

# Energy Efficiency in Hospitals

## Best Practice Guide



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# **Energy Efficiency in Hospitals**

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**March 2009**

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Published by:

**USAID ECO-III Project**

International Resources Group

2, Balbir Saxena Marg, Hauz Khas, New Delhi, India

Developed by:

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# ABOUT ECO-III PROJECT

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Energy Conservation and Commercialization (ECO) Program was signed between the Government of India (GOI) and USAID in January 2000 under a Bilateral Agreement, with an objective to enhance commercial viability and performance of Indian energy sector, and also to promote utilization of clean and energy efficient technologies in the sector.

Following the enactment of the Energy Conservation Act 2001, ECO-I Project supported GOI in the establishment of the Bureau of Energy Efficiency (BEE). Support to BEE was provided to set up procedures and authorities, establish office facilities and assist in several activities leading to the development of BEE's Action Plan including thrust area such as the development of an energy auditor certification program.

ECO-II Project provided BEE with necessary technical assistance and training support to implement two thrust areas of the Action Plan. First was to develop the Energy Conservation Building Codes (ECBC) for the five climatic regions of India, and the second was to support Maharashtra Energy Development Agency in developing strategies for energy conservation and implementation of selected programs.

The major objective of the on going ECO-III Project Program is to assist BEE in the implementation of the Energy Conservation Act. The focus areas include the development of Energy Conservation Action Plan at the State level, implementation of the Energy Conservation Building Code, improvement of energy efficiency in existing buildings and municipalities, inclusion of energy efficiency subjects in architectural curriculum, enhancement of energy efficiency in small and medium enterprises, etc.

Since November 2006, International Resources Group (IRG) with support from its partners (IRG Systems South Asia, Alliance to Save Energy and DSCL Energy Services) has been implementing ECO-III Project by working closely with BEE, Gujarat Energy Development Agency, Punjab Energy Development Agency, international experts, academic institutions, and private sector companies.

## Foreword

Hospitals are the backbone of the health care delivery system in India. Until early 1980s, the Government run hospitals and those operated by charitable organizations were the main providers of health care facilities. However in the 1980s and thereafter the sector has been attracting private capital in setting up hospitals and nursing homes.

According to a World Health Organization study, currently India has approximately 860 beds per million population, which is only one fifth of the world average of 3960. It has been estimated that with growing population and health care needs, 450,000 additional hospital beds will be required by 2010.

Large corporate groups and charitable organizations have brought private finance and these resources are being invested in developing health infrastructure and modern equipments and technologies leading to the availability of super-specialty hospitals across the country, especially in big cities. However these developments have led to higher energy-intensiveness in the hospital sector in India. Many modern hospitals may consume ten to fifteen times more energy per bed as compared to a typical government hospital, and this trend is likely to strain India's power sector substantially in the coming years. In fact, many hospitals have been relying heavily on diesel power generation to keep the hospital's critical facilities running in the absence of reliable power supply from the Utilities.

Sample studies in hospital sector have shown number of cost effective energy conservation opportunities, which have remained untapped due to several reasons. The major barriers have been low awareness among the management of the hospitals and limited availability of in-house expertise to identify and implement energy saving projects. Good energy management structure can bring in not only an energy efficient culture within the hospital but also provide substantial reduction in energy expenses without compromising on the quality of health care facilities to the patients. This Energy Efficiency Guide has been prepared to address these issues, and is expected to raise the level of awareness on energy efficiency among the hospital administrators and managers and inspire them to initiate and implement energy conservation program in their facilities.

I would like to thank USAID especially Mr. S. Padmanaban and Ms. Archana Walia, in the development of this Guide under the ECO-III Project. I would also like place on record my appreciation for the ECO-III Project Team comprising of Dr. Satish Kumar and Mr. Ravi Kapoor for their valuable efforts in compilation and analysis of various energy efficiency issues keeping in view the prevailing perspectives of the management of hospitals in India. I also appreciate DSCL for providing support to ECO-III Team in this task.

I am confident this Guide will serve as a valuable reference on energy efficiency for both the existing hospitals as well as the new hospitals which are likely to come up in the next couple of years, and look forward to receiving their valuable comments and suggestions to further enrich the quality of this publication.



(Ajay Mathur)

Date: 27<sup>th</sup> February, 2009

# ACKNOWLEDGEMENTS

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This document has been developed by International Resource Group under USAID ECO-III Project in association with the Bureau of Energy Efficiency (BEE).

I would like to acknowledge the tremendous support and encouragement provided by Dr. Ajay Mathur, Director General, and Mr. Sanjay Seth, Energy Economist of BEE in the preparation of the Guide. In addition, the constant support provided by Mr. S. Padmanaban, Sr. Advisor and Dr. Archana Walia, Cognizant Technical Officer, of USAID has facilitated ECO-III tremendously in the development of the Guide.

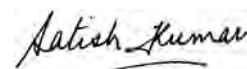
A document of this nature and scope would not have been possible without the team-work and the inputs drawn from various national and international resources. In this context, I would like to express my sincere thanks to Dr. G.C. Datta Roy, Ms. Nisha Menon, and Mr. Prakash Vankani of DSCL Energy Services in preparing the basic document and providing us with very useful field level energy data of various hospitals in India.

I would like to acknowledge the contributions of the ECO-III project staff – Mr. Ravi Kapoor for his leadership and coordination role, Ms. Meetu Sharma for the support in developing graphics and desktop layout, and Ms. Vidhi Kapoor for identifying and following up with hospitals during the document review process.

I would also like to acknowledge the feedback and comments received from Conzerv, Schneider Electric, Spectral Services, Post-Graduate Institute for Medical Education and Research, Pushpanjali Crosslay Hospital, and others who helped with the compilation of the guide.

Most importantly, I would like to acknowledge the following organizations and their publications, which have been utilized by us in developing the Guide:

1. Planning Commission, Government of India – 11th Five Year Plan (2007-12)
2. Director General of Health Services, Central Bureau of Health Intelligence – National Health Profile, 2007
3. Carbon Trust, United Kingdom – Hospitals Healthy Budgets through Energy Efficiency, 2007
4. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) – Saving Energy with Energy Efficiency in Hospitals, 1997
5. Leonardo Energy – Power Quality Utilization Guide – Hospitals



(Satish Kumar)

Date: 27<sup>th</sup> February, 2009



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# 1 INTRODUCTION

## Preamble

The Eleventh Five Year Plan (2007- 2012) of the Government of India States that the health of a nation is an essential component of development and vital to the nation's economic growth. Assuring a minimal level of health care to the population is a critical constituent of the development process.

Since Independence, India has built up a vast health infrastructure and health personnel at primary, secondary and tertiary care in public, voluntary, and private sectors. For producing skilled human resources, a number of medical and paramedical institutions have been set up.

As per 11<sup>th</sup> Five Year Plan public spending on health in India is amongst the lowest in the world currently (about 1% of GDP). However considerable achievements have been made over the last six decades to improve health standards, such as life expectancy, child mortality, infant mortality, and maternal mortality. Small pox and guinea worm have been eradicated and there is hope that poliomyelitis will be contained in the near future (Planning Commission, Government of India, 2007).

During the last few years there has been a great change in the availability of health care facilities in the country. As per the 11<sup>th</sup> Plan, number of government hospitals increased from 4571 in 2000 to 7663 in 2006, that is, an increase of 67.6%. Number of beds in these hospitals increased from 430,539 to 492,698 that is, an increase of 14.4%. However, more recent data from Central Bureau of Health Intelligence indicates the total number of Government hospitals in India at 9976 as of January 2007. Table 1 provides data on number of Government hospitals and beds in the States and Union Territories of India.

According to the 11<sup>th</sup> Plan, despite a steady increase in public health care infrastructure, utilization of public health facilities by population for outpatient and inpatient care has not improved. The NSSO (1986–2004) data shows a major decline in utilization of the public health facilities for inpatient care and a corresponding increase in utilization of the same from private health care providers in both rural and urban areas. Current figures are not available on number of private and NGO hospitals but in 2002; the country had 11,345 private/NGO hospitals (allopathic) mostly located in cities and towns with a capacity of 262,256 beds.

Table 2 provides the number of private hospitals and nursing homes in various states, which does not, however give the complete information (Doctors Online Web Site) for the country.

**Table 1: Government (Central government, State government and Local Govt. Bodies) Hospitals including Community Health Centers In India (Provisional)**

S. No.	State/UT	Rural Hospitals		Urban Hospitals		Total Hospitals		Reference Period
	India	No.	Beds	No.	Beds	No.	Beds	
		6,955	154,031	3,021	328,491	9,976	482,522	
1.	Andhra Pradesh	167	6220	192	28113	359	34333	01.01.2007
2.	Arunachal Pradesh	36	379	30	1674	66	2053	01.01.2005
3.	Assam	100	3000	-	-	100	3000	01.09.2004
4.	Bihar	101	3030	-	-	101	3030	01.09.2004

S. No.	State/UT	Rural Hospitals		Urban Hospitals		Total Hospitals		Reference Period
	India	No.	Beds	No.	Beds	No.	Beds	01.01.2007
		6,955	154,031	3,021	328,491	9,976	482,522	
5.	Chattisgarh	116	3514	22	2051	138	5565	01.01.2004
6.	Goa	9	452	11	2127	20	2579	01.01.2007
7.	Gujarat	1483	18832	229	22200	1712	41032	01.01.2008
8.	Haryana	56	1178	93	6484	149	7662	01.01.2008
9.	Himachal Pradesh	94	2146	55	5963	149	8109	01.01.2008
10.	(a) Jammu Division	28	830	8	870	36	1700	01.01.2000
	(b) Kashmir Division	33	990	23	1255	56	2245	01.01.2008
11.	Jharkhand	47	1410	-	-	47	1410	01.09.2004
12.	Karnataka	444	7290	424	35301	868	42591	01.01.2007
13.	Kerala	173	12450	77	15945	250	28395	01.01.2008
14.	Madhya Pradesh	275	8179	102	11739	377	19918	01.01.2008
15.	Maharashtra	424	15380	242	30593	666	45973	01.01.2007
16.	Manipur	24	669	4	1251	28	1920	01.01.2008
17.	Meghalaya	26	780	8	1839	34	2619	01.01.2007
18.	Mizoram	10	320	10	904	20	1224	01.01.2008
19.	Nagaland	123	1962	12	790	135	2752	01.01.2006
20.	Orissa	1623	5882	84	8668	1707	14550	01.01.2008
21.	Punjab	77	2100	172	8927	249	11027	01.01.2007
22.	Rajasthan	347	11850	128	20217	475	32067	01.01.2008
23.	Sikkim	29	700	3	820	32	1520	01.01.2008
24.	Tamil Nadu	533	25078	48	22120	581	47198	01.01.2008
25.	Tripura	16	500	15	1762	31	2262	01.01.2008
26.	Uttar Pradesh	397	11910	528	20550	925	32460	01.01.2007
27.	Uttarakhand	24	100	94	5413	118	5513	01.01.2007
28.	West Bengal	99	5171	284	44510	383	49681	01.01.2008
29.	A&N Island	6	355	1	450	7	805	01.01.2007
30.	Chandigarh	2	50	5	2150	7	2200	01.01.2004
31.	D&N Haveli	1	30	1	130	2	160	01.01.2008
32.	Daman & Diu	2	52	2	140	4	192	01.01.2004
33.	Delhi	21	972	102	20220	123	21192	01.01.2008
34.	Lakshadweep	5	160	-	-	5	160	01.01.2005
35.	Puducherry	4	110	12	3315	16	3425	01.01.2008

Source: Director General of State Health Services, Central Bureau of Health Intelligence, National Health Profile 2007

**Table 2: Numbers of Private Hospitals and Nursing Homes (Partial List)**

S. No.	State	Hospitals	Nursing Home	Total
1.	Andhra Pradesh	178 (inc. Nursing Homes)		178
2.	Assam	9	5	14
3.	Bihar	6	2	8
4.	Chandigarh	18	4	22
5.	Chhattisgarh	10	1	11
6.	Daman & Diu	3	0	3
7.	Delhi	147	25	172
8.	Goa	8	3	11
9.	Gujarat	477	46	523
10.	Haryana	110	27	137
11.	Himachal Pradesh	2	0	2
12.	Jammu & Kashmir	3	1	4
13.	Jharkhand	6	1	7
14.	Karnataka	110	12	122
15.	Kerala	124	4	128
16.	Madhya Pradesh	95	20	115
17.	Maharashtra	794	269	1063
18.	Manipur	1	0	1
19.	Meghalaya	2	0	2
20.	Mizoram	1	0	1
21.	Nagaland	1	0	1
22.	Orissa	11	8	19
23.	Pondicherry	7	1	8
24.	Punjab	49	4	53
25.	Rajasthan	82	5	87
26.	Tamilnadu	187	29	216
27.	Tripura	1	0	1
28.	Uttar Pradesh	134	22	156
29.	Uttaranchal	14	3	17
30.	West Bengal	80	66	146
Total				3228

Source: Doctors Online ([www.hindustanlinks.com](http://www.hindustanlinks.com))

According to the 60th Round of the NSSO (2007), privately operated health care delivery of services accounted for over half of all in patient hospitals and about 77% of all outpatient visits,

as per the 11<sup>th</sup> Plan. Proportion of private spending on health is one of the highest in India. Households in India spend about 5–6% of their consumption expenditure on health (NSSO). The cost of services in the private hospitals is very high. The rising costs of health care and growing expectations of the people are the challenges country is facing. The 11<sup>th</sup> Plan aims to enhance the contribution of the private sector through various measures including partnership with the government.

