Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Solar energy capacity assessment and performance evaluation of a standalone PV system using PVSYST

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A R T I C L E I N F O

Article history:
Available online xxxx

Keywords:
Performance ratio
PVSYST
Tilt angle
Si-poly PV Module

A B S T R A C T

In today's time, photovoltaic systems are continuously gaining popularity and emerging due to their high sustainability, autonomy, and viability. It is necessary to assess the performance of these systems to understand various aspects related to their operation. The study analyses the usefulness of a PV system installation that supplies electricity to an academic institution. This paper aims to evaluate the performance of a grid-connected silicon-poly PV system with a peak power of 20.0 kW and voltage of 17v. The software used for analysis is PVsyst (7.1.7 version). PVsyst is a widely used simulation software for estimating the energy yield and for optimizing the system design. The PVsyst software has been used to design a grid-connected PV system for the Karunya Institute of technology. The simulated system has silicon-poly PV modules assembled in it. Each module consists of numerous photovoltaic cells interconnected. Each module has a power rating of 180wP and voltage sizing of Vmpp (60-degree Celsius) 17.5v Voc (−10degree) 28.9v. The photovoltaic modules are assembled in a total of 13 strings. Modules in a string are series-connected. Each string in the system consists of 10 PV modules connected in series with a power rating of 20.8 kW. The arrangement is grid-connected with a utility meter. The weather dataset used for evaluation is extracted from PVsyst's database and has the attributes, solar radiation, and ambient temperature.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Nanoelectronics, Nanophotonics, Nanomaterials, Nanobioscience & Nanotechnology.

1. Introduction

The use of photovoltaic systems for electricity generation is becoming very prominent in recent times. This rise is mainly due to a shortage of other energy resources, e.g., fossil fuels. So there is a need to switch to reliable and sustainable resources such as photovoltaic systems. It taps the inexhaustible energy from sunlight and converts it into electrical energy [1–3]. It is cost-effective as it has only purchase and installation costs. PV systems are eco-friendly as it does not emit any hazardous gases. Hike in fuel prices is also one of the reasons for PV systems to gain popularity. Since India is a tropical country, it tends to be warm throughout the year and has solar energy in abundance. So, usage of solar panels has widened in countries like India. The government has also promoted the use of PV systems by offering incentives and exemptions from the tax [4,5]. In addition to these pros, PV systems also have certain demerits. The efficiency of a PV system is mainly based on the climatic conditions of a particular place. Not all counties around the globe have hot climates. So, the installation of solar panels in these regions might be impractical. Also, the cyclic variations of the seasons are a prime factor that has to be considered. The overall efficiency of a PV system is influenced by various factors such as the material of the photovoltaic cell, installation method, inclination or orientation of the system, arrangement

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https://doi.org/10.1016/j.matpr.2021.07.258
2214-7853/
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Please cite this article as: A. Shrivastava, R. Sharma, M. Kumar Saxena et al., Solar energy capacity assessment and performance evaluation of a standalone PV system using PVSYST, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2021.07.258

of the PV cells in the system, climatic conditions of the location, etc. [6,7]. Therefore, it is necessary to study or analyze these factors to gain knowledge on the characteristics that affect the power generation of a PV system. Analysis can be done manually, but technology has paved the way for developing various simulation software such as PV Planner, Homer Pro, PVsyst, etc. This software has proven to be advanced and rapid [8–13]. Moreover researchers are proposing various protocols in the field of healthcare [14–19] and vehicle communication[20–26] to protect the information exchanged among various devices to devices.

2. About PVSyst

PVsyst is considered as one of the standard simulation software that is in use. It was designed and developed by Swiss scientist Andre Mermaid & Co. It is used by most engineers worldwide as it provides rapid results and it is handy too. It carries out a detailed and explicit study on numerous parameters that influence the efficiency of a system. In addition to this, it has the ability to perform periodic estimations and report generation. The accuracy of PVsyst software is very close to the real/actual values. It also has other salient features such as color-coding to display error messages, warnings, etc.

3. Design methodology

The steps involved in simulation design are illustrated in the form of the flow chart in Fig. 1. The below step-by-step diagram depicts the procedure that has to be followed, simulating a design using PVsyst. Various steps involved in designing a grid-connected PV system in PVsyst's platform are as follows:

3.1. Set out the geographical location

Choose the geographical location for which the analysis has to be carried out for installing the PV system. The software provides options to choose between existing sites or new sites. PVsyst can identify and analyze any location on earth. The selected location has to be then associated with any satellite data source that is provided by the software (e.g., NASA-SSE satellite data). The parameters affecting the selected location will be displayed in a tabular form or, in some cases, be stored as a file. The below table illustrates the parameters of Coimbatore, Tamil Nadu, over a year. In PVsyst, the coordinates (latitudes and longitudes) are taken from NREL and are updated (Table 1).

