ENERGY CONSERVATION APPROACH USING ECBC- EQUEST SOFTWARE AT RGPV, BHOPAL – A STUDY

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Abstract: A growing concern about global warming and climate change, seeks way to reduce environmental impact by promoting energy conservation using Building. This paper presents a case study in the energy modelling of an existing energy efficient college building located in RGPV Campus Admin block. The potential impact of Energy Conservation Building Code (ECBC) of India, that is applicable on commercial buildings having more than 100 kW connected load or 120 kVA contract demand, has been analysed on RGPV (Administrative Block). Simulation models of these buildings have been created using their existing specifications to estimate the energy saving potential through ECBC.

IndexTerms: ECBC, Energy conservation measures, Building energy efficiency, Energy consumption in buildings

I. INTRODUCTION

Buildings account for more than 30% of electricity consumption in India being second only to industries. It has been estimated that the total built space in the country would increase five-fold from 2005 to 2030, and by then more than 60% of the commercial built space would be air- conditioned [1]. With so much to be built in the country in the following decades every new inefficient building constructed would represent a loss of precious energy for the coming decades. It is also estimated that the urban population of the country would rise to about 590 million by the end of 2030 [2]. This migrating population from villages to towns and cities would require additional buildings and energy and thus it is important to keep a check on the way these buildings would be built and behave. Building codes and standards for various aspects such as building structure, safety, water requirements, etc. establishes minimum criteria, following which a building would become safe and habitable. Building energy codes deal with the energy consumption aspect of the buildings. On one hand they save precious energy and on the other give monetary benefits compared to conventional buildings over a period of time. Codes are important for new buildings because it is easier, cheaper and gives long term operational benefit while implementing energy conservation measures in the case of new construction than through retrofitting.

Prior to the ECBC, the only country level code, which attempts to guide construction of energy efficient buildings is the National Building Code (NBC) of India. The first version of National Building Code was published in the year 1970 [5] by Indian Standards Institution (now Bureau of Indian Standards) to provide unified guidelines for construction practices in the country. It was prepared as a guiding code for municipalities and development authorities across the country for preparing local byelaws..
Various studies have been carried out around the globe to understand the impact of building energy codes on a large number of buildings. One of them carried out in Hong Kong where a set of more than 80 existing commercial buildings were studied and their energy savings potential were calculated, assuming the building energy code becomes mandatory [6]. In an another attempt to study the potential of energy savings in buildings at city level researchers have developed a modelling concept using a statistical approach in which they have categorized commercial buildings on the basis of their usage, size, planning and heat source system. They have assumed different energy conservation measures for building envelope, lighting and HVAC under different scenarios and projected energy saving potential till 2050 in a city [7].

This study aims to understand the energy management and energy conservation using building code approach at RGPV administrative block at Bhopal. It also aims to calculate their energy consumption and the potential of energy savings possible now when the ECBC has become mandatory in Bhopal. This methodology could also be used to calculate energy savings in any other city in India.

II. DESCRIPTION OF BUILDING ENERGY CODE OF THE COUNTRY

The Energy Conservation Act, 2001 empowers the Government of India to prescribe ECBC in India. Bureau of Energy Efficiency (BEE) an autonomous body under Ministry of Power, with support from United States Agency for International Development (USAID) under its Energy Conservation and Commercialization Project (ECO-II Project) launched the first version of ECBC for its implementation in commercial buildings on a voluntary basis. As the first stand-alone National Building Energy Efficiency code of India [10] it sets minimum energy performance requirements of Commercial Buildings and their components. ECBC has been developed by extensive data collection and analysis of different building types, materials, services and usage patterns. Different climatic zones in which building would be constructed were also taken into account. Base case simulation models were then developed for buildings using this background data in these climatic zones. A life cycle approach was taken and possible savings were calculated through its application. The result of these calculations gives specifications for different building components such as lighting, envelope, air conditioning, water heating, etc. Unlike NBC, ECBC provides specific number range for the performance of building features and components that affect building energy use and occupants comfort [11]. During its development phase various stakeholders such as architects, engineers, builders, material suppliers, were involved.

III. FEATURES OF ECBC

ECBC had initially set minimum performance standards of commercial buildings of connected load 500 kW or greater or a contract demand of 600 kVA or greater [13]. Later, the applicability of code was modified to 100 kW connected load and 120 kVA contract demand or greater, for expanding the scope [14]. The provisions of the code are not applicable to buildings that do not use electricity or fossil fuel and to manufacturing systems and units in a building.

