

A Case Study Conducted at DIU in Bangladesh Examines the Cost-benefit Analysis and Viability of Installing a Net Metering System Alongside Rooftop Solar Photovoltaics

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ABSTRACT

This paper presents the design, cost-benefit analysis, and feasibility assessment of a 3.09 MW rooftop solar net metering system implemented at Daffodil International University (DIU). The system consists of 4,290 Trina Solar modules, each rated at 720 W, and is projected to generate an annual electricity production of 3.615 GWh. The university's reliance on traditional grid electricity is greatly decreased by this renewable energy project, which results in significant cost savings. A detailed economic evaluation revealed a levelized cost of electricity (LCOE) of 0.0186 USD/kWh and a return on investment (ROI) of 277.17%, underscoring the system's financial viability. The rooftop system is designed as a highly efficient, interconnected mini-grid that enables optimized electricity distribution across all campus buildings, allowing for demand-based allocation of solar power. Modern design concepts are also incorporated into the project to optimize energy efficiency and flexibility. The findings of this study demonstrate that large-scale rooftop solar systems can serve as an economically feasible and environmentally sustainable solution for academic institutions, highlighting their potential to contribute significantly to renewable energy adoption. This study aims to serve as a model for similar installations in institutional settings, thereby promoting the integration of solar power into urban infrastructures and advocating for sustainable energy practices.

Keywords

Rooftop Solar, Net Metering, Levelized Cost of Electricity (LCOE), Institutional Sustainability, Renewable Energy Feasibility.

1. INTRODUCTION

This case study at Daffodil International University (DIU), Bangladesh, evaluated the feasibility and cost-benefit of installing a net metering system with rooftop solar photovoltaics (PV) to reduce energy costs and dependence on conventional energy sources. Through net metering, excess solar energy can be fed back into the grid, lowering electricity expenses [1].

Bangladesh's heavy reliance on natural gas (82% of electricity generation) has led to supply shortages and environmental concerns [2]. As fossil fuel costs rise, solar PV has become a viable alternative, with costs dropping by 90% since 2010 [3].

Bangladesh's Renewable Energy Policy aims for 10% of power from renewables, similar to global initiatives like the EU's 27% target by 2030 [4][5].

Studies worldwide show that grid-connected rooftop PV systems are cost-effective but face issues such as power fluctuation and outage vulnerability [6]. Integrating battery storage enhances reliability and reduces dependence on diesel generators [7].

Few studies in Bangladesh have focused on institutional rooftop PV installations [8]. Global examples—from Norway, Portugal, and India—highlight tools like PV*SOL and PVsyst for performance and payback analysis [9][10].

This DIU case study thus explores a sustainable and economical solar solution for educational institutions in Bangladesh by assessing energy output, installation costs, and long-term savings, aiming to inform decision-makers about renewable integration and energy security [11].

2. METHODOLOGY

2.1 Materials and Methods

Net metering allows solar photovoltaic (PV) system owners to earn credits for the excess electricity they feed into the grid, offsetting future bills when production is low. In this system, solar panels generate DC power, which is converted to AC by an inverter for use in homes or businesses. A bidirectional meter records both imported and exported electricity.

This setup lowers electricity costs, improves the return on investment, and promotes renewable energy adoption by reducing greenhouse gas emissions and dependence on fossil fuels.

A net metering PV system typically includes series-connected PV modules, a charge controller to regulate voltage, and battery storage for nighttime or low-sunlight use. This integrated design ensures reliable power, enhances energy efficiency, and supports environmental sustainability by maximizing the use of clean, solar energy.

2.2 Design Specification

The solar PV system at DIU consists of 4,290 Trina Solar 720W modules and eight Advanced Energy Solaron 333

inverters, providing a total capacity of 3.09 MW. This setup ensures reliable and efficient power generation for the campus. Solar Modules:

- Manufacturer: Trina Solar
- Model: TSM-NEG21C20 720W Polycrystalline
- Quantity: 4,290
- Total Capacity: 3.09 MW
- Key Specs: Vmp 41.3 V, Imp 17.44 A, Voc 49.4 V, Isc 18.49 A

Trina Solar modules offer high efficiency and stable performance under varying environmental conditions.

