FARMERS' PERCEPTION TO SOLAR IRRIGATION SYSTEM FOR POWER SELF-SUSTENANCE IN AGRICULTURE.

V. M. Modi[1], N. N. Desai[2] and Vinit Modi[3]

1 Associate Professor, College of Renewable Energy and Environmental Engineering, SDAU,S.K.Nagar-385506
2 Assistant Professor, College of Renewable Energy and Environmental Engineering, SDAU,S.K.Nagar-385506
3 Alumni, College of Renewable Energy and Environmental Engineering, SDAU,S.K.Nagar-385506
Email : vmmodee@gmail.com

ABSTRACT

North Gujarat region is predominantly known for agro based economy. As surface water sources are very much limited in these regions, irrigation mainly depends upon underground water strata available at different water table. (Viswanathan and Pathak, 2014, forthcoming). Close to 80% of the total irrigated area is dominated by deep and shallow tube wells while canal water covers hardly 20%. Gujarat ranked fourth in terms of energization of pump sets over the past three decades, showing more than fivefold increase in the number of pump sets from 2.62 Lakhs during 1983 to 14.28 Lakhs during 2017. Solar photovoltaic (PV) pumps are powered by an array of solar panels. Solar PV pumps are designed to operate on DC power produced by solar panels, or on existing AC pump with inverter. Solar pumps are easy to install and are generally "good" for the sustainability of boreholes due to their low extraction volumes spread over eight to ten hours a day. To cope up the ever increasing demand, the Gujarat government has provided solar-powered water pumps to farmers to reduce the burden on existing power plants and encourage the farmers to opt for solar powered pumps for their regular irrigation needs. A study on techno economic feasibility of solar water pumping system at farmers fields was carried out during 2015 and 2016 in the North Gujarat region. The study recommended the farmers to adopt 5 hp solar photovoltaic water pumping system coupled with micro irrigation system to promote eco-friendly daytime irrigation. The North Gujarat region is endowed by abundant solar radiation for 300-315 days with insolation of 4.5-6.5 kWh/m2/day. The system is found quite appropriate in the total head range of 5-85 m. Life cycle cost (LCC) of PV system was found to be 58.5% less compared with diesel pump set, average payback period was found to be about 04 years.

Keywords: *solar radiation, photovoltaic, irrigation, insolatio*

INTRODUCTION

The solar water pumping system is a stand-alone system operating on power generated by solar PV (photovoltaic) system. The power generated by solar PV system is used for operating surface/submersible pump for lifting water from open/ bore well or Surface water sources for irrigation and drinking water purpose. Ministry of New and Renewable Energy Sources (MNRE), Government of India formulated an ambitious program for installation of 50,000 SPV water-pumping systems over a period of 5 years. The daily average solar energy incident over India varies from 4 to 7 KWh/m^2 with about 300 clear sunny days per year with about 1800-2100 sunshine hours per year (depending upon location) (Ramchandra *et al.*2011). As per a recent notification issued by state energy and petro-chemicals department, the solar pumps are necessary as 27% of total electricity produced in the state is being used for agriculture purpose. In Gujarat, Uttar Gujarat Vij Nigam Limited (UGVCL) alone reported 90191 pending applications for power connection by 2015-16. (GERC,2015-16). Government itself is of the view to change power strategy and encouraging farmers to embrace solar irrigation system rather than waiting for grid electricity. Solar pumps are easy to install, require no nonrenewable energy, operate autonomously and may be "good" for the sustainability of boreholes due to their low extraction volumes spread over eight to ten hours a day.

North Gujarat region is predominantly known for agro based economy. As surface water sources (2000 Mcum) are very much limited in these regions, they mainly depend upon groundwater. (Viswanathan, 2014). Groundwater sources (mostly tube wells) dominates by irrigating close to 80% of the total irrigated area while canal irrigated area is hardly 20%. UGVCL provided more than 100 solar pumps predominantly in the Tharad Taluka of Banaskantha district. The study is an attempt to evaluate the techno-economics of solar photovoltaic (PV) water pumping system for Banaskantha district of Gujarat state.

