

IMPLEMENTATION OF SOLAR ENERGY IN AGRICULTURE: REVIEW

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Abstract

Country like India have some locations where solar radiation is very high which is waste as it falls on the ground. It has been estimated that if 1% of the received solar radiations can be converted to energy then this energy can meet the energy crisis of the future world. Not only in solar radiations but India also have a vast sector of agriculture that fill the stomach of major world population. Indian government have applied some policies to increase the use of solar energy to decrease the use of non-renewable resources. Current study discusses the various advancements in the utilization of solar energy in the agriculture of India that can be used to decrease the power consumption from non-conventional sources which are costly as well as not environmentally friendly. It has been concluded from current research that there is still further research is required to increase the application and efficiency of utilization of the solar power for its sustainable utilization.

Key words: Agriculture, Farmers, India, Renewable, Solar Energy.

Introduction

Agriculture is considered as the major source of food for the humans. However, the use of various energy production sources like coal power plants, vehicles, agricultural practices like stubble burning, use of fertilizer etc. have led to the devastating condition of the environment. It has been reported that these non-renewable resources will going to be depleted soon and there is requirement of resources that are renewable as well as they should be environment friendly. Agricultural farms also require a huge amount of power supply to irrigate, to run their tractors and to carry out various functions for the maintenance of the crops.

Several renewable sources of energy are available in the world like Wind energy, Hydro energy, Tidal energy, Geothermal energy and Biomass energy but solar energy has been considered as the best of them as it can be used for number of applications in the agricultural fields. Various researchers and scientists, who are trying to tackle the climate change and global warming, suggests the use of renewable sources of energy and are trying to raise the awareness about these energy sources. Changes in the climate and Global warming are rising by the utilization of fossil fuels and several processes that creates pollution. These sources of energies emit greenhouse gases that have the tendencies to capture the solar radiation coming on the earth which leads to the increase in the global temperature.

Developing countries like India face various challenges for the generation of electricity. More than 45% of the Indian houses do not receive electricity. With a tremendous growth in the population as well as the increasing in the temperature leads to enhanced efforts on increasing the awareness for the use of solar energy utilization to carry out their daily routine works. The consumption of electricity is increasing whereas the production of electricity is par away[1].*Requirement of Renewable sources of energy In Agriculture:*

As the energy requirement will grow in the up-coming years to irrigate the fields. Many fields are dried as a result on low levels of ground water and less availability of electricity to pump underground water. Dependency on the monsoon is increased but because on the delays in rainfall because of climate changes and global warming. Utilization of electricity in agriculture is mainly for the irrigation purposes. Production in the areas that are dry and are mainly dependent on the rain can be enhanced with the help of solar panels.

Benefits of Solar Energy:

Sun is the ultimate as well as unlimited source of energy. Solar power is the renewable source of energy that is emitted from the sun in the form of heat and light. This solar power can be utilized with the help of advances in the technology. This sunlight energy can be utilized with the help of solar panels, solar photovoltaic, solar heating, solar cooking.

Combination of solar energy with agriculture can help to achieve the sustainable farming. Presently many countries are implementing the solar energy in farming process to enhance the yield of the agriculture. In India government have introduced many schemes like Jawaharlal Nehru National Solar Mission (JNNSM) and introduced Rooftop PV and Small Solar Power Generation Programme (RPSSGP) for farmers[2]. But these schemes are not aware to the farmers in India. Most the equipment's in many countries are now equipped with the solar energy instead of using the other fuels like diesel, gas or oils. Some of the technologies are explained briefly in the following section:

Water Pumps:

In India, Farmers use water pumps that run on diesel to irrigate their fields. They use diesel, gas or oil powered water pumps to pump the water out of wells or from the open dams for various purpose of the farming. Countries like USA, Europe, France, Germany, China, Finland, Canada and India are implementing the various schemes for the purposes of irrigation. Different solar water pumping systems which consists of motor pump, switches, solar panels and tracking systems. These solar pumps are cost-effective, consumes less power as well as they emit less greenhouse gases. In India, the government of Rajasthan introduced a scheme named as KUSUM program that proposed that these fields will generate the power for ₹3.14/kwh. As per stated by the World Bank, solar power is better in operation, finance and environmental perspectives in some countries whereas few countries are still not aware about the benefits provided by the solar power.

