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Rooftop Solar Potential Assessment with Area-Specific Benchmarks

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Abstract

The potential for rooftop solar energy has conventionally been estimated using area-based benchmarks within a given region. This study presents a month-wise estimation of rooftop solar photovoltaic (PV) energy generation for Krishna Kanta Handiqui State Open University (KKHSOU), City Campus, Guwahati, based on area-specific benchmarking from Assam Don Bosco University (ADBU), Azara Campus, which shares a similar geographic and climatic profile. Using rooftop area availability, technical specifications of PV systems, and typical monthly generation patterns from ADBU as a reference, projected generation values were computed for KKHSOU's City Campus in Guwahati. The analysis of the results indicates that KKHSOU has strong potential to meet a significant portion of its electricity needs through grid-connected solar installations, paving the way for a more sustainable and cost-effective energy model for the university. This study makes a way for estimation of solar generation which reduces the university's dependence on conventional electricity sources and the potential economic benefits obtained thereof for other similar projects, using solar PV systems' real data from geographically proximate areas. The findings also highlight KKHSOU's contribution to global climate change mitigation efforts through the promotion of rooftop solar energy thereby supporting the reduction of carbon emissions at the local and global scales.

Keywords: Benchmarking, Grid-connected Systems, Photovoltaic (PV), Solar Energy Estimation.

Introduction

India's renewable energy sector has experienced rapid growth in the recent years, particularly in the deployment of rooftop photovoltaic systems. As of April 2025, India has installed 110 GW of solar capacity, of which 16.7% (18.37 GW) is achieved from rooftop installations of solar projects (1). Despite strong overall growth, the deployment rate of rooftop solar projects still remains substantially below the targets set by the Government of India (2). A significant factor contributing to the relatively low energy output from rooftop solar projects in India is the predominance of very small-scale residential installations which have a limited capacity of 5-20 kW (kilowatt) (3). To address this limitation, it is essential to promote large-scale rooftop adoption, particularly in sectors where installation areas can support systems of 100 kW capacity or more. In this context, office buildings, industrial establishments and educational institutions can play an important role in promoting green energy by utilising rooftop real estate for decentralized generation.

The current paper is an attempt to estimate the potential of such an installation of solar PV system by utilizing the free space on the rooftop of an institution in Guwahati, Assam, India. The institution campus selected for the current study is the Krishna Kanta Handiqui State Open University (KKHSOU) City Campus in Khanapara, Guwahati, situated at 26.118° N latitude and 91.814° E longitude. The campus covers an area of 8918 square meters and it is built on the Passive Green Building Concept. Moreover, the building represents a viable candidate for rooftop solar integration due to its extensive, underutilized rooftop space. Utilizing this rooftop space for solar power generation could lead to substantial longterm savings on electricity expenses for the institution as well.

For practical comparison and benchmarking, this study uses an established generation trend at Assam Don Bosco University (ADBU) campus at Azara, (26.129° N, 91.620° E), to forecast expected energy output from the other proposed rooftop system, based on real calculations on ADBU. The two campuses are about 18 kilometers aerial distance apart, having the same climatic condition

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including solar irradiance levels, temperature ranges and seasonal pattern of weather variations throughout the year. As such, the generation performance at ADBU Azara campus serves as a reliable benchmark for forecasting solar output at KKHSOU City Campus, in the absence of long term site specific data. The aerial views of KKHSOU City campus and ADBU Azara campus are shown in Figure 1(A) and 1(B).

