Walkthrough Energy Audit Report

KTDC Samudra Hotel Kovalam

Trivandrum, Kerala, India

August 2009

Report prepared by:

EMC Kerala, Ottotractions, Adelphi Consult

1. Executive Summary

A walkthrough energy audit was conducted in KTDC Samudra Hotel, to assess the energy saving potential of the hotel. This is a two star hotel with a total of 64 guest rooms and other standard facilities. Several Energy Performance Indices (EPI) was defined and used to compare the energy and environmental performance of the hotels. Current baseline of Energy Utilization Indices (EUI) and Carbon Emission Index (CEI) was calculated as well as the proposed new improved indices. The main segment of energy consumption in the hotel is on its air conditioning sections. Upon conducting the walkthrough, substantial energy saving potential exist in the hotel, with the focus on its building envelope and air conditioning section of energy consumption, as well as the installation of solar water heater. The baseline energy assessment has revealed a current Energy Utilization Index of 270.56 kWh/m^2/year, with an equivalency of 47.79 kWh/room/day, while the Carbon Emission Index was 0.1519 tCO_2/m^2/year. Several measures on energy conservation measures were recommended based on the observations as well as the utilization of software projections. Some of the aspects that could be improved includes the diesel generator efficiency, wall and roof insulations, using Variable Frequency Drive for air conditioning, and the installation of solar water heater, to list a few. By taking into consideration these recommendations, the energy consumption of the hotel would reduce, and the new EUI that could be achieved would be lowered to 154.49 kWh/m^2/year and 28.54 kWh/room/day respectively, while the CEI is also lowered to a value of 0.0911 tCO_2/m^2/year. This translates to a 42.9% build up area energy intensity reduction and 40.3% room wise energy intensity reduction. The GHG emission intensity shall also reduce 40.0% with the implementation of these energy saving measures.

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2. Introduction and Objective

A walkthrough energy audit was conducted in Samudra Hotel, Kerala, India on the 11th August, 2009. This hotel is one of the state owned hotels by Kerala Tourism Development Corporation. **The objective of conducting this audit is to identify the energy saving potential that exist in this hotel as well as the potential GHG emission saving that could be achieved by implementing energy saving and conservation measures.** This report is based on the findings and observations that were noticed during the walkthrough, with several recommendations for energy and GHG emission reduction.

The objective is thus to analyze the achievable percentage of energy saving potential in the parameters of **kWh/m^2/year** and **kWh/room/year** and Greenhouse Gas emission reduction in **tCO_2/m^2/year** for Samudra Hotel, with energy efficient measures.

3. Methodology

General

The energy audit is carried out based on walkthrough type energy audit, as well as placing special focus on identifying several sections that has the potential to implement energy savings measures. The following is a list of general procedure and information undertaken during the walkthrough energy audit during the hotel site visit:

1. General info of the hotel
2. Baseline energy description
    a. Passed energy consumption and bill, which includes electricity, oil, gas, and other fuel sources to understand the pattern and total energy consumption of the hotel
    b. Identify fuel type used to determine largest energy source usage
    c. Determine major energy use equipments to understand the energy distribution within the hotel
    d. Summarize the energy performance of the sector wise energy distribution
3. Energy analysis of the different sectors, including the building envelope, lighting, air conditioning, and domestic hot water production.
4. Recommendation of energy conservation measures

The primary goal of the walkthrough energy audit is to identify sources and areas of potential energy and cost saving throughout the hotel by measures of optimization, replacement, retrofitting, and on the other hand, to also provide recommendations on operational and maintenance practices improvements.

Investigation and Data Collection

The walkthrough energy audit was conducted on the 11th August 2009 in Kovalam, Kerala, India. It started at 11:30 am and lasted for approximately 4 hours. Prior arrangement was made with the manager of Samudra Hotel with regards to the walkthrough date.

Technical staff, Mr Samraj Mohan Joseph was the main person accompanying and explaining throughout our time. He also provided us with the past 1 month consumption data for the 2 diesel generators that were used in the hotel. This information was useful to investigate the efficiency of the respective generator by looking at the energy produced from the given quantity of diesel. Diesel generators are used regularly to power the hotel in times of grid electricity supply breakdown. In addition to that, diesel is also used to operate the boiler for domestic hot water production.

Electricity consumption along with their respective electricity bill was given for the month of January 2009 till June 2009, for the total of these 6 months.

Gas and diesel consumption for the hotel was provided for the same period of January to June 2009.

At the time of visiting, the officer did not have the resource to share with us an overview plan of the hotel construction and façade. The reasoning was that the hotel has been around for a long time and there were no records kept till date. Nevertheless, it was observed that there are two types of rooms in the resort – 62 Premium Rooms and 2 Deluxe Rooms. Layout plan with a rough estimated dimension of the hotel guest room plan was sketched during the walkthrough as it is the primary air conditioned area of the hotel. Number of electric consuming equipment and fixtures in both types of guestrooms was also noted down.

The walkthrough audit consisted of 1 site visit and possible future contact shall further information be required.

Documentation Review

Documentation of the overall floor plan and façade of the resort was not available, and therefore the areas were estimated and sketched. No passed energy audit was conducted in Samudra Hotel, even though the accompanying Engineer has mentioned that some minor energy conservation measures has been undertaken by the management, such as using CFLs in place of incandescent bulbs.

Initial Site Assessment

The walkthrough energy audit was guided and accompanied by Mr Samraj Mohan Joseph, Engineer of the maintenance office in Samudra Hotel. The assessment was done with a walkthrough around the resort facility and questions were made accordingly in each session, without the formal sitting down of interviewing.

The walkthrough team consisted of Mr. Suresh Babu, Certified Bureau of Energy Efficiency Energy Auditor of Ottotractions; Miss Deepa Kumar, Energy Technologist of Energy

Management Centre, Kerala; Mr. Sandeep Kumar, Project Assistant of Energy Management Centre, Kerala; and Mr. Jian Lee, Project Associate of Adelphi Consult, Berlin.

Monitoring and Data logging

Data was jotted down based on a prepared detailed questionnaire before and during the walkthrough audit, while some other unanswered fields of the questionnaire were completed after the walkthrough.

Original electricity bills for the month of January till June 2009 were photocopied to have a record of the actual bill being paid, the total power consumption along with the billing demand as well as to understand the occurrence of other miscellaneous charges.

All the bills for gas and diesel purchase for the months of January to June 2009 were also photocopied. These were then used as calculation of total gas and diesel consumption and fuel cost of the hotel during this 6 months period.

By obtaining a copy of the energy and fuel cost bills, a monthly energy data sheet was filled in. All the consumptions for these 6 months period were filled in duly. As for the electricity and fuel consumption and bill, though not being able to fill in for the complete 12 months period, precise records for the passed 6 months were provided.

Notes and several nameplate information as well as observations were noted down in a notepad throughout the walkthrough.

Photos were taken on several equipments, their nameplate, as well as other relevant observations.

4. Hotel General Info

The hotel is located on the South Western Coast of India, in the state of Kerala, with a 20 minutes road journey from the capital city of Kerala, Thiruvananthapuram, at the place called Kovalam. It covers a total area of 5 acres, and is located just by the sea shores of Kovalam Beach.

The air conditioned areas of the hotel are primarily in the guest rooms, conference hall, restaurant, bar, and the lobby area. The other areas of the hotel are naturally ventilated, taking advantage of the breeze while also ventilated by ceiling fans.

Description	Details
Name of Hotel	KTDC Samudra Hotel
Air Conditioned Area	2119.56 m2
Total Build up area	3517.24 m2, over a total land space of 5 acres
Star Classification	2 stars

Number of guest rooms	64 rooms
Contract demand	113 kVA
Transformer Capacity	500 kVA
Installed generator capacity	250 kVA, 110 kVA
Installed air conditioned capacity	236 kW
Installed lighting capacity	90.5 kW
Installed hot water	5.2 kW

Construction Material

Building material used for the whole building was observed to be using conventional building materials in India. Most of the air conditioned and non air conditioned areas that were observed has wall construction layers of cement on the inside and outside envelope layer, sandwiching the standard 9” brick in between.

