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Comparison of Energy Audit Methods for Buildings

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Abstract - *There are many systems in buildings such as lighting, cooling, heating, ventilation and boilers that require different quantities of energy. Energy demand may vary upon many factors such as occupancy level, outdoor conditions and performance of the systems. In this report, we try to develop a method to compare two methods of energy audit namely, a general walkthrough and a detailed energy audit. The aim of the present study is to develop a methodology to compare two types of approaches used in industry viz. Traditional theoretical energy audit vs. Computerized computational and analysis of energy audit, for identifying energy efficient measures to save energy costs. Initially the building for case study was studied regards to the equipment used in the buildings. Then the measures of energy savings were applied using both the methods of Energy audit stated above. The study showed that Walkthrough method of energy audit is a cheap, simple method and the reports generated are also simple for calculation compared to the reports generated from simulation in the software (detailed audit) which are costly & also needs special training and technical help for the study. Further, case study also showed that some energy efficient methods can be predicted only via simulation which cannot be predicted by walkthrough methods unless there are some previous proved results.*

Key Words: (Energy audit, Energy demand, Walkthrough audit, Simulation energy audit)…

1. INTRODUCTION

When there is need for the evaluation of energy performance of buildings and potential Energy Efficient Measures are to be identified, range of situations may take place. In some case, the facility in-charge will call for conducting a detail Energy audit to find ways to enhance the current system. Or may be in the other situation, facility in charge may invest less by replying on product literature that are normally adopted by users such as "turn lights off when not in use" etc. to reduce the energy use. Furthermore, there may be a situation that the facility in charge may not know the importance of energy audit and stays with the current system as it is and bears higher energy cost but does not invest in energy audits or measures to save energy. The scenario is chosen on the interest and gains of the company and its personnel. The alternatives can be chosen out of paying upfront invest cost with some risks involved or to reduce spending and stay with the current energy performance. Whatever the choice the facility in charge makes, it should be economically viable and justified by him. Energy audits may be done by general simple walkthrough or by doing the detail energy audit. Facilities personnel in identifying building operations and maintenance issues normally do simple walkthrough. A detailed energy audit report requires calculating actual performance and efficiency of building by conducting interviews, taking surveys and collecting data of systems associated with the building which is to be studied. The values collected from the study is then entered into a simulation tool where the Energy Efficient Measures can be recognized independently or within a combination to give a clearer realization of the energy usage and savings. In this report, we try to develop a method to compare two methods of energy audit namely, a general walkthrough and a detailed energy audit. The aim of the present study is to develop a methodology to compare two types of approaches used in industry viz. Traditional theoretical energy audit vs. Computerized computational and analysis of energy audit, for identifying energy efficient measures to save energy costs. Identifying the most cost-effective measures that can be used to reduce overall energy cost of a building. The Energy audit methods in this study will mostly concentrate on the material used in the construction and the type of energy consumption of those respective material.

2. LITERATURE REVIEW

K. Hassoneh et al. (2014) studied and applied the concept of green building in Jordan [1]. Insulation on the wall resisted the heat flow and kept the building cooler in summer and warmer in winter. Also properly insulated area can help in defining a proper size of HVAC, reducing initial investment on HVAC. Double glass glazing instead of single glass glazing can save 60% heat loss. Payback period of double glass is very less thus resulting in quick recovery of investment. Double glass glazing also reduces noise pollution. Occupancy sensors in classroom, offices and other utility areas can provide savings of 20-50% depending on the utility function. Replacing magnetic ballast with electronic ballast can save energy up to 25-30%. Dimmers can save 10-60% energy depending on the user. Larger window area facing south, east, west directions can save more energy in winter also it decreases glazing cost for north direction. The Payback period using above measures for saving energy is less than 3 years.

Ali Alajmi (2011) considered a 2-storied educational building of floor area 7020 square meters in Kuwait (Hot summer climate) based on energy consumption. Audit was done in two levels viz. walk through assessment and survey and data analysis [2]. Auditors of the study gave two types of recommendations. Non-retrofitting measures which involved no or minimal cost which saved 6.5% of building's annual energy consumption and Retrofitting measures saved 49.3% of building's annual energy consumption which involved

initial cost. This resulted in 52% of annual savings. Design builder software was used for the simulation of audit model and the results showed the payback period of 6 months for Not-retrofitting measures and most effective Retrofitting actions. CO2 emissions can be reduced to 648 tonnes in a year by implementing the measures suggested.

