AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

Faculty of Engineering

Project Title: " AIUB Solar Initiative: Promoting Sustainable Energy Practices on Campus"

Date of Submission:	17-05-2024		
Course Title:	Renewable Energy Technology		
Course Code:	EEE 4231	**Section:**	B
Semester:	Fall 2023-2024	**Degree Program:**	BSc in EEE
Course Teacher:	Dr. Nowshad Amin		

Declaration and Statement of Authorship:

1. I/we hold a copy of this Assignment/Study, which can be produced if the original is lost/damaged.
2. This Assignment/Study is my/our original work and no part of it has been copied from any other student's work or from any other source except where due acknowledgment is made.
3. No part of this Assignment/Study has been written for me/us by any other person except where such collaboration has been authorized by the concerned teacher and is acknowledged in the assignment.
4.
5. I/we have not previously submitted or am currently submitting this work for any other course/unit.
6. This work may be reproduced, communicated, compared, and archived to detect plagiarism.
7. I/we permit a copy of my/our marked work to be retained by the Faculty Member for review by any internal/external examiners.
8. . I/we understand that Plagiarism is the presentation of the work, idea, or creation of another person as though it is your own. It is a form of cheating and is a very serious academic offense that may lead to expulsion from the University. Plagiarized material can be drawn from, and presented in, written, graphic, and visual forms, including electronic data, and oral presentations. Plagiarism occurs when the origin of the source is not appropriately cited.
9. I/we also understand that enabling plagiarism is the act of assisting or allowing another person to plagiarize or copy my/our work.

** Student(s) must complete all details except the faculty use part.*

** Please submit all assignments to your course teacher or the office of the concerned teacher.

Individual Final project

Sl No	Name	ID	PROGRAM	SIGNATURE
1	**Shilamoni Shaha Neir**	20-43640-2	BSc in EEE	
2				
3				
4				
5				

Faculty use only		
FACULTY COMMENTS	**Marks Obtained**	
	Total Marks	

Abstract:

This report details the design and analysis of a solar photovoltaic (PV) system for the rooftop area of 11368 square feet at the AIUB campus. Our goal is to assess the feasibility and financial viability of installing a 2 kWp solar system while considering budget constraints and policies set by SREDA in Bangladesh. We utilized PVWatts Online Software to design the system, select suitable components, and perform ROI calculations. Our analysis includes evaluating the return-oninvestment period, environmental impact, and financial feasibility. During the LAB session, we will delve deeper into the design and address any potential implementation challenges.

Objective:

The primary goal of this report is to devise and evaluate a grid-tied solar photovoltaic system for the rooftop of the AIUB campus. To achieve this, we have set forth the following specific objectives:

1. To create a 2 kWp grid-tie solar system utilizing the PVWatts Online Software.
2. To fine-tune the system design while adhering to budgetary limitations and NEM regulations.
3. To scrutinize the return-on-investment period and financial feasibility of the solar PV system.
4. To evaluate the environmental impact of the suggested solar PV setup.

Introduction:

The global need to transition to sustainable energy sources has resulted in an increase in the adoption of renewable technologies, with solar photovoltaic (PV) systems emerging as a leader in this transformative path. In line with this change in basic assumptions, the proposed project aims to develop and analyze a grid-tied solar PV system adapted to the AIUB campus is 11368 square foot rooftop spread.

The primary objective of this undertaking is twofold: first, to harness solar energy as a clean and renewable resource for electricity generation; and second, to evaluate the economic viability and environmental implications of implementing such a system. By leveraging the PVWatts Online

Software, the project aims to delineate an optimized system design, resonant with both budgetary considerations and the regulatory framework outlined by the Sustainable and Renewable Energy Development Authority (SREDA) in Bangladesh.

This research provides an outline for discussing the complexities of the grid-tie solar PV system design process. It includes a thorough process that covers location selection, component procurement, optimization tactics, and financial analysis. The project aims to define the efficacy of solar energy integration on the AIUB campus and extrapolate lessons applicable to broader societal and environmental domains through thorough analysis and discourse.

