January /May 2023

Report on

Energy Audit

& Lighting Assessment study

Prepared For

Delhi College of Arts & Commerce

University of Delhi
Netaji Nagar, Delhi- 110023

Project No.: ITPL22-R-6009 A

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INDOHAAN TECHNOLOGIES PRIVATE LIMITED

ACKNOWLEDGMENT

M/s Indohaan Technologies wishes to express its thanks to the **Principal and Faculty of the Department of Environmental Studies staff of Delhi College of Arts & Commerce (DCAC)** for the support and courtesy extended to the visiting team during the data collection and study.

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CHAPTER 1
OBJECTIVES, PREAMBLE & METHODOLOGY

1.1 Introduction & Objectives

A walk-through audit and assessment study has been carried out in accordance with the Work order (DCAC/A-9/2022-23/515) dated 10th August 2022 issued by Delhi College of Arts & Commerce (DCAC) to assess the current electrical energy consumption scenario in the campus & to suggest measures that may be adopted by them for improving energy efficiency including potential contribution of Solar power-which has been recently installed & awaiting commissioning & tie-in to the NDMC grid.

Another objective is to assess the illuminance levels in various classrooms, tutorial rooms, seminar rooms, laboratories, offices & other sections of the academic and non-academic buildings & suggest recommendations for improvement using energy efficient lighting systems.

1.2 Preamble

Delhi College of Arts and Commerce (DCAC), a premier institution of higher learning, is a constituent college of the Delhi University, financed partially by the Govt. of NCT, Delhi. The College was established in 1987 under the aegis of the Delhi Administration once the erstwhile G.D. Salwan College closed its operation. Though it is now an entity independent of the Salwan Trust, yet in its formative years, it transformed out of the erstwhile G.D. Salwan College that was located in Rajinder Nagar.

The college offers 18 undergraduate courses leading to the Bachelor with Honours/Programme Degree with various paper options for students to choose from both under the CBCS mode and the erstwhile semester/ FYUP mode. The college also offers various add-ons and self-financed courses. It was also the pioneer college in Delhi University to introduce a three-year Honors Programme in Journalism in July-August 1989.

The college has also been making various efforts and initiatives to integrate cross-cutting issues such as gender, climate change, environmental education, human rights, ICT, etc. through various cells, societies, and community outreach programs**.**

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- Energy and Environment
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1.3 Methodology Adopted

To achieve the objectives stated in clause 1.1 above, the following methodology was adopted:

1. Inventory data of Lighting luminaries, Fans/Exhaust units, Window/Split Air conditioners, Computers/UPS, Laboratory equipment, Pumps, Transformer & all related Equipment for the electric distribution system and the areas occupied by the buildings was collected by a site visit.
2. Discussions held with the concerned electrical technician, coordinator & the Principal of the college
3. NDMC Energy bills & MCD Water bills were collected for the academic year April 2021- to March 2022.
4. Illuminance (Lux) measurement was carried out in selected sections of the college, Labs, offices, canteen, etc.

1.4 Assessment Study Team

Following were the members of the Audit/assessment team, who visited the College premises on 9th January 2023 for a Walk thorough audit, data collection and Lux measurement:

- Ms. Deepika Soorma
- Mr. Ashok Grover

1.5 Executive Summary

Summary of the major findings is presented below:

i. Based on the energy bill collected and the details of the various building areas, the approximate Energy Performance Index (EPI) was calculated as 20 kWH/sqmt/year. This is good and far below the limit of 90 kWH/sqmt/year as specified by GRIHA for educational buildings.

ii. The lighting level measured in almost all the classrooms and office spaces is very low. Hence, to improve lux levels and make it energy efficient, the replacement of lighting fixtures with LED lighting to be carried out in a phased manner.

iii. Based on the yearly consumption noted from the NDMC Energy bills for 2021-22, it is recommended to commission 50% of the Solar panels already procured & available in the college to achieve a substantial contribution by Renewable energy in the overall consumption.

iv. The remaining panels may be commissioned only after a cost-benefit analysis is done considering the best rates available for the sale of surplus power vis a vis cost incurred as outgo to the Solar power producer.

v. Wherever existing electrical devices/ appliances such as fans, ACs, etc need replacement, replacement with energy-efficient models should be done.