The code is applicable to five major areas of energy consumption in buildings which are:

- Building envelope
- Heating, ventilation and air conditioning
- Service water heating
- Lighting
- Electric power and motors

The code specifies few mandatory requirements and provides two alternate routes for buildings to comply with it: prescriptive route and the whole building performance route. In the prescriptive route, the building must comply with all the mandatory measures and prescriptive measures individually. In the prescriptive route of compliance, trade-off between various parts of the building envelope is permitted to provide some flexibility to the designer.[7]. In the second route of whole building performance, a building complies with the code as long as it meets all the mandatory criteria of the code and when the estimated annual energy use of the proposed design estimated by hourly energy simulation tools is less than that of the standard design. Detailed procedure for modelling the proposed design and the standard design are provided in the code.

IV. METHODOLOGY

The study is focused on the RGPV Admin block with climatic condition of Bhopal city (23.5◦N, 77.41◦E), capital of Madhya Pradesh. It lies in the composite climate zone according to ECBC. This climatic zone is characterized by extreme temperatures in summers and winters. Humidity is low in summers and high in monsoons. Direct solar radiation is high in all the seasons except for monsoons. Winds are hot in summer and cold in winters. This study has been carried out in three steps. Firstly, data for existing commercial building stock in the Bhopal city was collected and the trends were extrapolated for one years to estimate the growth of these buildings. Models were created using eQUEST 3.65 for each case studies.

The first model was created using the existing parameters observed in the case studies and the second one was created as per the ECBC recommendations. These two models were then simulated and their energy consumption was compared to achieve possible savings. Finally the energy saving potential in these buildings has been extrapolated to the city level to get the potential of energy savings in the RGPV Bhopal with mandatory status of the code [16]

4.1 Collecting building energy consumption data and calculating growth in the commercial buildings sector

Electricity consumption data of Admin building in the RGPV campus Bhopal was collected for the year 2018 from the Admin office. Then the buildings which had a connected load of more than or equal to 100 kW were identified. This gave the breakdown of energy consumption by different types of commercial buildings in the city. This one year data gave the growth in energy consumption in different types of commercial buildings having a connected load of more than or equal to 100 kW.

An institute building were identified and modelled in energy simulation software eQUEST 3.65. They were calibrated with the help of monthly and yearly electricity bills obtained from the administration/ management at the building. Image of Admin building is shown below

Fig. 1: Photograph of Admin building, RGPV campus, Bhopal

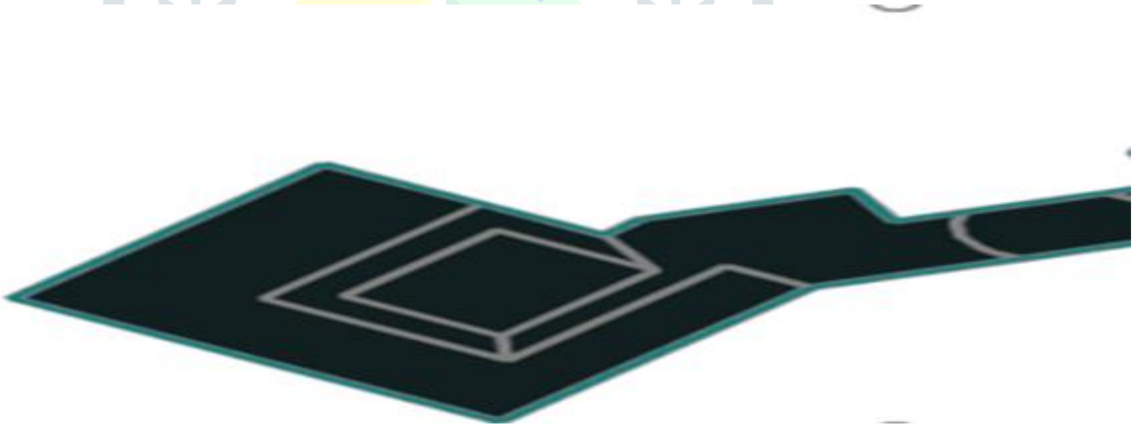


Fig. 2: eQUEST model of Admin Block –Study Area

Table-1 Electricity bills of RGPV Bhopal

CURRENT YEAR			
Month	**Max Demand(in kwh)**	**Total Bill(in rupees)**	**Per unit Charge (rupees per kwh)**
Jan	89510	63650.00	6.70
Feb	9006	6034.20	6.70

