Energy Audit of Green Building- CII Sohrabji Godrej Green Business Centre"

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Abstract: The building sector in India is growing at a rapid pace and contributing immensely to the growth of the economy. This augurs well for the country and now there is an imminent need to introduce green concepts and techniques in this sector, which can aid growth in a sustainable manner.

The green concepts and techniques in the building sector can help address national issues like water efficiency, energy efficiency, and reduction in fossil fuel use for commuting, handling of consumer waste and conserving natural resources. Most importantly, these concepts can enhance occupant health, productivity and well-being.

Against this background, the Indian Green Building Council (IGBC) has launched 'IGBC Green New Buildings rating system® to address the national priorities. This rating programme is a tool which enables the designer to apply green concepts and reduce environmental impacts that aremeasurable. The rating programme covers methodologies to cover diverse climatic zones and changing lifestyles.

IGBC has set up the Green New Buildings Core Committee under the leadership of Ar. Raghavendran, to develop the rating programme. This committee comprised of key stakeholders, including architects, builders, consultants, developers, owners, institutions, manufacturers and industry representatives. The committee, with a diverse background and knowledge has enriched the rating system, both in its content and process CII - Sohrabji Godrej Green Business Centre (CII Godrej GBC), cozily nestled close to Shilparamam, is the first LEED Platinum rated green building in India. The building is a perfect blend of India's rich architectural splendor and technological innovations, incorporating traditional concepts into modern and contemporary architecture. Extensive energy simulation exercises were undertaken to orient the building in such a way that minimizes the heat ingress while allowing natural daylight to penetrate abundantly. The building incorporates several world- class energy and environment friendly features, including solar PV systems, indoor air quality monitoring, a high efficiency HVAC system, a passive cooling system using wind towers, high performance glass, aesthetic roof gardens, rain water harvesting, root zone treatment system, etc. The extensive landscape is also home to varieties of trees, most of which are native and adaptive to local climatic conditions. The green building boasts a 50% saving in overall energy consumption, 35 % reduction in potable water consumption and usage of 80% of recycled / recyclable material. Most importantly, the building has enabled the widespread green building movement in India.

Keywords - Energy audit, Green audit, Carbon foot print analysis, Solar Energy, increase in efficiency, energy efficient appliances

The executive summary of the energy audit report furnished in this section briefly gives the identified energy conservation measures and other recommendation during the project that can be implemented in a phased manner to conserve energy, increase productivity inside the university campus.

100 KWp SOLAR PHOTOVOLTAIC ROOFTOP INSTALLATION

- Campus has 100 KWp solar photovoltaic roof top grid connected system installed on building-II. Total solar unit generation from Feb-2018 to June- 2021 by the system is 4,03,392 units. Solar Unit generation for the Year 2020-21 from July to june is 1,19,630 Units. It is about 33.45 % of total Energy consumption of the campus.

Solar Unit Generation (July 2020-June-2021)	Grid Unit Consumption (July 2020-June-2021)	Total Unit Consumption (Solar+Grid)	RE Share (%) Year 2020-21
1,19,630	2,27,580	3,47,210	34%

- LIGHTING SYSTEM: Campus has updated following conventional lighting fixtures by energy efficient LED lighting and purschse energy efficient lighting product for new construction under energy policy of the Campus.

Sr.No.	Type of Equipments	Conventional Lighting	No of Fixture
1	LED Tube light (20 w)	FTL (40Watt)	922
2	LED (5w)	Mirch Bulp (50Watt)	31
3	Ceilling Light LED Fixture(13w)	CFL Down Lighter (18Watt *2)	14
4	LED Bulb (7w)	CFL 15 Watt	2
5	LED Bulb (9w)	CFL 18 Watt	5
6	LED Bulb (30w)	HPSV Lamp 150Watt	4
7	LED Bulb (100w)	HPSV Lamp 250 Watt	12
8	LEDBulb (15w)	CFL 85 Watt	23
9	Hanging Light (20*2= 40w)	New Installation	2
10	T5 28*2 (56w)	FTL (36Watt *2)	318
11	Ceilling light 2*2 size (LED 36w)	New Installation	12
12	T5 (28w)	FTL (40Watt)	213
13	Ceiling LED Light (42w)	New Installation	3
14	Ceiling Light (5w) LED	CFL Down Lighter (9Watt *2)	24