3.2. Fixing of tilt and azimuth angle

The tilt angle is the angle of inclination of the system. This depends on the geographic location. The tilt angle must be in such a way that the system yields maximum output. The azimuth angle is defined as the angle between the south/north and the collector plane. In this simulation, the tilt angle and azimuth angles are 35 and 5 degrees, respectively.

3.3. Selecting a suitable PV module

Based on the panel material, panel quality, power output, and robustness, different PV modules can be selected from the list provided by the software. This simulation is carried out using a generic solar IR-45 BP 295 M Bifacial PV model.

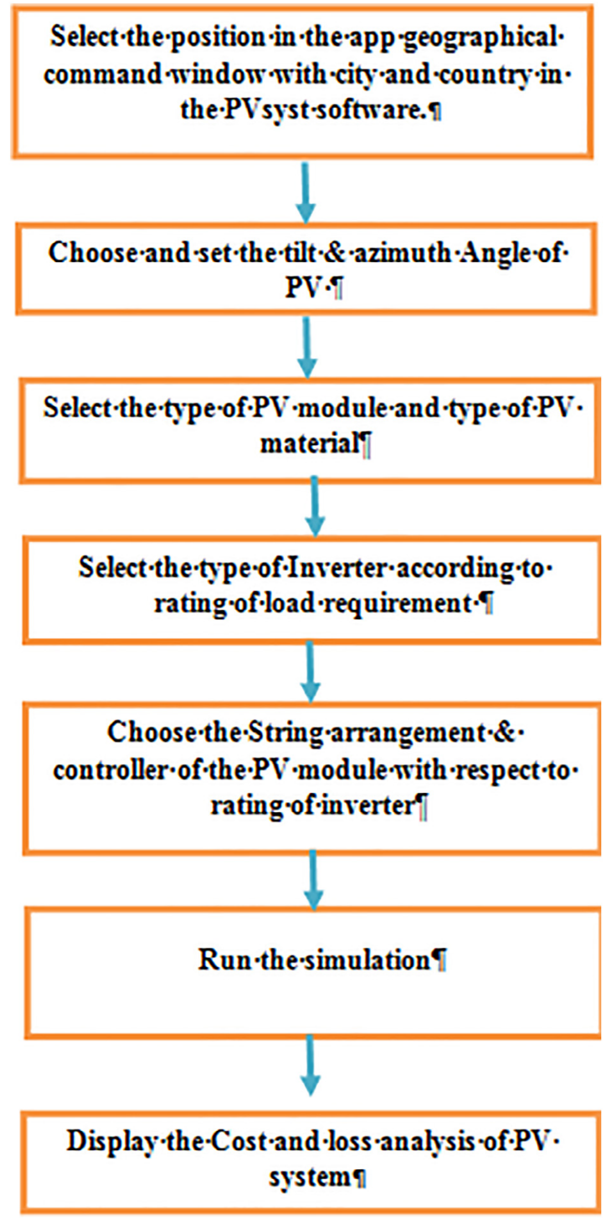

Fig 1. Step by step Algorithm for Analysis of PVsyst.

4. Objective

4.1. The primary object of the simulation in PVsyst is expressed below

- To estimate whether the installation of a PV system in an academic institute is achievable or not.
- Simulate the grid-connected PV system using PVsyst software.
- Determine explicit design, output, and wastage of the PV system.

Figure 2 represents the introduction to the project. The title of the project is entered. In the site file box, the site file can be chosen the map is available. City and country can be entered. The meteo file can be chosen with the help of NREL. Then on the main parameters page, orientation and system can be given.

Figure 3 shows the basic block diagram that represents the PVsyst software that could be used. The simplified sketch of the

Table 1
Comparative study of four town's located in and around Coimbatore.

Parameters	Kovai-chettipalayam	Kovai-udumalaipettai	Kovai-sulur	Kovai-pollachi
	Splitcells	*Splitcells*	*Splitcells*	*Splitcells*
Global horizontal irradiation (kWh/m^2)	2117.2	2146.9	2145.9	2135.5
Global incident Irradiation (kWh/m^2)	738.74	845.16	846.16	821.8
Ambient temperature (^{0}c)	23.58	25.60	25.61	26.57
Efficiency global. Corr. For IAM and shadings (kWh/m^2)	2141.8	2062.1	2191.0	2974.0
Energy injected into (MWh)	2086.2	2003.9	2137.0	2029.5

