

Design, Performance and Feasibility Assessment of Solar PV System for Irrigation

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Abstract— The energy crisis in Pakistan is a very major problem. The energy sector play a vital role in prospering the country. In Pakistan, the 10% of the total power and more is only consumed by Agriculture. The shortage of power greatly effects the food production. It was reported in “Pakistan Social and Living Standard Measurement” that almost seventeen out of every hundred households face food insecurity (moderate to severe). With the increasement in population, the problem may get worse and the country needs to take proper measure to make the food-sector self-supporting in terms of power. It is inevitable to use Solar PV system for agriculture sector in a country where the solar irradiance is in high number. In this study, the Solar PV system is used for irrigation of wheat field, the system Performance Ratio (PR), and the system loss diagram which showed all the major and minor loss throughout the process and in the end, the Life Cycle Cost Analysis (LCCA) has been done. So that the proper incite is given the reader by comparing both the Diesel Operated Irrigation System (DOIS) and Solar PV Irrigation System (SPIS). By adopting the method discussed in the research, the Power Sector which consume more than 10% will bring down the percentage with significant point and this 10% can be then used for other productivity. The food shortage and high food prices may also be reduced.

Keywords— Solar PV Irrigation System (SPIS), Renewable Energy, Energy, Agriculture.

I. INTRODUCTION

Pakistan is an agriculture country and the contribution of agriculture in economy is wide. In other words, the country can speedily prosper her economic position if the agriculture sector get develop but unfortunately, the farmers use regular watering methods to water their plant, which consume more power and are less efficient. Consequently, it will be inevitable to change from regular watering method to the renewable energy watering methods.

Pakistan is blessed with lot of solar irradiation. And the use of solar power in watering method is the need of time: for example, population [1]. Pakistan is the fastest growing population in South Asia and the world's 5th populace country. To mitigate the food and power shortage in near future, Pakistan

needs to take serious steps to overcome this problem [2]. It is pertinent to mention that Agriculture sector in Pakistan consume 10% of whole power and contribute 19% to GDP of the country [3].

Pakistan has installed solar PV system in irrigation in some areas of Punjab province. But due to poor feasibility assessment, untrained farmers, the system was not efficient and sustainable. And the farmers were not able to get full benefits out of it. In this paper, an example of Solar Power System in irrigation installed at Punjab Province of Pakistan will be elaborated. The purpose of this study is to research the problem faced to the farmers and non-efficient use of Solar PV System in irrigation.

II. LITERATURE REVIEW

In Pakistan, Solar PV system in irrigation should be used and Government of Punjab has also given subsidy to farmer at some time, for up to 80% to be used as an alternative of diesel operated irrigation because of the reasons: non-reliability of fossil fuels, longer life, and cost effectiveness.

In remote areas of Pakistan, which is manly off-grid. Solar PV system in irrigation is appropriate choice. As Pakistan is blessed with high solar irradiation. Solar powered water pumping systems have the ability to distribute drinking water without any type of additional power or the complicated upkeep. solar PV system for irrigation could be regarded as being large-scale. However, Photovoltaic solar panels are frequently utilized to perform various agricultural operations. In distant regions or in areas in which the utilization of an alternative energy sources is better. In short, the solar powered water pumping systems have been established in the course of the some past few years. And to consistently generate an adequate amount of electricity straight from solar irradiation in order to deliver water for animals. As it is true that Solar PV system for Large irrigation area require huge sum of money but that initial cost can be repay back in short time. It can be concluded that, solar PV system is best alternative of diesel operated water pumps for irrigation [4].

Particularly in drip irrigation system, where the water has to reach at other corner of the large farm, say 22 acres. The length

of pipes, diameter of pipes, curves and restraints, like for instance, valves in the pipes they all have a very significant effect on the pressure. And that should be thoroughly calculated before installation, in order to maintain a constant flow for the crops. The loss of pressure or pressure-loss, can be minimized by considering the proper length of pipes, proper diameter of pipes, minimize curves and reduce the number of restraints as possible.