March	9754	65354.80	6.70
April	8536	57191.20	6.70
May	9654	64681.80	6.70
June	9599	64313.30	6.70
July	8698	58276.60	6.70
Aug	9654	64681.80	6.70
Sep	9651	64661.70	6.70
Oct	8562	57365.40	6.70
Nov	8695	58256.50	6.70
Dec	9865	66095.50	6.70
TOTAL	**30670 kwh**	**744865.8 Rs.**	

The inputs which are given to eQUEST Software are as follows:

Table 2: Inputs in eQUEST software for existing case

Lightning Power Density EEM Details						
		Baseline Design			**Existing Case Lightning**	
Serial No	**Activities Area**	**Area (%)**	**Lighting (W/SqFt %)**	**Unoccupied Load (W/SqFt %))**	**Lighting (W/SqFt %)**	**Unoccupied Load (W/SqFt %))**
1	Office(Open Plan)	40.0	2.84	2.0	2.84	2.0
2	Office(Executive/Private)	30.0	2.62	0.0	2.62	0.0
3	Corridor	10.0	0.95	10.0	0.96	10.0
4	Lobby(Office Reception/ Waiting)	5.0	0.60	10.0	0.60	10.0
5	Restroom	5.0	1.20	0.0	1.30	0.0
6	Conference Room	4.0	3.30	0.0	0.3	0.0
7	Mechanical and Electrical Room	4.0	0.70	0.0	0.70	0.0
8	Copy Room	2.0	1.50	0.0	1.30	0.0