OBJECTIVE

To know the farmers' perception to solar irrigation system for power self-sustenance in agriculture

METHODOLOGY

The research methodology was divided into four components: data collection, design of different scenarios, technical evaluation, output analysis and economics of the system. The study involves field survey and collecting data of solar irrigation system in the Dantiwada, Palanpur and Tharad taluka from Banaskantha district of North-Gujarat, India. which were earlier operated either on diesel engine to pump water or relied on monsoon for agriculture. Majority of the farmers have adopted solar photovoltaic water pumping system coupled with micro irrigation system. Information was collected via questionnaire form. Photovoltaic water pumping (PVP) technologies are discussed in terms of their performance range, their technical features and economic viability with respect to diesel engine run water pumps. Initially 20 farms were surveyed, out of them four farms having heterogeneous land holding, water table, method of irrigation and cropping pattern were shortlisted for detailed study.

Pyranometer was used to measure global solar radiation. Ambient temperature and wind speed were measured with the help of digital thermometer and anemometer respectively. Economic analysis of the system carried out by employing life cycle cost analysis (LCCA) and Payback period (PBP). The capital cost, variable cost, fixed cost, total cost, revenue and net profit are the basic components for an economic analysis. of any system. The operating life of the PV panels was expected to be 20 years and life of diesel engine was considered as 10 years. The interest rate on capital was taken as 10 per cent and inflation rate assumed as 4% (Kolhe et al., 2002). Maintenance cost of system assumed to be a 0.1 percent of total capital cost. CO2 emission per litre of diesel 2.7kg (Chaurey and Khandpal, 2009) and availability of sunshine hours considered to be a 300 days in a year.

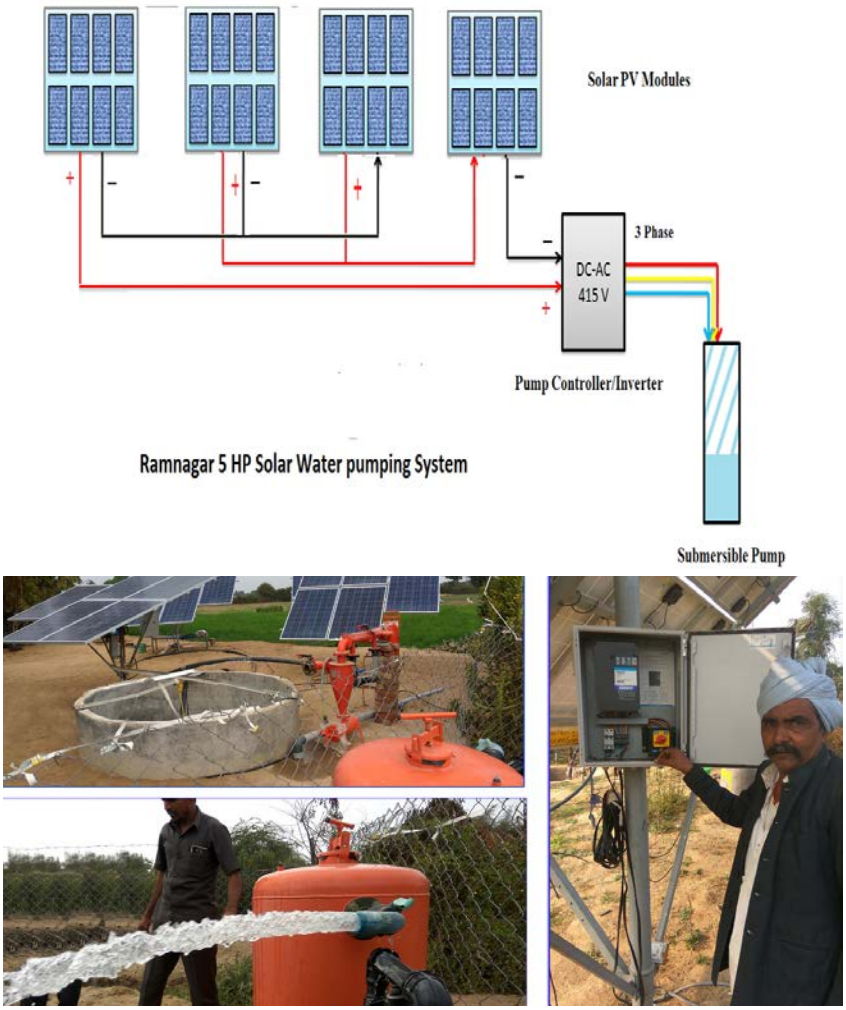

Fig.1:Solar Photovoltaic water pump in operation and line diagram of the system

RESULTS AND DISCUSSION

Performance evaluation of the system

Performance evaluation of short listed systems considering depth of water table, cropping pattern, water source, land holding and irrigation method were carried out on 10th January,2017 purposively to perceive the response of system under most stringent condition of less solar radiation and high irrigation demand. Figure 2 shows power out water discharge of the system at farm-1(total head 40 m) with reference to weather data.