Table 1: Comparing the solar water pump and diesel water pump

Facts	Solar water pumps	Diesel water pumps
Efficiency kW (hp)	0.5(0.75) to 75(100)	3.7(5) to 11(150)
Purchasing Cost	High	Moderate
Operation Cost	No operation cost	Very high
Maintenance cost	Small	High
Daily upkeep	Panel dusting in a week	Diesel lubrication minor & major servicing required, periodic overhauling must
Part Replacements	Moderate	Worn out parts need to be replaced often
labour	No labour required	High qualified labour required
Other	PV array can be used for electricity generation when the pump is not running	No
Environment	Pollution free	High air noise pollution

Solar Dryers:

Farmers use the dehydrators that run on diesel or gas to dry their crops so that they can be packaged and send to the storage facilities. Few farmers are using solar energy to dehydrate the crops after the harvest, this process is cost-effective as well as environment friendly. A solar dryer consists of Solar energy collector, drying tracks and shed. Farmers implement a fan that runs on the solar power which blows the hot air which circulates over the fan which dehydrates the crops.

Solar Mower:

Various farmers use the mowers that runs on the solar power to cut the crops or grasses just like the normal grass cutters. Energy provided by the solar power overpowers the mowers that runs on the diesel as they are harmful for the environment. Solar grass cutter consists of solar panel which is used to charge the battery, electric circuits, DC motors, Blades and 3 Wheels.

Solar Tractors:

Tractors can be seen on every farm and they are considered as the essential equipment of the farms. Tractors usually runs on diesel or gas; some scientists and researchers have implemented the solar panels on the top of the tractors so that these panels can receive the maximum sunlight so that these heavy tractors can run on the solar power. Solar panel associated with the combination of lithium batteries are changing the whole field of the farming. These tractors can be powered directly or indirectly by the solar power, few tractors runs on the lithium batteries and these batteries are charged by the solar panels, few tractors are implemented with the solar panels on the top and these solar panel runs the tractor or charge the batteries while the tractor runs.

Solar Greenhouses:

Greenhouses are used in various farms and these houses requires the heat for the crops. Solar panels implemented with these houses provides the enough heat for the betterment of the crops and further for the growth of the productivity. These green houses are used in the winters so that the crops can be grown in the harsh weather conditions. These solar greenhouses run on the solar power which provides solar energy heaters for the lightning and heating. These greenhouses help the farmers to grow the fruits and vegetables in the of-season by maintaining the desirable temperature.

Solar Water and Space Heaters:

Heaters for space and water are used by the farmers to provide the livestock with the desirable temperatures. These heaters use the solar power to convert sunlight into the heat energy. Poultry and pig industry face many troubles in providing heat and food as well as to maintain the income for the livestock industry. These solar water and space heater are needed to replace the dust and the toxic gases that are harmful for the crops and vegetation. These heaters can also be used to sanitize or clean equipment on various areas.

Solar Electric Fences:

Crops and vegetation are mostly ruined by the animals like cows, elephants, buffalos etc. farmers all over the world uses some or other type of fencing to secure their yields. Solar powered fencing composed of solar panels which provides electricity to the wires and whenever the animal or any organism touches the fencing it gives them the electric shock which prevents the crops.

Solar Pumping System

To irrigate the farming lands, Photovoltaic (PV) panels are used as they require slight amount of electricity to carry out various processes. This energy which is produced by the PV panels can be utilized to carry out several others processes like storing crops, fruits, vegetables or for spraying insecticides. The PV systems are not useful

for the industries that require very high input of power like the rice mills or the agricultural processes that require very high power. Simple solar pumping systems consist of solar panel, Submersible pumps, Solar charge controllers and batteries.