Inverters:

- Model: Solaron 333 (Advanced Energy)
- Quantity: 8
- Total Capacity: 2.66 MW (8 × 333 kW)
- Input Voltage Range: 300–600 V

The Solaron 333 inverters efficiently convert DC to AC power and ensure stable operation, even in low-light conditions, enhancing the system’s overall performance and reliability.

2.3 System Design

The 18-story structure that houses Daffodil International University's (DIU) campus has a total roof area of roughly 133900 square feet. Installing the photovoltaic system on the roof is part of its design. Location: The permanent campus of Daffodil International University (DIU) is situated in Ashulia, Savar, in the Bangladeshi city of Dhaka. The campus is located at roughly 90.3494° East longitude and 23.8980° North latitude. While still being close to the capital city, this picturesque setting provides students with a tranquil atmosphere. Modern educational amenities and a lively academic environment are features of the Ashulia campus. Because of its ideal location in Savar, which combines urban connectivity with natural surroundings, it is the perfect place for academic growth and development.



Fig 1: Location of DIU Campus.

In Dhaka, average solar irradiance ranges from 4–6.5 kWh/m²/day with about 7.55 hours of sunlight daily, giving an average irradiance of 626.5 W/m². The optimal tilt angle for solar panels matches the city’s latitude of 23.8°N, maximizing year-round energy absorption.

Using Helioscope software, the DIU solar mini-grid system was designed with 4,290 Trina 720W modules and eight

Solaron 333 inverters. The system operates under a net metering framework, enabling power sharing between campus buildings and exporting excess electricity to the national grid. This design ensures efficient energy use, reduces dependence on fossil fuels, and promotes sustainability and environmental responsibility across the university.

System Capacity Calculation: The proposed solar PV system has a nominal capacity of 3.09 MW. Due to factors such as site location, weather conditions, transmission losses, and module efficiency, the actual output is slightly lower. After accounting for these losses, the system’s effective capacity is approximately 3.08 MW.

Components: These tools are necessary for designing the aforementioned system on the campus of our university. The following lists all of the parts and their costs:

Table 1. Components of our system

No	Type	Manufacturer	Name	Quantity	Cost
1	PV Module	Trina Solar	TSM-NEG21C .20 720W	4290	1072500\$
2	Inverter	Advanced Energy	Solaron 333	8	16000\$
3	Cable		10 AWG (Copper)	408(3035 73.8 ft)	195662\$
4	Components		Feed-in-Meter	1	120\$
5	Components		Circuit Breaker 25A	12	70\$
6	Components		Fuse	2	2\$
				Total	1284354\$

2.4 System Analysis

A 3.09 MW rooftop solar PV system at Daffodil International University was analyzed using Helioscope to optimize design and performance under a net metering framework. The simulation ensured an efficient array layout, minimizing shading and maximizing energy output within roof space limits. Equipped with advanced inverters and monitoring systems, the design enhances reliability and real-time tracking. This installation will reduce grid dependency, lower electricity costs, and support DIU’s sustainability goals, while net metering enables efficient use of surplus energy and added financial benefits.

2.5 Simulation

The 3.09 MW solar PV system at Daffodil International University was simulated using Helioscope, analyzing energy production, performance ratio, and weather effects. The system’s total annual energy output is 3.615 GWh, with shading and mismatch losses of 0.4% and 3.1%, and overall system losses (AC, inverter, wiring, reflection, soiling, irradiance) totaling 21.2%.

Optimal operation is achieved at temperatures between 27.1°C and 44.1°C. The setup includes 4,290 Trina Solar 720W modules (3.09 MW) and eight Solaron 333 kW inverters. Modules were distributed across multiple campus buildings with varying azimuths and orientations to maximize sunlight exposure. A Helioscope shading analysis identified and minimized energy losses by optimizing panel placement and

tilt, ensuring higher efficiency and reliable annual generation of 3.615 GWh.

