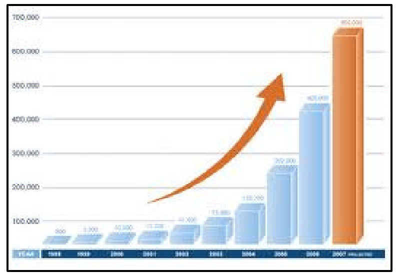
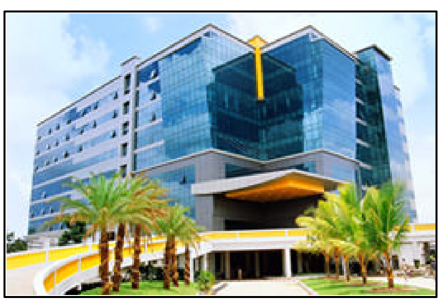
ENERGY CONSERVATION BUILDING CODE


SURVEY & ANALYSIS OF BUILDINGS IN THE STATE OF KERALA FALLING UNDER THE PURVIEW OF ENERGY CONSERVATION ACT- 2001



Prepared for:

Energy Management Centre

An Autonomous Centre under the Department of Power, Govt. Kerala
Thiruvananthapuram

By:

Kerala State Productivity Council

Productivity House, Post Box No.8, Kalamassery
Cochin

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We also thank the following organizations for their assistance in providing information

- **State Corporations/ Municipalities**
- **State Public Works Departments**
- **State Electrical Inspectorate**
- **Power Distribution Licensees**
  - **Kerala State Electricity Board, Vydyuthi Bhavanam, Trivandrum**
  - **Cochin Special Economic Zone (CSEZ), Kakkanad**
  - **Cochin Port Trust, W.Island, Cochin**
  - **KINESCO Power Utilities Limited, Kakkanad**
  - **Kannan Devan Hills Plantations Company (P) Ltd , Munnar**
  - **Rubber Park India (P) Ltd, Valayanchirangara**
  - **Technopark, Trivandrum**
  - **Military Engineering Service, Kataribagh, Naval Base, Kochi**
  - **Thrissur Corporation,Thrissur**
- **All Builders/ Building owners.**

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6. State Public Works Departments.
7. State Electrical Inspectorate.
8. Power Distribution Licensees.
    - Kerala State Electricity Board, Vydyuthi Bhavanam, Trivandrum.
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    - Rubber Park India (P) Ltd, Valayanchirangara.
    - Technopark, Trivandrum.
    - Military Engineering Service, Kataribagh, Naval Base, Kochi.
    - Thrissur Corporation, Thrissur.
9. All Builders/ Building owners where survey was conducted.

ABBREVIATIONS USED

ECBC	:	Energy Conservation Building Code
BEE	:	Bureau of Energy Efficiency
GBC	:	Green Building Council
LEED	:	Leadership in Energy and Environmental Design
GRIHA	:	Green Rating for Integrated Habitat Assessment
PWD	:	Public Works Department
EMC	:	Energy Management Centre, Kerala
KSEB	:	Kerala state Electricity Board
CSEZ	:	Cochin Special Economic Zone
KINFRA	:	Kerala Industrial Infrastructure Development Corporation
KW	:	Kilowatt
KVA	:	Kilovolt Ampere
CD	:	Contract Demand
EPI	:	Energy Performance Index

EXECUTIVE SUMMARY

E-1 There has been exponential growth in the commercial buildings in the state of Kerala in the last 10 years. Our analysis shows aggregate growth of commercial buildings, in the various bands of contract demand of 100kVA – 600 kVA and above, is 221% in the last 10 years. In this, commercial buildings with contract demand 100kVA - 200kVA band has shown highest growth rate of 251% (Please refer table -5 in chapter- 5**).**

E-2 The above growth has triggered rapid increase in energy consumption in the commercial building sector. In total commercial sector energy consumption is 2507 MU which is almost 18% of total consumption of 13870 MU.

E-3 Unlike industrial sector, commercial building sector lack trained technical manpower who can manage energy systems efficiently. Lack of proper data collection and management in energy use is another major issue prevailing in this sector, even though there are few exceptions.

E-4 This study was conducted with the objective to evaluate the number of building or building complexes which fall under the purview of EC act. The study identified 240 such buildings and evaluated the necessity of implementation of Energy Conservation Building Code (ECBC) in the state. A detailed ECBC compliance check and star rating were also conducted for a sample of 30 buildings as per Bureau of Energy Efficiency (BEE) norms to substantiate these findings. (Please refer paragraph 6.8 & 6.9 for details)

E-5 The survey could identify 240 commercial buildings falling under the EC act. The following table shows the category wise distribution of these buildings (Please refer chapter- 5 for details).

Sl. No.	Category of Building	Number of Buildings
1	Hospital	58
2	Hotel	55
3	Office Building	33
4	IT Building	22
5	Shopping Centre	44
6	Airport	5
7	Educational Institution	23
Total		**240**

E-6 Highest concentration of commercial buildings falling under the EC Act was found in Trivandrum district followed by Ernakulam and Thrissur (Please refer chapter-5 for details).

E-7 Energy Performance Index (EPI) of the selected buildings was computed based on the data collected. comparison of EPI of buildings in various categories viz office, hotels, hospitals, shopping complex, IT buildings, Airports and Educational Institutions, was also conducted (Please refer paragraph 6.7 for details)

E-8 Based on BEE's building energy star rating programme, the present star rating of these buildings were also determined considering their percentage air conditioned area. It may be noted that only 4 buildings out of 30 selected buildings are falling in the 5 star category. This indicates the scope of energy efficiency improvement potential existing in other buildings (Please refer paragraph 6.8 for details).

E-9 Comparing the results of ECBC compliance check and EPI computation it can be understood that apart from complying to parameters as per ECBC, factors like multiple mixed use activities within the same building (Eg. Some shopping malls have Cineplex and others use shopping cum office complexes), have distinct impact on EPI. Further divergence in EPI across buildings irrespective of their ECBC compliance rating is the different level of air conditioned area.

E-10 There are two buildings in the state which have obtained LEED rating and one has applied for GRIHA rating (Refer paragraph 6.10 for details).

E-11 Based on our detailed energy auditing experiences and the data obtained from the selected 30 buildings, it is estimated that there is 15-25% savings potential in the commercial buildings in various category viz, Hospitals, Hotels, Office buildings, IT buildings, Shopping centres, Airport and Educational Institutions (Please refer paragraph 6.12 & 6.13 for details). All the energy conservation measures identified as part of ECBC compliance parameters and can be incorporated at the design stage or can be implemented as a retrofit measure.

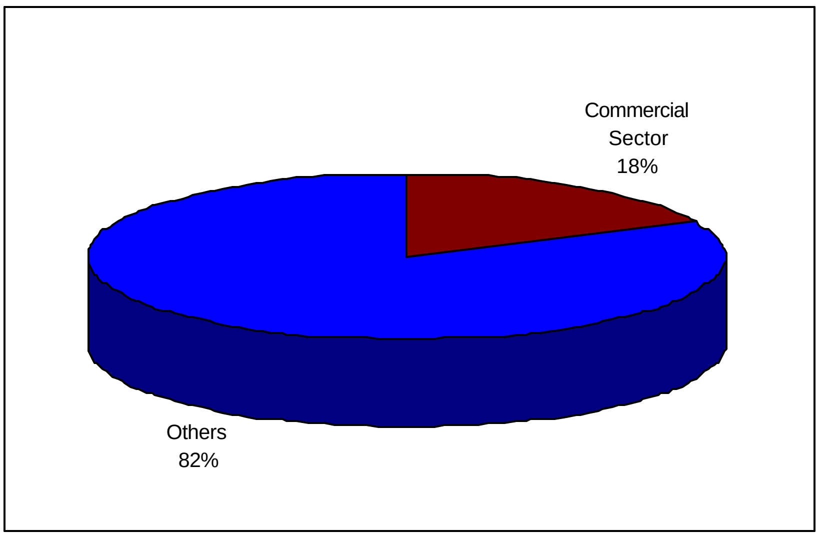
E-12 Observations and suggestions for ECBC implementation in the state is enlisted in Chapter 7.

1. INTRODUCTION

1.1 This study establishes a baseline database on the existing and upcoming buildings in the state that fall under the EC Act. A concerted effort is taken to understand energy usage in 30 such buildings to asses the energy saving potential and plan for strategy to ensure more energy efficient urban development as well as anticipate the benefit from appropriate intervention in existing and upcoming buildings.

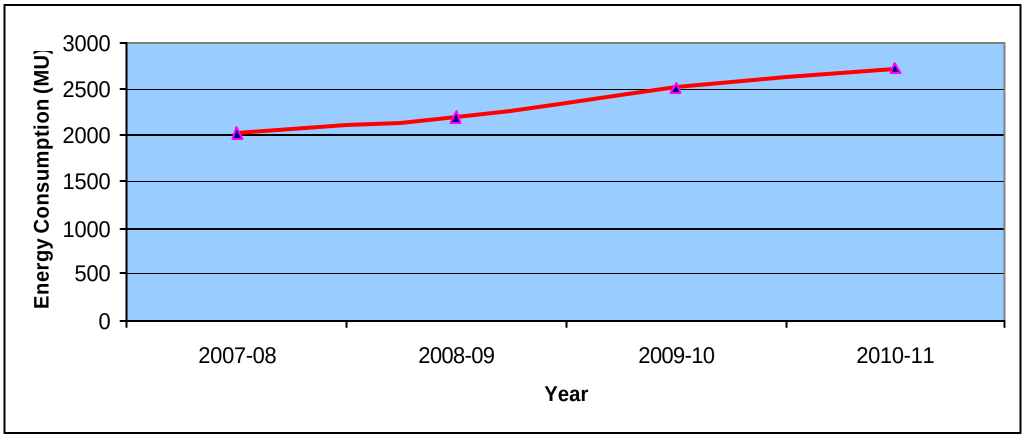
1.2 The commercial building sector represents about 18 % electricity consumption in Kerala. The total commercial sector energy sale is 2507 MU with a total consumption of about 13870 MU (Source: KSEB ARR & ERC for 2010-11).

Figure1: Energy Consumption Scenario in the State of Kerala.



1.3 The energy consumption in commercial sector is increasing rapidly in the state of Kerala. The chart given below shows the energy consumption in commercial sector in the state for the last three years and the projected consumption for the period 2010-2011.

Figure 2: Energy Consumption Trend in Commercial Building Sector in Kerala State.



Source: KSEB ARR & ERC for 2010-11

1.4 It is quiet evident from the above scenario that any policy initiative towards better energy efficiency in commercial sector will bring a great impact on reducing energy consumption in the state. The Energy Conservation Building Code (ECBC) was launched by Bureau of Energy Efficiency (BEE) in May 2007 as a first step towards the energy efficiency in commercial building sector in India.

1.5 Unlike industrial units most of the commercial buildings in the state do not have full time qualified technical work force who can understand, appreciate and implement energy efficiency in the day today operations. This makes implementation of ECBC at the stage of building design, all the more relevant.

1.6 The purpose of Energy Conservation Building Code (ECBC) is to provide minimum requirements for energy-efficient design and construction of buildings and their systems. The ECBC (also referred to as CODE) is a result of extensive work by the BEE and its committee of experts. It is written in code in affordable language to design, manufacturing and construction communities as an appropriate set of minimum requirements for energy efficient building design and construction.

1.7 **The Energy Conservation Act 2001 (Central Act 52 of 2001)** empowers the Central Government under section 14 (p) read with Section 56(2)(1) to prescribe Energy Conservation Building Code(ECBC). The Code defines norms and standards for the energy performance of building and their components based on the climate zone in which they are located. ECBC provides minimum requirements for energy – efficient design and construction of buildings. ECBC covers building envelope, heating, ventilation, and air conditioning system, interior and exterior lighting system, service hot water, electrical power system and motors.

1.8 **Chapter VI of the EC Act 2001 in Section 15 (a)** provides the State Government to amend the energy conservation building codes to suit the regional and local climatic conditions and may , by rules made by it, specify and notify energy conservation building codes with respect to use of energy in the buildings. It also allows the state government to direct every owner or occupier of a building or building complex being a designated consumer to comply with the provisions of the ECBC. Section 15 (b) of the EC Act also gives powers to direct every owner or occupier of a building or building complex being a designated consumer to comply with the provisions of Energy Conservation Building Code.

1.9 A detailed preview and features of EC Act and ECBC Code is shown in Chapter-8.

1.10 Energy Management Centre (EMC), the State Designated Agency (SDA) of BEE in the state of Kerala assigned the task of "Survey of building in Kerala State which fall under the Energy Conservation Act to identify and establish number of such buildings and evaluate the necessity of implementation of Energy Conservation Building Code in the state" to Kerala State Productivity Council. This report is prepared based on the survey and study conducted as per the above requirement.

2. SCOPE & OBJECTIVE

2.1. The ECBC is applicable to buildings or building complexes that have a connected load of 500 kW & above or a contract demand of 600 kVA & above. Generally, buildings or building complexes having conditioned area of 1,000 m^2 or more will fall under this category. The Code is presently under voluntary adoption in the country. (Please refer chapter 8 for more details).

2.2. Scope of Work

2.2.1. The scope of the study is to get a general overview of the buildings sector in the state with geographical locations of the major existing/on going and future projects and the expected growth in the build area across the state with region wise diagrammatic representation.

2.2.2. The study should cover a sample ECBC compliance check for a minimum sample of 30 buildings with ECBC compliance format.

2.2.3. There should be a list of all Leadership in Energy and Environmental Design (LEED) rated buildings in the state, along with a list of buildings which are planning to apply for the LEED rating.

2.2.4. Any building or group of building which are applying for any similar rating such as the Green Rating for Integrated Habitat Assessment (GRIHA) of the Ministry of New & Renewable Energy (MNRE) shall be collected and reviewed.

2.3. Objective

2.3.1. The objective of the study is to evaluate the number of buildings or building complexes which fall under the preview of EC Act.

