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Performance Assessment of Solar Photovoltaic Technology in Agriculture

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***Abstract*— The combination of renewable energy and farming is a winning combo. Energy production is to nation's economy like the way engine powers the vehicle. Renewable energy is promising source for energy production with sustainability. Solar energy is free of cost when utilized in any application and present in infinite amount. Agriculture sector struggles to meet the demand of food production with the present resources so switching to solar technology has a lot of advantages in terms of economy, environment and energy production. From last 20 years, solar energy has brought many changes especially in agriculture where it needed the most. The paper focus on the research work and current development of solar energy applications in agriculture field like PV panels in farm field, solar water pumping system, solar greenhouses, irrigation systems including manual and automatic, solar water heating and solar dryer with their working, setup and cost parameters. It is an approach to motivate people to use renewable energy source for energy production in automobile, space crafts, agriculture field, homes, etc. for sustainable development.**

***Index Terms*— Renewable energy, agriculture .**

I. INTRODUCTION

Energy production defines the economy of the nation. From 200 years mankind has depended on fossil fuels mainly coal, petroleum and natural gas for the production of energy but its drawbacks are more when concerned about production parameters as it is nonrenewable in nature and environmental problems. In thermal power plants, automobiles and generators mainly input fuel is fossil ones and produce and produce CO_2 and CO gases which further contributes to rise in earth's temperature and leads to global warming. Many steps have been taken towards climate change like Kyoto protocol (1997), clean development mechanism, Montreal protocol and establishment of UNFCCC regarding climate change due to these gases. Sustainability is a key to broad current scenarios to future ones and more ecofriendly [1]. The three main dimensions of sustainability are environmental, societal and economical [2]. China has invested $90 billion in renewable energy and leads globally in terms of investments [3].

Solar energy is created by nuclear fusion that takes place inside sun's core. It occurs when the protons of hydrogen atoms violently collide in the sun's core and fuse to create a helium atom. In its core, the sun fuses about 620 million metric tons of hydrogen every second. About 30% of radiation reaches the earth's surface reflects back into space. Every day the sun emits more power in one second than the world has used since time started [4]. In 2006, energy consumption from renewable source was 18%, in which biomass contributed 13% and hydroelectricity 3% [5]. Africa receives more than 2000 kWh of global radiation which is much greater than other countries [6].Climate change is one of the greatest problems in 21st century and increase in global temperature of earth's leads to global warming and threatens the wide applications and sustainability of agricultural system. The annular solar PV production was 2 GW in 2006 which increased 5 times in 2009 to reach 10 GW and has aimed for 20 GW in 2022 [7]. In India, to raise the GDP about 9% in next 20 years, it has to reach the mark of 207 GW by 2031 from the present stage of 212 GW [8]. Solar technology is a fast growing technology where a lot of investment is being made in R&D for increase in production capacity.

Figure 1.Solar panels in agriculture farm.

II. PHOTOVOLTAIC SYSTEMS

The PV cells were invented at Bell Lab in 1954 in United States [9]. The smallest unit of a PV system is solar cell which is connected with each other and has a layer of semiconductor material which produces DC electricity when exposed to the sunlight. PV cells can be made in ways, first concentrator type and second is flat panels form. Flat panels are normal PV panels but in concentrator cells, reflector guides the incident light and concentrates to the connected solar cells. A typical solar PV panel has an average life span of 25 to 30 years [1]. With renewable energy technology, the reduction in CO_2 emissions per kW is estimated to be 90 to 300 times lower than fossil equipped source. In 2018, the average installation cost for home owners was $2.87 to $3.85 per wall. According to energy world report, Indian farmers will have to pay only 10% cost of solar panels installation in

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their farm under the new scheme in the budget of 2018-19. The share of electricity consumption met by solar energy is more than 5% in Germany and 7% in Italy [10].

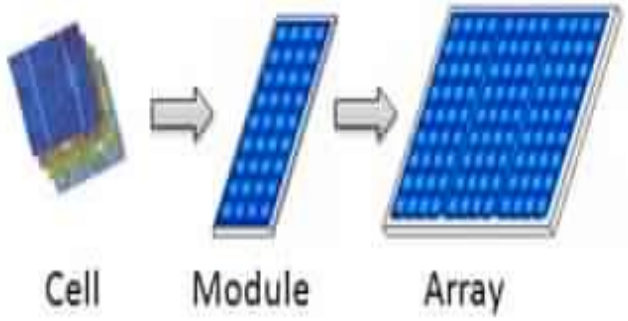

Figure 2.Formation of array from module and single cell.

