# Solar Energy Applications in Agriculture

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**Abstract**

The utilization of solar PV and solar thermal devices is India, which is endowed with abundant solar radiation with more than 325 clear sunny days is the best possible alternative to meet power requirement. Solar energy and farming are a winning combination. Wind, solar and biomass energy can be harvested forever, providing farmers with a long-term source of income. Solar energy can be used in agriculture in a number of ways, saving money, increasing self-reliance, and reducing pollution. Solar energy can cut a farm's electricity and heating bills. This eco-friendly and freely available energy can be used to supplement the energy needs for applications like water pumping, spraying and dusting, drying, winnowing and cooking. The solar PV pump can be used for irrigation in the remote farms whereas solar PV sprayer and duster are useful for plant protection. Farmers can use solar dryer for drying agricultural products as a value addition process, which are sold by farms at throw-away prices. Winnower-cum- PV dryer can be used for threshed materials and cleaning of grains in the absence of erratic and unreliable natural winds and also for dehydrating fruits and vegetables more effectively and efficiently. The animal feed which is fed to milch animals by using animal feed solar cooker. Building and barns can be renovated to capture natural day light, instead of using electric light, solar power is often less expensive than extensive power lines, making the farm more economical and efficient. These activities will enhance farm income by using solar energy in increasing crop production, reduce of post-harvest losses and increase milk production.

**Key words: Agriculture, photovoltaic, PV sprayer and duster, Solar, Solar dryer, Winnower**

## I. INTRODUCTION

The energy sector has a direct impact on the economic development of a country. Fossil fuels contribute more than 85-90% of the world's primary energy is source. The fossil fuel has a limited storage of and its price rise is one of the important reasons for recession and inflation in world's economy. To solve the problem of the decreasing economy and the energy sector's related issues, all over the world is focusing on an effective utilization of renewable energy resources like solar, wind, thermal. Fossil energy supplies became available about 200 years ago. In addition, shortages of cropland, fresh water, fossil energy (fertilizers and irrigation), and biological resources now severely affects agricultural production in many parts of the world. However, resources of fossil energy have begun to decline and this trend intensified after the year 2000. The Use of renewable energy in the farming systems has several different applications. Applications of renewable energy also include generation of power to do a number of farm works such as pumping water for irrigation, for keeping livestock, or for domestic use; lighting farm buildings; powering processing operations, and other uses. These forms of renewable energy include solar energy, wind and water power, oil from plants, wood from sustainable sources, other forms of biomass (plant material), and biogas (gas produced from fermentation of manure and crop residues). The foundation of all agricultural production rests on the unique capability of plants to convert solar energy into stored chemical energy. Solar energy is the most appropriate option among other renewable energy sources because the solar energy level is in line with the demand. Also, solar energy technologies have a long history. Between 1860 and the First World War, a range of technologies developed to generate steam by capturing the sun's heat to run engines and irrigation pumps. Further, it was estimated that solar energy of 1% of land area, wind power of 5% of land area and biogas (80% collection efficiency) can provide 1504 kWh per year energy per person but the average per person total energy consumption of India is 1,122 kWh per year. In this context, renewable sources of energy like solar energy, wind power and biogas need to be harnessed for the sustainable development in general and catering the farmer requirements in particular.

Taking into consideration the importance of solar energy and the increased attention humans are paying

to renewable energy, this paper investigates the solar energy applications in agriculture.

## II. SOLAR ENERGY TECHNOLOGIES

There are two ways to convert solar energy into electrical energy; a system using photovoltaic technology and another that uses solar energy captured by a heating systems. In the photovoltaic system, the sun rays are converted directly to electricity by semiconductors. In addition, in the method of heating, electrical power via the thermodynamic processes, with help of heat exchange equipment, can be converted to mechanical energy. These two methods are centralized and non-centralized. The photovoltaic method leads to more investments. However, in recent years with advances in the field of solar energy, thermal methods are used for power supply.

