

Solar Energy for Sustainable and Efficient Agriculture

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Abstract

Agriculture is the mainstay of Indian economy and a sustainable agriculture the need of the hour. Today in the developing world where technology is dominating all aspects of life, agriculture is no longer untouched. It would be very right to say that agriculture and technology are going hand in hand and it is the technological advancement which has taken agriculture at new heights. However technological advancements have their own disadvantages including climate change, pollution, new health issues and hazards, depletion of non-renewable resources etc., that need to be addressed cautiously and intelligently. Use of renewable energy source that too which is dependable and consistent could be an answer to all these issues without affecting the sustainability and efficiency of a sector like agriculture which is today striving for its sustainability. Sustainable and efficient agriculture is essential for maintaining the food security and livelihood of a strong and developing nation. Solar energy is one source of renewable energy which can support agricultural development in all areas including mechanical techniques, fertilizer applications, seed development, crop growth and maintenance, water efficient irrigation, post-harvest management and many more. The present review envisages the use of solar energy and its applications in the growth and development of sustainable and efficient agriculture. There are many uses of solar energy in agriculture including power pumps, solar dryers, power bulbs, heaters, fences and many more mechanical and electrical devices which can be better utilized with the help of solar energy. These alternative ways will help the Indian economy to grow more using least input and maintained output. Thus, solar energy can prove to be a suitable option for sustainable and efficient agriculture.

Keywords: Solar energy, sustainable agriculture, electricity, ultra-violet (UV) radiation

INTRODUCTION

Agriculture is the mainstay of Indian economy and is the ultimate pillar for the livelihood and food security of its people. Development in all areas of agriculture is the most important aspect of a developing nation. The technological development in the field of agriculture so far has provided food security to its population, however at very higher costs of environment and other resources. It is high time that we now shift our focus on the technologies that utilize renewable energy resources and are dependable and long lasting. Sun and its energy are a dependable and consistent source which is green and consumer friendly. The agricultural sector utilizes energy from many sources like water, coal, automobiles, stubble burning, fertilizer use and others, but it has exhausted many such resources. All agricultural operations from seed sowing to harvesting and processing require electricity, petroleum, air, water in one way or another as in the form of one type of energy or another. Today the whole world is concerned about many environmental issues like pollution, global warming, climate change and the depletion of non-renewable resources. Energy from

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the sun is one such resource that can be utilized for all these activities without affecting the environment. According to Saxena and Kumar, only 1% of radiation from sun is enough to meet the energy requirements of the world [1].

Role of Renewable Energy

Sun is the most reliable and limitless source of renewable energy. The energy from the sun is received on earth in the form of sunlight and ultimately as heat. However, utilization of solar energy or the heat and light from sun is not new to human civilization and it is being used as the very first source of energy for daily needs, viz., as a source of light, using heat for drying crops, food products, clothes and many more. Scientists and technologists recommend sunlight for synthesis of Vitamin D in the body, which is essential for human development and the source is totally free of cost.

The sunlight or the energy from the sun also referred to as radiations is received on the earth in the form of a spectrum of light which varies in its wave length. The two ranges of wavelength are: visible and infrared. The visible wavelength ranges between 400 and 700 nm (approximately) and is considered as most intense. The intensity of ultra-violet (UV) radiation from the sun is higher but the intensity of this spectrum is slightly lower. The technological advancements in the field of science, technology and engineering have helped us to harness this source of energy through solar panels, photo-voltaic cells (PVCs), reflectors and absorbers. These developments have also revolutionized the agriculture sector by meeting its energy requirements in many forms and are contributing in making agriculture more sustainable, efficient and progressive. The use of solar energy is meeting energy needs both in primary and secondary agricultural sectors and thus making all-round development and contributions in making the agriculture sector stronger and resourceful. Today we have many machineries and equipments which operate on energy received from the sun. These include various irrigation solutions including pumps and sprinklers, cultivation machinery from mowers to tractors, processing operations including harvesting to value addition, aiding storage and many more. These technologies are making agriculture smarter and innovative with more environmentally friendly approaches thus addressing the issues of climate change and economic management.

