Design And Analysis of Solar Charging Station by Using PVsyst Software

Mrs. P. Devi Supriya[1],B. Komala Priya[2], K. Nagendra Kumar[3]
Asst. Professor[1], Adhoc Faculty[2], Student[3]
School of Renewable Energy and Environment
Institute of Science & Technology JNTUK, Kakinada. India.
Department of School of Renewable Energy and Environment
Institute of Science & Technology JNTUK, Kakinada. India.

ABSTRACT: In present study the expansion of solar energy in India, considering economic and technological factors, this study aims to identify barriers to the expansion of solar charging stations and simulate solar powered charging station using PVsyst (Photovoltaic system) software. The study is unique in its approach of combining technical and economic analysis to facilitate the implementation of solar energy expansion in Kakinada (Vakalapudi). To achieve this goal, the technical analysis imulating the performance of a 50kWp (kilowatt 'peak' power output of a system) grid connected solar charging station for Vakalapudi and the simulation is carried out to obtain maximum electricity production and evaluate parameters such as incident radiation, performance ratio, energy into the grid, energy output at the array, and losses, technical and economic analysis, decrease in carbon dioxide emissions (CO2) using different modules. The produced energy with specific production of 1304 kWh/kWp/year, and the performance ratio (PR) was 71.16%.

Keywords: Photovoltaics, Electrical vehicles charging station, PV Syst software, Solid works, google location for charging station, Inverter specifications, performance ratio, energy to the grid, technical and economic analysis and array losses.

I. INTRODUCTION

1.1 Introduction to Solar Energy Charging Stations:

Solar energy charging stations, often referred to as solar EV charging stations or solar carports, combine photovoltaic (PV) technology with electric vehicle charging infrastructure. The basic idea is to utilize solar panels to capture sunlight and convert it into electricity, which is then used to charge electric vehicles. These stations can take various forms, ranging from standalone solar carports with integrated charging points to solar panels installed on existing structures such as parking lots or rooftops.

1.2Design Considerations for Solar Energy Charging Stations:

1.2.1 Solar Panels:

The heart of any solar energy charging station is the solar panels. These panels, usually composed of crystalline silicon or thin-film technology, capture sunlight and convert it into electricity. The efficiency and capacity of these panels play a crucial role in determining the overall performance of the charging station.

1.2.2 Energy Storage Systems:

To ensure a continuous power supply, solar energy charging stations often incorporate energy storage systems such as batteries. These batteries store excess energy generated during peak sunlight hours, making it available for use during periods of low sunlight or high demand. This storage capacity contributes to the reliability and stability of the charging station.

1.2.3 Charging Infrastructure:

The charging infrastructure includes electric vehicle supply equipment (EVSE) such as charging points or stations. These are strategically placed to allow vehicles to connect and recharge their batteries. The integration of smart charging technologies further enhances the efficiency of the station by optimizing charging schedules based on energy availability and demand.

1.2.4 Grid Connectivity:

Solar energy charging stations are often connected to the electrical grid. This connection serves as a backup, ensuring that vehicles can still charge when solar energy production is insufficient. Additionally, excess energy generated by the solar panels can be fed back into the grid, contributing to the overall energy ecosystem.

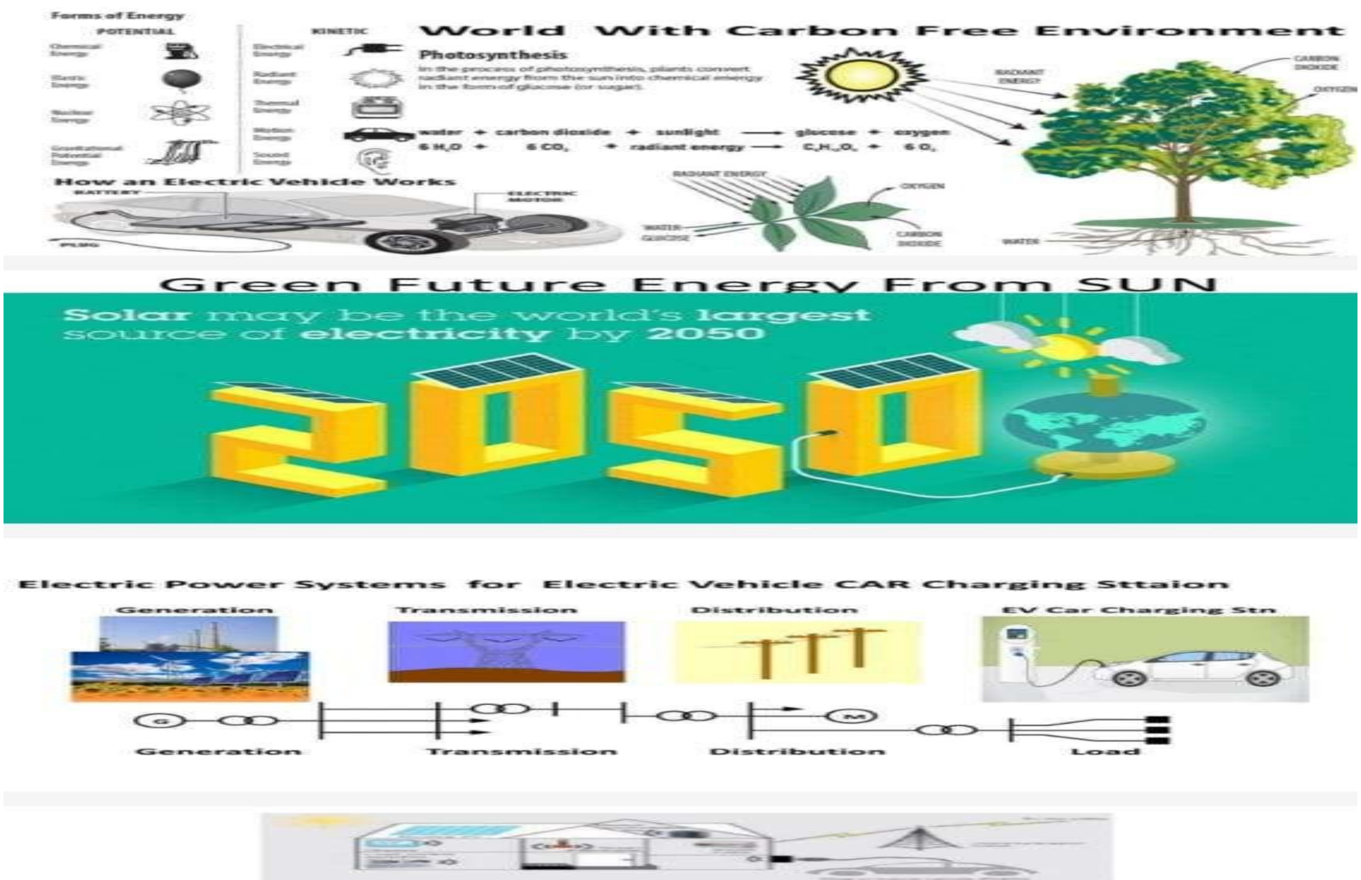


Fig 1. Solar energy charging system

II .Introduction to PVSyst Software:

PVSyst is a powerful software tool designed for the analysis and simulation of photovoltaic (PV) systems. Introduced by Valentin Software, PVSyst has become a cornerstone in the renewable energy industry, providing engineers, designers, and researchers with a comprehensive platform to model and optimize solar power installations. This software is crucial for assessing the performance, efficiency, and financial viability of solar projects across various scales.

PVSyst, short for Photovoltaic Systems, is an advanced software solution tailored for the solar energy sector.

