IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Mathematical Modelling of Engineering Problems
Vol. 10, No. 2, April, 2023, pp. 727-732
Journal homepage: http://iieta.org/journals/mmep

The Use of Hybrid Solar Energy to Supply Electricity to Remote Areas: Advantages and Limitations

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Special Issue: Hybrid Renewable Energy Systems and Integration

https://doi.org/10.18280/mmep.100245

Received: 20 August 2022
Accepted: 20 November 2022

Keywords:
sustainable energy, photovoltaic systems, photovoltaic power plant, energy storage, economic calculation

ABSTRACT

This study focuses on distributed generation (photovoltaic power plant). We evaluated material theories and solar energy distribution difficulties. The 100-kilowatt photovoltaic power plant's technical and economic features were then determined. Growing global population, finite energy supplies, and the negative environmental effects of irresponsible fossil fuel consumption have pushed renewable energy to the forefront of global concern. These factors have influenced the global trend toward renewable energy. This article introduces photovoltaic systems as a new energy source and calculates their technical and economic characteristics. Promoting the use of these systems, especially in areas remote from the electricity distribution network, while mitigating network development and fuel supply problems could reduce fossil fuel consumption. This method works in rural areas without electrical distribution. During the summer, the deviation angle is 15 to 20 degrees less than the latitude, and vice versa during the rest of the year. It reduces greenhouse gas emissions significantly, and in the near future, it will be economically feasible to do so if production of these systems is increased and construction costs are reduced.

1. INTRODUCTION

There are millions of inhabited islands and outlying communities all over the world that do not currently have access to the main electrical grid. These towns and islands are mostly located in remote areas. Several of these villages can be found on different islands. As a result of this, places like these frequently rely on diesel generators for their power source, or they lack any kind of power supply at all [1]. Renewable energy (RE) is the best alternative for generating power (electricity), enhancing the quality of the power source, and preventing the emission of diesel fuels. This is because RE is widely available in the region. RE is the best option available as a result of this reason [2]. Remote areas make great use of solar photovoltaic systems, which generate electricity while simultaneously being kind to the environment, never running out of resources, and being completely self-sufficient in their energy needs. On the other hand, recent studies have shown that the expense of installing solar photovoltaic panels in rural areas is far lower than the expense of building diesel generators in those same areas [3].

The rising use of renewable energy sources in more remote locations is coinciding with a growing interest in energy storage technology among academic groups. There are several different technologies available today for the purpose of storing energy, such as batteries and flywheels. Fuel cells, supercapacitors, and hydroelectric pumps all require compressed air for their operation. A summary of the various storage technologies the rising use of renewable energy sources in more remote locations is coinciding with a growing interest in energy storage technology among academic groups [4, 5].

Batteries and flywheels are only two examples of the several technologies that are currently available and can be used to achieve the objective of storing energy. There are many other technologies that can be used to achieve this goal as well. There are a wide variety of additional technological options available. In order for any device that converts energy to function properly, including fuel cells, supercapacitors, and hydroelectric pumps, compressed air is an absolute necessity.

This article is a summary of the many different approaches that can be taken in order to successfully store energy [6]. These approaches range from utilizing batteries to building underground storage facilities. Lead-acid batteries that are capable of being recharged are often sufficient to meet the vast majority of an independent renewable energy system's requirements for the storage of energy (particularly batteries with a deep discharge rate and high wheel stability). Another well-liked choice that falls under the umbrella of this class of technical breakthroughs is the utilization of fuel cells [7, 8].

When compared to conventional methods of producing energy, renewable sources of energy have a distinct energy structure. This is due to the fact that the development process for renewable energies requires a significant amount of initial investment capital, whereas the costs of maintaining renewable energy sources are relatively low. The initial investment costs are quite minimal when coming from conventional sources [9, 10]. It is possible to conceive of a variety of benefits accruing from the growth of renewable energy applications in the nation, the nature of which is generally determined by regional conditions, the qualities of alternative sources, and the concerns of society. It is possible to discuss the benefits of switching to renewable sources of energy [11]. Raising energy supply security, decreasing global warming, encouraging economic growth, creating jobs, increasing per capita income, and increasing social justice and environmental protection in all areas are some of the goals that we have set for ourselves. Renewable sources of energy not only help the environment but also provide access to secure and dependable hybrid solar energy sources in rural and underdeveloped areas. Therefore, it is vital to pay greater attention to the development perspective of these energies rather than only the economic view when working on the development of hybrid solar energy sources [12, 13]. If renewable energies are produced in the right way, they have the potential to play an essential part as sustainable energy sources in the process of countries attaining their goals for sustainable development. These energies are environmentally friendly, abundant, and trustworthy.

