
- **Energy Efficiency in Transport system**
  - Ambulances, Transport vehicles
  - Awareness to the Drivers
- **Energy Management System**
  - On- line energy management system
  - Networking the energy load centers to the PC
  - Monitor the energy consumption regularly and check the SEC.

Consolidated Statement of Energy Saving Projects	
Investment	2429500.00
Energy Saved	510648.14
Cost Saved	2741599.23
Annual energy Cosumption	1710581.36
% saving in Energy	29.85
Annual Energy Cost(including electricity and HSD)	8769212.00
% Saving in Energy Cost	31.26

Energy Performance Before Implementation

Area of the Building : 15543.00 m^2
KWh/ m^2 : 110.05
Total Number of Bed : 360
KWh/bed : 4751.61

Energy Performance After Implementation

Area of the Building : 15543.00 m^2
KWh/ m^2 : 77.20
Total Number of Bed : 360
KWh/bed : 3333.15

Thank you

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