## Energy Consumption in Indian Hospitals

National level energy consumption data in hospitals and nursing homes is not available in public domain. However ECO-III Project has made an estimate based on some sample survey and studies conducted in hospitals by DSCL Energy Services (DSCL) under the Project. Table 3 provides the electricity consumption and electricity cost estimates.

**Table 3: Estimated Electricity Consumption in Hospitals (including Community Health Centers) and Nursing Homes in India, 2008**

Hospital	No. of Beds	Estimated kWh/Bed/year	Assumed Electricity Cost per kWh	Estimated Electricity Consumption (Million kWh)	Estimated Electricity Cost (Rs. Millions)
Government Hospitals -Urban	328,491*	750 – 1500	Rs. 5	246 - 492	1232 - 2464
Government Hospital - Rural	154,031*	150 - 300	Rs. 4	23 - 46	92 - 184
Private/NGO Hospitals & Nursing Homes	500,000**	1000 – 2000	Rs. 6	500 – 1000	3000 – 6000
<b>Total</b>	<b>982,522</b>	<b>----</b>	<b>-----</b>	<b>769 - 1538</b>	<b>4324 - 8748</b>

Source: USAID ECO- III Project, 2009

\*Central Bureau of Health Intelligence, National Health Profile, 2007

\*\*Estimated for 2008: Based on number of beds as 262,256 in 2002 (11th Plan estimate) and an approx. 12% annual growth rate.

Basis and assumptions for arriving at the values in Table 3

- kWh/Bed/year in Urban Government Hospitals is based on sample studies conducted by DSCL under ECO-III Project
- kWh/Bed/year in Rural Government Hospitals is assumed to be 20% of that of Urban Government Hospitals
- kWh/Bed/year in Private/NGO Hospitals is from DSCL sample survey, and it takes into account Multi-specialty large hospitals in Metropolitan Cities, which may have kWh/Bed/year as high as ten times that of a normal Private/NGO Hospital

## Need for Energy Efficiency

Commercial building sector, which includes offices, hotels, hospitals, retail shops etc. has been growing at a fast pace. As per Central Electricity Authority, the growth of energy consumption in the sector has been highest at over 14% (see Table 4).

DSCL has estimated that if the growth continues at the present level, additional demand growth for power in the hospital sector would be over 8,500 MW per year. This would mean capacity addition of over 40, 000 MW in the 11<sup>th</sup> plan just to meet the additional demand of the

commercial sector.

Present power system is already inadequate to meet the existing demand. There are both peak demand and electricity shortages. Government of India has made a socially desirable plan for making power available to all by 2012. Thus, one of the key ways for managing current shortage and the future need of power is efficiency enhancement and conservation of energy resources. Due to the current situation of the commercial sector, it becomes even more important for this sector as a whole to put together greater effort in energy conservation.

**Table 4: Energy consumption in various end-use sectors**

Category	Electricity Consumption	
	% of total	Increase over last year
Domestic	21.10%	4.63%
Commercial	7.58%	14.61%
Industry	45.13%	7.36%
Public Lighting	1.09%	4.22%
Transport	2.10%	4.72%
Agriculture	19.03%	1.96%
Public Water Works	2.16%	6.65%

The Energy Conservation Act (EC Act), enacted in October 2001, with a view to institutionalize the mechanism of energy efficiency through various measures has identified the building sector as one of the key areas. The Bureau of Energy Efficiency (BEE), the statutory body under the Ministry of Power, has the responsibility to implement the provisions of the EC Act.

## Why This Document

Bureau of Energy Efficiency (BEE), Government of India has launched a program for energy conservation in the building sector. Several initiatives already introduced include:

- Standard and labeling of electrical appliances from energy efficiency perspectives;
- Energy Conservation Building Code (ECBC) for meeting minimum energy performance in new and existing buildings;
- Conducting investment grade audit in large number of Government buildings in different states through the State Designated Agencies;
- Implementation of energy conservation demonstration projects for the Central Government owned facilities including hospitals;
- Energy conservation awards for offices, hotels and hospitals;
- Introduction of star-rated labeling program for office buildings.

It is in this context that a meeting was organized in the office of the Indian Medical Association (IMA) under the auspices of BEE. The meeting was attended by large number of Doctors, Hospital Administrators and Engineering staff. Presentation was made on possible energy saving and cost reduction opportunities in the existing hospitals through retrofits, and through design stage intervention in new hospitals.

During the meeting deliberations, BEE was requested by IMA to prepare a document that can help the Doctors, Administrators and Engineering staff to:

- Monitor energy usage and consumption in hospitals
- Understand energy efficient practices and technologies in simple language
- Launch energy efficiency and conservation awareness program
- Implement energy conservation measures and realize the cost savings

Accordingly, this Guide has been prepared to address the above points and also citing relevant case examples from India and abroad.

Health care industry is amongst the largest employers in India and is also the largest in terms of revenue and its growth (Rs. 1253 billion in 2006 and projected to increase to Rs. 3642 billion by 2016), as per CRIS- INFAC, 2007. Indian hospitals are increasingly becoming global destination for medical and patient care. There is a corresponding growth of infrastructure to support the industry, resulting in an increased energy use in the hospitals. Several energy use assessment studies carried out by DSCL and others in hospitals indicate high potential for energy savings; nearly 20-30% of existing cost. Most of this potential to save energy has however not been tapped. Major barriers are:

- Low awareness among owners and facility managers on energy efficiency opportunities and approach to harness the same
- Limited availability of in- house expertise for identifying the energy savings projects and their implementation
- Lack of in-house energy management organization structure

This Guide developed under the ECO-III Project is intended to address the above barriers. It is believed that with increased level of awareness and utilization of services of energy efficiency specialists, many of the energy savings measures can be implemented with success.

### **Targeted Beneficiaries**

The targeted beneficiaries for this Guide include the management of hospitals and nursing homes who wish to identify and implement energy efficiency measures/projects. In the development of the Guide, care has been exercised for making it user friendly for the hospital administrators and engineering staff.

### **Scope of Application**

This Guide mainly focuses on existing hospitals and improvements that can be made through the adaptation and implementation of energy efficiency measures. The technical contents represent the best practices and available technologies for energy efficiency and hence can also be applied to new hospitals that are under planning and construction.

## 2 ENERGY USAGE IN HOSPITALS

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### Energy Use and Costs (CADET, 1997)

Hospitals are institutions for the care of the sick and injured and usually function 24 hours per day, all year round. They usually consist of large buildings, and careful control of their internal climate is considered necessary. Substantial amount of heat is normally generated internally by the occupants and operating equipment. An effective cooling (and heating depending upon the external weather conditions.) and ventilation systems combined with good insulation of hospital building, usually reduce hospital's sensitivity to the outside weather. Hospitals also require standby electricity generators to ensure a continuous supply of power in emergencies and critical operations.

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 normally over 50 years. During this period, the building is retrofitted and renovated many times. Reasons for this include the shorter life of technical equipment, the development of new types of equipment and health care facilities, new regulations, new energy-saving technologies and the ageing of the building itself.

When considering energy-efficiency in hospitals, it is important to keep in mind that it is not the end-use of energy alone, but also the need to control the indoor climate, that is one of the principal requirements. The indoor climatic requirements are determined by the hospital activities in the building. Once these are established, it is necessary to provide the required climate, ideally in the most economical way. In practice, energy efficiency is increasingly becoming important requirement, but medical considerations remain the top priority in the hospitals.

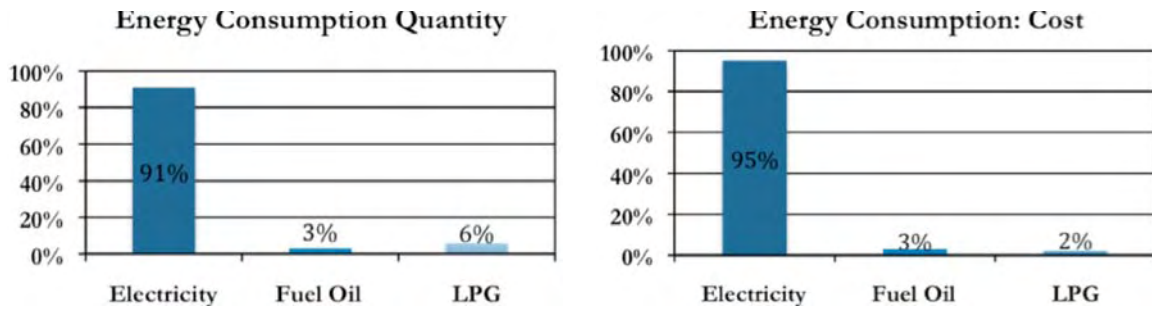
This Guide focuses primarily on existing hospitals, and the improvements in energy efficiency that can be made. However, it is generally true that newer hospitals consume more energy than older hospitals. This is mostly due to the more sophisticated type and extent of the services provided by more modern hospitals, as a result of which their buildings may at times offer greater scope for energy and cost savings. Energy efficiency and availability of newer technologies can assist in developing efficient hospital design.

According to DSCL, the hospitals, as large consumers of energy, have high bills for electricity and fuels, although they may represent a small proportion of the hospital's total operating cost. Review of the power and fuel expenses reported by 46 for-profit hospitals (CMIE PROWESS Database) for the last four years indicate that energy expenses range between 3-8% of total expenses. Even then these constitute a significant component, estimated as 15-20% of the hospitals operating and maintenance cost.

Hospitals purchase energy from outside in the form of fuels and electricity. Furnace oil/LPG/LDO/Gas is used for steam and hot water generation and other thermal applications such as catering and laundry facilities. In most of the hospitals, fuel oil (mainly high speed diesel) is mainly used for standby power generation sets, which are used for considerable period due to inadequate power supply from the Utilities in many states of India. Figure 1 provides the energy consumption and cost breakup in a typical hospital, which are based on DSCL studies.

The electricity consumption depends upon the extent and complexity of equipment and services provided in the hospitals. New hospitals often have proportionately more air conditioning, with its associated chiller plant, and more extensive ventilation systems to maintain health care facilities and standards.





**Figure 1: Energy Consumption in Hospitals**

In hospitals, energy brought in, is converted by a number of conversion systems into several internal energy streams to meet heating, cooling and other medical equipment requirements, (Power Quality Utilization Guide on Hospitals, Leonardo Energy, 2008) and there are energy saving opportunities in all the energy streams categorized as under:

- **Electricity** is used for a wide variety of purposes. Major electricity consumers in a hospital are cooling/heating equipment, lighting, air compressors, water pumps, fans and ventilation. Other applications include laundry equipment; kitchen and canteen equipment; ovens and geysers and medical equipment including autoclaves, office facilities such as computers and photocopiers, utilities such as lifts, refrigerators, water coolers, etc.
- **Heat Stream** is used in the form of steam and hot water. Steam is used in the kitchens and for humidification in HVAC and sterilization process. In addition steam is used to transport heat over longer distances. In many cases heat is transported from the heat generating station in the form of steam and then converted locally into central heating or hot tap water. Oil/Gas-fired boilers are used to generate steam and hot water.
- **Compressed air** can be divided into two main categories, namely medical air and technical air. Medical compressed air refers to the direct treatment and care of patients. Examples include breathing apparatus and surgical tools driven by the compressed air. The medical compressed air is subjected to very high standards for availability and quality. The technical compressed air is used for HVAC control systems, workshop applications or keeping containers under pressure.
- **Cold Stream** mainly takes the form of chilled water and is used for in-door climate control systems, for cooling and drying the ventilation air. In many cases cold stream is generated centrally by means of compression coolers. In combination with cogeneration, absorption-cooling machines are used to supplement compression coolers.

## Major Electricity End-Users in Hospitals

### HVAC System

In many large and centrally air-conditioned hospitals, HVAC systems may consume 40% of total electricity consumption. Air Conditioning and Ventilation system in hospitals is required for:

- Maintaining the requisite indoor temperature, air distribution and humidity levels for thermal comfort.
- Maintaining indoor air quality, particularly in areas requiring prevention of infection

Building envelope design plays a very important role in the determination of HVAC capacity in the hospital.

