

# **Analysis of Energy Consumption, CO<sub>2</sub> Emission & Its Conservation for Living Room in Residential Building - A Case Study in Mumbai, India**

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**ABSTRACT:** This study shows the energy conservation potential hold by living rooms in old existing residential building CHANDRAMUKHI CHS situated in Borivali West, Mumbai, India. The study shows the savings in energy consumption, CO<sub>2</sub> emission rate & electricity cost for the lightings and electrical appliances used in living room. In this study, selected measures for energy conservation related to lighting system were taken into consideration & suggestions were given for energy conservation.

**KEYWORDS:** residential building; energy conservation, living room, CO<sub>2</sub> emission, electricity cost, electrical appliances, LED lights, building performance and energy efficiency.

## **I. INTRODUCTION**

India is witnessing tremendous growth in infrastructure & construction development. The construction industry in India is one of the largest economic activities & is growing at an average rate of 9.5% as compared to the global average of 5% [1]. As the sector is growing rapidly, preserving the environment poses a host of challenges. The building sector in India is growing at a rapid pace and contributing immensely to the growth of the economy.

The energy consumption at the residential level either in building or houses is the major part of India. As per the report of Central electricity authority (CEA), the energy consumed by residential sector is 22.97% of total electrical energy generated in India, which is about three times greater than that of commercial buildings [5]. One of the reasons for above is due to the buildup area for residential sector is seven times greater than commercial building sector. Due to modernization, improved standard of living & improved economic conditions of peoples in India, the residential sector is growing & consumption of electricity is increasing with the increase in the use of modern home appliances, air-conditioners & other electrical equipment. So the objective of this study is to catch this great opportunity to reduce the electrical consumption of residential sector by investigating electrical consumption of lighting systems & various home appliances.

## **II. LITERATURE REVIEW**

The literature was searched for residential building electrical energy consumption, the power consumption of conventional lighting fixtures & LED lighting fixtures used in residential buildings. The literature study also consists of IGBC rating system for existing residential building society. The literature survey gives a projection of electrical consumption for future & growth in home appliances population. [2] IGBC green residential societies rating system for existing multi-dwelling communities give a set of guidelines for residential societies to implement measures that will

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reduce the consumption of electrical energy & natural resources. The main objective of IGBC green residential societies rating system is to develop green societies. It would enable existing residential developments to incorporate and monitor the environmental friendly concepts that would result in tangible and intangible benefits to the residents. As per the World Bank, the module is used to project the growth in electrical home appliances population in the residential sector in India to fiscal 2031–32[3] as shown in Fig 2.1.

Energy use projections and savings potentials, a technical report states that the annual electricity use per household is predicted to increase from 650 kWh in 2012 to 2750 kWh by 2050 [4]. Green existing buildings can have tremendous benefits, both tangible and intangible. The most tangible benefits are the reduction in water & energy consumption. The operational savings through energy & water efficiency could range from 15 - 30 % [1].

From the above discussion, it states that the existing residential building sector in India is having huge potential & market for energy conservation of electrical lightings & appliances used in the home as the population of appliances will increase in future due to change in lifestyle of the peoples. It states that the new rating systems formed by the IGBC for existing residential societies & certification levels can be achieved by following aggressive energy conservation policies.

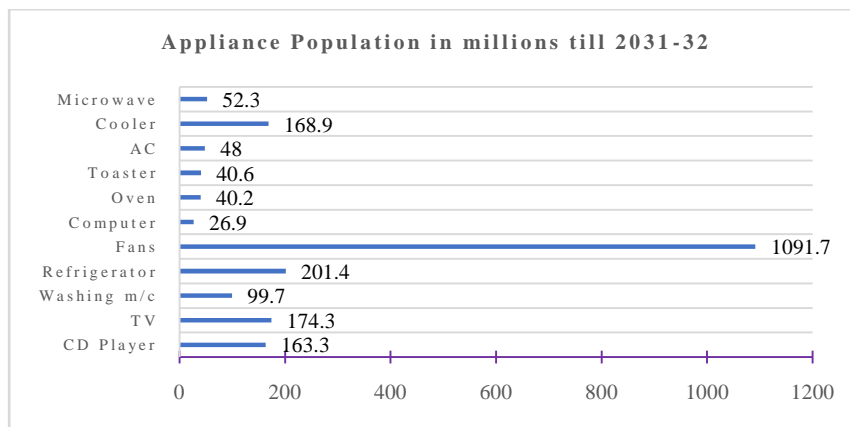


Fig 2.1 Appliance Population till the year 2031 – 32 as per World Bank

### III. BUILDING ENERGY AUDIT

Data is collected for the energy capacity, rating, quantity & duration of lighting & home appliances use in the society by consumers. Data is collected from existing residential building CHANDRAMUKHI CHS located at Eksar Road, Borivali West, Mumbai - 400092, Maharashtra, India.