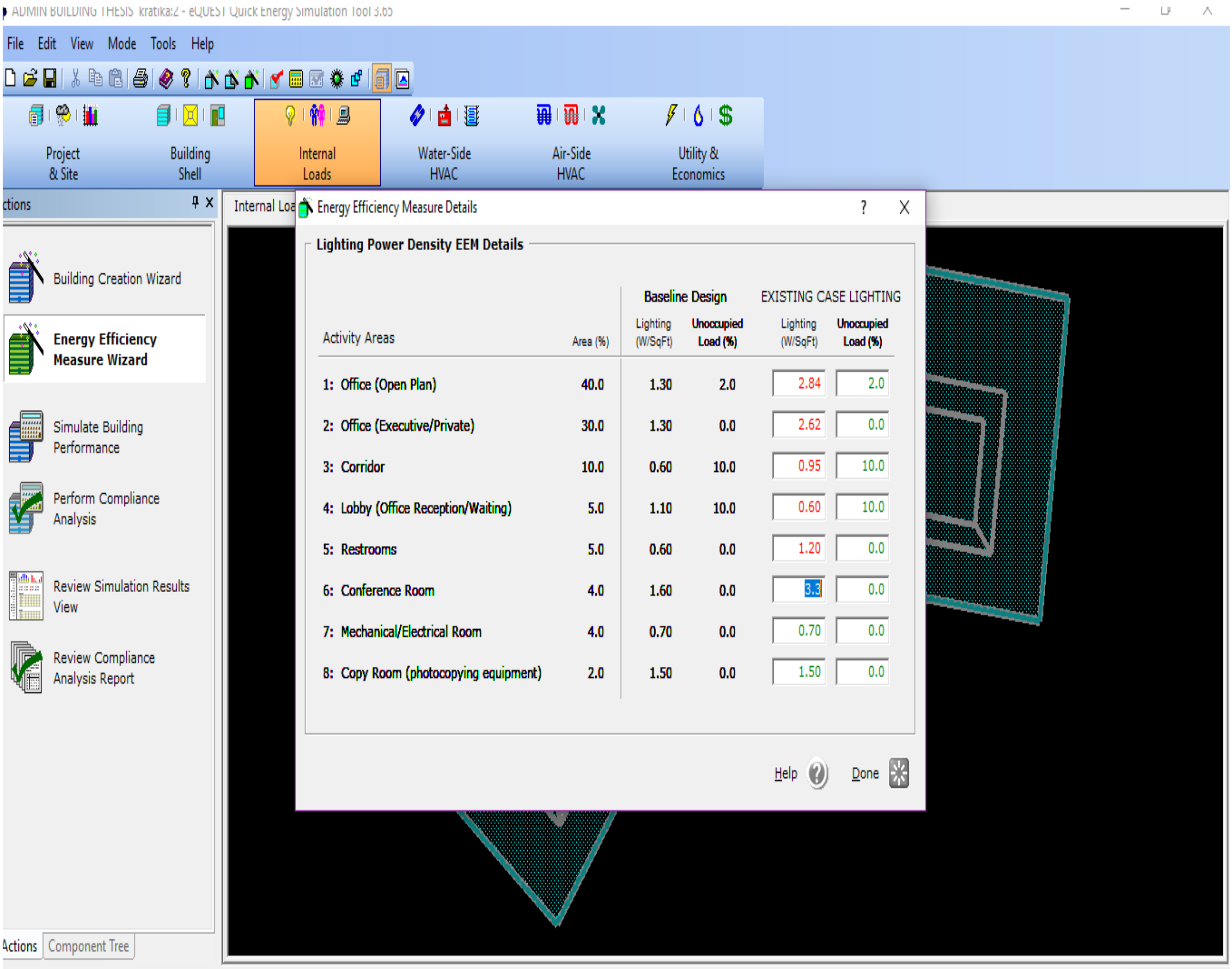


Fig. 3: Inputs in eQUEST software for existing case

The inputs which are given to eQUEST Software are as follows:

Table 3: Inputs in eQUEST software for recommended case

Lightning Power Density EEM Details						
		EXISTING CASE LIGHTING			**RECOMMENDED LIGTNING**	
Serial No	**Activities Area**	**Area (%)**	**Lighting (W/SqFt %)**	**Unoccupied Load (W/SqFt %))**	**Lighting (W/SqFt %)**	**Unoccupied Load (W/SqFt %))**
1	Office(Open Plan)	40.0	2.84	2.0	1.13	2.0
2	Office(Executive/Private)	30.0	2.62	0.0	1.04	0.0
3	Corridor	10.0	0.95	10.0	0.38	10.0
4	Lobby(Office Reception/ Waiting)	5.0.	0.60	10.0	0.24	10.0

5	Restroom	5.0	1.20	0.0	0.48	0.0
6	Conference Room	4.0	3.30	0.0	1.32	0.0
7	Mechanical and Electrical Room	4.0	0.70	0.0	0.28	0.0
8	Copy Room	2.0	1.50	0.0	0.6	0.0