System Metrics	
Design	DIU
Module DC Nameplate	3.09 MW
Inverter AC Nameplate	2.66 MW Load Ratio: 1.16
Annual Production	3.615 GWh
Performance Ratio	77.6%
kWh/kWp	1,170.4
Weather Dataset	TMY, 10km Grid, Meteornorm 8 (meteornorm_v8)
Simulator Version	fd80c747b5-1a85375270-1f583026b3-779542fe30

Fig 2: System Metrics of Our Simulation.

This analysis is vital for refining the PV system's design and layout, ensuring maximum efficiency and return on investment. The study advances the dependability and efficiency of solar energy systems in practical applications by proactively tackling these shading problems. The report is given below, which we calculated for our system.



Fig 3: Location of DIU Campus.

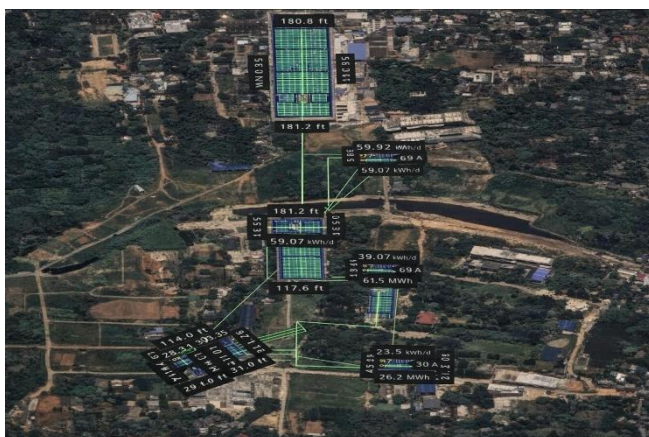


Fig 4: System Design.

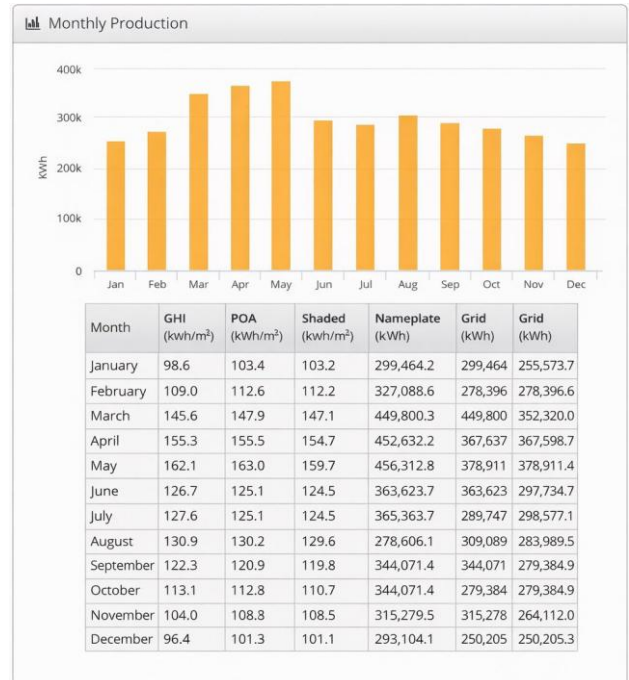


Fig 5: Monthly production rate of our solar PV system.

Annual Production			
	Description	Output	% Delta
Irradiance (kWh/m ²)	Annual Global Horizontal Irradiance	1,489.8	
	POA Irradiance	1,507.8	1.2%
	Shaded Irradiance	1,502.1	-1.0%
	Irradiance after Reflection	1,447.1	-3.3%
	Irradiance after Soiling	1,418.1	-2.0%
	Total Collector Irradiance	1,418.1	0.0%
Energy (kWh)	Nameplate	4,382,017.6	
	Output at Irradiance Levels	4,347,790.7	-0.8%
	Output at Cell Temperature Derate	3,925,707.3	-9.7%
	Output After Mismatch	3,802,184.3	-3.1%
	Optimal DC Output	3,799,930.9	-0.1%
	Constrained DC Output	3,729,631.6	-1.9%
	Inverter Output	3,633,237.2	-2.6%
Energy to Grid	3,615,071.2	-0.5%	
Temperature Metrics			
	Avg. Operating Ambient Temp	27.1 °C	
	Avg. Operating Cell Temp	44.1 °C	
Simulation Metrics			
	Operating Hours	4679	
	Solved Hours	4679	
Temperature Metrics			
	Avg. Operating Ambient Temp	27.1 °C	
	Avg. Operating Cell Temp	44.1 °C	
Simulation Metrics			
	Operating Hours	4679	
	Solved Hours	4679	