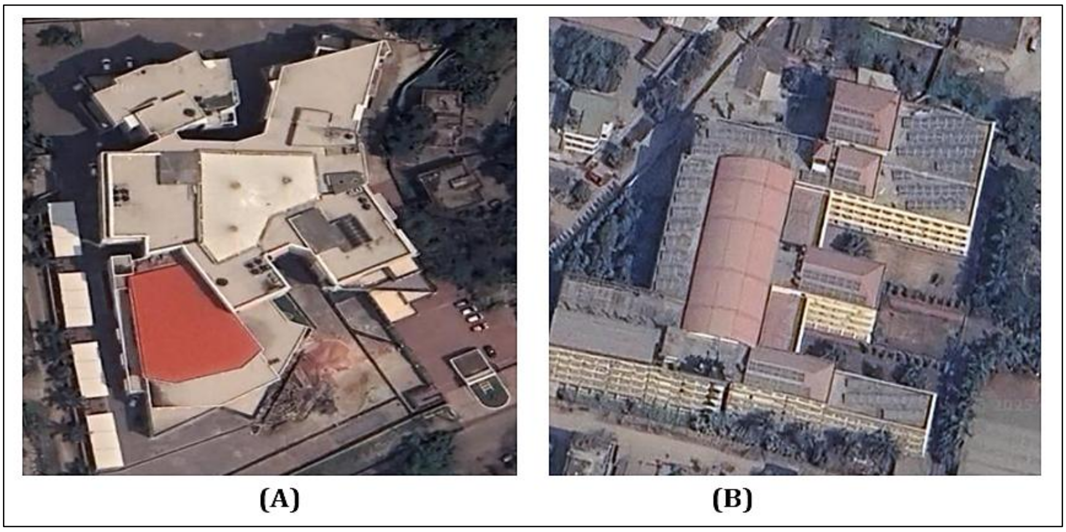

Figure 1: (A) Google Earth Satellite view of KKHSOU City Campus, (B) Google Earth Satellite view of ADBU Azara Campus

India has seen a substantial increase in solar PV installations due to favorable government policies such as the National Solar Mission and subsequent Ministry of New and Renewable Energy (MNRE) guidelines. Rooftop solar has been promoted particularly for educational and public institutions under schemes like Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) and Grid Connected Rooftop Solar Programme – Phase II (4).

For all these schemes the accurate estimation of solar potential has become a necessity, which depends on geographic and climatic variables. Tools such as NASA's POWER database, PVGIS (Photovoltaic Geographical Information System), and MNRE's solar maps are widely used to obtain location-specific irradiance data for developing such estimates (5-7).

Energy yield is generally estimated using simulation tools like PVsyst and SAM (System Advisor Model), or by simplified area-based benchmarking techniques using energy yield per square meter (8). As reported in past studies, as well as in many other recent literatures, the researchers also develop models based on rooftop area and local irradiance to predict month-wise solar generation with about ±10% accuracy in most of the cases (9-10).

A study evaluated a solar-biomass hybrid system for an academic building at Delhi Technological University, showing that it could reliably generate 376,780 kWh/year, meet peak loads of 65 kW, and reduce CO_2 emissions by 161 tonnes (11). Another study at MANIT Bhopal estimated, based on simulation, that a 5 MW solar PV plant installed on available open spaces and rooftops could generate approximately 8,304 MWh annually and was projected to mitigate about 173,318 tonnes CO_2 emissions over a 25-year operational lifespan (12). A study reported the performance analysis of a 417-panel system at Government Engineering College, Bharuch, with an average performance ratio of 80.28% and 172 MWh annual energy yield over a period of 5 years (13). Similarly, TERI-HAL's 10 kWp installations across Bengaluru schools demonstrated net metering viability and energy education benefits (14).

Area-based estimation methods further support this benchmarking approach. Silchar's solar potential study used tilted-surface models for institutional PV feasibility, while a 45 kWp semi-arid campus system achieved reliable energy yields with notable CO_2 savings (15-16). Assam-specific mapping estimates 7-13 GW rooftop potential via satellite imagery, and IEA benchmarks confirm empirical yield data's superiority over simulations (17-18). These findings are consistent with the KKHSOU-ADBU methodology, which emphasizing real-data transfer for proximate sites.

Economic assessments commonly use metrics like Levelized Cost of Electricity (LCOE), Payback Period (PBP), and Net Present Value (NPV). The researchers proposed a simplified payback calculator tailored for educational institutions in tropical climates (19).

Several studies document carbon savings of 0.8–1.0 kg CO_2 per kWh of solar electricity generated. For institutional setups, this contributes not only to direct emission reductions but also aligns with ESG (Environmental, Social, and Governance) targets (20-25).

The key findings from the literature reviewed have been summarized in Table 1.

Table 1: Summary of Key Findings from Literature Review

Focus Area	Key Insight
Benchmarking methodology	Area-based estimates are valid within ±10% using known irradiance data
Simulation support	PVsyst and SAM are most widely used tools
Financial viability	Payback period for institutional systems is 4–7 years
Academic deployment	Rooftop PV in campuses is viable, especially with net metering and subsidies
Environmental benefits	Each kWh of solar energy can reduce ~0.82 kg of CO_2 emissions

After a comprehensive literature review on the topic, several key research gaps are identified, to be addressed through the current work. First, accurate estimation of rooftop solar potential in highly fluctuating environment, like that of Assam is not reported in any of currently studied literature. Second, for locations with limited site-specific solar generation data availability, the other possible methods, such as generalized benchmarking-based estimation, is not done by the researchers, as per the common literature. Additionally, the integration of real-time meteorological datasets and use of machine learning algorithms for prediction of solar generation, using these data, has not been attempted by the researchers.