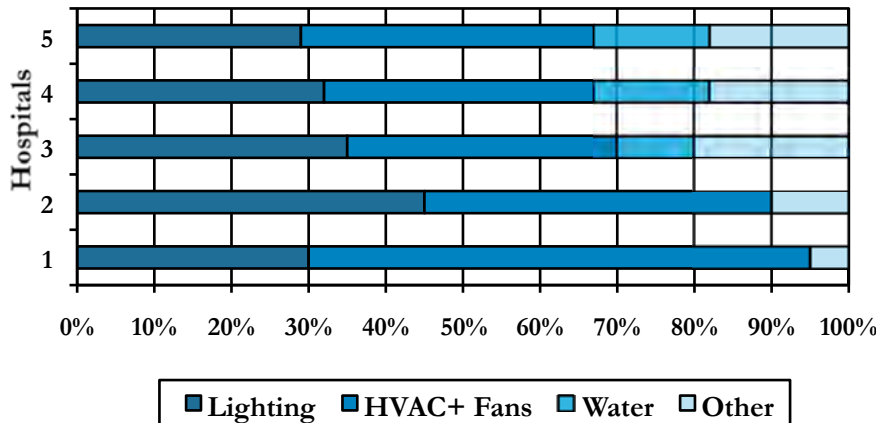
### Lighting

Lighting is a major electricity consumer next only to HVAC systems. Requirement of lights in a hospital varies widely depending upon the activity, time of day and the occupancy level. The

complexity can be well understood from the simple fact that National Building Code (NBC) 2005 recommends Illuminance level varying from one lux for night lighting in some areas to 750 lux in operation theaters for general requirements. At times special lights are used with illumance of 10,000- 50,000 lux in operation theaters.

## Water Pumps

Water is consumed in different sections of the hospitals for various requirements. In most hospitals, water pumping systems may account for 5-15% of total electricity consumption and offer scope for reducing energy consumption. Figure 2 provides the break up electricity consumption in five hospitals.



**Figure 2: Break up of electricity in consumption in five hospitals**

From Figure 2 the range of electricity consumption for major end-users can be summarized as under:

- HVAC: 30-65%
- Lighting: 30-40%
- Water pumping: 10-12%
- Others: 5-15%

Share of different consumption is related to some divergent factors related to service offered, occupancy and climate zone in which hospital is located. However, generally lighting and HVAC applications constitute about 75% of electricity consumption in a hospital.

## Energy Saving Approaches

In each of the key end-use areas, there are three basic approaches to save energy (Carbon Trust, 2007).

- **Switching off** — All energy-consuming equipment should be switched off when not in use. This can be done manually by hospital staff or automatically with special devices.
- **Maintenance** — A number of energy efficiency measures can be carried out as part of routine maintenance procedures at no extra cost.
- **Refurbishment** — Energy saving measures can be extremely cost-effective when planning for refurbishment in the hospital.

## Indoor Climate Requirement

All hospital buildings can be unique in design and size, and the different specialized services they provide. Their technical systems must be designed and adjusted to meet the facilities requirements and needs of indoor environment. Many countries have regulations that outline how these requirements are to be fulfilled, through proper design and operation of medical and technical facilities and the building itself. This is mainly accomplished by regulations for thermal insulation, ventilation, lighting, and indoor temperature levels (Carbon Trust, 2007) discussed below:

### Thermal Insulation

The thermal properties of the building envelope are very important, as a well air conditioned hospital often requires a temperature level of 21-22°C throughout the year, but is limited to a maximum of around 26°C during the warmer months. In several European countries' regulations are usually in the form of mandatory maximum levels for U-values (coefficients of thermal transmittance) for the entire building envelope, including walls, foundations, roof and windows. In India, this is being currently attempted by Energy Conservation Building Code (May 2007) particularly for new buildings, having a connected electricity load of 500 kW or more or a contract demand of 600 kVA or more.

### Ventilation

For hospitals, it is not always the heat generated that decides the ventilation and cooling/heating rates (as is normal for commercial buildings, such as offices), but the hygiene considerations. As indoor air is contaminated by occupants (some of them may be patients) and activities in the hospital, it must be renewed in order to eliminate contaminants, odours and pollutants.

In many European Countries, room ventilation levels typically range from 35-140 m<sup>3</sup> per person/hour depending on the function of the room (e.g. general or intensive-care). Operating theatres are usually among the rooms having the highest demands, with ventilation rates around 30-55 m<sup>3</sup>/square meter/hour.

In India, National Building Code (2005) recommends 6-8 air changes per hour in hospital wards, and 15-25 air changes per hour in sterilizing departments of the hospitals.

### Lighting

Daylight is, by far the most desirable type of illumination for the human comfort. Design of areas used by patients should always provide for windows. Their size, orientation and position in rooms must provide sufficient lighting levels, and should give a view of the outside surroundings and the sky. This adds to a patient's feeling of contact with the outside world, which is important, psychologically, in healing.

Often in conflict with the above benefits are the unwanted effects of glare and overheating due to solar radiation. These, if not avoided, result in considerable discomfort for the patients, and an increased need for cooling energy. For this reason sunshades and blinds should be fitted to the affected windows. Maximum utilization of daylight is best provided by having sun shades and blinds automatically controlled by sensors triggered by sunshine and wind, but manual controls should always be available for individual adjustment. Hospitals also usually have a substantial number of windowless rooms, in which daylight is, of course, not a practical solution. In these cases, artificial lighting, which is energy efficient, must be employed to maintain comfort levels.

### Temperature

To maintain comfort levels for patients, a typical temperature for patients' rooms and recovery rooms is 24-26°C during summer months. This value could be maintained at 21-23°C during the colder part of the year.

When temperature discomfort is identified, it is usually more efficient to localize the sources of discomfort and treat these, rather than to increase or decrease the room temperature. This can be done, for example, by covering cold walls, erecting screens against cold drafts from windows, window frames and badly positioned air vents, and minimizing isolation by installing sunshades.

### **Indoor Air Humidity**

Indoor air should neither be too dry (which causes dehydration) nor too humid (which causes perspiration and increases the risk of fungal growth). The comfort range covers, relative humidity of 45-55%, at temperatures of 24-26°C normally required in patients and recovery rooms.

Strict hygrometric controls are often only applied in rooms where conditions are more critical, i.e. in operation theatres, intensive-care wards, etc.

# 3 ENERGY BASELINE AND BENCHMARKING IN HOSPITALS

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## Measuring Energy Performance

Where are we and where should we be going? What lies at the heart of these questions is the belief that we should track how far we have come in order to know how far we have left to go. This applies to the monitoring of energy performance in hospitals as well. In hospitals, measuring energy performance is sometimes easier said than done. Not only is a baseline needed to benchmark from, but a clear destination is also needed. In majority of hospitals in India, the energy managers do not have an easy way to gauge the energy performance of their hospitals, or for that matter a destination to go for (Hospitals Engineering & Facilities Management, 2005).

It is believed that the managers need to know how their buildings perform with respect to energy in order to make the most effective management decisions. Knowing that energy-efficient equipment have been employed, is not enough, whereas knowing the actual energy consumption will enable confirmation of intuition, evaluation of maintenance practice, ensuring proper equipment installation or the implementation of other measures that save significant amount of energy.

Energy benchmarking has been undertaken for comparing the energy use in commercial facilities in a few countries with a view to compare the energy performance of a building with an established standard or norm. In fact, it can be used as a first step towards implementing an energy management program in the hospital.

## Benchmarking Indicators

Two indicators most commonly used internationally for benchmarking in hospitals are (Leonardo Energy, 2008):

- a) Annual energy consumption per square meter of the hospital's building area
- b) Annual energy consumption per inpatient bed in the hospital

It is important to bear in mind that these indicators are based on technical characteristics of the building. If sufficient data is generated and compiled then it is desirable to compare hospitals on the basis of energy consumption both per bed and per square meter. One difficulty that stands in the way of benchmarking is the degree of outsourcing in the hospital. For instance, some hospitals contract out their catering and laundry activities, which lead to a lower energy consumption by the hospital itself and thus have lower energy baseline and benchmarks.

Both indicators have their own particular disadvantages:

- When taking the built-up area into consideration, the hospital management need to decide which areas of the hospital building are included in the benchmark or not (e.g. outdoor gardening, car parks, roads, corridors and equipment floors). Secondly how much of the hospital's built-up or the carpet area is air conditioned or non-conditioned in real situation.
- When taking beds into consideration, hospitals built-up or carpet area per bed is the critical factor. This factor is determined by the type of hospital and by the design criteria of its construction. One needs to take into account, the trend towards higher quality of health care and greater privacy for patients, which may lead to a lower number of beds per room and thus a greater number of square meters per bed. Secondly, many hospitals have combined metering of energy consumption of out-patient department and in-patient

department. Therefore for an effective benchmarking, independent sub-metering of the two may be essential.

Another method of benchmarking is the one normally used in process industries, namely benchmarking on the basis of "production" by the hospital. The parameters used for "production" in hospitals could be the number of patient overnights or the number of bed-days actually used annually. From this, one can determine the energy consumption per overnight. However, this depends to a large degree on the type of hospital, and on trends in healthcare facilities. For instance, the number of overnights per treatment has fallen sharply in recent years, because the number of treatments has risen considerably for the same number of beds. There is also a possibility that with increasing load of inpatients and scarcity of room space in the hospitals, lesser area per patient is provided. Climate conditions also greatly affect energy consumption in hospitals, and thus climate based benchmarks could be more meaningful or alternatively they need to be normalized sufficiently for an effective comparison.

## Benchmarking Approaches

In practice, two following approaches for benchmarking are adopted.

- **Internal Benchmarking;** where energy performance of a building is compared against its own previous performance over a period of time. This approach is typically used to compare performance before and after retrofit measures have been implemented for energy savings.
- **External Benchmarking;** involves comparison of energy performance of similar buildings against an established standard or baseline. This is typically used to set performance targets for the future.

The Benchmarking offers following advantages:

- It assists in initiating an in-house energy saving program or a macro level energy efficiency program.
- It determines how a building's energy use compares with others; this immediately helps the management in identifying savings potential.
- It facilitates the management to set targets for improved performance and monitoring them on a continuing basis.
- It facilitates the building owners gaining recognition for exemplary achievement in energy performance
- It assists the Service Providers to communicate energy performance of buildings in terms of "typical" vs. "best practice" benchmark
- It helps utility companies to compile energy data from various buildings and track energy use and its growth trends.

Looking at the advantages and disadvantages into consideration, it is useful for the hospital management to analyze the above-mentioned indicators for establishing the energy benchmarks in the hospitals.

## Benchmarking in US (Energy Efficiency Guide for Utah Business, US, 2006.)

The U.S. Environmental Protection Agency and Department of Energy through the ENERGY STAR® Program have developed an energy performance benchmarking tool. The tool enables building owners to evaluate the energy performance of their buildings (including hospitals, hotels offices, medical offices etc.) on a scale of 1-100 relative to similar buildings nationwide. The rating system accounts for the impacts of year-to-year weather variations, as well as building size, location, and several operating characteristics. Buildings rating of 75 or greater qualify for the ENERGY STAR label.

## Benchmarking in Indian Hospitals

Under ECO-II Project, DSCL carried out energy audits in six Government hospitals in Gujarat, Table 5 and Table 6 indicate the energy consumption and energy baseline data.

**Table 5: Energy consumption data for Government hospitals in Gujarat**

S. No.	Name of the Hospital	Number of Beds	Area (m <sup>2</sup> )	Electricity Consumption (2007-2008), Million kWh/annum	Electricity Cost, Million INR /annum
1	G.G. Hospital, Jamnagar	1394	31296	1.044	5.273
2	S.S.G Hospital, Vadodara	1513	19355	1.80	9.18
3	Sir.T.General Hospital, Bhavnagar	720	58985	1.32	6.648
4	Civil Hospital, Rajkot	850	45709	1.128	5.496
5	New Civil Hospital, Surat	1050	36927	1.74	7.488
6	General Hospital, Junagadh	510	14021	0.559	2.852

*Source: DSCL study supported by USAID ECO-III Project; 2008.*

**Table 6: Base-line of energy use in Government hospital buildings in Gujarat**

S. No.	Name of the Hospital	Number of Beds	Area (m <sup>2</sup> )	kWh/Bed/Year	kWh/m <sup>2</sup> /year
1	G.G. Hospital, Jamnagar	1394	31296	749	33.4
2	S.S.G Hospital, Vadodara	1513	19355	1190	93.0
3	Sir. T. General Hospital, Bhavnagar	720	58985	1833	22.4
4	Civil Hospital, Rajkot	850	45709	1327	24.7
5	New Civil Hospital, Surat	1050	36927	1657	47.2
6	General Hospital, Junagadh	510	14021	1096	39.9

*Source: DSCL study supported by USAID ECO-III Project; 2008*

Energy use benchmarks represented as kWh/bed/year varies significantly from 749 to 1833. These variations can be due to several reasons, as discussed earlier, and this deserves an in-depth analysis before drawing any specific conclusion with respect to energy efficiency in their facilities.