Methodology:

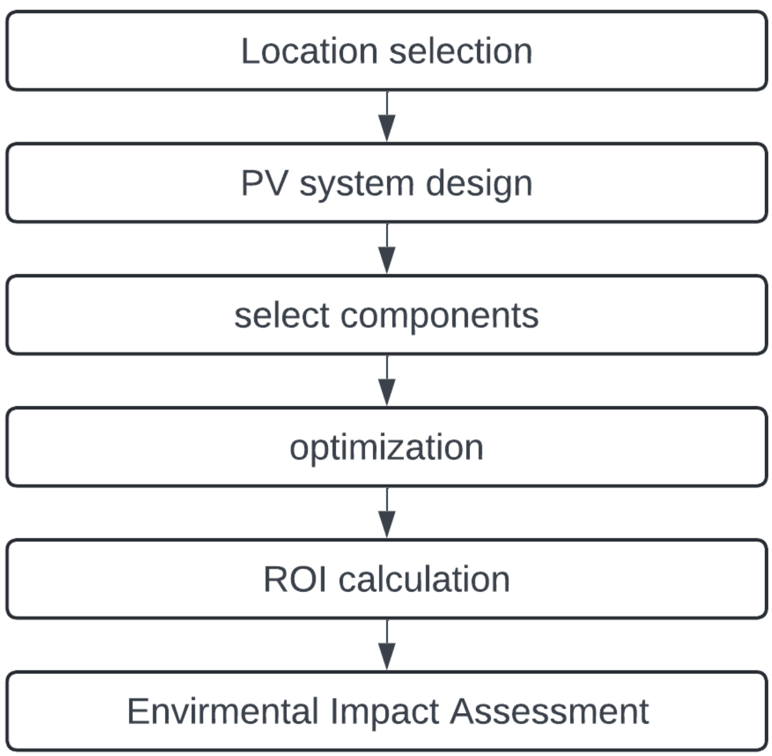


Figure 01: Block diagram of PV system design

1. **Location Selection**: The 11,368 square feet rooftop area at the AIUB campus is selected for system installation.

2. **PV System Design**: The PVWatts Online Software is utilized to design a 2 kWp grid-tie solar PV system.
3. **Component Selection**: Appropriate solar panels, inverters, mounting structures, cables, and connectors are selected.
4. **Optimization**: The system design is optimized based on budget constraints and the NEM policies set by SREDA.
5. **ROI Calculation**: The return-on-investment period is calculated by considering initial installation costs, savings from reduced electricity bills, incentives, and maintenance expenses.
6. **Environmental Impact Assessment**: The environmental benefits of the solar PV system are evaluated, including reductions in greenhouse gas emissions and decreased reliance on fossil fuels.

Apparatus:

1. Solar Panels.
2. Mounting Structures.
3. Grid-tie Inverters
4. Cables and Connectors.
5. PVWatts Online Software.

NEM (Net Energy Metering (NEM):

An overview of the intricacies involved in designing grid-tied solar PV systems is given by this research. It involves a comprehensive procedure that addresses financial analysis, component procurement, optimization strategies, and site selection. Through in-depth analysis and discussion, the project seeks to determine the viability of solar energy integration on the AIUB campus and extrapolate insights applicable to larger societal and environmental domains.

The policy outlines the tariff structure for electricity exported to the grid, typically at a rate equivalent to the retail electricity price or at a predetermined feed-in tariff (FiT) set by the government. Eligibility criteria ensure that grid-tie solar PV systems meet technical standards and comply with safety regulations, thereby providing peace of mind to system owners. The NEM scheme employs bi-directional meters to accurately measure both electricity consumption from the grid and excess electricity exported by the solar PV system, ensuring transparency and accuracy. Billing arrangements under the NEM policy facilitate the crediting of surplus electricity exported to the grid against the consumer's electricity bill, thereby maximizing savings.