Based on the research gap identified from the study of the literature, as presented above, a number of objectives are derived. The first one is the estimation of month-wise solar energy generation potential of a large free rooftop area, such as that of the KKHSOU campus, using the area-specific benchmarks derived from real generation data of the nearby ADBU campus. The other objective of the study is also to measure the usable rooftop area across campus buildings and suggest feasibility of installation of rooftop PV systems in similar settings of other institutions in the region.

The novelty of the present study lies in its methodology considering month-wise, area-specific solar generation benchmarks, which are derived from real operational data. Unlike conventional simulation-based estimations, this method utilizes empirically validated metrics, for Guwahati's micro-climate. This benchmarking technique offers a practical, low-cost, user friendly alternative for data-scarce regions.

Description of the Existing Solar Plant Considered for Benchmarking

The existing solar power plant at ADBU is an on-grid system comprising 508 polycrystalline silicon solar panels, three inverters, and associated electrical accessories. The PV modules are installed on the rooftops of the academic and administrative buildings, with 400 panels installed on the concrete roof of the academic/administrative buildings and 108 panels on the tinned roof. Each module covers an area of 1.94 m^2, resulting in a total solar panel area of 986 m^2. The modules are mounted at a fixed tilt angle of 23° and an azimuth angle of 0° facing South direction. The overall plant layout is illustrated in Figure 2.

In the given layout, the total 508 solar panels, each rated at 315 Wp, are connected to three grid-tied inverters each rated at 60 kW. The inverters convert the direct current (DC) output from the solar PV modules into alternating current (AC) used by the grid. Inverter-I and Inverter-II each interface with 200 panels, while Inverter-III connects to 108 panels. The outputs of Inverter-I and Inverter-II are routed through 1.1 kV, 3.5-core, 25 sq. mm XLPE copper armored cables, protected by 125A, 4-pole MCCBs (Molded Case Circuit Breakers), to a 250A, 3-phase, 4-wire aluminum busbar. Inverter-III feeds into a 100A busbar. Both the 250A and 100A busbars are connected to the main 350A aluminum busbar using 1.1 kV, 3.5-core, 25 sq.mm XLPE copper armored cables, each protected by MCCBs rated at 250A and 100A, respectively. Downstream of each MCCB, R-Y-B phase indicator lamps are connected via 2A fuses followed by Type-II surge protective devices to mitigate transient overvoltage. The load required for the academic and administrative buildings alongside the load required for the hostels and staff quarters of ADBU are tapped from points in the main busbar. A 250 kVA distribution transformer connects the institution side (line voltage of 400 V) with the utility side (line voltage of 11 kV). Power flows bi-directionally between the institution and utility grid via a net energy meter which tracks the kWh (kilowatt hour) import and export. Detailed technical specifications of the solar panel and the inverter of the ADBU campus are provided in Table 2 and Table 3.