Existing Building Information

This multi-story building is a residential building which is a G+4 story residential building with two wings A & B located in Borivali West, Mumbai. Gross floor area of the building is 8350ft<sup>2</sup>. The floor to floor height is varying from 12 to 13 ft approximately. It consists of total 19 flats combining both A & B wing.

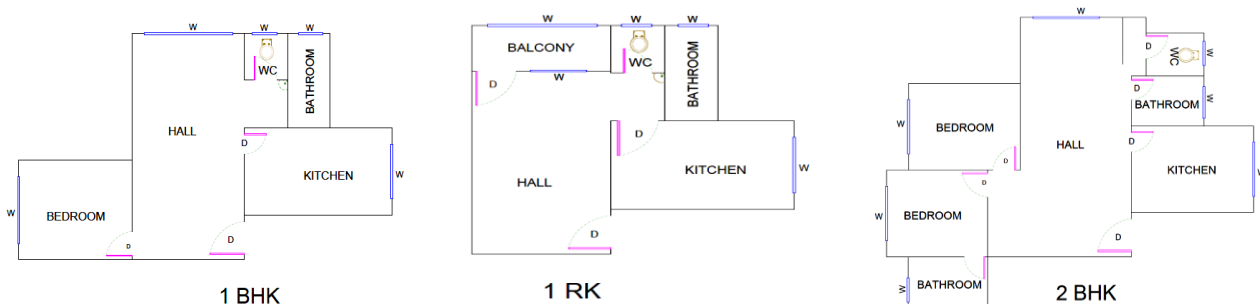


Fig.3.1 Floor Plan for 1 BHK, 1RK & 2 BHK Flat

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CHANDRAMUKHI CHS has two wings A & B. Wing A is 2BHK & 1BHK flats apartment whereas B wing is 1RK flats apartment. The schematic floor plan is shown in Fig.3.1. The below sketches was designed by using software AutoCAD 2016. The energy audit in the CHANDRAMUKHI CHS is carried out in following steps:

- Preliminary survey of the building
- Accounting lightings & electrical appliances in use
- Estimation of energy consumed by appliances, CO<sub>2</sub> emission & electricity cost
- Estimation of opportunities to reduce energy consumption, CO<sub>2</sub> emission & electricity cost

As part of the preliminary survey, the residents of the building were visited to understand the electricity load consumption & data is gathered. In visit sensitivity of residential peoples is understand. Few interesting facts were found they are:

1. Excess illumination found in some flats.
2. Lesser than required illumination found in some flats.
3. Only few resident using LED lights.
4. Occupants scared to replace existing Incandescent & CFL lights with LED due to unawareness.
5. Less use of energy efficient appliances.
6. Occupants keep the fans switched ON when not in use.
7. Mosquito coils kept 24 x 7 switched ON.

## Living Room Area

The building has around 19 flats & each has one living room. As data is collected for 13 flats so we have data for 13 living rooms. The energy consumption per day, electricity cost, CO<sub>2</sub> emission in living rooms & the appliances used are shown in Table I. Table also shows the effect of using energy efficient appliances on energy consumption savings, electricity cost savings & CO<sub>2</sub> emission reduction.

Replacing fluorescent TL with LED TL:

i) For fluorescent TL:

The fluorescent tube lights used are of 40 W capacity for the average duration of 5.04 hrs in the living room for building.

$$\text{Units Consumed} = \text{Rating} \times \text{duration/day} \times \text{qty} \times 30 \times 12 = 0.04 \times 11 \times 5.0417 \times 30 \times 12 = 798.61 \text{ units/yr}$$

$$\text{Electricity Cost} = \text{Units Consumed/yr} \times \text{Unit rate} = 798.61 \times 7 \text{ INR} = 5590.24 \text{ INR/yr}$$

$$\text{CO}_2 \text{ Emission} = \text{CO}_2 \text{ emission rate} \times \text{kWh/yr} = 0.24 \times 798.61 = 188.71 \text{ kg CO}_2/\text{yr}$$

ii) For LED TL:

The fluorescent tube lights of 40 W capacity are replaced by LED TL of 18 W capacity

$$\text{Units Consumed} = \text{Rating} \times \text{duration/day} \times \text{qty} \times 30 \times 12 = 0.018 \times 11 \times 5.0417 \times 30 \times 12 = 359.37 \text{ units/yr}$$

$$\text{Electricity Cost} = \text{Units Consumed/yr} \times \text{Unit rate} = 359.37 \times 7 \text{ INR} = 2515.61 \text{ INR/yr}$$

$$\text{CO}_2 \text{ Emission} = \text{CO}_2 \text{ emission rate} \times \text{kWh/yr} = 0.0237 \times 359.37 = 8.52 \text{ kg CO}_2/\text{yr}$$

iii) Savings:

By using energy efficient LED we can save the units consumed, electricity cost & CO<sub>2</sub> emission.

$$\text{Units Consumed} = \text{UC by 40 W FTL} - \text{UC by 18 W LED TL} = 798.61 - 359.37 = 439.23 \text{ units/yr}$$

Reduction in units consumed for tube light is 439.23 kWh units/year, which can reduce the load on electricity grids & power generation plants.

$$\text{Electricity Cost} = \text{EC by 40 W FTL} - \text{EC by 18 W LED TL} = 5590.24 - 2515.61 = 3074.63 \text{ INR/yr}$$

Reduction in electricity cost for tube light is 3074.63 INR/year, which can save the money & can reduce expenses.

$$\text{CO}_2 \text{ Emission} = \text{CO}_2 \text{ emission by 40 W FTL} - \text{CO}_2 \text{ emission by 18 W LED TL} = 188.71 - 8.52 = 180.19 \text{ kg CO}_2/\text{yr}$$

Reduction in CO<sub>2</sub> emission for tube light is 180.19 kg/year, which can save the carbon foot print & helps in pollution reduction.

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Similarly, calculations can be done for other appliances used in the Living room.

In total existing appliances in the living room area consumed 11784.69 units/year. The total units consumed can be reduced by 6087.89 units/year with the application of energy efficient & BEE star rated equipment. The unit's consumption for living room can be reduced by 51.66% per year.

The total electricity cost for living room area is 86627.98 Rs per year, which can be reduced by 45850.03 Rs per year with the application of energy efficient & BEE star rated equipment. The electricity cost for living room can be reduced by 52.93% per year.

The total CO<sub>2</sub> emission by existing appliances in the living room area is 9.295 tons per year which can be reduced to 3.058 tons of CO<sub>2</sub> per year with the application of energy efficient & BEE star rated equipment. The CO<sub>2</sub> emission in the living room can be reduced by 55.75% per year.

From the above & tables, if energy efficient electrical appliances used the possible savings in units consumed, electricity cost & CO<sub>2</sub> Emission for living rooms of CHANDRAMUKHI CHS for the period of 1 year is shown in Table II.

TABLE II  
SAVINGSFORCHANDRAMUKHI CHS

Area	Units Consumption in kWh	Electricity Cost in INR	Co2 Emission in Kg
Living Room	6087.89	45850.03	5182.95

The possible savings in electricity consumption, electricity cost & CO<sub>2</sub> emission for living rooms in one residential building is 6.088 MWh, Rs. 45850.03/- & 5.183 tons of CO<sub>2</sub> respectively in a span of one year after applying energy efficient policy & BEE star rating. As the population of residential buildings & homes in Borivali is huge the available energy conservation potential is huge. Similarly, if we look at the population of residential sector in Mumbai & in India, available energy conservation potential is very huge in numbers. If energy conservation & BEE star rating is implemented to such a huge population of the residential buildings in Mumbai & residential sector in India then very huge amount of energy, energy cost & CO<sub>2</sub> emission can be conserved. Which will reduce the greater load on power grids in India & also reduce carbon foot prints?