Bangladesh's NEM policy framework fosters a climate that is ideal for the extensive application of solar energy solutions, hence promoting economic growth, environmental sustainability, and energy security. Grid-tie solar PV systems can be tailored to meet budgetary constraints and take advantage of government financial incentives by utilizing the NEM policy. In conclusion, the NEM policy is a great tool for encouraging Bangladeshis to install solar PV systems, and its advantages are clear to see.

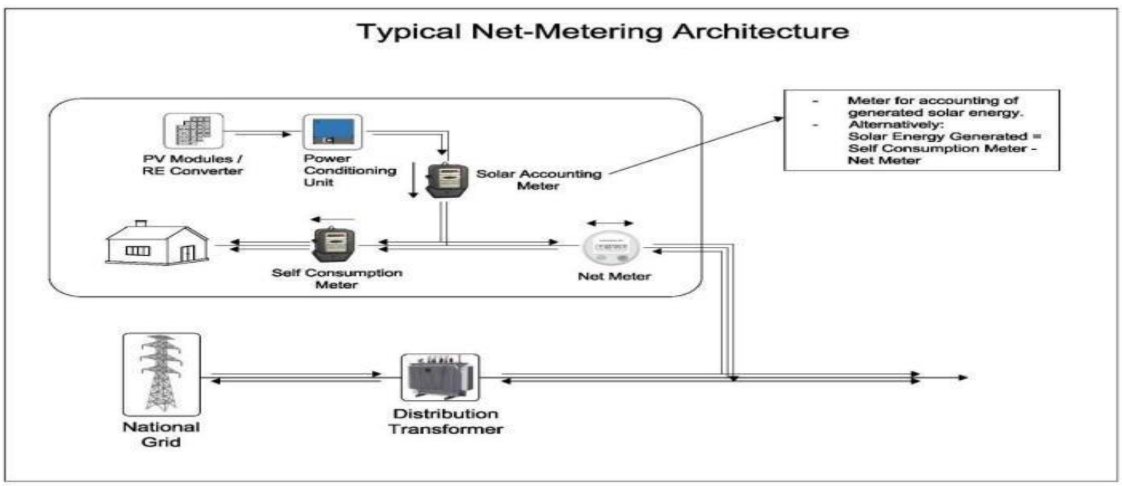


Figure 2: Typical net metering architecture

<u>Simulation result:</u>

- Design a 2 kWp grid-tie solar PV system for the rooftop area of 11368 square feet.
- Optimize the system according to budget constraints and NEM policies.
- Select appropriate components for efficient electricity generation and transmission.