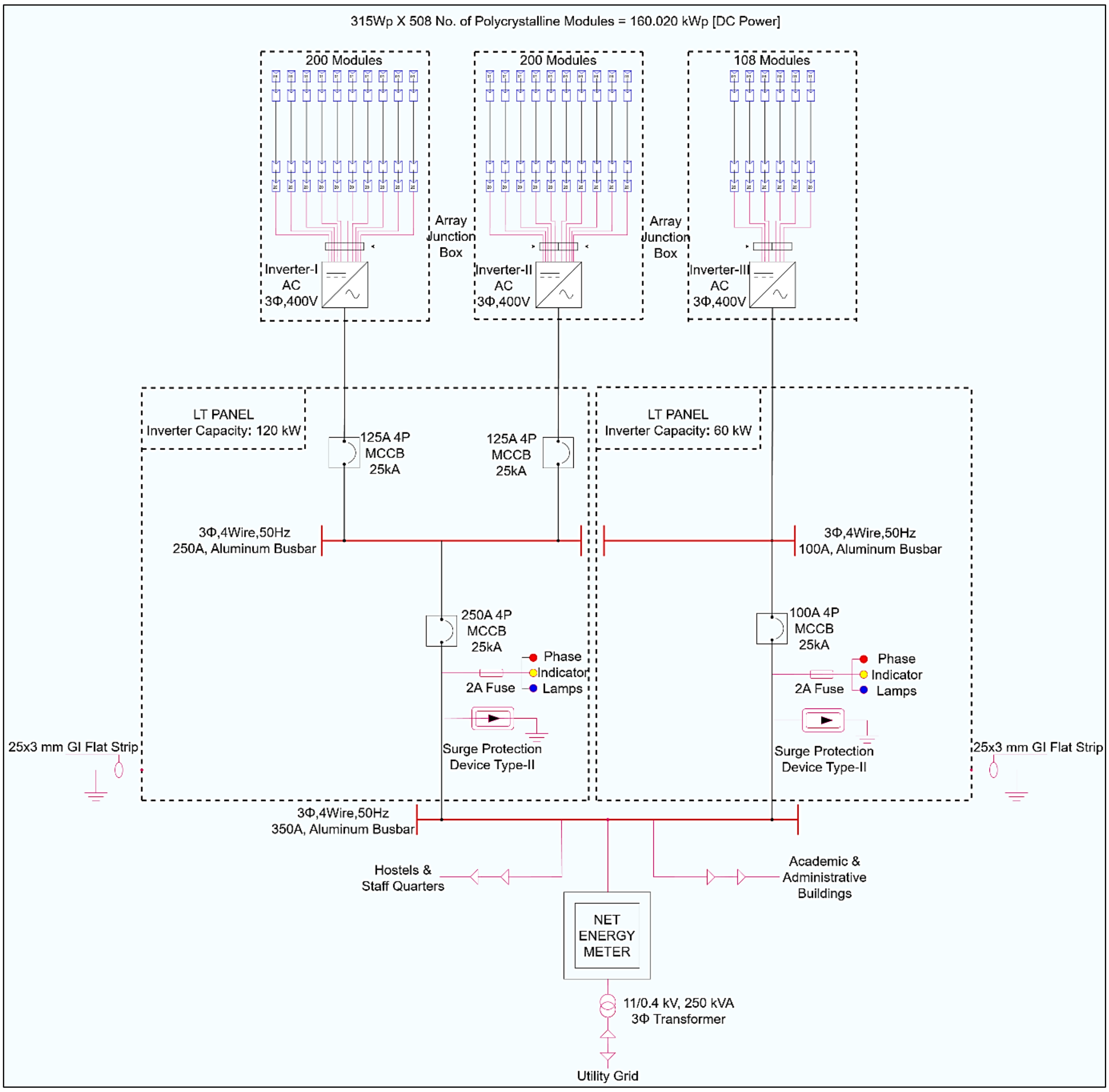

Figure 2: Module Layout Diagram of the Existing Solar PV Plant at ADBU

Table 2: Technical Specification of the Existing Solar Panel

Particulars	Specifications
PV model number	ELDORA VSP.72.315.03
Solar cells per modules (Units)	72
Dimension (LxWxH)	(1956x992x36) mm
Weight	27 kg
Nominal Operating Cell Temperature	45 ^{0}C
Temperature Coefficient of power	-0.43 %/^{0}C
Electrical Characteristics	
Open Circuit Voltage	46.04 V
Short Circuit Current	8.85 A
Maximum Power	315 W_p
Maximum System Operating Voltage	1000 V(TUV) 600 V(UL)
Voltage at Maximum Power Point(V_{mpp})	38.33 V
Current at Maximum Power Point(I_{mpp})	8.22 A
Module efficiency	16.41 %
Maximum series fuse rating	15 A
Fill Factor	77.33 %

Table 3: Technical Specification of the Inverter

Particulars	Specification
Model Number	hopeSun 60KTL
Max. Input Voltage	1100 V
Max. Input Current	45 A
Max. Input Power	90 kW
MPPT voltage range	(200-1000) V
Rated Output Voltage	230 V / 400 V (3P + N + PE)
Rated Output Current	86.5 A
Rated Output Power	60 kW
Max. Output Current	95 A
Max. Output Power	66 kW
Power factor	0.8(lead) – 0.8(lag)
Max. Efficiency	98.5 %
Operating temperature	-40 ^{0}C to 60 ^{0}C

Energy Consumption Pattern of the Target Campus

The electricity consumption patterns across eight blocks (A to H) of the KKHSOU City Campus over a period from March 2022 to February 2025 has been depicted in Figure 3. It indicates that the month-wise consumption for the year 2022–23 ranged between 20,000 to 40,000 kWh. In comparison, the KKHSOU city campus recorded a monthly consumption range of 15,000 to 45,000 kWh in 2023–24, and 20,000 to 50,000 kWh in 2024–25. It has been observed that the consumption of electricity across the campus increases year on year. This analysis helps the institution to forecast electricity expenses more accurately, manage budgets effectively, and assess the feasibility of rooftop solar deployment to achieve minimization of electricity consumption costs.