Solar Panel

Solar panel consist of solar cells which are composed of semiconductor materials. The main function of these solar cells is to convert the solar energy that is falling on them to the DC electricity power. The number of cells and the rating of the load are directly dependent on each other. If the load increases then there is a requirement to increase the amount of solar cells. One of the main drawback of these panels is that they needed to be aligned to the angle of the sunlight to generate maximum output.

Submersible Pump

It is a type of pump which is submerged deep inside the a well, where there is a natural stream of water or up to the groundwater level. The size and power of the pump is decided by the depth of the well as well as the available ground water level.

Solar Charge Controller

It is one of the main components of the solar pumping system or any solar power system. It helps in the accurate charging of the batteries. The main function of the solar charge controller is to control the voltage as well as the current of the solar panel.

Batteries

Batteries associated with the solar panels are generally used to store the power generated by the solar panels. This stored power can be used in the night, when there is less availability of sunlight.

Importance of renewal energy for agricultural farm:

The significance of integrating renewable energy and agricultural farming has been illustrated by several literature reviews. The various forms of solar energy technology applications were explored for crop and grain drying, room and heating systems, greenhouse heating, photovoltaic solar systems, and irrigation water pumps. The solar panel/photovoltaic (PV) system has been considered as the most suitable choice in agricultural works, especially in remote rural areas, as the management of the solar panel system is inexpensive without impact on the environment and can be used for several applications. This is further endorsed by Qoaider and Steinbrecht [3], who researched the economic viability of PV technologies in supplying irrigation energy needs in remote agricultural communities in rural arid regions with the goal of enabling farmers to reduce the high cost of producing diesel electricity. The secret to leading the region to sustainable growth is this revolutionary energy technology scheme. It is theoretically planned, including the life cycle cost (LCC) estimates of a PV device that can support the entire villages' energy requirements. This solar panel generator has the ability to pump approximately 111,000 m³ of lake water every day to irrigate 1,260 ha of land and also to electrify the houses of the neighbouring villages. By contrasting the efficiency of the solar panel system generator with that of the diesel generator, the researchers noted that diesel produced electricity per unit costs 39 c€ kW h⁻¹ while a PV unit costs only 13 c€ kW h⁻¹, which is considerably cheaper. Also, Bardi et al. [4] explored the potential for farmers to migrate from fossil fuels to renewable green energy sources, which may lead to an improvement in the quality and quantity of food processing for many types of farms. It can also supply power for the operation of agricultural machinery, such as road transportation, and for field research. At present, only a few machinery operators in the agriculture industry are aware of the challenges associated with the depletion of fossil fuels and global warming. This is the root cause of the climate change crisis. The problem will escalate unless there is a change of attitude among farmers. It is also advisable for growers to use energy-saving equipment for growing crops and to use the PV system to optimize land, as it is economical, cost-saving that can be used for numerous

uses. Additionally, Santra et al. [5] found the agro-voltaic system as the potential source of energy for agricultural productivity because, even in hot arid weather conditions, it had different choices for using the device.

Application of Solar Systems in Agriculture:

PV energy is the best option for remote farming, and thanks to advances in agricultural technology, there are various applications of solar panel innovations in agricultural farming, as seen below:

- A water pump that helps the irrigation of the crops cultivated
- Mechanical capacity for the supply, transportation, transport, purifying and disposal of agricultural products
- Space for poultry and greenhouse cooking, shelter or reproduction.

Dupraz et al. [6] explored the best techniques for transforming solar radiation into both electricity and agriculture by constructing a variety of solar panels for the light transmission system in a cultured crop and using a crop model that can forecast its productivity. It is also referred to as photovoltaic or agro-photovoltaic farming (APV) and is a natural solution to agriculture's availability of renewable and renewable electricity. In order to improve the mild shade of the crops, this device was established by growing the solar panels to 2 m above the ground. There are a range of factors affecting agricultural development, like climate conditions, adequate water availability and energy supply. Therefore, it is necessary to optimize agricultural production and enhance land use through the implementation of modern technology with creative economic efficiency farming strategies and the efficient use of limited land resources with minimal environmental effect. The DC energy from the solar panel is transmitted to the battery. This DC supply is supplied from the battery to the converter to transform it into AC power. In order to produce heat or regulate temperature in the greenhouse, the AC power is used to drive the ventilation systems.