Its primary objective is to facilitate the design, simulation, and evaluation of PV systems by offering a range of tools and features. Developed by Valentin Software, a company with a strong reputation in renewable energy software, PVSyst has gained widespread acceptance in the industry due to its accuracy and versatility.
The software is equipped to handle diverse PV applications, from residential rooftop installations to large- scale solar farms. Its user-friendly interface, coupled with a sophisticated simulation engine, allows users to model the behavior of solar power systems under various conditions accurately. PVSyst is compatible with different PV technologies, making it adaptable to the evolving landscape of solar energy.

III. A SolidWorks software-designed solar-powered charging station system is suggested:

3.1 Solid Works software introduction:

Using SolidWorks, design is a complex process that combines creativity, accuracy, and invention to bring ideas to life virtually. Dassault Systems' SolidWorks is a potent computer-aided design (CAD) programme that is used extensively across a range of sectors to create three-dimensional (3D) models and simulations. Because of its strong features and intuitive interface, this programme has established itself as a mainstay in engineering, manufacturing, and product development.
Fundamentally, SolidWorks offers engineers, designers, and architects an extensive toolkit for designing, visualizing, and evaluating their concepts in three dimensions. The programme makes use of parametric modelling, a method that lets users construct designs with restrictions, relationships, and parameters. This makes it simple to update and modify the model as the design changes.
SolidWorks' ability to do parametric design is one of its main advantages. With the help of this capability, designers may specify the sizes and connections between different parts to produce a model that is both flexible and adaptive. A design's ability to immediately reflect changes made to one section in other related parts streamlines the iterative design process and lowers the possibility of mistakes. With this parametric method, designers may explore various design iterations quickly and with increased efficiency.

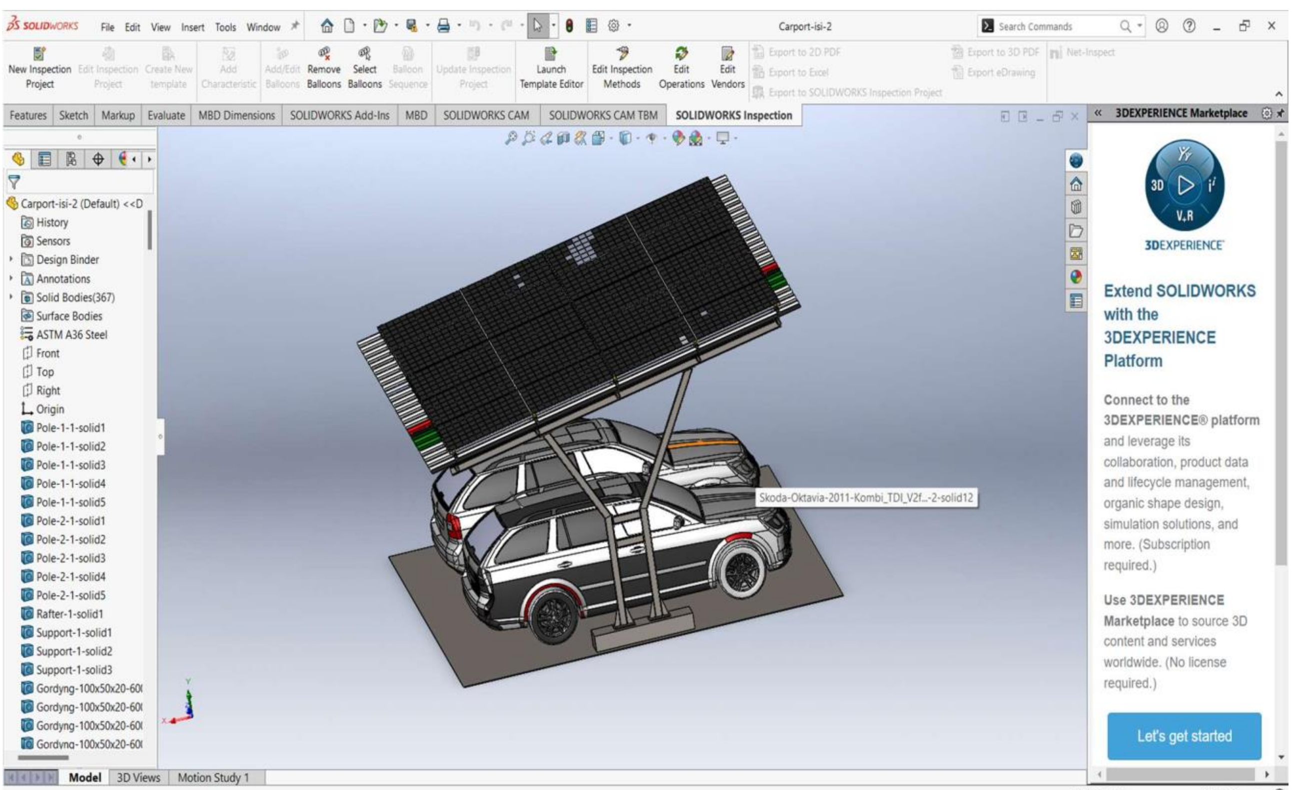


Fig 2. solar powered charging station design by using SolidWorks software

IV. BEACON INVERTER 5KW AC OVERVIEW:

1.Power Rating:

The Beacon Inverter 5kW AC is designed to handle a power rating of 5 kilowatts (kW) on the alternating current (AC) side. This indicates its capacity to convert direct current (DC) power generated by solar panels into usable AC power for residential or commercial applications.

2. Photovoltaic (PV) Compatibility:

The inverter is likely compatible with standard photovoltaic solar panels. It should be able to efficiently convert the DC electricity generated by the solar panels into AC electricity suitable for powering appliances and feeding excess energy back into the grid.

3. Single or Three-Phase Operation:

Inverters can be designed for single-phase or three-phase operation, depending on the electrical requirements of the installation. The Beacon Inverter 5kW AC may support either a single-phase or three-phase electrical system, providing flexibility for various applications.

4. Efficiency and Performance:

Efficiency is a critical factor in inverter performance. The Beacon Inverter 5kW AC is expected to have a high efficiency rating, indicating how effectively it converts DC power to AC power. Look for features such as Maximum Power Point Tracking (MPPT) technology, which optimizes energy harvesting from the solar panels.

5. Compliance and Certifications:

The Beacon Inverter 5kW AC is expected to comply with relevant industry standards and certifications. This may include safety certifications, grid compliance, and adherence to regulations in different regions.

6. Durability and Weather Resistance:

Inverters are typically installed outdoors and are exposed to various weather conditions. The Beacon Inverter 5kW AC is likely designed with durability in mind, featuring robust construction and protection against factors like moisture, dust, and extreme temperatures.

7. Cooling and Heat Dissipation:

Efficient cooling mechanisms are crucial for the longevity and optimal performance of inverters. The Beacon Inverter 5kW AC may utilize advanced cooling technologies to dissipate heat generated during operation, ensuring stable and reliable performance over the long term.

8. User-Friendly Interface:

The inverter is expected to have a user-friendly interface for easy installation and configuration. This may include an LCD screen or LED indicators that provide information about the system's status, energy production, and potential issues.

9. Warranty and Support:

Manufacturers typically provide warranties for their inverters, ensuring that customers have peace of mind regarding the product's reliability. The Beacon Inverter 5kW AC is likely to come with a warranty, and the manufacturer may offer customer support services for technical assistance and issue resolution.

