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Role of Solar Photovoltaic Technology in Development of Social Work

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ABSTRACT

The depleting fossil fuels and environmental concerns are paving the way for the development of renewable energy sources for power generation. The generation of electricity through solar photovoltaic (PV) is one of the best ways to increase energy security and address environmental concerns. Various remote areas in developing countries like India lack access to electricity at houses, community health and education facilities. Electricity generation by using stand-alone solar PV systems make the electrification of isolated areas possible. The maturation of PV technology and reduction in the cost of PV modules have made the availability and use PV more profound. Solar PV generated power can be used for lighting purpose; water pumping application for meeting the domestic and irrigation water demand; flour milling; vaccine refrigeration at health centers; running communication devices like radio and television sets which help in linking rural people to the urban centers, etc. This paper presents the role of solar photovoltaic power in sustainable development of communities especially in rural areas.

KEYWORDS: *Photovoltaic, Stand-Alone, Electrification, Power, PV Modules*

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INTRODUCTION

Energy consumption is a major indicator of socio-economic development of a country. Demand for energy is escalating throughout the world due to growing world population, fast technological and economic development. The conventional sources of energy like coal, oil and gas have been playing a significant role in meeting the energy requirements of the world. To achieve sustainable development, continuous flow of clean and secure energy is required which has lesser environmental impacts [1]. Use of solar energy for electricity generation provides a viable option for power generation especially in areas which are not connected to the utility grid. India is located between the Tropic of Cancer and the Equator and hence has abundant solar potential which can be used for power generation. Due to its locational advantage, on average, the country experiences 250 to 300 sunny days per year and receives an average hourly radiation of 200 MW/km2. The annual global radiation varies from 1600 to 2200 kWh/m2, which is typical of the tropical and subtropical regions [2].

Thus, solar energy provides a great opportunity for India to have a sustainable energy scenario. The vast solar potential of India can be used for obtaining useful electrical energy by using solar PV generators. The photovoltaic generation is a technique of converting solar radiation or photon energy into direct current electricity using a semiconductor material that exhibits photovoltaic effect. Lack of electricity supply in rural areas cause hindrance in facilitating activities of community. Access to electricity is important to community service facilities in rural areas. In rural health clinics and schools, electric lighting provides public security and allows facilities to remain open in the evenings. Beyond lighting, electricity is used to power an array of appliances, such as vaccine refrigerators, and other specialized equipment; pump water; and for using communication devices—from radios and television sets to computers and videocassette players— linking rural people to information, markets, and urban centers. The declining costs and increasing production of PV modules is making PV generated electricity affordable to people in rural areas [3].

The Government of India has launched DeendayalUpadhyaya Gram JyotiYojana for rural electrification. Also the Ministry of New and Renewable Energy is conducting Solar Home Lighting System program in the country to promote use of solar PV generation. Various applications of solar photovoltaic for the development of community are discussed in the following sections of the paper.

Solar Lighting and Cellular Phone Charging System

The use of PV generated power for lighting and mobile phone charging systems is the most widely used applications. For lighting household, schools, health centers, community halls, etc. PV generated power can be utilized. Apart from these applications solar power can also be used for lighting street lights, traffic signals, public information

sign boards. The design of Solar PV based LED lighting system suitable for a class room is a suitable application for solar lights as electric lighting (up to 200 times brighter than kerosene lamp) directly improves the quality of life. It allows children to study in the evening and women to gain some precious time for them or to extend income generating work into the evening hours [4,5]. A typical solar PV stand-alone system with storage unit for domestic applications is shown in Fig.1.

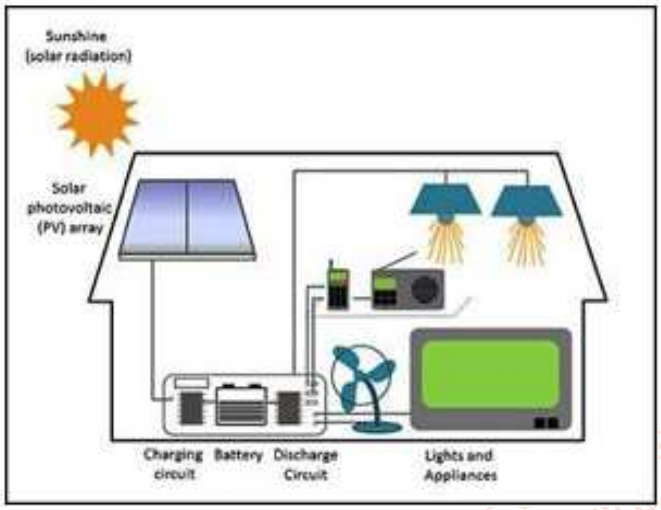

Fig. 1: Solar standalone system for electricity generation [6]

