

# Chapter 10

## Assessment of Sessional Solar Energy Using PVSyst and SAM



Sukanta Roga , Ajmira Lokesh, Sashwat Jain, Araveti A. N. Vinay, Rishabh Chauhan, Challa Karthik, Soumyabrata Das , and Yogesh Kumar

**Abstract** The purpose of this paper is to present an assessment of energy production from a photovoltaic system over its first year of operation, along with a financial model for the system. In order to meet the modern era's needs, they are on the verge of exhausting our fossil fuels, natural gas, and coal resources. The use of solar energy is one of the vast renewable energy resources. Solar energy is one of the most abundant sources of renewable energy. Photovoltaic systems (PVSyst) software has gained much popularity in this era due to its high accuracy and sustainability. Simulation software called system advisory model (SAM) is widely used to estimate the economic value of solar energy. Data set generated by HB-2, VNIT Nagpur, under different climatic and operating conditions is considered a PV system-generated data set. They have used a long-term data set taken from Meteor Norm 8.0 source. SAM software was used to analyze the cost, savings, and economic data from the PVSyst system model. PVSyst simulation results showed specific energy production of 1535 kWh/kW/year. Simulated results show that without the system, the usage cost was \$104,614, and with it, it was \$62,512, with a simple payback period of 10.6 years. Solar energy assessment has become more accessible and robust through software such as PVSyst and SAM, which are proven reliable for estimation and valuable for case studies in developing countries.

**Keywords** Photovoltaic · Performance ratio · PVSyst · SAM

## 1 Introduction

Around the world, fossil fuels are scarce, coal. Global energy consumption has shown an increment of 2% since 2000 and it shows that by 2035 analysts predict that there

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S. Roga (✉) · A. Lokesh · S. Jain · A. A. N. Vinay · R. Chauhan · C. Karthik · Y. Kumar  
Mechanical Engineering Department, Visvesvaraya National Institute of Technology Nagpur,  
Nagpur, India  
e-mail: [rogasukanta@gmail.com](mailto:rogasukanta@gmail.com)

S. Das  
Electrical Engineering Department, Visvesvaraya National Institute of Technology Nagpur,  
Nagpur, India

will be an increment of 25%. The increase in power requirement will increase the emission of greenhouse gasses, making life on earth very problematic. To compensate for this growing need for energy and save the environment, there is a need to develop reliable renewable energy, both financially stable and a good energy source. Solar, wind, and hydropower are the most used renewable energy forms [1]. Solar energy is generated through an array of Photovoltaic cells containing various elements, mainly silicon which absorbs solar radiation and converts it into electricity through the PV phenomenon. Photovoltaic cells have shown rapid production growth, creating interest among various global investors. This paper portrays the simulation of PV system and its economic data which is done through SAM software [2, 3].

Financial efficiency is a critical entry point for a high-performance photovoltaic (PV) system. Your evaluation depends on whether the trustee predicts the outpouring of the system's life force. Input in one place, life force predictions are based on a range of parameters, including system configuration, system technology, and existing weather conditions. Considering how system losses vary over time with any system damage components is essential. The use of photovoltaic systems for power generation is most prominent in recent times. Therefore, reliable and Sustainable switch resources such as photovoltaic systems are needed. It hits the endless thing energy from the sun and converts it into electrical energy.

It is expensive as it has only purchase and installation costs. PV systems are environmentally friendly as they do not emit any haze-strong gases. Rising fuel prices are also one reason PV systems have gained popularity. As India is tropical, it is warm all year round and has abundant solar solid energy. Therefore, the use of solar panels has increased significantly in the country, trying as an India. The government also encouraged the use of PV systems by providing benefits and exemptions to the tax. In addition to these benefits, PV systems are also guaranteed to be evil. The efficiency of the PV system is based primarily on local climates. Not all regions near the globe have a tropical climate. Therefore, installing solar panels in these regions may not be possible. Also, cyclic variation seasons are an essential factor to consider. The overall efficiency of the PV system is influenced by various factors such as the material for a photovoltaic cell, installation method, tendency or position of the system, and planning.

One may think that the initial cost for the total equipment is too high, so they expect the appropriate returns from the system. To make this happen, a proper simulation should be carried out. They use system advisor model (SAM) to evaluate and to find the payback period and the amount generated from the system [4].