2.3.2. The study shall involve buildings which are under construction which fall in the bracket of connected load 500 kW or contract Demand of 600 kVA as well as buildings which have already constructed, in the immediate past two years and also old buildings which are in the above threshold and where alterations in the system are being made will also fall under the preview of ECBC.

2.3.3. The survey will identify the number of such buildings and evaluate the necessity of implementation of Energy Conservation Building Code (ECBC) in the state.

3. CHALLENGES FACED

3.1. The data collection for this project activity was rather straightforward, requiring interaction with key governmental agencies (mainly State Electricity board, Electrical inspectorate & Local self government) as well as building owners. Major challenges faced in the data collection was the following

- Varying level of organization of the data.
- Lack of formal procedure for reporting.
- Assimilating, archiving and sharing the data.
- Lack of ownership and responsibility for documentation of the data.
- Limited understanding of the importance of this task in the context of larger national opportunity for improving energy availability through more efficient utilization of the same.

3.2. While the project team was able to overcome these challenges through sustained interactions and support from Energy Management Centre, Kerala State Electricity Board (KSEB), Electrical Inspectorate, Public Works Department (PWD) and Local Self Government (LSG).

3.3. The challenges faced in collection of the data present an opportunity in developing normative procedures for comprehensive documentation, information management, and analysis of data in a routine manner.

4. APPROACH AND METHODOLOGY

4.1. A core team consisting of KSPC officials, architects and management consultants was formed for the project "survey of buildings at state level which fall under the EC Act and Data Analysis". The initial phase of the study involved identification and discussions with all stakeholders for understanding various issues that require attention during the study.

4.2. A list of stake holders identified are the following,

- Building owners
- Local Self Government Institutions
- Kerala State Electrical Inspectorate
- Builders
- State PWD
- Power Distribution Licensees
- Building Maintenance Engineers
- Facility Users
- Facility Owners
- Facility Maintainers
- Architects
- Equipment Suppliers

4.3. Based on the input received from these discussions, a format to collect database to suit the defined functions of the project was created. The questionnaire prepared underwent many rounds of modifications and refinement to accommodate the view points of various stake holders.

4.4. The second phase involved the data collection directly from the identified stake holders. The data collection involved discussions with the concerned officials and also physical verification, cross checking of data provided wherever necessary.

4.5. To conduct sample ECBC compliance check as per 2.2.2 of scope, a user friendly ECBC compliance checklist was also incorporated in the questionnaire mentioned above (Please refer *Annexure-I).* This format was developed based on the ECBC compliance checklist given in the ECBC user guide published by BEE as well as the check list provided in the tender document issued by EMC.

4.6. Based on the data collected as per the above format, a database of the buildings was prepared containing the following information.

- The name of the building
- Location/ address
- Building envelope and Built up area
- Connected load of the building and the hours of its operation
- Annual energy consumption
- Present status- i.e. whether occupied/under construction or design stage.
- Mechanical systems and equipment, including heating, ventilating, and air conditioning, (HVAC).
- Service hot water heating.
- Interior and exterior lighting.
- Electrical power distribution and monitoring.

5. PROJECT SETTING – COMMERCIAL BUILDING SCENARIO IN THE STATE

5.1. As per the survey conducted during the period November 2009 to February 2010, a total of 240 commercial buildings falling under EC Act were identified in the state. Please see the below table showing the categories in which they fall under EC Act.

Table 1: Category wise distribution of buildings falling under EC Act.

Sl. No.	Building Category	No. of Buildings
1	600 kVA & above *	62
2	500 kW & above *	149
3	Upcoming Buildings **	29
	Total	240

* Buildings falling in the category of 600 kVA & above contract demand are not included in the category of 500 kW& above connected load.

** In the upcoming building category both 500 kW & above connected load and 600 kVA & above contract demand buildings are included.

5.1.1. Please refer *Annexure II* for the detailed list of buildings.

5.2. Sector wise Distribution

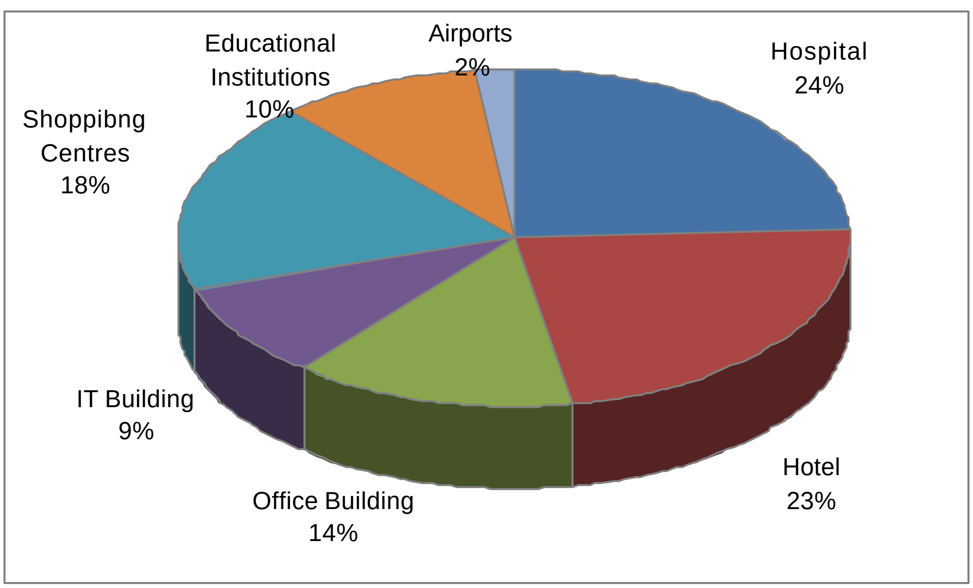
5.2.1. The survey revealed that the maximum numbers of commercial buildings are in hospital and hotel sector.

5.2.2. The following table and figure shows the sector wise distribution of commercial buildings which fall under the EC Act.

Table 2: Sector wise Distribution of Commercial Building which Fall Under the EC Act.

Sl. No.	Category of Building	No. of Buildings
1	Hospital	58
2	Hotel	55
3	Office Building	33
4	IT Building	22
5	Shopping Centers	44
6	Educational Institutions	23
7	Airports	5
Total		**240**

Figure 3: Sector wise Distribution of Comme rcial Building Which Fall Under the EC Act.



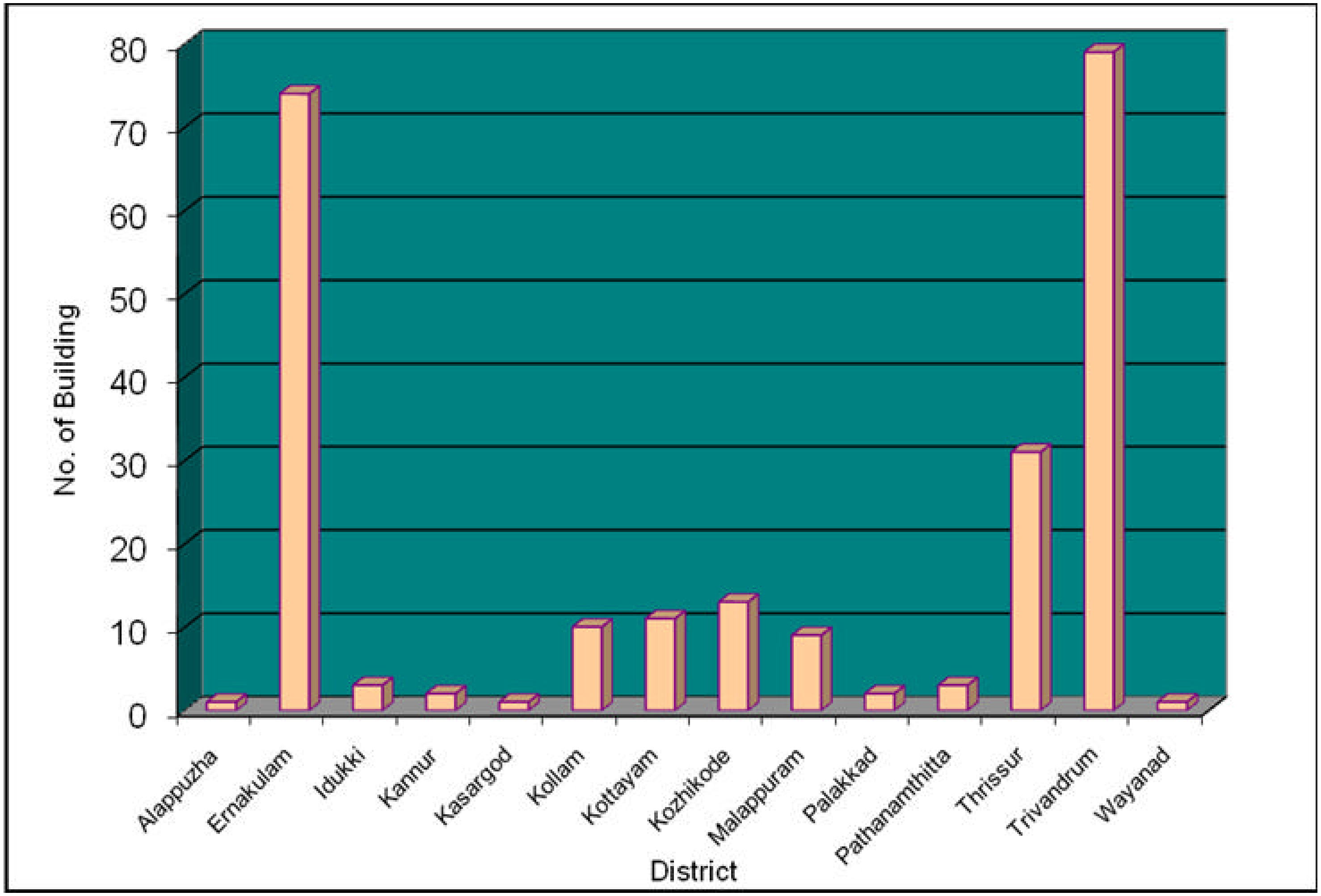
5.3. District wise Distribution

It was observed that there is a concentration of commercial building in the district Trivandrum followed by Ernakulam and Thrissur that fall under the EC Act. The following table shows the district wise distribution of commercial building which fall under the EC Act.

Table 3: District Wise Distribution of Commercial Building Which Fall under the EC Act.

Sl. No.	District	No. of Buildings
1	Alappuzha	1
2	Ernakulam	74
3	Idukki	3
4	Kannur	2
5	Kasargod	1
6	Kollam	10
7	Kottayam	11
8	Kozhikode	13
9	Malappuram	9
10	Palakkad	2
11	Pathanamthitta	3
12	Thrissur	31
13	Trivandrum	79
14	Wayanad	1
Total		**240**

Figure 4: District Wise Distribution of Commercial Building Which Fall under the EC Act.



5.4. Category wise and District wise Distribution

5.4.1. An analysis was carried out to find out the distribution of different category of commercial buildings across different districts in the state of Kerala. Table-4 and figure-5 shows the category wise distribution of commercial buildings in different districts in the state of Kerala.

5.5. Geographical Distribution of Commercial Buildings

5.5.1. Based on the number of commercial buildings falling under energy conservation act identified in each districts across the state of Kerala, the location of commercial buildings across the state has been plotted to understand the major hub of commercial buildings. Refer figure - 6 for the geographical distribution of commercial buildings surveyed across the state of Kerala.

Table 4: Category Wise Distribution of Commercial Building in Different Districts which fall under the EC Act.

Sl. No.	District	Category of Building							Total
		Hospital	Hotel	Office Building	IT Building	Shopping Centers	Educational Institutions	Airports	
1	Alappuzha	1							1
2	Ernakulam	13	20	12	10	12	6	1	74
3	Idukki	1	1			1			3
4	Kannur	1				1			2
5	Kasargod		1						1
6	Kollam	3	6			1			10
7	Kottayam	2	4			2	3		11
8	Kozhikode	4	2	2		3	2		13
9	Malappuram	5				1	1	2	9
10	Palakkad					2			2
11	Pathanamthitta	1				1	1		3
12	Thrissur	12	3	1		10	5		31
13	Trivandrum	14	18	18	12	10	5	2	79
14	Wayanad	1							1
	Total	**58**	**55**	**33**	**22**	**44**	**23**	**5**	**240**

Figure 5: Category Wise Distribution of Commercial Building in Different Districts