Rajesh Chedwal et al. (2015) estimated energy saving potentials of commercial buildings at Jaipur city categorically based on star rating [3]. Category-1 were hotels with no stars or one star that had low luxury, category-2 were hotels with 2 & 3 star hotels that had moderate type of luxury, category-3 comprise of 4 & 5 star hotels that had all high standard of luxuries. Energy Conservation and Building Codes (ECBC) and Advance Energy Efficient Measures (EEMs) beyond ECBC were implemented viz. HVAC and building envelope and lighting systems were used for the estimation of potential energy savings in the commercial buildings. eQUEST software was used for simulation of energy consumption models of hotel buildings and the results were compared with actual energy consumption of each category. Energy savings of 37.2%, 18.42% and 25.82% of category-1, 2 &3 respectively were estimated by implementing ECBC measures with a payback period of 2.39-6.42 years whereas by adopting advanced EEMs energy savings were estimated to be 61.75%, 53.92%, 54.61% for category-1, 2 & 3 respectively and a payback period of 4.22 to 5.11 years.

K.M. Odunfa et al. (2015) took into account the standard design considerations, guidance of ASHRAE, fundamental cooling load equations [4]. Three buildings in Nigeria were studied with the view of potential energy saving by orienting the directions of building in the most appropriate way and selecting the most efficient cooling equipment for the buildings. The three buildings viz. Faculty of Science, CBN, Department of Chemistry when oriented in North-South direction consumed 155.34 kW, 244.75 kW, 86.35 kW respectively of energy whereas when the buildings are oriented in East-West directions, the energy consumed is 163.6 kW, 232.04 kW and 90.64 kW respectively. This result showed that the buildings oriented in East-West directions require more energy consumption than the buildings oriented in North-South directions. Also buildings oriented in North-South directions allow maximum ventilation and natural light in all climatic conditions.

Gousia Sultana and Harsha H. V. (2015) conducted energy audit process at Nandi Institute of Technology and Management Science, Bangalore to identify areas of energy wastage and estimating energy saving potential measures by method of walk-through energy audit [5]. The result showed that there was an appreciable difference between the actual connected load and the actual power consumption. The reason found were- location of institute was in rural interiors where Government power supply shutdowns were frequent. In such periods, power was obtained from diesel generator or UPS batteries installed in the campus at various locations, thus the actual consumption of the energy from Government power supply was hugely reduced due to interrupted power supplies. Recommendations from the auditors saved Rs. 59,405 /- and energy savings of 10435.84 kWh and a Capital investment of Rs. 2,42,062 /-. By adopting the suggested recommendations, there will be saving of 41.66 % of energy and 30.6 % of annual cost.

Saeed Banihashemi et al. (2015) studied Climatic, parametric and non-parametric analysis of energy performance of double-glazed windows in different climates [6]. A four-story building representing the conventional type of residential apartments for four climates of cold, temperate, hot-arid and hot-humid was selected for simulation. Energyplus software was used for the simulation of the same. The conclusion was made from the study that the windows act differently in terms of energy performance and its effect depends on the location, climatic condition and physical properties. Using double glazed windows was useful in both cold and hot months whereas in cold and hot-humid climates where heating and cooling loads are prevailing respectively, they were beneficial in only those dominant months. Double-glazed was advantageous for saving energy in all four climates on the other hand; which proved to have significantly higher values of saved energy than the others.

Siddharth Lohia and Swati Dixit (2015) observed that substitution of normal Single glazed windows with Double glazed windows with LED bulbs and 5 star rating appliances has more energy benefits than the normal Single glazed windows [7]. Replacing Double glazed windows with Triple glazed windows ones had more energy efficiency but at more costs. It was concluded that the Double glazed windows are perfect for Indian weather conditions, especially in North India where there are burning summers and fair winters. Further it was suggested that that double glazed window with uPVC frame is best suited for Indian building and houses. However it has certain disadvantages as compare to triple glazed window such as investment cost were high in tripled glazed windows.