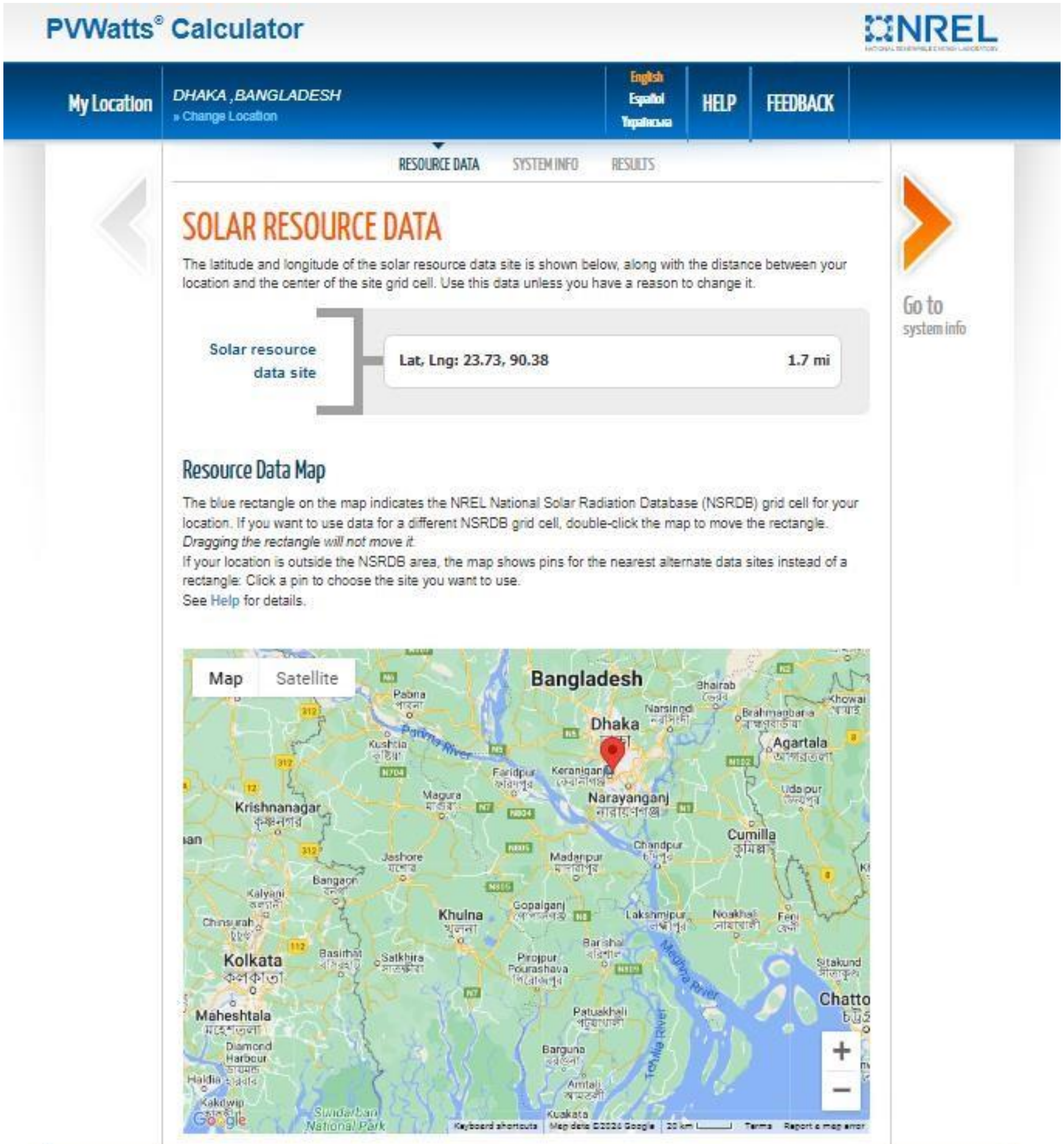


Figure 3: Location selection.