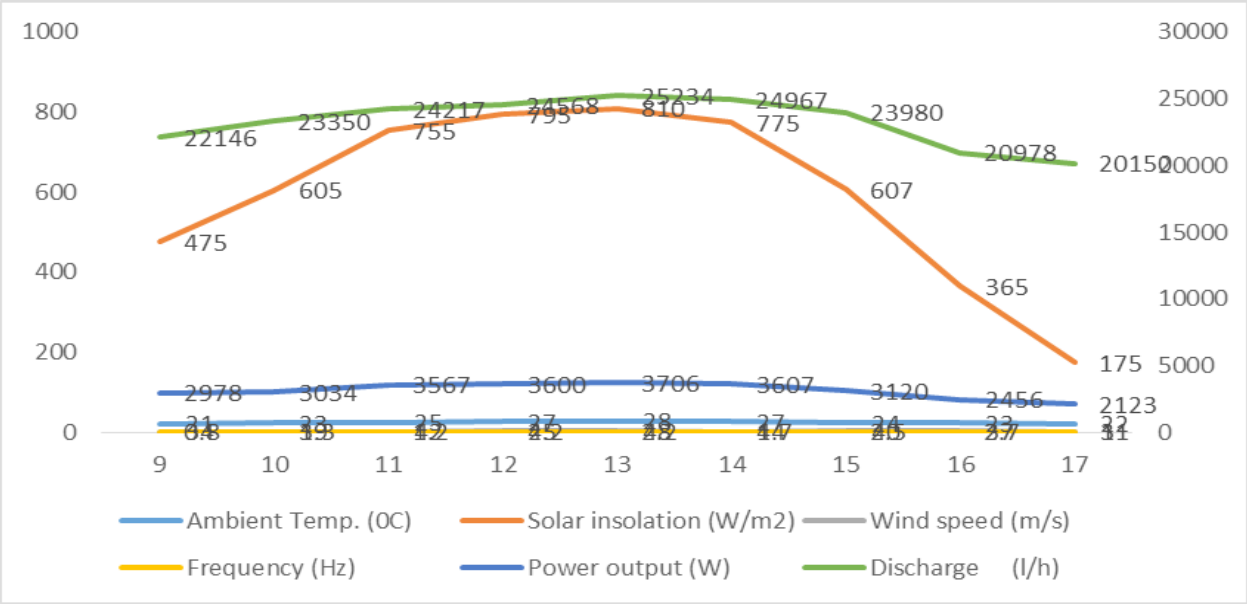

Fig. 2: Performance of solar photovoltaic water pumping system with respect toweather parameters at farm-1.

Results shows that, maximum power generation and water discharge where found to be 25234 lph and 3706 W respectively at 13:00hrs, when ambient temperature and insolation recorded were 28^{0}C and 810W/m^2 respectively. It was revealed that water discharge and power correlate with the solar insolation. The available discharge was sufficient to satisfy water requirement of 5 acre farm, which was about 2,00000 liter per day by sprinkler irrigation system.