BEE in association with ECO-III project has currently undertaken a major initiative to establish benchmarks of energy use in office buildings, hotels and hospitals. In this context, for hospitals a brief questionnaire (Table 7) has been developed to capture relevant data. Hospitals have started providing data to BEE and ECO-III project to analyze and establish benchmarks, and this is expected to facilitate hospitals to initiate energy efficiency programs in their facilities.

**Table 7: Questionnaire- Hospital Building Information and Energy Data** (Source: USAID ECO-III Project)

Primary Data		Year: .....	
No.	Item	Value	
1	Connected Load (kW) or Contract Demand (kVA)		
2	Installed capacity: DG/GG Sets (kVA or kW)		
3	Annual Electricity Consumption, purchased from Utilities (kWh)		
	Annual Electricity Consumption, through Stand by Diesel Generating (DG)/Gas Generating (GG) Set(s) ( kWh)		
	Total Annual Electricity Consumption, Utilities + DG/GG Sets (kWh)		
4	a) Annual Cost of Electricity, purchased from Utilities (Rs.)		
	b) Annual Cost of Electricity generated through DG/GG Sets (Rs.)		
	c) Total Annual Electricity Cost, Utilities + DG/GG Sets (Rs.)		
5	Fuel used for generating steam & water heating	FO/LDO, etc in appropriate units LPG/N Gas, etc. in appropriate units	
6	Fuel used for in-house power generation in appropriate units	HSD (or any other fuel oil) (KL) N gas/LPG, any other (Cu. m)	
7	Area of the Hospital (exclude area used for students' education, staff residences, hostels, parking, lawn, roads, etc.)	a) Total Built Up Area (sq. ft. or sq. m.)	
		b) Total Carpet Area (sq. ft. or sq. m.)	
		• Conditioned Area	
		• Non Conditioned Area	
	c) Non-active Carpet Area* (sq. ft. or sq. m.)		
8	Major Buildings Blocks in the Hospital (Specify below)		
	a)	No. of Floors	
	b)	No. of Floors	
	c)	No. of Floors	
10	Hospital	Total no. of Employees	
		Total no. of Out-Patients serviced annually	
		Total no. of Patient Beds in the hospital	
		In-patient Overnights ((% Occupancy)	
11	Installed capacity of Air Conditioning (AC) System in the Hospital	Centralized AC Plant (TR)	
		Package ACs (TR)	
		Window & Split ACs (TR)	
		Total AC Load (TR) a) + b) + c)	
12	Installed Lighting load (kW) in the Hospital		
13	Installed Water Pumping load (kW) in the Hospital		
14	Installed Plug Loads (Medical equipment, Computers and others) (kW)		



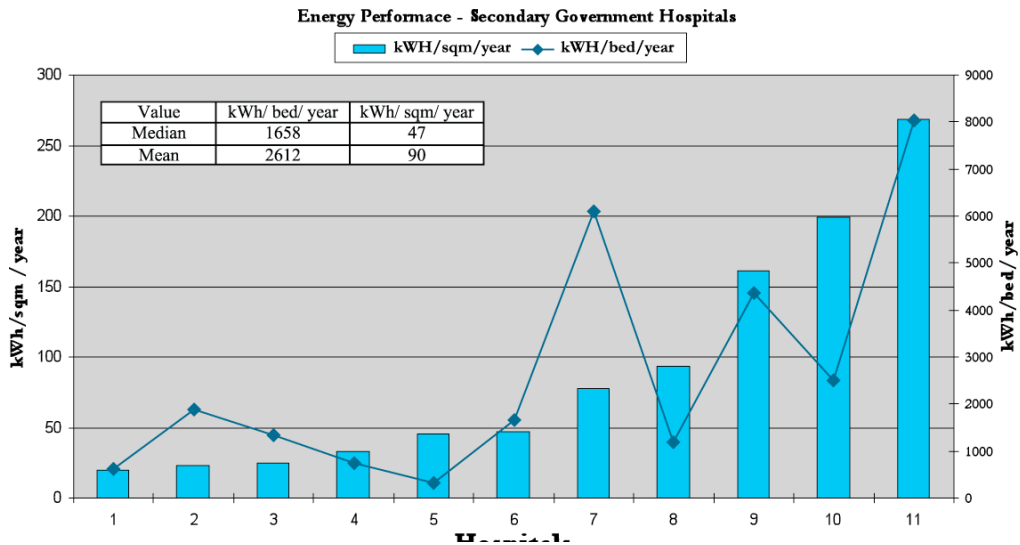
15	Water consumption in the hospital (exclude garden, hostels, residences, students' education areas, etc.) (kilo liters)		
	Estimated Hot water consumption in the hospital (kilo liters)		
16	Hospital Services	Catering (whether in-house or out-sourced)	
		Laundry (whether in-house or out-sourced)	
17	Whether sub-metering of electricity consumption for Air Conditioning, Lighting, Water pumping, Plug Loads, etc. done: Yes/No		

\* Portion of Total Carpet Area (e.g. auditorium, seminar halls, large conference rooms, etc.) which is not used actively on daily/regular basis, and normally AC systems and lights are kept switched off.

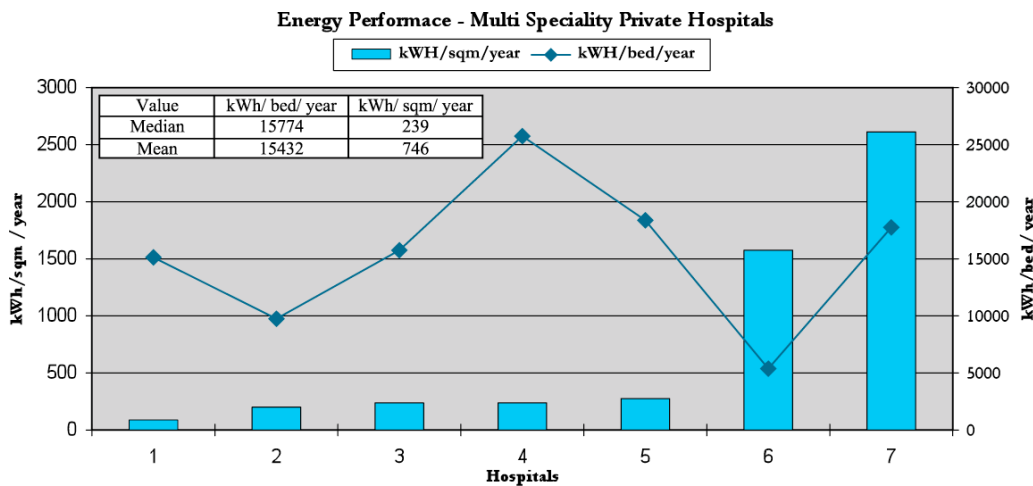
Based on energy audits conducted and information collected using the above questionnaire by ECO-III project, the following trends have been seen in 11 government hospitals and seven multi-specialty private hospitals (Table 8, Figure 3 and Figure 4)

**Table 8: Energy Benchmarks in selected hospitals – Sample Survey**

S. No.	Type	Category	Climate	No. of Beds	kWh/sqm /year	kWh/bed/year
1	Private	Multi-specialty	Hot & Dry	600	1581	5415
2	Private	Multi-specialty	Composite	130	274	18331
3	Government	City/municipal	Warm & Humid	100	20	608
4	Government	City/municipal	Warm & Humid	330	45	321
5	Private	Multi-specialty	Composite	937	197	9782
6	Private	Multi-specialty	Composite	500	2610	17762
7	Private	Multi-specialty	Composite	500	235	15774
8	Private	Multi-specialty	Warm & Humid	224	239	25781
9	Government	City/municipal	Hot & Dry	1513	93	1194
10	Government	City/municipal	Warm & Humid	1394	33	749
11	Government	City/municipal	Warm & Humid	850	25	1330
12	Government	City/municipal	Hot & Dry	1050	47	1658
13	Government	City/municipal	Hot & Dry	720	23	1886
14	Government	City/municipal	Composite	272	77	6091
15	Government	City/municipal	Composite	200	199	2500
16	Government	City/municipal	Composite	1100	161	4364
17	Government	City/municipal	Hot & Dry	638	269	8026
18	Private	Multi-specialty	Composite	1402	84	15181



**Figure 3: Energy consumption in City/Municipal Government Hospitals**



**Figure 4: Energy consumption in Multi-Specialty Private Hospitals:**

ECO-III project, in partnership with the Bureau of Energy Efficiency, has also been collecting building level energy consumption information for different types of hospitals in the private and the public sectors. The energy benchmarks indicated have been derived under this initiative. The dataset collected through the survey is very small and thus the energy consumption variations are quite large and the mean kWh/bed/year is quite skewed. ECO-III project plans to conduct a more detailed analysis of the data once the sample size becomes sufficiently large. However, considering the complete absence of energy use benchmarks in the public domain, ECO-III project is publishing the results of this preliminary analysis in this report. This attempt is mainly to raise energy benchmarking awareness among different types of hospitals.

# 4 ENERGY EFFICIENCY OPPORTUNITIES IN HOSPITALS<sup>1</sup>

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## Space Cooling and Heating

### **Eliminating energy waste does not have to compromise patients' comfort.**

Most managers recognize the importance of having an effective cooling and heating systems to keep patients and staff comfortable. It is often possible to reduce energy wastage while improving internal comfort conditions at the same time. Setting appropriate temperatures, ensuring that cooling and heating equipment and controls are operated and managed correctly can help reduce costs. In fact, it is possible in many hospitals to save up to 30% on cooling and heating costs through the implementation of energy saving measures.

### **Obtain Feedback**

Encourage staff to report any areas that are too hot, cold or draughty. Investigating problem areas can help to identify operation and maintenance issues. If these issues are addressed, the hospital staff and patients are less likely to adjust the temperatures by opening windows while heating or cooling is on, or bringing in portable electric heaters or fans. Therefore in order to maintain appropriate internal temperatures, the temperature settings should be in accordance to the activity taking place in the area. A good starting point is to know NBC (2005) recommended temperatures for specific areas in hospitals (See Table 9).

**Table 9: Recommended temperatures for specific areas in hospitals**

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

*Source: National Building Code of India (2005)*

### **Check Controls**

Some signs of poor control in hospitals include:

- Cooling/Heating being too high or not high enough, because the thermostat is located where sunlight, draughts, radiators or equipment affect the reading.
- Thermostats being set to minimum level for cooling (or maximum level for heating), because staff believes this will make the space cool up (heat up) faster. It does not; it simply results in over cooled (or overheated) space.
- Cooling/Heating being on in unoccupied areas, because timers and thermostats are not set correctly.

Check controls thoroughly and regularly. Ensure system operating hours match the times when heating, ventilation and cooling are required, as needs vary throughout the day. Fit simple time switches in smaller spaces, such as treatment and consulting rooms, to automate this process.

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<sup>1</sup> This Chapter has been adapted from “Hospitals- Healthy Budget through Energy Efficiency, CTV024, 2007” with kind permission from the Carbon Trust.

It is important to ensure time settings are reviewed every month or so to check that they are correct. Many systems function inefficiently because someone made a short-term adjustment and then forgot about it — for example, in waiting areas of specialist wards with occasional extended hours. Although heating or cooling may be required during these extra hours, building services (such as heating, ventilation and lighting) should be set so that they revert back to normal operating times outside these periods to minimize energy wastage.

#### **REMEMBER**

Patient welfare comes first, so seek further guidance before turning the cooling or heating up or down.

### **Zoning**

Hospital buildings frequently have areas with different time and temperature requirements such as in waiting areas or individual private rooms. This can be problematic where only one overall heating or cooling control system exists. In this instance, consider dividing the area into zones with separate controls for cooling/heating (other systems such as lighting can also be zoned in a similar way). The extra control often results in increased comfort for patients and staff, and saves money as well.

### **Keep the Conditioned Air in**

Easy access to hospitals is imperative at any time of day or night. However, during summer months open doors allow cooled conditioned air to escape and hot air to enter. The thermostat then senses a temperature decrease and automatically switches on cooling which may be unnecessary. The same happens with heated air in winter months. Try to keep external doors open only when absolutely necessary. Alternatively, install automatic doors or a draught lobby, particularly in frequently used building entrances. Lobbies should be large enough to provide unrestricted access and enable one set of doors to be closed before the other is opened. Where possible, the two sets of doors should have automatic control to increase ease of access and help keep the conditioned air in.

### **Keep Systems Clear and Unobstructed**

Make sure that the conditioned air is not obstructed by furniture or equipment and also keep filters clean. This ensures better circulation of air into the space and reduces the energy required to meet the cooling and heating demand.

### **Localize Control**

A thermostatic radiator valve (TRV) is a simple control valve with an air temperature sensor, used to control the heat output from a radiator by adjusting water flow. Correctly fitted and operated, TRVs can provide efficient temperature control in areas, which have different usage patterns, such as treatment and consulting rooms.

### **Upgrade Controls**

Many existing systems have old, inefficient time and temperature controls. Upgrading them is worthwhile as they can pay for themselves very quickly through savings on energy bills. Sophisticated cooling/heating systems can adjust themselves in line with the changeable weather conditioned. A compensator is a form of control for heating systems that automatically regulates the cooling/heating temperature based on the weather. An optimum start controller learns how quickly the building reaches the desired temperature and brings the cooling/heating on at the optimum time prior to building occupancy, again depending on the weather.