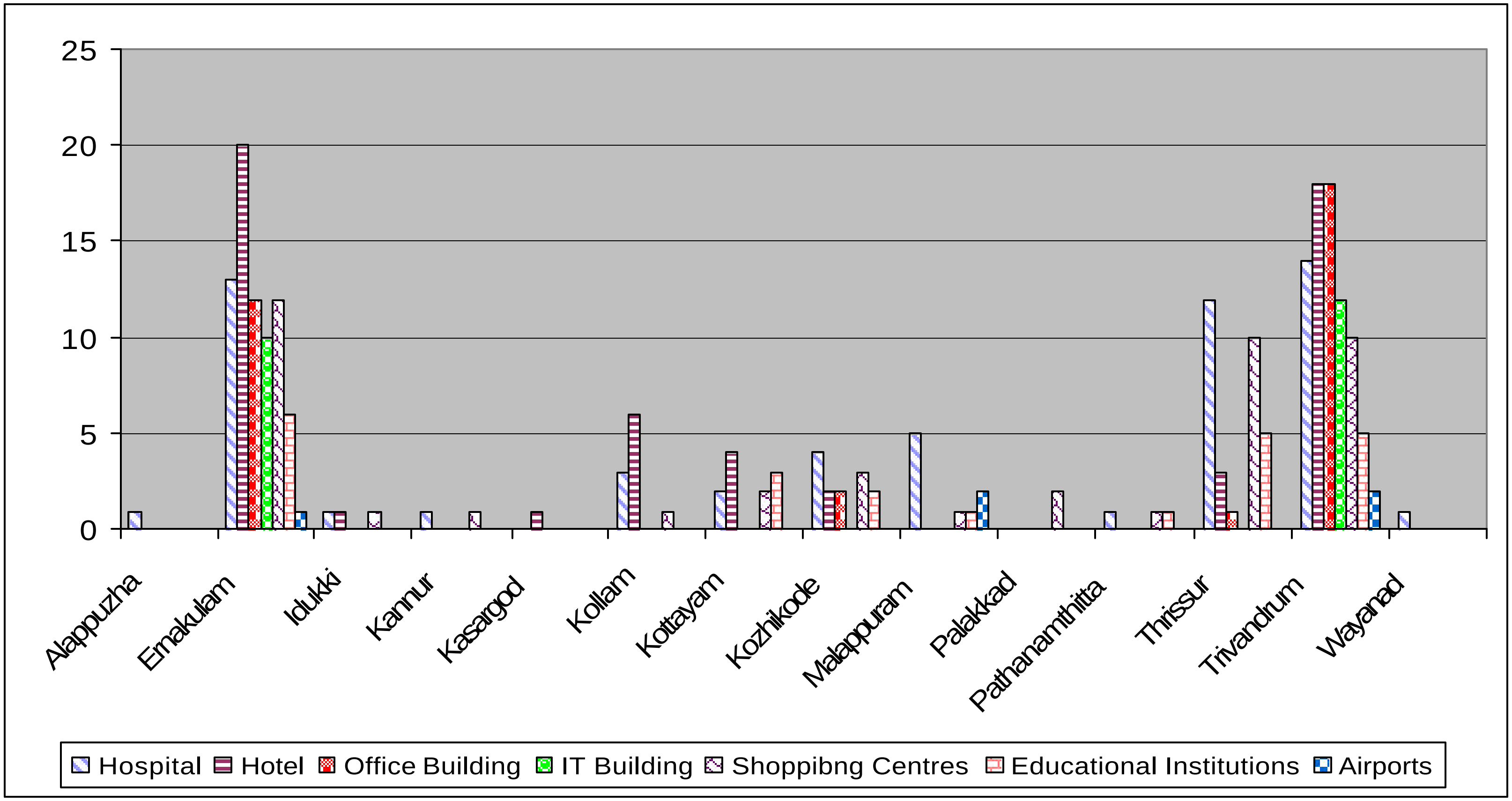
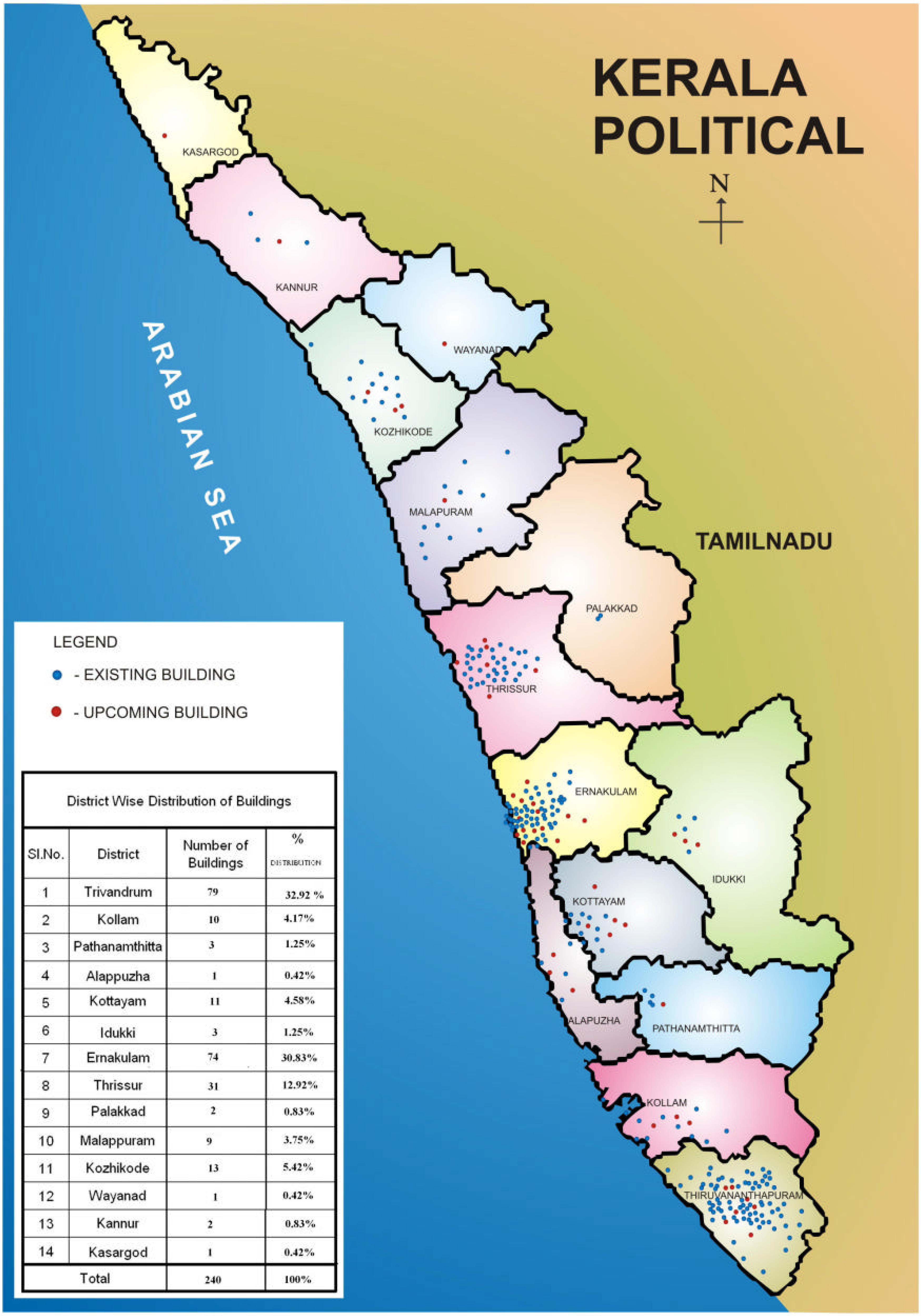


Figure 6: Geographical Distribution of Commercial Buildings Surveyed across the state of Kerala.



District Wise Distribution of Buildings

Sl.No.	District	Number of Buildings	% DISTRIBUTION
1	Trivandrum	79	32.92 %
2	Kollam	10	4.17%
3	Pathanamthitta	3	1.25%
4	Alappuzha	1	0.42%
5	Kottayam	11	4.58%
6	Idukki	3	1.25%
7	Ernakulam	74	30.83%
8	Thrissur	31	12.92%
9	Palakkad	2	0.83%
10	Malappuram	9	3.75%
11	Kozhikode	13	5.42%
12	Wayanad	1	0.42%
13	Kannur	2	0.83%
14	Kasargod	1	0.42%
Total		240	100%

5.5.2. The major districts, where the concentration of commercial buildings is found high are Thiruvananthapuram, Ernakulam, Thrissur and Kozhikode. The geographical distribution of commercial buildings (Existing and upcoming) in these districts are given in the following maps.

Figure 7: Geographical distribution of commercial buildings in Thiruvananthapuram district.

Figure 8: Geographical distribution of commercial buildings in Ernakulam district.

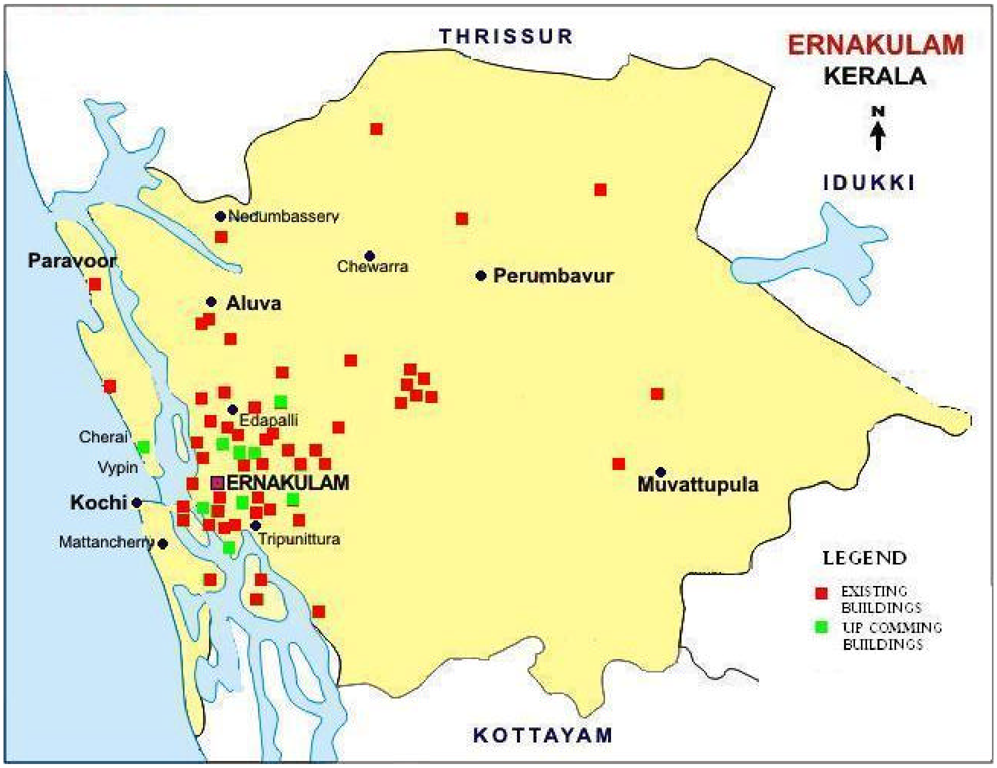


Figure 9: Geographical distribution of commercial buildings in Thrissur district.

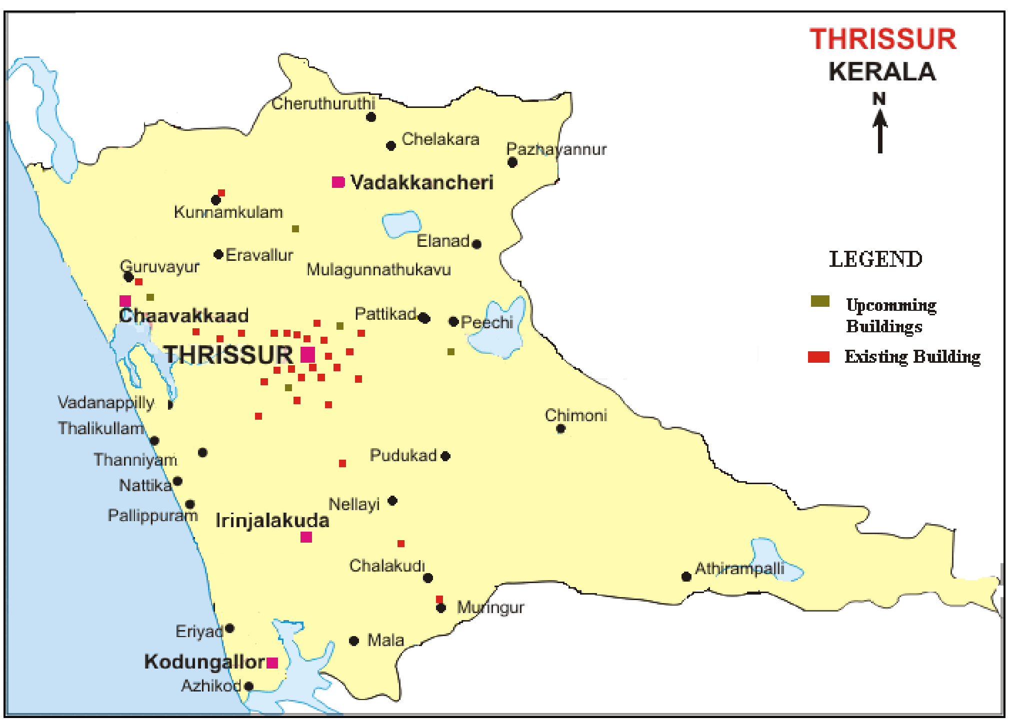


Figure 10: Geographical distribution of commercial buildings in Kozhikode district.

5.6. Building Growth Rate

5.6.1. Growth rate of commercial buildings falling under EC Act 2001 is 3.2% based in an analysis of last 10 years. But there is high growth in buildings having contract demand between 100 kVA & 200 kVA which are 67.7% is the average growth rate in the last 10 years for buildings in this category not falling in the EC Act.

5.6.2. The following table shows the building growth profile in the state of Kerala with contract demand for 100 kVA to 600 kVA & above.

Table 5: Sector Wise Number of New Commercial Buildings with Contract Demand 100 kVA to 600 kVA & above.

Year Contract Demand	Upto 2000 Existing Building	2000 New Building	2001 New Building	2002 New Building	2003 New Building	2004 New Building	2005 New Building	2006 New Building	2007 New Building	2008 New Building	2009 New Building	Total	%ge Distribution of buildings with varying CD bands	Aggregate Growth of buildings with varying CD Bands
100-200	177	14	27	25	23	40	42	51	39	85	99	622	67.7%	251%
200-300	49	9	6	10	12	13	13	12	14	17	13	168	18.1%	243%
300 - 400	19	5	3	3	1	5	2	6	1	6	7	58	5.9%	205%
400 - 500	12	1	-	3	-	2	2	2	2	3	7	34	3.3%	183%
500 - 600	17	-	2	-	2	-	1	3	-	1	2	28	1.7%	65%
600 & Above	23	1	4	3	2	-	2	2	2	4	1	44	3.2%	91%
Total	297	30	42	44	40	60	62	76	58	116	129	954	100	221%

Figure 11: Growth profile of Commercial Buildings in the state of Kerala with different band of Contract Demands.