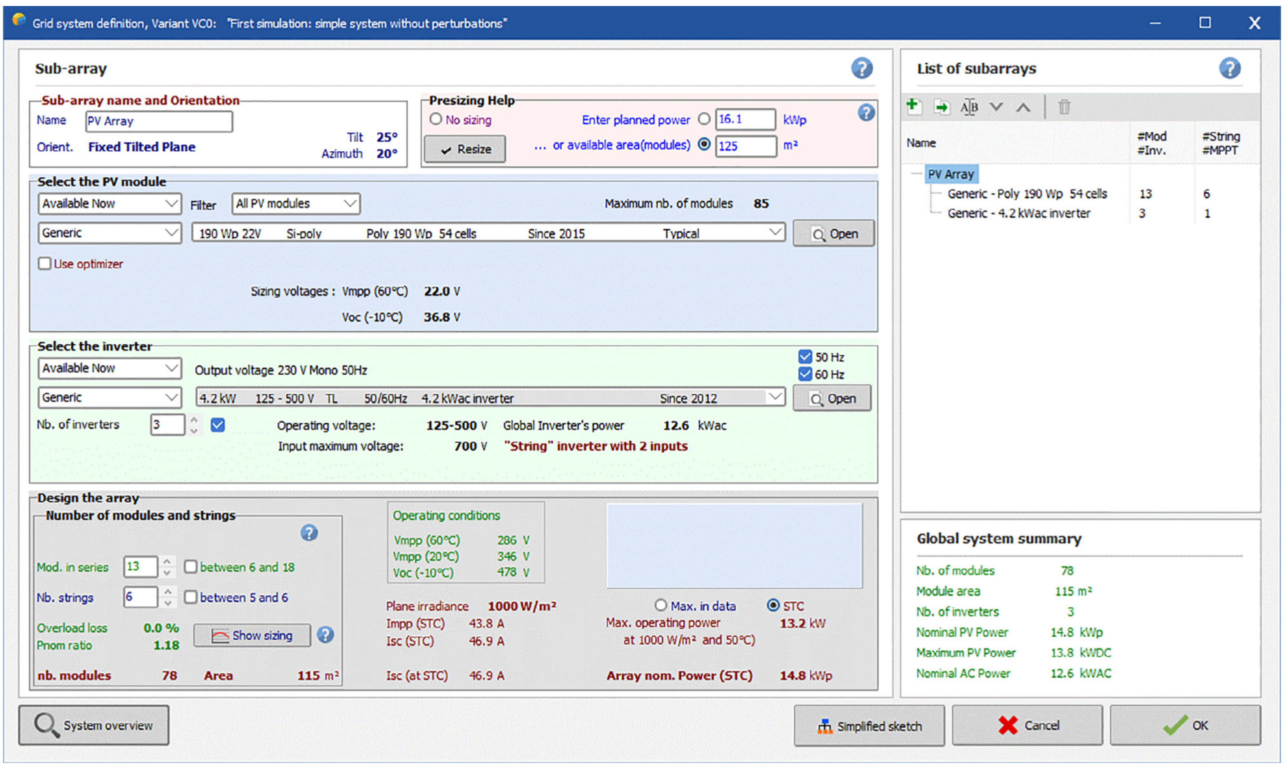

Fig 2. Project page layout and important settings.

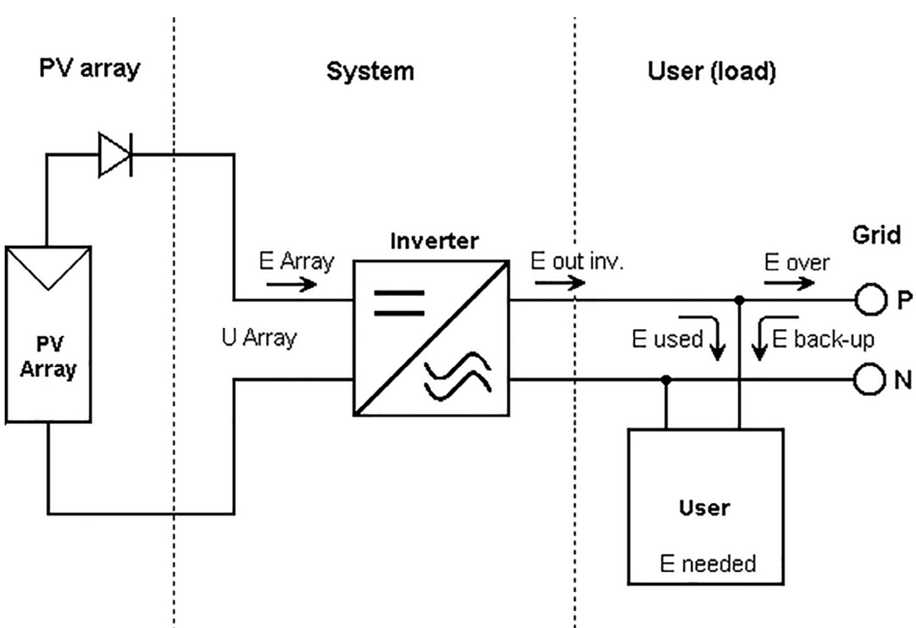

Fig 3. Simplified sketch of block diagram.