Vinod Kumar and A.M.Mahalle (2016) experimented and studied the effect of green roof over the building in terms of Thermal performance and cooling prospective in mild warm climate of India [8]. Experiments were done by comparing the exposed roof and a roof with green plantations. It was observed that the room air and interior surface temperature of the green roof were reduced by a margin of 17% and 22% respectively. Heat flux studies showed that the peaks are lowered and also the heat fluctuation through the green roof assembly is lower than that of the exposed roof in the case of heat in-leak. The simulated model prepared in this study had been very much matched by the experimental data, thereby efficiency of the model is confirmed clearly.

Subhash Mishra et al. (2013) studied about the energy saving in different type of building walls by selecting a proper insulation material and optimal insulation thickness [9]. An energy saving of 53.51% was achieved by using light weight concrete wall as compared to stone wall. The optimum insulation thickness and payback period for the different types of wall (Brick, Light Weight Concrete and Stone) was calculated. Loss of heat was calculated by using Degree-Days method. Glass Wool (GW) was selected as the insulation material. The study suggested that the optimum insulation thickness varies between 0.154m and 0.1703m and payback period varies between 1.17 years and 1.53 years depending

on insulation material, external wall material and climatic condition.

3. AIMS AND OBJECTIVES

The primary objective of this investigation is to find out efficiency factor of Energy Audit Methods. More specifically, the research had the following objectives:

(a) To generate a model that can support the decision of selecting the approach of Energy audit.

(b) To set up parameters which stakeholder should fix before deciding the Energy audit methods such as Budget allocated, time allowed for study & analysis, extent to technology required for audits.

(c) To predict the results of approach selection for energy audits for any typical type of building.

4. EXPERIMENTAL PROGRAMME

The experimental programme in this study comprised execution of a preliminary 21-days energy audit of building i.e. Shopping complex at Kalyan, Dist. Thane The systems studied and assessed as part of the Energy Audit and Energy Conservation Strategy devising process included the following:

• Lighting Systems & Architectural Features.
(a) First, we would study the results of Energy audit of the building by simulation based 'EQuest" software.

(b) Secondly, we would study the results of Energy audit of the building by Walkthrough method.

(c) At last, we would compare the Pros and Cons of both the above-mentioned methods and try to give conclusions based on the comparison made.

4.1. Methodology

Initially, a general strategy was prepared and defined to carry out the Energy audit of the building under the case study with both the methods viz. Walkthrough method and Simulation based energy audit. All the data required for the analysis was collected by manually observation and past data sheets available with the authorities. The architectural properties of the building were analyzed and some of the basic features of the buildings were identified for retrofitting. Types and properties of energy consuming lighting appliances were gathered, such as Capacity, length of use, efficiency of the appliances. The data for this study were limited to architectural and lighting systems which existed in the building. Data regarding the HVAC was excluded from the study. To summarize the comparative statements, a matrix with all the predictions were prepared for setting a benchmark for the decision maker.

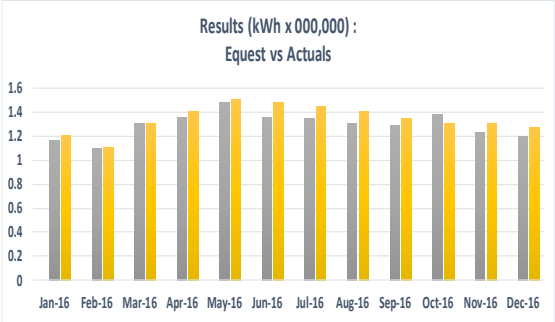
4.2. Case Study

In this experimental work, following building was considered as a case study:

Location: Kalyan, Maharashtra	Climate Zone: Warm and Humid
Building Gross Area: 5,52,000 sqft	Air-Conditioned Area: 3,58,000 sqft
Non-Air-Conditioned Area: 1,94,000 sqft	Number of Floors: 3 Nos.
Building Use: Retail, Departmental store	Construction Year: 2008