The roof of the hotel is also observed to be using conventional roof building materials in India. The roof is composited with 3 layers, with brick tiles of 1.5cm thickness cascading each other at the sky facing layer, which is followed by a thermal coating roof feel layer of 2.0 cm and the inner layer of wooden panel with 1.5 cm thickness. Window data along with its frames were directly estimated and observed by the audit team without the necessity of asking the accompanying technical staff.

Almost all of the windows in the facility consisted of single glazed windows on a wooden panel frame, in both air conditioned and non-air conditioned areas.

Seasonal Occupancy

The months of June to September is deemed to be off peak season for the hotel, while the peak season of the resort is from October to May, with the super peak season being towards the end of December till beginning of January. Detailed occupancy figures were not available during the time of visit. An estimation was used for the analysis of general occupancy in this hotel, as the occupancy data for the hotel seemed to be of confidentiality. The occupancy rate for off peak season is estimated to be 35% while the peak season is estimated to have occupancy of 90%.

5. Baseline Energy Description

Three different energy sources are used in this hotel - Electricity, High Speed Diesel (HSD) and Liquefied Petroleum Gas (LPG). Electricity is generally used for all electrical components, while diesel is used to operate the diesel generator and the boiler, while gas is mainly used for kitchen cooking purposes.

Breakdown of average monthly energy consumption according to its type is as portrayed in Figure 1:

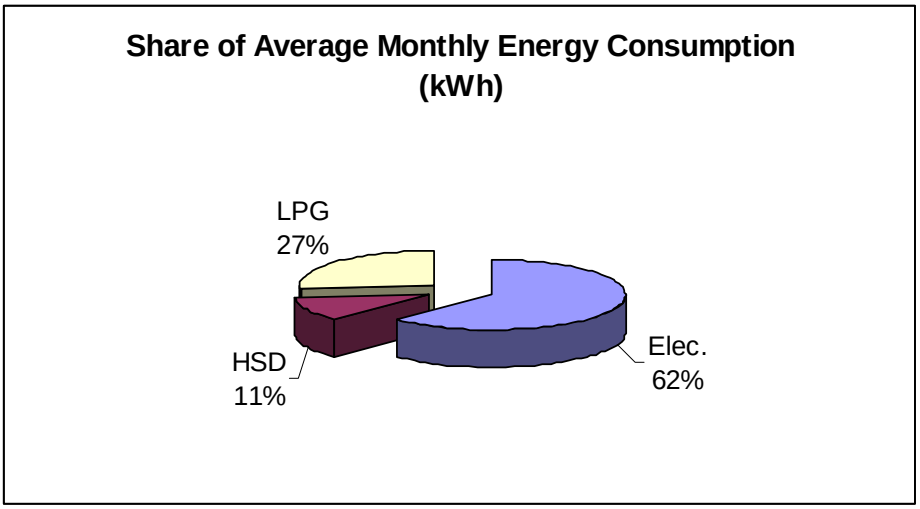


Figure 1: Average Monthly Energy Consumption of Samudra Hotel

Electricity is the primary source of energy consumption in Samudra Hotel, followed by gas and diesel.

This corresponds to the energy bill of these different types of fuels as per displayed in Figure 2. In which electricity being the main consuming energy, contributes to the major portion of energy bill for the hotel.

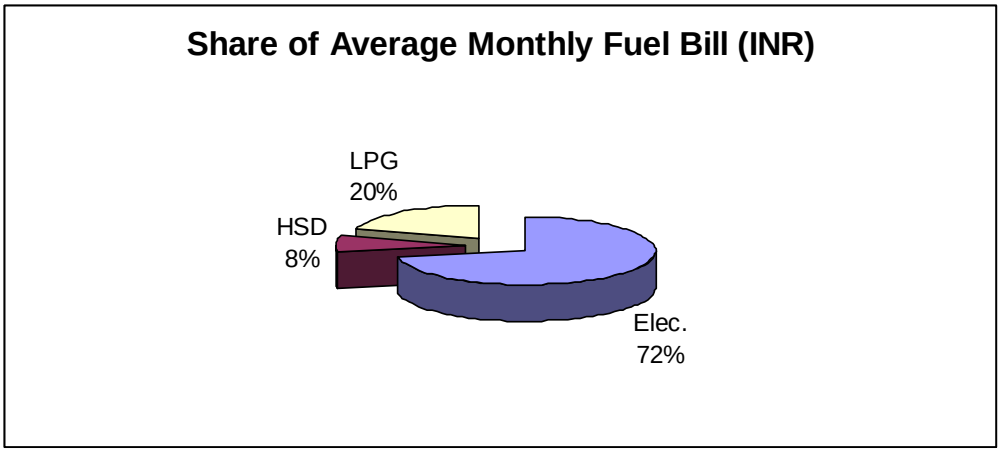


Figure 2: Average Monthly Bill Breakdown

By converting the entire different fuel source into a similar unit of kWh, the fuel cost per kWh is compared in terms of INR/kWh. This conversion is done based on a general 9500/860 kWh/liter factor for diesel, and an 11500/860 kWh/kg factor for gas.

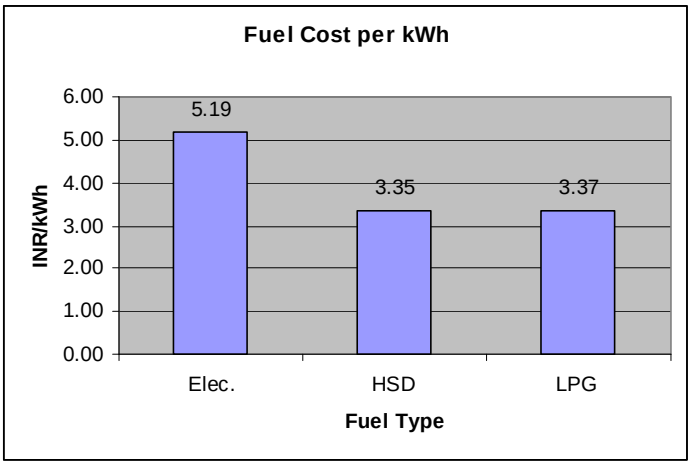


Figure 3: Fuel Cost per kWh

From Figure 3, it could be observed that the fuel cost per kWh of electricity is more than 1.5 times more expensive than diesel and gas cost.

By taking the average monthly cost for all these three fuel types and divide it by the total kWh equivalency energy produced, the per kWh cost of all these fuels is 4.51 INR/kWh.

Electricity Distribution of Electrical Components

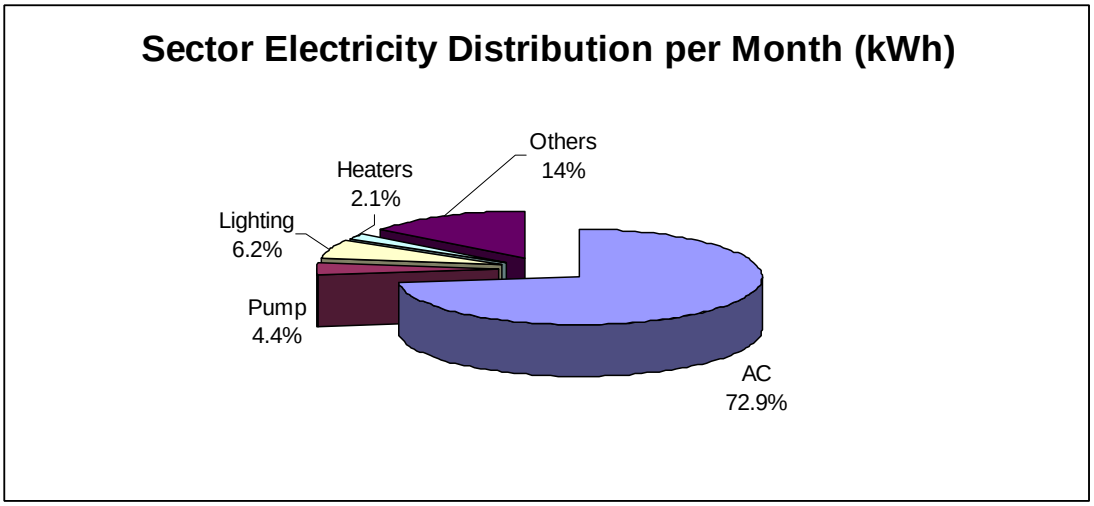


Figure 4: Sector Electricity Distribution per Month in Samudra Hotel

As can be viewed from the energy distribution of Samudra Hotel Figure 4, most of the energy is used on air conditioning. This is followed by lighting, pumps, heaters and boilers, and other utilizations such as kitchen.