## III. SOLAR PV OPERATED WATER PUMPING

Water is the primary source for the world to exist as said by the famous Tamil poet Thiruvalluvar, who says that world will not exist without water. Water is one of the most basic necessities for crop production. The demand for water to irrigate the crops is ever increasing. Irrigating the crops at right stages is highly important factor for consistent production from agricultural farms. Under rainfed agriculture also life saving irrigation during long dry spell was found to be beneficial for crop survival and to obtain the targeted yield. To achieve more production per drop of water used pressurized irrigation systems like, drippers, sprinklers etc are of great role to play. However, ensured power supply is essential to operate these systems. Solar PV operated pumping systems are quite useful to operate the pressurized irrigation system. Solar PV pumps will reduce the number of electric pumps and diesel pumps which are in operations in the country for irrigation purpose. The electric and diesel pumps are highly energy intensive and therefore if replaced with solar pumps may greatly contribute to country's energy security. The solar pumps had the capacity to withdraw water from a depth of about 75 m and therefore may be beneficial in those areas where groundwater is not deeper than 75 M. Moreover, solar pumps are directly operated by solar irradiance and therefore diurnal and seasonal variations of it play a key role in implementation of solar photovoltaic pumps in a place. Solar photovoltaic pumps are quite useful for irrigating the crops using solar energy. Solar photovoltaic pumps can be best used with pressurized irrigation system e.g. drippers, sprinkler etc. Small-sized solar photovoltaic pumps of 1 HP capacity is best suitable to irrigate crops from surface water reservoir in to greenhouses, polyhouses, shade net houses for high-value vegetable production. Solar photovoltaic pumping systems viewed as one of the most viable options for future energy security in agriculture. Solar photovoltaic pumping system has additional advantages over other pumping systems apart from lower life-cycle cost. The additional benefits are listed below.

1. Photovoltaic panels of a solar pumping system reduce the Carbon emission in atmosphere at a rate of 1,360 kg carbon per year per sq. meter panel area;
2. Assured power supply in a solar photovoltaic pumping system enables the farmer to get an improvement in crop yield;
3. During off time, electricity generated by the solar photovoltaic pumping system may be used for domestic needs and for operating small farm machines;
4. Solar photovoltaic pumping system may be used in far remote locations, where electric grids are not available.

Considering the low lifecycle cost and above said benefits, solar photovoltaic pumping system will obviously be considered as the first choice by farmers to irrigate crops and gaining momentum among farmers in installing solar PV water pumping in their farms.

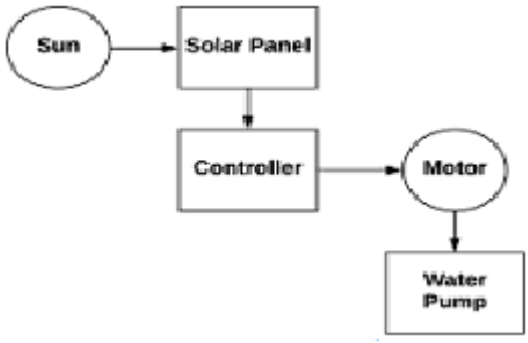


Fig1.Solar Water Pumping

## IV. SOLAR DRYER

Drying of food is one of the oldest methods of food preservation and the most popularly used method by the mankind all over the world, which is used to enhance the strength of the food. Drying food is nothing but the removal of excess moisture present in it so that the material can be stored for a long time and be protected against spoilage due to the presence