CHAPTER 2

ENERGY CONSUMPTION ANALYSIS

2.1 Analysis based on inventory data

As per the stated methodology, an inventory of the electrical appliances available in the college has been obtained & tabulated in Table 1 below.

Further, in view of non–availability of complete data on the Solar power plant, first-principle calculations have been done to work out per annum generation of Solar power as shown in Table 2 based on the nameplate rating read out from the photograph of the PV m

See Figure -1 for actual photographs of the installed panels procured along with snapshot of the photovoltaic power module showing power generation data

Table 1 Inventory of installed Electrical appliances

No. of Classrooms	Solar Power Plant rating (kWp)	No. of Tube lights	No. of LED fixtures	External/ Street light	No. of ACs	No. of fans	No. of LCD projector	No. of Computers	No. of printers	No. of Photo-copier machine
70	200	535	354	15	41	463	16	100	25	3

Table 2 Detail of Photovoltaic panel & calculated generation of Solar power

	Make	**Jinko Solar**	
	Model no	JKM-545M-72HL4-V	
A.	No of panels (= 240+144)	384	Nos.
B.	Rated power of panel (Pmax) as per Name plate reading	545	KW
C.	Daily time for Sun exposure (average)	6	hrs
D.	Calculated daily generation considering 75 % efficiency in conversion= (A *B * C * 0.75)/1000	941.76	kWH
E.	Calculated generation per annum considering 300 good days for Solar radiation /downtime etc	282528	kWH
	Say	**2,80,000**	kWH

As part of the detailed assessment, we have worked out the expected energy demand from the nameplate rating of equipment & compared the same vis a vis NDMC Energy bills.

Our calculated results & observations are tabulated in Tables 3 & 4 on pages 11 onwards.

Other notable Energy conservation measures adopted by the college include prominent signage for switching off lights & electrical appliances when not in use & providing false ceilings in the staff room for reducing the load & hence consumption by the Air conditioners.

See Fig 2 for geo-tagged photos of these features.

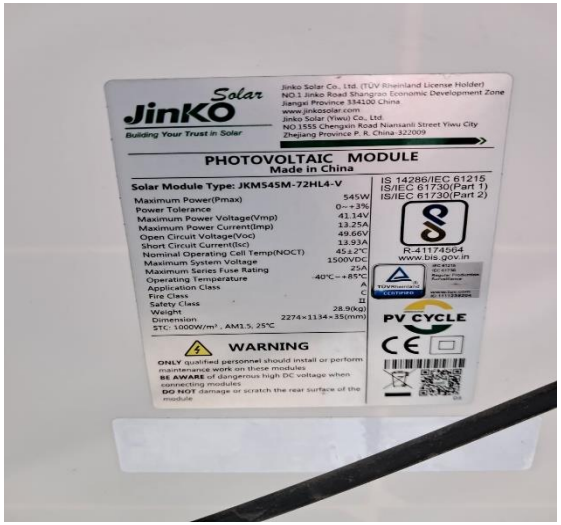


Figure 1 Actual photographs of installed Solar panels & name plate of power module