The uses of renewable energy can be broken down into two primary categories: power plant applications, which are used to generate electricity; and non-power plant applications, which are utilized to generate heat and cooling. There is an application of styles and formatting [14].

As a novel strategy in this paper, we will be attempted to provides various novel technologies that are used to store energy. This paper also provides an introduction to photovoltaic systems, a novel type of hybrid solar energy system. Furthermore, we will evaluate stand-alone renewable energy systems which is typically make use of rechargeable lead-acid batteries (particularly batteries with a deep discharge rate and high wheel stability). Moreover, we will measure electricity requiring in order to convert solar energy, which is only available at certain times of the day, into a dependable power source that can provide a constant supply of electricity from hybrid solar energy. So, nowadays the issue of energy storage is the most important one in PV (Photovoltaic Panels) power generating and, in this paper, we focus on this subject in order to provide new manner to increase PV power generating system.

2. RESEARCH METHODS

In this section will be looked by how to estimate the total amount of solar radiation on the earth's surface and how utilizing hybrid solar energy in order to supplying electricity in remote areas.

2.1 Implementation of solar energy systems for electricity generation

Because the ability of each nation's economy to generate electricity is directly proportional to that nation's level of economic development, an increase in the generation of electricity as a source of added value has been a topic of discussion over the course of the past decade. In this context, the employment of environmentally friendly power sources and renewable energy sources is recommended in the event that more sophisticated technologies are acquired [15]. It is unavoidable and will have a big impact on the country's progress in terms of producing the necessary amount of energy. Since the sun is the greatest and sole source of energy on the planet, the energy that it emits is used in a variety of ways to give the energy that is required for non-fossil fuels. hybrid solar energy is easy to access and apply, this is crucial [16].

2.1.1 General implementation of a photovoltaic system

Solar panels

As can be seen in Figure 1, solar panels are made up of a number of modules that are linked to one another. Panels are assembled into arrays when they are all connected to one another.

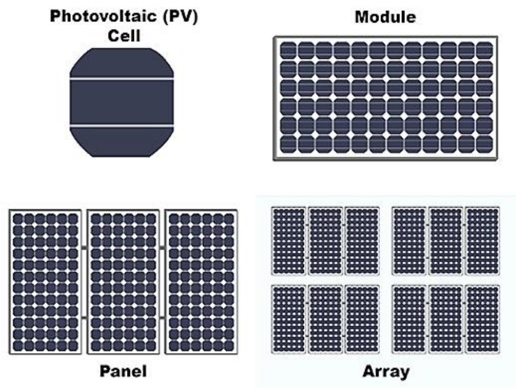

Figure 1. Cell, module, panel and arrays

Generally speaking, photovoltaic arrays can be connected in either series or parallel. These arrays are deployed in a stationary condition with a moving detector that adjusts to the inclination of the sun depending on the time of year. The trackers can spin on one axis or on two axes, and they always keep the solar panels facing in the direction of the sun's radiation. As a result, the output efficiency of the panels can be increased by up to two times, as is demonstrated in Figure 2 [17, 18].

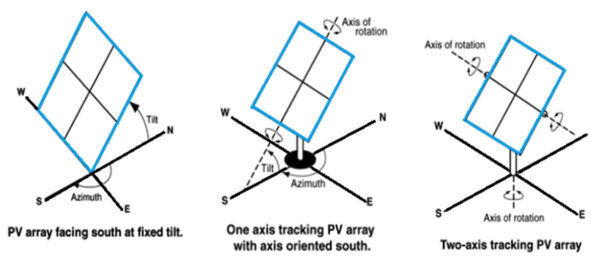

Figure 2. Types of photovoltaic arrays

Battery

The battery bank includes a number of batteries that are usually 12 volts and are connected in series and supply the required voltage of the system. In systems detached from the grid, the energy stored in the batteries is used at night or other necessary periods. Batteries are employed in the support systems in case of power failures in the national network, systems connected to the network do not need batteries [19].

Converter

Converters are used to change the direct current (DC) electricity that is generated by solar panels into alternating current (AC) electricity. Converting devices can come in a variety of shapes and sizes, and some of them can achieve extremely high levels of efficiency [20].

Battery charge control device

In solar systems that are separated from the grid, the battery charge control device is utilized in order to prevent either the complete discharging of the batteries or the overcharging of the batteries. A battery charge control device is a standard component of any solar system that is not connected to the local electrical grid [21].

Metal or building structures

They are an essential part of photovoltaic systems and serve the purpose of supporting the module in a certain direction and at a particular angle with respect to the sun. Structures of buildings are typically built of metal or synthetic materials that are resistant to environmental elements like wind and rain. The installation site of solar systems is taken into consideration during the design and selection process for building structures [22].