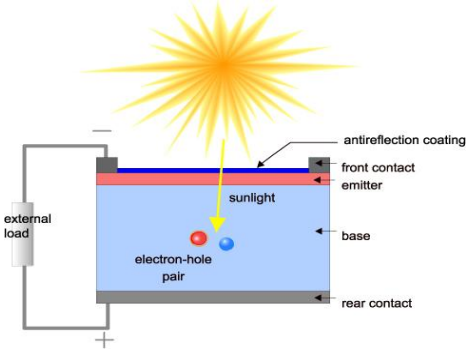

Figure 3. structure of solar cell.

III. SPACE AND WATER HEATING SYSTEM

Solar thermal space heating captures the sun's energy to supplement the existing heating system for home or commercial building. The heating system intensifies sun's power to heat water or air then used to heat the building. This system provides hot water of low to medium temperature for poultry farms and pens for cleaning purpose; system requires a collector, storage tank, plumping and pump which can together provide hot water of 60^0C when required in any amount. China is largest investor and manufacturer of solar PV system and solar water heater [3]. The efficiency of energy conversion can be calculated by the ratio of desired output to desired input [11].

$$\eta = \frac{m.C.(T-t)}{A.\int_t^T (\text{Solar Power})dt}$$

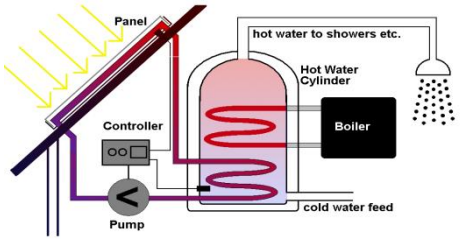

Figure 4. Solar water heating system

IV. WATER PUMPING SYSTEM

Solar water pumping system is made up of 3 components; PV panels, controller and pump. The advantage of this system over diesel fuel based system are; is reliable and have a long life, noise free, one time investment, no fuel cost, low maintenance cost and labor cost. There are 21 million irrigation pumps in India out of which 9 million are powered by diesel and 12 million by electricity grid [12]. Generally DC and AC pumps of 2 HP to 5 HP are installed in the setup. A system having 128 W PV array and a submersible pump can produce 750 to 1000 gallons of water per day from 200 foot drilled well [5]. This system produces energy in day hour only so it will be efficient and effective if battery stores the energy produced in day time to supply in night when needed. Water pumping efficiency can be calculated by

$$\eta = \frac{\rho.g.Q.h * 100}{P.a}$$

Water pumping system is of two types, one is direct system in which energy produces during day time only when needed in any operation and second is battery coupled system but adding battery may reduce the overall efficiency of the system it supplies the voltage 1 to 5V lower than the actual voltage produced during the day time and also depends on temperature and how well the battery is charged and to counter this reduction, pump controller is used which boosts the battery voltage to the pump [13]. Ministry of New and Renewable Energy (MNRE) is planning to implement 30,000 solar water pumping system per year for irrigation of farms with the cooperation of NABARD [12]. At the global level, cost of solar pumped water ranges from $0.03 to $0.15 per day and per gallons ranges from $0.002 to $0.007 per gallon [13].

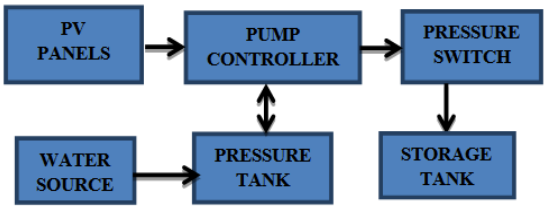

Figure 5.Direct solar waterpumping system.

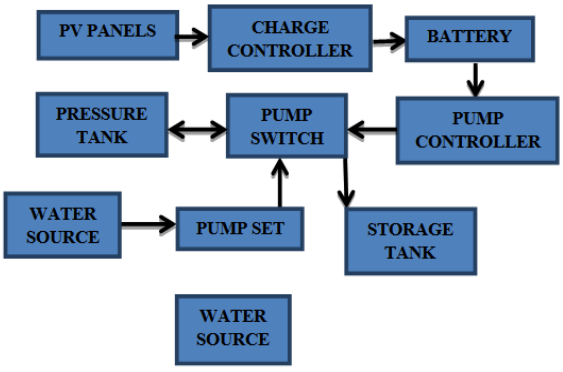

Figure 6. Battery coupled solar water pumping system.