Methodology

The methodology adopted for estimating solar energy generation from rooftop installation requires certain prerequisites. These prerequisites include:

i. Rooftop area determined through physical measurement

ii. Solar generation data specific to the geographical location of the rooftop

iii. Efficiency of the solar panels intended for installation on the rooftop

For implementing the PV generation estimation methodology, ADBU, Azara Campus is taken as the reference campus. ADBU has implemented a 160 kWp grid-tiled rooftop PV system with approximately 986 m^2 of active solar panel surface area. The average generation efficiency at ADBU is approximately 162 kWh per m^2 per year, or 13.5 kWh per m^2 per month, under Guwahati's average solar irradiance conditions. The generation efficiency is determined based on the average generation, calculated from the four years of generation data of ADBU campus at Azara, as shown in the following.

Total generation at ADBU Azara Campus from 1st January 2021 to 31st December 2024 = 639,212 kWh.

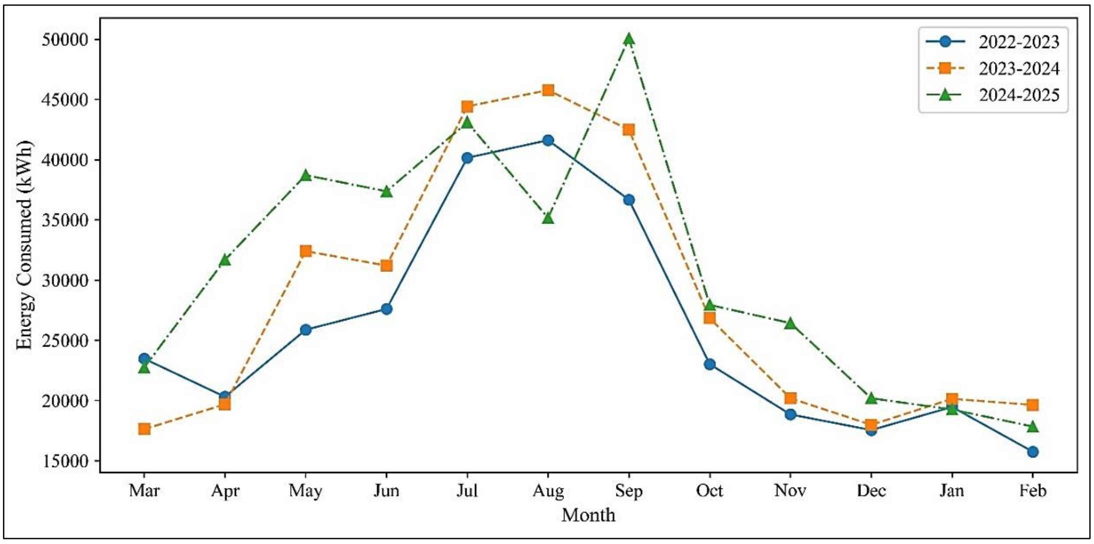

Figure 3: Monthly Energy Usage at KKHSOU from 2022 (March) to 2025 (February)

Average generation per year = $\frac{Total\ generation\ in\ 4\ Years\ in\ kWh}{4} = \frac{639{,}212}{4} = 159{,}803\ kWh$

Average generation per year per m² = $\frac{Average\ generation\ per\ year\ in\ kWh}{Active\ solar\ panel\ surface\ area\ in\ m^2}$

$= \frac{159803\ kWh}{986\ m^2} = 162\ kWh/m^2$

Average generation per month per m² = $\frac{Average\ generation\ per\ year\ per\ m^2}{Number\ of\ months\ in\ a\ year}$