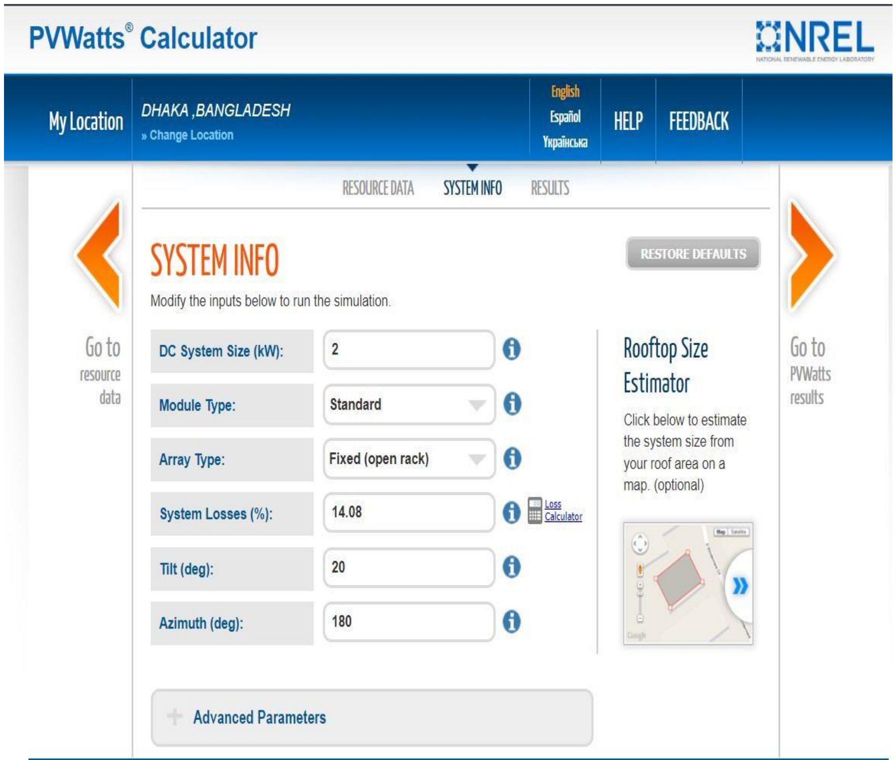
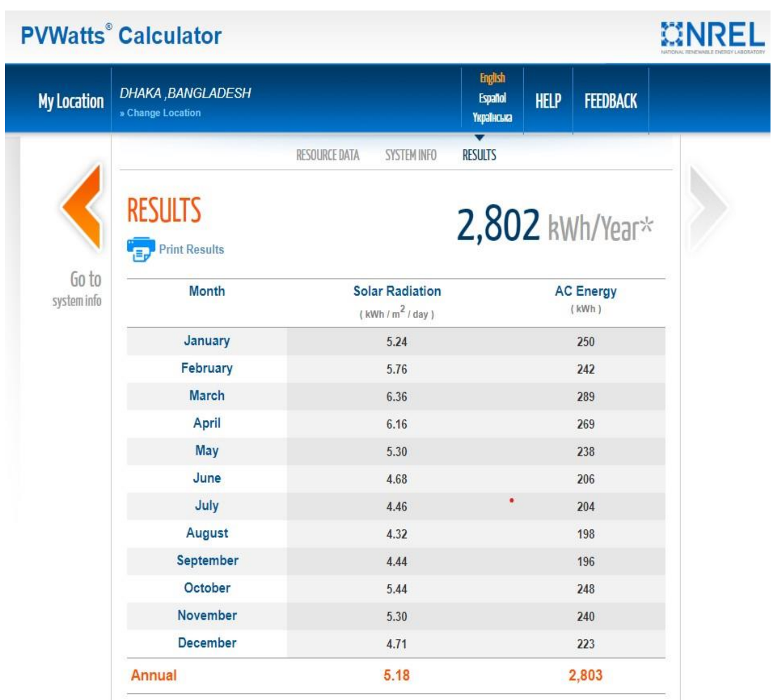


Figure 4: System data input.



Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	5.24	250
February	5.76	242
March	6.36	289
April	6.16	269
May	5.30	238
June	4.68	206
July	4.46	204
August	4.32	198
September	4.44	196
October	5.44	248
November	5.30	240
December	4.71	223
Annual	5.18	2,803

Figure 5: Result of 2 KW PV system.

Location and Station Identification	
Requested Location	DHAKA ,BANGLADESH
Weather Data Source	Lat, Lng: 23.73, 90.38 1.7 mi
Latitude	23.73° N
Longitude	90.38° E
PV System Specifications	
DC System Size	2 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	20°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)
Monthly Irradiance Loss	Jan 0%, Feb 0%, Mar 0%, Apr 0%, May 0%, June 0%, July 0%, Aug 0%, Sept 0%, Oct 0%, Nov 0%, Dec 0%
Performance Metrics	
DC Capacity Factor	16.0%

Figure 6: PV system performance metrics.