## 2 Literature Review

The observation from the papers is that designing work for the photovoltaic systems is mainly done in PVsystem software, and the economic data simulations are done in SAM software. The annual performance of the system is around 80% [5], and the improvements done in lead-acid battery technology increase the efficiency up

to 70% over its working period [6]. Various studies during the last decade indicate solar energy added more capacity worldwide than any form of energy. The “Global trends in renewable energy investment 2019”, commissioned by the United Nations Environment’s economy division, paints a bright picture for the future of renewables. It reveals that from 2010 to 2019, the world has invested 2.6 trillion dollars into clean energy and boosted capacity from 414 to 1650 gigawatts. In 2019, renewables accounted for 12.9% of the world’s electricity. This saved around 2 billion of carbon emissions and reduced environmental pollution.

The report generated by the United States in 2019 indicates that installing new wind and solar equipment was cheaper than maintaining coal plants in 70% of cases around the globe. It also suggests that developed countries like Australia could reach 50% renewables without making any policy changes against the environment. The United Nations Global summit, conducted on 23rd September in New York City, aims that solar energy should be the primary mode of replacing electricity from coal to prevent environmental pollution due to greenhouse gasses released from burning fossil fuels like coal, etc. India considers an essential target of achieving to generate at least 100 GW of solar energy by the year 2020 [7, 8].

## ***2.1 Limitations in Study/Research***

The PV systems power production is exponentially decreased in cloudy environments and low irradiance areas; current studies are only limited to ideal conditions for the systems. For these situations, excess power needs to be generated during the high irradiance and accumulated in the other forms of energy. To store the energy, good batteries need to develop which are affordable and efficient enough for a viable option [9]. Current research mainly involves the conversion of energy into mechanical or the production of hydrogen. Not a lot is done to store the point in the batteries. Most storage systems still use lead-acid, Li-ion can be used for better efficiency, but the cost is high. The battery technology needs to be further improved and massively produced. Further new battery technology is to invent.

The system’s effectiveness slows down over time due to various degradation methods. The assessment of lifelong energy assumptions is based on mathematical formulas and considers different types of completion. Although this model is standard, it can have specific effects on climate and technology from degradation levels, and the perceived uncertainty can be changed depending on the location and PV system technology. PVsyst as software is magnificent in predicting the generation of a system. Photon.info was a very reliable source to update the component’s data; for the time being, they are not operating, and this means most of the new technology components need to be added manually, which increases the possibility of human error.

PVsyst doesn’t provide any details for after the side of the inverter. Unlike other software, PVsyst doesn’t offer a single-line diagram and all the details that come with it. Sometimes, the simulated results don’t make sense according to reality, but

generally, excellent software to use and rely on for designing [10, 11]. SAM financial model uses the cash flow technique, i.e., saved money over its period, to analyze the project's financial system. The software is also used to design various renewable systems and assess the power output from different seasons in its working period.

There is a common misconception that SAM tools can completely mitigate your risk of a costly and disruptive audit. Studies show zero correlation between having a SAM tool and whether you will end up paying audit fees or how much you will ultimately pay. Access this helpful guide to understand limitations that can cause compliance gaps, and surprise true-up fees, double-paying for the same licenses, and incorrect SAM reporting [4].

Wind and solar energy conversion systems require an efficient control system for smooth operation of various components. Pitch angle control is crucial to the proper operation of wind turbine blades. Power converter control scheme is developed to generate PWM for IGBT switches. The simulated wind energy conversion system's computational results were acquired, and its performance is examined [12–14]. All control schemes are capable of controlling the system and making it capable of tracking the MPP, keeping all reactive powers below zero as desired. Comparatively to classical conventional systems, ANFIS provides better alternatives; they are faster converging, perform better, and exhibit less oscillation during steady-state conditions [15, 16].