of moisture. Drying increases shelf life of the food by reducing the microbial and enzymatic activity and reducing the rate of chemical reactions. Drying reduces weight and volume of the food products to a lager extent; thereby the packaging, storage and transportation costs are reduced to a greater extent. In the case of drying, in addition to preventing the loss, the marketing can be controlled at sensitive times and milk, potatoes, onions, tomatoes, coconuts etc., required by many consumers (such as barracks, restaurants, etc.) can be delivered in a dried for. Sun drying of crops and grains are the age old practice followed by our ancestors. Solar dryers protect grain and fruits and vegetables, reduce losses, dry faster and more uniformly, and produce a better quality product than open-air methods. Solar-drying technology offers an alternative, which can process the vegetables and fruits in hygienic conditions as per national and international standards and with zero energy costs. It saves energy, time, occupies less space, improves product quality, makes the process more efficient and protects the environment. Much research has been conducted about the dryer by many researchers and they have reported more than 66 different solar dryers having different configurations, capacity, the products dried and their cost. Fuller (Fuller, 1995) and Ekechukwu et al. have reviewed many solar dryers, and compared their performance and applicability with respect to rural areas. Sharma has presented a comprehensive review of the various designs, details of construction and operational principles of the wide variety of practically realized designs of solar-energy drying systems and a systematic approach for the classification of solar-energy dryers has been evolved. A review of new technologies, models and experimental investigations of solar driers has been presented by Ramana. Solar dryers are conventional dryers so that supplementary equipment is added to enable a significant proportion of the thermal energy required for drying to be replaced by solar energy. In these types of dryer, a planned, and generally optimized drying process can be achieved to obtain superior product quality and good economic performance. Any influence of the weather conditions on product quality and on the performance of the dryer can be eliminated by using an independent energy source, if needed, and proper control facilities. The construction of the solar assisted dryers is relatively complex compared to other dryers. They usually consist of a solar collector, a fan, a heat storage system, a burner/heater, and a control system. They can handle large quantities and deliver good product quality.

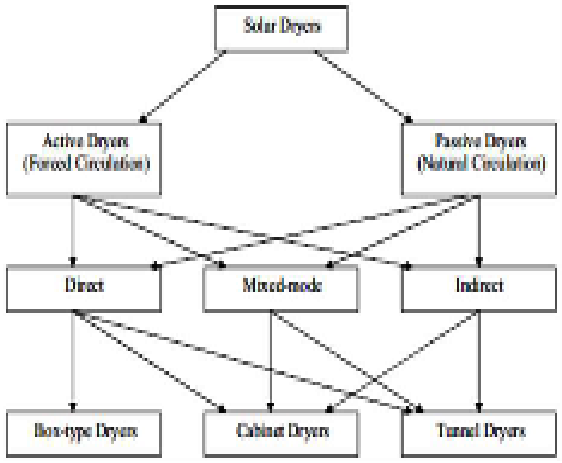


Fig. 2 Classification of Solar Dryers

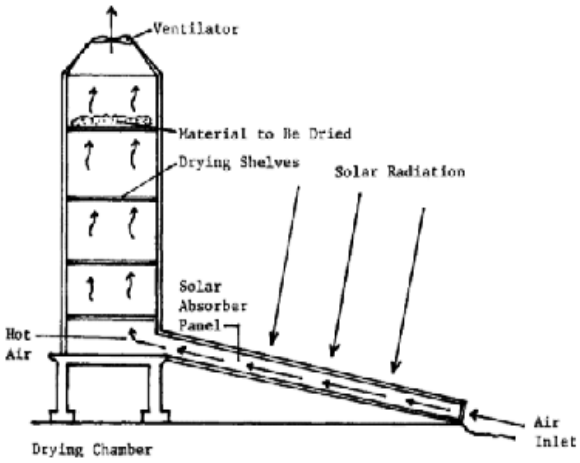


Fig 3. Schematic sketch of Solar dryer

## V. SOLAR POWERED PLANT PROTECTTION EQUIPMENTS

Pest and diseases can cause a damage of nearly 35% of the crop production when the timely intervention was not done. Uniform and timely spraying of liquid formulations or dusting of plant protection chemicals throughout the crop field at a faster rate is important for effective control of pest and diseases. In keeping the above facts in mind several solar powered equipments were designed and developed e.g. solar powered sprayer, solar powered duster, etc.