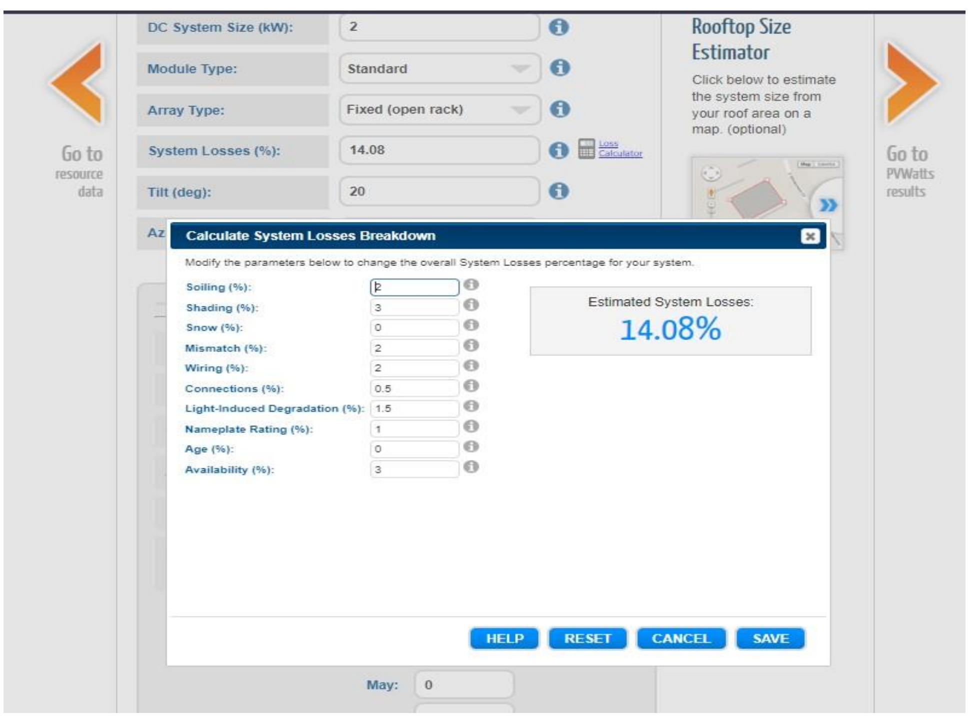


Figure 7: Losses calculation.

	A	B
1	PVWatts Monthly PV Performance Data	
2	Requested	DHAKA ,BANGLADESH
3	Location	Lat, Lng: 23.73, 90.38
4	Latitude (D	23.73
5	Longitude (	90.38
6	Elevation (i	12
7	DC System	2
8	Module Typ	Standard
9	Array Type	Fixed (open rack)
10	Array Tilt (c	20
11	Array Azim	180
12	System Los	14.08
13	DC to AC S	1.2
14	Inverter Eff	96
15	Ground Co	NA
16	Albedo	From weather file
17	Bifacial	No (0)

33	Month	Daily Avera	DC Array O	AC System Output (kWh)
34	1	5.243	261.435	249.629
35	2	5.764	253.801	242.362
36	3	6.364	302.679	289.015
37	4	6.163	281.336	268.515
38	5	5.299	249.864	237.859
39	6	4.68	216.748	205.809
40	7	4.457	215.142	204.21
41	8	4.324	208.293	197.868
42	9	4.442	206.397	196.238
43	10	5.441	260.081	248.086
44	11	5.304	251.095	239.601
45	12	4.715	233.345	222.619

Figure 8: Excel sheet of PV calculation.

SREDA | E-Service Desk for Solar

Solar Inter-Row-Spacing Calculator

SL.	Topics	Quantity	Unit
1.	Module Dimentions: 1740 mm * 1030 mm * 32 mm Each Module Capacity: 300 Wp 5 Modules in X-direction, 2 Modules in Y-direction, 3 Rows Tilt Angle 23^0, Minimum Elevation Angle 25.39^0, Azimuth Angle 133.59^0	Your Input Values	
2.	Lenth in X-direction for a single row	5.15	m
3.	Length in Y-direction for a single row	3.48	m
4.	Module Capacity in a single Row	3	kWp
5.	Total Module Capacity	9	kWp
6.	Active Height of a Row	1.39	m
7.	Active Length of a Row	3.2	m
8.	Length of the Free Space for a row	2.02	m
9.	Active Area of a single Row	16.5	m^2
10.	Free Area for a single Row	10.41	m^2
11.	Total Area of a single Row	26.91	m^2
12.	Active Area% : Free Area%	61 : 39	
13.	Total Area in Square Meter *[n rows and (n-1) free spaces]*	70.32	m^2
14.	Area Per kWp	7.8	m^2
15.	Total Area in Acre *[n rows and (n-1) free spaces]*	0.02	Acre
16.	Area Per MWp	1.9	Acre

Figure 9: SREDA 2KW PV system design.