Figure 2 False ceiling for energy conservation

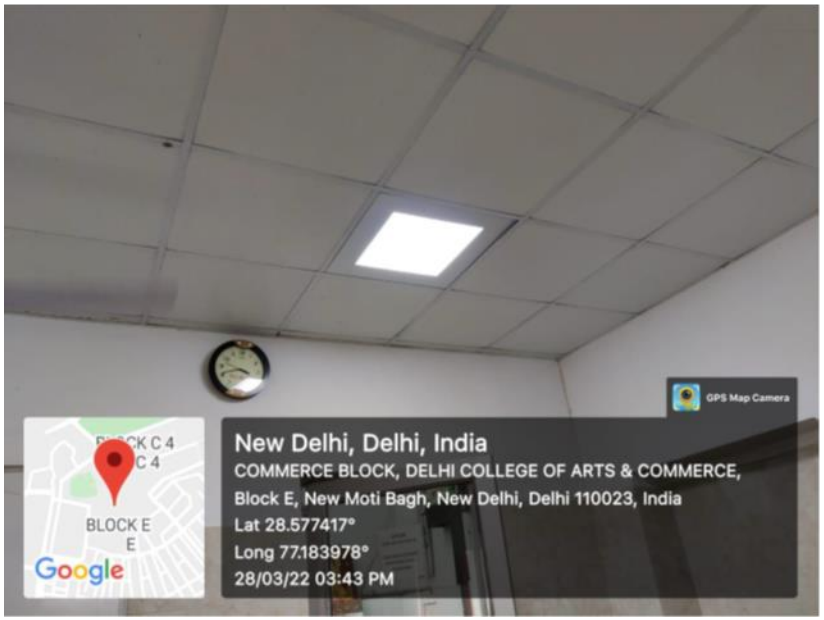
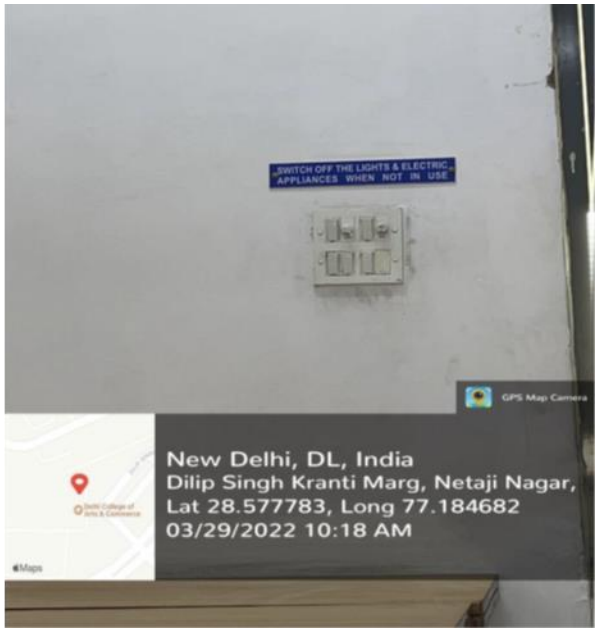


Figure 3 Signage for switching off Lights



2.1.1 Energy demand calculation of installed equipment

The energy demand is calculated based on the nameplate rating of all the Lights & other electrical appliances as per the inventory listing and the result is tabulated in Table 3 below against each function.

Table 3 Calculated Energy demand based on Nameplate rating

		Unit
i) Calculated demand for Lighting (70% Lights working for 4 hrs X 25 days /month X 9 months (vacation period excluded)	24669	kWH
ii) Calculated demand for Outdoor Lighting (12 hours working x 365 days)	16425	
iii) Calculated demand for Air conditioning (70% A/c working x 4 hours x 25 days/month x 5 summer months)	16275	
iv) Calculated demand for Fan running (70% Fans running x 4 hours x 25 days/month x 9 months (vacation period excluded)	3125	
v) Calculated demand for Computers, printers, etc	66	
vi) Calculated demand for Water Pumps, Water Cooler (2 hour running for pumps & 365 dyas running of Cooler)	1697	
vii) Calculated demand, which is expected to be consumed in the Summer months (April 2021-Sept 2021)	51610	
viii) Calculated demand in Winter months (Oct 2021- March 2022) with full lighting load (AC & Fan not running)	44545	
ix) Summation of total energy demand = vii+ viii)	96155	