- Campus has replacement of 922 No of "conventional T-12 (40 Watt) and T-8 (36 Watt)" tube light by energy efficient LED lighting (20Watt) fixture.
- 318 no of Conventional (40 Watt *2) tube Light replaced by (28 W *2) Energy efficient (T-5) LED light
- 31 no of conventional down lighter (50Watt Mirch lamp) by (5 Watt) energy efficient LED light
- 14 no of conventional ceiling light (CFL)replaced by (13 Watt) energy efficient LED light.
- 7 no of 18 Watt CFL replaced by 7 & 9 watt LED bulb.
- 13 No HPSV lamp 150 Watt & 250Watt replaced by 30 Watt & 100 Watt LED Street Light.
- 30 No of (2 × 2) square fitting (72 Watt CFL)) by (1 ×1) square fitting (36 Watt) LED Lighting in office and conference area.
- 12 No of (2 × 2) square fitting (36Watt CFL)) by (1 ×1) square fitting (15 Watt) LED Lighting in office and conference area.

AREA OF IMPROVEMENT

POWER FACTOR IMPROVEMENT

- The average power factor was 0.90 for the year 2020-21. Campus has consume addation 22807 units and loss power Rs 1,32,280 /-
- It was observed that capacitor bank is not working & need to update immediately.

LIGHTING SYSTEM

- There is still good potential for replacement of conventional lighting (CFL by LED lighting) (CFL downlighter by LED down lighter) (36 X 2 =72-Watt square fixture by 36-Watt LED Square Fitting) by energy efficient lightings. Expected energy saving and simply payback period is subject of load factor and annual operating hours.
- Installation of "Timer control on focus light and street lighting" in campus recommended for energy saving in the campus.

TIMER CONTROLLED STREET LIGHTS

- Installation of "Timer control on high mask and street lighting" in Campus is recommended.

CEILING FAN AND EXHAUST FAN:

- Replacement of "conventional ceiling fan (60 Watt to 80 Watt)" by energy efficient star rated fan or BLDC based energy efficient fan (20 to 25 Watt) in "admin building, class rooms, laboratories and faculties cabin" have great potential for energy saving.

- Replacement of "conventional exhaust fan (90 Watt to 125Watt)" by energy efficient star rated fan or BLDC based energy efficient Fan (20 to 40 Watt) in main building class rooms, laboratories and faculties cabin have great potential for energy saving.

IOT BASED ENERGY MONITORING SYSTEM AT MAIN FEEDER

- Installation of "Cloud based (IoT based) energy monitoring system" power house will be good initiate for energy monitoring as well as student demo project for management. Expected energy saving potential about 2 to 4%.
- Installation of energy meters on indivisual building block with IOT system will monitor line losses of the system. It will give real time measurement of power factor and line losses from the cable.

SYNCHRONIZATION OF DG SET WITH SOLAR SYSTEM

- Installation of "Cloud based fuel and unit generation monitoring system" in DG set will help to monitor specific unit generation by DG set failure of the grid power.
- It was observed that during the power failure of the grid, solar unit generations also stop. Synchronization of the solar system with DG set increases the utilization capacity of the solar system.

TRANSFORMER LOSS OPTIMIZATION:

- Replacement of "existing conventional sub–station by new compact type sub-station" in HT yard is highly recommend to management to develop "Demo Project" in centre will be technology up gradation as well as learning center for student and faculties.
- Replacement of existing transformer (315 KVA) by "Energy efficient star rated transformer by BEE, Government of India or energy efficiency level-3" can be good project for management for energy saving as well as learning center for student and faculties.