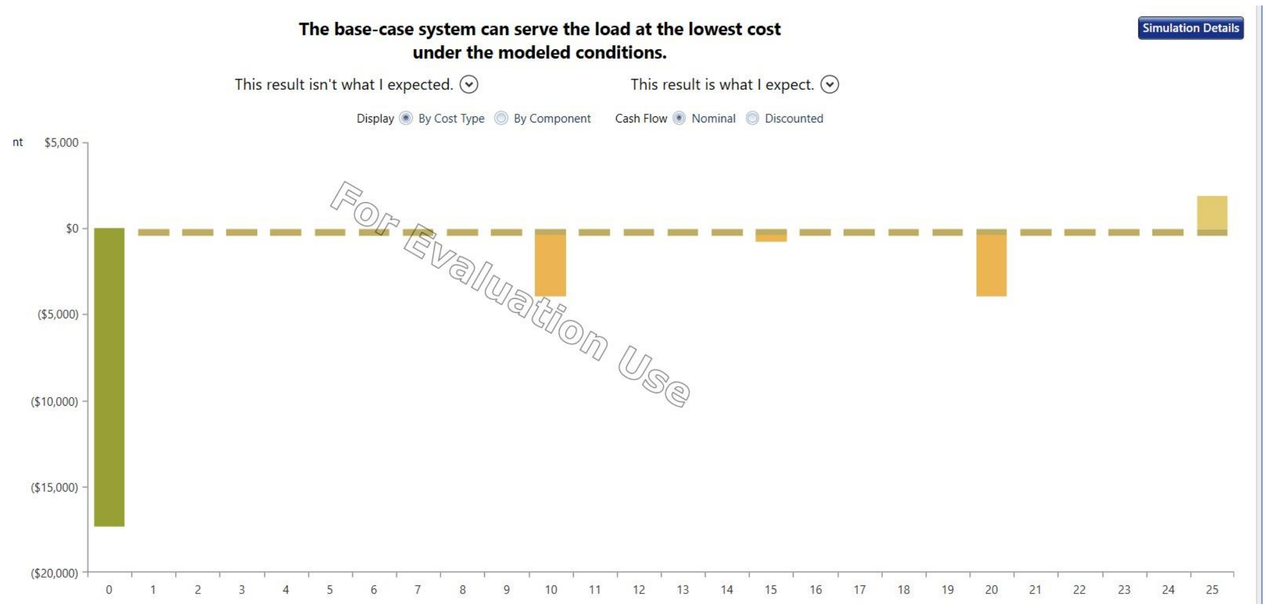


Figure 10: ROI Calculation.

<u>Analyze on ROI (return on investment) period and other issues:</u>

Determine the return-on-investment period based on initial installation costs, savings from reduced electricity bills, incentives, and maintenance costs.

To accurately determine the Return on Investment (ROI) for grid-tie solar PV systems, various financial factors must be considered, including installation costs, ongoing electricity savings, government incentives, maintenance expenses, and system lifespan. The purchase of solar panels, inverters, mounting structures, and associated components typically covers the initial installation costs. In this scenario, the initial investment is assumed to be 1.6 lakh tk.

The cumulative savings from reduced energy bills over the system's lifespan are an essential contributor to the ROI. In this case, with a monthly savings of 7k tk, the ROI can be significantly impacted by electricity savings. Additionally, government incentives such as tax credits or rebates can be used to offset the initial investment and positively impact the ROI. Therefore, the availability and extent of such incentives must be considered when calculating the ROI.

Maintenance expenses are necessary for optimal performance, although they are low for solar PV systems. A monthly maintenance cost of 4k tk is factored into this analysis to provide a more precise ROI assessment. Furthermore, the lifespan of the system, which is typically around 25 to 30 years, can also impact the ROI. Longer lifespans result in extended periods of electricity savings, which can shorten the ROI period.