2.2 Suitable conditions for installing and operating photovoltaic systems

The orientation of the panels, the placement of the panels, and the weather conditions all have an impact on their overall efficiency. In the summer, the energy output of a photovoltaic panel is multiplied by five, whereas in the winter, the panel's output is multiplied by two. As an illustration, a panel with 55 watts produces 260 watts per hour during the summer but only 140 watts per hour during the winter [23]. The number of cloudy days, the strength of the wind and how fast it blows, the amount of precipitation and the height of the snow, both of which are used to calculate the distance of solar panels from the surface of the earth, the degree to which the air is hazy or steamy, as well as the number of lightning strikes and the number of thunderclaps, are all factors that are considered in weather forecasting. When building solar systems, one of the things that must be taken into consideration is the availability of appropriate safety equipment [24].

(A) The installation direction of PV panels is critical for best efficiency. The southern orientation in the northern hemisphere is the optimal direction to capture solar energy for fixed panels, as opposed to tracker panels that track maximum solar radiation. An 18-degree deviation to the west or east has little effect on the efficiency of solar panels [25].

(B) In addition to the direction, the panel's deflection angle is a significant consideration in the design of solar systems. The angle of deviation is the angle formed by the solar panels with respect to the horizon, and its value is. It can vary up to 90 degrees. The angle of the sun's beams varies throughout the year due to the departure of the earth's axis. As a result, the deviation angles differ between winter and summer. In the summer, the deviation angle is typically between 15 and 20 degrees less than the latitude, and in all seasons, the deviation angle is approximately 15 to 20 degrees greater than the intended area's latitude. Snowfall has an effect on the ideal deflection angle as well. The deviation angle is often estimated to be around 65 degrees in order to prevent snow accumulation on the solar panels [26].

(C) Examining the installation site's time location and conditions in relation to the movement of the sun, the possibility of the shadow of surrounding heights and mountains, or even the shadow of buildings and trees, and determining the hours of the day when the presence of these shadows may prevent direct sunlight from reaching the installation site. The solar panels have been inspected. As a result, it is attempted that not only do the solar panels create shadows on one another, but that buildings and other natural impediments do not cast shadows on the solar panels as well. PV arrays with 50 shades raise their output power to 85 percent. For residences with chimneys, the array installation position should be as far away from the chimney's shadow as feasible, as well as the soot particles that come out of the chimney [27].

(D) Longitude and latitude, as well as the height of the solar system installation, are required factors in calculating sunlight power. On bright days, 85-90 percent of the sunshine (1,100 W/m^2) is found, and this quantity is higher in high altitudes and arid places, depending on the size of the PV arrays in the site conditions; the arrays may be mounted on the roof, the ground, or masts. The modules installed on the buildings have been designed to withstand wind speeds of up to 185 km/h. Concrete bases are used to keep P panels stable when they are installed on the ground. The module installation height from the ground level should be greater than the maximum snowfall in the area. Solar modules can be put on masts distant from surrounding shade sources such as trees and buildings in the case of small systems (1 or 2 modules) [28, 29].

(H) At high temperatures, the efficiency of all types of modules diminishes to some amount. This is not a huge concern as long as the ambient temperature does not exceed 85°F. The modules should be placed in such a way that complete ventilation is achievable. The free flow of air around the modules will improve their efficiency. This also prevents the accumulation of solid waste materials behind the solar modules, which protects the roof from rotting and electrical connections from failing [30]. When exposed to low temperatures, the efficiency of all different kinds of modules degrades to varied degrees. Some modules are more susceptible to this effect than others. This should not be a major reason for concern so long as the average temperature does not get higher than 85 degrees Fahrenheit. It is essential that the modules be organized in such a way that they receive enough ventilation at all points throughout their entirety. It is possible to improve the efficiency of the modules by increasing the volume of air that is allowed to freely circulate around them. This prevents the accumulation of solid waste materials behind the solar modules, which in turn protects the roof from decay and the electrical connections from failing to function properly.

3. RESULTS

The primary findings of this research were reported in this section, which included technical and economic calculation of a 100-kW photovoltaic power panel.

3.1 Technical and economic calculation of a 100-kW photovoltaic power plate

According to the information of the company that manufactures photovoltaic modules in India and the number of solar hours, which according to the global map for India is around 8 hours, the loss of peripheral equipment such as connections and buffers is equal to 12%, the loss of the inverter device is equal to 12%, the loss of batteries is equal to 11%, and the loss of the simultaneity coefficient is equal to 7% for all types. If the rated power of the panels is 45 watts, the number of solar panels required for the above consumption can be computed. In addition, lead acid batteries are used to store the energy produced by the panels and use it at night or on cloudy days, and their capacity can be computed based on the number of overcast days (up to 4 consecutive cloudy days), as shown in Table 1 [31].