$= \frac{162}{12}\ kWh/m^2$

$= 13.5\ kWh/m^2$

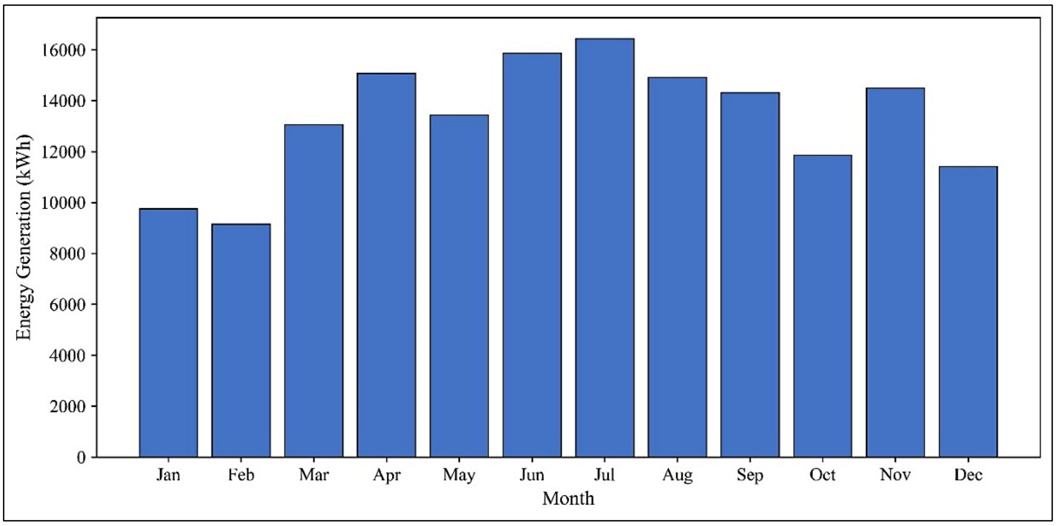

Figure 4: Monthly Average Solar Energy Generated at ADBU Azara Campus

The monthly average energy generated (in kWh) by PV panels in the ADBU Azara campus is shown in Figure 4.

Calculation of normalized ADBU weight for a given month is presented in the following. This gives the overview of the weights used for benchmarking of solar generation. Table 4 shows the monthly solar energy generation at ADBU campus.

Table 4: Monthly Solar Energy Generation at ADBU

Month	Solar Generation (kWh)
January	9751.44
February	9146.62
March	13064.79
April	15073.60
May	13445.82
June	15857.86
July	16446.65
August	14920.69
September	14320.80
October	11861.24
November	14502.42
December	11410.64
Annual	***159802.57***

The total annual solar energy generation at ADBU is 159,802.57 kWh.
If all months contributed equally, the monthly generation would be:

Monthly generation = $\frac{Annual\ generation\ at\ ADBU}{12} = \frac{159{,}802.57}{12} = 13{,}316.88$ kWh

The normalized ADBU weight for a given month is defined as the ratio of the actual monthly generation to the equally distributed monthly generation:

Normalized ADBU weight = $\frac{Actual\ monthly\ generation}{Monthly\ generation\ if\ all\ months\ contributed\ equally}$

For example, the normalized ADBU weight for the month of January is: $\frac{9751.44}{13316.88} = 0.73$
Similarly normalized weights for the remaining months are calculated.

As mentioned earlier in the paper, the target campus to estimate solar generation based on the reference benchmarks of ADBU Azara Campus is the KKHSOU City Campus. The total rooftop area measured across all blocks at KKHSOU is 4034 m^2 as shown in Table 5. The total usable rooftop area for each block for solar panel installation is estimated by manually delineating rooftop boundaries in Google Maps using the built-in distance measurement feature, wherein a closed polygon is drawn around each roof to obtain the enclosed area (26). It lets the user draw polygons on top of satellite images obtained from Google Maps to calculate area. An on-site rooftop survey has also been carried out to validate and rectify errors in the calculated effective area by the software. Thus, the total effective rooftop area available across all blocks at KKHSOU is found to be 1819 m^2 as shown in Table 5.

Table 5: Block-Wise Usable Area for Solar PV System Installation at KKHSOU City Campus

Block	Rooftop Area (m^2)	Usable Area (m^2)	Average Usable Area
A	517	174	34%
B	441	263	60%
C	436	220	50%
D	314	51	16%
E	487	0	0%
F	246	52	21%
G	997	781	78%
H	596	278	47%
Total	**4034**	**1819**	-

As per standard practice, assuming 70% coverage due to structural and safety constraints, the active panel area is estimated at 1273 m^2.
Using ADBU's benchmark of 13.5 $kWh/m^2/month$:
Estimated average monthly generation at KKHSOU campus (kWh) = 1273 × 13.5 = ~17185 kWh

Since, the benchmark chosen is within the same geographical area of Guwahati, with the aerial distance of less than 20 km, it provides reference values, for computation of estimated solar PV generation effectively. Such benchmarking techniques are very common in solar generation computations done for a prospective area of PV system installation.

