Strategies to Enhance Solar Energy Utility in Agricultural Area of Rajasthan State, India

Sujit Kumar1*, Shripati Vyas2, Ritesh Tirole3, Megha Vyas4, Sasanka Sekhor Sharma5, Srawan Singh Rao6

1Department of Electrical and Electronics Engineering, Jain (Deemed to be University), Bangalore, India
2, 4, 5Department of Electrical and Electronics Engineering, College of Technology and Engineering, Udaipur, India
3Department of Electrical and Electronics Engineering, Sir Padampat Singhania University, Udaipur, India
6Department of Electrical Engineering, Noida Institute of Engineering and technology, Greater Noida, India

*sujitvj.kumar@gmail.com

Abstract. Energy plays an important role in the monetary and social expansion of any country. However, there used to be a general deficiency of rural energy development policies that focuses on agriculture. Agriculture has a dual role, i.e. it acts as an energy user in crops as well as an energy supplier in solar electricity generation. Rajasthan, the largest state of India, is blessed with the highest solar insolation. However, solar energy has not been fulfilled yet, predominantly in the field of the agricultural sector, where irrigation is still being done by outdated conventional methods. This paper focuses on the development of strategies to enhance solar energy use in the agriculture sector of Rajasthan state India. An intensive survey was being conducted among scientists, academicians, farmers, and government officials regarding the know-how of present policies and schemes for the different applications of solar energy in Rajasthan state India. The survey reveals that not only the farmers and rural persons but the intellectual world is also unaware of the different policies of solar program prevailing in the state. Based on the survey, various strategies have been suggested to accelerate the solar program among the rural and agriculture sectors of Rajasthan state India.

1. Introduction
Solar energy is the most massive renewable resources available in the world [1]. This yield can be compared to the solar insolation that reaches the earth in 1 hour, which is equal to humans’ total energy in the whole year [1]. It exceeds the current annual global energy consumption and any acceptable requirement in upcoming years [2]. As the energy demand is continuously increasing in the world, many countries, including India, are looking into the future to enact policies and programs for solar energy hardening.
India is blessed with a surplus of solar resources. In India, the average solar radiation intensity is 200 MW / km$^2$, with almost 300 sunny days per year. Solar is essential, although currently underutilized energy resources in India can improve energy supply (especially in remote areas) and increase the security of India's energy supply. The solar radiation level ranges from the western region with the lowest annual radiation energy in the north-eastern areas. India receives solar energy equal to (5000) trillion kWh per year. Daily radiation incidence varies from 4 to 7 kWh / m$^2$. [3].

Solar energy policies are administered at the central level by the Indian Ministry of New & Renewable Energy (MNRE) and the Indian Renewable Energy Development Agency Limited (IREDA) and state-owned energy development agencies States. The Indian Government has raised the overall renewable energy goal to 175 GW, including 100 GW of solar power to be achieved by 2022. [3].

2. Current Policy, Practice, And Regulations in India

The national action plan on climate change (NAPCC) is the organization set up by the Government of India. “In mid-2008, the Prime Minister’s Climate Change Council plan identifies eight main missions: the National Solar Mission, the National Enhanced Energy Efficiency Mission and the National Green India Mission” [2]. The first mission was carried out in three separate phases, eventually deploying 20 GW Grid Connected Power Plants and generating 2 GW of off-grid solar power covering 2 x 10$^7$ m$^2$ by 2022, so that 15 % of India's electricity could come from renewable sources by 2020. [2]. Presently 5% of power is targeted to “purchase from renewable, which will be increased by 1% each year to reach 15% by 2020” [2]. “Sanction 6(1) (c) of the Indian Electricity Act, 2003 (EA, 2003) also encourages the generation and purchase of electricity from non-conventional energy sources. This sanction finalized its recommendation on various topics, such as guidelines for determining the percentage of non-conventional energy procurement, the proportion of different non-conventional energy sources within the general procurement obligation (PRO) percentage and the Renewal Energy Certificate (REC) process” [3].

“The purpose of the REC mechanism is to resolve the mismatch between the availability of non-conventional energy resources in the state and the requirement of mandatory agencies to comply with the Renewal Procurement Obligation (RPO) in other countries, which results in the faster overall growth of India's non-conventional energy sector over the last two years” [4].

3. Solar Energy Potential in Rajasthan

Rajasthan, the largest state of India, constitutes about 10.4% of the geographical area of India. Traditional energy sources, such as coal, are limited [4]. There are only two perennial rivers, Chambal, and Mahi, whose hydroelectric capacity has been almost completely realized. [3]. Rajasthan has around 208,110 square km of desert land. According to the US Department of Energy, Rajasthan receives the second-largest amount of solar radiation in the world. The State of Rajasthan receives maximum solar radiation intensity in India with very low average rainfall. It also has unutilized low-cost desert land available in abundance. It has more than 300-325 sunny days in a year with solar radiation of about 6-7 kWh/m$^2$/day [5].