As a purpose of study, Electricity bills of year 2016 were obtained and studied. Consumption of units (kWh) were taken into consideration. As against these actual consumption figures, results were obtained from the Equest software for each of the month. Following table shows the variation in the results obtained from Equest vs Actuals:

Table -1: Monthly consumption Variation in the results obtained from Equest vs Actuals



Units (kWh x 000,000) Year 2016	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Total
As per Equest software	1.17	1.09	1.31	1.35	1.48	1.35	1.35	1.31	1.28	1.38	1.23	1.20	**15.48**
As per Actual Electricity Bill	1.20	1.10	1.30	1.40	1.50	1.48	1.45	1.40	1.35	1.30	1.30	1.28	**16.06**
Variation in Results	2.92%	0.73%	-0.38%	3.29%	1.67%	8.51%	7.24%	6.79%	4.89%	-5.77%	5.08%	6.64%	**3.59%**

Overall, there was only 3.59% variation annually. Hence, we can considerably rely on the results obtained from the Equest software. Following detail results were obtained for a Baseline model prepared for the Mall:

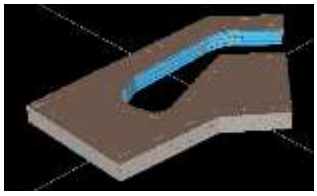


Fig.- 1: Model prepared in EQuest – 3D View

Baseline Comparison:

The results obtained for the baseline model gave readings that yearly consumption was Rs. 2167 Lakhs i.e. average monthly consumption was approx. Rs. 180 Lakhs. Whereas, as per actuals, the yearly consumption of electricity was Rs. 2248 Lakhs i.e. average monthly consumption was approx. Rs. 187 Lakhs.

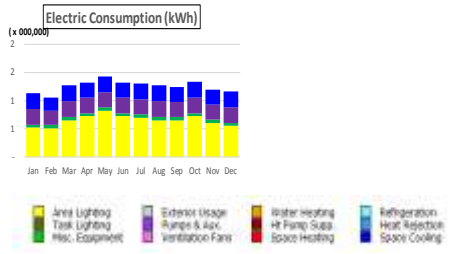
4.3. ENERGY AUDIT BY SOFTWARE- EQUEST:

Now, the model in the software was modified with changes in the construction pattern as follows:

Retrofit 1: RCC Over Hangs

RCC Over Hangs were added over the windows to see the variation in the Energy consumption pattern. Size of the overhang were considered as 8 inches in depth and 3 feet in the width. Results showed a reduction of about 3.30% in Space cooling, but energy for Area lighting was increased by 1.1%. Overall energy was reduced by about 2.71%. In terms of the monetary value, there would be savings of Rs. 58.83 Lakhs annually. The cost of intervention would be about Rs. 50.54 Lakhs. Hence the payback of the intervention would be only 10.3 months.

Table -2: Results obtained from the Equest software, after the construction of overhang



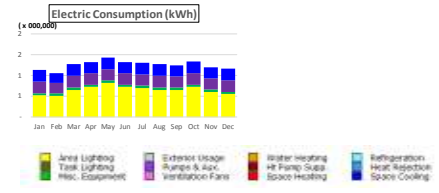
Electric Consumption (kWh x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.52	0.51	0.66	0.73	0.82	0.73	0.70	0.66	0.66	0.73	0.61	0.55	7.86
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.67
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Eqip.	0.28	0.25	0.28	0.27	0.28	0.27	0.28	0.28	0.27	0.28	0.27	0.28	3.27
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.28	0.24	0.28	0.27	0.28	0.27	0.28	0.28	0.27	0.28	0.27	0.28	3.26
Total	1.13	1.06	1.27	1.32	1.43	1.32	1.31	1.27	1.25	1.34	1.20	1.16	15.06

Retrofit 2: Single Reflective coatings over windows

Single Reflective coatings were added over the full height windows to see the variation in the Energy consumption pattern. Reflective coatings were considered of the standard company and were considered completely covering the windows on one side of the window Following results were obtained from the Equest software, after the adding of Single Reflective coatings.:

Table- 3: Results obtained from the Equest software, after using Single Reflective coatings over windows