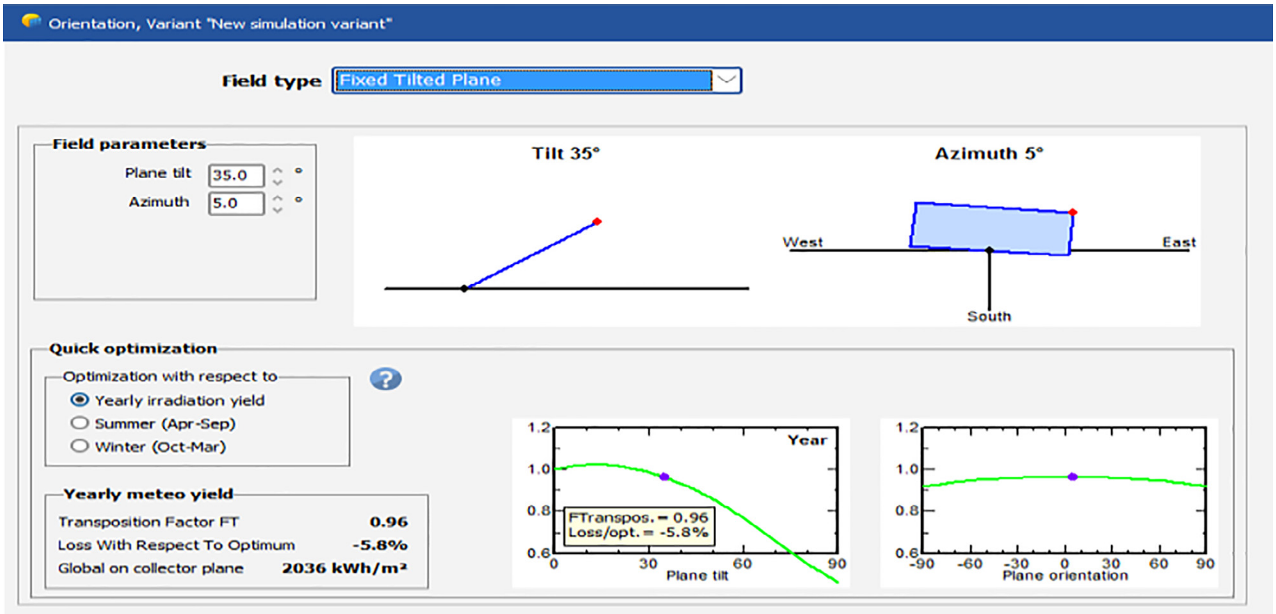

Fig 4. Orientation simulation page.

PV array system (inverter) to the user (load) is represented (Fig. 4. Fig. 5. Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10. Fig. 11.).

On this page, the orientation is done. The simulation is done with the help of choosing the field type, field parameters, and optimization. The field type can be chosen with the help of a fixed tilted plane, tracking plane, vertical or horizontal plane. The field parameters plane tilt and azimuth can be chosen. The period of optimization can be chosen yearly, summer or winter.

This horizon line drawing represents the legal time. The shunt triangle and azimuth angle can be represented. The azimuth height and diffuse factor can be done.

The array voltage sizing can be done with current [A] and voltage [V]. Power sizing: inverter output distribution can be done with energy [kWh] and array power [kW]. The power sizing characterizes PV array Phnom (STC) Phnom (ac) Pmax.

The simulation output can be taken. Four output graphs are daily input/output, performance ratio and solar fraction SF, array power distribution, array temperature, and effective irradiance.

The simulation output can be taken. There are four output graphs: daily input/output, performance ratio and solar fraction SF, array power distribution, array temperature vs. effective irradiance.

System summery and financial summary, PV module, inverter, installation and load then it could be calculated regarding currency.

This diagram represents the energy losses in PV panels such as global horizontal irradiation, global incident in the panel, nominal array energy (STC), array virtual energy of MPP, available virtual energy at inverter output, and energy injection grid.