Fig 3. Beacon inverter 5kw ac

4.1 Location for solar powered charging station:

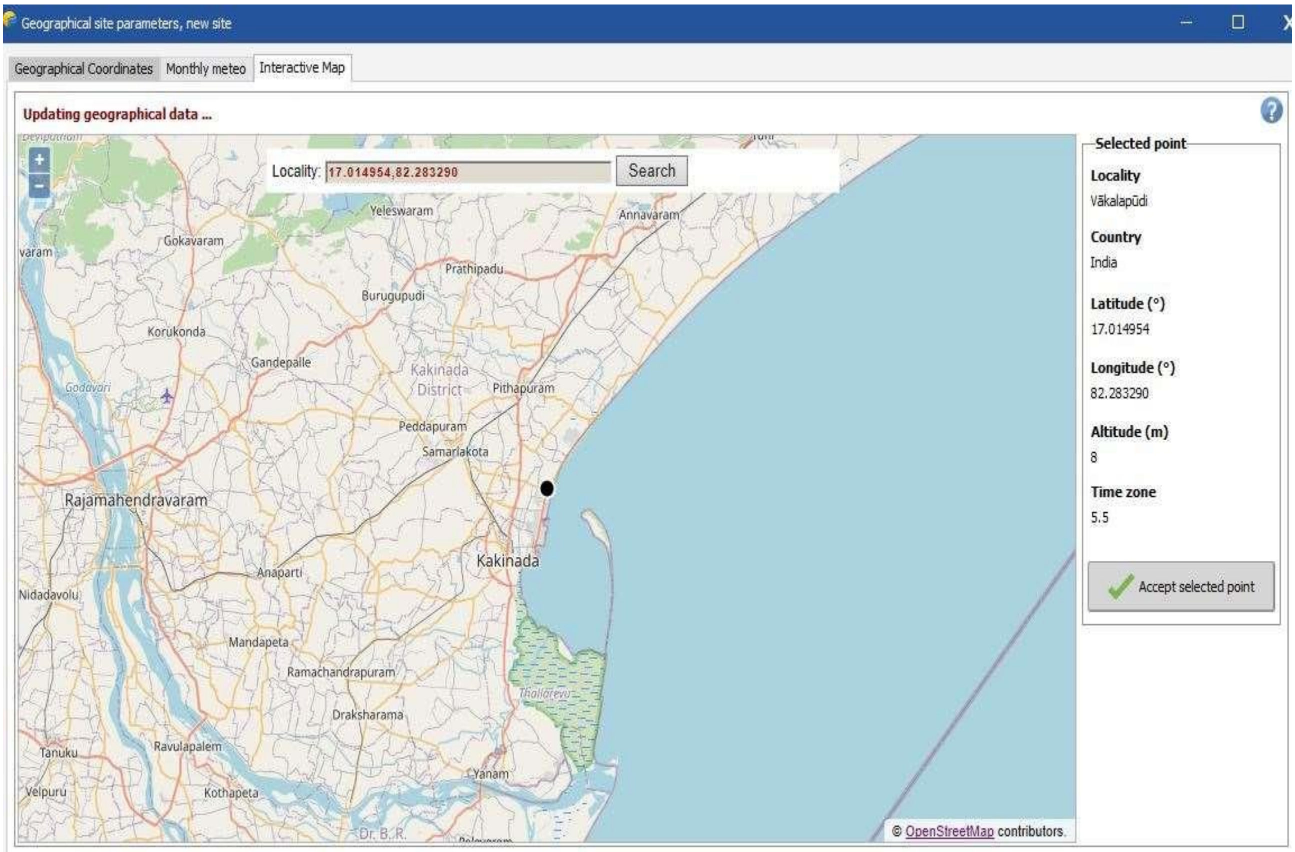


Fig 4. Dashboard for selecting location

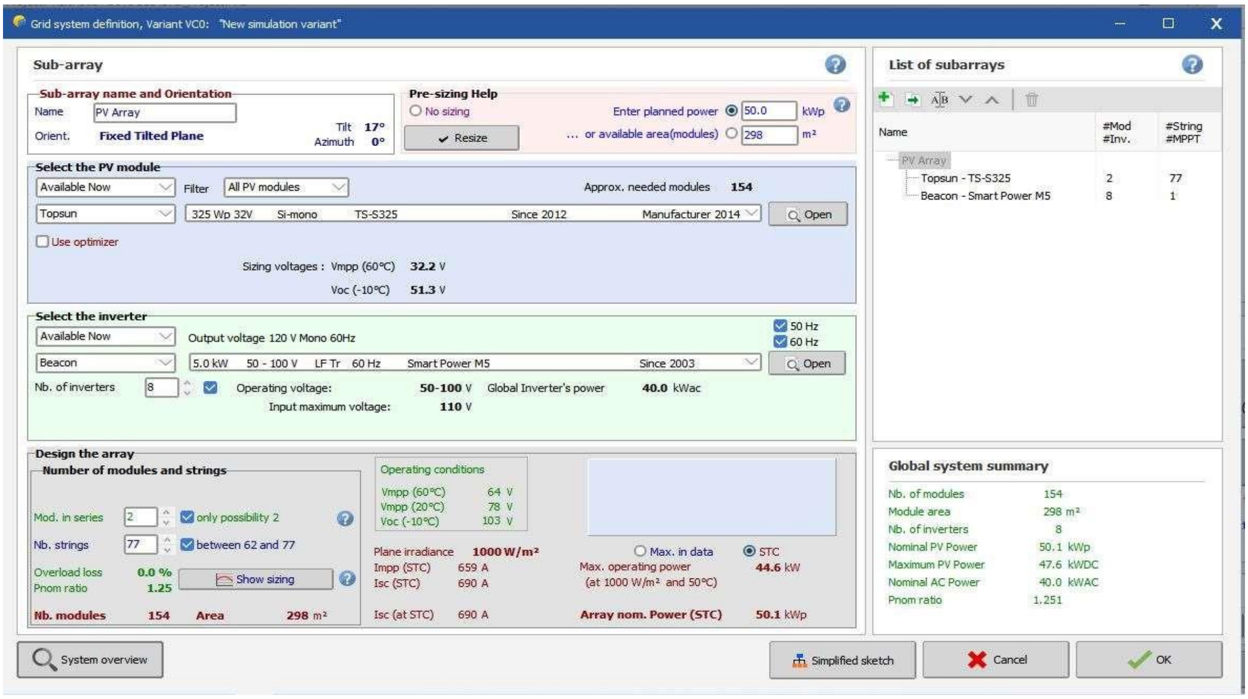


Fig 5. Dash board for choosing the inverter specifications

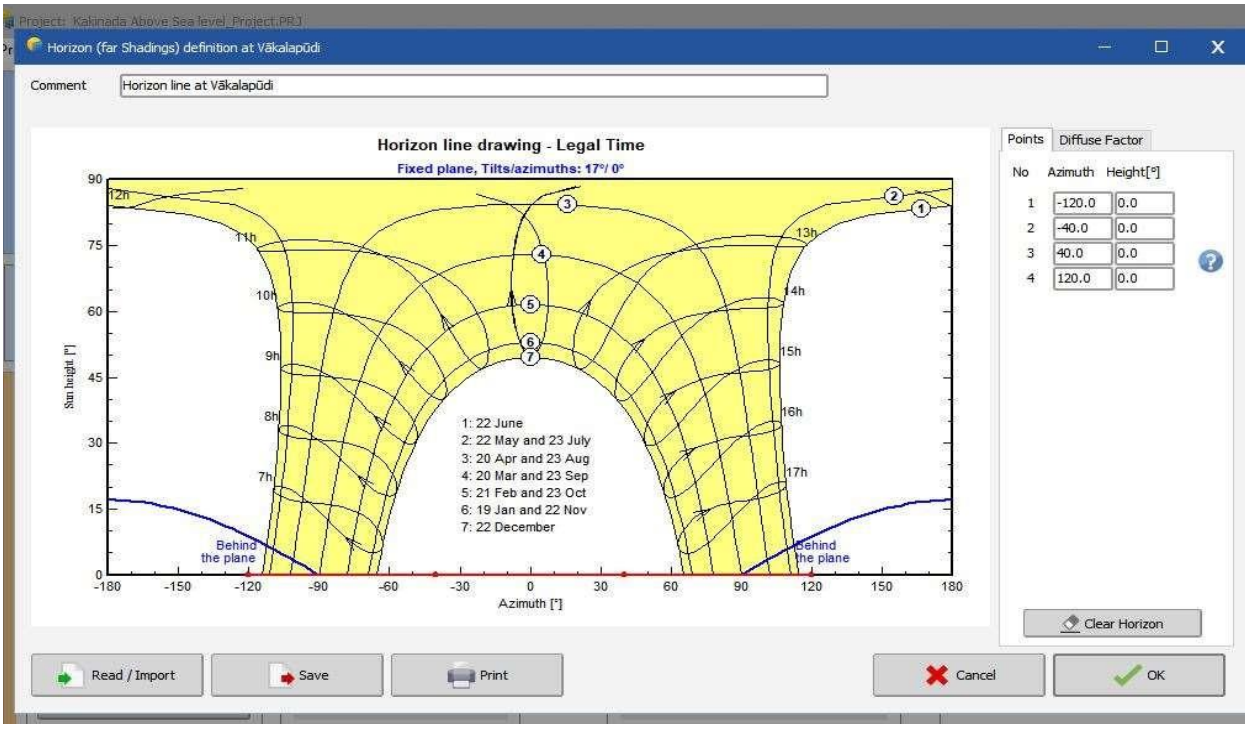