The inputs in eQUEST software for recommended case

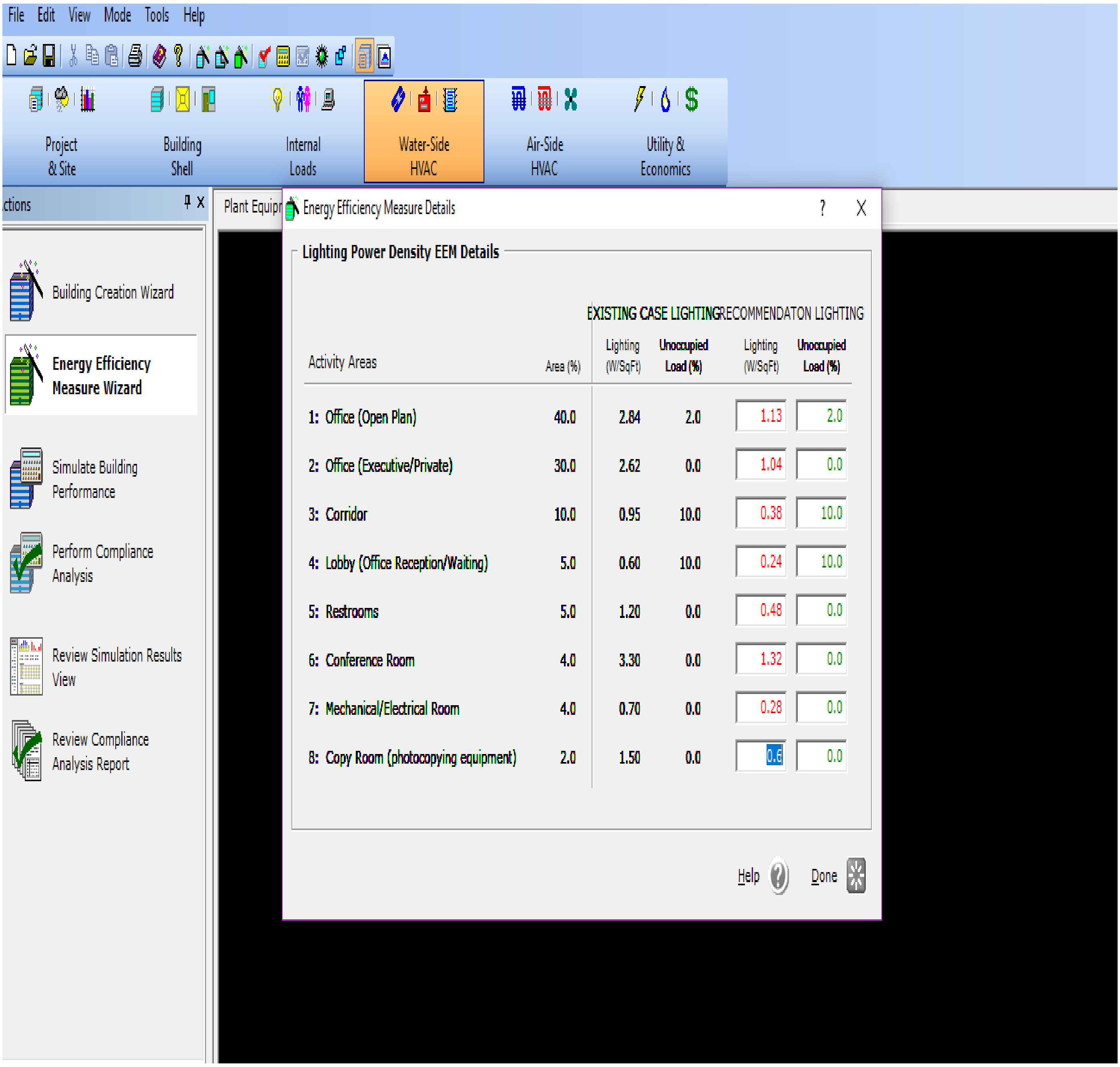


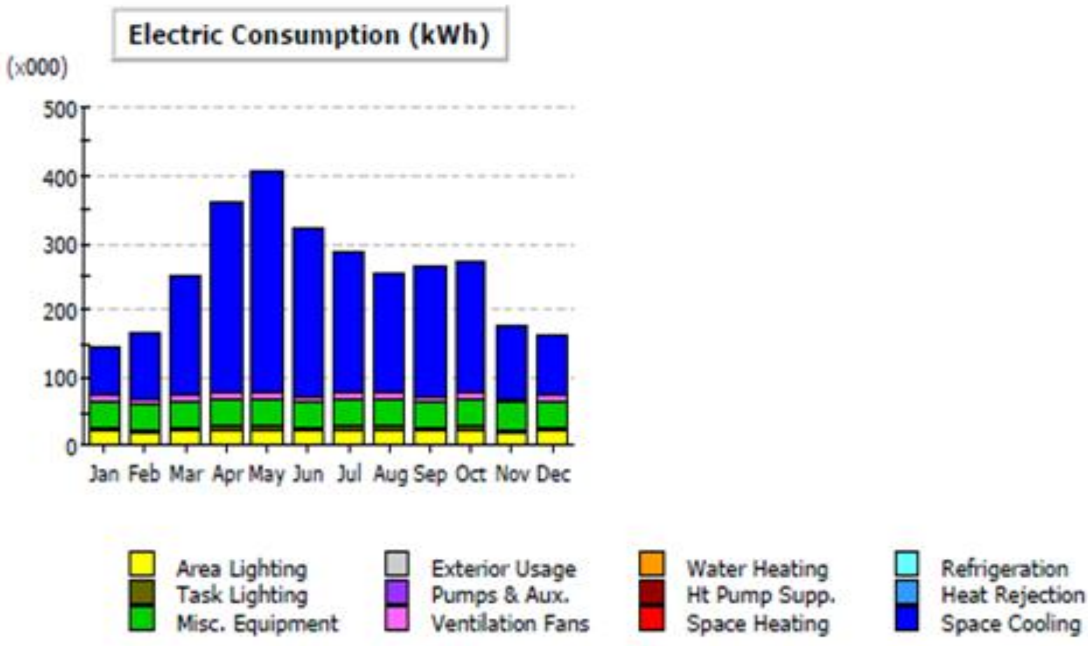
FIG 5 –Electricity Consumption in Existing case building RGPV campus, Bhopal.