APPLICATIONS OF SOLAR ENERGY

Irrigation Systems

Irrigation is the primary operation in agriculture. Our farmers use various types of pumping sets to collect water and irrigate their crops. Availability of water for irrigation purposes is not easy as it varies from crop to crop and from land to land. Every geographical terrain is not supportive of providing sufficient water for irrigation, as sometimes the water table of the area is a problem and sometimes the water availability creates an issue. Harvesting water for irrigation purposes especially in low rainfall areas is very challenging. The traditional practices like wind or animal operated pumps are very tedious and involve human and animal energy which makes it tiresome. Also, the use of mechanical pump sets which operate on electricity, diesel, gas and other petroleum sources need huge economical investments. Thus, many farmers depend on monsoon and rainfall to water their crops. However, increasing concern on global warming and climate change has reflected that this dependency is alarming and affecting agriculture production severely. Solar operated systems are a suitable answer to all these problems and it may surely assist agricultural operations in climate dependent regions [2–6].

With the advancement in the field of science and technology all over the world, various scientists are working hard towards making the world cleaner and greener. Harnessing solar energy for various day today activities and meeting energy needs is an important step towards this. The use of photovoltaic (PV) in agriculture, also referred to as agro-photovoltaic (APV) is the most popular and dependable option [7]. For this purpose, a solar panel is used to receive the energy from the sunlight and stores it as DC (Direct Current) energy in solar battery, which is further received by the converter to convert it to AC (Alternate Current) or the ultimate electricity. This electricity thus generated can be utilized for many normal agricultural operations. Many other minor solar operated equipments including solar

charge controllers, solar batteries, switches, solar panels and tracking systems can be used wisely to support water requirements and irrigation activities in agriculture. Additionally, these solar operated pumps and irrigation systems are economical and utilize less energy and are environmentally friendly.

Green House

Though agriculture is the major livelihood supporting operation in the world however increasing urbanization and imbalanced agricultural input-output is forcing our farmers to quit agriculture and thus we are facing a decline in production figures and land use patterns. Also, climate change and global warming are making the traditional agricultural practices more challenging. To meet these ever-changing requirements in agriculture, our scientists are coming up with new technologies to support agricultural production. Farming in green houses, glass houses and tunnel farming are some of the environment friendly as well as economical approaches to support agriculture production. However, these structures also require various machinery for proper working; and this machinery ultimately depends on electricity or petroleum products for proper functioning.

The green house requires major equipment like fans, heaters, mist/fog/water sprayers and in-built irrigation system to support growth and production of crops inside the closed and protective environment of a green house or glass house. All these operating systems can be operated using solar panels, which could be more economical and eco-friendlier. A fuzzy logic-based management system can be standardized to support the requirements of temperature and moisture inside a greenhouse [8]. This set up requires humidifiers, ventilation controllers, induction motor, heating/cooling systems etc. This set-up equipment can efficiently control the environment inside the greenhouse and is suitable for long-term production. The fuzzy logic-based controller and PV system can save energy and reduce the input thus supporting the production practice economically.

Tractors

Tractors are major machinery used in every farm for one or more operation(s), from land preparation to harvesting and transportation. These are operated on diesel, as it needs more horse powers (term used for energy requirements in machinery) to perform efficiently. As an energy conservation option and to make this equipment more eco-friendly, efforts are being made to install solar panels on its body. These PV panels can save energy from the sun and convert it to mechanical energy through batteries. The lithium batteries in some of the tractors can be easily charged using solar energy directly or indirectly. The use of solar energy in operating these tractors will save fuel (petroleum or gas) and will prove to be eco-friendly, thus making agriculture more profitable by reducing the input costs.

Dryers

Crops contain moisture at the time of harvesting and need proper drying for long storage. Open Sun drying is a common practice amongst the farmers for maintaining moisture in their crops for storage purposes, but it is quite challenging in areas with low photoperiod or heavy rains. Additionally, the changing environment conditions, pollution, and reduced land availability contribute to the challenge more often. Mechanical or electrically operated dryers and even the common fans used for artificial drying require long supply of uninterrupted electricity. This adds to the input costs of the product which most of the time goes unclaimed or unnoticed. Solar dryers and reflectors are suitable answers to this and have proved to be useful.

The mechanical solar dryers operate on photo voltaic operated DC-AC system which operates the fans and heaters inside the closed cabinet of various sizes. The ventilation system may be manual or automatic [1]. These dryers and drying units can be easily fitted in open or covered area.