Energy Performance Summary

Consumption of Room

As for the focus of this energy audit, the total consumption of the room would be a focus area. The walkthrough has then done an assessment on the total consumption of the guest rooms in the hotel. The total consumption of all the guest rooms in Samudra hotel was calculated and gives an average of 19.34 kWh/room/day energy consumption.

There are two types of guest rooms in Samudra Hotel, 62 Deluxe Room and 2 Premium Room. In each of the Deluxe Room, there are 8 CFL (11W) and 1 T5 (8mm) Fluorescent tube (28W). As for the 2 Premium Rooms, there are 18 CFL and 2 T5 Fluorescent. The average operational hours of these lights are estimated to be 4 hours per day.

The following calculation was carried out to calculate the total electricity consumption of the guest rooms:

- Daily lighting consumption of the rooms: 62[8*11+1*28]*4 + 2[18*11+2*28]*4 = 30.8 kWh/day
- Daily Sony 32" LCD in 64 rooms = 109W*4 hours*64 = 27.9 kWh/day
- Daily ceiling fan operation = 75W*12 hours*64 = 57.6 kWh/day
- Centralized air conditioning:
    - Total AC consumption for 1 month = 42480 kWh/month
    - This AC load satisfies the total AC area of 2119.56 m^2
    - AC area for 64 guest rooms is 1678.88 m^2
    - Therefore, average electricity consumption of AC for 64 rooms = 1678.88*42480/2119.56 = 33648 kWh/month
    - Which is 1121.6 kWh/day for all 64 rooms
- Total energy consumption for 64 rooms daily = 1237.9 kWh/day
- Giving an average of 19.34 kWh/room/day

64 rooms consumption per month = 1237.9 kWh*30 = 37137 kWh/month

In addition to this, the calculation of percentage energy consumed in guest rooms is calculated. This is done by using the room consumption of 37137 kWh and dividing it by the peak month of January with 56200 kWh and then multiplying it with a 0.90 occupancy.

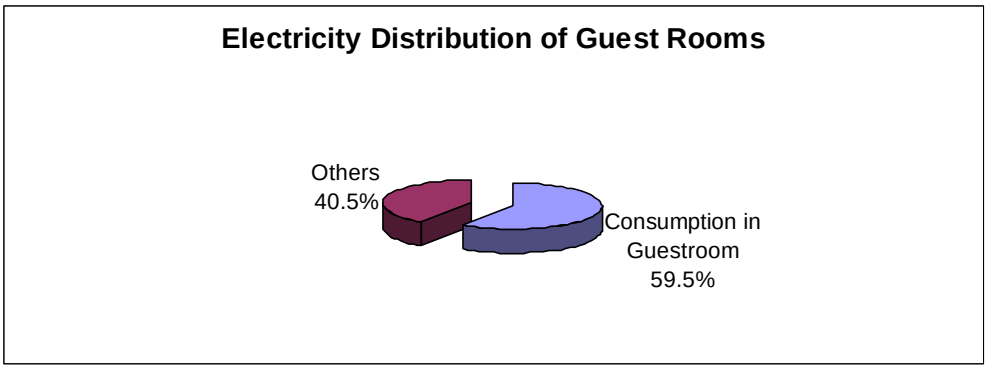


Figure 5: Electricity Distribution of Guest Rooms to Other Electricity Sections

As per displayed in Figure 5, a percentage of 59.5% in total electricity consumption of the hotel is consumed in the guest rooms per month. Therefore, the remaining 40.5% electricity consumption in the hotel is for common utilities and other electricity consumption in other areas out of the guest rooms such as conference hall, restaurant, kitchen, backdoor offices, sewage plants, etc...

Energy Performance Indices

Energy Performance Indices (EPI) are a set of indices that are defined as the total energy consumed per day divided by the total unit of measurement, which could be total number of rooms, total hotel build up area, or total occupied nights to name a few. For the purpose of this report, two types of EPI are used. The Energy Utilization Index (EUI) is based on the total energy consumed per day in kWh over the total number of occupied room as well as the hotel build up area.

To calculate the EUI of Samudra Hotel, the total energy consumption of the peak month in January 2009 is used. The occupied rooms have an occupancy rate of 90%, which is an average of 57 occupied rooms in this particular month. Based on the above information, EUI is calculated:

Total energy consumption of all fuels in January 2009 = 84443.60 kWh
Average daily consumption in January 2009 = 84443.60/31 = 2723.99 kWh
EUI = 2723.99/57 rooms = 47.79 kWh/room/day

The Energy Utilisation Index (EUI) of Samudra Hotel was calculated to be **47.79 kWh/room/day**.

Another value of EUI is calculated based on the energy consumption over the total build up area of the hotel. In the case of Samudra Hotel, the total annual energy consumption of all fuel type is estimated to be 951631.12 kWh/year. Taking this value over the build up area of 3517.24 m^2, the EUI is **270.56 kWh/m^2/year**. ‘

Occupancy Factor towards Electricity Consumption

The peak month of Samudra Hotel is on the month of January. Referring to the Energy data sheet that was filled in by the Engineer in charged, the electricity consumption of the hotel in January 2009 is 56200 kWh. This is the peak month with

an estimated percentage of 90% occupancy. On the other hand, the low season of the resort is predicted to be in the month of June 2008, with an occupancy rate or 35%. Again referring to the data sheet, June 2009 has an electricity consumption of 47334 kWh. Having these two information, the following equations are formulated, which describes the electricity consumption at a given month in Samudra Hotel:

$$y + 0.35x = 47334$$
$$y + 0.9x = 56200$$

Solving the two equations, the value of x is 16120 and the value of y is 41692. Where "y" is the fixed operational cost and "x" is the variable cost that is dependent on the occupancy of the hotel at a given month.

Therefore, electricity consumption of the hotel could be related to the occupancy of the hotel with the following equation:

Electricity consumption at certain month,

$$E = y + ßx$$
$$E = 41692 + 16120\ ß$$

Where ß is the occupancy factor of the hotel in a specific month , from the range of 0 for no occupancy to 1.0 for full occupancy.