## Ventilation and Air Conditioning

In modern hospitals, ventilation can account for large energy consumption. Although an integral part of hospital design, it is possible to reduce the amount of energy that ventilation systems consume by focusing on some key energy saving opportunities.

Ventilation is required not just to combat heat gains from lighting, staff, patients and specialist equipment but, more importantly, to provide high air change rates in operating theatres and on the wards to help eliminate airborne bacteria. It is important to remember that a certain level of ventilation for infection control is vital in healthcare buildings. Always seek advice from a technical specialist or microbiology department before implementing any major changes. National Building Code (National Building Code, 2005) and ASHARE 2007 recommends the air changes, given in Table 10.

**Table 10: General Comfort Conditions as per NBC, 2005 and ASHRAE Handbook 2007 HVAC Application**

Function Space	Minimum Total Air Changes per Hour
<b>NATIONAL BUILDING CODE, 2005</b>	
Sterilization	15-25
Wards	6-8
<b>ASHARE HANDBOOK 2007 HVAC APPLICATION</b>	
<b>Surgery and Critical Care</b>	
Operating Room (all outdoor air system)	20
Operating Room (re-circulating air system)	20
Delivery room (all outdoor air system)	20
Delivery room (re-circulating air system)	20
Recovery room	6
Nursery suite	12
Trauma room	12
Anesthesia storage	8
<b>Nursing</b>	
Patient room	6
Toilet room	10
Intensive care	6
Protective isolation	12
Infectious isolation	12
Isolation alcove or anteroom	10
Labor/Delivery/Recovery/postpartum	6
Patient Corridor	4
<b>Ancillary</b>	
Radiology X-ray (Surgical and Critical Care)	15
Radiology X-ray (Diagnostic and Treatment)	6
Radiology Darkroom	10
Laboratory general	6

Function Space	Minimum Total Air Changes per Hour
Laboratory bacteriology	6
Laboratory biochemistry	6
Laboratory cytology	6
Laboratory glass washing	10
Laboratory histology	6
Laboratory nuclear medicine	6
Laboratory pathology	6
Laboratory serology	6
Laboratory sterilizing	10
Laboratory media transfer	4
Autopsy	12
Non-refrigerated body-holding room	10
Pharmacy	4
<b>Administration</b>	
Admitting and Waiting Rooms	6
<b>Diagnostic and Treatment</b>	
Bronchoscopy, sputum collection, and pentamidine admin	12
Examination room	6
Medication room	4
Treatment room	6
Physical therapy and hydrotherapy	6
Soiled workroom or soiled holding	10
Clean workroom or clean holding	4
<b>Sterilizing and Supply</b>	
Sterilizer equipment room	10
Soiled or decontamination room	6
Clean workroom and sterile storage	4
Equipment storage	4
<b>Service</b>	
Food preparation center	10
Laundry general	10

## SAFETY FIRST — VENTILATION SYSTEMS

The use of ventilation for infection control is paramount so always seek professional advice before making alterations to systems.

Ventilation systems for clinical areas in hospitals differ from those in most commercial buildings in one critical respect: they need to use full fresh air with no recirculation. This can create very high energy demands and is expensive to operate.

It is therefore important to distinguish between separate non-clinical areas such as administrative rooms, which do not have this constraint, as some further energy efficiency measures may apply to these. In general, air should flow from clean to neutral to dirty areas within a hospital, and outlet grilles should be sited at locations that do not present a health and safety risk.

### Take Advantage of Natural Ventilation

As simple as it sounds, 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. It may be possible to use windows and doors to provide good levels of natural ventilation in some areas within a hospital, allowing mechanical ventilation to be switched off or turned down to save energy. When opening vents, doors and windows, always consider security implications. It is also advisable to check the quality of outside air before letting it in.

### Set a Temperature ‘Dead Band’

Do not let heating and cooling operate at the same time. This can be avoided by setting a temperature ‘dead band’ — a wide gap between the temperatures at which heating and cooling cut in. For example, in a hospital ward, the heating may be set to switch off when a temperature of 19°C has been reached and cooling would not come on until the temperature exceeds 24°C. (Figure 5)

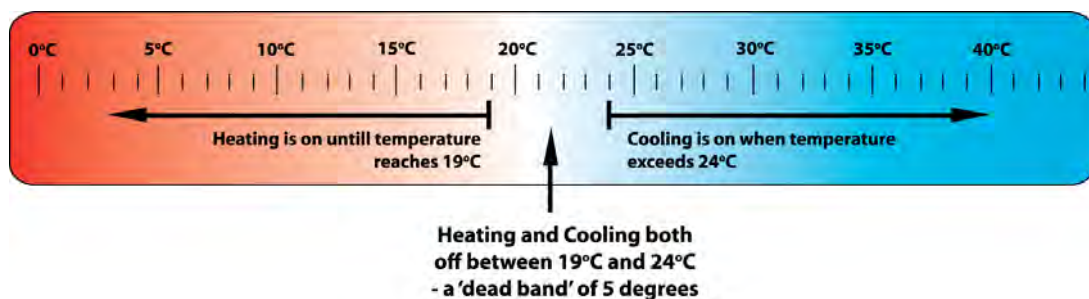


Figure 5: Diagram of ‘dead band’ control providing recommended temperatures in hospitals wards

### Maintain System Components

Energy consumption in HVAC system can increase substantially if regular maintenance is not undertaken. Dirty or faulty fans, air filters, air ducts and components directly affect system efficiency and increase running costs and risk of breakdown. The performance of the whole system should be reviewed annually and replacement parts ordered as necessary. Always consult a maintenance specialist.

### Mixed Mode Systems

Some hospitals use what is known as a ‘mixed mode’ system, which uses a combination of both natural and mechanical systems. The building uses natural ventilation, heating and cooling where possible, with mechanical systems being used only when needed. There are various advantages to such a system:

- The building becomes more adaptable to a wide range of requirements
- The occupants have more control over their environment
- Hospitals can cut down on energy spend.

**MYTH** — Turning air conditioning thermostats 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.

**Top Tip:**

To save energy and increase comfort, it is better to reduce the amount of heat produced in an area than to raise ventilation rates. If you are concerned that your system is not operating correctly, or if staff or patients complain about draughts from ventilation fans, talk to your maintenance specialist.

### Variable Speed Drives

Fans do not need to operate at full speed all of the time and variable speed drives (VSDs) can help to reduce costs by enabling the output speed of the fans to match requirements at different times of the day. This reduction in speed saves energy and there are corresponding heating and cooling cost savings too.

### Building Energy Management Systems

A Building Energy Management System (BMS or BEMS) is based on a network of controllers and offers closer control and monitoring of building services performance, including cooling, heating, ventilation and air conditioning. This is shown on a computer screen in real time and allows settings to be changed quickly and easily. BEMS can reduce total energy costs by 10% or more so they are well worth considering.

Energy Management Systems (EMS) have been installed in a number of hospitals in India. These systems offer advantages of monitoring and optimization of operation of chiller compressors, air handling units, pumps, fans, etc. They can also facilitate in continuous monitoring of energy consumption in different departments of the hospital.

### Hot Water

Water costs within a hospital can be considerable and this is made worse when hot water is wasted, as the energy used to heat water has been wasted too. However, water is a metered and controllable resource and it is possible to save a significant amount of water simply by implementing some inexpensive efficiency measures. Conservation of water also reduces the pumping requirement, which saves energy.

### Consider Water- Saving Devices

The largest area for potential savings is through the installation of water-conserving devices such as:



- **Tap restrictors** — these provide equal flow at a number of taps in a washroom and can reduce water flow by 15%.
- **Push taps** — these only operate when pressed, turn off after a brief time period and are ideal for areas where taps may be left running.
- **Shower regulators and water-efficient shower heads** — these decrease the volume of water coming out of a tap or shower and can reduce water flow by 20%.
- **Infrared controllers** — these provide water only when required, switch off automatically and can save between 5 and 15% of water per tap per year.

#### **Top TIP:**

Taps and toilet flush mechanisms fitted with infrared controllers are a particularly good idea because they also reduce the opportunity for the spread of infection.

### **Supply Efficiently**

It is inefficient to supply isolated and infrequently used hot water taps from a central hot water storage tank because of heat loss from long pipe runs. Consider installing a point-of-use instantaneous water heater in such cases. These can be extremely economical where hot water demand is intermittent, yet essential such as for hand washing.

### **Regular Maintenance for Optimum Performance**

Maintain water services including taps, storage facilities and pipework on a regular basis and ensure all drips are fixed immediately. Check for water vapour, flooded ducts and corrosion around joints or fittings on pipe-work to identify water leakage and prevent water wastage.

### **Run an Awareness Campaign**

Encourage staff, possibly even the visitors to the hospitals, to report any issues such as dripping taps, overflowing cisterns and inefficient water-saving/flushing devices in toilets so they can be repaired before the problem escalates.

### **Maintain Boilers and Pipe-work**

It is important to ensure boilers are required to be serviced regularly by a reputable firm or maintenance contractor. A regularly serviced boiler can save as much as 10% on annual heating costs. Boilers, hot water tanks, pipes and valves should be insulated to prevent heat loss. Payback can usually be expected within a few months of installation, with additional savings in subsequent years.

### **Lighting**

Effective lighting is essential for healthcare staff to carry out their work properly, yet it is possible to achieve significant savings in this area and improve the quality of the lit environment.

Lighting can account for over 20% of the total energy use of the electricity used in a typical hospital. Good lighting design can reduce costs and have the added benefit of decreasing internal heat gains, thus reducing the need for air conditioning too.

The lighting of healthcare buildings requires specific knowledge of a wide range of light sources and lamp types. Normal standards and methods of lighting may not be appropriate. If in doubt, always seek professional advice before making major changes to a lighting system.

## ‘Switch Off’ Policy

Involve all staff in making energy and cost savings. As part of an awareness campaign, conduct regular meetings, place suitable stickers above light switches and put posters up in the staff areas.

Make a member of staff responsible for going around at set times during the day to check lighting. For example, a morning check would include making sure that external lights are switched off, if there is sufficient daylight.

## Label Light Switches

Help staff to select only those lights they need, by labeling light switches suitably. As part of general policy, lights in unoccupied areas should be switched off but remember to consider health and safety implications, particularly in corridors and stairwells. Key areas for security lighting include pharmacy drug stores, laboratories and residential accommodation.


## Maintenance

Without regular maintenance, light levels can fall by 30% in 2–3 years. Keep windows, skylights and light fittings clean. Replace old, dim or flickering lamps and keep controls in good working order by ensuring timers are set correctly and that any occupancy sensors are clean. Encourage staff to report maintenance issues. This will help maintain the desired light output and, in turn, provide a safer, more attractive environment for both staff and patients.

## Install Low-Energy Lighting

Upgrade lights to the most efficient suitable options (See Figure 6). For example, at many locations in the hospitals, any ‘standard’ tungsten light bulbs can be upgraded directly to energy saving compact fluorescent lamps (CFLs) which use 75% less energy, produce less unwanted heat and last 8–10 times longer. Replace blackened, flickering, dim or failed fluorescent tubes with triphosphor coated ones. Triphosphor coating provides a more natural, brighter light for the whole life of the tube. If the tubes are 38mm (1.5 inch), replace them with slimmer 26mm (1 inch) tubes or T5, (5/8<sup>th</sup> of an inch) fluorescent lamps.

Electronic Ballast EB 214 TL5			
Lamp :	2 x ‘TL’5 14W	In :	0.14A
P <sub>in</sub> :	33W	PF(λ) :	0.98
U <sub>n</sub> :	240V-	BF (μ) :	0.95
f <sub>n</sub> :	50/60Hz	t <sub>a</sub> :	0.50°C
Voltage Range: 180-270 V			



**Figure 6: Energy-Efficient Lighting Options (T5 and T8 lamps with electronic ballasts for general purpose lighting, CFLs as replacement for incandescent lamps)**

## **LIGHTING**

- Install compact fluorescent bulbs in place of incandescent in hospital rooms, halls, and elevators.
- Install energy-efficient lighting in all other spaces, being sure to replace T-12 fixtures with T-8 or T-5 fixtures with electronic ballasts.
- Install and calibrate automatic lighting controls in conjunction with skylights and clerestories in open areas to dim lights in response to daylight.
- Install LED exit signs.
- Upgrade parking lot lighting to save energy.

**MYTH** — It is better to leave fluorescent lighting on as starting it up wastes more energy than if it remains permanently switched on.

**REALITY** — Fluorescent tubes use only a few seconds worth of power in start-up — therefore, energy is always saved by switching it off when leaving a room.

Specify high frequency fluorescent lighting systems and mirror reflectors whenever fluorescent lighting is to be replaced. This should be included in the hospital's purchasing policy. High frequency tubes reduce energy use and heat output, eliminate flicker and hum, extend lamp life (by up to 50%) and can allow dimming — all of which can make a ward more comfortable.