Table 4 Energy Consumption details as per NDMC Electricity Bill

i) Yearly consumption of units as per NDMC Electricity bills for period- April 2021 to March 2022		80795	kWH
ii) Break up of above consumption for Summer months (April 2021 –Sept 2021)		41310	
iii) Break up of above consumption for Winter months (Oct 2021 to March 2022)		39485	
iv) % Utilization of Available Inventory *based on Actual consumption vis a vis Demand as per the Nameplate rating shown in Table 3* - **See Note 1**	Summer	80 %	%
	Winter	86.6 %	
v) Calculated MDI Average value based on yearly consumption noted in (i) above		224	KW
vi) Total Sanctioned load based on the addition of individual loads as indicated below for the 2 meters installed in the college a) Meter No. CT/PT/BE85056 – 78.85 KW b) Meter No. CT/BE85203 - 90 KW		168.85	
vii) Referring to (v) & (vi) it is noted that Power is consumed in excess of the sanctioned load -**See Note 3**			

Notes:	
1.	Looking at the % utilization value, it appears that the College is utilizing the available inventory (Lights, Fans, AC, etc.) very conservatively specially in the Summer months, which is a commendable performance on Energy conservation
2.	Also see below Table 5 for an evaluation of EPI (Energy performance index) as per Green Rating for Integrated Habitat Assessment (GRIHA), which is a commendable performance on energy conservation
3.	Notwithstanding the good performance as mentioned in Note 1 above, in view of excess consumption, as noted in (vii), it is highly recommended that the procured 200 KW Solar photo voltaic system (SPVS) should be commissioned & connected to the Main grid on an urgent basis to avoid any likely penalty by NDMC for exceeding the sanctioned limit in future. See Chapter 4 for specific recommendations

Table 5 Evaluation of EPI as per GRIHA

Evaluation of the Energy Performance Index as per Green Rating for Integrated Habitat Assessment (GRIHA)		
Section wise	Values	Unit of Measurement
Academic building (approx. 1 Acre)	4046.9	Sqmt
Annual power consumption	80,795	kWH/ year
Energy Performance Index (EPI)	19.96 say 20	kWH/sqmt/year
GRIHA criteria for EPI for academic buildings for 8 hours of working (Criteria 8 of GRIHA Manual Version 2015)	90	kWH/sqmt/year

CHAPTER 3
EVALUATION OF LIGHTING PERFORMANCE

3.1 Lighting - Energy Saving & Lux improvement measures

3.1.1 Implementation of LED system for energy saving

LED Luminaire system provides superior luminous efficiency > 100 lumens /Watt & when selected /installed by professional experts can achieve the allowable limit of Lighting power density (LPD) = 9 W/m2 as set out in ECBC 2016 code for University /Schools

It is noteworthy to mention that the College has already taken the lead in this direction & has started fixing LED lights on case to case basis when the existing T5 tube lights (38W) reach their end of life and need replacement. They have discontinued further procurement of T5 lights, but at the same time would like to utilize the available quantity with discretion till it is stocked out, which is a prudent approach to follow

3.1.2 Lux improvement measures – Short-term & Immediate

Referring to Table 6 on page 15, it is observed that in almost all areas, the Lux levels are far below the illumination norms prescribed by the National Building Code (NBC)

Therefore, an immediate mitigation action is suggested for installing additional LED lights at the correct locations using appropriate fixtures based on a detailed engineering assessment

The resultant increase in energy demand of additional LED fixtures can be met by commissioning the already installed Solar plant which can more than cover the increased wattage & thus completely fulfilling all the objectives set for this assignment as emphasized again

- Meeting benchmark levels of illuminance & at the same time
- Substantial contribution coming from renewable sources.