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TABLE I Energy Consumption for Living Room

Sr. No.	Device	Spec	Rating (W)	Duration /day (hrs.)	Qty (no's)	Units Consumed kWh/		Electricity Cost in INR		Co2 Emission Kg		
						Year	Saving/yr.	Year	Saving/yr.	kg/kwh	Year	Saving/yr
1	Tube Light (Fluorescent)	4 ft	40	5.04	11	798.61		5590.24		[12] 0.24	188.71	
		4 ft LED TL	[42] 18	5.04	11	359.37	439.23	2515.61	3074.63	0.02	8.52	180.19
2	Incandescent Bulb	Zero	[42] 15	17.67	4	381.61	368.89	2671.25	2582.21	0.24	90.17	89.87
		LED	[42] 0.5	17.67	4	12.72		89.04		0.02	0.30	
3	Cloth Iron		1000	0.29	3	312.12	78.03	2184.84	546.21	[12] 0.82	255.94	63.98
		Surya Hero	750	0.29	3	234.09		1638.63		0.82	191.95	
4	CFL Bulb		[43] 3	5.00	2	10.80	7.20	75.60	50.40	[16] 0.06	0.60	0.51
		LED	1	5.00	2	3.60		25.20		0.02	0.09	
			8	5.00	1	14.40	9.00	100.80	63.00	0.06	0.80	0.67
		LED	3	5.00	1	5.40		37.80		[12] 0.02	0.13	
			11	7.00	2	55.44	30.24	388.08	211.68	0.06	3.07	2.47
		LED	5	7.00	2	25.20		176.40		0.02	0.60	
			14	6.00	1	30.24	15.12	211.68	105.84	0.06	1.67	1.31
		LED	7	6.00	1	15.12		105.84		0.02	0.36	
			18	3.00	1	19.44	9.72	136.08	68.04	0.06	1.08	0.84
		LED	9	3.00	1	9.72		68.04		0.02	0.23	
5	LED Bulb		15	0.10	1	0.54		3.78		0.02	0.01	
			15	0.10	1	0.54		3.78		0.02	0.01	
6	AC kWh/day for 8 hrs used for 4 months year	1.5 TR	9.45	3.50	2	992.25	287.70	6945.75	2013.90	0.82	813.65	235.91
		5 Star INV 1.5 TR	6.71	3.50	2	704.55		4931.85		0.82	577.73	
		1 TR Split	[40] 5.2	5.00	1	390.00	195.00	2730.00	1365.00	0.82	319.80	159.90
7	Fan (Ceiling)	56 Inch	[40] 100	15.67	12	6768.00	4196.16	47376.01	29373.13	0.82	5549.76	3440.85
		Super Fan/BEE Star 56 inch	38	15.67	12	2571.84		18002.88		0.82	2108.91	
8	TV	21" LCD	[39] 32	5.00	1	69.00	38.00	402.50	238.70	0.82	47.15	46.60
		21" LED	13	5.00	1	31.00		163.80		0.02	0.55	
		32" LCD	80	5.00	1	172.00	116.00	1003.33	688.33	0.82	117.53	116.47
		32" LED	25	5.00	1	56.00		315.00		0.02	1.07	
		36" LCD	[38] 106	12.00	1	229.00	155.00	3206.00	2087.12	0.82	375.56	371.77
		36" LED	37	12.00	1	74.00		1118.88		0.02	3.79	
		26" LED	20	6.00	1	38.00		302.40		0.82	35.42	
		32" LED	25	0.57	1	56.00		35.97		0.82	4.21	
9	Mobile Charger		5	1.86	20	83.88		587.16		0.82	68.78	
			5	1.86	20	83.88		587.16		0.82	68.78	
10	Mosquito Soln. heater		5	12.50	4	112.50		787.50		0.82	92.25	
11	Vacuum	10 min / week	1400	0.02	1	13.99		97.90		0.82	11.47	
12	Laptop	17"	90	1.50	4	194.40		1360.80		0.82	159.41	
		15"	65	3.50	4	327.60		2293.20		0.82	268.63	
13	Wifi Router		6	18.00	3	116.64		816.48		0.82	95.64	
14	TV Set up Box		4	16.67	6	144.00		1008.02		0.82	118.08	
15	Music System	10 min / day	100	0.16	2	11.70		81.90		0.82	9.59	
16	CD Player	30 min / day	200	0.50	3	108.00		756.00		0.82	88.56	
17	Hair Dryer	10 min / day	1500	0.17	1	90.18		631.26		0.82	73.95	
18	Coddles Phone		4	24.00	1	34.56		241.92		0.82	28.34	
<b>Total</b>						<b>16149.51</b>	<b>6087.89</b>	<b>118401.63</b>	<b>45850.03</b>		<b>12353.81</b>	<b>5182.95</b>
<b>By Existing Appliances</b>						<b>11784.69</b>		<b>86627.98</b>			<b>9295.56</b>	
<b>By Energy Efficient Appliances</b>						<b>4364.81</b>		<b>31773.65</b>			<b>3058.25</b>	