In system curve vs pump curve graph, we can see the operating point can be shifted by introducing constraints like valves etc. to the flow of water.

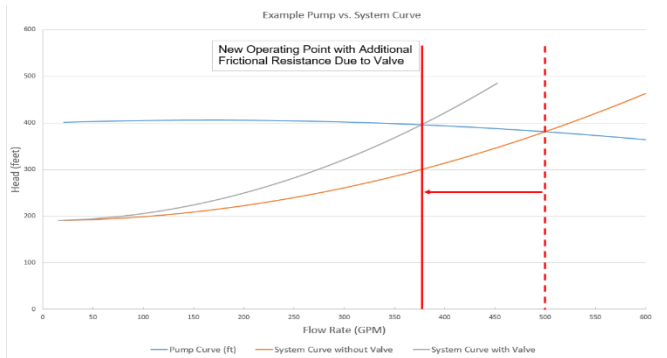


Figure 1 Pump vs System Curve

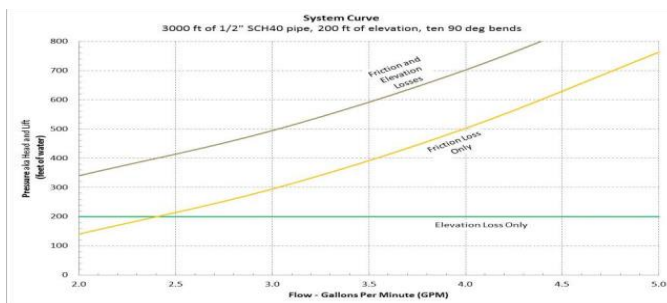


Figure 2 system curve

A. Flow

We use the word flow not only for liquid, but for gas and electricity too. Flow is the moving of liquid or gas in regular manner. Here in this research, flow is use for the flow of water in a solar PV system for irrigation. It usually denoted in Gallons per minute (GPM) of gallons per hour (GPH). The relation of pressure with flow is inverse, an increase of pressure will decreases the flow and vice versa [5].

The relation of pressure and flow can be adjusted and tuned depending on the need of reach. If we increase the pressure in order to the reach the other end of the farm, the flow will be reduces and diameter of pipe will also be reduced at that end.

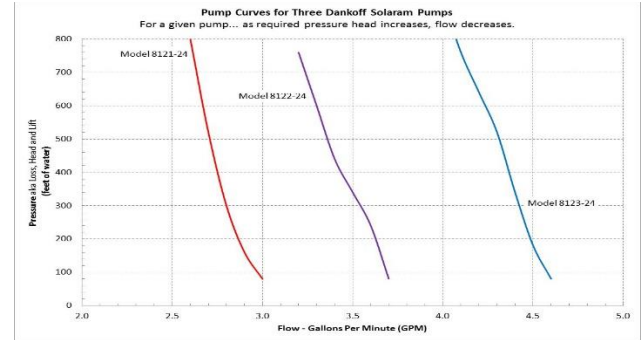


Figure 3 Flow variable in the solar powered water pumping system.

By Joining the pump and system curves help us in forecasting that whether the pump will do its function properly as desired or not. If we have the data of curves and all the plumbing system, by changing the flow rate we will get our operated point. The three pumps will deliver 2.75, 3.3, and 4.1 GPM correspondingly [6].

III. METHODOLOGY

A. Data Collection

Data was collected mainly through internet from verified and official national and international websites, for example:

- Alternate Energy Devolvement Board Pakistan (AEDB)
- Pakistan Agriculture Research Council (PARC)
- World Bank, Asian Development Bank (ADB)
- Different Punjab Government websites for renewable energy data
- Water Aid Globally
- Pakistan Council of Research in Water Resources (PCRWR).