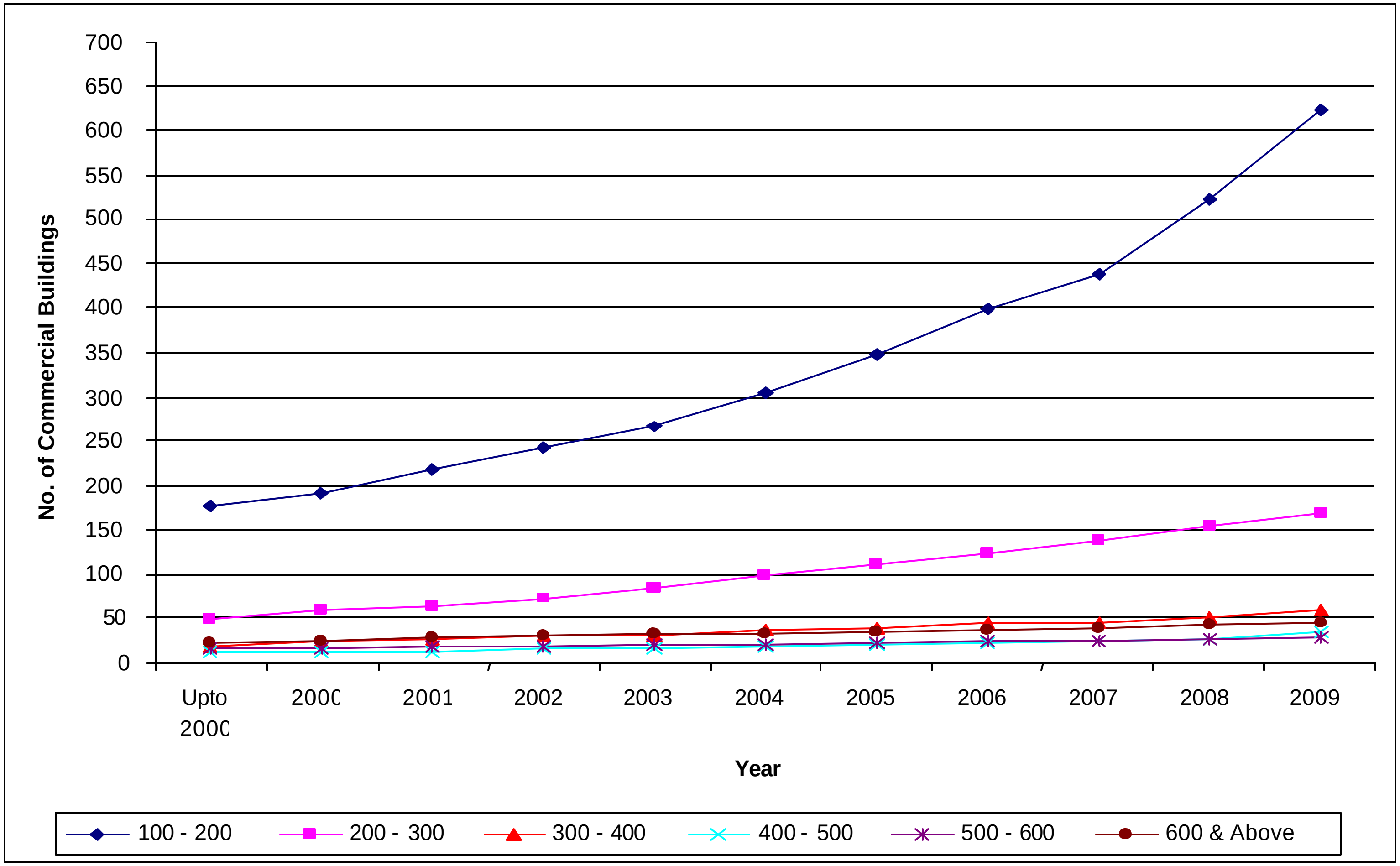
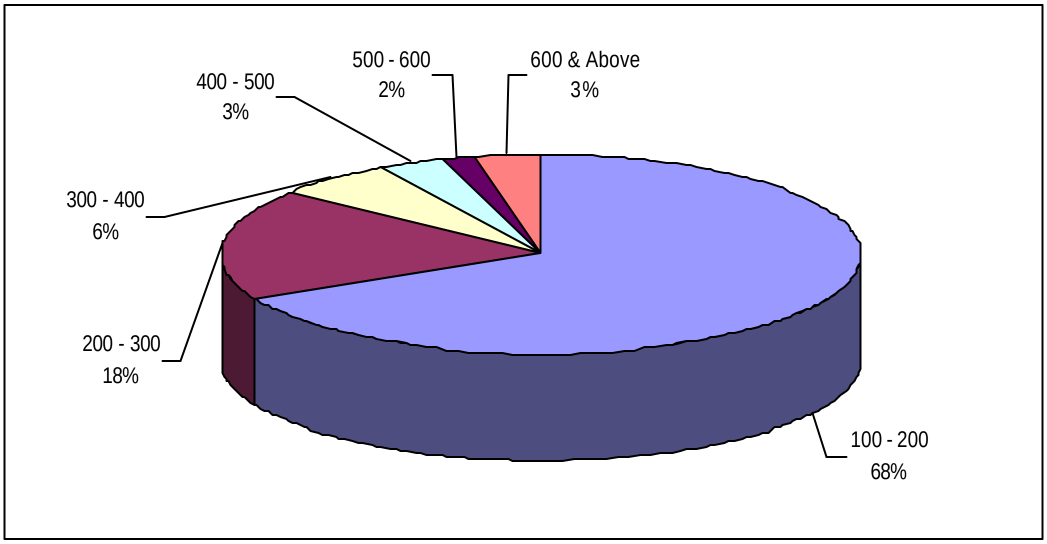


Figure 12: Distribution of New Commercial Buildings came into Existence in the state of Keraladuring the period 2000– 2009.



5.5.1 From the above it is clearly evident that buildings falling in the category of 100-200 kVA have the highest growth rate. Any energy efficiency initiative implemented in this category of buildings would lead to a better energy consumption scenario in the state. Therefore while implementing ECBC in the state of Kerala these buildings may also be included in the act to have a good reduction in Energy demand.

6. ECBC COMPLIANCE SURVEY AND ANALYSIS

6.1. A total of 240 buildings identified in the state of Kerala which fall under EC Act of which 30 selected buildings were selected from different categories for the ECBC compliance survey and detailed analysis.

6.2. The following major areas were covered for the ECBC compliance survey. Please refer *Annexure - I* for the questionnaire used for the detailed compliance survey.

- Building Envelop
  - a. Insulation materials and their R-values
  - b. Fenestration U-factors, SHGC, Visible light transmittance and air leakage
  - c. Overhang and sidefin details
  - d. Envelop sealing details
- Lighting
  - a. Automatic shut off
  - b. Space controls
  - c. Dimmers
  - d. Photo sensors
  - e. Separate control
  - f. Tandem wiring
  - g. Energy efficient lighting
- Electrical power distribution
  - a. Energy efficient transformer
  - b. Proper metering
  - c. Energy efficient motors
- Metering & Monitoring
  - a. kVA & kWh
  - b. Power factor
  - c. Phase & neutral current
  - d. Harmonics (>1000 kVA)
- Power factor
  - a. Average system pf>0.95

b. APFC panels

❖ Service Water Heating

a. Utilizing solar water heating

b. Specifying heating equipment efficiency

c. Maximizing heat recovery and minimizing electric heating

d. Insulating hot water storage tanks and pipelines

e. Reducing standby losses

f. Reducing heat and evaporation losses in heated swimming pools

❖ HVAC system

a. Time clock

b. Dead band of 3 °C

c. VFD for cooling tower

d. Insulation for duct and pipes

6.3. The buildings selected for the compliance survey and analysis were from categories like office, shopping centre, IT Park, Hotel, Hospital, Airport, Educational Institutions etc. The following table shows the number of buildings surveyed from different sectors.

Table 6: Category Wise Distribution of Buildings Surveyed in the State.

Category	Number of Buildings					
	Trivandrum	Cochin	Thrissur	Palakkad	Calicut	Total
Office	1	1				2
Shopping Centre	1	3	1	1	1	7
IT Park	2	5				7
Hotel	2	5				7
Hospital	1	2			1	4
Airport	1	1				2
Educational Institution					1	1
Total	8	17	1	1	3	30

6.4. Consolidated statement of data collected from the survey of 30 selected buildings, which fall under the purview of EC act in the state, is attached as *Annexure- III*.

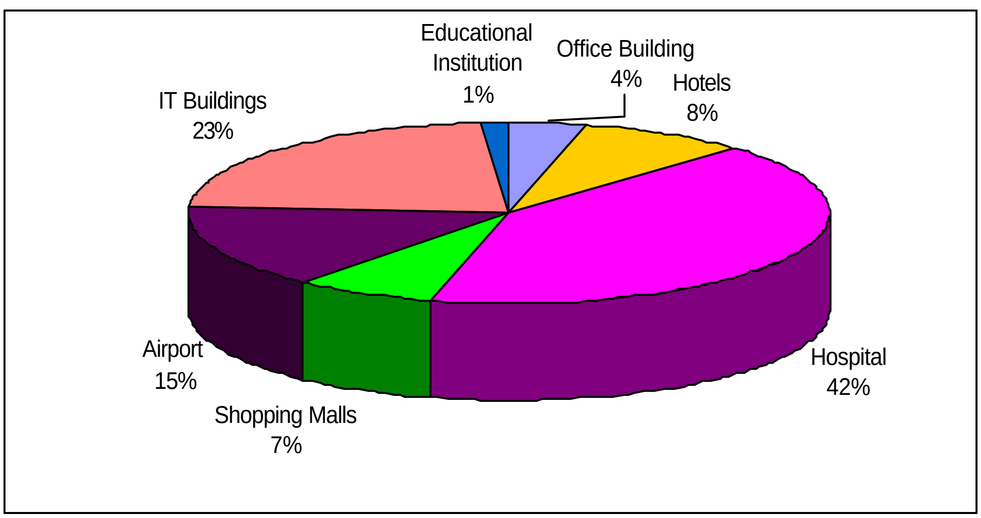
6.5. A rating system has been developed to check compliance of the selected buildings on the mandatory requirements to be followed for an ECBC compliant building. The major areas comes under the mandatory requirements are lighting, Electrical power distribution, HVAC, Metering system, Power factor etc. Refer *Annexure-IV* for the details.

6.6. Energy Distribution in Commercial Buildings in the State of Kerala.

6.6.1. Based on the information received from commercial buildings surveyed, an attempt has been made to project the energy consumption pattern of commercial buildings in the state of Kerala. For this purpose, 62 buildings having contract demand 600 kVA & above has been considered (energy intensive building). From this it is revealed that the major energy consuming sector in the state of Kerala is by Hospitals (42%) followed by IT buildings (23%).

6.6.2. The following figure shows the electricity consumption pattern in various commercial buildings with contract demand 600 kVA and above in the state of Kerala.

Figure 13: Energy Consumption Profile in Commercial Buildings in the State of Kerala. (Contract Demand 600 kVA & above)



6.7. Energy Performance Index (EPI).

Energy Performance Index (EPI) is defined as the Energy consumption of the building per Sq Meter per year.

The EPI of a commercial building varies according to the total built-up area, power consumption, nature of operation and geographical location of the building. Following table shows average energy consumption and EPI of each building (Calculated).

Table 7: Energy Performance Index (EPI) of Various Categories of Buildings Studied Across the State of Kerala.

Sl. No.	Category	Name of building	District	Total Built Up Area (m^2)	Annual Energy Consumption (kWh)	EPI $kWh/m^2/Year$
1	Office	Federal bank Ltd.	Ernakulam	9011	3417000	152.00
2		Government Secretariat	Trivandrum	31140	2028816	65.15
3	Hotels	Abad Hotel (P) Ltd	Ernakulam	7483	2721048	363.63
4		Taj Malabar	Ernakulam	10170	3057452	300.63
5		Taj Kerala Hotels & Resorts	Ernakulam	8803	2355561	267.59
6		Gokulam Park Plaza International	Ernakulam	5618	1543416	274.73
7		Middle East Hotel Company (P) Ltd	Ernakulam	13130	2940000	223.91
8		Kovalam Hotels Ltd.	Trivandrum	27347	5629358	205.85
9		Dodla International	Trivandrum	17658	3910000	221.43
10	Hospitals	Amritha Inst. of Medical Sci. & Res. Centre	Ernakulam	181734	12015000	66.11
11		Lakeshore Hospital & Research Centre Ltd	Ernakulam	20965	7078000	337.61
12		Malabar Institute of Medical Science Ltd	Kozhikode	37520	4568892	121.77
13		Kerala Institute of Medical Sciences	Trivandrum	27881	5900000	211.61
14	Shopping Centers	Kalyan Silks Trichur (P) Ltd	Ernakulam	12082	1832970	151.71
15		Seematty Textiles	Ernakulam	6192	2160765	348.96
16		Oberon Edifices &Estates (P) Ltd	Ernakulam	34967	5340632	152.73
17		Focus Mall	Kozhikode	22366	1716380	76.74
18		Malabar Castle (P) Ltd. (Big Bazar)	Trivandrum	6413	1480000	230.78
19		Big Bazar	Thrissur	6243	1220800	195.55
20		City Centre (Big Bazar)	Palakkad	5109	1399789	273.98

Sl. No.	Category	Name of building	District	Total Built Up Area (m^2)	Annual Energy Consumption (kWh)	EPI kWh/m^2/Year
21	IT Buildings	L&T Technopark	Ernakulam	37080	3254000	87.76
22		Vismaya Infopark	Ernakulam	22028	6870000	311.88
23		Thapasya Infopark	Ernakulam	13000	2844335	218.79
24		Wipro Technologies Ltd.	Ernakulam	87198	6299025	72.24
25		Muthoot Technopolis	Ernakulam	32993	5671135	171.89
26		Electronics Technology Park	Trivandrum	79000	7767455	98.32
27		IBS Software Services (P) Ltd	Trivandrum	8268	1996000	241.41
28	Airports	Cochin international airport ltd.	Ernakulam	74000	12499846	168.92
29		International Airport Authority of India	Trivandrum	29153	9600000	329.30
30	Educational Institution	Indian Institute of Management	Kozhikode	48400	1920200	39.67

6.8. Energy Performance Index & Star Labeling

6.8.1. From the data collected as per the questionnaire, the energy performance index (EPI) of each building is calculated (Refer table 7). Based on BEE's building energy star rating programme, the present star ratings of these buildings were determined considering their percentage air conditioned area and climatic zone. The state of Kerala belongs to warm & humid climate zone (Source: ECBC user guide). The table-8 shows the details of energy star rating given to 30 different commercial buildings selected for the study which fall under the EC act. (Refer *Annexure V & VI* for BEE's star rating programme and different climatic zones in India).