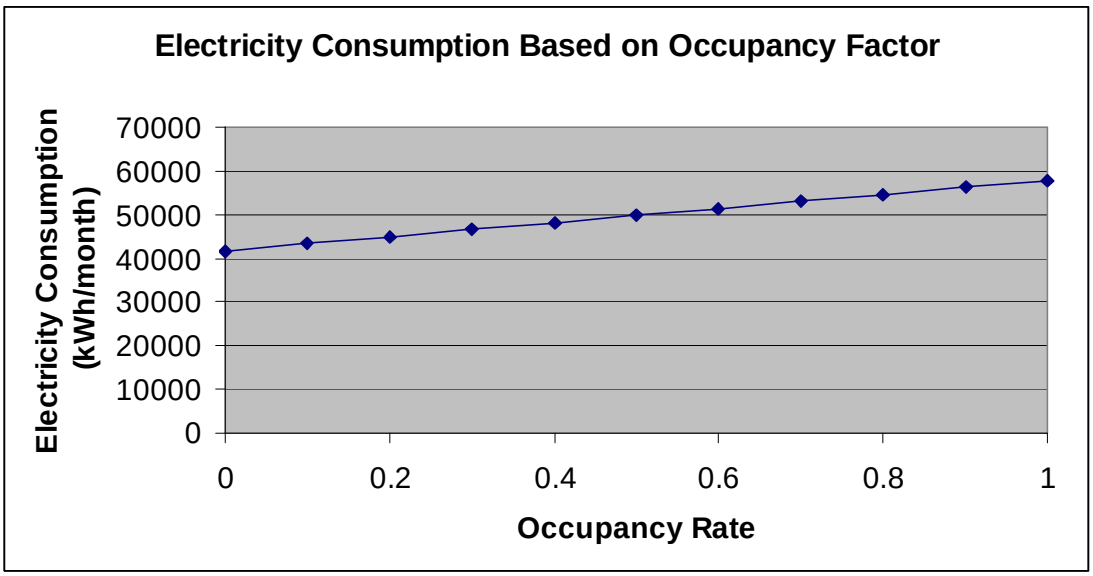


Figure 6: Monthly Consumption based on Occupancy Factor

Based on Figure 6, the monthly consumption of the hotel depends on the occupancy of the hotel in that particular month. A fixed operational electricity consumption of 41692 kWh per month is prevalent, regardless of the occupancy. It makes logical sense that the electricity consumption increases along with higher occupancy rate of the hotel, as per portrayed in the graph.

Benchmark Overview

Several energy benchmarks for the hotel sectors worldwide have been established throughout these years. Several of these, within and outside India are looked upon to get a perspective of how the energy consumption of Sumadra Hotel stands with these benchmarks.

1. **U.S. Department of Energy Information Administration**

Comparative data is derived from the 2003 raw data files from Commercial Building Energy Consumption Survey, U.S. Department of Energy Information Administration. The 2007 data shall be released in fall 2009.

Cooling degree day of Trivandrum is generated by BizEE Degree Days, Weather Data for Energy Professionals at http://www.degreedays.net. It is based on the location 76.95E,8.47N, with a base temperature of 15.5C, from the date of 1/8/2008 – 5/8/2009. The total cooling degree day is 4497.3. Referring to the CEC 2003 definition[1], Trivandrum is located in the climatic zone 5 if comparing with the US climatic zones.

Taking this into account and comparing this with the benchmark from Commercial Building Energy Consumption Survey, U.S. Department of Energy Information Administration at, unfortunately, the gross energy intensity for sum of major fuels for the Lodging category in climatic zone 5[2] was not given any result due to over 50% error range.

Electrical gross energy intensity for lodging in climatic zone 5[3], 10 billion kWh in 56.49 million square meters, gives 177.02 kWh/m^2.

2. **The Energy Resources Institute, New Delhi, India**

According to the Baseline Study of Indian Hotels conducted by TERI[4], a three star hotel has an average Energy Performance Index of 280 kWh/m^2/year. In addition to this, TERI had also came out with the Energy Performance Index in terms of rooms per hotel, which has the value for three star hotels at 70 kWh/room/day.

3. **Leonardo Energy, Laborelec[5]**

[1] Climate zone (30-year average) definitions: Zone 1 = Under 2,000 CDD and more than 7,000 HDD; Zone 2 = Under 2,000 CDD and 5,500-7,000 HDD; Zone 3 = Under 2,000 CDD and 4,000-5,499 HDD; Zone 4 = Under 2,000 CDD and fewer than 4,000 HDD; Zone 5 = 2,000 CDD or more and fewer than 4,000 HDD.

[2] Commercial Building Energy Consumption Survey, U.S. Department of Energy Information Administration, Table C10, Consumption and Gross Energy Intensity by Climate Zone for Non-Mall Buildings, 2003: http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set9/2003pdf/c10.pdf

[3] Commercial Building Energy Consumption Survey, U.S. Department of Energy Information Administration, Table C20. Electricity Consumption and Conditional Energy Intensity by Climate Zone for Non-Mall Buildings, 2003: http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set10/2003pdf/c20.pdf

[4] The Energy Resources Institute, India. Energy Scenario in Hotel Industry in India (Unpublished). Feasibility Study of the Energy Campaign for the Hotel and Catering Industry in India. TERI, India & Adelphi Consult GmbH, Berlin, Germany.

[5] Hendrikx, N. (2008). Power Quality and Utilization Guide: Hotels. Leonardo Energy, Laborelec. Last assessed at www.leonardo-energy.org at 2009-04-02.

The energy benchmark laid here describes the fuel and electricity index for the hotel sector in Europe. It is divided into small and medium sized hotels without complete air conditioning, as well as large hotels with air conditioning and more equipment. For the case of Samudra Hotel with full air conditioning in all its guest rooms and several other facilities, the index for large hotels with air conditioning fits the context of this hotel. The fuel index for large hotels given by this benchmark is:

Mean: 266 kWh/m2/y
Max: 350 kWh/m2/y
Min: 220 kWh/m2/y

As for the electricity index for the large hotels, it is as follows:

Mean: 143 kWh/m2/y
Max: 182 kWh/m2/y
Min: 100 kWh/m2/y

Energy Utilization Index Benchmarking with Samudra

Based on the above mentioned benchmarking systems, Table 1 portrays the performance of Samudra Hotel towards these benchmarking. The total floor area calculated is 3517.24m^2.

	USEIA	Leo Energy	TERI	Samudra
Electrical Index (kWh/m2/yr)	177.02	143		169.23
Fuel Index (kWh/m2/yr)		266		101.33
Energy Index (kWh/m2/yr)			280	270.56
Energy Index (kWh/room/day)			70	47.79

Table 1: Summary of Energy Utilization Index Benchmarks

Energy Allotment

Table 2 describes the primary and secondary energy usage allotment of some of the end usage in Samudra Hotel.

No.	End Use	Primary	Secondary
i.	Cooling/AC	Electricity	Diesel
ii.	Domestic Hot Water	Diesel	-
iii.	Lighting	Electricity	Diesel

Table 2: Energy Allotment of Energy Consuming Sections

6. Environmental Performance Summary

The burning of fossil fuel to generate electricity, either in the power plant or in the hotel's own vicinity, releases gases into the atmosphere. These gases affect the environment due to carbon dioxide that is one of the primary sources of global warming, as well as sulphur dioxide that causes acid rain.

To have an understanding of the environmental performance of Samudra Hotel, all the fuels used to power the hotel is taken in account by looking at their emissions of carbon dioxide. This is done by converting the fuel source into amount of carbon dioxide in kg, produced by per kWh of the fuel used.

Referring to the National Productivity Council's Presentation on Energy Efficiency in Hospitality Industry[6], the factors used to convert the consumed fuel to the amount of CO_2 releases are as follows:

- Oil, 0.29
- Gas, 0.21
- Electricity, 0.72

It was also given that a typical hotel releases annually about 160 kg of CO2 per square meter of floor area, which is equivalent to approximately 10 tons per bedroom.

Another reliable source from the Central Electricity Authority, Ministry of Power India, the weighted average GHG emission factor could be used to understand the environmental performance of hotels in India[7].

Weighted Average Emission Rate (tCO2/MWh) (incl. Imports)			
	2005-06	2006-07	2007-08
NEWNE	0.84	0.82	0.81
South	0.73	0.72	0.72
India	0.81	0.80	0.79

Table 3: Weighted Average Emission Rate of Indian Grid

As Kerala is covered by the Southern India regional grid, the weighted average emission rate of the Southern electricity grid of India is used in this report. The value in 2008 is 0.72 tCO_2/MWh, which is the value for the weighted average emission rate including the fuel imports as illustrated in Table 3. However, the Southern grid has not been importing fuel from other places as shown in the CEA table in Table 4.