ENERGY MANAGEMENT WORKSHOP AND TRAINING:

- Develop energy management policies for Campus. Establish a procurement policy that is energy saving and eco-friendly.
- Conduct awareness and training programs for faculty, student and non-teaching staffs. Conduct seminars, workshops and exhibitions on energy management education.
- Involve all stakeholders- encourage involvement of government, foundations, and industry in supporting interdisciplinary research, education, policy formation, and information exchange in energy management system.

Energy Conservation Measures & Case Studies

Case Study No.-1

Power factor improvement

Observation:

It was observe that average power factor in electricity bill in last 12 month 0.90 & annual power factor surcharge is Rs. 1,14,035/- paid by campus to electricity board. Details of monthly power factor & surcharge in below:

S.N o.	Month& Year	Average Power Factor	KWh Units	KVAh Units	KVAh Unit Difference due to low power factor
1	Jul-20	0.900	15045	16746	1701
2	Aug-20	0.890	14994	16770	1776
3	Sep-20	0.910	13578	14844	1266
4	Oct-20	0.900	11736	12999	1263
5	Nov-20	0.900	14937	16644	1707
6	Dec-20	0.940	22524	23934	1410
7	Jan-21	0.940	32037	33450	1413
8	Feb-21	0.940	25401	27057	1656
9	Mar-21	0.900	19410	21477	2067
10	Apr-21	0.890	16403	20422	4019
11	May-21	0.890	9099	12209	3110
12	Jun-21	0.870	9609	11028	1419
		Average =0.900	Total =2,04,773	Total =2,27,580	Total=22,807

Recommendation:

- It is highly recommended organize visit of dealer/suppliers for local area.they will be cross check the existing Relay & existing capacitors.
- After that above action capacitor bank should be uapdate and carried out capacoitor health check up at monthly bases.

Calculation:

- Annual Average power factor in Electricity Bill= 0.90
- Additional Unit due to low Power Factor= 22807 KVAh/ Year
- Additional Payment@Rs. 5.00 per KVAh= 22807*5= 114,035/-
- Expected Investment for System Improvement= Rs. 50,000/-
- Simple Pay Back Period= 5.3 Months.

Case Study No.-2

Replacing (1000W) helogen light with 250W LED lights

Sr. No	Items	Parameters	Units
1	Total (1000W) Helogen light	No.	4
2	Rated Power	Watt/ unit	1000
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	330
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	15840
6	Replacement		
7	Replacement with 250W LED Light	Watt/unit	250
8	Unit Consumed Annually	kWh/Year	3960
9	Energy Saving (Old- New Annual Consumption)	kWh	11880
10	Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	71,280/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs2500/- per item	INR	10,000/-
13	Total Investment	INR	10,000/-
14	Net Annual Saving	INR	71,280/-
15	Simple payback (Investment/annual savings)	Month	1.7

Note : simple pay back period defend on working hours & load factor of the system.

Case Study No.-3

Replacing (36W*1=36 Watt) FTL with 20W LED lights

Sr. No	Items	Parameters	Units
1	Total (36W)FTL	No.	213
2	Rated Power	Watt/ unit	36
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	23004
6	Replacement		
7	Replacement with 20W LED Light	Watt/unit	20
8	Unit Consumed Annually	kWh/Year	12780
9	Energy Saving (Old- New Annual Consumption)	kWh	10224
10	Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	61,344/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs 110/- per item	INR	31,950/-
14	Total Investment	INR	31,950/-
15	Net Annual Saving	INR	61,344/-
16	Simple payback (Investment/annual savings)	Month	6.2

Note : simple pay back period defend on working hours & load factor of the system.

Case Study No.-4

Replacing (36W) Ceiling light FTL with 20W LED lights

Sr. No	Items	Parameters	Units
1	Total (36W) Ceiling light FTL	No.	12
2	Rated Power	Watt/ unit	36
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	1296
6	Replacement		
7	Replacement with 20 W LED Light	Watt/unit	20
8	Unit Consumed Annually	kWh/Year	720
9	Energy Saving (Old- New Annual Consumption)	kWh	576
10	Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	3,456/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs200/- per item	INR	2,400/-
13	Total Investment	INR	2,400/-
14	Net Annual Saving	INR	3,456/-
15	Simple payback (Investment/annual savings)	Month	8.3

Note : simple pay back period defend on working hours & load factor of the system.