In this study, the energy estimation has been calculated based on polycrystalline PV panels with 16.41% efficiency. The estimated energy output would be higher if monocrystalline panels are used, because of their higher values of efficiency ranging from 18% to 22%. These panels are made from a single crystal of silicon, which helps electrons to flow more freely, resulting in greater power generation per unit area compared to polycrystalline panels.

However, it is noteworthy that there is a potential urban heat/shading difference at KKHSOU campus, as compared to the reference campus (ADBU). This could affect the yield by ±5-10%, leading to the requirement of a site-specific validation via on-site pyranometer data before implementation.

Results

The results from the area-specific benchmarking methodology reveal substantial rooftop solar potential at KKHSOU City Campus. It is projecting an annual generation of 206,392 kWh, based on ADBU's empirically derived efficiency of 162 $kWh/m^2/year$ applied to 1,273 m^2 of active panel area. This comprehensive analysis, structured across key performance dimensions, demonstrates technical feasibility, economic viability, and environmental benefits for grid-connected PV deployment in educational institutions within Assam's subtropical climate. Detailed month-wise projections and comparative metrics underscore the reliability of nearby-site benchmarking over generalized simulations.

Annual and Monthly Energy Generation Potential

The projected annual energy output for KKHSOU stands at 206,392 kWh, derived from 1,273 m^2 active panel area at ADBU's benchmark yield of 162 $kWh/m^2/year$. This equates to an average monthly generation of 17,185 kWh. Table 6 details month-wise estimates using normalized ADBU weights from 2021-2024 data. It shows a peak output in July (21,309 kWh, 1.24 time the average) and minimum in February (11,858 kWh, 0.69 times the average), reflecting Guwahati's solar seasonality. This granularity enables precise system sizing for 160 kWp capacity, aligning with ADBU's operational 160 kWp installation across 986 m^2.

Table 6: Month-wise Estimated Generation of KKHSOU City Campus using the Benchmark of Normalized ADBU Weights

Month	Normalized ADBU Weight	KKHSOU Estimated Generation (kWh)
January	0.73	12545
February	0.69	11858
March	0.98	16841
April	1.13	19419
May	1.01	17357
June	1.19	20450
July	1.24	21309
August	1.12	19247
September	1.08	18560
October	0.89	15295
November	1.09	18732
December	0.86	14779
Total		**206392**

Seasonal Variability and Climatic Influence

Guwahati's monsoon-dominated sub-tropical climate drives pronounced seasonal variability. The summer-monsoon months are June to August, yielding 12-24% above average due to high irradiance despite cloud cover. While during the winter months from December to February it drops by 14-31% below average from shorter days and fog. Such variability necessitates hybrid grid-tied designs with net metering to balance intra-annual fluctuations.

Comparison with Benchmark Campus Performance

ADBU Azara Campus, 18 km distant at similar coordinates (26.129°N, 91.620°E), generated 639,212 kWh over 2021-2024 from 986 m^2 installed area, validating the 162 kWh/m^2/year benchmark under identical irradiance of 4.5-5.5 kWh/m^2/day annually and temperatures in the range of 22-32°C. KKHSOU's projected specific yield matches ADBU's at 162 kWh/m^2/year. It clearly outperforms simulation-based estimates, e.g., PVsyst's 150-155 kWh/m^2/year for Guwahati. Primarily it incorporates real derating factors like 16.41% polycrystalline efficiency and 23° tilt.

Rooftop Utilization Efficiency across Blocks

Physical surveys and distance measurement feature in Google Maps yielded 4,034 m^2 total rooftop area at KKHSOU, with 1,819 m^2 usable 45% gross utilization, after shading/obstacle deductions, concentrating in Blocks G (781 m^2, 78%) and B (263 m^2, 60%), while Block E offers none. At 70% packing density, this yields 1,273 m^2 active area, achieving 35% overall utilization efficiency comparable to institutional benchmarks (30-40%), but superior to residential (20-25%) due to flat concrete roofs.

Therefore, given a conservative power tariff of ₹9 per unit, as set by Assam Power Distribution Company Limited (APDCL) as of May 2025,

Annual Savings = 206392 × ₹9 = ₹18.57 lakhs/year

This offsets approximately 45% of KKHSOU's annual electricity consumption, which ranges between 400,000–500,000 kWh as seen in the historical data from March 2022 to February 2025. However, the actual capacity will align with APDCL clearance, staying within net metering limits and transformer constraints for the site.