Always consult a qualified lighting specialist before upgrading lighting systems and refer to BEE Star labeled lamps to ensure it is efficient.

## **Switching in Parallel**

Hospitals tend to have a lot of windows, particularly on wards and in consulting areas. This provides a good opportunity to maximize daylight. Wire lights so that those closer to the windows can be switched off, while the rest remain on with separate controls. This is called 'switching in parallel' and enables staff and patients to make the most of natural daylight, which is usually preferred. As a result, less lighting is used, reducing energy consumption and additional heat generated by the lights, which, in turn, means that less cooling is required.

## **Occupancy Sensors**

Occupancy sensors ensure lights only operate when there is somebody there to require them. These are especially useful in, for example, the following spaces:

- Intermittently used office areas
- Toilets and washroom facilities
- Storerooms
- Areas where lighting is zoned.

### **TOP TIP:**

Always make the most of natural daylight. Research indicates that increased daylighting in patient rooms may ease post-surgical pain, decrease the use of pain medication and reduce the length of stay in the hospital.

Occupancy sensors can also be used to lower light levels in corridors at night time, which can be an effective cost-saving measure. However, it is imperative to maintain minimum light levels so as not to compromise health and safety standards.

Occupancy sensors may not be appropriate for wards and in patient rooms where people may not be moving frequently enough to be detected.

#### **REMEMBER**

Lighting design is complex and many of the examples given here are general guidelines, appropriate for reception areas and other common rooms in healthcare units. Some tips will not be appropriate for specialist areas, so always seek advice before making any changes to the lighting in your hospital.

## **Office and Small Power Equipment**

Office and small power electrical equipment may account for more than 10% of total electricity use within, the hospital.

Office and IT equipment is widely used in hospitals, particularly in administration section and reception areas. Other common small power appliances include equipment such as kettles, electric cookers, toasters, microwaves and other electrical appliances including vending machines, televisions, vacuum cleaners, etc.

### **Turn off and Power Down**

Where equipment is left on unnecessarily there are opportunities to make significant savings. Switch off all equipment when not in use and enable power-down modes. This reduces the energy consumption and heat produced by equipment, lowering cooling costs and improving staff and patient comfort. The lifespan of this equipment will also be extended, and the risk of breakdown reduced.

#### **PLUG LOADS**

- Use low-energy sleep functions on computers, printers, and copiers.
- Consider BEE labeled/ISI Marked office equipment and appliances for procurement.

#### **REMEMBER**

Ensure that the entire Staff are aware of switch-off policies and inform them of the cost and environmental benefits of doing so. It is important to get policies endorsed by senior management.

### **Seven-day timers**

These only cost little but reduce the likelihood of machines being left on out of hours. They can be fitted to photocopiers, printers, drinks and vending machines. Check with your equipment supplier first about any service agreements particularly in vending machines (see the top tip below).

### **Maintain Equipment**

Check and clean all heat-emitting equipment regularly, including keeping filters free of dust. This is not just to improve cleanliness and appearance; dirt can reduce the effectiveness of equipment and affect its cooling down process. Seek advice from the manufacturer on servicing schedules in order to maintain optimum efficiency.

## **Reduce the Risk of an Area Overheating**

Place heat-emitting equipment such as printers and photocopiers in a separate, ventilated area with good airflow. This helps prevent overheating, removes potential emissions from the equipment and reduces noise.

## **Purchase for Your Requirements**

With healthcare units under increasing pressure to spend budgets wisely, it makes sense to work out the whole life cycle cost of the item, that is the capital cost plus the running costs in energy over the lifetime of the equipment. Slightly higher costs of some energy efficient equipment can often pay back very quickly. This could be an important policy point for the hospital's procurement department, which may only consider the capital outlay in its decisions.

## **Catering**

Water and energy usage in catering department are areas that can offer major energy savings without compromising hygiene or resources.

Efficient catering facilities can reduce the energy requirement per meal significantly. Energy consumption in kitchens can represent more than 10% of total hospital energy usage. This is equivalent to 1-2 kWh/bed/day.<sup>2</sup> Managing consumption can have additional benefits of improving the quality of the food produced as well as the working environment for kitchen staff.

### **Raise Awareness Amongst Kitchen Staff**

- Do not switch on too soon — most modern catering equipment reaches optimum temperature quickly. Label equipment with its preheat time and educate staff to switch on only when required
- Avoid using catering equipment to warm the kitchen space on staff arrival in winter months
- Switch off heating and cooking equipment immediately after use
- Avoid overfilling saucepans and kettles, and use lids where possible
- Keep fridge and freezer doors closed and defrost at manufacturers' recommended intervals to save energy and prolong equipment lifetime
- Switch off equipment, lights and exhaust fans when they are not being used.

### **Purchase Equipment with running costs in Mind**

Although gas-fired equipment is often more expensive to buy than electrical or steam equivalents, savings made on running costs make it an attractive option. Equipment that automatically switches off, such as pan sensors on hobs, can save on energy costs. Select ovens with large, double-glazed viewing windows to reduce the need to open doors to inspect contents.

When purchasing any domestic-sized catering equipment such as fridges, freezers or dishwashers refer to BEE efficiency label and always look for the most efficient rated models.

### **Consider Heat Recovery**

Large volumes of warm air are expelled from kitchens. Many managers do not realize that heat can be recovered using heat recovery devices, which can significantly reduce energy costs. An air-to-water recovery device is often the most effective method of recovering heat because it can then preheat hot water, providing a year-round use for the recovered heat.

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<sup>2</sup> Schneider Electric India Pvt. Ltd.

## Maintain Kitchen Extract Ventilation

Ventilation units and extractor hood grease filters should be kept free from dust and grease and cleaned at regular intervals, as recommended by the manufacturer. Regular cleaning of ventilation systems can increase efficiency by as much as 50% compared with unmaintained systems. There is also a reduced risk of breakdown.

## Monitor with Sub-Meters

Sub-metering kitchen areas can provide an extra incentive for staff to be efficient, by showing how energy is used in this facility and how subsequent efforts have paid off. Catering in hospitals is at times outsourced so there is the additional benefit of allowing for budget allocation and charging to take place.

## Laundry

Laundry facilities are extremely energy-intensive. With an average of three kg of dry laundry per bed per day, laundries are big consumers of steam. They may account for as much as 10-15% of a hospital's total energy consumption in large modern hospitals.<sup>3</sup> Water usage is also an important issue. Make sure that laundries are targeted in the site-wide energy strategy. Some actions to consider are listed below:

- Most steam-heated laundries will generate excess low-grade heat that can be conveniently re-used elsewhere across the site
- Water recovery by recycling the rinse water from washer extractors is a proven means of reducing water usage
- Total water recovery is becoming more acceptable and should be investigated
- Heat recovery via heat exchangers from hot effluent is standard practice and can be used on all types of machine
- Consider combined heat and power (CHP) or Co-generation systems, which might be viable for many sites (if reliable gas supply is available) that incorporate a laundry.

## Specialist Equipment

The specialist nature of a hospital environment means that there is a significant amount of energy-intensive equipment, such as medical fridges, mortuary and pharmacy cold stores, laboratory equipment, X-ray, CAT-Scan, MRI machines, etc.

Each specialty area will have a wide range of equipment. Since each item requires careful evaluation, and because of the potential risks to the welfare of the patients, this Guide does not provide in-depth guidance on this topic. However, careful purchasing, along with maintaining good housekeeping practices can generally keep consumption to a minimum, as detailed in the action points below.

## Portable Medical Equipment

While being both convenient and cost-effective, portable medical equipment can cost hospitals in terms of energy use. Fortunately, energy performance can be tackled in several ways:

- **Establish a purchasing policy** — choosing the most efficient equipment will reduce energy use and heat gains.

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<sup>3</sup> Schneider Electric India Pvt. Ltd.

- **Raise awareness of energy management techniques** — encourage staff to switch off devices when they are not being used, or to make use of built-in standby or power-down modes.
- **Building design** — deal with heat gains generated by medical equipment in the context of the building's overall design strategy. For example, instead of installing air conditioning for an entire department, consider local comfort cooling that can be used as required.

#### **REMEMBER**

Always check with an expert before switching off or altering controls on specialist equipment.

## Refrigeration Equipment

The energy consumption of refrigeration equipment can be reduced by:

- **Defrosting** — follow the manufacturer's recommendations to save energy and prolong the lifetime of equipment.
- **Maintenance** — check door seals on cold rooms, fridges and frozen stores and replace if damaged. Keep condensers and evaporator coils clean and free of dust and check systems have the correct amount of refrigerant.
- **Temperatures control** — maintain correct temperatures on cooling equipment and avoid over-cooling. Keeping refrigerated equipment at the correct temperature is better for the stored contents and for energy savings. Energy consumption by refrigeration equipment can be reduced by 2–4% if the set cooling temperature can be increased by 1°C. Set the temperature based on manufacturer's recommendations.

#### **TOP TIP:**

Ensure X-ray machines, film processors and other significant, individual pieces of equipment are switched off when not required.

## Medical Gases

Where medical gases are supplied in bottles or other storage vessels and connected to manifold systems, they have a negligible impact on energy use. However, medical compressed air, medical vacuums and anesthetic gas scavenging, all use pumps and compressors, which consume a significant amount of energy. Consider the following actions:

- Selecting plant and equipment using whole-life costing techniques
- Monitoring (but not controlling) plant operation via a Building Management System to identify unexpected usage and highlight possible problems
- Providing localized systems for applications such as dentistry, medical physics, laundry and sterilizers to minimize distribution energy and potential leakage.

## Sterilization and Disinfection

To operate effectively, sterilization and disinfection departments require equipment that is particularly energy intensive. As packing areas need to be kept particularly clean, the ventilation to this department is filtered by high-efficiency particulate air (HEPA) filters and usually air-conditioned. In order to minimize energy consumption, consider:

- Using cascade systems where conditioned air from the cleanest space (packing) flows to neutral then to dirty areas
- Using heat recovery in these areas as heat is often emitted 24 hours per day
- Choosing sterilizing and disinfecting equipment on the basis of energy usage as well as

performance — energy usage and whole-life cycle costs can differ widely between manufacturers

- Insulating sterilizer bodies and pipe-work connections, valves, flanges and so forth, to minimize standby losses
- Metering the department for each utility and specifying individual energy metering for each major washer and sterilizer.

## Motors and Drives

Motors are generally running out of sight, sometimes constantly, every day of the year. The value of the electricity consumed by an electric motor over its life is typically 100 times the purchase price of the motor itself. It is therefore important to ensure that motors (and their associated drives) are as efficient as possible.

Considerable energy savings can be achieved by good system design to minimize the motor load. A small increase in duct or pipe size can significantly reduce system losses and thus greatly reduce the fan or pump power required.

Low-loss motors, variable-speed controls and effective control can realize substantial savings.

## Building Envelope

Considering the age and outdated design of many hospital buildings, it is not surprising that some can be inefficient.

### **Identifying and repairing problems quickly can help avoid expensive problems later on.**

Typically, two thirds of Energy (for cooling/heating) from a hospital is lost through the building envelope, with the remaining third being lost through air infiltration and ventilation. The rate at which energy is lost depends on:

- The temperature difference between inside and outside
- The insulation properties of the building envelope
- The amount of fresh air entering the building either by controlled ventilation or through poorly fitting windows, doors or joins in walls

Improving building envelope in a hospital makes good sense for many reasons:

- Better temperature control — it can lower cooling and ventilation costs and prevent overheating
- Enhanced patient comfort — a more comfortable ward gives patients the best conditions for a faster recovery
- Improved productivity — staff morale and output can be enhanced by providing a more comfortable working environment through reducing draughts, solar glare, overheating and noise
- Lower capital expenditure — a more efficient, well insulated hospital needs smaller heating and cooling plant
- A brighter, cleaner environment — this may help increase patients' confidence in the care the unit is providing

### **DID YOU KNOW?**

Fan power requirements are high in buildings that are poorly insulated and draughty because of the need to distribute larger volumes of air. Improving insulation can help to reduce this need.



## Undertake Regular Maintenance

Identify potential building envelope problems as part of routine maintenance and deal with them promptly. In particular, repair gaps or holes in walls, windows, doors and skylights immediately. Preventing the loss of heated or cooled air provides instant savings and also improves the appearance of a hospital. It is more comfortable for staff and patients too.

## Establish a Housekeeping Schedule

Compile a regular checklist to address areas where energy is lost via the building structure. If the hospital is large, it would be worth delegating this to several members of staff, all of whom can work from the same checklist. A comprehensive schedule includes checking walls, floors, roofs and skylights, doors and windows, including frames and panes.

Keep windows and external doors closed as much as possible when cooling/heating is on and consider sealing unused doors or windows to further reduce draughts.