Year 2007-2008 (Imports only)

[6] NPC (2009). Energy Efficiency In Hospitality Industry. Presented during E-HotCat Conference 28 May 2009 in New Delhi. Pawan Kumar, National Productivity Council. Available at http://www.ehotcat.adelphi-consult.com
[7] CEA (2008). CO2 Baseline Database for the Indian Power Sector Version 4.0. Central Electricity Authority. Ministry of Power, Government of India. Last assessed at http://www.cea.nic.in/planning/c%20and%20e/Government%20of%20India%20website.htm on 2009-04-19

To From	NEWNE	Southern	India
NEWNE	--	0.0	
Southern	3,252.5	--	
Bhutan	5,230.0	0.0	5,230.0
Nepal	0.0	0.0	0.0
Total Imports	8,482.5	0.0	5,230.0

Table 4: Fuel Import of Indian Grid in year 2007-2008

This value translates to an emission of 0.72 ton of carbon dioxide to the atmosphere, for each MWh produced in the power plants. This value includes the inter-regional and cross border electricity transfer. In addition to this, the transmission and distribution loss of the electricity is taken into account as this loss does happen in the actual situation. By calculating a value of 5% transmission and distribution loss, the net GHG emission factor for electricity from the grid in this case of Indian hotel is valued to be 0.758 tCO_2/MWh. This value will be used to evaluate the general GHG emission factor of this report.

For measures that use other energy fuel source apart from electricity, the weighted average GHG emission factor is utilized as well. With reference to the National Productivity Council, New Delhi[8], the average emission factor for diesel in India is 0.29 tCO_2/MWh and the value for natural gas is 0.21 tCO_2/MWh.

The environmental performance is measured by the Carbon Emission Index (CEI). In this report, CEI is defined as the total CO_2 emission in a year due to the energy consumption, over the total build up area.

The current Carbon Emission Index (CMI) was calculated to be **0.1519 tCO_2/m^2/year.**

7. Building and System Energy Saving Analysis

Building Envelope

Current Situation

Total amount of guestrooms in Samudra Hotel is 64 units, with 62 Premium Rooms and 2 Deluxe Rooms. The guestrooms characteristics are compiled to look into the possible energy saving measures:

Guest rooms characteristics in Samudra Hotel:

Deluxe room build up area = 32.68 m^2
AC area = 25.84 m^2
Total AC area for 62 deluxe room = 1602.08 m^2

Premier room build up area = 55.2 m^2
AC area = 38.4 m^2
Total AC area for 2 premier room = 76.8 m^2

[8] NPC (2009). *Energy Efficiency In Hospitality Industry.* Presented during E-HotCat Conference 28 May 2009 in New Delhi. Pawan Kumar, National Productivity Council. Available at http://www.ehotcat.adelphi-consult.com

Total AC area of resort (including conference, restaurant, bar and lobby) = 2119.56 m^2

Height of AC area on average is 3 meters high.

- wall area for deluxe room: 2(3.8*3)+2(8.6*3)= 74.4 m^2
- wall area for premium room: 2(6*3)+2(9.2*3)= 91.2 m^2
- Total area of wall for 64 rooms = 62*74.4 + 2*91.2 m^2 = 4795.2 m^2

Wall area	40 main	12 left	10 right	2 premium	Total (m^2)
North	456	309.6	114	36	915.6
East	1032	136.8	258	55.2	1482
South	456	309.6	114	36	915.6
West	1032	136.8	258	55.2	1482

Table 5: Orientation of Guest Room Wall

- There are 4 blocks of guest rooms as per calculated in Table 6. The accumulative wall orientation direction are calculated respectively:
  - Northward area = 915.6 m^2
  - Eastward area = 1482 m^2
  - Southward area = 915.6 m^2
  - Westward area = 1482 m^2

Description	Layer	Thickness mm	Conductivity W/m - °C	Conductance (W/m²)/°C
Exterior film coefficient				33.402
Cement plaster	1	10.0	0.700	70.000
Brick - clay	2	229.0	1.400	6.114
Cement plaster	3	10.0	0.700	70.000
Interior film coefficient				8.350
U-value - nominal			(W/m²)/°C	2.925

Table 6: Wall Layers Composition

The wall composition of the layers in Samudra Hotel is as per displayed in Table 7, with the corresponding U-value for this construction.

The window areas of the resort consist primarily of single glazed window in all observed installations. The window frame is made out of wood panel.

Roofing in the resort is of conventional roofing in India. The following Table 8 displays the current situation of the roofing layers, along with its U-value. The total roof area of the guest rooms are equivalent to the total guest rooms AC area, which is 1678.88 m^2.

Description	Layer	Thickness mm	Conductivity W/m - °C	Conductance (W/m²)/°C

Exterior film coefficient				56.783
Brick - clay	1	15.0	1.400	93.333
Roofing felt - layered asphalt	2	20.0	0.170	8.500
Wood - soft	3	15.0	0.120	8.000
Interior film coefficient				9.309
U-value - nominal			(W/m²)/°C	2.643

Table 7: Roof Layers Composition

The energy analysis of building envelope relates to the amount of energy consumed on the air conditioning system. Therefore, energy analysis of this would be looked upon in the air conditioning energy analysis section.

Air Conditioning System Description

Current Situation

The areas in the hotel that are air conditioned are mainly the guestrooms, conference hall, restaurant, bar and lobby. Other areas in the vicinity are ventilated by ceiling fan or natural ventilation.

The resort has an installed air condition capacity of 236 kW. This load runs the central air conditioning for the air conditioning areas in the hotel. It is being maintained at an average range of 23°C.

Based on the electricity distribution of the hotel, air conditioning itself stands for almost 73% of the total electricity consumption in the hotel.

AC Area	Area (m2)	no.	Section Area
Guest room		64	1678.88
Conference	120	1	120
Restaurant	136	1	136
bar	63.08	1	63.08
Lobby	121.6	1	121.6
Total			2119.56

Table 8: Air Conditioned Section Area

The breakdown of air conditioned area in terms of section is as displayed in Table 9 and their respective distribution in terms of overall percentage is shown in Figure 7.

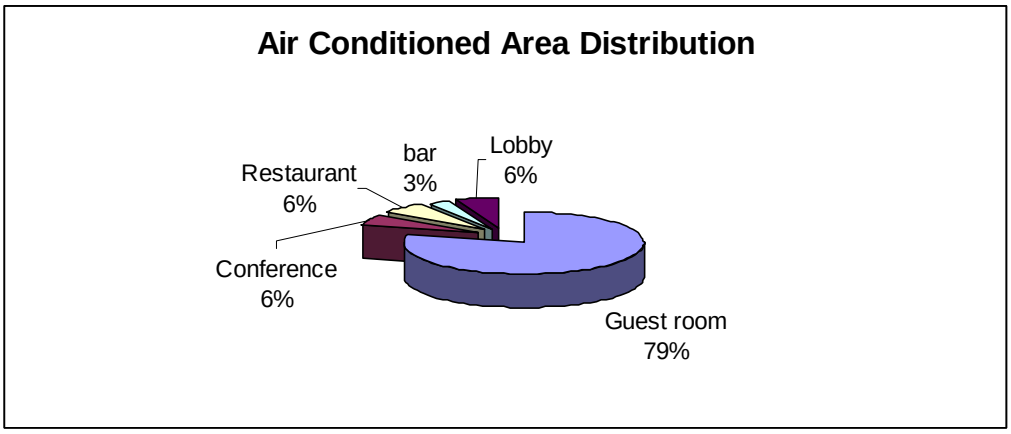


Figure 7: Air Conditioned Area Distribution

During the walkthrough, it was observed that in unoccupied guest rooms, the air conditioning is being turned on. Housekeeping practice of the hotel leaves the air conditioning on with the lowest temperature of 16°C. The reasoning for this practice is that the indoor air quality of the guest room is maintained, serving as a dehumidifier, as well as the furniture in the guest rooms would not be distorted by the harsh sea side air.