Fig 6. Sun radiation path at Vakalapudi

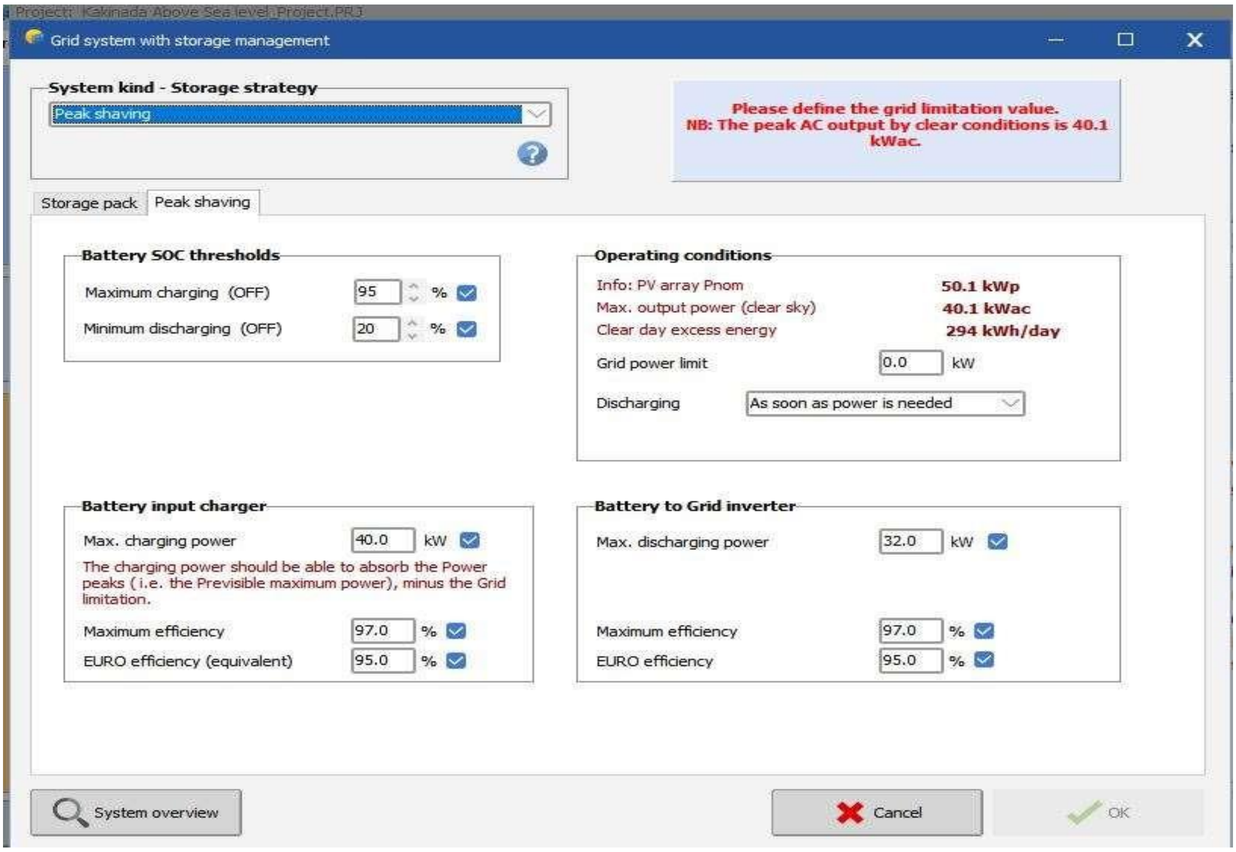


Fig 7. Battery Operational specifications

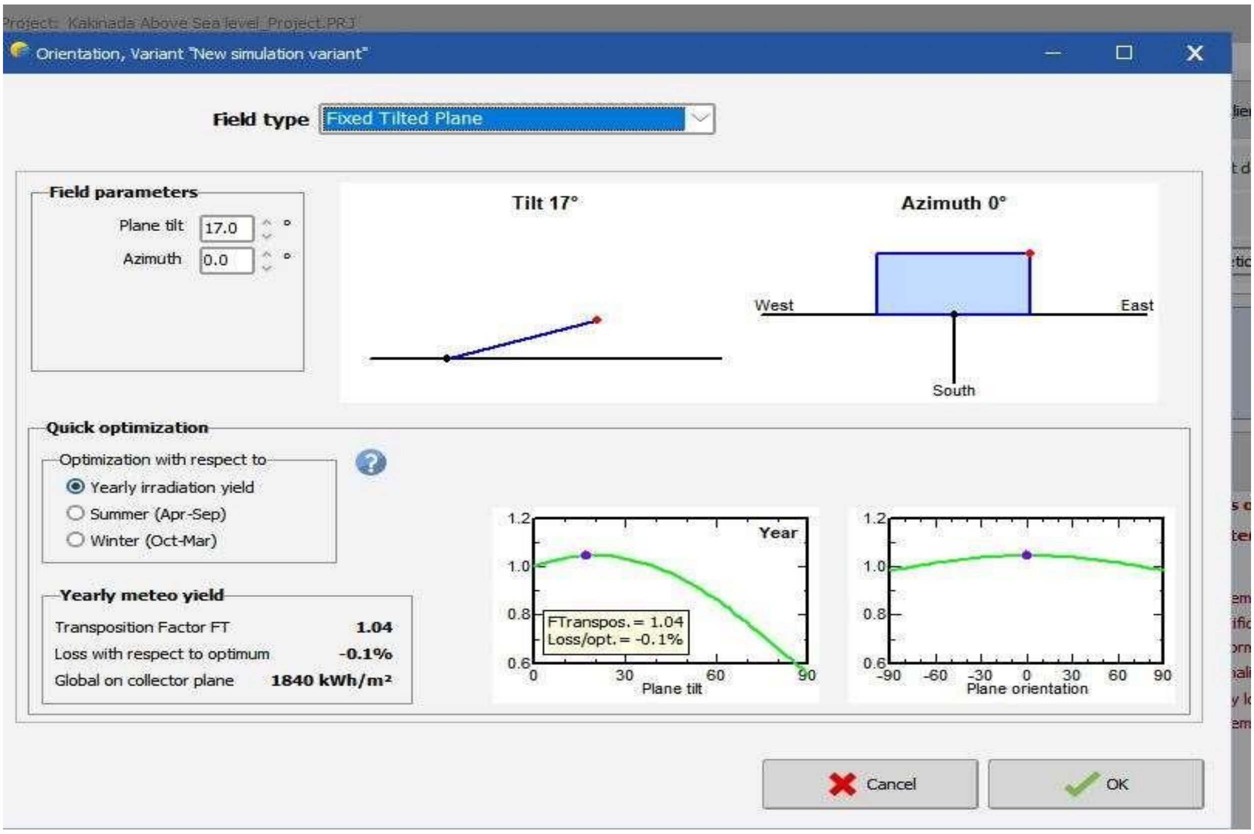


Fig 8. choosing tilted plane to get maximum yield

V. RESULTS AND DISCUSSION

5.1Report of Technical and economic analysis from pv syst software:

PVsyst - Simulation report

Grid-Connected System

Project: Kakinada Below Sea level

Variant: New simulation variant

No 3D scene defined, no shadings

System power: 50.1 kWp

Vākalapūdi - India

Project: Kakinada Below Sea level

Variant: New simulation variant

PVsyst V7.2.11
VC0, Simulation date:
30/12/23 09:26
with v7.2.11

Project summary

Geographical Site		**Situation**		**Project settings**	
Vākalapūdi		Latitude	17.01 °N	Albedo	0.20
India		Longitude	82.28 °E		
		Altitude	8 m		
		Time zone	UTC+5.5		
Meteo data					
Vākalapūdi					
Meteonorm 8.0 (1996-2015), Sat=78% - Synthetic					

System summary

Grid-Connected System		**No 3D scene defined, no shadings**			
Simulation for year no 10					
PV Field Orientation		**Near Shadings**		**User's needs**	
Fixed plane		No Shadings		Unlimited load (grid)	
Tilt/Azimuth	17 / 0 °				
System information					
PV Array			**Inverters**		
Nb. of modules		154 units	Nb. of units		8 units
Pnom total		50.1 kWp	Pnom total		40.0 kWac
			Pnom ratio		1.251

Results summary

Produced Energy	65.24 MWh/year	Specific production	1304 kWh/kWp/year	Perf. Ratio PR	71.16 %

General parameters

Grid-Connected System

No 3D scene defined, no shadings

PV Field Orientation

Orientation		**Sheds configuration**		**Models used**	
Fixed plane		No 3D scene defined		Transposition	Perez
Tilt/Azimuth	17 / 0 °			Diffuse	Perez, Meteonorm
				Circumsolar	separate
Horizon		**Near Shadings**		**User's needs**	
Free Horizon		No Shadings		Unlimited load (grid)	

PV Array Characteristics

PV module		**Inverter**	
Manufacturer	Topsun	Manufacturer	Beacon
Model	TS-S325	Model	Smart Power M5
(Original PVsyst database)		(Original PVsyst database)	
Unit Nom. Power	325 Wp	Unit Nom. Power	5.00 kWac
Number of PV modules	154 units	Number of inverters	8 units
Nominal (STC)	50.1 kWp	Total power	40.0 kWac
Modules	77 Strings x 2 In series	Operating voltage	50-100 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.25
Pmpp	44.6 kWp		
U mpp	68 V		
I mpp	659 A		
Total PV power		**Total inverter power**	
Nominal (STC)	50 kWp	Total power	40 kWac
Total	154 modules	Number of inverters	8 units
Module area	298 m²	Pnom ratio	1.25
Cell area	265 m²		

Array losses

Array Soiling Losses		**Thermal Loss factor**		**DC wiring losses**	
Loss Fraction	3.0 %	Module temperature according to irradiance		Global array res.	1.7 mΩ
		Uc (const)	29.0 W/m²K	Loss Fraction	1.5 % at STC
		Uv (wind)	0.0 W/m²K/m/s		
Module Quality Loss		**Module mismatch losses**		**Strings Mismatch loss**	
Loss Fraction	-0.8 %	Loss Fraction	2.0 % at MPP	Loss Fraction	0.1 %
Module average degradation		**IAM loss factor**			
Year no	10	ASHRAE Param: IAM = 1 - bo(1/cosi -1)			
Loss factor	0.4 %/year	bo Param.	0.05		
Mismatch due to degradation					
Imp RMS dispersion	0.4 %/year				
Vmp RMS dispersion	0.4 %/year				

Spectral correction

FirstSolar model

Precipitable water estimated from relative humidity

Coefficient Set	C0	C1	C2	C3	C4	C5
Monocrystalline Si	0.85914	-0.02088	-0.0058853	0.12029	0.026814	-0.001781

System losses

Unavailability of the system

Time fraction	2.0 %
	7.3 days,
	3 periods

Main results

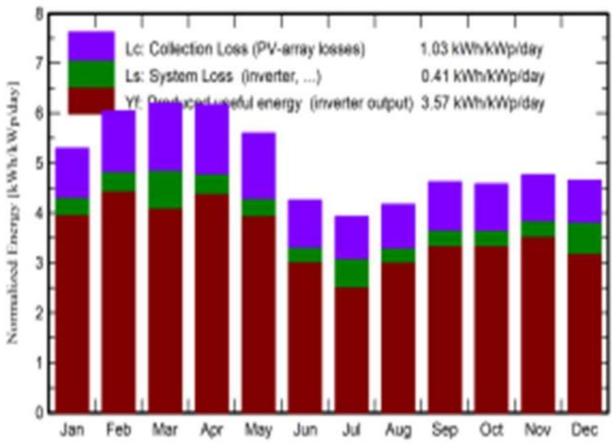
System Production

Produced Energy	65.24 MWh/year	Specific production	1304 kWh/kWp/year
		Performance Ratio PR	71.16 %

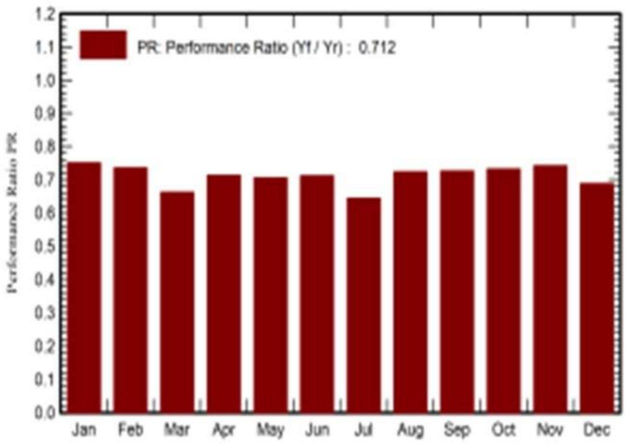
Economic evaluation

Investment		**Yearly cost**		**LCOE**	
Global	30657406.84 INR	Annuities	0.00 INR/yr	Energy cost	-78374 INR/kWh
Specific	613 INR/Wp	Run. costs	-5144040000.00 INR/yr		
		Payback period	0.0 years		

Normalized productions (per installed kWp)