**a. Solar Powered Sprayer:**

It is used for spraying of agricultural chemicals in agricultural field. The energy requirement of DC pump of the PV sprayer is met through by connecting a 120 $W_p$ capacity (60 Wp × 2 Nos) solar photovoltaic modules. So that the energy produced may be directly used by DC motor. To provide

continuous supply of power to the sprayer and other uses, a battery (two batteries 12V, 7Ah each) is usually attached with the sprayer. Performance indicators of the solar powered sprayer are that an application rate of 84 litre per hr and area covered is 0.21 ha per h were observed and reported. The application rate varies as per the availability of solar irradiation, the application rate was between 80 and 90 litre per h based on the solar irradiation. The capacity of the tank used in the sprayer was from15 to 30 litre and with one filling, the sprayer can cover an area of about 0.15 ac. The approximate maximum cost of the solar powered sprayer is Rs.25, 000.00

**b. Solar photovoltaic duster:**

Dusters are equipments used to apply pesticides in dry powder form. For example pesticides like Sulphur, Malathion powder are to be applied in dry powder form as dusts over the target. It essentially comprises a photovoltaic module (7.5 $W_p$), a metal carrier, storage battery (12 V, 7Ah) and specially designed compatible dusting unit. The photovoltaic module is carried over the head/shoulder with the help of a light metal carrier made of aluminium (Al) sheet, which provides shade to the worker and simultaneously charges the battery to run the duster. The battery is stacked in a bracket, which is fixed to the panel carrier. The field capacity of the device is about 0.075 ha per h. Approximate cost of this device is about Rs.9, 000.00

Fig. 3 Solar Powered Sprayer

**VI. PV winnower-cum-solar dryer for winnowing and drying of agricultural produces**

Winnowing and drying are two important post-harvest operations, which require attention. The villagers find difficulty in cleaning the threshed material, during the lull season of natural winds. Generally in rural areas, small-farm holders thresh the material in their village threshing floor and then carry out the winnowing by pouring down the threshed material against wind, which is shown in Fig.4.


Fig. 4. Conventional Winnowing

Locally available tray is used to winnow the material by the agricultural labour standing on a platform with stretched hands. When the tray is shaken, the material falls down, and if there is natural wind, it blows away the lighter particles like husk and grain falls down. In the absence of natural winds, the farmers are handicapped and as electrical supply is intermittent, they have to wait for the wind. Moreover if the wind velocity more than the threshold velocity then the grain will also be washed away by the wind with husk and other dirt particles. The PV winnower-cum dryer were used for winnowing threshed materials in the absence of erratic and unreliable natural winds and also for dehydrating agricultural produces more effectively and efficiently (Fig. 5). In the off seasons the solar PV module can also be used for domestic lighting and other house hold electrical applications.