V. GREENHOUSE HEATING

Greenhouse is a structure used in agriculture nowadays to grow plants with better quality and enables gardeners to grow out of season vegetables and fruits since this system retains solar heat. First solar greenhouse was developed in 1970's

during the oil crisis. The structure is normally oriented towards south in order to maximize the heat absorption. Solar energy can be used in 3 ways in greenhouse; first is inactive type, where it uses thermal energy from solar radiation, second is active type which uses picks and transfer heat fluid and in the third type, PV cells are used so the outcome of solar radiation becomes electrical. The net construction cost for 200 square foot greenhouse is about $800 which extends the growing season and costs less than $10 per year to heat. The structure is designed to maximize the utilization of solar energy but in fully closed greenhouse, there is no ventilation window so the excess latent heat and sensible heat needs to be removed and can be stored using seasonal or daily thermal storage technology [18].

Figure 7.Solar greenhouse setup.

VI. SOLAR DRYER

All most all agricultural products can be produced by drying. It offers an alternate which process the vegetables and fruits in sanitary conditions to national and international standards and with zero energy cost [9]. Keibling listed 66 different solar dryers, their configurations, capacity, the products dried and their costs. The beneficial comparison of solar dryer with fuel mechanical drying is; prevents fuel dependency, cost effective, reduces environmental impact and easily manageable [14]. Solar dryer consists of solar connectors, fan, heat storage system, heater and a control system. It is of two types, first is direct solar dryers in which the substance is directly exposed to the sunlight needed to dehydrated. Generally have a black absorbing surface that collects light and converts into heat energy. Second is indirect solar dryer, in which incoming air is heated by black surface rather than directly heating a substance to be dried. This heated air is passed over the substance and move out through the chimney carrying all the moisture from the substance. Classification of solar dryers and drying modes [9].

Figure 8.Solar Dryer.

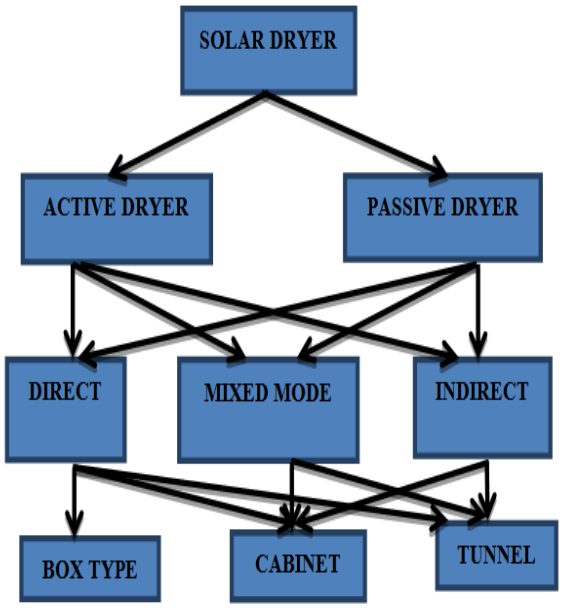

Figure 9.Classification of solar dryer and modes.

VII. IRRIGATION SYSTEM

The projected population of India being 1500 million by 2050 and agriculture remaining as a primary source of livelihood in rural area and now it's time to focus towards increasing the productivity with sustainability [15]. According to sectorial demand pattern of electricity, agriculture sector demands 21.5% of electricity [7]. Irrigation is the artificial application of water to the soil [16]. For irrigation purpose, Cadmium Telluride cells with an efficiency of 19% are better option [6]. While irrigating the crops or farm land, lot of water gets waste when operated manually especially at this time of water scarcity which is not good so the concept of automatic irrigation system comes into play to counter this loss. The automatic irrigation system helps to irrigate the crop in suitable amount at the time of need when required and not before and definitely not after so as to save water loss. The available traditional techniques are; ditch irrigation, terraced irrigation, drip irrigation and sprinkler irrigation [8]. Ditch irrigation includes digging ditches out and seedlings are planted in rows. In terraced irrigation, land is made into steps and supported by retaining

walls. Drip irrigation is the most efficient in all methods in which water drops near the root zone of a plant in a dripping motion. Sprinkler system is based on overhead sprinklers, sprays or guns, installed on permanent risers. Automatic system can combined with different technology so as to get better results and accessibility for different operations.