See Chapter 4 for specific recommendations on the commissioning of Solar panels

Table 6 Iilluminance level (Lux measurement) & comparison with NBC code

Note: *All units are in Lux as measured by Lux Meter (AMPROBE make LM-100) & the measurements are done at the working plane level*

Room description	Measured Lux (Average)	Room description	Measured Lux (Average)	NBC illuminance requirement Table 4 Section 8 Part 1
Board room	220	PWD room	52,68,60	300
Principal's room	231, 240	Computer Lab - 1	53, 68, 146	
Library near Window	1180	Computer Lab - 2	58,342, 225	
Library near Table 1	258	Room no. 12	101, 119	
Library near Table 2	276	Room no. 15	76,122	
Library near Table 3	252	Medical Room	115	
Library near Table 4	210	Hall	97,158,75	
Teacher reading room	80, 150	Room no. 28	197	
Commerce class room no 56	145, 162, 111	Room no. 25	112, 98, 194	
		Staff room	95	
Corridor	20			100
		Legend	OK wrt NBC Code	
			All other areas	Need improvement

CHAPTER 4
RECOMMENDATIONS

We have further analysed the observations & recommend the implementation of the following measures for mitigating shortcomings of low illuminance levels, providing the opportunity for enhancing Energy conservation & at the same resulting in monetary savings.

Also see Table 7 on the next page, wherein these recommendations are elaborated along with their tangible benefits & other related aspects for demonstrating an increased level of environmental friendliness & sustainability

i. Replacing existing Tube lights to energy-efficient LED lights @ 20 -23 W in a phased manner. Refer Sr. no a) in Table 7

ii. Installation of additional LED lights for substantial Lux level improvement to say around 200-300 lux in all the rooms after a detailed engineering study. Refer Sr. no b) in Table 7

iii. *Commissioning of the 200 kWp Solar photovoltaic plant with 50% panels as recommended in Sr. no c) in Table 7*

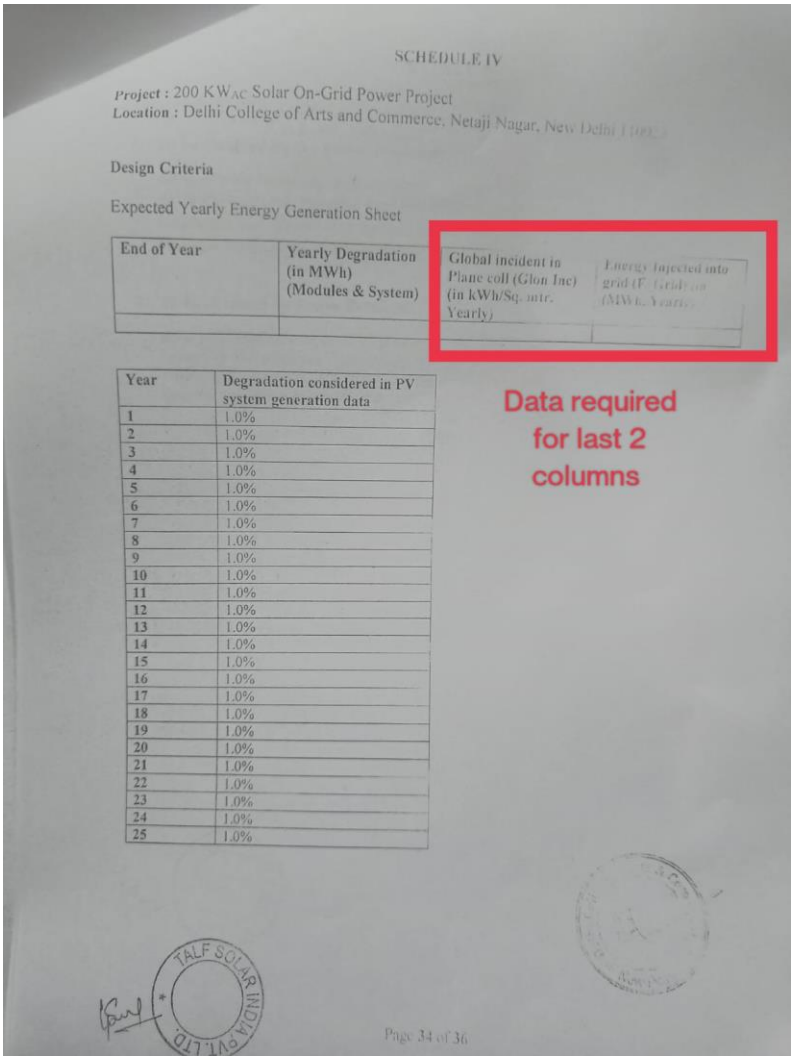
iv. Obtain missing information relating to expected annual power generation, as marked in the snapshot of the Schedule IV document of the Solar power purchase agreement (See figure 4 on page 20) from the supplier