Fig 6: Annual Production

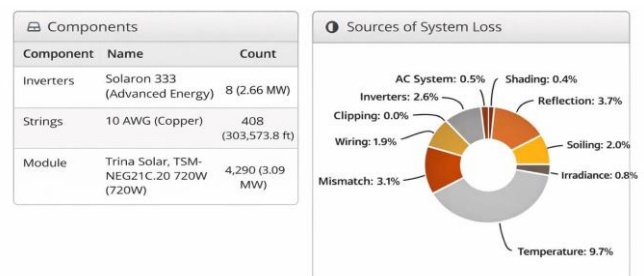


Fig 7: Components & The losses ratio

Condition Set												
Description	Condition Set 1											
Weather Dataset	TMY, 10km Grid, Meteornorm 8 (meteornorm_v8)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a		b		Temperature Delta						
	Fixed Tilt	-3.56		-0.075		3°C						
	Flush Mount	-2.81		-0.0455		0°C						
	East-West	-3.56		-0.075		3°C						
Soiling (%)	Carport	-3.56		-0.075		3°C						
	J	F	M	A	M	J	J	A	S	O	N	D
Irradiation Variance	5%											
Cell Temperature Spread	4°C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Uploaded By		Characterization								
	TSM-NEG21C.20 720W (Trina Solar)	HelioScope		Spec Sheet Characterization, PAN								
Module Characterizations	Device	Uploaded By		Characterization								
	Solaron 333 (Advanced Energy)	HelioScope		Default Characterization								

Fig 8: Condition Set

Field Segments									
Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Landscape (Horizontal)	13°	178°	2.0 ft	34x3	28	2,856	2.06 MW
Field Segment 2	Flush Mount	Landscape (Horizontal)	13°	08°	0.0 ft	1x2	18	36	25.9 kW
Field Segment 3	Flush Mount	Landscape (Horizontal)	13°	0.8°	2.0 ft	9x2	42	756	544.3 kW
Field Segment 4	Flush Mount	Landscape (Horizontal)	13°	1°	0.0 ft	1x2	33	66	47.5 kW
Field Segment 5	Flush Mount	Landscape (Horizontal)	13°	9°	2.0 ft	2x3	4	24	17.3 kW
Field Segment 6	Flush Mount	Portrait (Vertical)	Module: 130°	13° 57°	1.0 ft	2x3	6	36	108.0 kW
Field Segment 7	Flush Mount	Landscape (Horizontal)	13°	57°	0.0 ft	2x1	34	150	24.5 kW
Field Segment 8	Flush Mount	Landscape (Horizontal)	13°	57°	0.0 ft	1x1	34	34	24.5 kW
Field Segment 9	Flush Mount	Landscape (Horizontal)	13°	1°	0.0 ft	1x1	66	66	47.5 kW
Field Segment 10	Flush Mount	Landscape (Horizontal)	13°	2°	0.0 ft	1x2	32	64	46.1 kW
Field Segment 11	Flush Mount	Landscape (Horizontal)	13°	5.5°	0.0 ft	1x2	32	64	46.1 kW
Field Segment 12	Flush Mount	Landscape (Horizontal)	13°	11°	2.0 ft	2x3	23	138	99.4 kW

Fig 9: Racking Position, Orientation, and Number of Module Information on this table.

3. RESULT AND DISCUSSION

The mathematical calculation was used to evaluate the economic feasibility of a net metering solar PV system for Daffodil International University. It analyzed load profiles, system optimization, and lifetime costs, showing that integrating solar PV with net metering is cost-effective for commercial buildings in Bangladesh.

With 4–6.5 kWh/m²/day of solar radiation and peak sunlight in March–April, Dhaka offers ideal conditions for solar energy. The design considered panel capacity, inverter size, battery storage, and placement to maximize output within spatial limits.