6.8.2. From this we could find that only 4 buildings are falling in five star category. This indicates that there is a good scope for improving energy efficiency in other buildings.

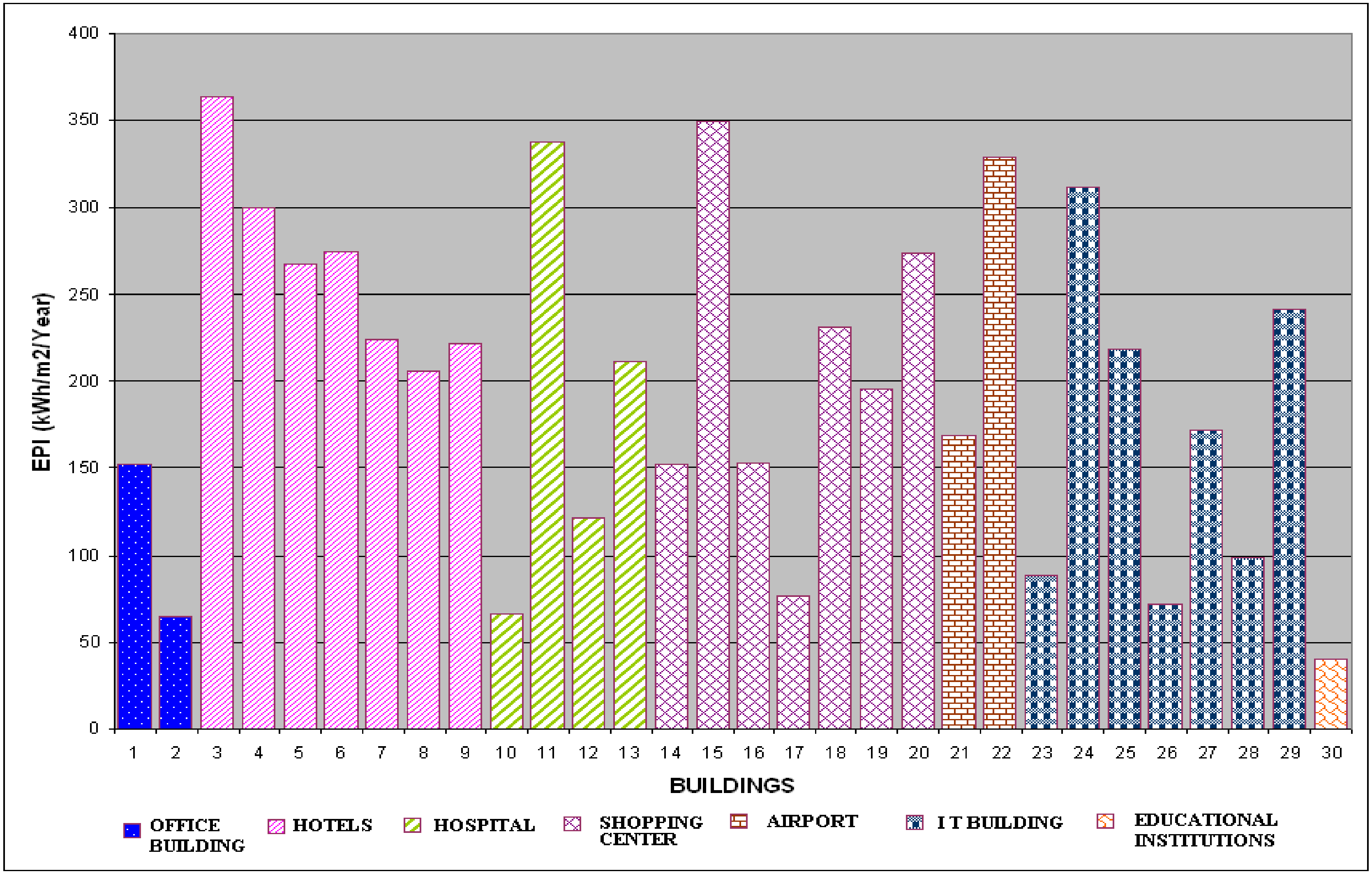
Table 8: Energy Performance Index & Star Labeling of Buildings Surveyed in the State of Kerala.

Building No	Category	Name of Building	Built Up Area (m^2)	% Air Conditioned Area	EPI kWh/m^2 /Year	Star Rating
1	Office	Federal bank Ltd.	9010	59%	152	2
2		Government Secretariat	31140	25%	65	2
3	Hotel	Abad Hotel (P) Ltd	7483	70%	364	0
4		Taj Malabar	10170	58%	300	0
5		Taj Kerala Hotels & Resorts	8803	51%	268	0
6		Gokulam Park Plaza International	4885	81%	275	0
7		Middle East Hotel Company (P) Ltd	13130	75%	224	0
8		Kovalam Hotels Ltd.	27347	26%	206	0
9	Hospital	Dodla International	17651	80%	221	0
10		Amritha Inst. of Medical Sci. & Res. Centre	181734	11%	66	2
11		Lakeshore Hospital & Research Centre Ltd	20965	38%	338	0
12		Malabar Institute of Medical Science Ltd	37520	60%	122	4
13		Kerala Institute of Medical Sciences	27870	67%	212	0

Building No	Category	Name of Building	Built Up Area (m^2)	% Air Conditioned Area	EPI kWh/m^2/ Year	Star Rating
14	Shopping malls	Kalyan Silks Trichur (P) Ltd	12082	54%	152	2
15		Seematty Textiles	6192	79%	349	0
16		Oberon Edifices &Estates (P) Ltd	34967	50%	153	2
17		Focus Mall	22366	57%	77	5
18		Malabar Castle (P) Ltd. (Big Bazar)	6413	68%	231	0
19		Big Bazar	6242	84%	196	1
20		City Centre (Big Bazar)	5109	85%	274	0
21	Airport	Cochin international airport ltd.	74000	56%	169	2
22		International Airport Authority of India	29153	82%	329	0
23	IT Park	L&T Technopark	37080	97%	88	5
24		Vismaya Infopark	22028	79%	312	0
25		Thapasya Infopark	13000	77%	219	0
26		Wipro Technologies Ltd.	87198	77%	72	5
27		Muthoot Technopolis	32993	85%	172	2
28		Electronics Technology Park	79000	49%	98	0
29		IBS Software Services (P) Ltd	8268	87%	241	0
30	Educational Institution	Indian Institute of Management	48400	59%	40	5

6.8.3. Figure 14 shows the category wise comparison of EPI of buildings selected for the study.

Figure 14: Category wise Comparison of EPI of the buildings selected for the Survey.



6.9. ECBC Compliance Check

6.9.1. ECBC compliance check was conducted for the selected 30 buildings. From this a compliance matrix was developed consisting of 21 parameters as detailed below.

Table 9: ECBC Compliance Parameters

Area	Parameters
Building Envelop	1. Insulation materials and their R-values 2. Fenestration U-factors, SHGC, Visible light transmittance and air leakage 3. Overhang and sidefin details 4. Envelop sealing details
Lighting	1. Automatic shut off for lights 2. Space controls 3. Dimmers for lighting 4. Photo sensors for external lighting 5. Separate control for luminaries 6. Tandem wiring 7. Energy efficient external lighting
Electrical power distribution system	1. Energy efficient transformers 2. Additional metering for TFR loss calculation 3. Energy efficient motors
Proper metering system provided	1. kWh & kVA 2. Power Factor 3. Phase Current 4. Neutral Current 5. Current harmonics (>1000 kVA CD)
Power factor	1. Average system pf (>0.95) 2. APFC provided
HVAC system	1. Time clock provided 2. Dead band of 3 ^{0}C provided 3. VFD for CT fan 4. Insulation for piping and duct working
Service Water Heating	g. Utilizing solar water heating h. Specifying heating equipment efficiency i. Maximizing heat recovery and minimizing electric heating j. Insulating hot water storage tanks and pipelines k. Reducing standby losses l. Reducing heat and evaporation losses in heated swimming pools

6.9.2. Based on the above matrix ratings were assigned to each building in percentage for its level of compliance on the above parameters. The following table shows the ECBC compliance rating in percentage for each building selected for the study.

Table 10: ECBC Compliance Ratings of different buildings Surveyed

Sl No:	Category	Building Name & location	Percentage ECBC Compliance					ECBC Compliance of the building (%ge)
			Lighting	Electrical power	Metering system	Power factor	HVAC system	
1	Office	Federal Towers cochin	43%	0%	75%	100%	50%	55%
2	Office	Secretariat Trivandrum	29%	0%	60%	100%	0%	33%
3	Hotel	Abad Plaza Cochin	57%	0%	75%	50%	50%	55%
4	Hotel	Taj Malabar Cochin	100%	0%	75%	100%	67%	80%
5	Hotel	Gateway Hotel, Cochin	71%	0%	75%	100%	50%	65%
6	Hotel	Gokulam Park inn Cochin	43%	0%	75%	100%	50%	55%
7	Hotel	Middle East hotel co ltd (Dreams) Cochin	86%	0%	75%	100%	67%	75%
8	Hotel	Dodla International (Taj) Trivandrum	100%	0%	75%	100%	50%	75%
9	Hotel	Kovalam hotel (leela)	57%	67%	100%	100%	33%	70%
10	Hospital	Amritha institute of medical science Cochin	29%	67%	60%	100%	67%	62%
11	Hospital	Lakeshore Hospital Cochin	43%	0%	75%	50%	33%	45%
12	Hospital	KIMS Trivandrum	43%	0%	100%	100%	50%	60%
13	Hospital	MIMS Calicut	71%	0%	60%	100%	33%	57%

Sl No:	Category	Building Name & location	Lighting	Electrical power	Metering system	Power factor	HVAC system	ECBC Compliance of the building (%ge)
14	Shopping Center	Kalyan Silks Cochin	43%	0%	50%	100%	50%	50%
15		Seematti Cochin	43%	0%	60%	100%	17%	43%
16		Oberon Mall Cochin	29%	0%	60%	100%	50%	48%
17		Focus Mall Calicut	43%	33%	100%	50%	33%	55%
18		Malabar Castle (Big Bazaar) trivandrum	43%	33%	75%	100%	50%	60%
19		Big Bazar Thrissur	43%	0%	75%	100%	50%	55%
20		Big Bazar Calicut	43%	33%	75%	50%	50%	55%
21	Airport	CIAL	43%	67%	60%	100%	17%	52%
22		Trivandrum Airport	71%	0%	60%	100%	17%	52%
23	IT Building	L&T Techno park Cochin	100%	67%	80%	100%	67%	90%
24		Vismaya, Infopark	57%	33%	100%	100%	67%	76%
25		Thapasya, Infopark	29%	67%	100%	100%	17%	57%
26		Electronics Technology park	43%	0%	100%	100%	50%	62%
27		IBS	43%	100%	100%	100%	67%	81%
28		Wipro Ltd.	57%	100%	60%	100%	67%	76%
29		Muthoot Technopolis	57%	67%	60%	100%	67%	71%
30	Educational Institution	IIM Calicut	43%	0%	75%	50%	17%	40%

6.9.3. By comparing table 8 & 10 it can be noted be noted that apart from ECBC Compliance, factors like multiple mixed use activities within the same building, (e.g. some shopping malls have a Cineplex and others were shopping-cum-office complexes), have a distinct impact on its energy performance index. Further divergence in energy performance index across buildings irrespective of their ECBC compliance rating is due to the different level of air-conditioned area.

6.10. LEED Rated building in the State of Kerala

6.10.1. Green building design is a practical and climate conscious approach to building design. Various factors, like geographical location, prevailing climatic conditions, use of locally available and low embodied energy materials and design parameters relevant to the type of usage of the building are normally taken into consideration. Such an approach ensures minimum harm to the environment, while constructing and using the building.

6.10.2. A green building uses minimum amount of energy, consumes less water, conserves natural resources, generates less waste and creates space for healthy and comfortable living.

6.10.3. The anticipated long term benefits of green building are

- Reduction in power demand by factory buildings
- Reduction in GHG emissions
- Reduction in potable water consumption
- Increase of green cover in new factory premises, thereby reducing heat island effect
- Recharge of aquifers with storm water
- Enhanced indoor air quality leading to at least 1% productivity gains

6.10.4. **IGBC Green Factory Building Rating System**

6.10.5. IGBC Green Factory Building rating addresses green features under the following categories:

- Site Selection and Planning
- Water Conservation
- Energy Conservation
- Material Conservation
- Indoor Environment Quality and Occupational Health

- Innovation & Design Process

6.10.6. Different levels of green building certification are awarded based on the total credits learned. However, every Green factory building should meet certain mandatory requirements, which are non-negotiable.