Case Study No.-5

Replacing (36*2=72W) FTL with (20*2=40W) LED lights

Sr. No	Items	Parameters	Units
1	Total (2*36W)FTL	No.	262
2	Rated Power	Watt/ unit	72
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	56592
6	Replacement		
7	Replacement with (2*20W) LED Light	Watt/unit	20
8	Unit Consumed Annually	kWh/Year	15720
9	Energy Saving (Old- New Annual Consumption)	kWh	40872
10	Total Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	245232/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs 500/- per item	INR	91,700/-
13	Total Investment	INR	91700/-
14	Net Annual Saving	INR	2,45,232/-
15	Simple payback (Investment/annual savings)	Month	4.5

Note : simple pay back period defend on working hours & load factor of the system.

Case Study No.6

Replacing (15W) CFL lights with 8W LED lights

Sr. No	Items	Parameters	Units
1	Total (15W) CFL	No.	5
2	Rated Power	Watt/ unit	15
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	225
6	Replacement		
7	Replacement with 8 W LED Light	Watt/unit	8
8	Unit Consumed Annually	kWh/Year	120

9	Energy Saving (Old- New Annual Consumption)	kWh	105
10	Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	630/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs150/- per item	INR	750/-
13	Total Investment	INR	750/-
14	Net Annual Saving	INR	630/-
15	Simple payback (Investment/annual savings)	Month	14.3

Note: simple pay back period defend on working hours & load factor of the system.

Case Study No.7

Replacing 22W PL (CFL) Light with 11W LED light

Sr. No	Items	Parameters	Units
1	Total (22W) PL (CFL)	No.	54
2	Rated Power	Watt/ unit	22
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	3564
6	Replacement		
7	Replacement with (11W) LED Light	Watt/unit	11
8	Unit Consumed Annually	kWh/Year	1782
9	Energy Saving (Old- New Annual Consumption)	kWh	1782
10	Total Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	10.692/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs 250/- per item	INR	13,500/-
13	Total Investment	INR	13.500/-
14	Net Annual Saving	INR	10.692/-
15	Simple payback (Investment/annual savings)	Month	15

Note : simple pay back period defend on working hours & load factor of the system.

Case Study No.8

Replacing (18*2=36W) Down lighter (CFL) with 5*2=10W LED

Sr. No	Items	Parameters	Units
1	Total (18*2 W) Down lighter (CFL)	No.	138
2	Rated Power	Watt/ unit	36
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	14904
6	Replacement		
7	Replacement with (2*5W) LED Light	Watt/unit	10
8	Unit Consumed Annually	kWh/Year	4140
9	Energy Saving (Old- New Annual Consumption)	kWh	10764
10	Total Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	64,584/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs 500/- per item	INR	69,000/-
13	Total Investment	INR	69,000/-
14	Net Annual Saving	INR	64,584/-
15	Simple payback (Investment/annual savings)	Month	13

Note: simple pay back period defend on working hours & load factor of the system.

Case Study No.9

Replacing (36*4W=144W) picture warm light with 72W LED lights

Sr. No	Items	Parameters	Units
1	Total (4*34W)picture warm light	No.	5
2	Rated Power	Watt/ unit	144
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	2160
6	Replacement		
7	Replacement with 72W LED Light	Watt/unit	72
8	Unit Consumed Annually	kWh/Year	1080
9	Energy Saving (Old- New Annual Consumption)	kWh	1080
10	Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	6,480/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs 2000/- per item	INR	10,000/-
13	Total Investment	INR	10,000/-
14	Net Annual Saving	INR	6,480/-
15	Simple payback (Investment/annual savings)	Month	18.5

Note : simple pay back period defend on working hours & load factor of the system.