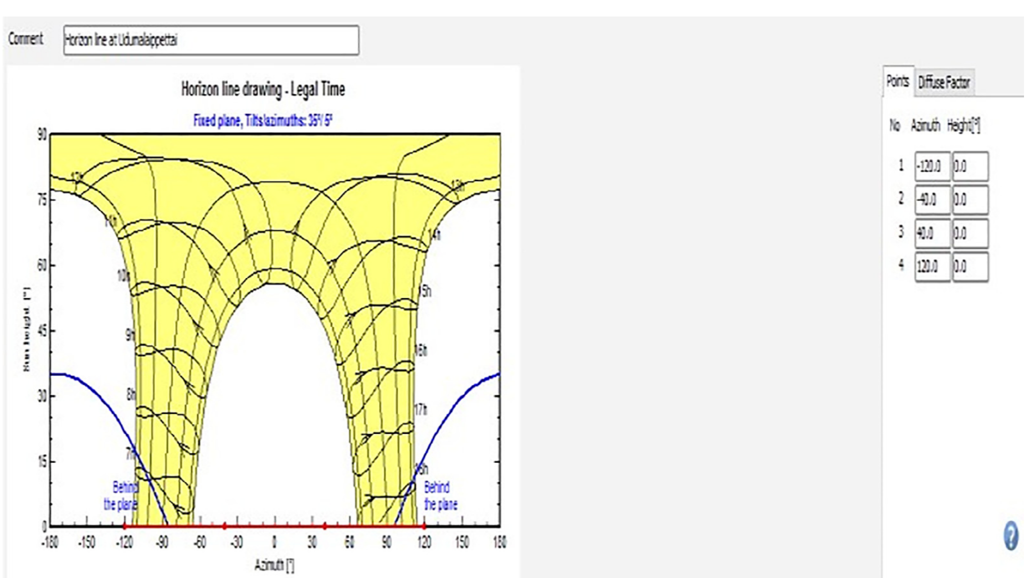

Fig 5. Sun path moving direction.

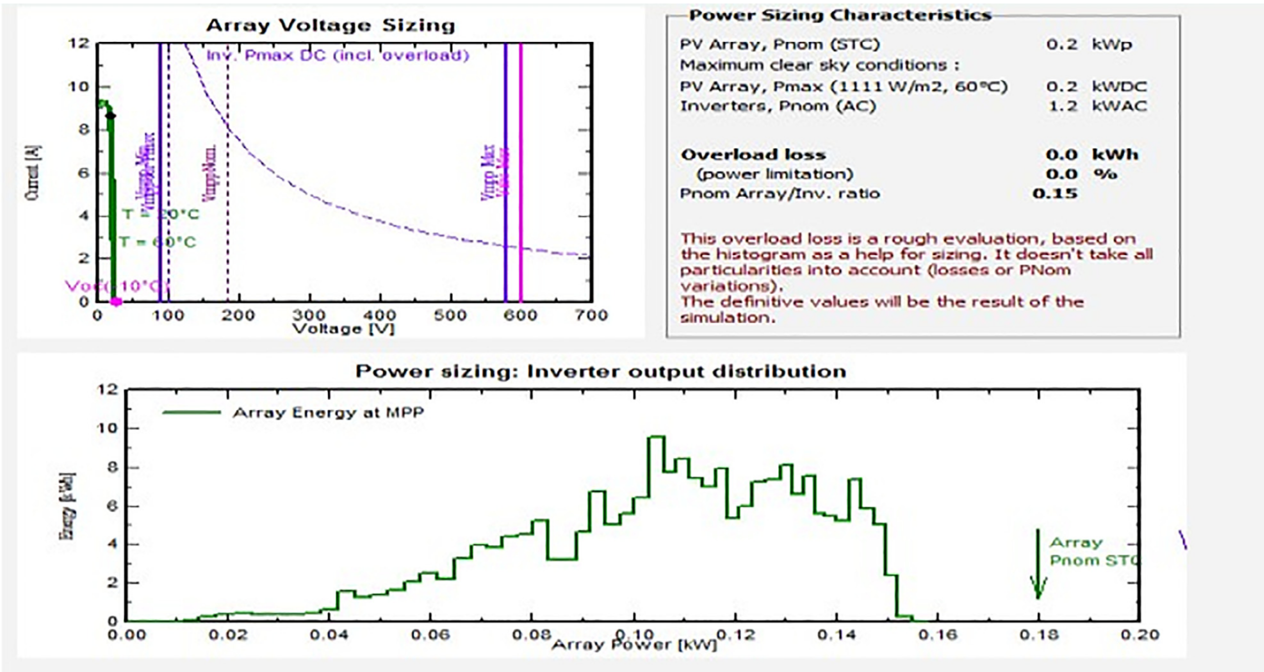

Fig 6. Array/inverter sizing conditions.