Electric Consumption (kWh x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.50	0.49	0.63	0.70	0.79	0.70	0.67	0.63	0.63	0.70	0.59	0.53	7.56
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.71
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Eqip.	0.29	0.26	0.29	0.28	0.29	0.28	0.29	0.29	0.28	0.29	0.28	0.29	3.38
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.30	0.26	0.30	0.29	0.30	0.29	0.30	0.30	0.29	0.30	0.29	0.30	3.48
Total	1.15	1.07	1.28	1.32	1.43	1.32	1.31	1.28	1.25	1.34	1.21	1.17	15.13

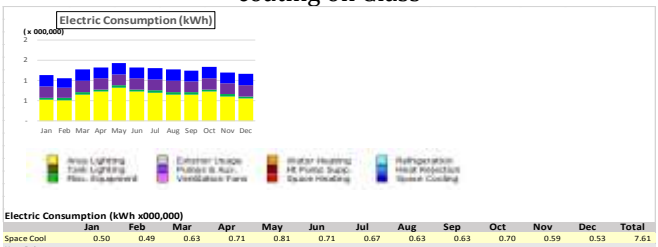
Results showed a reduction of about 7.00 % in Space cooling, but energy for Area lighting was increased by 8.00%. Overall energy was reduced by about 2.28%. In terms of the monetary value, there would be savings of Rs. 49.35 Lakhs annually. The cost of intervention would be about Rs. 68.19 Lakhs. Hence the payback of the intervention would be only 17 months.

Retrofit 3 : Combination of RCC Over Hangs & Single Reflective coatings

Combination of RCC Over Hangs & Single Reflective coatings were added to the building to see the variation in the Energy consumption pattern.

Following results were obtained from the EQuest software, after the adding of the Combination of RCC Over Hangs & Single Reflective coatings:

Table- 4: Results obtained from the Equest software, after Combination of RCC Over Hangs & Single Reflective coating on Glass



Electric Consumption (kWh x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.50	0.49	0.63	0.71	0.81	0.71	0.67	0.63	0.63	0.70	0.59	0.53	7.61
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.66
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Eqip.	0.27	0.24	0.27	0.26	0.27	0.26	0.27	0.27	0.26	0.27	0.26	0.27	3.17
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.27	0.26	0.28	0.27	0.27	0.28	0.29	0.29	0.28	0.27	0.27	0.27	3.30
Total	1.10	1.05	1.24	1.30	1.40	1.31	1.28	1.25	1.23	1.29	1.17	1.13	14.75

Results showed a reduction of about 9.00% in Space cooling, but energy for Area lighting was increased by 2.5%. Overall energy was reduced by about 4.77 %. In terms of the monetary value, there would be savings of Rs. 103 Lakhs annually. The cost of intervention would be about Rs. 118 Lakhs. Hence the payback of the intervention would be only 14 months.

4.4.ENERGY AUDIT BY WALKTHROUGH METHOD:

Energy Savings are proposed for this particular case study using various methods namely: Lighting System, Using Solar Panels etc.
These options for energy savings will be studied after taking into consideration of the actual data collection from building and area surrounding within the premises. The data collection is done using the prescribed forms.
Here the case study was done manually by visiting the site and most of the data was recorded manually after consulting the technical personnel on site.

4.4.1. Lighting System- Replacement of Existing CFLs, Halogens & Tube lights by LED lights.

The lighting system of the Mall was accessed through visual observation across the mall, technical specification of all

lighting instruments and light meter readings. The information recorded during study is presented below in tabular form which includes fitting type, loads on each fixture and lux levels.

4.4.2. Overall Lighting System Characteristics:

The existing low efficacy lighting system can be replaced by high efficacy LED bulbs with equivalent lumens are proposed in this case study. Existing CFL bulbs did not needed any other installation cost except for LED bulbs. However, replacing existing Tube lights, CDMT and Halogen needed replacement cost of changing the sockets required for LED bulbs. Prices of LED bulbs are considered from the current market rates. Cost of labour, sockets, fixtures, LED bulbs are considered of the standard ISI marks and of best quality available in market.