The various levels of rating awarded are:

- 'Certified' to recognize best practices
- 'Silver' to recognize outstanding performance
- 'Gold' to recognize national excellence
- 'Platinum' to recognize global leadership

6.10.7. **Evaluation procedure of criterion of LEED**

IGBC Green Factory Building Rating System		
	Site Selection & Planning	**Available Points**
Mandatory Requirement 1	**Compliance with Local Regulations**	
Mandatory Requirement 2	**Soil Erosion Prevention & Control**	
SS Credit 1	Contaminated Site Remediation	1
SS Credit 2	Access to Public Transport / Shuttle Services	3
SS Credit 3	Basic Amenities	2
SS Credit 4	Natural Topography and Landscape, 20%, 30%	2
SS Credit 5	Heat Island Effect on Roof and Parking Areas	4
SS Credit 6	Non Fossil Fueling Facility for Vehicles	1
SS Credit 7	Design for Differently Abled	2
SS Credit 8	Night Sky Pollution Reduction	1 **16**
	Water Conservation	
Mandatory Requirement 1	**Rainwater Harvesting, 50% Roof and Non - Roof Run-Off**	
Mandatory Requirement 2	**Low Flow Water Fixtures**	
WC Credit 1 WC Credit 2	Limit Turf Area, 20%, 30%, 40% Drought Tolerant Species, 30%, 40%	3 2
WC Credit 3	Management of Irrigation System	2

WC Credit 4	Rainwater Harvesting, 75%, 95%	6
WC Credit 5	Non-process Wastewater - Treatment, 75%, 95%	4
WC Credit 6	Water Use Reduction, 20%, 30%	4
		21
Energy Conservation		
Mandatory Requirement 1	**CFC-Free Equipment**	
Mandatory Requirement 2	**Minimum Energy Performance**	
EC Credit 1	HCFC Free / Low Impact HCFC Equipment	1
EC Credit 2	Optimise Energy Performance, 10%, 12.5%, 15%, 17.5%	6
EC Credit 3	Metering	2
EC Credit 4	On-site Renewable Energy,5%,10%, 15%	6
EC Credit 5	Green Power, 50%, 75%, 100%	6
EC Credit 6	Eco-friendly Captive Power Generation for Factory Building Requirement	2
		23
Material Conservation		
Mandatory Requirement 1	**Handling of Non-process Waste (Post Occupancy)**	
MC Credit 1	Waste Reduction During Construction, 50%, 75%	2
MC Credit 2	Materials with Recycled Content, 10%,20%	2
MC Credit 3	Local Materials, 50%, 75%	4
MC Credit 4	Material Reuse, 5%, 10%	4
MC Credit 5	Certified Wood/ Rapidly Renewable Building Materials and Furniture, 50%, 75%	4
		16
Indoor Environment Quality and Occupational Health		
Mandatory Requirement 1	**Tobacco Smoke Control**	
Mandatory Requirement 2	**Minimum Fresh Air Requirements**	
Mandatory Requirement 3	**Avoid Use of Asbestos in the Building**	
IEQ Credit 1	Improved Fresh Air Ventilation	4
IEQ Credit 2	Building Flush Out	2

IEQ Credit 3	Day Lighting 50%, 75%, 95%	6
IEQ Credit 4	Low VOC Materials	2
IEQ Credit 5	Reduction of Workmen Fatigue (Break out spaces)	2
Indoor Environment Quality and Occupational Health		
IEQ Credit 6	Eco-friendly Housekeeping Chemicals	1
IEQ Credit 7	Aerobic & Cardiovascular Gymnasium	2
		19
Innovation in Design		
ID Credit 1.1	Innovation in Design	1
ID Credit 1.2	Innovation in Design	1
ID Credit 1.3	Innovation in Design 1	1
ID Credit 1.4	Innovation in Design	1
ID Credit 2	IGBC AP	1
		5
	Total Points	**100**

6.10.8. **IGBC Green Factory Building Certification Levels**

Certification Level	Points
Certified	51-60
Silver	61-70
Gold	71-80
Platinum	81-100

6.10.9. As per the scope of study 2.2.3, commercial buildings which are LEED rated/ planning to apply for LEED rating were identified. Only two buildings identified with LEED rating in the state of Kerala and are given below.

Table 11: LEED Rated Green Buildings in Kerala.

Project	Location	Rating
Wipro Technologies	Kochi	Gold
Leadership Development Institute, TCS	Thiruvananthapuram	Silver

6.11. GRIHA Rating System for Building

6.11.1. GRIHA, an acronym for Green Rating for Integrated Habitat Assessment, is the National Rating System of India. It has been conceived by TERI and developed jointly with the Ministry of New and Renewable Energy, Government of India. It is a green building 'design evaluation system', and is suitable for all kinds of buildings in different climatic zones of the country.

6.11.2. 'Abode'. Human Habitats (Buildings) interact with the environment in various ways. Throughout their life cycles, from construction to operation and then demolition, they consume resources in the form of energy, water, materials, etc. and emit wastes either directly in the form of municipal wastes or indirectly as emissions from electricity generation. GRIHA attempts to minimize a building's resource consumption, waste generation, and overall ecological impact to within certain nationally acceptable limits / benchmarks.

6.11.3. **The benefits**

6.11.3.1. On a broader scale, this system, along with the activities and processes that lead up to it, will benefit the community at large with the improvement in the environment by reducing GHG (greenhouse gas) emissions, reducing energy consumption and the stress on natural resources. Some of the benefits of a green design to a building owner, user, and the society as a whole are as follows:

- Reduced energy consumption without sacrificing the comfort levels
- Reduced destruction of natural areas, habitats, and biodiversity, and reduced soil loss from erosion etc.
- Reduced air and water pollution (with direct health benefits)
- Reduced water consumption
- Limited waste generation due to recycling and reuse
- Reduced pollution loads
- Increased user productivity
- Enhanced image and marketability

6.11.4. **Rating System**

6.11.5. GRIHA rating system consists of 34 criteria categorized under various sections such as Site Selection and Site Planning, Conservation and efficient utilization of resources, Building operation and maintenance, and Innovation points. Eight of these 34 criteria are mandatory, four are partly mandatory, while the rest are optional. Each criterion has a number of points assigned to it. It means that a project intending to meet the criterion would qualify for the points. Different levels of certification (one star to five stars) are awarded based on the number of points earned. The minimum points required for certification is 50.

6.11.6. **Evaluation procedure of criterion of GRIHA**

List of criteria	Points	Remarks
Criteria 1: Site Selection	1	Partly mandatory
Criteria 2: Preserve and protect landscape during construction /compensatory depository forestation.	5	Partly mandatory
Criteria 3: Soil conservation (post construction)	4	
Criteria 4: Design to include existing site features	2	Mandatory
Criteria 5: Reduce hard paving on site	2	Partly mandatory
Criteria 6: Enhance outdoor lighting system efficiency	3	
Criteria 7: Plan utilities efficiently and optimize on site circulation efficiency	3	
Criteria 8: Provide, at least, minimum level of sanitation/safety facilities for construction workers	2	Mandatory
Criteria 9: Reduce air pollution during construction	2	Mandatory
Criteria 10: Reduce landscape water requirement	3	
Criteria 11: Reduce building water use	2	
Criteria 12: Efficient water use during construction	1	
Criteria 13: Optimize building design to reduce conventional energy demand	6	Mandatory
Criteria 14: Optimize energy performance of building within specified comfort	12	
Criteria 15: Utilization of fly ash in building structure	6	

Criteria 16: Reduce volume, weight and time of construction by adopting efficient technology (e.g. pre-cast systems, ready-mix concrete, etc.)	4	
Criteria 17: Use low-energy material in interiors	4	
Criteria 18: Renewable energy utilization	5	Partly mandatory
Criteria 19: Renewable energy based hot-water system	3	
Criteria 20: Waste water treatment	2	
Criteria 21: Water recycle and reuse (including rainwater)	5	
Criteria 22: Reduction in waste during construction	2	
Criteria 23: Efficient waste segregation	2	
Criteria 24: Storage and disposal of waste	2	
Criteria 25: Resource recovery from waste	2	
Criteria 26: Use of low - VOC paints/ adhesives/ sealants.	4	
Criteria 27: Minimize ozone depleting substances	3	Mandatory
Criteria 28: Ensure water quality Criteria 29: Acceptable outdoor and indoor noise levels	2 2	Mandatory
Criteria 30: Tobacco and smoke control Criteria 31: Universal Accessibility	1 1	
Criteria 32: Energy audit and validation		Mandatory
Criteria 33: Operations and maintenance protocol for electrical and mechanical equipment	2	Mandatory
Total score	100	
Criteria 34: Innovation (Beyond 100)	4	
Total score	**104**	

6.11.7. **Scoring points for GRIHA**

Points scored	Rating
50–60	One star
61-70	Two star
71-80	Three star
81-90	Four star
91-100	Five star

6.11.8. Building Applied for GRIHA Rating in the State of Kerala.

Only one building found to be applied for GRIHA rating in the state of Kerala.

- Indian Institute of Science Education and Research – Thiruvananthapuram

6.12. Energy Conservation Opportunities identified in Commercial Buildings in different Sectors

6.12.1. The Kerala State Productivity Council (KSPC), one of the pioneer energy auditing firms in the state of Kerala, has been doing energy audits since 1993. Based on the past experience in conducting investment grade detailed energy audit and the present survey findings, the major areas for energy efficiency improvement in commercial building sector are identified. The following table shows savings potential in each category by implementing the energy efficiency measures in the suggested areas. A brief description of energy efficiency measures in the identified areas are given in 6.13.

Table 12: Major Energy Conservation Areas Identified in different category Commercial buildings

Category	Major Energy Saving Areas	Saving Potential
Hospital	1. Lighting 2. Power Factor Improvement 3. HVAC 4. Pumping system 5. Service water heating	20%
Hotel	1. Lighting 2. HVAC 3. Pumping System 4. Service water heating	20%
Office Building	1. HVAC 2. Lighting 3. Power Factor Improvement	25%
IT Building	1. HVAC 2. Lighting 3. Power Factor Improvement 4. Pumping System	25%

Category	Major Energy Saving Areas	Saving Potential
Shopping Centre	1. HVAC 2. Lighting 3. Electrical motors 4. Power Factor improvement	20%
Airport	1. Lighting 2. Electrical Motors 3. HVAC 4. Pumping System 5. Power Factor Improvement 6. Compressed Air System	15%
Educational Institution	1. Lighting 2. HVAC 3. Pumping System	15%

6.13. Major Energy Conservation Opportunities in Commercial Buildings.

6.13.1. Lighting system

a. Maximize sunlight use through use of transparent roof sheets, north light roof, etc.

b. Scope for replacements of lamps by more energy efficient lamps, with due consideration to luminaries, color rendering index, lux level as well as expected life comparison.

c. Replace conventional magnetic ballasts by more energy efficient ballasts, with due consideration to life and power factor apart from watt loss.

d. Select interior colors for light reflection.

Image 1: Internal lighting provided

e. Modify layout for optimum lighting.

f. Providing individual / group controls for lighting for energy efficiency such as:

- On / off type voltage regulation type (for illuminance control)
- Group control switches / units
- Occupancy sensors
- Photocell controls
- Timer operated controls
- Pager operated controls
- Computerized lighting control programs

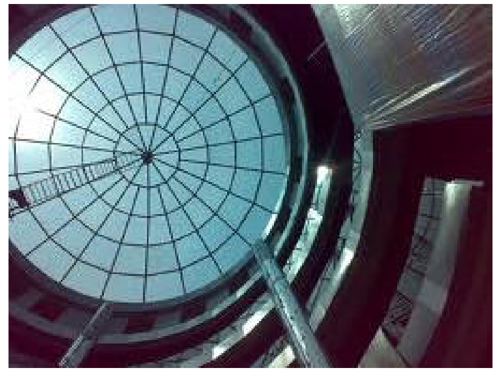


Image 2: Natural Lighting

g. Install input voltage regulators / controllers for energy efficiency as well as longer life expectancy for lamps where higher voltages, fluctuations are expected.

h. Replace energy efficient displays like LED's in place of lamp type displays in control panels / instrumentation areas, etc.

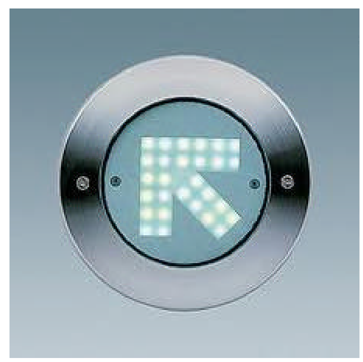


Image 3: LED Exit sign

6.13.2. HVAC System

a) Cold Insulation

Insulate all cold lines / vessels using economic insulation thickness to minimize heat gains; and choose appropriate (correct) insulation.

Image 4: Chiller unit

b) Building Envelop

Optimize air conditioning volumes by measures such as use of false ceiling and segregation of critical areas for air conditioning by air curtains.

c) Building Heat Loads Minimisation

Minimise the air conditioning loads by measures such as roof cooling, roof painting, efficient lighting, pre-cooling of fresh air by air- to-air heat exchangers, variable volume air system, optimal thermo-static setting of temperature of air conditioned spaces, sun film applications, etc.

d) Process Heat Loads Minimisation

Minimize process heat loads in terms of TR capacity as well as refrigeration level, i.e., temperature required, by way of:

i) Flow optimization

ii) Heat transfer area increase to accept higher temperature coolant

iii) Avoiding wastages like heat gains, loss of chilled water, idle flows.

iv) Frequent cleaning / de-scaling of all heat exchangers

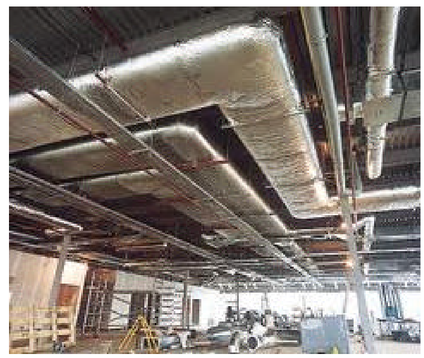


Image 5: HVAC Duct

e) At the Refrigeration A/C Plant Area.

i) Ensure regular maintenance of all A/C plant components as per manufacturer guidelines.

ii) Ensure adequate quantity of chilled water and cooling water flows, avoid bypass flows by closing valves of idle equipment.

iii) Minimize part load operations by matching loads and plant capacity on line; adopt variable speed drives for varying process load.

iv) Make efforts to continuously optimize condenser and evaporator parameters for minimizing specific energy consumption and maximizing capacity.

v) Adopt VAR system where economics permit as a non-CFC solution.