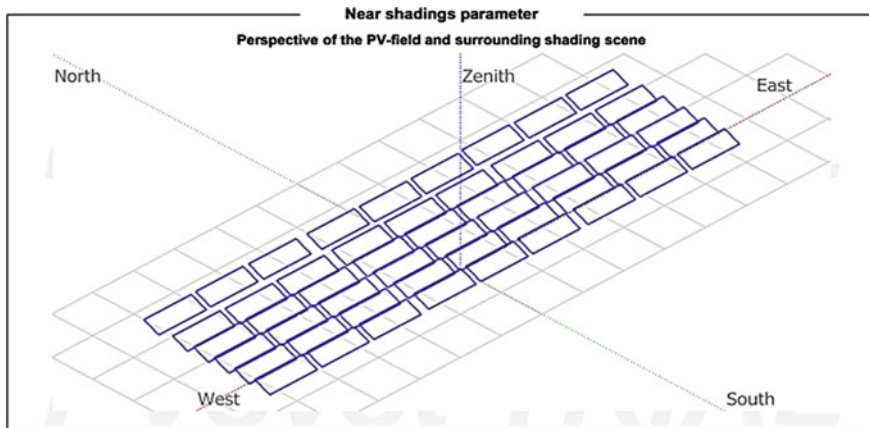
## ***2.2 Aim and Motivation of Study***

The study aims to increase the production from the photovoltaic system. This can be achieved by simulating and considering various degradation factors like irradiance, shading, etc. Further research is to store the power generated in batteries and design a financially viable system to attract investors to shift to renewable energy.

## **3 Result and Discussion**

This part of the report represents the result obtained by performing the simulation in PVsyst. PVsyst version 7.2 has been used for the simulation. The tilt angle and azimuth angles were 25° and 0°.

For the designed system, the total available solar energy throughout the year was found to be 544387 kW with a specific production of 1535 kWh/kWp/year, a performance ratio of 60.91%, and solar fraction SF of 96.35%, while the energy used was 425286 kW/year. The number of battery packs required for the storage of solar energy was found to be 1233, along with a capacity of 24660 Ah. The battery lifetime was estimated to be around 5 years, with cycles SOW of 95.8% and Static SOW of 80%.



**Fig. 1** Net shading parameter

The generated report of PVsyst consists of various details like different parameters of losses considered, sun orientation, placement of solar panels above sunroof with their tilt and Azimuth angles, battery along with PV system and its failures. The figure is shown in this report gives the picture of solar panels along with shading areas and inclinations and a few more critical information.

This section discusses the financial model generated. They show the monthly distribution of energy production of a 350 kW PV system in the first year of its operation, as shown in Fig. 1. The energy production decreased in the monsoon season, which is expected due to low solar radiance because of the clouds. This is the period where energy demand is also low. This type of system can be put to the maximum to save money. Figure 2 shows the normalized energy production, whereas Fig. 3 represents the performance ratio. Figure 4 shows monthly electricity supplied to the grid.

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The annual energy and various financial parameters, such as the amount saved in the first year and the payback period for the system are referred [4]. Considering the high initial cost of the system, this case study shows that it can pay back itself in the first half of its life with proper maintenance, and it can save more money in its overall life. The solar systems can be more profitable with an increase in the cost of fossil fuels, and the payback can even go down if the scenario happens in a period. Solar energy is a sustainable energy model for power generation and environmental protection. Power utilization in places with higher solar irradiance can be reduced by employing a simple PV system of 5 kW to reduce dependency on the government.