Mostly, the western part of Rajasthan is blessed with ample solar energy. Jodhpur, also known as the Sun City of India, receives maximum solar radiation. Barmer, Bikaner and Jaisalmer are also central regions with the best solar radiation in the country [6]. As a result, Rajasthan is likely to emerge as the universal pivot for solar power globally. Figure 1 shows the useful resource of solar radiation and the availability of vast wasteland areas in Rajasthan's Thar Desert region. [6]. Therefore, Rajasthan is likely to arise as the universal pivot for solar power in the country. Figure 1 shows a safe source of solar radiation and the availability of large areas of wasteland in the Thar Desert region of Rajasthan [4].
Figure 1. Solar power potential in Rajasthan State

4. APPLICATION OF SOLAR ENERGY IN AGRICULTURE

4.1. Crop and Grain Drying
In the old days, solar energy is used directly to dry crops and grain. However, due to the open environment, the crop and grains are subjected to damage by birds, rain, wind, and then contaminated and dirt. The sophisticated system of solar dryers protect grain and fruit, reduce losses produce a better quality product than that of when dried in the open air.

4.2. Space and Water Heating
Diary operations have air and water heating requirements. Nowadays, pig farms raise animals in covered buildings in controlled temperature and air quality enhance the health and growth of the animal beings. For cleanliness purposes and removing indoor air, toxic gases, and moisture, proper planning can be set. By the best planning and designing, solar air/space heaters can be incorporated.

4.3. Greenhouse Heating
Solar energy is also being used in greenhouse heating. Commercial greenhouse typically used the sun to supply their lighting needs rather than to heat. Solar greenhouse, in recent trends, is designed to use solar energy both for heating and lighting purpose.

4.4. PV Remote Electricity Supply
In Solar PV “electricity generation, PV panels convert solar radiation directly to electricity” [5]. Solar electricity generation is possible while PV panels get solar radiation; its electricity generated depends upon the intensity of solar radiation coming to PV panels and strikes directly perpendicular to the PV modules. The higher the intensity of radiation, the higher will be the electricity generation. The generated electricity can have a lot of applications as it can directly feed electrical power to an appliance and also can store energy in a battery. In the remote area where there is a problem in sending electrical power, it can be used as a standalone electricity generation. Other merits covered by solar electricity are that PV systems are comparatively cheaper and require less maintenance.
4.5. Water Irrigation Pumping

“Renewable energy sources have been a hot topic since the acknowledgment of the energy crises throughout the world. As a result, people are turning toward the photovoltaic (PV) power system for future energy solutions. However, there are some drawbacks to the field testing with real photovoltaic modules such as cost and heavy dependence on the weather conditions. The dominant problems associated with direct-coupled PV are the non-linear supply of power and the resultant complexity in providing an optimized load match. The output from a PV array is a non-linear and time-dependent source of power that changes according to the variation in solar irradiance throughout a day, as well as the attenuating effects of PV cell temperature. This directly influences the performance characteristics of a load (or motor pump), which is generally designed for and operated from, a fixed voltage source” [5]. In remote areas where power lines are not physically possible due to environmental conditions, solar Photovoltaic (PV) water pumping systems are proving to be the most cost-effective water pumping option.

5. Initiatives in Solar Sector in Rajasthan

Although solar PV electricity generation yield is very small due to physical hazards as well as poor technology. “In the commercial ground, we are hardly on 18% on efficiency. But the Rajasthan government is continuing to encourage private sector investment through various fiscal and promotional schemes. The Government had made a project to develop Jodhpur, Jaisalmer, and Barmer as Solar Energy Enterprises Zone (SEEZ). For example, the Mathania solar power project (140MW) is the first solar/thermal hybrid power plant in the country. Integration of Solar energy and Thermal power plant is set known as integrated solar combined cycle (ISCC) technology in which parabolic mirrors have been used to focus sun heat and further drive the turbine to generate electrical power. This plant is producing 40MW of energy, cost 1 million/MW, and still cheaper than other methods” [7]. In parallel, some additional solar power like 100 kW plant in Gourir (Jhunjhunu) [7], solar refrigerator in Balesar (Jodhpur) [7], and solar village in Jaipur [7] are working productively. Many competitors in the private sectors are involved in active participation in solar energy like Reliance and Moser Bear who already have plant capacities of 1 – 5 MW each [7].