6.13.3. **Electrical System**

a) Electrical motors

i) Avoid voltage variation/ unbalance

ii) Replacement of inefficient motors with energy efficient motors

iii) Avoid the usage of oversized motors

iv) Replace the existing motor rewounded more than three times as its efficiency reduces in each rewinding.

v) Usage of Soft starters with energy saver

vi) Provide Variable speed drives for loads with varying demands.

vii) Avoid the idle running of motors

viii) Provide capacitors at load end for high rated motors to improve the power factor and hence reduce energy loss.

Image 6: Power Distribution panel

b) Electrical Load Management

i) *Maximum demand controllers*:

- Maximum Demand Controller is a device designed to meet the need of industries conscious of the value of load management.
- Alarm is sounded when demand approaches a preset value.

ii) Automatic power factor controllers

- APFCR is installed to switch ON & switch OFF capacitors for PF correction.
- Different types of APFCR available are Same rating Capacitor switching, Appropriate rating Capacitor switching & Static VAR Control switching.

iii) Reactive Power Compensation

- Reactive component of the network is reduced and so also the total current in the system from the source end.
- I2R power losses are reduced in the system because of reduction in current.
- Voltage level at the load end is increased.
- kVA loading on the source generators as also on the transformers and lines upto the capacitors reduces giving capacity relief. A high power factor can help in utilising the full capacity of your electrical

system.

iv) Operation of Captive Generation and Diesel Generation Sets.

v) Shedding of Non-Essential Loads.

vi) Storage of Products/in process material/ process utilities like refrigeration.

vii) Rescheduling of Loads.

c) Transformers

i) Use energy efficient transformers as its losses are less compared to ordinary transformer.

ii) Parallel operation of transformers.

iii) Optimum loading of transformers to have better operating efficiency.

iv) Relocation of transformers and sub-stations near to load centers, reducing LT network and hence distribution losses.

Image 7: Energy Efficient Transformer

6.13.4. **Pumping System**

i) Conduct water balance study to minimize water consumption

ii) Avoid idle cooling water circulation in DG sets, compressors, refrigeration systems

iii) In multiple pump operations, judiciously mix the operation of pumps and avoid throttling.

Image 8: Pumping System

iv) Have booster pump for few areas of higher head

v) Replace old pumps by energy efficient pumps

vi) In the case of over designed pump, provide variable speed drive, trim / replace impeller or replace with correct sized pump

vii) Give efficiency of the pump due consideration while selecting a pump.

viii) Select pumps to match head flow requirements.

ix) Select a motor to match the load with high efficiency.

x) Optimize the piping design.

xi) Monitor all important system parameters like: motor kW, pump head, flow temperature.

xii) Use pumps in series and parallel so that mismatch in system design or variations in operating conditions can be handled properly.

xiii) Use variable speed drives for variations of flow due to process requirement.

xiv) If the head flow is higher than needed by 5 to 15%, (i) The existing impeller should be trimmed to a smaller diameter, (ii) or a new impeller with a smaller diameter is to be put.

xv) In multistage pumps, add or remove stages to the existing pump, allowing an increase / decrease in delivered head of flow, if required

6.13.5. Service Water Heating System

i) Utilize solar water heating

ii) Specify heating equipment efficiency

iii) Maximize heat recovery and minimizing electric heating

iv) Insulate hot water storage tanks and pipelines

v) Reduce standby losses

vi) Reduce heat and evaporation losses in heated swimming pools

Image 9: Solar Water Heating System

7. OBSERVATIONS AND SUGGESTIONS

7.1 By comparing ECBC compliance rating and EPI of selected buildings considered for the study it can be understand that apart from ECBC compliance factors like multiple mixed use activities within the same building (e.g. Some shopping malls have a Cineplex and others were shopping cum office complexes), have a distinct impact on the EPI. Further divergence in EPI across buildings irrespective of their ECBC compliance rating is due to the different level of air conditioned area.

7.2 From the survey and analysis we could see wide variation in the EPI of buildings from the same category. In the case of Reserve Bank of India, Foreign Exchange Division Cochin the EPI is 99 kWh/ M^2/Year, where as in the case of Federal towers Cochin which is having similar kind of operation is having an EPI of 152 kWh/ M^2/Year. According to BEE standards, the Reserve Bank is a 5 star rated building and Federal Bank would be 2 star rated building. The variation in EPI of these buildings is due to the varying operating hours of the buildings in a year (average 252x8 hours for Reserve Bank and 313x8 for Federal Bank). Therefore while calculating the EPI of buildings for assigning the star ratings, the annual operating hours of buildings must also be considered to get the exact picture of their energy performances.

7.3 Similarly in the case of hotel sector the EPI will be different for business hotels, luxury hotels and resorts. The occupancy of these hotels is the deciding factor while calculating the EPI. In the case of The Gateway Hotel, Cochin (business hotel with an EPI of 267.59) and Taj Malabar, W. Island Cochin (luxury hotel with an EPI of 300.63), the difference in EPI is about 33 kWh/m2/year. Therefore there must be separate systems for calculating EPI for different classes of hotels.

7.4 In IT sector, there is huge difference in EPI for different IT buildings. The major reason for this difference in EPI is due to the fact that some IT buildings have data centers which are energy guzzlers and this will have huge impact on their EPI.

7.5 From the study it could be seen that some buildings with a contract demand of 100 kVA is having connected load of 500 kW & more. As per the EC Act, any commercial building having a connected load of 500 kW & more or contract demand 600 kVA & more will fall under the purview of ECBC. From the above fact, buildings with contract demand of 100 kVA can also fall under the EC Act. It may be noted that contract demand is more indicative of the energy consumption of a building than its connected load. Also from the discussion on building growth in commercial building in paragraph 5.5.3, it can be seen that growth rate of 100 to 200 kVA contract demand buildings is the highest. Therefore it will be only prudential to reduce contract demand criteria to a lower value for bringing more buildings that can create an impact on states energy scenario under the purview of ECBC.

7.6 Any commercial buildings who are willing voluntarily to come under the EC Act should be encouraged with tax rebate and incentives. This will enhance positive benefits of ECBC reaching more buildings.

7.7 Local climate variations with in the state should be accounted in ECBC. There may be multiple zones in Kerala like coastal, plateau and high range.

7.8 The procedure for compliance verification and approval can be as follows.

7.8.1 The applicant may send the building scheme with ECBC compliance matrix to the approving agency for approval with a copy to SDA. Approving authority's trained personal may confirm the compliance or furnish deficiency report if any for resubmission. SDA can also undertake compliance verification and preparation of report. SDA will forward its report/approval to the applicant as well as to the approving authority. SDA will provide compliance certificate to the approving authority with a copy to the owner within a period of one month. In the wake of no deficiency in the compliance matrix provided by the applicant, SDA may provide a compliance certificate to approving authority with a copy to the building owner.

7.8.2 The entire process of verification and approval should ensure that the approval takes place during the design stage itself to avoid any large scale retrofit at a later stage.

7.8.3 During the compliance check, all electrical systems may be inspected by Electrical Inspectorate; and all other aspects including building envelope by the Chief Town Planner/ District Town Planner. Inspection report should be filed to the SDA with a copy to the LSGI. LSGI should scrutinize these compliance reports and attach with their pre commission/ commission approval. A copy of the compliance reports by these agencies may also be forwarded to the SDA.

7.8.4 Regional local committee shall be constituted with stakeholders of Govt. like LSGI, Town Planning, PWD, KSEB, Electrical Inspectorate, SDA etc. for periodical review.

7.8.5 Yearly compliance audit may be done by a third party assessor and not the agency who gives building permit or certification such as the local self government agency or Electrical Inspectorate.

7.8.6 Standardization of basic energy efficiency requirements in electrical equipments such as Standards and Labeling Programme of Bureau of Energy Efficiency may be incorporated in the verification and approval process.

7.8.7 ECBC code may be implemented as such. Any modifications required may be treated as a case to case basis.

7.8.8 ECBC Implementation Phases

Phase 1: Intensive awareness campaign for all building sector professionals ie; all stakeholders in ECBC

Phase 2: Voluntary Implementation for 1 year in Energy Intensive Buildings (ie; buildings with more than or equal to 500kW connected load or 600kVA contract demand) and to be made mandatory from the second year

Phase 3: Voluntary implementation for 5 years for all commercial buildings (other than the energy intensive buildings mentioned above) and to be made mandatory from the sixth year onwards.

7.8.9 ECBC complaint materials may be included in the Government material schedule.

7.8.10 Training and certification of concerned officials of Local self government Institutions (LSGI) involved and responsible for building scheme in ECBC compliance verification. Training and certification may be preferably conducted by the State Designated Agency (SDA).

7.8.11 Energy Performance Index in terms of units per square meter may be benchmarked for Small, Medium and Large buildings in different categories and incentives based on the same may be proposed / given.

7.8.12 Initiative to implement ECBC should be taken in government buildings as a first step to lure others in to the benefits of ECBC.

7.8.13 Retrofit to be provided within a specified compliance period - phase out period. Penalty to be imposed, for exceeding time limit for compliance.

8. ABOUT EC ACT/ ECBC CODE

8.1 The Energy Conservation Building Code (ECBC) is to provide minimum requirements for energy-efficient design and construction of buildings and their systems.

8.2 The ECBC is an EC Act, 2001 driven document by central government, with enforceable provisions for the state. The following sections of the EC Act, 2001 are referred for the project survey of buildings at state level which fall under the energy conservation act.

14(p)	prescribes energy conservation building codes for efficient use of energy and its conservation in the building or building complex;
15(a)	amend the energy conservation building codes to suit the regional and local climatic conditions and may, by rules made by it, specify and notify energy conservation building codes with respect to use of energy in the buildings;
56(i)	the form and manner in which the status of energy consumption be submitted under clause (l) of section 14;
57(2) (a)	energy conservation building codes under clause (a) of section 15;

8.3 The area of study includes the collection of details as per ECBC compliance form. This area covers the following parts

- Building Envelope
- Heating, Ventilation and Air Conditioning
- Service Water Heating and Pumping
- Lighting
- Electric Power

8.4 Compliance Requirements

As mentioned above, all the buildings or building complexes with a connected load of 500 kW or greater or a contract demand of 600 kVA or greater have to comply with the Code. Buildings with 1,000 m^2 or more of conditioned area are likely to fall under the above load conditions. The following sections which deal with mandatory and prescriptive requirements of new and existing buildings are related to this specified threshold area. It is important to mention here that these mandatory and prescriptive requirements are applicable only where the building has a connected load of 500 kW or more or contract demand of 600kVA or more.

8.4.1 Mandatory Requirements

Compliance with the requirements of the Code shall be mandatory for all applicable buildings mentioned under this Code.

8.5 New Buildings

The Code compliance procedure requires the new building to fulfil a set of mandatory provisions related to energy use as well as show compliance with the specified requirements stipulated for the different building components and systems.

8.5.1 Additions to Existing Buildings

The Code also applies to additions in existing buildings. The requirements are triggered when new construction is proposed in the existing building.

8.5.2 As per the Code:

Where the addition plus the existing building exceeds the conditioned floor area of 1,000 m^2 or more, the additions shall comply with the provisions, compliance may be demonstrated in either of the following ways:

- The addition alone shall comply with the applicable requirements, or
- The addition, together with the entire existing building, shall comply with the requirements of this Code that would apply to the entire building, as if it were a new building

8.5.3 Exception to above:

When space conditioning is provided by existing systems and equipment, the existing systems and equipment need not comply with this Code. However, any new equipment installed must comply with specific requirements applicable to that equipment.

8.5.4 Alterations to Existing Buildings

When making alterations to an existing building, the portions of a building and its systems that are being altered must be made to comply with mandatory and prescriptive requirements.

8.5.5 As per the Code:

Where the existing building exceeds the conditioned floor area threshold (of 1000 m^2 or more), portions of a building and its systems that are being altered shall meet the conditions. The specific requirements for alterations are described in the following subsections.

8.5.6 Exception to above:

When the entire building complies with all of the provisions of the Code, as if it were a new building.

8.5.7 Building Envelope

As per the Code:

Alterations to the building envelope shall comply with the requirements of the Code or fenestration, insulation, and air leakage applicable to the portions of the buildings and its systems being altered.

8.5.8 Exception to above:

The following alterations need not comply with these requirements provided such alterations do not increase the energy usage of the building:

- Replacement of glass in an existing sash and frame provided the U-factor and SHGC of the replacement glazing are equal to or lower than the existing glazing.
- Modifications to roof/ceiling, wall, or floor cavities, which are insulated to full depth with insulation.
- Modifications to walls and floors without cavities and where no new cavities are created.

8.6 Heating, Ventilation, and Air Conditioning

As per the Code:

Alterations to building heating, ventilating, and air-conditioning equipment or systems shall comply with the requirements applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

Mandatory Requirements

The Code contains mandatory requirements for the following elements of the HVAC system:

- Natural Ventilation
- Equipment Efficiency
- Controls
- Piping and Ductwork
- System Balancing.
- Condensers
- Economizers
- Hydronic Systems

8.6.1 Natural Ventilation

As per the Code:

Natural ventilation (of buildings) shall comply with the design guidelines provided for natural ventilation in the National Building Code of India 2005, (NBC, 2005) Part 8, 5.4.3 and 5.7.1

8.6.2 Energy Conservation in Ventilation System

Maximum possible use should be made of wind-induced natural ventilation. This may be accomplished by following the design guidelines

i. Adequate number of circulating fans should be installed to serve all interior working areas during the summer months in the hot dry and warm humid regions to provide necessary air movement at times when ventilation due to wind action alone does not afford sufficient relief.

ii. The capacity of a ceiling fan to meet the requirement of a room with the longer dimension D meters should be about 55 D m^3/min.

iii. The height of fan blades above the floor should be (3H + W)/4, where H is the height of the room, and W is the height of the work plane.

iv. The minimum distance between fan blades and the ceiling should be about 0.3 meters.

v. Electronic regulators should be used instead of resistance type regulators for controlling the speed of fans.

vi. When actual ventilated zone does not cover the entire room area, then optimum size of ceiling fan should be chosen based on the actual usable area of room, rather than the total floor area of the room. Thus smaller size of fan can be employed and energy saving could be achieved.

vii. Power consumption by larger fans is obviously higher, but their power consumption per square meter of floor area is less and service value higher. Evidently, improper use of fans irrespective of the rooms dimensions is likely to result in higher power consumption.