Table- 5: Saving resulted by replacing the existing CFLs, Tube lights, CDMT and Halogens by equivalent lumen LED bulbs

Existing				Replaced by					
Type	Watt	Qty	Total Watts	Type	Watt	Qty	Total Watts	Cost (Rs.)	Investment (Rs.)
CFL	8	155	1240	LED	8	155	1240	180	27900
CFL	14	5743	80402	LED	10	5743	57430	220	1263460
CFL	15	2922	43830	LED	10	2922	29220	220	642840
CFL	16	1194	19104	LED	10	1194	11940	220	262680
CFL	20	8	160	LED	15	8	120	250	2000
CFL	28	581	16268	LED	20	581	11620	280	162680
CFL	30	62	1860	LED	20	62	1240	280	17360
CFL	35	465	16275	LED	20	465	9300	280	130200
CFL	36	233	8388	LED	27	233	6291	400	93200
CFL	40	504	20160	LED	27	1008	27216	400	403200
Tube Light	15	23	345	LED	15	23	345	350	8050
Tube Light	28	248	6944	LED	22	248	5456	410	101680
Tube Light	36	488	17568	LED	25	488	12200	450	219600
Tube Light	40	78	3120	LED	25	156	3900	450	70200
Tube Light	48	217	10416	LED	27	434	11718	500	217000
Tube Light	60	140	8400	LED	27	420	11340	500	210000
CDM-TC	50	5789	289450	LED	27	5789	156303	550	3183950
CDM-TC	35	109	3815	LED	25	109	2725	500	54500
CDMT	35	78	2730	LED	25	78	1950	500	39000
CDMT	70	519	36330	LED	27	1557	42039	550	856350
Halogen	25	16	400	LED	25	16	400	450	7200
Halogen	70	628	43960	LED	27	1256	33912	500	628000
Halogen	250	132	33000	LED	150	132	19800	2100	277200
Halogen	400	39	15600	LED	150	117	17550	2100	245700
Halogen	800	23	18400	LED	150	138	20700	2100	289800
	Total		698165		Total		495955		9413750
	`+ existing LED		276815		`+ existing LED		276815		
	Total Watts		974980		Total Watts		772770		
Hrs. of Operation is considered as 8 Hrs. per Day & 30 Days per month									
Total kWh / month			233995	Total kWh / month			185465		
Total kWh consumed / year			2807942	Total kWh consumed / year			2225578		
Annualized Savings in kWh								kWh	582364.8
Annualized Savings in Rs.								Rs.	8153107
Investment for LED Lights								Rs.	9413750
Simple Pay Back Period								Years	1.15

The above study shows that the option of replacing the existing CFLs, Tube lights, CDMT and Halogens by equivalent lumen LED will result in the saving of the energy worth Rs. 81.53 Lakhs annually. The approximate retrofitting cost of replacing existing lighting system by LED would be 94.13 Lakhs.

Hence payback period would be approx. 14 months. Here we can conclude that replacing the inefficient CFLs, Tube lights, CDMTs and Halogens with equivalent lumen LED would result in saving of 21% of energy.

4.4.3. Use of Solar System for External lighting:

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. Here, in this case, the external lighting is suggested for the alternate supply of Solar power.

Table- 6: Savings resulted by replacing the existing Halogens by Solar system.

External Lighting			
Type	Watt	Qty	Total Watts
Halogen	70	628	43960
Halogen	250	132	33000
Halogen	400	39	15600
Halogen	800	23	18400
Total			110960
Total kWh / month			26630
Total kWh consumed / year			319565
Capacity of Solar System required for replacement			80 kW
Cost of Solar system			4 crores
Annualized Savings in Rs.			43.75 Lakhs
Payback Period			9 years

Considering the external halogen lights are replaced with the LEDs, the approx. power consumption is about 319.5 kW. Installation cost of solar panel having capacity of 4kW = around Rs. 5 lakhs as per standard market rates.
Here, if the external complete lighting system of halogen lights is replaced by equivalent lumen LEDs, we can conclude that Solar system of 80 kW must be installed, which would cost approx. 4 crores.

Installation of the solar system will result in approx. 43.75 Lakhs. Payback period can be considered as 9 years. The standard payback of solar system is 6-9 years for standard type of solar brands in the market.