The cost-benefit analysis compared installation expenses (modules, inverters, batteries) with long-term savings on electricity bills, confirming the system’s economic and environmental sustainability through reduced fuel use and operational costs.

Table 2. Energy Consumption Data

Month	Electricity usage, in kWh	Electricity usage per day, kWh
Jan	2401955	77482.41
Feb	3165544	105518.13
Mar	4534592	146277.16
Apr	4145715	138190.5
May	5997927	193481.5
Jun	7762644	258754.8
Jul	2894376	93366.96
Aug	4190444	139681.47
Sep	4012934	129449.48
Oct	2174877	72495.9
Nov	3261833	105220.4
Dec	2454550	79179

3.1 Feasibility Study

The study assesses the practicality of installing a net metering solar PV system at Daffodil International University, considering solar availability, shading effects, and grid connection regulations. It also evaluates the technical integration of the PV system with the existing electrical infrastructure and its overall impact on campus operations and efficiency.

3.2 Electricity Production Estimation

The solar PV system is estimated to have a capacity of 3.09 MW. Table II displays the average electrical energy generation for each day and month for Dhaka based on this data, as well as the average number of bright sunshine hours per day. The average amount of energy generated annually is 3.615 GWh, which is equivalent to 117136363.63 USD.

Table 3. Average Electricity Generation by Day and Month, Taking into Account Estimation

Month	Sunlight Duration (hours)	Production of Energy Every Day (KWh)	Monthly energy Generation (KWh)
Jan	8.7	8519.12	255,573.70
Feb	9.1	9440.71	273,780.80
Mar	8.8	11744	352,320.00
Apr	8.9	11858.02	367,598.70
May	8.2	12633.04	378,991.40
Jun	4.9	9604.34	297,734.70
Jul	5.1	9639.39	289,181.70
Aug	5.8	9970.43	309,083.40
Sep	6.0	9758.31	292,749.50
Oct	7.6	9152.9	283,739.90
Nov	8.6	8803.73	264,112.00
Dec	8.9	8071.13	250,205.30
Total			3,615,071.10

On average, DIU experiences 120 days off each year, including weekends, holidays, and semester breaks. During these days, any excess electricity generated by the solar PV system is fed back to the grid. The daily average energy available for grid feedback is calculated in Table III. It is also observed that there is no surplus energy for feedback, except on the off days, as shown in Table IV.

Table 4. Energy Consumption and Production

Month	Electricity usage (kWh/day)	PV Energy's projected output (kWh/day)
Jan	77482.41	8519.12
Feb	105518.13	9440.71
Mar	146277.16	11744
Apr	138190.5	11858.02
May	193481.5	12633.04
Jun	258754.8	9604.34
Jul	93366.96	9639.39
Aug	139681.47	9970.43
Sep	129449.48	9758.31
Oct	72495.9	9152.9
Nov	105220.4	8803.73
Dec	79179	8071.13

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3.3 Basic Playback Evaluation

A condensed form of cost/benefit analysis is the simple payback method. This approach determines the number of years required for the improvement to pay for itself.

Total system cost, in US dollars = 1284354 USD

Electricity bill savings per year = Yearly energy Generation × Per unit electricity cost

$$= (3,615,071.10 \times 0.073) = 254184.69 \text{ USD}$$

$$\begin{aligned} \text{Simple payback time} &= \frac{\text{Cost of the system}}{\text{Annual savings, years}} \\ &= \frac{1284354}{254184.69} = 5.05 \end{aligned}$$

Estimated simple payback period: 5.05 years.

3.4 Per-Unit Energy Cost(LCOE)

Over the course of its lifetime, a generating plant's average net present cost of producing electricity is measured by the Levelized Cost of Energy (LCOE). It is determined by dividing the total lifetime energy production by the total lifetime costs.

$$LCOE = \frac{\text{Total Cost}}{\text{Total Energy Produced}}$$

Initial investment (system cost): 1,296,854 USD

Annual maintenance cost = USD 500

Total maintenance cost over 25 years = 500×25= 12,500 USD

Total costs over 25 years = Initial investment + Maintenance cost + Project building cost

Total Costs = (1,284,354 +12,500 +39,062) = 1,335,916 USD

Total Energy Produced = Total energy generation over the system lifetime (in kWh).