This data will ensure the supplier's firm commitment for the performance of the panels in accordance to the first–principle calculations shown in Table-2, which forms the basis of our recommendation in Sr. no iii above

Table 7 Suggested Energy conservation measures

a) Recommendation for replacement of all existing Tube lights to energy-efficient LED lights @ 23W			
Expected %age power load reduction if all 535 existing tube lights are converted to LED @ 23 W will be		29.7 %	%
b) Recommendation for Installation of additional LED lights with fixtures for substantial Lux level improvement to say around 200 – 300 lux			
i)	Estimated additional LED fixtures that may be required to improve illuminance requirement to meet NBC code	say 500	Nos.
ii)	Increase in lighting consumption on a yearly basis due to additional 500 fixtures will be	7%	%
iii)	To offset the impact of the increase in overall energy consumption due to the provision of additional LED fixtures, it is imperative to immediately commission the Solar power plant. Also, see Sl no. C iii) to C v)		
c) Recommendation for immediate commissioning / hook-up of 50% panels of the 200 kWp Solar PV plant			
i)	A 200 kWp Solar power plant (with 388 panels) will generate 280,000 KWH per annum as calculated in Table -2	280,000	KWH
ii)	The generated Solar power as noted above will be much more than the yearly consumption recorded as per the actual Energy bill for the year 2021-22 (=80,795 KWH) by more than	> 300 %	%
iii)	Therefore, it may not be desirable to commission the entire 200 KWp plant since a substantial generation will have to be transferred back either to the Main Grid & /or to a regular consumer in the vicinity. A cost-benefit analysis is required to be carried out for selling surplus power at the prevalent rate vis a vis outgo to Solar power producer		
iv)	Unless there are immediate expansion plans to add new facilities within the college & thereby increase in-house consumption, it t would be prudent to commission only 50% of the Solar panels at this time for captive use & negotiate the sale of surplus power		
v)	Finally, the above action when implemented, will result in a 100 % contribution by Renewable energy, which will set a good benchmark for the college on eco-friendliness & meeting sustainability criteria.		

Figure 4 Schedule IV of Solar Power purchase agreement



SCHEDULE IV

Project : 200 KW_{AC} Solar On-Grid Power Project
Location : Delhi College of Arts and Commerce, Netaji Nagar, New Delhi [illegible]

Design Criteria

Expected Yearly Energy Generation Sheet

End of Year	Yearly Degradation (in MWh) (Modules & System)	Global incident in Plane coll (Glon Inc) (in kWh/Sq. mtr. Yearly)	Energy Injected into grid (E_Grid) (in MWh. Yearly)

Year	Degradation considered in PV system generation data
1	1.0%
2	1.0%
3	1.0%
4	1.0%
5	1.0%
6	1.0%
7	1.0%
8	1.0%
9	1.0%
10	1.0%
11	1.0%
12	1.0%
13	1.0%
14	1.0%
15	1.0%
16	1.0%
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22	1.0%
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25	1.0%

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Note: Refer Sr no iv) of Chapter 4 for obtaining missing data in the above document