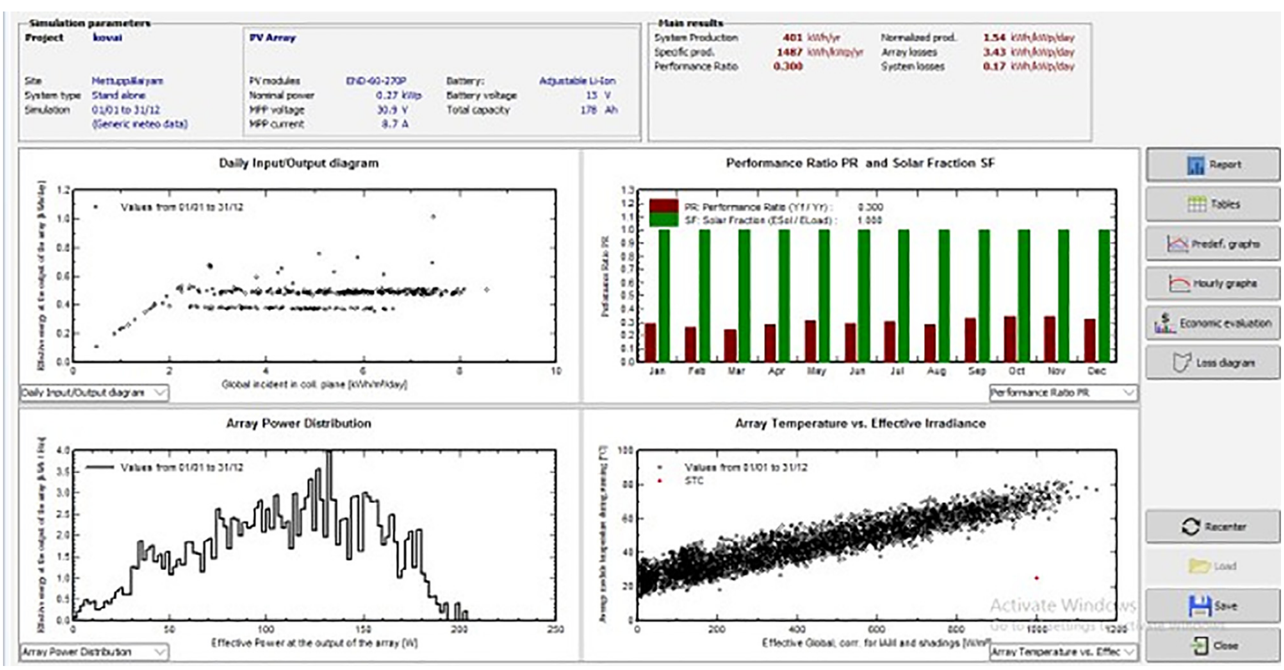

Fig 7. Performance ratio and Array power distribution.