## Regularly Check the Building for Dampness and Moisture Damage

Moisture can cause significant damage to the building structure and reduce its insulating properties. It is also unsightly and even though it may not reflect the quality of the healthcare offered, patients could be concerned by what appears to be dirty and unkempt premises. Prolonged dampness can lead of mould growth, which can be very dangerous for the health of patients and hospital staff.

Repair split down-pipes, faulty gutters and leaky roof tiles as soon as an issue becomes apparent. Do not just opt for a quick fix — repair the cause and save time on expensive work later on. Regularly check for signs of damp and condensation at least once a year, preferably prior to winter months.

## Check and Maintain Insulation

Ensure that hot water and heating pipes are insulated. Similarly, check accessible loft spaces to make sure that insulation is in good condition and replace if required. As well as saving energy by reducing heat loss from the pipe, insulation can also improve internal comfort by reducing the risk of overheating.

### **BUILDING ENVELOPE**

- Install high-efficiency, specularly -selective glazing carefully chosen for sun exposure on each facade and other variables.
- Install interior or exterior shading devices.
- Install insulation in strategic locations.
- Undertake air sealing, including duct work.

## Make the Most of Curtains and Blinds

As well as providing privacy for patients, curtains and blinds play an important role in protecting the building. If correctly chosen, they can reduce draughts and help rooms retain more of their residual heat overnight during winter months. Close curtains and blinds at the end of the day to keep the heat in. The same process can help in summer to reduce heat in rooms that receive direct sunlight. Blinds can also be an effective way of controlling direct daylight and glare.

## Improve Glazing

Double glazing should be considered when replacing windows. Not only does it offer improved thermal and optical properties to improve building performance, it can also help reduce the noise levels inside the hospitals providing better acoustical comfort for patients. Some window units

even have integrated blinds and/or allow for secure night opening, which can provide additional ventilation and cooling benefits.

High performance glass has a coating that improves its insulation properties. Coatings that allow daylight through but block or reduce heat (infrared component of solar radiation) can be particularly effective at reducing overheating from direct sunlight, therefore lowering mechanical cooling requirements.

In highly glazed spaces such as waiting rooms and atria, it may be more effective to replace some of the glazing with insulated blank panels. This will reduce the amount of light entering the space but provide better insulation and reduce heat and glare problems associated with a large area of windows.

### Install More Insulation During Refurbishment

Large amount of heat can enter the building through an uninsulated roof, which increase the energy consumption for cooling the space below the roof. Insulating roof and unfilled external cavity walls is an effective and inexpensive way of saving energy. Energy Conservation Building Code (Ministry of Power, 2007) prescribes U- factor for roof and opaque walls of hospitals (operating 24 hours). The Table 11 highlights the same.

**Table 11: Prescriptive Values of Maximum U – factor (W/m<sup>2</sup>K) for Hospitals (24-hour use buildings), Energy Conservation Building Code 2007**

Roof Assembly		Opaque Wall Assembly	
Climate Zone	Max. U – factor (W/m <sup>2</sup> C)	Climate Zone	Max. U – factor (W/m <sup>2</sup> C)
Composite, Hot & Dry, Warm & Humid, and Cold	0.261	Composite, Hot & Dry, Warm & Humid, and Moderate	0.440
Moderate	0.409	Cold	0.369

Source: Energy Conservation Building Code 2007

Many hospital buildings have flat roofs and single external walls making insulation measures more difficult, disruptive and costly. Improvements to these are most cost effective during refurbishment projects and should always be considered when the opportunity arises.

### Combined Heat and Power (CHP) /Cogeneration System

CHP can offer an economical method of providing heat and power, which is less environmentally harmful than conventional methods.

CHP/Cogeneration is the simultaneous generation of heat and power in a single process. CHP/Cogeneration equipment usually burns fossil fuel such as natural gas or fuel oil to generate electricity on-site.

At a power station, the heat generated when electricity is produced has to be dissipated via cooling towers. With CHP, the heat is recovered on-site, and used for space heating and hot water. This means that overall, the process is more efficient, so less fuel is used.

To gain maximum benefit from CHP, the system needs to be in operation for as many hours of the year as possible.

With year-round requirements for electricity and significant amounts of hot water, hospitals are ideally suited to using CHP/Cogeneration System.

### Consider Combined Heat and Power (CHP)/Cogeneration System

In an appropriate application, CHP/Cogeneration System can reduce a hospital's energy bill substantially. Hospitals are good candidates for CHP/CoGeneration System due to their year-round demand for heat and power.

However, not all sites are suitable for CHP, nor will they have good payback. Make sure that the site is investigated properly, including a complete financial and technical appraisal from an expert. One particular issue, especially relevant in the Indian context while considering CHP option, is to thoroughly investigate the options for natural gas supply to the hospital site to ensure that the fuel for the CHP system can be reliably and cost-effectively procured to derive full benefits of the system.

#### **COMBINED HEAT AND POWER (CHP) SYSTEM**

Investigate installing a combined heat and power system to supply all of the hospital's electricity, space heating, hot water, and steam loads. Hospitals are good applications for CHP because of their need for highly-reliable power free of dips or surges, and their high, constant thermal load. When properly sized and designed, such a system can save substantial money, avoid the large thermal losses associated with conventional power generation at utility plants, avoid the transmission and distribution losses associated with delivering the power over power lines, and avoid separate fuel usage for heating and steam.

Incorporate an absorption chiller into the CHP design. An absorption chiller that runs off the waste heat from a CHP system drastically cuts down on peak-time electricity used for cooling loads.

### **Information for Hospitals without CHP Installed**

#### **When to consider CHP Installation**

The best time to consider CHP in existing buildings is when the heating plant is being replaced, so that the CHP unit can be integrated with the heating system. The commercial value of the electricity and heat produced by a CHP unit is greater than the combined cost of the fuel and maintenance required for the system to operate.

#### **Understand Existing Heat and Electricity Loads**

When considering CHP, it is important to carefully assess its application and feasibility. Space requirements should be considered, along with a detailed evaluation of the system's engineering, economics, reliability, operation and maintenance. To justify the cost of investment, the aim should be to maximize the use of all the heat and hot water that the system can produce. Every hospital is different and therefore a detailed cost analysis is essential.

#### **Investigate Funding Opportunities**

If budgets cannot stretch to investing in CHP, explore options for third party funding. Energy services and contract energy management options absorb the initial cost and risks associated with installation, maintenance and operation of a CHP unit. Charging arrangements vary but under certain contracts, a hospital may only pay for fuel used by the CHP unit and receive the heat for free, as well as paying a reduced price for electricity.

### **Information for Hospitals with CHP Installed**

#### **Maintenance Issues**

CHP systems require regular maintenance to ensure efficient operation and reduce risk of breakdown. Major maintenance should be carried out as part of a planned shutdown. When deciding on the timing and duration of a shutdown, always consider cost implications such as for labour and materials required to carry out the planned work as well as additional costs of meeting

the site’s heat and power requirements from other sources. For smaller installations, shutdowns are normally undertaken by the CHP supplier who also maintains the unit.

## Monitor Performance

A CHP system should be monitored to ensure it is operating correctly. Look out for factors that affect performance such as changes in output and fuel consumption, air temperature and pressure in gas turbine installations. It is also important to monitor the rate that system performance changes as this provides a basis for planning maintenance tasks and plant overhauls. Always explore why performance is failing to meet the specification as this could indicate maintenance requirements. It will also be reducing the cost effectiveness of the system.

### **FACT:**

CHP can have financial, environmental and strategic benefits. A well-designed and operated CHP plant can reduce energy consumption and substantially. However, CHP schemes represent a significant long-term investment so the economics need to be studied carefully before a decision is made.

## Action Checklist

	Action
	Set temperature controls to suit the space and only have cooling/heating on when required
	Minimize heat wastage by closing doors and keeping radiators unobstructed
	Maintain boilers and pipe-work for optimal operation
	Revise control options — consider optimum start, compensators and TRVs
	Fit water-saving devices
	Try to ventilate and cool with natural methods
	Check that heating and cooling are not operating at the same time
	Switch off all non-essential lights
	Find the most efficient lighting options
	Install controls — consider time switches, occupancy sensors and daylight sensors
	Wire lights to switch in parallel
	Turn off unused electrical and office equipment
	Consider life cycle costs when purchasing equipment
	Check for air loss through the building fabric of floors, walls, roofs and windows
	Repair gaps in the building fabric immediately so heated or cooled air is not escaping
	Insulate as much as possible, including pipe-work
	Get all staff involved — write an energy policy and run an awareness campaign
	Monitor energy usage by checking meter data and bills
	Consider sub-metering, especially in energy intensive departments
	Set targets and devise an action plan
	Consider combined heat and power (Co-generation) if the hospital site has appropriate demand

## Next Steps

There are many easy low and no-cost options to help save energy expensive and improve the energy performance of your hospital:

### Step 1. Understand your energy use

Look at your hospital and identify the major areas of energy consumption. Check the condition and operation of equipment and monitor the power consumption over one week to obtain a base figure against which energy improvements can be measured.

### Step 2. Identify your efficiency opportunities

Compile an energy checklist. Walk round your building and complete the checklist at different times of day and night to identify where energy savings can be made.

### Step 3. Prioritize your actions

Draw up an action plan detailing a schedule of improvements that need to be made and when, along with who will be responsible for them.

### Step 4. Seek specialist help

It may be possible to implement some energy saving measures in-house but others may require expert help. Discuss the more complex or expensive options with a qualified Energy Efficiency Specialist.

### Step 5. Make the changes and measure the savings

Implement your energy saving actions and measure against original consumption figures. This will assist future management decisions regarding your energy priorities.

### Step 6. Continue managing your business for energy efficiency

Enforce policies, systems and procedures to ensure that your business operates efficiently and that savings are maintained in the future.

## Case Studies – Achievements by Indian Hospitals (Express Healthcare, 2008)

Several hospitals in India have identified many energy efficiency opportunities in their facilities to save energy and costs. Some of these cases are highlighted briefly as under:

### Apollo Hospitals, Chennai

**Year of Implementation:** 2006

**Energy Audit:** Initially done in-house. Now, taken care of by Conzerv.

**Measures:**

- Replaced reciprocating compressors with centrifugal and screw type compressors.
- CFL with electronic chokes for lighting.
- Maintaining power factor of 0.97.
- APFC fitted with harmonic suppression filters.
- Replaced old elevator machinery with variable frequency drive.



- Minimized diesel generation by using steam generation.
- Waste steam used to pre-heat water.

**Result:** 61.31 units of power consumption per day in 2005 was reduced to 57.62 in 2006

### **Batra Hospital & Medical Research Centre, New Delhi**

**Year of implementation:** 1999

**Energy Audit:** In-house

**Measures:**

- Installation of economizer in the boiler to recover the flue gas waste heat.
- Use of steam from boiler to meet the hot water requirement.
- Installation of energy efficient lighting system.
- Improving power factor.
- Change of impellers in the pumping system for the air conditioning system.
- Change of existing inefficient AHUs to new AHUs.
- Installation of VFDs for AHU blowers and CT fans.



**Result:** Saving Rs 12-15 lakh in electricity bills per month. Honored with Energy Conservation Award from the Government of India for the year 2007.

### **Jehangir Hospital, Pune**

**Year of implementation:** 2004

**Energy Audit:** In-house

**Measures:**

- Installation of timers on AHUs.
- Installation of power factor panels.
- Inception of solar water heating system.
- Maintaining water quality in condenser and chilled water system.
- Installation of AC VFD.
- Replacing electronic ballast.
- Setting up of bio-gas plant.
- Installing energy savers on AC.
- Using bio-gas for hot water.



**Results:**

- Saving almost Rs 46.25 lakh/annum.
- Honored with state level second prize in 'Energy Conservation & Management', which was instituted by Maharashtra Energy Development Authority (MEDA) in 2005.
- Awarded state level first prize in 'Energy Conservation and Management' in 2006.

## **Kovai Medical Centre, Coimbatore**

**Year of implementation:** 2004

**Energy Audit:** Conzerv

**Measures:**

- Installation of building monitoring system.
- Electric heaters replaced with solar heaters.
- Maintaining power factor of 0.95.
- Installation of digital meters.
- Connection of equipments with UPS to use optimum load.
- Inception of screw type compressors in ACs.
- Reduction in the current harmonics.
- Reducing the power consumption of AHU and pumps in ACs.



**Results:** Saving up to Rs 25 lakh every year in electricity bills.

## **Ruby Hall Clinic, Pune**

**Year of implementation:** 2001

**Energy Audit:** Honeywell

**Measures:**

- Installation of solar heating panels.
- Utilizing waste heat recovery from air-conditioning systems.
- Installation of water treatment plant.
- Optimizing indoor and street lighting.
- Checking the air-conditioning systems.
- Implementation of effective automation and control.