Performance Ratio PR

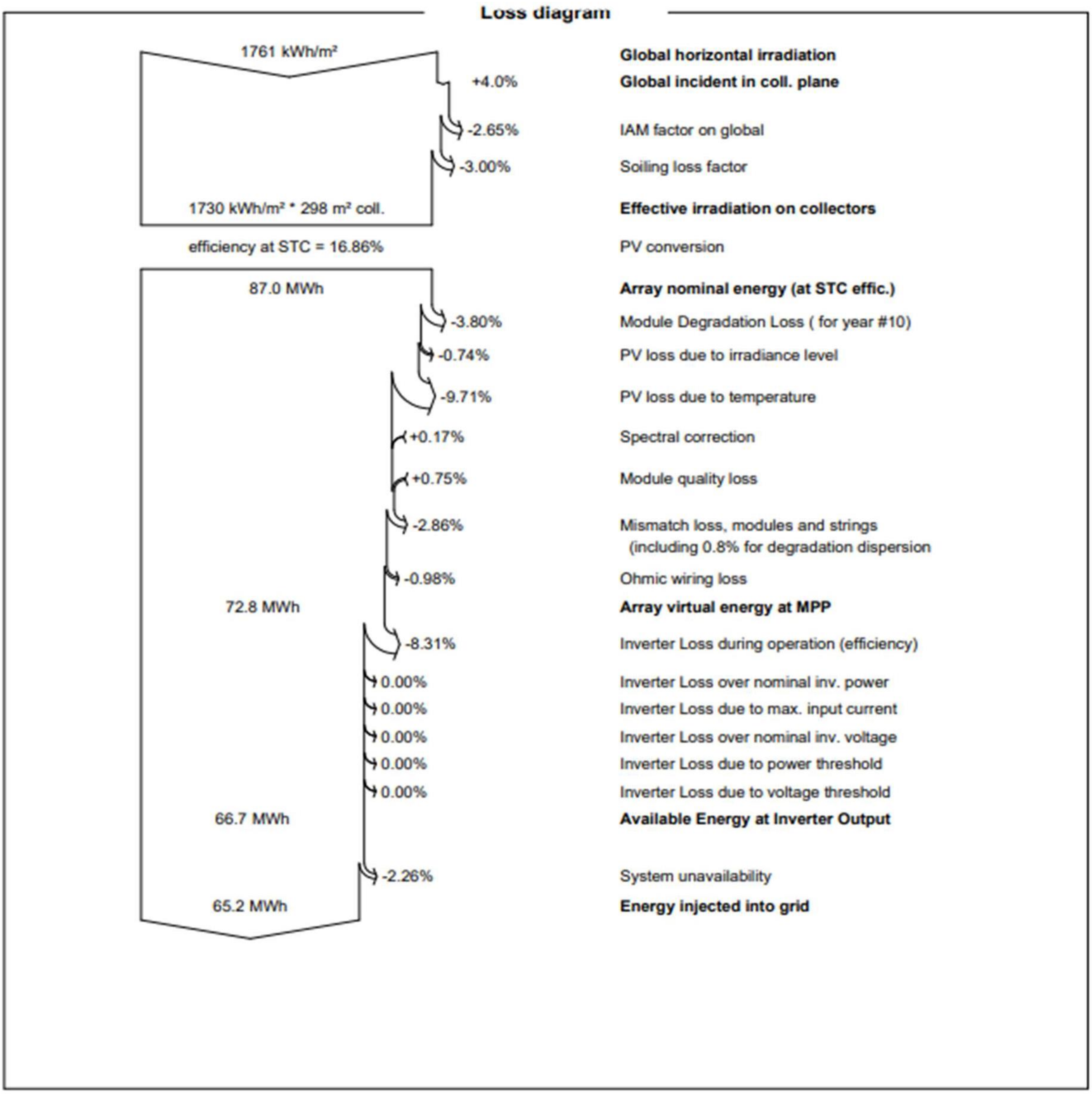


Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	139.9	58.03	23.21	164.3	155.6	6.712	6.173	0.751
February	150.4	59.58	25.34	169.4	160.7	6.789	6.241	0.736
March	182.5	78.93	28.41	192.4	182.4	7.554	6.380	0.663
April	187.2	86.70	30.57	185.3	175.2	7.200	6.614	0.713
May	183.5	98.65	32.95	173.7	163.7	6.680	6.136	0.706
June	136.8	89.09	31.21	127.8	120.0	4.992	4.553	0.712
July	129.2	86.90	29.86	121.7	114.2	4.809	3.924	0.644
August	132.8	90.86	28.99	129.3	121.7	5.141	4.688	0.724
September	136.5	80.81	28.16	138.7	130.9	5.515	5.041	0.726
October	132.9	79.34	27.77	142.0	134.0	5.682	5.205	0.732
November	125.4	62.63	25.39	143.0	135.3	5.792	5.315	0.743
December	124.1	68.45	23.55	144.4	136.3	5.940	4.974	0.689
Year	1761.2	939.98	27.96	1832.0	1730.0	72.805	65.244	0.712

Legends

GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		



5.2 Unavailability losses:

It is in some cases valuable to anticipate framework disappointments or upkeep stops within the generation desires. A framework inaccessibility as a division of time (or a number of days). For these disappointing hours, the framework will be considered inert (OFF) amid the recreation. The opportunity of characterizing periods of inaccessibility of the framework. Usually as a rule unusual, it is additionally conceivable to inquire PVsyst for making these periods in a arbitrary way (up to 5 periods of any length along the year).