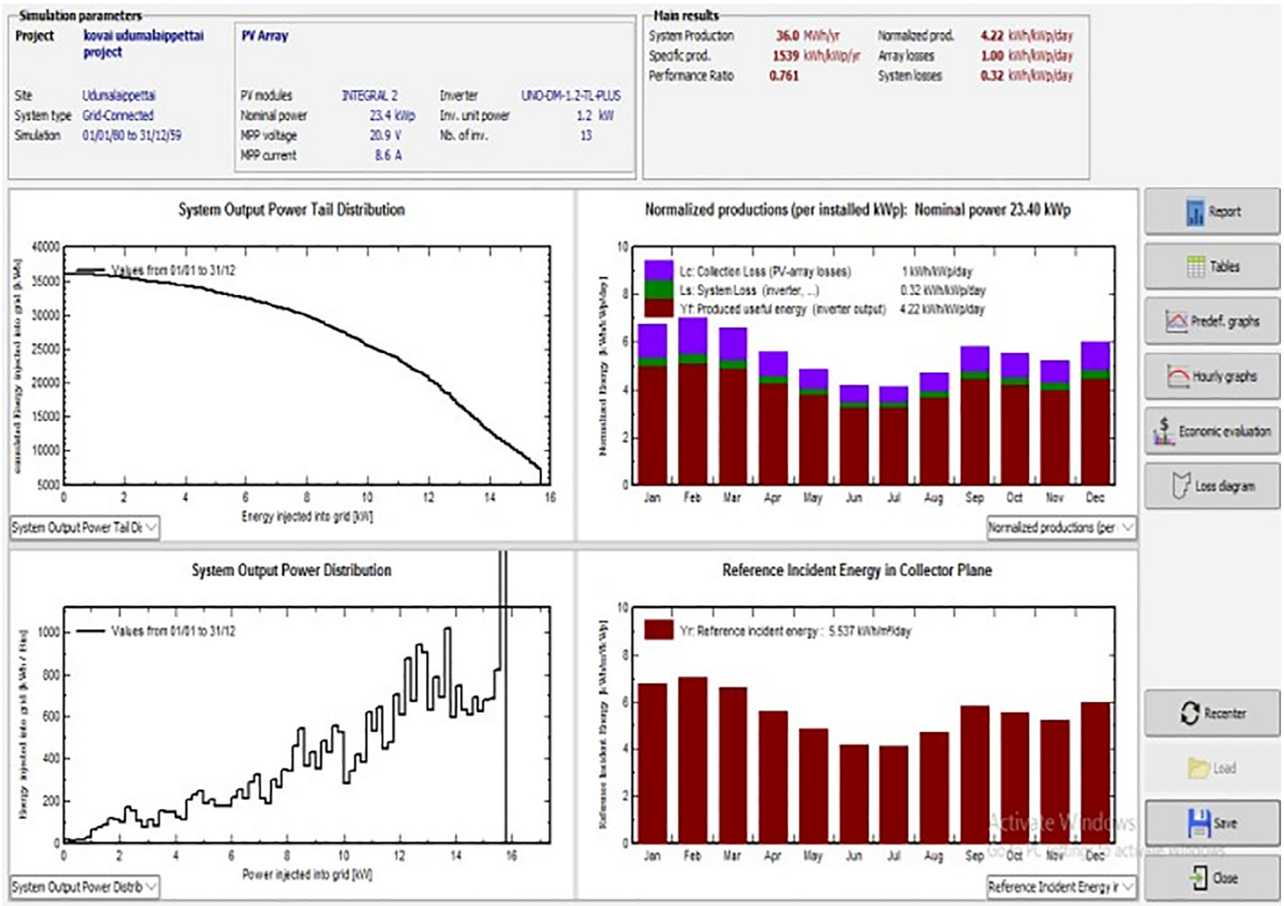

Fig 8. Normalised Production and system output power distribution.

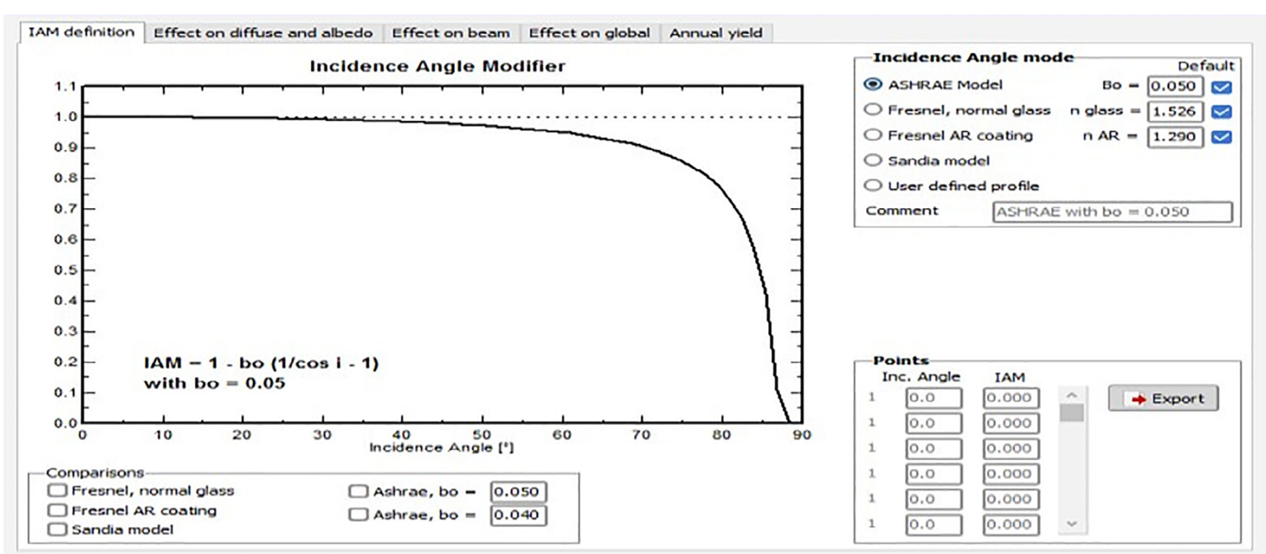

Fig 9. Detailed study of IAM (incidence angle modifier).