Table 1. Calculate the number of panels and batteries

Estimation of the daily production energy of a panel	
Panel Capacity (Wp)	85
Conversion Factor (Wp to wh/d)	3.45
Energy Production	293.3 Ah/d
Estimating the minimum number of panels required	
Number of panels required	1765
Production energy of a panel (wh/d)	5.375 Ah/d
Total energy required (with 10% extra)	468000 wh/d
Estimated amp hours per day for battery charging (Ah/d)	
Net energy required	358900 wh/d
Battery voltage	24 v
Ampere hours required per day	14954 Ah/d
Estimate the minimum required battery capacity	
Ampere hours required	13751.4 Ah/d
Number of consecutive cloudy days	4d
Number of batteries required (battery 250Ah)	220

Economic calculations: One of the methods of economic evaluation of solar power plants is the life cycle cost analysis method. The life cycle cost method is usually used to determine the economic feasibility of the project, where the future costs are discounted to the present value. In the following model, which is designed based on the life cycle cost analysis method and according to the technical characteristics of the photovoltaic system, taking into account factors such as the actual discount rate, system lifetime, the amount of radiation in the area [32].

In general, the cost of producing power with solar systems is determined by three major factors: a) solar radiation in the area; b) module efficiency; c) module cost; d) system cost; e) system lifetime and interest rate based on the price inquiry from in the estimation of this project, the solar panel manufacturing business employed 85w panels with dimensions of 125cm x 550cm.

In order to calculate the unit energy cost of the photovoltaic system, the results of Table 2 are obtained from the life cycle cost analysis method with the assumption of 0.08 reduction. Therefore, according to life cycle analysis calculations, cost and life cycle analysis calculations, the energy unit cost of the photovoltaic system with a discount rate of 8% is equal to 287 rupee per kilowatt hour due to the selection of different scenarios (different discount rates). The calculation of the real discount rate is based on the inflation rate and the nominal accompanying rate; Because considering that most of the resources used in the photovoltaic system are capital goods and have an increase in price due to the inflation rate, it is necessary to include the inflation rate in the calculation of the real interest rate. In this way, considering the interest rate of 25% and the inflation rate of 13%, the real discount rate will be equal to 8% [33, 34].

$$i = \frac{1+r}{1+p} - 1 = \frac{1+0.25}{1+0.13} - 1 = 0.08 \qquad (1)$$

Table 2. Unit cost of photovoltaic system energy

Row	Variables	Abbreviations	Amount
1	Real discount rate	i	0.08
2	System lifetime	n	30
3	Return on investment	CRF	0.0664
4	Insurance cost	INS	0
5	Indirect cost factor	ID	0.30
6	Investment cost of modules (rupee / m^2)	MOD	7567786
7	The cost of peripherals related to the area (rupee / m^2)	BOS	1120000
8	Power-related side costs (rupee / kw)	PC	2190000
9	Annual maintenance fee	OM	43000
10	Maximum solar radiation (kw / m^2)	SP	1
11	Annual solar radiation to the surface of the panels (kwh / m^2)	1 NSOL	1979
12	Photovoltaic module efficiency (%)	N mom	0.18
13	Performance of peripheral equipment	nbos	0.9
14	Solar cell temperature correction factor (%)	nt	0.93
15	Power status efficiency (%)	pc	0.97
16	The cost of producing solar electricity (rupee / kwh)	Cpv	2951

4. CONCLUSION

The information that has been presented up to this point makes it possible to draw the conclusion that, of the three real interest rates that have been considered, the one associated with the third rate, which is the real interest rate of five percent, results in the lowest cost of producing electricity through photovoltaic means, which is 2,951 rupees. This conclusion can be reached because the data that has been provided up to this point makes it possible to draw this conclusion. On the basis of the information that has been provided up to this point, one can derive the conclusion that has been stated here. On the basis of the data that has been presented up to this point, one is able to deduce the conclusion that has been discussed here. When one takes into account all of the information that has been supplied, one is able to arrive at the aforementioned conclusion. Our team has arrived at the conclusion that the production of solar energy is no longer economically viable due to the removal of subsidies for the generation of energy as well as the rise in the price of power to 654 cents per kilowatt-hour. These two factors combined have led us to this conclusion. In order for us to reach this conclusion, it was imperative that we take into consideration these two aspects. This is subject to the restriction that the location of the consumer must be within a reasonable distance of the national grid in order for this to be applicable. As a consequence of this, the installation of a transmission line or the use of a diesel generator is not required to meet the requirements. On the other hand, this is subject on the consumer's location being within a reasonable distance of the national grid in order for this to be applicable.

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