A greenhouse model with a fuzzy-based management system was also proposed by Maher et al. [7] to maintain the indoor greenhouse environment utilizing induction motors, heating systems, and so on for ventilation, heating, humidification, and dehumidification applications for sustainable greenhouse agricultural production with efficient climate control for increased yield. Their analysis has demonstrated the usefulness of both the fuzzy controller and the PV generator in greenhouses to conserve electricity and reduce the cost of agricultural production.

Operation of solar power in agricultural farm:

The solar panel system generates low-cost renewable electricity, and is the perfect option for remote agricultural activities, like pumping water for agricultural irrigation. The operation of the solar panel technology system, however, includes the following: enough electricity, solar panel, pump controller, motor pump, water resources and water tank. Several silicon cells or solar cells are present in the solar panel. The solar cell is the panel's smallest unit. As sunlight lands on the solar sheet, the solar cells harvest energy from the sun. Solar energy is transformed by semiconductors into direct current (DC) energy, so the alternator in the pump regulator transforms DC to AC or alternating current and the energy is passed to the water pump, after which the water from the water resource is drained by the motor and stored in the water tank[8].

Factors affecting performance of Solar Power:

The production efficiency of solar panels is influenced by several factors, like:

Load resistance: The voltage with which the panel can work is determined. The panel's performance depends on the strength of the load, so a control system that monitors the maximum power point must balance the load's voltage and current operating specifications.

Sunlight Intensity: The solar panel's current is equal to the solar radiation.

Cell Temperature: The panel works less effectively, and the voltage falls as the cell temperature increases above the normal production temperature of 25 ° C. Consequently, it is possible to regard heat as a response to electron movement. A panel at 80-90 C, for every degree increase in temperature, loses 0.5 percent in efficiency. Therefore, for the construction of the mounting scheme to remove heat, airflow over and under the panel is necessary to remove heat.

Shading: Usually, subtle shading of PV panels resulted in a drastic reduction in production. Maghami et al. [9] further supports that variables like solar irradiance and cell temperature affect the ability of a solar panel device. In addition to these factors, other contributing factors, including the durability of other elements and other environmental factors, influence its efficiency. The local ecosystem refers to the environment wherein human actions, including the urban environment, forms of vegetation and weather patterns, have been directly or indirectly developed. All these factors will technically influence the efficiency of the solar panel by a reduction in power production, from 2-50 percent in various areas[10].

Advantages and disadvantages solar panel system in agricultural farm:

Advantages: There are many advantages of using renewable energy technology, such as solar panel water pumping system:

- A) no petrol prices
- B) no noise and air waste,
- C) reduced maintenance costs and solar panel spare parts are cheaper than having a generator powered by a diesel engine.
- D) safe, plentiful and usable.
- E) can be used in a variety of sectors, including agriculture.

Solar energy technology has now become an option for seed drying, greenhouse cooking, crop output power water units, poultry and small-scale irrigation. This was confirmed by Brudermann et al. [11], who took into account the economic and environmental variables involved with the use of solar panels in agriculture. Similarly, Maher et al. [7] showed the usefulness of both the fuzzy controller and the PV generator in saving energy and reducing the expense of growing greenhouse crops. Therefore, the use of solar panels in agriculture will address the problems correlated with an increase in populations and less land, while at the same time encouraging the production of controlled farming activities in order to increase the economic income for farmers and to boost the climate by lowering CO₂ emissions into the atmosphere.

Disadvantages: Installation and initial setting costs are the major disadvantages of the use of solar panel systems. The current cost of PV electricity is relative to traditional power plants, as reported in the World Energy Evaluation report, and it is a major obstacle to large-scale PV deployment. There are also several questions associated with greenhouse production, such as: 1. Internal Climate management 2. Changing the decision on supply control 3. The need for the system to be calibrated to change environmental conditions.