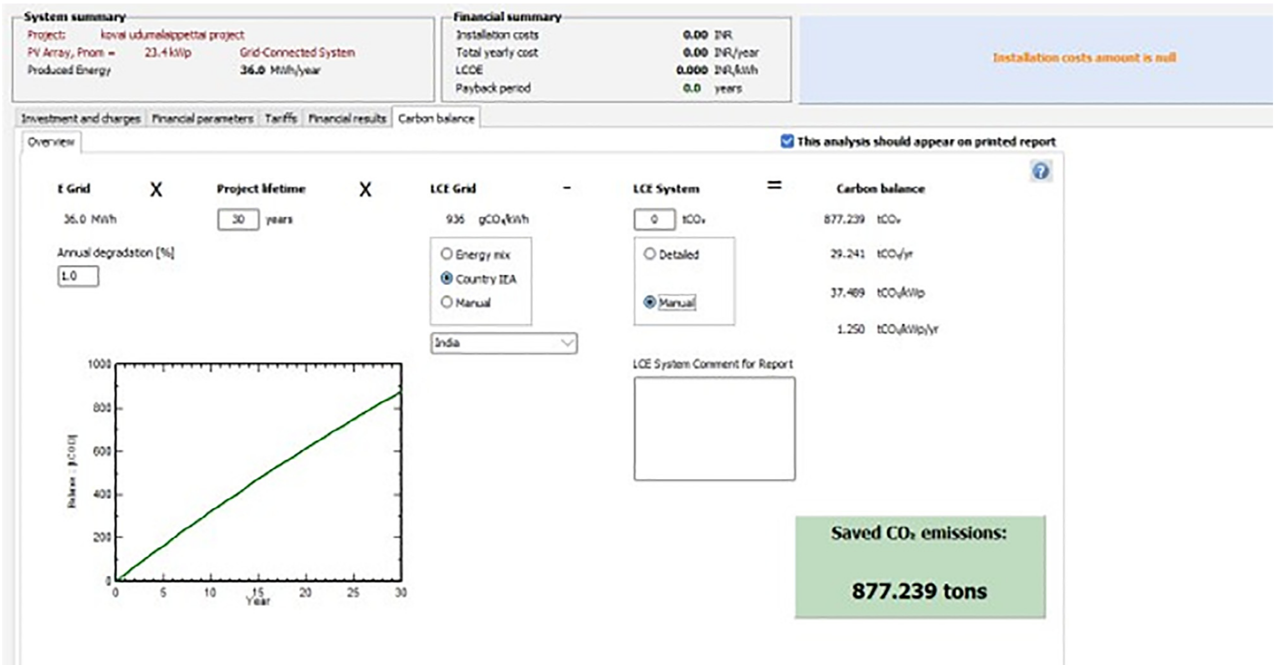

Fig 10. ECONOMIC analysis.

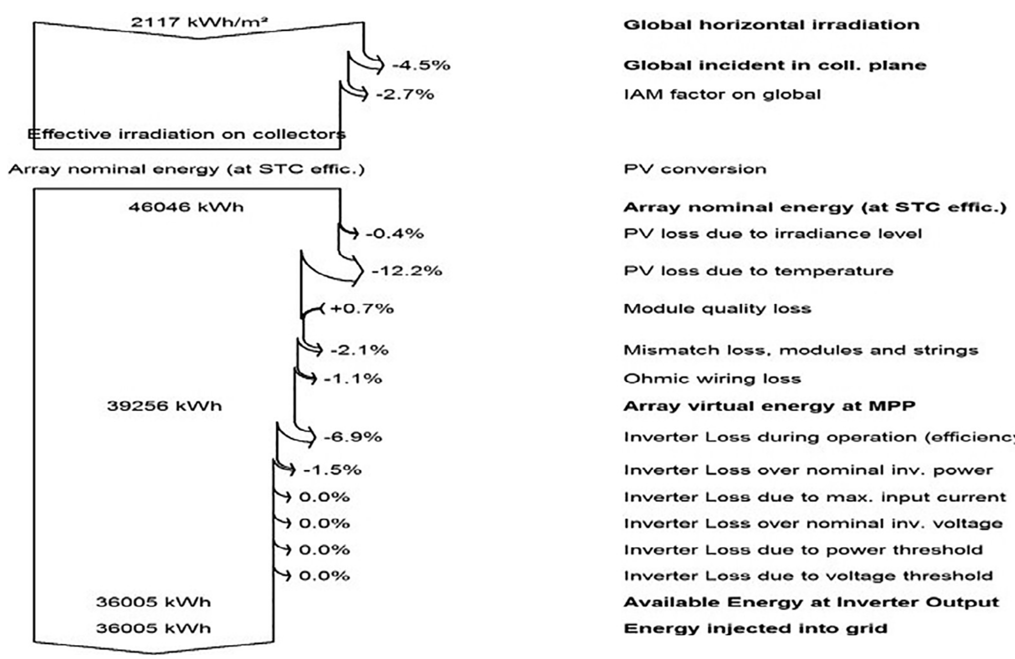

Fig 11. The energy loss diagram.

5. Conclusion

The feasibility of building a photovoltaic device to supply an educational institution's electric load can be simulated and implemented based on the results. The PVsyst software is used to model a stand-alone photovoltaic device. Based on the simulation results, the sizing of the solar panel and inverter model can be selected with the required load demand. The sizing method is highly dependent on the geographic location of the site. The system's detailed configuration, performance, and losses diagram have all been developed.

CRediT authorship contribution statement

Anurag Shrivastava: Conceptualization, Data curation. **Rajneesh Sharma:** Formal analysis, Funding acquisition. **MohitKumar Saxena:** Investigation, Methodology, Project administration. **V. S hanmugasundaram:** Resources, Software, Supervision. **MotiLal Rinawa:** Validation, Visualization. **Ankit:** Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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