Solar powered street light system is another vital lighting application of solar PV power. A remote village Mawlynnong in Meghalaya has very erratic supply from utility grid due to its location. As a part of corporate social responsibility a non-profit organization named IDFC Limited (Infrastructure Development Finance Company Limited) installed 30 solar street lights in the village which enhanced tourism development of the village [7]Moreover, the solar PV based portable chargers for cellular phones are of utmost important for rural communities which do not have utility grid connectivity. PV based cell phone chargers are simple applications which use solar panel, DC-DC converter and battery for charge storage [8]. A solar cell phone charging system is shown in Fig. 2

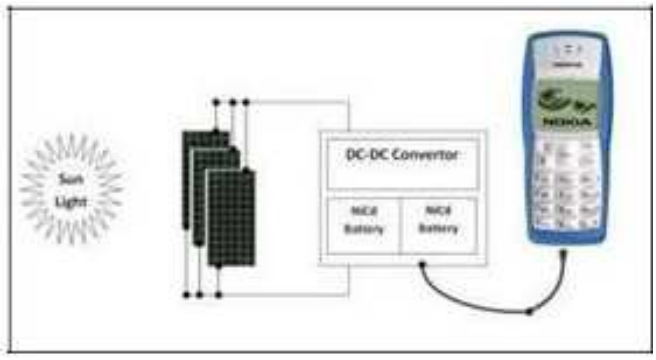

Fig. 2: Solar PV based cellular phone charging [8] solar photovoltaic based refrigeration

Solar PV based refrigeration systems are considered to be a suitable application for remote areas. The solar refrigeration systems can be used for refrigeration of vaccine at health facilities in rural areas. Also these can be used for cold storages for agricultural crops, perishable items and refrigeration of milk and milk products. For cooling milk the temperature should be brought down up to 0-4 ºC [9]. A cold storage facility for storage of fresh horticultural produce (6–8 tonnes), powered by solar photovoltaic with battery backup has been developed at CIAE, Bhopal. In the cold storage chamber at 12±1°C temperature and 90±2% relative humidity the shelf life of mangoes is increased to 15 days as compared to 4 days at ambient temperature. The shelf life of the tomato and capsicum increased up to 15 days and 21 days, respectively, in the cold storage as compared to 4–5 days at ambient storage [10]. A solar PV based refrigeration system is shown in Fig.3.

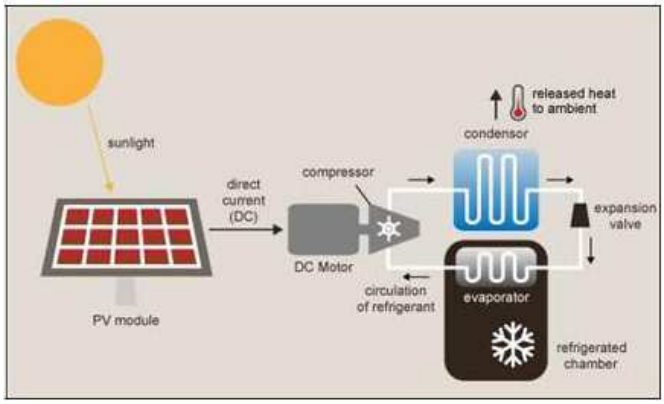

Fig. 3: Solar PV based refrigeration system [10] Solar photovoltaic based

Water pump

The shortage of grid electricity in remote areas makes the use of solar powered water pumping system one of the most important applications of solar energy. It is similar to conventional water pumping system except the power source which is solar energy in this case. The flow rate of water pumped in solar powered pump is dependent on the incident solar radiation and size of the PV array. Water tanks can be used to store water instead of using battery sets for charge storage to meet the water requirement in low radiation or absence of sunlight. A typical solar water pumping system usually consists of three parts: PV generator, impedance matching part and hydraulic part [11]. A schematic diagram of a typical solar PV water pumping system is shown in Fig. 4. The PV generated electricity is DC. The PV generator is connected to the water pump through the motor which can be DC or AC. So, a power conditioning unit is required to make the PV output Suitable to operate the motor. The water pump is installed at a water source and from there it pumps water to the water reservoir. The water is pumped from water source level to reservoir level. The elevation through which water is pumped is termed as pump head.

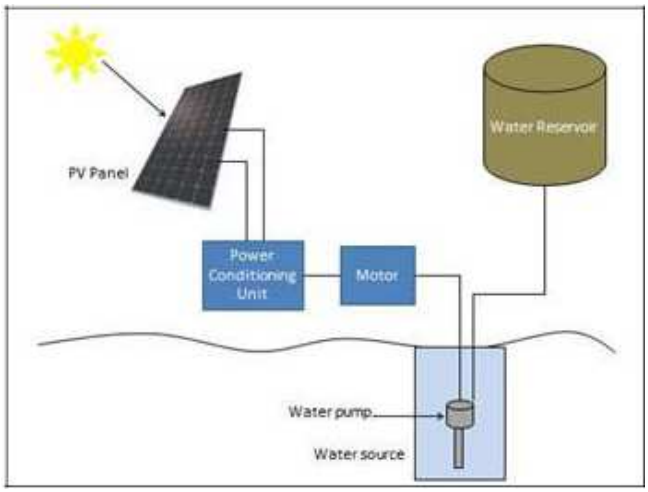

Fig. 4: Solar PV water pumping system [11]