Total energy generation over 25 years is given as 71,673,750 kWh.

The formula to calculate the Levelized Cost of Energy (LCOE) is:

$$\begin{aligned} \text{Levelized Cost of Energy} &= \frac{\text{Total Costs}}{\text{Total Energy Produced}} \\ &= \frac{1,335,916 \text{ USD}}{71,673,750 \text{ kWh}} \\ &= 0.0186 \text{ USD/kWh} \end{aligned}$$

The Levelized Cost of Energy (LCOE), or the per-unit energy cost for this solar PV system, is 0.0186 USD/kWh. This means it costs approximately 2.39 BDT to generate one kilowatt-hour (kWh) of electricity using this system over its 25-year lifespan.

3.5 Return on Investment (ROI)

The ROI measures the profitability of the investment and is calculated by comparing the net savings (savings minus costs) to the initial investment.

$$ROI = \frac{\text{Total Savings} - \text{Total Costs}}{\text{Initial Investment}} \times 100$$

Total Savings

Initial investment (system cost) = 1,335,916 USD

Annual savings from electricity bills = 254184.69 USD

Total savings over 25 years = 71,673,750 kWh×0.0703 USD
= 5038664.625 USD"

The formula to calculate the Return on Investment (ROI) is,

$$\begin{aligned} ROI &= \frac{5038664.625 \text{ USD} - 1,335,916 \text{ USD}}{1,335,916 \text{ USD}} \times 100 \\ &= 277.17\% \end{aligned}$$

The Return on Investment (ROI) of 277.17% for the solar PV system indicates that the investment not only covers its initial costs but also generates a significant profit over its 25-year lifetime.

3.6 Annual Excess Production

The solar photovoltaic (PV) system has a capacity of 3.09 MW and generates an average of 3.615 GWh of energy annually, which is equivalent to 3,615,000 kWh. Over its estimated lifetime of 25 years, the system is projected to generate a total of 71,673,750 kWh. Additionally, it is expected to experience 75 off days during this period.

Now, Yearly energy generation = 3.615 GWh

$$= 3,615,000 \text{ kWh}$$

To find the average daily energy generation, divide the total yearly generation by the number of days in a year (365 days):

$$\begin{aligned} \text{Average Daily Energy Generation} &= \frac{\text{Total Yearly Energy Generation}}{\text{Total Days in year}} \\ &= \frac{3,615,000 \text{ kWh}}{365 \text{ day}} \\ &\approx 9904.1 \frac{\text{kWh}}{\text{day}} \end{aligned}$$

Next, we will calculate the total energy produced during the 75 off days:

$$\begin{aligned} & \text{Energy generated in 75 days} \\ &= \text{Daily energy generation} \\ & \times \text{Number of off days} \\ &= 9904.1 \frac{\text{kWh}}{\text{day}} \times 75 \text{ days} = 742807.5 \text{ kWh} \end{aligned}$$

The excess energy produced during the 75-off days of the solar PV system is approximately 742807.5 kWh. For pages other than the first page, start at the top of the page, and continue in double-column format. The two columns on the last page should be as close to equal length as possible.

4. CONCLUSION AND FUTURE WORK

The feasibility and successful installation of a 3.09 MW rooftop solar net metering system at Daffodil International University (DIU) are highlighted in this study, illustrating the potential of renewable energy systems in educational environments. With an annual energy production of 3.615 GWh, the system helps to promote environmental sustainability and lower campus electricity costs. An outstanding LCOE of 0.0186 USD/kWh and an astounding ROI of 277.17% were found in the thorough economic analysis, demonstrating the project's long-term advantages and financial feasibility. benefits.

The system's architecture, which operates as an interconnected mini-grid, guarantees effective energy distribution throughout campus buildings, maximizing the use of solar power while adjusting to real-time demand. This creative method not only improves energy management but also sets the standard for solar projects in comparable institutional or urban.

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