Environmental Benefits and Emission Reduction

Assuming 0.82 kg of CO_2 avoided per kWh (standard Indian grid emission factor):

CO_2 Emission Reduction = 206392 × 0.82 kg/year = ~169 tonnes/year

This indicates that the system contributes to an annual reduction of approximately 169 tonnes of CO_2, which would otherwise have been emitted if the same energy were supplied by conventional power grid. Such a reduction not only aligns with sustainability targets and environmental compliance but also enhances the institution's contribution to global climate change mitigation efforts.

As discussed above, displacing 206,392 kWh averts 169 tonnes CO_2/year at India's 0.82 kg/kWh grid factor. This is equivalent to 7,000 trees' annual sequestration. This supports SDG 7 and 13 as well as Assam's RE targets, positioning KKHSOU as a green campus exemplar.

Grid Offset and Load Matching Analysis

KKHSOU's historical consumption of 400,000-500,000 kWh/year aligns well with 206,392 kWh solar output. It rises to 60% in peak summer months when loads increase significantly due to air conditioning loads. Daily load matching via net metering minimizes curtailment, as ADBU's bi-directional flow demonstrates, with solar peaks (10 AM-3 PM) covering daytime academic loads effectively.

Economic Impact and Cost Offset

At APDCL's ₹9/kWh tariff (May 2025), annual savings reach approximately ₹18.57 lakhs, with payback under 6 years, assuming ₹40,000-50,000/kWp installation costs and subsidies. The levelized cost of electricity (LCOE) falls to ₹3.5-4.5/kWh versus grid ₹9/kWh, yielding 14-18% IRR. This can be further enhanced by Assam's net metering and MNRE incentives.

Technology Choice Sensitivity

Polycrystalline panels (16.41% efficiency, used at ADBU) yield baseline 206 MWh; monocrystalline (18-22%) could boost output by 10-25%, shortening payback despite 10-15% higher cost. This is an ideal case for space-constrained blocks.

Discussion

The applicability of the results specify that the area-specific benchmarking method can be transferred directly to data-scarce campuses. By measuring usable rooftop (e.g., using the distance measurement feature in Google Maps), we can apply proximate site's normalized monthly weights (Table 6), and scale by 162 kWh/m^2/year, which is an ideal proposition for Assam's educational institutions like the university and college campuses where comprehensive load and resource data are unavailable. Therefore, the method provides a scalable and cost-effective framework for preliminary planning and decision-making to support wider adoption of rooftop solar energy in the educational institution.

Conclusion

The solar energy potential on the roof of KKHSOU City Campus has been estimated before the actual placement of solar panels, using area-based benchmarking. This study demonstrates that KKHSOU has substantial potential for rooftop solar generation, which, if modelled based on the ADBU benchmark, could generate over 206 MWh annually, reducing grid dependency significantly, while lowering operational costs, and contribute to Assam's climate change related targets. Integration with the state grid infrastructure is now technically more feasible, and the economic payback period is projected at under 6 years, considering decreasing PV costs and favorable policies. A detailed feasibility study will surely lead to favorable results and will act as an example for many other institutions in the region.

To expand the work, further research could incorporate region specific meteorological datasets and historical solar generation data from existing solar installations to improve the accuracy and applicability of the analysis. By leveraging a combination of benchmarked rooftop area, climatic variables, and building-specific metadata, machine learning techniques can be used to analyze complex, non-linear relationships among multiple variables to estimate not only the total solar generation potential but also the associated cost, expected revenue, and long-term profitability of solar installations with higher precision. ML models (e.g., Random Forest or LSTM) used for such estimation of solar generation could use inputs like rooftop area, NASA POWER irradiance, on-site load data and ADBU-like benchmarks to predict yield, LCOE, and payback.

Abbreviations

ADBU: Assam Don Bosco University, IEA: International Energy Agency, KKHSOU: Krishna Kanta Handiqui State Open University, LCOE: Levelized Cost of Electricity, MCCB: Molded Case Circuit Breaker, MNRE: Ministry of New and Renewable Energy, NPV: Net Present Value, PVGIS: Photovoltaic Geographical Information System, SAM: System Advisor Model, XLPE: Cross-Linked Polyethylene.

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Author Contributions

Antara Mahanta Barua: wrote the Introduction, conducted data collection and analysis, composed the Conclusion and Future work sections, Dhritiman Das: facilitated the existing PV system, supported data collection and analysis, Bikramjit Goswami: conceived and designed the study, involved in subsequent analysis, including the Results and Discussion.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this research work.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that AI-assisted tools were used for grammar correction and to enhance the overall quality of the manuscript.

Ethics Approval

This study was conducted in accordance with the ethical guidelines and principles.

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