Settings to allow the crops or plants grown on the underground surface to yield similarly.

- In order to standardize the design and size of projects for solar panels or photovoltaic agriculture, a standardized standard must be developed. To meet farmers' requirements, solar panel manufacturers need to produce a range of relevant PV items for agricultural production.

- To inspire farmers to use sustainable renewable energy generation equipment rather than using traditional fossil fuel energy for a pollution-free environment, government planners need to make technologies with due regard of cost and quality.
- Needs farmers' training on how to use and operate the PV system, along with the provision of a great support system.

Agricultural output is very significant because it affects the food security of a nation through its annual yields. Therefore, it is necessary to boost production performance by adapting to technological advances. Nevertheless, there is an increasing question about environmental effects related to the rising use of energy from fossil fuels in farming practices that emit a lot of CO₂. As a result, businesses and governments, both public and private, are rapidly finding ways to minimize greenhouse gas emissions from day-to-day manufacturing and equipment activities worldwide by converting to green energy, i.e. by transitioning to alternative forms of renewable energy such as solar energy. For the farming sector, solar panel agriculture brings new opportunities as it continues to promote the growth of modern agriculture, even in rural areas. Agricultural field equipment, construction and processing facilities are continuously being developed led to the evolution of the solar panel power system in agricultural techniques. Due to government policies of revolutionary agricultural technology, solar panel agriculture has rapidly evolved in developed countries, resulted in rural farm electrification and greenhouse equipment to increase productivity while minimizing land use. However, in order to maximize the mixture of solar panel energy production and agricultural in developing countries, further studies and realistic investigations must be carried out using innovative designs with lower construction costs while generating greater performance[12].

Conclusion

In general, it can be argued from the above-mentioned literature that solar energy can provide permanent solution to many of the problems facing the planet today, including, among others, climate change, energy scarcity, conservation of the atmosphere and drought. As illustrated in the literature, farmers in the U.S., EU and Asian countries are at the forefront of embracing solar energy, but regardless of the fact that these technology have tremendous benefits, as seen in this article, most farmers in the African continent have less acceptance of solar systems for agriculture. The African continent is also endowed with increased radiation from sunshine and has 60% of the world's fertile space.

For agricultural applications such as electrical shielding, threshing, aerating, grinding, drainage, purification, etc., solar power is appropriate. These day, Indian farmers generally use solar energy in the water industry, particularly in the irrigation system, for their farming. Farmers, nevertheless, assume that the original cost of solar water pump systems is greater than the diesel water recirculating pump, but both systems never consider production and repair costs. One of the most important aspects is the PV collection of solar water pump systems that can be used for producing electricity if irrigation is not a necessity. Solar water pumping systems can effectively fulfil the requirements of irrigation water for marginal farmers in the landholding system. Because of rising fuel prices on a regular basis, pump sets are deployed in India every year. In order to reduce fuel usage, the solar water pump system allows better usage. The solar water pump is no invention as solar water pumps for various styles have already been available for three decades. Using up to 30 percent of the usable energy of the world will devote valuable capital in continuing to use more of the output of electricity. It maintains that, depending on the frequency of the energy market and of thermal power plants, certain costs are levied on society and the environment. From all the above, we infer that the solar pumping system is more viable for watering India's farming compared to the diesel engine pumping system. In an economic level, if solar energy is constantly used, solar water pumps are not more costly, while their capital costs are high.

Recommendations:

There are several recommendations or proposals to boost the economic and environmental performance of solar panel systems in agricultural. The following guidelines are summarized as follows:

- The performance of cell and module transfer can be increased to reduce the kWh-cost of PV.
- It is important to use semi-transparent PVPs to improve the transmission of light to the crop.
- The use of concentrator cells in sunny regions is required to increase long-term device conversion performance.
- In order to minimize the cost of manufacturing of solar cells and components, the quantity of material required to make the cells could be limited.
- It should have about 5m raised framework with solar panels along with various solar panel designs to create shades on the cultivated ground.

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