Energy Saving Analysis

Turning on the air conditioning in unoccupied guest room is a waste of energy. Dehumidifier devices could be used which could maintain the indoor air quality of unoccupied room. This could be complimented with housekeeping practices of natural ventilation by opening the windows.

> An analysis is done on the peak season of January 2009, with the occupancy rate of 90%. This means that there are 10% out of all the rooms, which is 8 rooms, having the air conditioning running even though it is unoccupied. It has been calculated that each guest room has a daily air conditioning consumption of 17.53 kWh/day. Taking 8 rooms over a period of 1 year gives a minimum energy saving of 51.188 MWh/year.

Currently, air conditioning contributes to most of the electricity consumption of the hotel, which is a total of 42480 kWh per month.

> However, if Variable Frequency Drive could be installed with the air conditioning system, a saving of 15% of the current electricity consumption used on the AC could be achieved. This would translate to a monthly saving of 6372 kWh, and a yearly saving of 76.464 MWh.

In addition to this, a software is utilized to further calculate the air conditioning saving potential with respect to its building envelope. The software that was used is RETScreen Clean Energy Project Analysis Software[9]. It serves the purpose of assessing both the energy consumed as well as the GHG emission analysis.

[9] The RETScreen Clean Energy Project Analysis Software is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia, www.retscreen.net.

Software Measure #1: Double Glazed Windows

Base Case:

- window area for deluxe room: 3.6*2 = 7.2 m2
- window area for premium room: 4.8 *2 = 9.6 m2
- Total area of windows for 64 rooms = 465.6 m2
- Table 10 shows the orientation and the total area size of the guest room windows:

Window area	40 main	12 left	10 right	2 premium	Total (m2)
South	288		72	19.2	379.2
West		86.4			86.4

Table 9: Orientation of Guest room Windows

  - Southward area = 379.2 m2
  - Westward area = 86.4 m2
- Temperature of air conditioning is maintained at 16°C, for calculation purposes, the temperature used is 16°C.
- The current property of the windows is slider type clear windows with single layer, as described in Table 11.

	Area	U-value	SHGC	
	m²	(W/m²)/°C		Description
South	379.2	5.25	0.68	Single, Clear
West	86.4	5.24	0.68	Single, Clear

Table 10: Characteristics of Single Glazed Window

U-Value: U-Value indicates the rate of heat flow due to conduction, as a result of temperature difference between inside and outside. The lower the U-factor, lower the heat transferred through the glass[10]. In other words, a lower U-Value provides better temperature containment of the conditioned air in the room, and therefore would reduce the energy required to maintain the set temperature in the room.

Solar Heat Gain Coefficient: SHGC is the fraction of external solar radiation that is admitted through a window or skylight, both directly transmitted, and absorbed and subsequently released inward. The solar heat gain coefficient (SHGC) has replaced the shading coefficient (SC) as the standard indicator of a window's shading ability[11].

[10] CII (2008a). High Performance Glass from Indian Green Building Council. Confederation of Indian Industry. CII-Sohrabji Godrej Green Business Centre, Hyderabad, India. Last assessed at http://www.igbc.in:9080/site/mmbase/attachments/48292/Glass_Bulletin_final_-_emailable.pdf on 2009-03-16

[11] SHGC is expressed as a number between 0 and 0.87, SC as a number between 0 and 1; i.e., the relationship between SHGC and SC is: SHGC = SC × 0.87. The lower a window's SHCG, the less solar heat it transmits, and the greater its shading ability. SHGC may be expressed in terms of the glass alone or may refer to the entire

Therefore, the lower the SHGC, the better it is in terms of glazing in preventing solar heat gain.

Proposed case:

The proposed case are with the same casement type clear window, but with double glazed, with the new characteristics described in Table 12.

	Area	U-value	SHGC	
	m²	(W/m²)/°C		Description
South	379.2	2.77	0.58	Double, Clear
West	86.4	2.77	0.58	Double, Clear

Table 11: Characteristics of Double Glazed Window

By having an additional layer of glass, it acts as an extra insulation layer. Double glazed pane windows are basically two layers of glass with a certain space apart and are sealed to form a single glazed unit with air in between the glass layers. These glass layers and the air in between them shall act as an insulation layer to resist heat flow better as compared to a single layer window.

As a result of this, the U-Factor and the SHGC is lowered.

By using the peak season occupancy of 90%, the energy analysis of base case and proposed case of replacing single glazed to double glazed windows is performed. During no occupancy, the AC is turned off and the temperature used is the annual average temperature in Trivandrum of 27.3°C, as per referred to in the RETScreen Software.

Software Measure #2: Increasing AC set temperature to 24°C

The current set temperature of the air conditioning in the guest rooms are set at 16°C. An analysis on the electricity saving potential and GHG emission reduction is performed by setting the AC set temperature to 24°C.

Software Measure #3: Insulation of Wall

The walls of the hotel guest rooms are built using normal wall construction material of cement and bricks. An energy analysis on an extra insulation layer on the wall of the rooms was performed, to observe the energy savings that could be achieved. In this analysis, gypsum board with a thickness of 12.5 mm is selected. The advantages of gypsum board are that it improves fire resistance rating, as well as the reduction of the sound transmission. The new U-Value is lowered further to a value of 2.831 compared to 2.925 without the gypsum board, as per described in Table 13.

window assembly. USDOE. Solar Heat Gain Coefficient. United States Department of Energy. Last assessed http://www.daviddarling.info/encyclopedia/S/AE_solar_heat_gain_coefficient.html at 2009-03-14.

Description	Layer	Thickness mm	Conductivity W/m - °C	Conductance (W/m²)/°C
Exterior film coefficient				33.402
Cement plaster	1	10.0	0.700	70.000
Brick - clay	2	229.0	1.400	6.114
Cement plaster	3	10.0	0.700	70.000
Gypsum board	4	12.5	0.160	12.800
Interior film coefficient				8.350
U-value - nominal			(W/m²)/°C	2.381

Table 12: Characteristics of Wall with Extra Insulation

Software Measure #4: Insulation of Wall and Roof

Maintaining the proposed wall insulation, the roofing insulation is improved by adding a 9.5 mm thickness layer of gypsum board. The new U-value is reduced to a value of 2.284 than the initial 2.643, as per described in Table 14.

Description	Layer	Thickness mm	Conductivity W/m - °C	Conductance (W/m²)/°C
Exterior film coefficient				56.783
Brick - clay	1	15.0	1.400	93.333
Roofing felt - layered asphalt	2	20.0	0.170	8.500
Wood - soft	3	15.0	0.120	8.000
Gypsum board	4	9.5	0.160	16.842
Interior film coefficient				9.309
U-value - nominal			(W/m²)/°C	2.284

Table 13: Characteristics of Roof with Extra Insulation

Summary of Software Recommendations Energy and GHG Saving

No.	Description	Energy (MWh)			% saving	GHG (tCO2)		GHG Reduction (tCO2)
		Base	Propose	Save		Base	Propose	
1	Double Glazed Window	2260.2	2205.8	54.4	2.41%	1713.2	1672.0	41.2
2	Increase Set Temperature	2260.2	1032.5	1227.7	54.32%	1713.2	782.6	930.6
3	Wall Insulation Gypsum	2260.2	1005.7	1254.5	55.50%	1713.2	762.3	950.9
4	Roof Insulation Gypsum	2260.2	998.8	1261.4	55.81%	1713.2	757.1	956.1

Table 14: Summary of RETScreen Energy Saving and GHG Reduction

Table 15 illustrates the energy saving and GHG reduction of several proposed measures. The GHG emission factor used is 0.758 tCO_2/MWh, which includes a 5% transmission and distribution loss.

Lighting System Description

Current Situation

Lighting in the vicinity of the hotel consist of guestrooms, indoor areas such as restaurant, bar, conference hall, lobby and corridors, exterior lightings as well as backdoor areas of staffs and operating sections.