Another popular solar dryer is a reflector and absorber type which absorbs sun heat through a reflecting panel and heats up the area. The dryers reduce input costs, save time and energy and dry the crops effectively.

Mowers and Cutters

Crop thinning and mowing is an important operation which on large farms is done by mechanical diesel operated mowers. To replace these, solar operated mowers have been introduced which have outperformed the diesel operated mowers. These mowers are fitted with solar Photo Voltaic cells that save the energy in battery or charge the battery for further operation. The simple unit is fitted with solar panels with battery, basic mower wheels, blades, DC motor and some electric circuit to connect various parts of the unit.

Bug Trap

Insects and pests are the major predators of the crops. Every year lakhs of money is spent on the purchase of these chemical based insecticides and pesticides and sometimes it does not work at all. This requires investment which is sometimes of no use and the crops are lost. To reduce this investment cost, UV illumination technology has been used to develop bug traps. The solar wavelengths of different ranges attract various types of nymphs and adults responsible for infesting crops. A collector is fixed at the bottom of the trap with detergent solution. The UV illumination technology illuminates the bulb fitted inside the trap and displays a light spectrum that attracts the nymphs and adults of insects and pests which once trapped fall in the detergent well and die. This is an innovative and cheap source of crop protection.

Miscellaneous

Many efforts are being made to make agriculture more efficient and sustainable. Some of the equipments using solar PV have been developed by modifying the traditional equipment as lights, fans, choppers, mixers etc. where mechanical energy is received through solar batteries. Some of the animal care equipments like milch machines, massagers, heaters etc. are also in practice to minimize the input costs at various stages of agricultural operations.

LIMITATIONS OF SOLAR ENERGY

Our earth has varied geographical terrains throughout and the movement of sun and earth around their axis affects the photo period or the duration of light on the earth. These geographical terrains, forests and tree coverage, exposure to sun etc. are some of the factors that affect the energy of sunlight reaching the earth. Due to these limitations, sun energy cannot be completely harnessed for full utilization. Other factors including energy potential analysis of the sun, technological as well as economical potential of the equipment developed should also be considered. Some of the factors viz., geographical terrain including land/sand/soil type, distribution of water or water bodies, population density and cluster, green cover or forest and trees in and around the area etc. affect the solar potential and energy production. Proper assessment of the technology/ equipment developed should be done for better utilization and potential use. The local, regional and conventional technologies must also be considered before use.

INDIAN GOVERNMENT INITIATIVES

Various human and animal activities involving energy use affect our surrounding environment. During the period of 2014–2019, CO₂ emissions have increased up to 1.3%. Various Government and non-government agencies are working together to popularize use of solar energy options amongst the population. Initiatives of Indian government including RPSSGP (Roof top PV and Small-Scale Power Generation Program) activities, JNNSM (Jawaharlal Nehru National Solar Mission) are connecting people for the use of solar energy [9].

Various national as well as state level initiatives are being adopted to popularize these technologies and adaptation by farmers e.g., KUSUM initiative by Rajasthan government, NABARD-PNB initiative for solar dryers in Madhya Pradesh, various subsidy programs on dryers, mowers etc. [10].

CONCLUSION

There are many renewable energy sources accessible throughout the globe, including wind, hydro, tidal, geothermal, and biomass energy, but solar energy is the best of them since it can be utilized for a

variety of agricultural purposes. Various academics and scientists working to combat climate change and global warming advocate for the usage of renewable energy sources and are working to increase awareness about them. Agricultural production is important because it has an impact on a country's food security via yearly harvests. As a result, technical advancements must be used to improve manufacturing performance. Nonetheless, there is growing concern about the environmental consequences of the increased use of fossil fuel energy in agricultural methods that release a lot of CO₂. Therefore, companies and governments, both public and private, are converting to green energy, or migrating to alternative sources of renewable energy such as solar energy, to reduce greenhouse gas emissions from day-to-day production and equipment operations across the globe. Solar energy may offer a long-term solution to many of the world's current issues, including climate change, energy shortages, atmospheric conservation, and drought. Farmers in the United States, the European Union, and Asian countries are at the forefront of adopting it. The use of photovoltaics in agriculture is expected to make a significant contribution soon that requires urgent planning for the potential benefits and efficient use at the farm level. Therefore, the co-existence of “agrovoltatics” will be essential for the developments of agriculture and agroindustry.

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