Case Study No.10

Replacing (36*2=72W) sqarringng fitting FTL with (18*2=36W) LED lights

Sr. No	Items	Parameters	Units
1	Total (2*36W) sqarringng fitting FTL	No.	47
2	Rated Power	Watt/ unit	72
3	Operating Hrs	Hrs/day	12
4	Operating Annual Days	Days/Year	250
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	10152
6	Replacement		
7	Replacement with (2*18W) LED Light	Watt/unit	36
8	Unit Consumed Annually	kWh/Year	5076
9	Energy Saving (Old- New Annual Consumption)	kWh	5076
10	Total Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	30,456/-
11	Cost Benefit Calculation		
12	Capital Cost @Rs 3500/- per item	INR	94,000/-
13	Total Investment	INR	94,000/-
14	Net Annual Saving	INR	30,456/-
15	Simple payback (Investment/annual savings)	Month	37

Note: simple pay back period defend on working hours & load factor of the system.

Case Study No.11

Replacing Ceiling Fan 80W by 28 W BLDC Ceiling Fan

Sr. No	Items	Parameters	Units
1	Total Ceiling Fan 80	No.	877
2	Rated Power	Watt/ unit	80
3	Operating Hrs	Hrs/day	16
4	Operating Annual Days	Days/Year	200
5	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	224512
6	Replacement		
7	Replacement with 28 W BLDC Ceiling Fan	Watt/unit	28
8	Unit Consumed Annually	kWh/Year	78579
9	Energy Saving (Old- New Annual Consumption)	kWh	145932
10	Annual Energy Cost Saving @ Rs. 6.00 per unit	INR	8,75,596/-
11	Cost Benefit Calculation		
12	Capital Cost @1800 per item	INR	15,78,600/-
13	Total Investment	INR	15,78,600/-
14	Net Annual Saving	INR	8,75,596/-
15	Simple payback (Investment/annual savings)	Month	21.6

Note: simple pay back period defend on working hours & load factor of the system.

Case Study No.12
Air Conditioning System
Recommendation:

- It is recommended to replaced Sprit AC by BEE star rated AC
- It is recommended "Fall Ceiling "in air conditioning area. It will be reduced air conditioning load of AC and unit consumption.
- According to studies, for every one degree we raise the temperature of AC to, up to 6% electricity can be saved, So far, the default temperature for AC's in India was 20 or 21 Degrees. Thus by increasing it to 24 degree you bare savings 18 to 20 % electricity- It is simple Maths.
- Reduced the infiltration from door and window in air conditioning area
- Keep doors and windows closed in air-conditioned space, particularly doors leading to stairwells and external areas.
- Avoid Usage of Air-conditioners in the evening hours & favorable climate conditions.
- Use pedestal fan instead of air-conditioners duringnon laboratory hours.
- Installation of energy saver for each AC.
- Insulate wall & ceiling.
- Routine maintenance for air filters& cooling pins to make proper operation at regular interval.
- Use air curtains in front of door to avoid false air entry.

Case Study No.-13
Lighting

- Switch off lights when absent from your work area for more than 30 minutes including in bathrooms, meeting rooms, lecture theatres and corridors.
- Maximize the use of natural light and turn on lights only when there is inadequate lighting.
- Promote LED lamps instead of incandescent bulbs.
- Promote electronic chokes for florescent lamps instead of EMT chokes.

Case Study No.-14
Computer and Monitors

- Online UPS – Battery Status Indication. It can be switched-off during non-use period. To minimize no-load power consumption.
- Advice on PC energy saving features like advanced LED monitor.
- Switch-off the Offline UPS. When the power failure is less. Improves life of SMF Batteries. Over charging will leads to bulging of batteries and leads to battery failure.
- Adjust your power management settings to put your screen to sleep if it is not in use for more than five minute

CONCLUSION

Green building reduces energy consumptions in numerous ways. Decrease embodies energy of the building through efficient design, use of recycled and local materials and recycling construction waste. Green building design reduces energy consumption over its lifetime. Strategically placing windows and skylight can eliminate the need for electrical lighting during the day. High quality insulation reduces temperature regulation costs in both summer and winter. Green building consumes less water as compared to conventional building.
The campus exhibits the elements from planning to post operation stage in the overall building lifecycle that can be adopted to become green and energy efficient.

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