In January 2010, there was a MoU from Clinton foundation with the Rajasthan government to supply technical support and additional essential aid to launch parks utilizing solar having the competence of 3,000 MW – 5000 MW. Under the Generation Based Incentive Scheme (GBI), the Rajasthan government has permitted two projects in 2008. For developing a 66 MW plant state government has sanctioned solar projects from various 11 private sectors to assemble RPO prerequisites. Later, with the introduction of the National Solar Mission Scheme (NSM), the Rajasthan government then approved these projects to be handled under the NSM [7]. Further, RPOs and a feed-in tariff for Renewable Energy Projects have been provided on time by Rajasthan Electricity Regulation Commission (RERC). “In 2011, many investors were selected for installing PV plant of 800 MW MNRE under the project named NSM” [7]. The mechanism has been established to counterbalance the superior price of solar power. Recently, in the aggressive submit, the tax came in the assortment of Rs. 2.44 per unit (pu), while the rate of the unregistered conservative energy was nearly Rs. 3 pu. As a result, the pu cost of the bundled energy was found about Rs. 3.5 pu [8].

The state government has started providing subsidy to the farmers in 2011-12 to establish a solar irrigation pump in their farms. The subsidy amount was up to 90% and was launched through the horticulture department. In the later years, the subsidy amount was reduced slightly and was 75% up to 2016-17. However, despite all these schemes, the farmers and villagers are still devoid of electricity for their basic requirements. By extensive and intensive surveys and analysis of the above-mentioned points, a detailed report will be developed to improve the active participation of solar applications in agriculture in Rajasthan state.
6. Result And Discussion
It is to find out the reason for the non-success of solar policies in Rajasthan; we have carried out an intensive survey among the following stakeholders.

(i) Teaching faculty and Scientists (ii) Farmers (iii) Officials of Government Departments.

6.1. Survey with teaching faculty and scientists
Academic faculty must spread the knowledge among stakeholders. For an academician/scientist working in an agriculture university, it is their prime duty to spread the knowledge of agriculture and its allied sectors among students as well as farmers. Solar energy and its application in agriculture is one such area that can be treated as a knowledge extension area. Hence, a survey was conducted among teaching faculties of the agriculture branch of Rajasthan state agriculture university. There are five state agriculture universities in Rajasthan namely,

1. Agriculture University, Kota
2. Agriculture University, Jodhpur
3. Maharana Pratap University of Agriculture and Technology, Udaipur
4. Swami Keshwanand Rajasthan Agricultural University, Bikaner
5. Sri Karan Narendra Agriculture University, Jobner (Jaipur)

Figure 2. A survey was done among Teaching/Scientist Community
A questionnaire was prepared and circulated among teaching faculties of agriculture. The results have been illustrated through Figure 2, which states that only Maharana Pratap University of Agriculture and Technology, Udaipur is having a separate department namely Renewable Energy Engineering and that too 75% of faculties are working in solar thermal applications and very few of them have the knowledge about solar photovoltaic and its applications in agriculture use.

Further, the extension department of these Universities carry out the training on conventional topics like methods of irrigation, type of seeds, use of fertilizers, etc. but a very few of them conduct a training program on the employment of solar energy in agriculture area due to which the farmers are not aware of the use of solar energy in agriculture applications.

6.2. Survey with among farmers

An intensive survey was conducted among the farmers of different villages of the district like Udaipur, Rajasmand, Chittorgarh, and Banswara of Rajasthan. A questionnaire was prepared, and questions were put before the farmers, and accordingly, the analysis was carried out, as shown in Figure 3 – Figure 6. In each village, our research team has met near about 30-40 farmers. From Figure 3, it is clear that on average, 85% of people don't have any information about Government Solar Schemes.

Hence, in these villages, most of the farmers (more than 90%) don't have a solar irrigation pump. It was also concluded from the survey that more than 80% of the farmers are interested in installing solar irrigation pumps on their farms. A similar survey was conducted in Rajasmand District covering villages Railmagra, Deogarh, Khamnor, and Kumbhalgarh. It is clear from Figure 4 that the farmers of Rajasmand Village (more than 80%) are ignorant about the usage of solar energy for agriculture applications.
Figure 4. A survey was done among farmers of Rajasmand Villages

During the survey, 80% of the farmers had shown their keen interest in establishing a solar irrigation pump in their farms. In Rajasmand district, 40% of farmers from Railmagra village possess a solar irrigation pump right from 2012. The reason was that most of the farmers were literate, and one of their relatives was in the Government Department. Thus, the literacy of farmers is also one of the important factors in knowing about Government schemes. The data analysis of the Chittorgarh district is shown in Fig. 5.

Figure 5. A survey was done among farmers of Chittorgarh Village
The Villages which were being surveyed in Chittorgarh district had solar irrigation pump on their farms. It was due to advertisement by Government authorized company namely, Jain Irrigation Private Limited. These villages were Begun, Bhadesar, Bhainsrorgarh, and Dunga. However, these pumps were limited to literate and rich farmers. Still, poor and illiterate farmers belonging to scheduled caste or scheduled tribe are ignorant about Government solar schemes. However, more than 90% of farmers of the above-mentioned categories have shown their willingness if the Government provides a subsidy of up to 90%. Banswara district shown in Figure 6 comes under tribal regions of Rajasthan state.