8.6.3 Acceptable operative temperature ranges for naturally conditioned spaces.

Allowable indoor operative temperature for spaces that meet these criteria includes two sets of operative temperature limits - one for 80% acceptability and one for 90% acceptability. The 90% acceptability limits may be used when a higher standard of thermal comfort is desired.

1 met = 58W/m: for typical office activity, one person is likely to produce 100-125 watts of heat.

8.6.4 Energy Efficiency Terms

Coefficient of Performance (COP) - Cooling

The ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.

Coefficient of Performance (COP) – Heating

The ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions.

Energy Efficiency Ratio (EER)

The ratio of net cooling capacity in BTU/hr to total rate of electric input in watts under designated operating conditions.

Integrated Part-Load Value (IPLV)

A single number figure of merit based on part-load EER, COP, or kW/ton expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

8.6.5 Controls

Controls are one of the most critical elements for improving efficiency of any HVAC system. Controls determine how HVAC systems should operate to meet the design goals of comfort, efficiency, and cost-effective operation. In this context, the Code specifies the use of time clocks, temperature controls/thermostats, and two-speed or variable speed drives for fans.

8.6.6 Time clock Control

As per the Code,

All mechanical cooling and heating systems shall be controlled by a time clock that:

a. Can start and stop the system under different schedules for three different day types per week
b. Is capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and
c. Includes an accessible manual override that allows temporary operation of the system for upto 2 hours

Exceptions to the above are:

a. Cooling systems < 28 kW (8 tons)
b. Heating systems < 7 kW (2 tons)

8.6.7 Temperature Control

As per the Code:

All heating and cooling equipment shall be temperature controlled. Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3°C (5°F) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

It is important to clearly establish design conditions and ensure adequate dead band between cooling and heating set points to avoid conflicting thermostat control conditions. Increasing the dead band can make the system more stable and efficient.

8.6.8 Controls for Cooling Towers and Closed Circuit Fluid Coolers

As per the Code:

All cooling towers and closed circuit fluid coolers shall have either two speed motors, pony motors, or variable speed drives controlling the fans.

8.6.9 Variable Speed Drive

A variable speed drive (VSD) is an electronic device that controls the rotational speed of a piece of motor-driven equipment (e.g. a blower, compressor, fan, or pump). Speed control is obtained by adjusting the frequency of the voltage applied to the motor. This approach usually saves energy for varying-load applications.

Through the application of VSD on the cooling tower fan, the fan speed can be reduced during lower ambient conditions for reducing energy consumption. However condenser water reset strategy may require condenser fan speeds to be maintained to improve chiller efficiency by lowering condenser water temperature. At lower loads the overall system efficiency should be the driver as pumping and tower fan energy form significant proportion of overall chiller plant energy.

8.6.10 Piping and Ductwork

Pipe Insulation

To minimize heat losses, the Code requires that piping of heating and cooling systems, (including the storage tanks,) must be insulated. The Code specifies required R-values of insulation for heating and cooling systems based on the operating temperature of the system.

As per the Code:

Insulation exposed to weather shall be protected by aluminium sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above, or be painted with water retardant paint.

8.6.11 Ductwork

As per the Code:

Ductwork should be properly air sealed and also be protected from moisture absorption. Condensing moisture can cause many types of insulation, such as fibreglass, to lose their insulating properties or degrade.

8.6.12 Duct Sealing

Duct sealing is critical to avoid air leaks that prevent the HVAC system from functioning as designed and operated. The Code currently does not provide any guidance on ductwork sealing. The energy code can be referred for appropriate seal levels for all ductwork in order to minimize energy losses from the HVAC system.

8.7 Service Water Heating

As per the Code:

Alterations to building service water heating equipment or systems shall comply with the requirements applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

8.7.1 General

For some building types such as large hotels and hospitals service water heating can be major energy consumer. Inefficiency in water heating is caused primarily by inefficiency of the heating equipment and by heat loss from hot water storage tanks and distribution piping network.

ECBC through mandatory requirements seeks to minimize energy usage in water heating systems by:

- Utilizing solar water heating
- Specifying heating equipment efficiency
- Maximizing heat recovery and minimizing electric heating
- Insulating hot water storage tanks and pipelines
- Reducing standby losses
- Reducing heat and evaporation losses in heated swimming pools

8.7.2 Mandatory Requirements

As per the Code:

Residential facilities, hotels and hospitals with a centralized system shall have solar water heating for at least 1/5 of the design capacity.

Exception to above:

Systems that use heat recovery for at least 1/5 of the design capacity. There are two types of solar water heaters. Passive heaters collect and store solar thermal energy for water heating applications and do not require electrical energy input for recirculating water through solar collector. Active heaters collect and store solar thermal energy for water heating applications and require electrical energy input for operation of recirculation pumps or other components.

An exception is provided by the Code for systems that use heat recovery systems for at least one-fifth (20%) of the design capacity. For example heat is rejected from the air conditioner's condenser to the atmosphere. By recovering this waste heat and utilizing it to heat water, wherever feasible, it is possible to substantially reduce water-heating costs.

8.8 Lighting

As per the Code:

Alterations to building lighting equipment or systems shall comply with the requirements of applicable to the portions of the building and its systems being altered. New lighting systems, including controls, installed in an existing building and any change of building area shall be considered an alteration. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

Exception to above:

Alterations that replace less than 50% of the luminaires in a space need not comply with these requirements provided such alterations do not increase the connected lighting load.

8.8.1 General

Although there is no simpler way to reduce the amount of energy consumed by lighting systems than to manually turn lights off whenever not needed, this is not done as often as it could be. In response to that problem, the Code requires several automatic switches that either work on time schedule or sense the presence of occupants.

8.8.2 **Automatic Control Strategies**

Several different approaches can be used to control electric lighting. The control hardware and design practices are discussed below

- **Scheduling Control:** Use a time scheduling device to control lighting systems according to predetermined schedules
- **Occupancy Sensing:** Control lights in response to the presence or absence of people in the space
- **Day lighting:** Switch or dim electric lights in response to the presence or absence of daylight illumination in the space

- **Lumen Maintenance:**Gradually adjust electric light levels over time to correspond with the depreciation of light output from aging lamps.

8.8.3 Space Control

Along with control s for individual lights or sets of pictures, master controls are required for each space which can shut off all the lights within the space.

a. Control a maximum of 250 sq.m. (2500 sq.ft) for a space less than or equal to 1000 sq.m. (10000 sq.ft) for a space greater than 1000 sq.m. (10000 sq.ft).

b. Be capable of over riding the required shut off control for no mo re than 2 hours.

c. Be readily accessible and located so that the occupant can see the control.

8.8.4 Control in Day lighted areas

Luminaire in day lighted areas greater than 25 sq.m. (250 sq.ft shall be equipped with either a manual or automatic control device that :

- Is capable of reducing the light out put of the luminaries in day lighted areas by atleast 50%.
- Controls only the luminaries located entirely within the day lighted areas.

8.8.5 Exterior lighting control

Lighting for all exterior applications not exempted shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning of the exterior lighting when day light is available or the lighting is not required.

8.8.6 Additional control

The following specialty lighting spaces are required to have a controlled device that separates lighting control from that of the general lighting.

a. **Display / accent lighting**: display / accent lighting greater than 300 sq.m. (3000 sq.ft) area shall have a separate control device.

b. **Case lighting**: lighting in cases used for display purposes greater than 300 Sq.m. (3000 sq.ft) area shall be equipped with a space control device.

c. **Hotel and motel guest room lighting:** Hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaries and switched receptacles.

d. **Task lighting** : supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaries or be controlled by a wall mounted control device provided the control device.

e. **Non visual lighting**: lighting for non visual applications, such as plant growth and food warming shall be equipped with a separate control device.

8.8.7 **Exit signs**

Internally illuminated exit signs shall not exceed 5 W per face. Electrically powered exit signs normally use incandescent bulbs. Most LED and CFL exit signs can meet this requirement. Due to their low power consumption, LED exit signs can be purchased with built in backup power supplies.

8.8.8 Exterior building grounds lighting

Lighting for exterior building grounds luminaries which operate a greater than 100 W shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaries controlled by a motion sensor.

Efficacy of lamp (with or without ballast) is the lumens produced by a lamp or ballast system divided by the total watts of input power (including the ballast), expressed in lumens / watt.

8.8.9 Prescriptive requirements

The prescriptive requirement of the code regulates both interior and exterior lighting power.

8.8.10 Interior Lighting power

The prescriptive requirements limit the installed electric wattage for interior building lighting.

For interior lighting power requirements, the installed lighting power used by luminaries, including lamp, ballast, current regulators and central devises is calculated.

8.8.11 Installed interior lighting power

The installed interior lighting power calculated for compliance with the code shall include all power used by the luminaries, including lamps, ballast, current regulators and control devices except as specifically exempted.

Exception to above

If two or more independently operating lighting systems in a space are controlled to prevent simultaneous user operations, the installed interior lighting power shall be based solely on the lighting system with the highest power.

8.8.12 Exterior lighting power

Lighting power limits are specified for building exterior applications have some limits as per ECBC. The connected lighting power for these applications must not exceed this allowed limit. In addition, trade offs between applications are not permitted.

Exemption for the above

b. Specialized signal, directional and marker lighting associated with transportation.

c. Lighting used to highlight features of public monuments and registered historic landmarks structures or builders.

d. Lighting i.e. integral to advertising signage.

e. Lighting i.e. specially designated as required by a health or life safety statue, ordinance or regulations.

8.8.13 Electric Power and Motors

As per the Code:

Alterations to building electric power systems and motors shall comply with the requirements applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

8.8.14 General

ECBC has only mandatory requirements for electric power systems installed in buildings. These provisions are related to distribution transformers, electric motors, power factor, and distribution losses.

Mandatory Requirements

The mandatory requirements of the Code cover the following electrical equipment and systems of building:

- Transformers
- Energy- Efficient Motors
- Power Factor Correction
- Electrical Metering and Monitoring
- Power Distribution Systems

8.8.15 Transformers

Power transmitted from power plants, is in the form of high-tension voltage (400 kV - 33 kV). The reasons for transmitting HT voltage are:

- Reduced conductor size and investment on conductors.
- Reduced the transmission losses and voltage drop.

As per the Code:

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. In addition, the transformer must be selected such that it minimizes the total of its initial cost in addition to the present value of the cost of its total lost energy while serving its estimated loads during its respective life span. ECBC lists various transformer sizes of dry-type and oil-filled transformers and their associated losses at 50% and full load rating.

8.8.16 Measurement and Reporting of Transformer Losses

As per the Code:

All measurement of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer. All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out.

8.8.17 Induction motors

The induction motor is the dominant motor in use today with over 90 percent of the installed horsepower largely because it is rugged, has no brushes or slip rings, and is simple, reliable, and cheap.

As per the Code:

Motors shall comply with the following:

a. All permanently wired polyphase motors of 0.375 kW or more serving the building and expected to operate more than 1,500 hours per year and all permanently wired polyphase motors of 50 kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency not less than IS 12615 for energy-efficient motors

b. Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor

c. Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served

d. Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.

e. Motor users should insist on proper rewinding practices for any rewound motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices

f. Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed and a similar record shall be maintained

8.8.18 Power Factor Correction

As per the Code:

All electricity supplies exceeding 100 A, 3 phases shall maintain their power factor between 0.95 lag and unity at the point of connection.

Power factor correction is the process of adjusting the characteristics of electric loads in order to improve power factor so that it is closer to unity (i.e. 1). In simplified, electrical terminology, power factor is the difference between real (kW) and reactive power (kVAR). It is a measure of how effectively current is being converted into useful work output and, more specifically, is a good indicator of the effect of the load current on the efficiency of the supply system. Power factor correction (PFC) may be applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network or, correction may be installed by individual electrical customers to, for example, reduce costs charged to them by their electricity supplier while simultaneously improving energy efficiency. A high power factor is generally desirable in a transmission system to reduce transmission losses and improve voltage regulation at the load. PDF is normally achieved by the addition of capacitors to the electrical network which reduce the burden on the supply.

8.8.19 Check-Metering and Monitoring

A significant barrier to achieving energy efficiency during the operation of a building is inadequate metering systems and monitoring plans. Building operators cannot be expected to manage energy if they cannot measure energy use. To improve a building's energy performance over its operating life, and optimize the energy-efficient requirements, the Code requires that the building's performance be measured.

Metering is about having information that allows buildings energy managers to analyze and track changes in energy demand and, therefore, to manage their energy consumption more effectively. Energy metering is not a new concept and has been used by large energy-intensive buildings for many years to monitor energy consumption.

The Code requires check-metering based on following three scenarios:

a. Services exceeding 1000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and Total Harmonic Distortion (THD) as a percentage of total current.

b. Services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh).

c. Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh).

8.8.20 Power Distribution Systems

As per the Code:

The power cabling shall be adequately sized as to maintain the distribution losses not to exceed 1% of the total power usage. Record of design calculation for the losses shall be maintained.

An engineer or contractor can demonstrate the real savings as well as the advantages of lower generated heat and increased flexibility of the installation with a properly sized distribution system. In addition, when less heat is generated, the result is reduced energy requirements for fans and air conditioning systems.