V. RESULT

Building Simulation model of subject building was calibrated on the basis of monthly energy bills for one year. The yearly energy consumption of the RGPV was 30670kwh, while the energy consumption of the simulated model after calibration was found to be 30730.4kwh Fig. 5shows the simulated and actual energy consumption of the subject RGPV building. It was observed both simulated and measured consumption were close to each other and have shown errors within permissible limits.

Present study was carried out in RGPV Admin building of Bhopal that belongs to composite climatic zone of India. The study investigated, energy saving potential through adoption of energy efficiency measures recommended by Energy Conservation Building Code (ECBC) and subsequently, adoption of advance energy efficiency measures (EEM) beyond ECBC, implemented worldwide to improve energy efficiency in commercial buildings. The study concludes that there is potential of energy savings through implementation of ECBC building code that significantly increases further through advanced level energy efficiency measures.

The first part of the study gives a breakdown of electricity consumption commercial of Admin building in RGPV



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	70.9	96.9	176.4	280.0	328.6	249.3	209.9	176.7	191.6	195.4	108.7	86.9	21,71.3
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	8.3	7.5	8.3	8.7	8.7	7.9	8.7	8.7	7.9	8.7	7.5	8.3	99.2
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	40.6	36.7	40.6	41.1	41.7	39.0	41.7	41.7	39.0	41.7	38.0	40.6	482.3
Task Lights	3.5	3.2	3.5	3.7	3.7	3.3	3.7	3.7	3.3	3.7	3.2	3.5	41.8
Area Lights	23.4	21.1	23.4	24.3	24.4	22.3	24.4	24.4	22.3	24.4	21.2	23.4	278.9
Total	146.7	165.4	252.2	357.8	407.1	321.8	288.3	255.1	264.1	273.8	178.5	162.7	30,73.4

FIG 5 – Electricity Consumption in baseline case building RGPV campus, Bhopal.

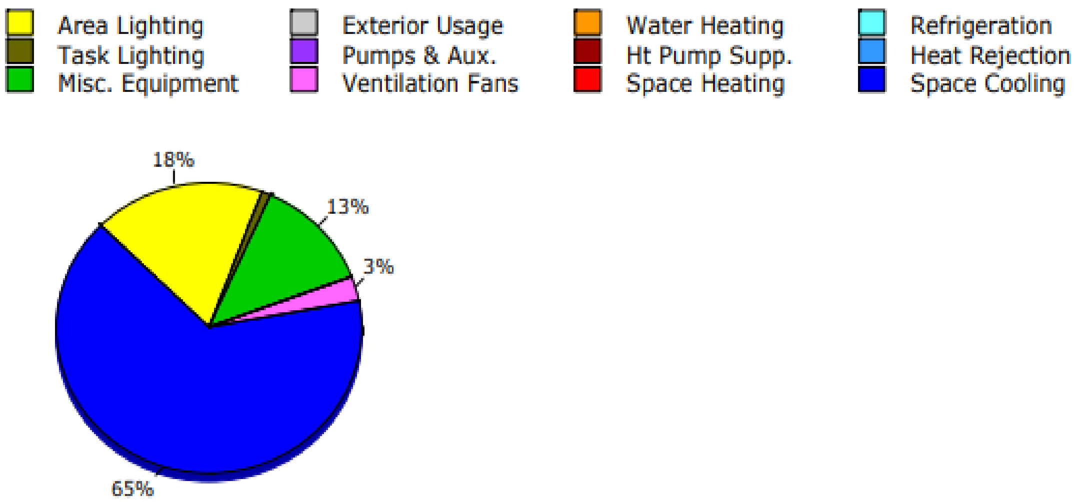
The electricity consumption of existing case lightning load are simulated in eQUEST software and the result are as shown below

FIG 6 – Electricity Consumption in Existing case building RGPV campus, Bhopal

The study was carried out in RGPV Admin building of Bhopal that belongs to composite climatic zone of India. The study