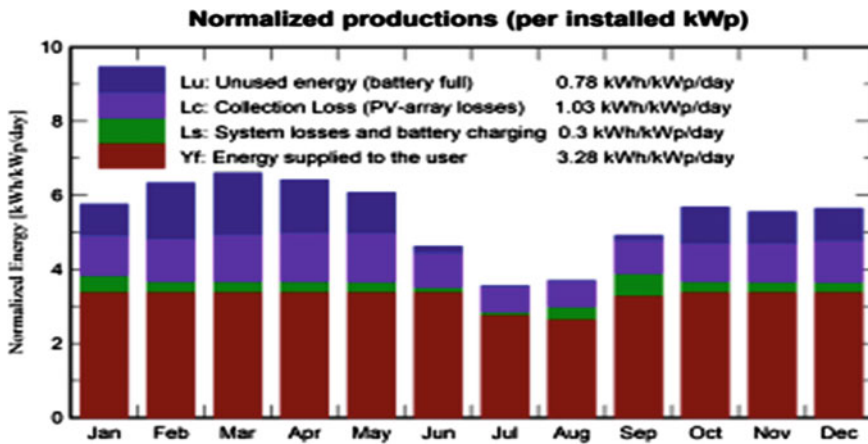


Fig. 2 Normalized productions

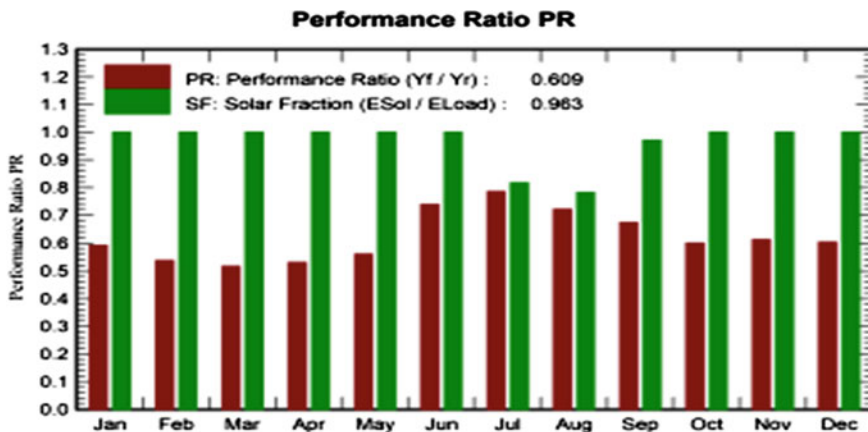


Fig. 3 Performance ratio

These types of studies can further be improved to provide an affordable PV system for residential places in high terrain regions where electricity is quite challenging or sites where fossil fuels cost more than solar energy. The case study shows a high amount of energy production in India compared to other countries in the northern hemisphere, but the solar degradation factor can go up to 2.8%. Thus uncertainties are to be considered in the assessment model; when an investor is interested in setting up a PV system, this can show a difference of 9 to 20%. Hence an investor should be aware of the financial risks for an extended period when sure profit is expected.

A further case needs to be done to improve solar energy production and the cost to use in commercial and automobiles to building a green environment.

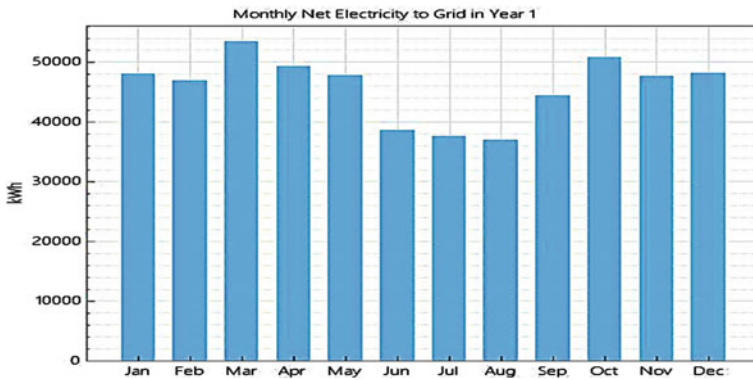


Fig. 4 Monthly net electricity to grid

## 4 Conclusion

This work focuses its high point on using solar energy by utilizing today's technology such as PVsyst and Sam software. PVsyst shows cases of a system model for the critical area and helps evaluate the total power, performance ratio, etc., by running the simulation. It provides accurate data with reasonable assumptions of degradation rates and uncertainty levels. SAM is software that helps in providing all the in-depth details related to the designed system's economy. For the chosen location HB-2, VNIT Nagpur, the data was acquired from Meteonorm 8.0 source. During different seasons throughout the year, all the required parameters are entered into the system, and the simulation is run. The required results were obtained, which stated the total energy available to be 544.38 MW/year and the performance ratio to be 60.91%, whereas the used energy was found to be 425.28 MW/year and the battery life was found to be 5 years. Later the system was analyzed by SAM software with the same parameters as obtained by the PVsyst results. The simulation was run, and the required results were obtained, which concluded that the design of data without the system costs \$104,614, whereas with the system costs around \$62,512. A significant difference in initial cost was observed when both the scenarios were compared. Thus, stating the use of SAM software is more helpful and prominent. The simple payback period came out to be around 10.6 years. It states the importance of using solar energy, especially these days due to the lack of availability of coal and petroleum in most countries around the globe. It is essential to use technology to restrict the initial setup cost, which is generally too high. PVsyst and SAM are one such software which was found to be very accurate and sustainable, making them available to the vast majority of the people and enhancing the use of solar energy for future generations.



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