Figure 8 shows the distribution of lighting electricity with regards to these different areas.

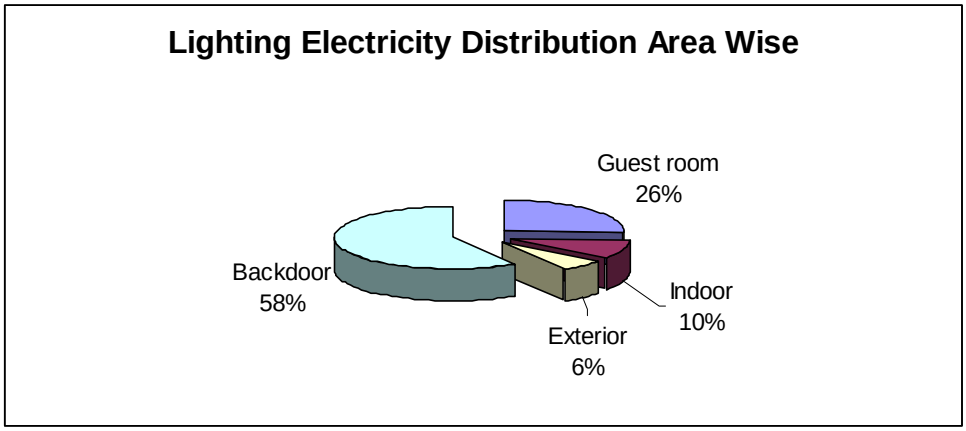


Figure 8: Lighting Electricity Distribution Area Wise

The lighting fixtures characteristics of the guestrooms were observed and noted. In the deluxe rooms there are 8 CFLs and 1 T5, while the premium rooms have 18 CFLs and 2 T5. The room that was visited has comfortable luminance of lights and were controlled manually by wall switches as well as bedroom master key control device.

Energy Saving Analysis

Due to much of the lighting fixtures in the hotel already using CFLs light bulbs, the overall contribution of lighting in the total consumption of the hotel is relatively low.

Nevertheless, it was noted that most of the backdoor lightings are currently using T12 fluorescent tubes. T12 has a rated power of 40 W, along with the choker of 12 W, it has a total rated power of 52 W. Considering 75 fixtures of T12 in the backdoor areas of Samudra Hotel over the average daily consumption period of 18 hours, the daily energy consumption of T12 in the backdoor areas are 52*18, 0.936 kWh.

On the other hand, T5 has a rated power of 28 W, with a slightly less luminance which is not prominently noticeable. By replacing these T12 with T5, the new daily energy consumption would be 28*18, 0.504 kWh. This is to note that T5 fluorescent bulbs would not required chokers.

With this, the amount of daily electricity saved would be 0.432 kWh/day. This would translate to a 157.68 kWh/year saving.

Domestic Hot Water (Heater) System Description

Current Situation

The total domestic hot water production in Samudra hotel is attained by their own boiler with a 5.2 kW capacity. This boiler is estimated to provide the daily hot water consumption of 3000 liters during peak periods.

Energy Saving Analysis

Due to the abundance of sun in this state of Kerala, throughout the entire calendar month, solar water heater is an attractive recommendation. During the time of walkthrough, it was noticed that there seemed to be a lot of available and unobstructed sunlight areas in the facility that could be taken advantage to install solar water heater panels. Taking into account this as well as the climatic condition in Kovalam, flat plate collected based solar water heater is recommended.

A normal estimation of 70-80% saving of fuel bills could be achieved with the installation of solar water heaters. A figure of 75% saving is considered from the current fuel consumption needed to satisfy the hotel hot water production demand for guest rooms as well as kitchen usage. The boiler capacity of 5.2 kW operating over 8 hours per day consumes 41.6 kWh/day. A 75% saving would result in a daily saving of 31.2 kWh, which translates to a yearly energy saving of 11.388 MWh for the diesel fuel consumption.

This recommendation is viable even though the hotel officer was sharing his concerns over the lack of incentives from the government at this moment to implement solar water heater for hot water production.

8. Other Recommended Energy Conservation Measures

Diesel Generator

There are two diesel generator in the hotel – 110kVA and 250kVA. The energy produced and the corresponding diesel consumption was obtained for a timeframe of 1 month. The following Table 16 summarizes the 1 month detail for both the diesel generator.

Generator	Operation Date	Total Energy Produced (kWh)	Diesel Consumed (liters)	Efficiency (kWh/L)
250 kVA	1.6.09 – 30.6.09	528	180	2.933
110 kVA	1.7.09 – 30.7.09	440	405	1.085

Table 15: Diesel Generator Characteristics

From the above given information, analysis on the energy saving potential of both the diesel generator is done. By looking at the 250 kVA generator, the efficiency of the generator is calculated.

180 liters of diesel produces 528 kWh, this translates to 2.933 kWh/L. By using the standard of benchmark figure of 3.8 kWh/L in India, the achievable potential of this generator is (3.8-2.933) 0.867 kWh/L. This gives a potential saving of 22.8%.

If this percentage saving of 22.8% is achieved, it will save a total of 180*0.228, 41 liters of diesel per month. By converting this amount of diesel in the efficient condition, it would potentially save 41*9500/860, 453 kWh per month, which is 5436 kWh/year.

The efficiency of the 110 kVA generator is then looked upon and realized that there is an even huger saving potential in this generator, in which 405 liters of diesel produces 440 kWh, this translates to 1.085 kWh/L. Again, by using the standard of benchmark figure of 3.8 kWh/L in India, the achievable potential of this generator is (3.8-1.085) 2.715 kWh/L. This gives a potential saving of 71.4%.

If this percentage saving of 71.4% is achieved, it will save a total of 405*0.714, 289 liters of diesel per month. By converting this amount of diesel in the efficient condition, it would potentially save 289*9500/860, 3192 kWh per month, which is 38304 kWh/year.

> The total savings that could be achieved by improving the efficiency of the diesel generators is 43740 kWh/year.

In addition to this, the generator could only feed in a block of 5 liters at once. Even though the required diesel would be somewhere less of 5 liters, it could only be fueled with the multiple of 5 liters.

Pump

The hotel treats its own sewage in its vicinity. The sewage treatment area is located not too far from the main hotel entrance, towards the area of the beach. It is a small scale treatment plant and the resulting treated water is used for watering the plants in the hotel. The sewage treatment goes through a general physical and chemical process, with a tower and sedimentation pond. This is eventually pumped up to two storage tanks which are located approximately 100 meters away from the treatment area, with an estimated 25 meters higher elevation. Extra energy is required to pump the treated water to these tanks due to its location.

The two pumps used for the sewage treatment is fueled by high speed diesel. The average operating time of these pumps is 3 hours per day. With the rated power of each pump of 1.5 kW, the total rated power of the sewage pumps are 3.0 kW. The daily energy consumption is 9 kWh.

Assuming a pump efficiency of 70%,

Hydraulic power for 1 pump = Pump power * pump efficiency
= 1.5 kW * 0.7 = 1.05 kW

Hydraulic power is also defined as:

Hydraulic power (kW) = flow rate (liters/second) * distance raised (m) /100

With the current storage tank at 25 meters height, the flow rate is calculated to be 4.2 liters/second.

Current Hydraulic Power = 4.2 * 25 /100 = 1.05 kW

Energy for 2 pumps working at average 3 hours a day = 2*3*1.05 = 6.3 kWh/day = 2299.5 kWh/year

If the storage tank is moved closer to the sewage treatment, with a new tank height of 2 meters elevation, the energy consumed would be:

New Hydraulic power = 4.2 * 2 / 100 = 0.084 kW

New Energy for 2 pumps working 3 hours a day = 2*3*0.084 = 0.504 kWh/day = 183.96 kWh/year

The energy saving achieved per year = 2115.54 kWh/year

In addition to that, during the time of walkthrough in the hotel, it is noticed that the staffs were using the treated sewage water to water the plants. Watering in the afternoon, under the hot scorching sun would result in greater evaporation. By using a 10% extra evaporation during afternoon watering, watering in the morning and evening could save on energy required to treat the water, as well as pump the water to the storage tanks.