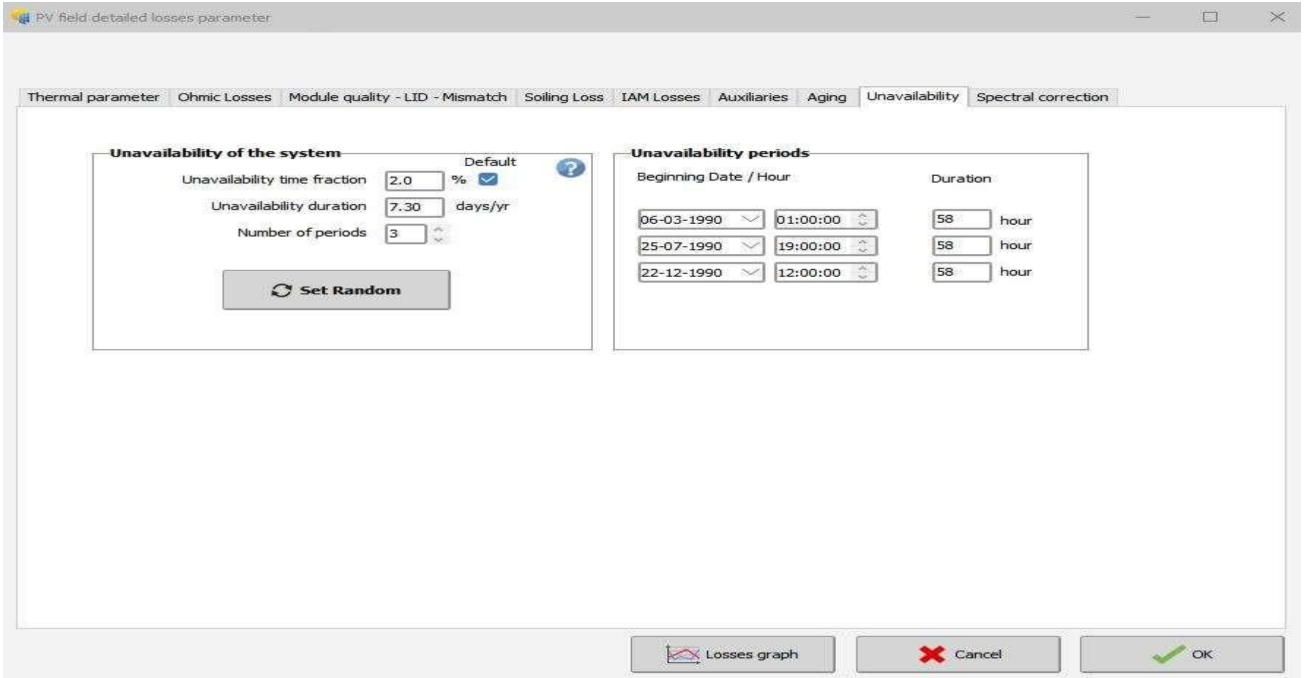
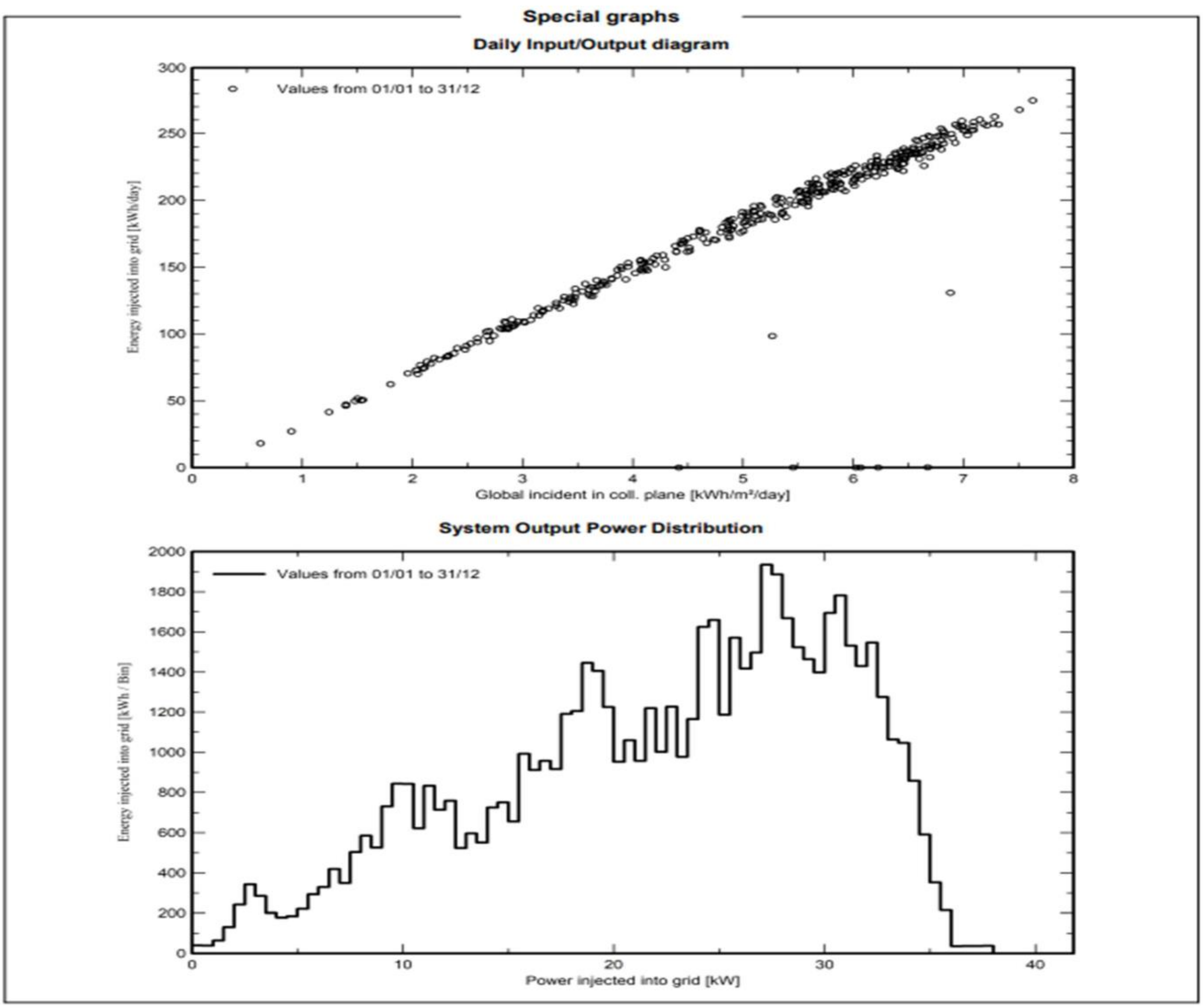


Fig 9. Unavailability losses from PV syst report



Cost of the system

Installation costs

Item	Quantity units	Cost INR	Total INR
PV modules			
Supports for modules	154	3468.00	534072.00
Studies and analysis			
Engineering	1	108000.00	108000.00
Permitting and other admin. Fees	1	108000.00	108000.00
Environmental studies	1	108000.00	108000.00
Economic analysis	1	108000.00	108000.00
Installation			
Global installation cost per module	154	750.00	115500.00
Global installation cost per inverter	8	17419.35	139354.84
Transport	1	540000.00	540000.00
Settings	1	540000.00	540000.00
Grid connection	1	540000.00	540000.00
Land costs			
Land purchase	1	22416480.00	22416480.00
Land preparation	1	5400000.00	5400000.00
Total			30657406.84
Depreciable asset			534072.00

Operating costs

Item	Total INR/year
Maintenance	
Salaries	216000000.00
Repairs	5400000.00
Cleaning	5400000.00
Security fund	5400000.00
Land rent	21600000.00
Bank charges	1080000.00
Administrative, accounting	1080000.00
Subsidies	-5400000000.00
Total (OPEX)	-5144040000.00
Including inflation (4.40%)	-5144040000.00

System summary

Total installation cost	30657406.84 INR
Operating costs (incl. inflation 4.40%/year)	-5144040000.00 INR/year
Produced Energy	65.2 MWh/year
Cost of produced energy (LCOE)	-78373.940 INR/kWh

Financial analysis

Simulation period

Project lifetime	1 years	Start year	2023

Income variation over time

Inflation	4.40 %/year
Production variation (aging)	0.00 %/year
Discount rate	5.50 %/year

Income dependent expenses

Income tax rate	37.00 %/year
Other income tax	0.00 %/year
Dividends	0.00 %/year

Financing

Own funds	30642273.19 INR
Subsidies	15133.65 INR

Electricity sale

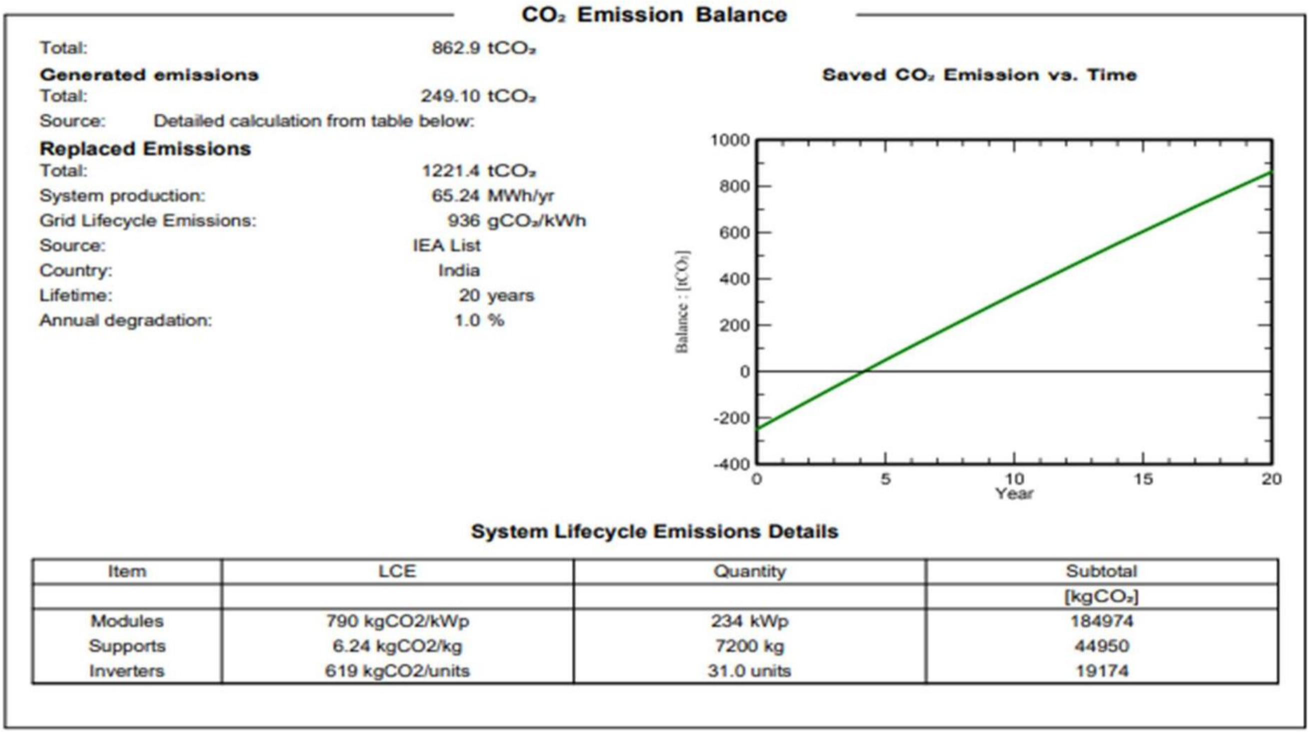
Feed-in tariff	7.0000 INR/kWh
Duration of tariff warranty	20 years
Annual connection tax	0.00 INR/kWh
Annual tariff variation	0.0 %/year
Feed-in tariff decrease after warranty	50.00 %