**Results:** Reduction of consumptions by over 27 per cent.

## **Sterling Hospital, Ahmedabad**

**Year of implementation:** 2006

**Energy Audit:** In-house

**Measures:**

- All desktop PCs have a screensaver of 2 minutes.
- On all electric panels, the hospital has pasted request to switch off light on leaving the room.
- Building AC has four quadrants, where chillers are switched off when unoccupied.
- OPD, physio and dialysis are in the basement. So, after 8 pm, the entire block can be switched off.
- At night, main reception area is not working; only emergency area is working.
- CFL lights installed to give yellow and soothing look to main reception.
- Light sensors at all patient area, health check-up and OPD.



- Alternate Saturday off for admin staff proved cheaper than their salary and effective cost.

**Results:** Total net payout was Rs 3 lakh and earned savings of more than Rs 20 lakh every year.

### **Post Graduate Institute for Medical Education & Research, Chandigarh**

**Year of Implementation:** 2005 - 08

**Energy Audit:** PHD Chamber of Commerce and Industry

**Measures:**

- Installation of screw chillers with variable speed pumping system
- Installation of energy efficient motors for air handling units
- Installation of energy efficient variable voltage variable frequency drive in elevators
- Replacement of old boilers with an energy efficient one with economizer and air pre-heater
- Installation of centrifugal chillers with variable frequency drive
- Replacement of lightening fixtures in operation theater
- Repair and re-installation of solar water heating system





# 5 IMPLEMENTING ENERGY MANAGEMENT PROGRAM IN HOSPITALS<sup>4</sup>

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In a wider sense, energy management can be described as a way of improving the energy efficiency in an existing hospital by continuously striving towards decreased energy consumption. This includes operating and maintaining the hospital in a way that sustains the energy efficiency gains achieved.

Even at the design stage of a hospital building, as well as considering its energy-efficient design and that of the installations, attention should also be paid to the future energy management needs of the hospitals. These needs include the ability to measure and monitor energy consumption of the different energy end-uses.

There are a number of steps that must be taken to introduce and implement energy management program in a hospital.

## Organization

Since any serious energy conservation program will continue over a long period of time (ideally throughout the building's lifetime), an energy manager should be appointed and made responsible for the energy management of the hospital. To give energy management the relevant priority, and to make it effective, it should be given the same importance as the management of other cost centers in the organization. It should, of course, also have its own budget and be held accountable like other cost centers. The budget for energy management can normally be allocated as a percentage of the annual energy costs.

When appointing an energy manager, it is natural to first look within the existing organization. If such a person is found, it is important and necessary to release this person from his/her other duties as far as possible, since energy management should not be an additional task assigned to a person already fully occupied. If such a person is not found within the organization, then a new manager should be recruited from outside.

The Energy Manager should be adequately qualified and trained for this purpose, unless someone with the necessary qualifications is already employed at the hospital. The energy manager should possess a number of skills – computer abilities, a good understanding of hospital facilities and building energy systems, familiarity with utility data and tariff structures, building energy survey skills, etc.

A positive attitude towards energy management program by the hospital's top management is a vital factor in the success of such program. The introduction of an energy management program can be realized in many different ways. This depends on the type and size of the hospital, its location and the existing organization structure. However, with every energy management program it is important to monitor daily performance and to clearly define the responsibilities of each level in the management hierarchy.

There are a number of general steps to be taken which are applicable to every energy management program. These steps are described below.

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<sup>4</sup> This Chapter has been adapted from "Hospitals- Healthy Budget through Energy Efficiency, CTV024, 2007" with kind permission from the Carbon Trust and CADDET's • Saving Energy with Energy Efficiency in Hospitals (Maxi Brochure 05).

## Energy Audit

The practical work within each energy management program should start with an energy audit.

An energy audit:

- Identifies all energy end-uses within the buildings under investigation;
- Estimates how much energy is used by each end-use;
- Determines the amount of energy used in relation to desirable values.

As already mentioned, it is usually necessary to contract an external specialist/consultant to assist with the energy audit. Additionally, the more information the energy manager can supply to the consultant, the more helpful this will be, and the lower the price of the energy audit.

There are a number of questions which are of interest to the consultant, and which could be investigated before requesting an estimate. Examples include:

- How is the hospital building used i.e. operating hours, number of occupants, etc.?
- Are there any architectural drawings available to obtain a better understanding of the building envelope?
- Is the electricity used measured on each floor, or at one single point, and what installations do the meters serve?
- What energy tariff or tariffs are used?
- Is there a history of prior retrofits?

The energy audit can be accomplished at different levels, each new level being more detailed than the previous one, and can be terminated after each level if so desired. (for more details, refer to Energy Assessment Guide for Commercial Building (USAID ECO-III Project, 2008) Before requesting quotes from consultants, the termination level of the audit should be defined.

Independent of the level at which the energy audit is carried out, the audit always results in a certain amount of detailed information about different energy end-uses, and should also indicate energy efficiency opportunities and the potential energy savings for the end-uses investigated. It is important that overall goals are set at the beginning of the energy management process. These goals should be tough, but achievable and measurable. In addition, a deadline for achieving these goals should be set. The goals can be expressed as key energy performance indicators discussed in Chapter 3 of these Guide. (for example as kWh/bed/year kWh/m<sup>2</sup>/year, etc.).

Once the energy audit is completed, the second major decision is made: whether the energy management program should be restructured in any vital way. A decision against an investment based on the energy audit results could be based, for example, on an assessment that the payback period would be too long for all of the energy conservation alternatives found. Once the decision to continue with the energy management program has been made, the next phase of the program is to prioritize the measures that will be implemented.

### Prioritizing Possible Measures

The simplest way to prioritizing energy conservation measures is by cost-effectiveness. When calculating the cost-effectiveness, some kind of economic model is required. There are a number of different models that can be used, but when studying different alternatives the model used should adequately take into account the savings throughout the lifetime of the measure. However, the simple payback period for any investment should not be too long.

There are two steps in dealing with a maximum payback period. First, select measures with the simple payback method. Then, prioritize these measures by using another, more detailed, economic model.

Note that the simple payback period does not measure profitability, nor does it take into account the lifetime of the assets. It is, however, commonly used and well understood and gives the decision makers a tool for quickly approving or rejecting investments, according to company policy.

After selecting and prioritizing energy conservation measures, a third major decision needs to be made, i.e. which measures are to be implemented?

### Implementation of Measures

Once it has been decided which energy conservation measures are to be implemented, the energy management continues with the practical work of implementing them. At this stage of the process, agreements with manufacturers should be made and, depending on the complexity of the measure, consultants hired to assist with the design work. If consultants are necessary at this stage, then their costs should have been taken into account when prioritizing the measures.

### Financing Energy Saving Projects

As per DSCL, typically energy saving measures/projects the options for financing energy saving projects in organizations includes:

- Financing by the organizations from its operations budget
- Financing by the organizations from its capital budget
- Debt financing from a financial institutional (e.g. commercial bank)
- Third Party Financing (TPF) through involvement of an Energy Service Company (ESCO) to implement the projects under ‘performance contracting’.

### Performance Contracting

In the building sector, particularly in North America, it is common that ESCO is engaged to identify and implement the energy saving projects. ESCO undertakes such projects under two main business models discussed below:

A guaranteed savings performance contract where the organization obtains TPF from a lender based on guarantee (technical and financial) from an ESCO that the savings accrued through implementation of an energy saving project would cover the repayment of the debt. In case of a shortfall, the ESCO would be obliged to cover it. In case of surplus, the ESCO and the organization would agree to share it at a pre-agreed rate. In this case the ownership of the assets would remain with the organization.

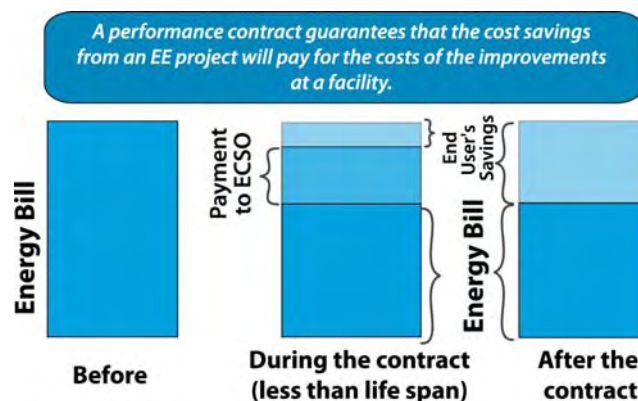


Figure 7: Illustration of the Concept of ESCO

A shared savings performance contract where the ESCO arranges for TPF of the projects and the savings are shared between the ESCO and owner at a pre-negotiated percentage. The

ownership of the assets would transfer to the owner at the end of the contract term. Figure 7 illustrates the general concept of ESCO.

### **Maintenance and Follow-up**

Once the measures/projects have been implemented it is time to start maintenance and follow-up procedures. Maintenance is important to maintain high efficiency and to prevent breakdowns. The monitoring of the measures and, as far as possible, other energy end-uses in the hospital give the energy management staff overall control of the energy usage. This control will be very useful if malfunctions occur in the energy system. Sometimes, when one part of the system is not operating correctly, this can be disguised by other functions compensating for the failure. A typical example of this is when more heat than necessary is delivered to an area while, at the same time, the temperature is controlled by the cooling system. This leads to both excessive heating and cooling being delivered unnecessarily to the same place. (Source: CADDET, 1997)

#### **DID YOU KNOW?**

It is possible to save 5-10% of a healthcare building's total energy costs by implementing some common sense, good housekeeping measures. Even better, energy savings made through good housekeeping yield immediate results and require no financial investment or specialist skills.

The process of energy management is by no means finished after the implementations of Energy Management Program have been carried out for the first time. The program is repeated in cycle, perhaps with emphasis on different area each time. Using this continuous energy management process major and lasting energy savings could be achieved.

### **Sustaining Energy Management Program (Carbon Trust, 2007)**

Gaining everyone's involvement is crucial if energy savings are to be achieved and maintained.

Most savings are within the control of staff. It is important to ensure that all staff members are aware of the benefits that energy efficiency can bring to a hospital in order to get them involved and committed to an energy management program. Benefits include:

- A better environment for patients, which may help their recovery time
- Healthier and more productive working conditions for staff
- Cost savings which can be spent on improving healthcare facilities.

### **Responsibility at all Levels**

Every staff member must be on board in order to make a hospital energy efficient. Establish a clear energy policy and have it endorsed by the Hospital Board. Communicate this throughout all levels of staff. Consider appointing energy champions or an energy team for different systems of the hospitals as this can improve involvement and awareness on-site.

### **Involve Staff**

All employees should be aware of areas of waste and trained to operate equipment and controls correctly. It is important to emphasize the cost of wasting energy, and how it impacts on hospitals resources. Motivate staff — ask their opinions and encourage them to review their own working practices to increase energy savings. Competitions, campaigns and team projects are great ways to get buy-in. Reinforce the benefits of improving their work area and give them a sense of ownership of energy management.

### **Train Maintenance Staff (Energy Efficiency Guide for Utah Business, 2006)**

Ensure building maintenance and cleaning staff are enthusiastic about savings and adopt work habits that support energy efficiency.

- Ensure that key maintenance people are properly trained in the use of the facility's energy management system.
- Involve the staff in energy savings efforts, provide efficiency education for work and home, and encourage their suggestions on energy savings opportunities.

### **Undertake Regular Walk Rounds**

Carry out regular good housekeeping walk rounds. Note down and act on any maintenance measures needed in order to avoid expensive problems later on. As patterns of energy use vary throughout the day, it is advisable to carry out a series of walk rounds at different times to get a better idea of where and when energy is being wasted. A walk round helps to:

- Establish current operating practices
- Identify wasteful practices and ensure they do not recur
- Demonstrate commitment to improving energy performance
- Identify further opportunities for savings.
- During a walk round, look at all parts of the building, including the cooling/heating, lighting and building fabric (envelope) as well as any electrical equipment.

### **Monitor Energy Use**

Understand the hospital's energy consumption by reviewing energy invoices over the last year. This should help build a picture of the site's monthly performance. Larger hospitals may have meters recording half-hourly electricity consumption. Inspecting half-hourly data is also a good way to see when (and sometimes where) energy is being used, and is an effective way to identify potential savings.

If the facility does not have a half-hourly electricity meter, at least check and record monthly fuel and electricity meter readings. Compare this information with the hospital's invoices to check for accuracy.

The information gathered can provide a picture of current energy use which can be used to monitor ongoing performance, showing where savings have made a difference. As well as measuring progress, the figures can be used to compare the site with similar hospitals to see how it is performing. Establishment and monitoring of energy performance through benchmarking can be very helpful.

### **Set Targets**

The manager need to inform staff how much energy is currently being consumed. Then, when the energy saving program gathers momentum, it will be possible to track progress and highlight energy savings. It is important to set targets. But these need to be realistic: many start by aiming for 5% savings each year.

### **Sub - Metering**

Sub-meters can be helpful in understanding how energy is used across the hospital facilities. The information they provide can highlight areas where cost savings can be made and justify investment. Target particularly energy-intensive areas. Sub-metering, and any subsequent monitoring and targeting of energy use, can act as an incentive for managers to reduce energy costs by providing some financial reward for doing so.

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