To provide a comprehensive analysis, regulatory compliance, technological advancements, and potential financial risks must also be considered. Adherence to regulations, staying informed about industry trends, and mitigating investment risks are crucial to maximizing economic benefits and contributing to sustainable energy initiatives.

ROI Period calculation:

Initial Installation Costs: 1.6 lakh tk

Electricity Savings: 2k tk

Monthly Maintenance Cost: 7k tk

Assuming no government incentives or tax credits for simplicity, we will focus on the direct savings from reduced electricity bills.

To determine when the cumulative savings surpass the initial investment, we can use the following formula:

$$ROI\ period = \frac{Initial\ Installation\ Costs}{Monthly\ Savings} = \frac{1{,}60{,}000\ tk}{7000\ tk/month} = 23 \text{ months}$$

So, in this scenario, the system would begin generating profit after 23 months (about 2 years).

Regulatory Compliance: Ensuring compliance with regulatory requirements, including building codes, safety standards, and grid interconnection regulations, is essential for the successful implementation of grid-tie solar PV systems.

Technological Advances: Monitoring advancements in solar PV technology and industry trends can inform decision-making regarding system design, component selection, and optimization strategies.

Financial Risks: Assessing potential financial risks, such as fluctuations in electricity prices, changes in government policies, and market uncertainties, is crucial for mitigating investment risks and maximizing returns.

Financial Viability: Assess the financial feasibility of the project by comparing the ROI period with the expected lifespan of the system.

Environmental Impact: Evaluate the environmental benefits of generating clean energy, such as reducing greenhouse gas emissions and dependence on fossil fuels. By conducting a thorough ROI analysis and addressing relevant considerations, well-informed decisions regarding the implementation of grid-tie solar PV systems can be made by stakeholders. This will not only foster economic prosperity but also contribute to environmental sustainability.

Discussion:

After analysis, it has been determined that the energy needs and sustainability objectives of the AIUB campus can be met by the suggested grid-tie solar PV system. The system optimization was thoroughly approached by utilizing PVWatts Online Software and adhering to NEM regulations in the comprehensive design methodology. However, several critical points require further discussion and consideration.

Firstly, additional avenues to reduce initial installation costs need to be explored to further enhance the economic viability of the system, despite the favorable ROI period of 23 months. This could involve leveraging government incentives or exploring alternative financing models.

Secondly, the environmental impact of the proposed solar PV system should be discussed in greater depth, focusing on its potential to reduce greenhouse gas emissions and dependence on fossil fuels. Highlighting these environmental benefits emphasizes the broader significance of renewable energy adoption beyond financial considerations.

Lastly, potential implementation challenges such as regulatory compliance, technological advancements, and financial risks need to be addressed to ensure the successful deployment and long-term sustainability of the solar PV system. By fostering dialogue and cooperation, stakeholders can work together to navigate these challenges and maximize the system's positive impact.

This discussion provides an opportunity to critically evaluate the proposed solar PV system, identify areas for improvement, and chart a path toward its successful implementation and integration within the AIUB campus infrastructure.

Conclusion:

The grid-tie solar PV system designed for the AIUB campus rooftop area demonstrates the potential for renewable energy adoption in Bangladesh. By optimizing the system design and conducting a thorough financial analysis, the project highlights the feasibility and benefits of solar energy utilization. Further discussions during the LAB session will contribute to refining the design and addressing implementation challenges, ensuring the successful deployment of the solar PV system.

References:

[1] PV Watt calculator online software.

[2] "The Solar System: Pictures and Information on the Sun, Moon, Moon Phases, Planets." On Truth & Reality: Philosophy Physics Metaphysics of Space, Wave Structure of Matter. Famous Science Art Quotes. N.p., n.d. Web. (Accessed: 18 May 2024).

[3] Choi, C.Q."Solar System – Facts and Information about the Planets and Solar System." Space.com. N.p., n.d. Web. (Accessed: 18 May 2024)

[4] "The Solar System: The Sun, Planets, Dwarf Planets, Moons, Asteroids, Comets, Meteors, Solar System Formation." Windows to the Universe. N.p., n.d. Web (Accessed: 18 May 2024).