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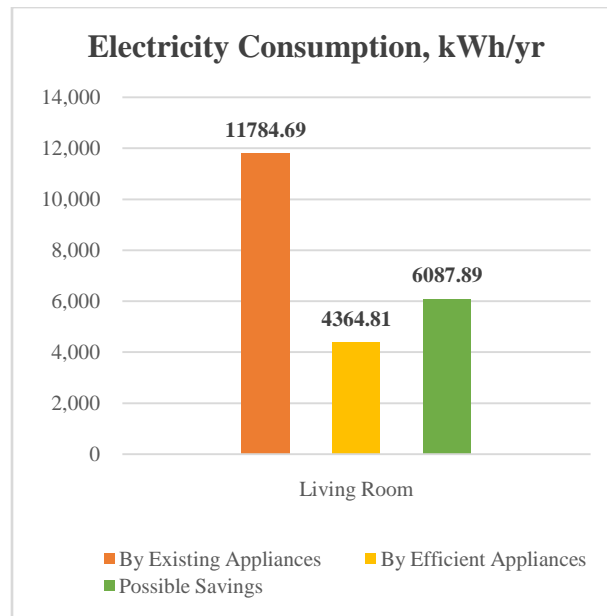


Fig 3.2 Electricity Consumption for Living Room

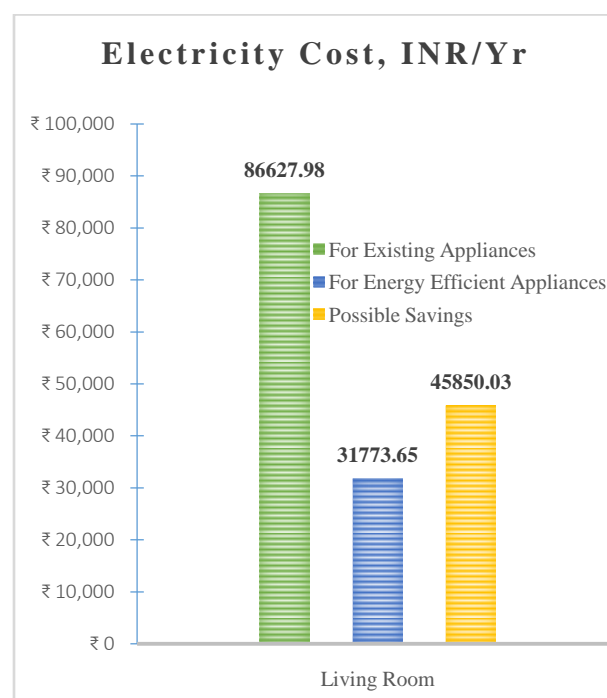


Fig 3.3 Electricity Cost for Living Room

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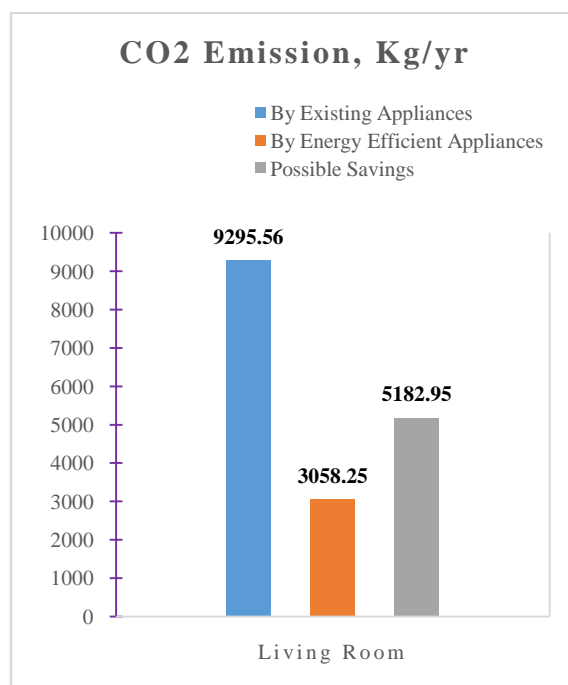


Fig 3.4 CO<sub>2</sub> Emission for Living Room

#### IV. CONCLUSION

The above study & work shows that the potential of existing residential buildings & societies in saving electricity consumption, electricity cost & CO<sub>2</sub> emission is huge in India. The use of LED lighting's is making a great difference in energy conservation & CO<sub>2</sub> emission. The above work also expresses the benefits of using energy efficient & BEE star rated appliances.

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