Kitchen

During the walkthrough in the kitchen area of the hotel, several improvements that is contributing to wastage in LPG were observed. Some of the noticeable ones were the stove head fire burning in orange flame, as well as the pots being covered by dark carbon on the outer layer, reducing the heat being transferred from the stove to the cooking spot. By replacing the stove head to yield a blue burning flame, and by removing the dark carbon layer on the cooking pots, a conservative 5% saving of the LPG used for cooking could be achieved.

Taking the average monthly LPG consumption of 1575 kg, a 5% saving would save 78.75 kg of LPG per month.

This translates to 78.75*11500/860, 1053.05 kWh saving per month, which is 12.637 MWh/year.

Summary of Recommended Energy Saving Measures

Table 17 illustrates the recommended energy saving measures, with their respective expected energy and environmental saving per year. The weighted GHG emission factor of 0.758 tCO_2/MWh is used to calculate the amount of CO_2 reduction.

Area	Recommendations	Energy Saving		Environmental Saving (tCO2/year)
		Electricity (MWh/year)	Diesel/Gas (MWh/year)	
Air Conditioning	Turn off AC in unoccupied room	51.188		38.8005
Refrigeration and AC	Using VFD	76.464		57.9597
Building Envelope	Double glazing window, increasing set temperature, adding wall and roof insulations	338.2		256.3556
Backdoor Lighting	Replace T12 with T5 fluorescent tubes	0.158		0.1198
Domestic Hot Water Production	Installation of solar water heater		11.388	3.3025
Diesel Generator	Replace with higher efficiency DG		43.74	12.6846
Pump	Relocate treated sewage water storage tank		2.116	0.6136
Kitchen	Replace stove head and cooking utensils		12.637	2.6538
	Total	**338.358**	**69.881**	**275.7299**

Table 16: Summary of Recommended Energy Saving Measures

New Energy Performance Index After Recommendation

Energy saved with new measures	408239	kWh/year
	34019.92	kWh/month
New energy consumption refering to December 2008	50423.69	kWh/month
	1626.57	kWh/day
New EUI for 57 rooms (90% occ)	**28.54**	**kWh/room/day**
Current EUI	47.79	kWh/room/day
Percentage Saving Achieved	**40.2**	**%**

Table 17: Calculation of New EUI (kWh/room/day)

The current EUI of Samudra Hotel is 47.79 kWh/room/day. By taking into account the new recommendations, **a reduction in EUI of 40.2%** could be achieved, with a value of 28.54 kWh/room/day based on 90% occupied room, with the calculation as shown in Table 18.

Current annual energy	951631.1	kWh/year
Energy saved with measures	408239	kWh/year
New annual energy	543392.1	kWh/year
Total floor area (m2)	3517.24	m2
New EUI	**154.49**	**kWh/m2/year**
Current EUI	270.56	kWh/m2/year
Percentage Saving Achieved	**42.9**	**%**

Table 18: Calculation of New EUI (kWh/m^2/year)

The current EUI based on annual energy per area is 270.56 kWh/m^2/year. Upon taking into account the new measures, table 19 shows the calculation to achieve the new EUI of 154.49 kWh/m^2/year, **with a reduction of 42.9%.**

The current Carbon Emission Index (CEI) is 0.1803 tCO2/m^2/year. By taking into account the GHG emission factor in Table 20, over a total build up floor area of 3517.24 m^2, the new CEI is calculated as in Table 21 and has a value of 0.0608 tCO2/m^2/year (0.1519-0.0911), **with a reduction of 40.0%**.

fuel type	tCO^2/MWh
electricity	0.758
diesel	0.29
gas	0.21

Table 19: GHG Emission Factor

	Base case (MWh)	tCO2/m2/yr	Proposed savings (MWh)	tCO2/m2/yr	Percentage Reduction
Total Annual Elec.	595.216	0.1283	338.358	0.0729	
Total Annual Diesel	103.682	0.0085	46.458	0.0038	
Total Annual Gas	252.736	0.0151	240.1	0.0143	
Total CEI		**0.1519**		**0.0911**	**40.0%**

Table 20: Calculation of New Carbon Emission Index (CEI)

9. Conclusion

The walkthrough energy audit conducted in Samudra Hotel had revealed the potential of saving in terms of energy as well as environmental GHG emission reduction. It has achieved its objective of assessing the improvement in Energy Performance Indices which reduces the energy and GHG emission from the range of 40-42% of the current level. The recommended energy conservation measures were based on observation and experience of the energy audit team. Further investigation and analysis for the energy saving potential of the hotel could be conducted to have a more thorough detailed energy audit. Nevertheless, the walkthrough energy audit had provided substantial information on the existence of energy saving potential in this particular hotel.

10. Index

Energy Data Sheet

	(kWh)	(INR/kWh)	(INR)	(liters)	(kg)
	Elec.	Cost	Elec.	HSD	LPG
Aug-08					
Sep-08					
Oct-08					
Nov-08					
Dec-08					
Jan-09	56200	5.40	303263	741	1500
Feb-09	52298	5.64	294872	855	1750
Mar-09	51086	4.87	248862	722	1200
Apr-09	42080	5.07	213437	703	1500
May-09	48610	5.23	254008	684	2000
Jun-09	47334	4.88	230912	988	1500
Jul-09					
Total	297608		1545354	4693	9450
Avg monthly	49601.3		257559	782.2	1575.0
Avg monthly in kWh	49601.3			8640.2	21061.0
Avg monthly cost (INR)			257559	28940.167	70875

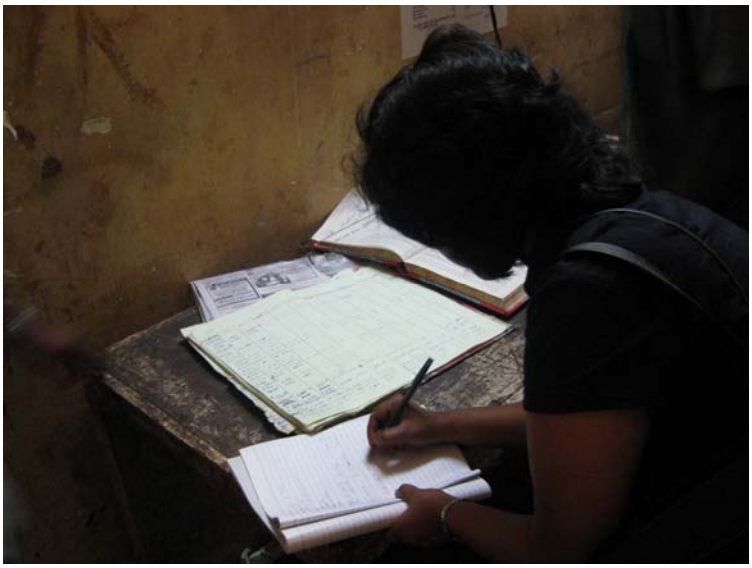
Photos

Building façade of the western block of Samudra Hotel

Building façade of the main guest room block

Lobby of Samudra Hotel is air conditioned

Open air swimming pool area of the hotel



The energy audit team taking down details of the fuel consumption

Windows of guest room are single glazed with sliding wooden panel

Sewage treatment area of the hotel

Incandescent bulb used in the cold storage area of the hotel. Heat produced by the bulb gives extra cooling load for the air cooling

Kitchen pots have thick layer of carbon on its surface reduces heat transfer. Gas stove flame has noticeable amount of yellow flame

Housekeeping practice keeps guest room air conditioning to the lowest during time of walk through. Energy audit team instantly tuned it up