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas Btu	Steam Btu	Chilled Water Btu
Space Cool	25,09.9	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	-	-	-
HP Supp.	-	-	-	-
Hot Water	-	-	-	-
Vent. Fans	110.8	-	-	-
Pumps & Aux.	0.0	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	482.3	-	-	-
Task Lights	41.8	-	-	-
Area Lights	700.9	-	-	-
Total	38,45.7	-	-	-



Electricity

investigated, energy saving potential through adoption of energy efficiency measures recommended by Energy Conservation Building Code (ECBC) and subsequently, adoption of advance energy efficiency measures (EEM) beyond ECBC, implemented worldwide to improve energy efficiency in commercial buildings. The study concludes that there is potential of energy savings through implementation of ECBC building code that significantly increases further through advanced level energy efficiency measures.

The annually electricity consumption of recommended case lightning load are as shown below

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas Btu	Steam Btu	Chilled Water Btu
Space Cool	21,71.3	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	-	-	-
HP Supp.	-	-	-	-
Hot Water	-	-	-	-
Vent. Fans	99.2	-	-	-
Pumps & Aux.	0.0	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	482.3	-	-	-
Task Lights	41.8	-	-	-
Area Lights	278.9	-	-	-
Total	30,73.4	-	-	-

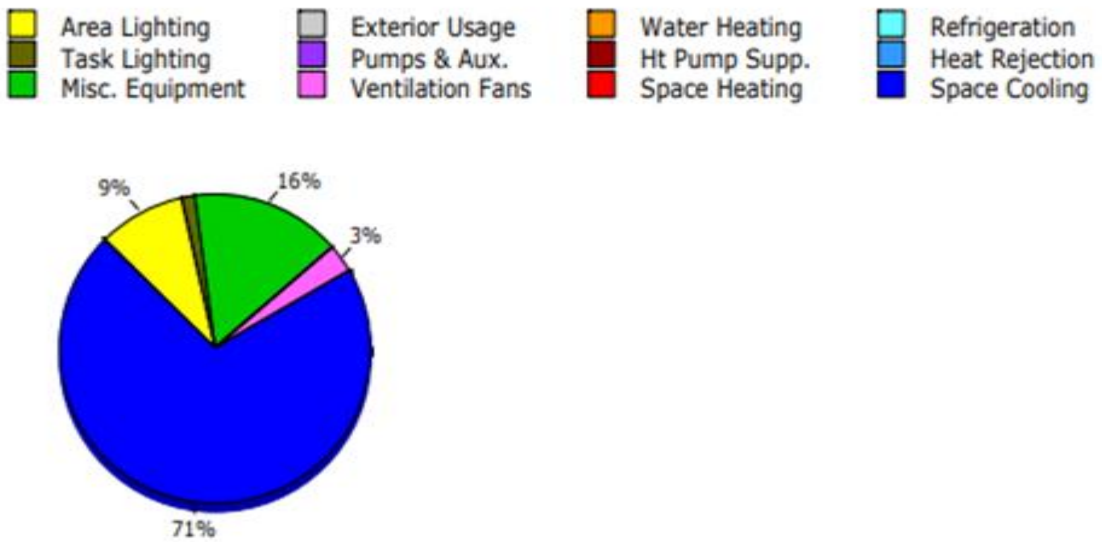
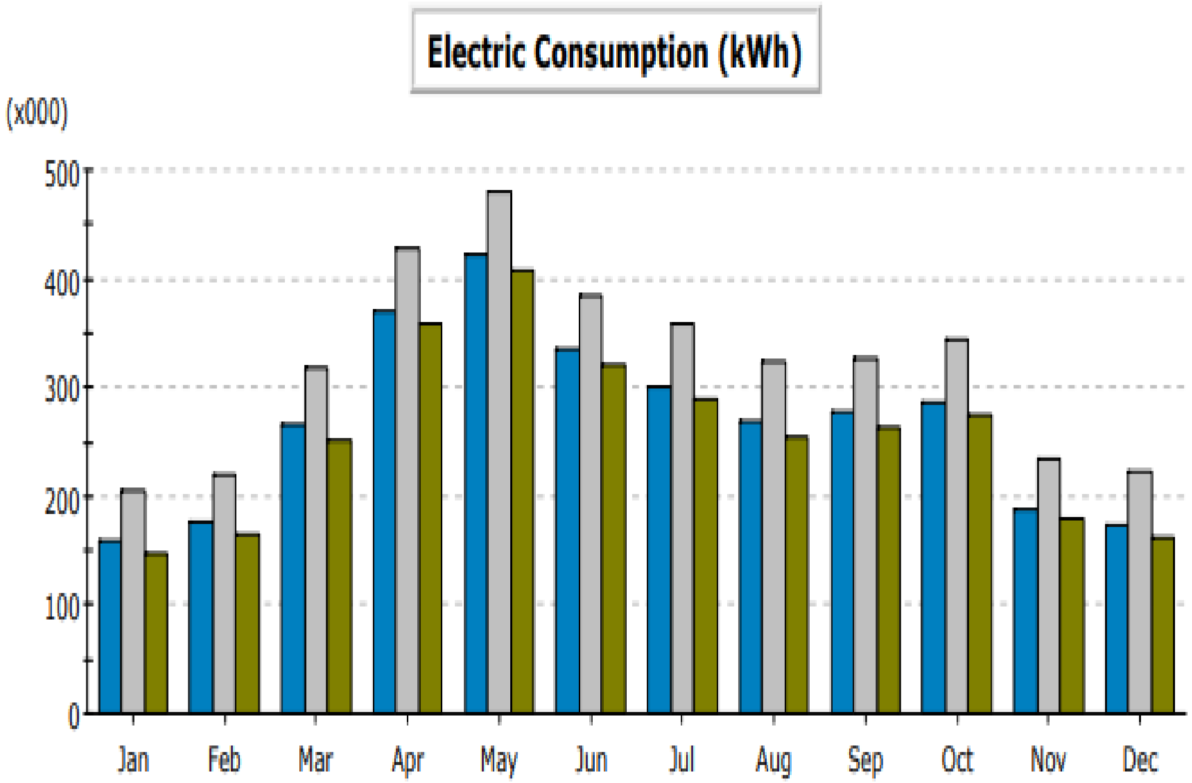