The system with arduino and GSM technology consists of arduino UNO, GSM SIM module, DHT, humidity sensor, 12V relay, BC 547 transistor voltage regulator [16]. The system checks water pump which can be activated via SMS when required. Once the system is connected, it turns off after reaching the appropriate humidity level and it can be disconnected through sms also.

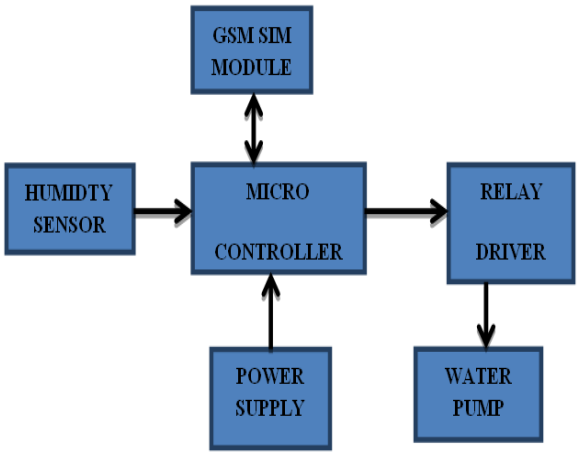

Figure 10. System setup with arduino and GSM

In solar powered automatic drip irrigation system (SPADIS), it includes wireless sensor technology which consists of pump, battery, solar panel, soil moisture sensor microcontroller and the battery capacity should be 30-40% higher than the pump capacity for trouble free operation [8]. This type of system can be used in football and cricket stadium for irrigation purpose. According to the report of Bureau of Electrical Energy there are approximately 17 million agriculture pump sets in India and every year 0.5 million new connections are installed with an average pump capacity of 5 HP. With the advancement in drip irrigation system, it has benefited in many ways as moisture within the root zone can be maintained at field capacity, recycled non potable water can be used, field leveling is not necessary and the water distribution is highly uniform.

For the analysis of water content,

Gravimetric water content (GWC) =

$$\frac{mass\ of\ wet\ soil - mass\ of\ dry\ soil}{mass\ of\ dry\ soil}$$

Volumetric water content =

$$\frac{\text{bulk density of } soil * \text{GWC \%}}{\text{density of water}}$$

Bulk density =

$$\frac{mass\ of\ dry\ soil}{volume\ of\ soil}$$

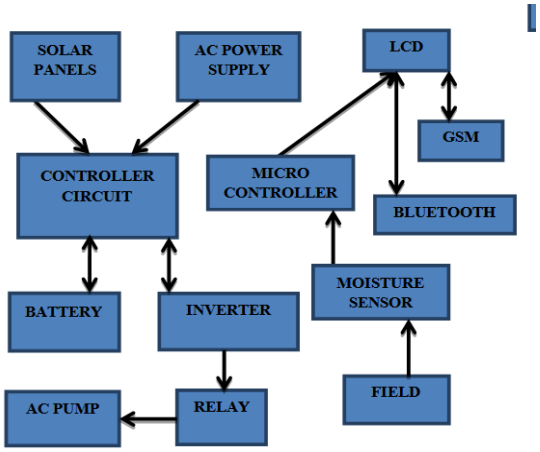

Figure 11. Drip irrigation system setup.

Another type includes the PLC and SCADA technology. The system consists of PLC, SCADA, power supply, flow meter and solenoid valve [17]. This method is more beneficial than traditional ones as this doesn't face the problems like empty running, overflow and leakage and minimizes the human effort. After some modifications, this system can detect the exact location of pressure drop in the setup.

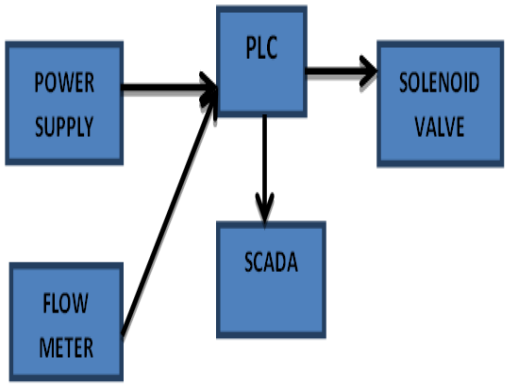

Figure 12.PLC and SCADA technology system setup.