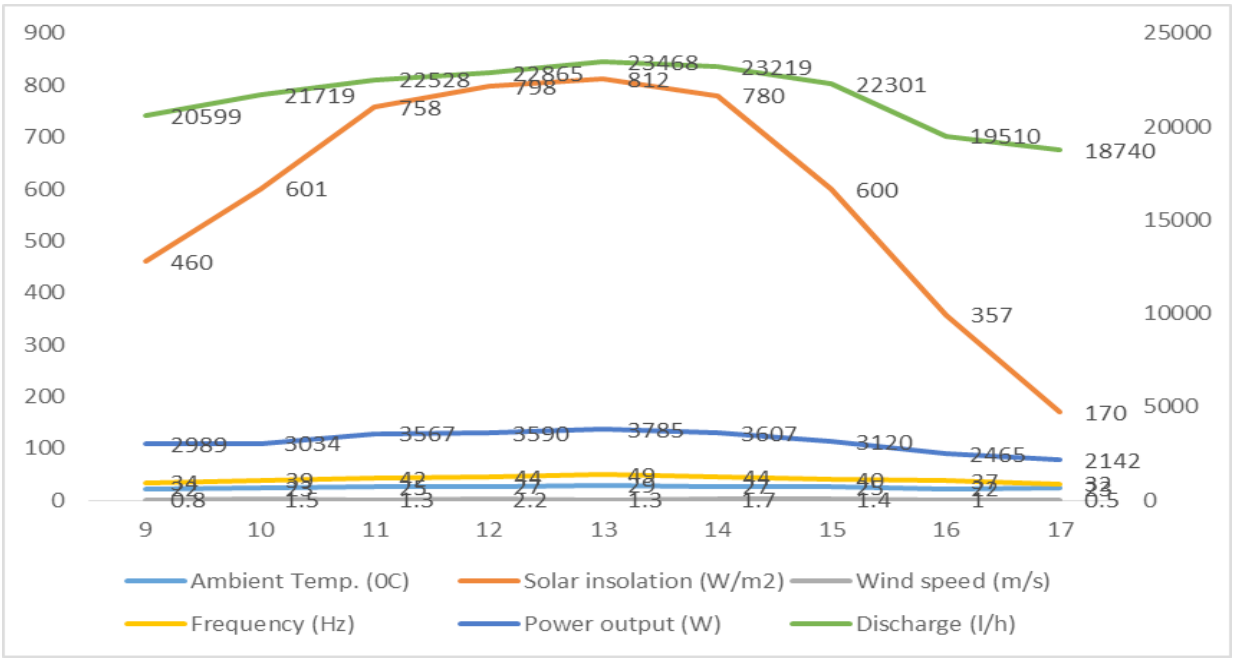

Fig. 3 : Performance of solar photovoltaic water pumping system with respect to weather parameters at farm-2.

Figure 3 show the system performance for the farm-2 which was drawing water from 85 m deep bore well. Result shows that maximum power generation and water discharge were 3785W and 23468 lph respectively at 13:00 hrs., when ambient temperature and insolation were 29^{0}C and 812 W/m^2 respectively. Average water discharge found was 21661 liter per hour and total water discharge per day recorded was 194949 liter.

The system is coupled with sprinkler irrigation system. Total water requirement of 10 acre farm is about 4,00000 liter per day, so nearly two full sunny days are required to irrigate the entire field.

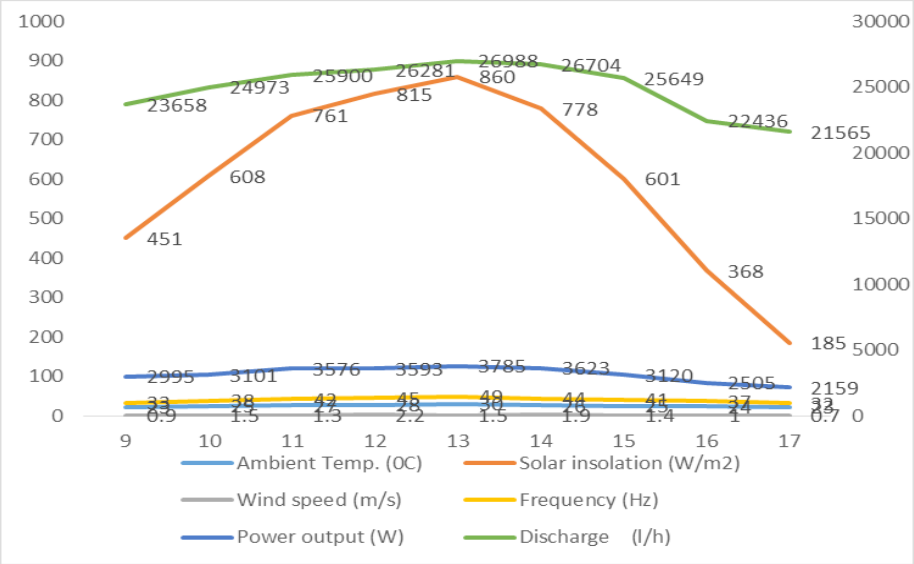

Fig. 4: Performance of solar photovoltaic water pumping system with respect to weather parameter at farm -3

Figure 4 show the performance parameters of the system for the farm-3 which was drawing water from 5 m deep open well. Result shows that maximum power generation and water discharge were 3785 W and 26988 lph respectively at 13:00hrs., when ambient temperature and insolation were 30^{0}C and 860 W/m^2 respectively. Average water discharge found was 24906 liter per hour. The day delivered total water equivalent to 224254 liter. The system is coupled with drip irrigation system which was laid down in pomegranate crop. Total water requirement of 10 acre farm was about 60,000 liter per day, so the system was found most appropriate to satisfy need of the farm, surplus water could be delivered to neighboring farm.