Fig. 7: The annually consumption of recommended case Building RGPV Campus Bhopal

This project on energy conservation approach in RGPV Admin block has paved way for ECBC implementation in existing buildings as well as the recommended case ones. ECBC implementation has been surrounded with a lot of questions since its inception. Every new initiative has to face a lot of uncertainty. The results in this particular show significant decrease in the energy usage as and delivery of a better performance. The building performance was enhanced whereas on the other hand, few issues came forward, which need to be dealt with to strengthen the implementation process and hence the comparisons graph as shown below-



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Run 1.	158.3	175.9	264.6	371.3	420.7	333.9	301.5	268.3	276.2	287.2	189.1	174.0	32,21.1
Run 2.	206.3	220.7	317.3	428.5	478.5	385.7	357.9	324.1	327.4	343.3	234.0	222.0	38,45.7
Run 3.	146.7	165.4	252.2	357.8	407.1	321.8	288.3	255.1	264.1	273.8	178.5	162.7	30,73.4
Run 4.													
Run 5.													

1. ADMIN BUILDING THESIS kratika - Baseline Design (05/16/19 @ 16:16)
2. ADMIN BUILDING THESIS kratika - EXISTING CASE LIGHTING (05/16/19 @ 16:17)
3. ADMIN BUILDING THESIS kratika - RECOMMENDATON LIGHTING (05/16/19 @ 16:17)

Fig. 8: Comparison Graph between baseline design, existing case lightning, recommended case lightning

The final part of the study included extrapolating these savings for admin building over a period of one years and calculating energy that could be saved during that period. As expected admin buildings show maximum potential of energy savings each year. The reason behind this is the exponential growth expected during coming years.

VI. CONCLUSION

The study concludes that there is vast potential of savings possible through the implementation of ECBC in the country. An urgent need to implement ECBC is required in order to capture the savings. It also highlights the fact that different buildings have different energy saving potential depending on the construction specifications, usage, systems and equipment's installed, conditioned area and other factors. Present study shows an energy saving of 12.55%. It is concluded that envelope and HVAC contribute to major energy saving opportunities in these buildings. Envelope measures show maximum energy saving potential in Admin building and it would lead to maximum savings in these buildings.

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