6.3. A survey among Government Department Officials

Every year Rajasthan Government launches a solar scheme to provide a subsidized solar irrigation pump to the farmers. To find out the details of the scheme, we visited the Horticulture Department of districts like Udaipur, Rajasmand, Chittorgarh, and Banswara. In 2016-17 Solar Scheme provided a 75% subsidy to the farmers having 3 HP and 5 HP pumps for their farmhouse. However, the condition laid was that the farmers should have 0.5 hectares for 3 HP and 1 hectare for 5 HP pump. Very few farmers of the district, which was chosen by us for our research work, fulfil this condition. Most of the farmers have very small farmland like one biga, two biga, and maximum up to 3 biga (a biga is a unit of area of land), which cannot be covered under the solar scheme and thus most of the farmers of these districts couldn’t avail the benefit of the scheme.

In 2016-17 Government has sanctioned 150, 100, 249, and 110 solar irrigation pumps for the districts Udaipur, Rajasmand, Chittorgarh, and Banswara respectively. The official of the Horticulture Department was visited to get the exact details of the scheme. From the detail session it is noticed that the officer responsible for subsidy has the following advice to the farmers who interested to have a solar irrigation pump in their field:

- The farmer should have more than 0.5 hectare land.
- The farmer should pay 25% of the total cost.
- If the farmer has more than 1.5 hectares of land, the farmer should have 1.5 hectares land only for use solar irrigation pump.

In Figure 6, a bar chart is given. The chart shows the awareness program among farmers in Banswara villages having solar irrigation pump or not. The survey shows that more than 90% farmers are willing to have solar irrigation pump if the Government provides a subsidy of up to 90%.

Figure 6. A survey was done among farmers of Banswara Village

- Having Solar Irrigation Pump
- Not Having Solar Irrigation Pump
- Willing to have Solar Irrigation Pump
- Doesn’t have any information

Most of the farmers (more than 90%) are ignorant about the use of solar energy in agriculture and allied sectors. Many of the villages are still without electricity. In the survey, many farmers had shown their interest in establishing a solar irrigation pump in their field. The farmers were advised to meet the officer in charge of the District Horticulture Department, Government of Rajasthan to avail of the subsidy schemes benefit on solar irrigation pump. Further, they were being motivated to contact their Surpanch to establish subsidized standalone systems in their homes to get electricity.
Department told that most of the beneficiaries of these schemes were rich, literate, and general category farmers. The illiterate and poor farmers remain ignorant about these schemes while the SC/ST category farmers couldn't afford it in want of money. Further, it has been pointed out that very few awareness programs were organized by the Horticulture Department. Hence, farmers remained ignorant about these schemes. Passiveness is also observed among field officers of government departments in advertising this policy due to the lack of incentives by the Government.

7. Conclusion
Rajasthan has the highest potential in terms of solar energy, yet the output is not at par. Also, there is a huge gap between demand and supply on the use of solar energy in agriculture in Rajasthan State. Hence policymakers should make such a policy so that the solar energy program can be accelerated among rural persons and farmers. The following are the recommendations carved out from the survey for achieving the above-mentioned objective.
1. Awareness workshop should be organized by Universities/ICAR Institute/Govt. Organizations for the farmers, students, and scientists to familiarize themselves with the scope of solar energy in agriculture and its allied sectors. These should be organized at Atal Sewa Kendra established by Govt. of Rajasthan for villagers.
2. Incentive schemes for the officers implanting solar schemes of Govt. for farmers and rural areas should be launched.
3. Government should introduce subsidy schemes for community farming, i.e. five to six farmers join hands and have a common solar irrigation pump.
4. Loan given to the farmers for installing solar irrigation pumps in their farms should be either have zero % interest rate or minimum interest (0.5 – 1%).
5. Toll-free number should be provided to the farmers where farmers can take information about solar subsidy schemes directly from the office of their district.
6. Skill centre related to the solar products should be established at the village level where the technician will be appointed from the village itself selected through Panchayat.
7. Two or more than two Govt. organizations should join together to provide more subsidies (up to 90%) to the farmers.
8. Incentives based schemes should be launched by the Govt. for the companies/firms authorized to install solar products (solar irrigation pump) in the villages. Further, companies should be directed to fill all the official forms related to particular solar schemes for the benefit of farmers.
9. Annually, a progress report should be monitored regarding the working of the solar system, production of agriculture products by some authorized agency.
It has expected that by implementing some recommendations, we can hope for a better Rural India about energy needs.

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