Return on investment

Payback period	0.0 years
Net present value (NPV)	3041426849.26 INR
Return on investment (ROI)	9925.6 %

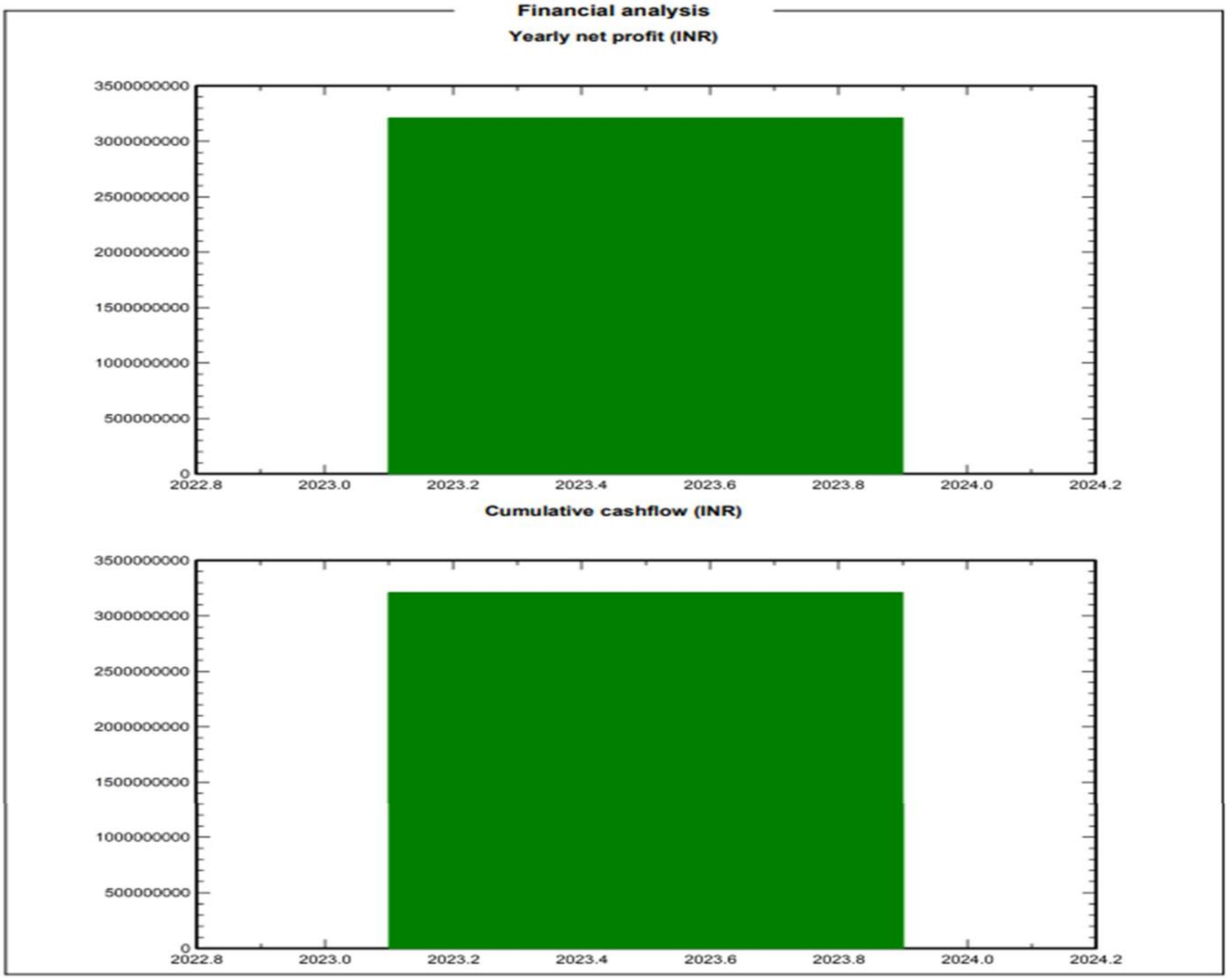
Detailed economic results (INR)

	Electricity sale	Run. costs	Deprec. allow.	Taxable income	Taxes	After-tax profit	Cumul. profit	% amorti.
2023	456705	-5144040000	0	5144496705	1903463781	3241032924	3041426849	10025.6%
Total	**456705**	**-5144040000**	**0**	**5144496705**	**1903463781**	**3241032924**	**3041426849**	**10025.6%**



Item	LCE	Quantity	Subtotal
			[kgCO₂]
Modules	790 kgCO2/kWp	234 kWp	184974
Supports	6.24 kgCO2/kg	7200 kg	44950
Inverters	619 kgCO2/units	31.0 units	19174

Fig.10 CO_2 Emissions



VI. CONCLUSION AND FUTURE SCOPE

The solar charging station project, using PVSYST software, successfully designed and simulated solar charging station, maximizing energy generation potential. The construction phase involved site preparation, foundation installation, and panel mounting techniques. The solar charging station was connected to the electrical grid, adhering to interconnection agreements and regulatory requirements. Regular maintenance activities were implemented to optimize performance and longevity. The solar charging station significantly reduced carbon emissions of 249.10tons and air pollution compared to conventional energy sources, contributing to the local ecosystem and mitigating the project's environmental impact, and we got the performance ratio of 71.16% and specific energy production of 1304 kwh/year and also installation cost is 3crores and operational cost for 20 years is 50crores and profit from this solar charging station is 30crores.The array losses are about 3.0% and thermal losses of 29.0 Wm^2 and the 8 nits of inverter with max efficiency, and also no.of used modules are 154 contains 50 kWp at STC conditions.

Solar charging stations have proven effective in reducing environmental pollution, improving community health, and enhancing overall quality of life. Collaboration between researchers, engineers, and communities is vital to address challenges and optimize the effectiveness of solar charging systems. The roadmap for future implementations of solar charging stations includes increasing capacity, enhancing energy storage technologies, integrating with smart grids, promoting research and development, and strengthening policy support to accelerate the transition towards a sustainable and renewable energy future.

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