5. RESULTS AND DISCUSSION

5.1. Comparison of Energy Audit methods in terms of Energy Efficiency:

Here, we have studied two nos. EEMS of each approach. The followings results can be summarized and compared in terms of Energy efficiency:

Table -7: Comparison between EEMs in terms of efficiency.

Sr. No.	EEMs	Annual Savings (Rs. in Lakhs)	Cost of Retrofit (Rs. in Lakhs)	Payback Period (months)
A	**EEMs by Simulation (Equest - software)**			
1	Retrofit: RCC Over Hangs	58.83	50.55	10
2	Retrofit: Single Reflective coatings over windows	49.36	68.19	17
3	*Retrofit Combination: RCC Over Hangs & Single Reflective coatings*	*103.31*	*118.74*	*14*
B	**EEMs by Walkthrough Method:**			
1	Retrofit: Replace CFL & Tube light by LED	*81.53*	*94.14*	*14*
2	Retrofit: Use of Solar Energy for External lighting	*44.74*	*399.46*	*107*
	Total	***126.27***	***493.59***	

From the above comparative statement, we can see that Energy savings resulting from the two retrofits model done in EQuest software resulted in an annual savings of Rs. 103.31 lakhs with the investment of Rs. 118.74 lakhs, giving Payback period of 14 months. While, the energy savings from the two most popular Walk-through methods resulted in annual saving of Rs. 126.27 lakhs with the investment of Rs. 493.59 lakhs. Here we can conclude that conventional walkthrough methods which are popular have larger payback period as compared to the tangible methods in EQuest methods.

5.2. Comparison of Energy Audit methods in terms of reliability:

From the process of the energy audits by both the methods i.e. by Walkthrough method and by Simulation (Software) method, we have opinion that by Simulation method the result prediction is more accurate as compared to Walkthrough method. Because, Simulation by EQuest is based on algorithms and techniques which are tried and tested. These results are simulated keeping in consideration for various practical situations and variable conditions. Hence, results obtained from the EQuest software can be relied upon. Whereas, the results obtained from Walkthrough methods EEMs are predicted based on energy savings obtained from a single product and this factor is multiplied into the number of units retrofitted. This does not implicate the variable practical situations on site, neither it takes care of specific location and environmental condition.

5.3. Comparison of Energy Audit methods in terms of costs involved:

From the process of the energy audits by both the methods i.e. by Walkthrough method and by Simulation (Software) method, we can say that by Simulation method the result prediction is much more as compared to Walkthrough method. Because, the consultation fees involved in professional software like EQuest involves more cost compared to a general know methods of walkthrough audits. Here we can say that Walkthrough audit is cheaper than Simulation method.

5.4. Comparison of Energy Audit methods in terms of time consumed:

From the complete audit procedure till obtaining final reports, we can conclude that the time needed for Energy audit by walkthrough method takes more or less same time as compared to Simulation methods. The elaborative data collection in case of Walkthrough methods in certain format needs time. In the undertaken case study of shopping complex of about 5.5 lakhs sqft built up area, time taken to collect data was about 25 days of 5-6 hours each. While time needed for suggesting EEMs based on the data collected needed about 7 days. In totality, walkthrough method audit and suggestions took 1 month of time. While for the process of energy audit by simulation, most of the data was commonly collected at the time of Walkthrough audit, the prorate time for data collection for simulation method took about 12 days of 5-6 hours each. While the model preparation in EQuest software, data feeding in the EQuest software and obtaining the results took about 15 days. In totality, it took about 27 days of time. Hence, we can say that time needed for simulation and walkthrough method is almost the same.

5.5. Comparison of Energy Audit methods in terms of technology and skill involved:

Comparison of Energy audit by the aforesaid methods cannot be compared based on the skills required for the audits process because the skill required in walkthrough method are based on personal skills such as communication skill, manual audit reporting skill; whereas the skill required for simulation methods basically requires computer technology skills in addition to the manual data collection skill. Here, the EEMs based on the walkthrough method requires manual intervention in calculation. Any typographical or calculation manual error can result in change of results. Whereas, in simulation method, manual involvement is only upto the data entry into the software. The calculation and results are obtained by the operation of the software.

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