VIII. CONCLUSION

The current scenario of energy production is not favorable with sustainability term. Energy production from fossil fuels is a traditional method but leads to increase in pollution and global warming as CO_2 is the final product exposed to the atmosphere in many operations so switching to renewable energy source and focusing on solar energy has given a hope of keeping the sustainability term alive. Applying this technology to the agriculture field is winning combination and benefits to both the farmer and the government. Solar PV panels installation requires one time investment only and benefits with clean energy production and have a long life of 30 years. Solar greenhouse enables to grow off season crops and powers the entire system with free input energy solar dryers helps in drying procedure of crops and switching to automatic solar irrigation system benefits in reduction in loss

of water and time consumption of farmers. It is by sharing knowledge and resources these changes can be achieved.

REFERENCES

[1] Benedetto Nastasi, Umberto Di Matteo (2016) Solar energy technologies in Sustainable Energy Action Plans of Italian Big Cities, Energy Procedia 101 (2016) 1064- 1071.
[2] Nidia S. Caetano, Teresa M. Mata, Antonio A. Martins, Manuel Carlos Felgueiras (2017) New trends in energy production and utilization, Energy Procedia 107 (2017) 7-14.
[3] Frauke Urban, Sam Geall, Yu Wang (2016) Solar PV and solar water heaters in China: Different pathways to low carbon energy, Renewable and sustainable energy reviews 64 (2016) 531-542.
[4] M. K. Al Enazi, A. A. Alomar, K. I. Alinzi, A. M. Alsaeed, Automatic Solar Digital Wireless Irrigation Systems for Open Areas and Green Houses, VOLUME1-No 1- JANUARY 2017.
[5] Chikaire, J. Nnadi, F. N., Nwakwasi, R. N., Anyoha, N.O, Aja O. O., P. A. and Nwachukwu C. A., SOLAR ENERGY APPLICATIONS FOR AGRICULTURE, Volume 2, September 2010.
[6] Saeed Mohammed Wazed, Ben Richard Hughes, Dominic O'Connor, John Kaiser Calautit, (2017) Solar Driven Irrigation Systems for Remote Rural Farms, Energy Procedia 142 (2017) 184-191.
[7] V. S. Korpale, D.H. Kokate, S.P. Deshmukh, Performance Assessment of Solar Agriculture Water Pumping System, EnegyProcedia 90 (2016) 518-524.
[8] Sonu Kumar, C. Sethuraman, Kota Srinivas, Solar Powered Automatic Drip Irrigation system (SPADIS) using Wireless Sensor Network Technology, IRJET, Volume:04 issue:07 july 2017.
[9] Mohammad VahediTorshizi, AtefehHosseiniMighani, The Application of Solar Energy in Agricultural Systems, Journal of Renewable Energy and Sustainable Development (RESD), Volume 3 issue 2, June 2017- ISSN 2356-8569.
[10] Sergio Copiello, Carlo Grillenzoni, Solar Photovoltaic Energy and its Spatial Dependence, Energy Procedia 141(2017) 86-90.
[11] Jennifer L. Jones, Margareta Kalka, Hector Mendoza, Stefanie Robinson, Alejandra Rueda, Jessica Vechakul, Solar Water Heater Project, May 13, 2013.
[12] PradipNarale and Prof. Narendra Singh Rathore, Solar Water Pumping System for Agriculture, energetica INDIA Aug 15.
[13] B. Eker, Solar Powered Water Pumping Systems, Trakia Journal of Sciences, Volume 3, No. 7,pp 7-11, 2005, ISSN 1312-1723.
[14] Pranav C. Phadke, P.V. Walke, V. M. Kriplani, Direct Type Natural Convection Solar Dryer: A Review, IJARSE, Volume 4, Issue No. 02. February 2015, ISSN 2319-8354(E).
[15] A Sumalatha, G Eswar Kumar, Energy Efficient Solar Powered Automatic Irrigation System, International Journal of Engineering and Management Research, Volume-7, Issue-3, May-June 2017, ISSN: 2394-6962.
[16] SurabhSuman, Shanu Kumar, RatnajeetSarkar, GautamGhosh, Solar Powered Automatic Irrigation System on Sensing Moisture Content Using Arduino and GSM, IJARECE, Volume 66, Issue 6, June 2017, ISSN: 2278-909X.
[17] GaddipathiBharathi, ChippadaGnanaPrasunamba, Automatic Irrigation System for Smart City Using PLC and SCADA, IJSRCSEIT, Volume 2, Issue 4, ISSN: 2456-3307.
[18] MortezaTaki, Abbas Rohani, MostafaRahmati-Joneidabad, Solar Thermal Simulation and applications in greenhouse ISSN:2214-3173.