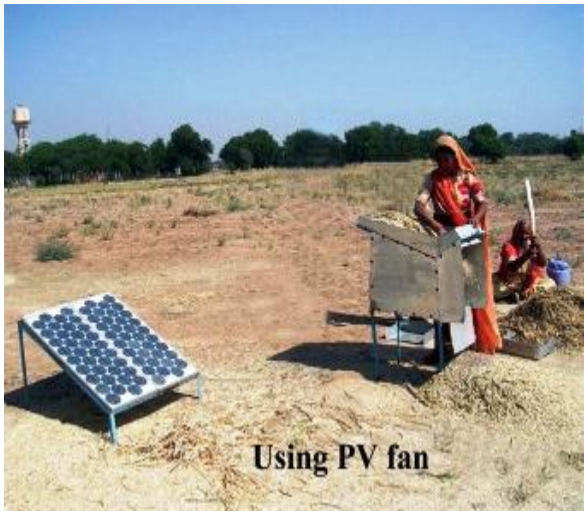

Fig. 5 Winnowing using PV fan

## VII. SPACE AND WATER HEATING

Livestock and diary operations often have substantial air and water heating requirements. Modern pig and poultry farms raise animals in enclosed buildings, where it is necessary to carefully control temperature and air quality to maximize the health and growth of the animals. These facilities need to replace the indoor air regularly to remove moisture, toxic gases odors, and dust. Heating this air, when necessary, requires large amount of energy. With proper planning and design solar air/space heaters can be incorporated into farm buildings to preheat incoming fresh air. These systems can also be used to supplement natural ventilation levels during summer months depending on the region and weather. Solar water heating can provide hot water for pen or equipment cleaning or for preheating water going into a conventional water heater (Goedseels, 1986; WFE, 2002). In a family's energy cost water heating alone account for as much as 25 percent and in case of dairy operations up to 40 percent of the energy used is in water heating. A properly-sized solar water heating system could cut those costs in half (Garg, 1987; UCS, 2009). The solar water-heating systems can be broadly classified in to four basic types. All these systems have three similarities: a glazing (typically glass) over a dark surface to gather solar heat; one or two tanks to store hot water; and associated plumbing with or without pumps to circulate the heat-transfer fluid from the tank to the collectors and back again (Schnepf, 2005; Schnepf, 2007; Svejkovsky, 2006).

## VIII. GREENHOUSE HEATING

Another agricultural application of solar energy is greenhouse heating. Commercial green house typically rely on the sun to supply their lighting needs, but are not designed to use the sun for heating. They rely on gas or oil heaters to maintain the temperatures necessary to grow plants in the colder months. Solar greenhouse, however are designed to utilize solar energy both for heating and lighting. A solar greenhouse has thermal mass to collect and store solar heat energy, and insulation to retain this heat for use during the night and on cloudy days (EREC, 2002). A solar green house is oriented to maximize southern glazing exposure. Its northern side has little or no glazing and is well insulated. To reduce heat loss, the glazing itself is also more efficient than single-pane glass, and various products are available ranging from double pane to cellular glazing. A solar greenhouse reduces the need for fossil fuels for heating. A gas or oil heater may serve as a back-up heater, or to increase carbon dioxide levels to induce higher plant growth (NYSERDA, 2009). Passive solar greenhouses are often good choices for small growers, because they are a cost-efficient way for farmers to extend the growing season. In colder climates or in areas with long periods of cloudy weather, solar heating may need to be supplemented with a gas or electric heating system to protect plants against extreme cold. Active solar greenhouses use supplemental energy to move solar heated air or water from storage or collection areas to other regions of the greenhouse (Svejkovsky, 2006).

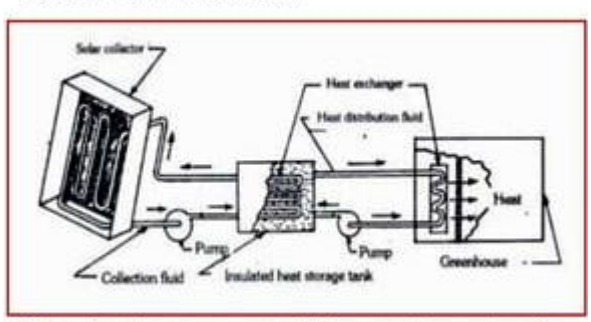

Fig. 6 Solar green House heating

## IX. CONCLUSION

Change is the permanent thing in this world, so also Agricultural technology is also changing rapidly. Farm machinery, Post harvest technologies, Farm buildings and production facilities are constantly being undergoing changes and improvements. Cheaper, clean and improved sources of energy are needed for efficient and smooth operations of the facilities and their sustainable development. These sources of energy are clean, risk-free and constitute no harm to human race and environment.

There are many reasons why it is important to adopt some kind of alternative source of energy generation before we run out of current sources which produce electricity for us. Solar energy is available in abundant amount on the earth and shifting our electricity requirements to solar energy is most likely to be the option in the coming future.

One should weigh and consider these factors when using and installing a clean energy source like solar system. Payback periods may be shortened by the multiple use of a solar system, such as for space heating and crop drying. Photovoltaic (PV) technology, can offer a variety of practical alternative energy solutions.

The solar energy can be found even in the farthest corners of the world and it can be developed to electric power, which is very much used in the agricultural activities. Usage of solar energy can be done in the majority of agricultural activities mentioned above cases. In addition to it, the steady decline in the availability of fossil fuel energy sources and its cost escalation makes the inexpensive and easily available Green energy as an alternative in the field of agriculture.

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