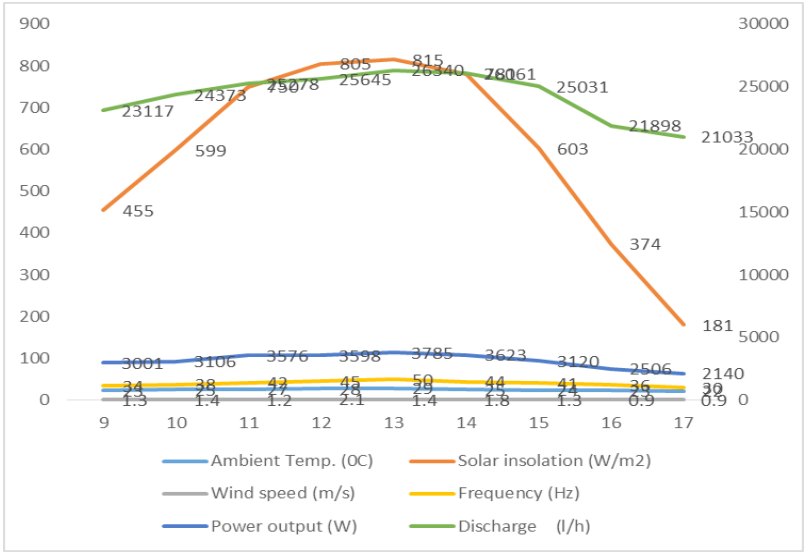

Fig. 5 : Performance of solar photovoltaic water pumping system with respect to weather parameters at farm-4.

Figure 5 show the weather data and corresponding performance of solar water pumping system for the farm-4 drawing water from 9 m deep open well. Result shows that maximum power generation of 3785 W was recorded at 13:00 hrs. When ambient temperature and insolation were 29^{0}C and 815 W/m^2 respectively. Maximum water discharge

was recorded at 13.00 hrs. when insolation was maximum.

Average and total water discharge found were 24308 liter per hour and 218776 liter per day respectively. The farmer was holding 25 acres of land and still practicing traditional method of irrigation, so the present water discharge was not sufficient as water requirement was quite high. The solar irrigation system covers 65 percent of irrigation need, rest of the water requirement was fulfilled by diesel engine pump set. The farmers was recommended to install micro irrigation system to reduce burden on diesel pump set to improve profitability.

2 Economic Analysis

Table 1 : Economic analysis for solar PV water pumping system

Sr. No.	Particulars	Farm-1	Farm-2	Farm-3	Farm-4
1	Installed cost of PV pumping system, ₹	5,00000	4,95000	3,75,000	3,75,000
2	Power, hp	5	5	5	5
3	Depreciation in ₹ @ 5% per year	25,000	24750	18750	18750
4	Interest in ₹ @ 5% per year	25,000	24,750	18,750	18,750
5	Maintenance ₹ @ 0.1% of A	500	495	375	375
6	Total annual Expenditure for solar pump, ₹	50,500	49,995	37,875	37,875
7	Power available per day from PV array, kWh	25.05	25.15	25.30	25.29
8	Operating days per year	300	300	300	300
9	Electricity production @ ₹ 4.50/kWh in ₹	33818	33953	34155	34142
10	Operating hrs per day	7	8	8	8
11	Operating hours per year	2100	2400	2400	2400 + 1292 for diesel pump
12	Area under irrigation, acre	5	10	10	25
13	Total Head (m)	40	85	5	9
14	Water requirement per day(lpd)	200000	400000	60000	1000000
15	Cost of diesel engine pump set with accessories (₹)	50000	50000	50000	50000
16	Depreciation, ₹ @ 10% per year	5000	5000	5000	5000
17	Interest in ₹ @ 5% per year	2500	2500	2500	2500
18	Repair and Maintenance ₹ @ 2% of (M)	1000	1000	1000	1000
19	Cost of fuel(Diesel) saved per year@ ₹ 60.	126000	144000	144000	221520
20	Total annual Expenditure for diesel pump (₹)	134500	152500	152500	230020
21	Environmental benefit CO2 emission = (1 lit/hr × operating hrs./year × 2.7kg CO2), t/year	5.67	6.48	6.48	9.96
22	Net Profit (19-6), ₹	84,000	102,505	1,14,625	192,145
23	Payback, Years	5.95	4.83	3.27	1.95