Solar powered water pumping systems can be used to pump water for domestic needs, agricultural needs and for other commercial purposes by the people. Such systems are making the lives of people of rural areas easy even in severe weather conditions like snow and ice. Moreover there is a natural relationship between requirement of water and the availability of solar power which makes the use of this system more appropriate [12].In India also various state governments are providing subsidies to farmers for installing solar water pumping systems. Such programmers have been very successful in states lie Rajasthan and Bihar. In 2010, Rajasthan became the first state in India to provide 86 % capital subsidy on small solar pumps for irrigation and in the next five years close to 20,000 pumps were installed. Similarly, in Bihar, Bihar Saur KrantiSinchaiYojna (BSKSY) led to installation of 1560 pumps in three years after its launch in 2012 [13].

Solar photovoltaic based flour mills

In rural areas which do not have good transport facilities usually make flour of their produce at home by using saddle stone, pestle or mortar for grain milling which is exhausting and time consuming and carried out exclusively by women. Usually a low capacity 2 to 5 kg/h motorized mill requires 50 to 200 W and solar PV based flour mills could be used for such small power requirements. These mills could be used for milling locally grown grains and could help the rural community to become self-sufficient [14]. Fig. 5 shows a typical solar powered flour milling system. It consists of a hopper from where the grains are fed to the system. The PV panels produce electricity which drives the motor. One of the millstones is fixed while the other is movable. The motor through a spur-gear arrangement rotates the movable millstone and the grains are milled and collected at the flour outlet. Scatec Solar, a Norwegian company and Development Alternatives(DA), an Indian nonprofit organization launched community solar power plant (CSPP) projects in two villages Rampura and Gopalpura in Jhansi district, Uttar Pradesh in 2009. Under this project solar powered flour mills were also installed in the villages [15].

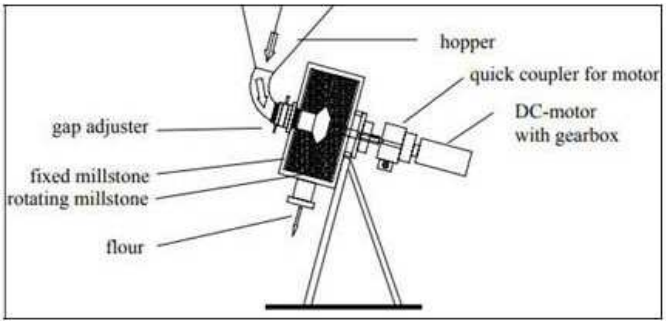

Fig. 5: Solar PV based flour milling system [14]

Scope of research in PV system development for rural communities

From the previous sections it can be seen that ample research work has been done to improve the PV system design for various applications in rural areas. As the efficiency of solar modules is low (around 22% for mostly used polycrystalline modules), it is required that the overall system efficiency of the whole system should be improved by optimum designing and maintenance. Improvement of existing designs can bring a positive change in the process of development of communities. Government is also encouraging the use of solar PV for electrification of rural areas by introducing schemes to promote solar photovoltaic technology. Several private companies are also helping in the process of development of communities with the use of solar photovoltaics as a part of their corporate social responsibility (CSR). Several applications of solar PV in rural areas and their typical system design are mentioned in Table 1.

Table 1: Various solar PV systems for rural applications

Type of PV application	Typical system design
Street light	35/70 Wp, electronics, battery, 1 or 2 CFL
Lights, radio/TV and small appliances	20-300 Wp, electronics, battery, appliance
Cellular phone charging system	50 system with a socket to charge cell phone batteries
Computer equipment in rural offices	8-300 systems powering lights, fax, TV, etc.
Health clinics	150-200 , electronics, deep cycle batteries, small refrigerator/freezer
Portable water pumping system	1-4 kWp, electronics, pump, reservoir
Water desalination	1-2 needed to power reverse osmosis or other water desalination units for 1 m3 per day
Irrigation	900 , electronics, small DC or AC pump and water tank
School and training centres	PV system for power lights, TV/VCR, PCs
Cooling for preservation of perishable food items	PV/wind hybrid system or 300-700 Wp PV with DC refrigerators (upto 300 L)
Veterinary clinics	300 , batteries, electronics, refrigerator/freezer, 2 tube lights

Conclusion

Power generation using solar photovoltaics (PV) is an attractive option to be used in electrification of rural areas around the world. Maturity of PV technology and decrease in the price of PV systems has increased the usage of PV for electricity generation especially for the areas where the utility grid does not reach. Solar generated power provides access to electricity to rural households and community facilities like schools, health centers, community halls, etc. Solar lights, solar portable cellular phone charging systems, solar water pumping system, solar based cold storage and refrigeration systems, etc. are some of the applications of solar photovoltaics which help in the development of rural communities. For the sustainable development of communities solar photovoltaic technology is a clean and reliable source of renewable energy.

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