Table 1 shows the economic analysis of solar PV irrigation system on replacement of diesel pump. The results show that solar irrigation system is found quite advantageous as compared to traditional diesel engine pump set. Monetary benefit found for the farm 1, 2, 3 and 4 was ₹ 84,000, ₹ 1,02,505, ₹ 1,14,625 and ₹ 1,92,145 respectively. The system helps environmental by CO_2 emission reduction of about 5.67, 6.48,6.48 and 9.96 tons per year for farm 1,2,3 and 4 respectively. Payback period worked out for the farm-1 and 4 were 5.95, 4.83 years respectively. Owing to drastic reduction in price of PV systems, payback period came down sharply for the farm-3 and 4 as 3.27 and 1.95 years respectively. Besides this the system makes day time irrigation possible.

Life cycle cost analysis

Table 2: System cost comparison by life cycle cost analysis

Sr. No.	Costs	PV system (₹)	Diesel engine (₹)
1	Capital cost(CC)	5,00000	50,000
2	Maintenance cost (MC)	10,000	10,000
3	Fuel/Energy cost (EC)	None	12,60,000
4	Replacement cost (RC)	50,000	25,000
5	Total cost	5,60,000	13,45,000
6	Salvage cost	5,000	8,000
7	**Life cycle cost (LCC)**	**5,55,000**	**13,37,000**

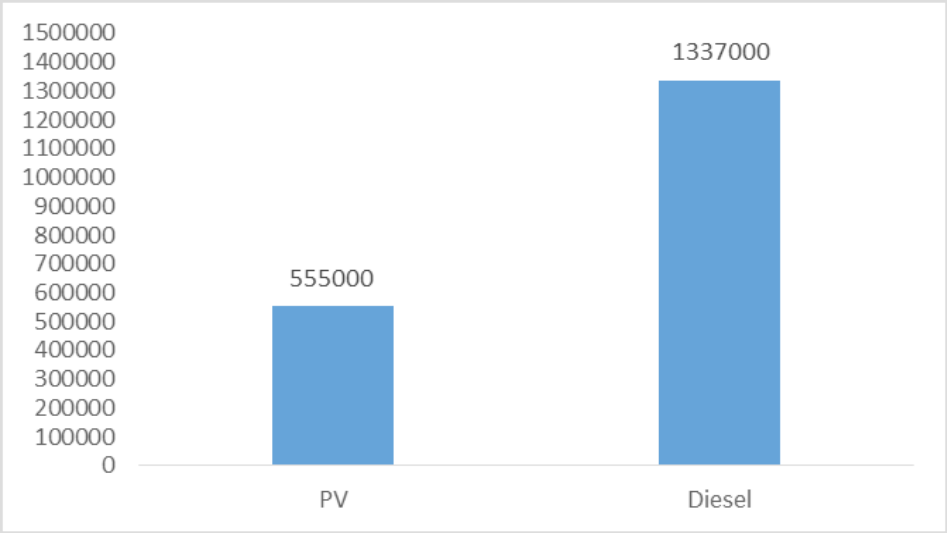

Fig. 6: System cost comparison by life cycle cost analysis

Table 2 and figure 6 depicts comparison of life cycle cost (LCC) analysis between PV and diesel irrigation system. Significant difference was found in LCC as it stood more than double for diesel pump set as compared to solar PV irrigation system.

CONCLUSION

Solar Photovoltaic water pumping system of 5 hp capacity coupled with micro irrigation system is suitable for the farmers of North-Gujarat region appropriate in the total head range of 5-85 m to promote eco-friendly daytime irrigation. The North Gujarat region is endowed by abundant solar radiation for 300-315 days with insolation of 4.5-6.5 kWh/m^2/day. Average water discharge through solar pump was found to be 661-3306 liter/hour more as compared to water delivered by diesel pump set. The system saves diesel fuel to the tune of Rs. 1,26,000 to 2,21,520 for annual operating hours of 2100-3692. CO_2 emission reduction was worked out as 5.67-9.96 tones/year. Life cycle cost (LCC) of PV system was found to be Rs 555000/- while that of diesel engine was Rs 13,37,000/-. When compared with diesel pump set, average payback period was found to be about 04 years.

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