B. Statistical data

Which are comprised of quantifiable data and are mainly associated with:

Climate of the subject area: 1, rain data. 2, temperature data. 3, humidity in the concerned area

- Global horizontal irradiation in Pakistan,
- Sunset and sunrise time, in other words. Length of day,
- peak solar hours
- population of the area
- Current food ratio in Pakistan, and future predicted food crisis data.

Past papers were studied based on solar PV system for irrigation. Data was collected from

- Ministry of National Food Security and Research (MNFSR)
- Pakistan Agricultural & Research Council (PARC)

- Read different research papers and websites on solar PV

Furthermore, parallel with data collection from internet a field visit was also conducted at Punjab where the solar PV system was already installed at some fields by Punjab Government, Pakistan, giving 80% subsidy.

C. Process and Refinement of Data

The data that was collected from different sources were gathered and analyze. Some of the data which was useful were further refined to the desirable statistical data. The solar Panels that were installed in different fields in remote areas of Punjab was get to know i.e. Yingli solar. This is a company solar manufacturing Chinese company. In our PVsyst simulation, same Yingli solar has been used to get the practical inclined results.



Figure 4 Solar Power Nameplate

As different place have different water depth and different water need. Based on the crops, season (time of year), altitude, temperature, and humidity in the air [6]. The average Water depth was selected and the area was selected Punjab.

Tilt for summer and winter was also calculated based on the latitude of Punjab –Pakistan.

D. Analysis of Computer Simulated Results

Its detailed analysis based on its performance and economic investigation that will help the country in agriculture, alternative energy and food sector.

E. Visit data

A wheat field in Punjab was selected. Where the drip irrigation was installed for wheat field. It was single time investment. The payback was calculated, which was 6 years.

The field was 22 acres. Two motors were installed one was 4 kW and another was 7.5 kW.

For 4 kw, the PV system which was installed has output power of 5.4 kw. The margin which was left was 1.4 kW for cloudy days and undesired situation

I. for Pump 1:

There were two foundation. Foundation 1 has 8 solar PV Panels each of 320 watts. And on foundation 2 has 10 solar PV

Panels each of the 320 same voltage. Combine, they were giving the output power of 5760 watts. The motor pump which was installed for irrigation was of 4 kW.



Figure 5 Pump 1 specification

The first foundation was giving a total output power of 5760 watts. The pump Siemens 1le10021ba234aa4 can easily be run by the installed 1st foundation. The extra 1760 were left for the situations like cloud and dust, in which the output power reduce.

For Pump 2:

There were four foundations as the pump needed relatively more power than the first one. Foundation 1 and 3 has 6 solar PV Panels each of 320 watts.

And on foundation 2 and 4 has 10 solar PV Panels each of the 320 same voltage.



Figure 6 Pump 2 specification

Combine they were giving the output power of 10240 watts. The motor pump which was installed for irrigation was of 8.6 kW.

The first foundation was giving a total output power of 10240 watts. The pump Siemens 1LE0102-1CA1-8.6kw can be easily be run by the installed 2nd foundation. The extra 1640 were left for the situations like cloud and dust, in which the output power reduce so that the pump does not lag behind.

The polycrystalline solar panels from yingli solar were installed. The characteristic and quantity is given below Table.1 in tabular form.

All the wiring was done underground. The total cost of the installed setup was approximately 1.5 Million Pakistani Rupees. From the visit the researcher got the data that later used in computer simulation through PVsyst.

Table 1 Characteristic of Yingli Solar Panel 360 Watt

Characteristic	quantity
TC Power Rating	320W
PTC Power Rating	298.3W 1
STC Power per unit of area	15.3W/ft2 (164.9W/m2)
Peak Efficiency	16.49%
Power Tolerances	0%/+5%
Number of Cells	72
Nominal Voltage not applicable in this type	
I MP	8.64A
V mp	37V
I sc	9.18A
V oc	46V
NOCT	46°C
Series Fuse Rating	15A
Maximum System Voltage	1000V

For simulation in computer, there were some data obtained from different sources as discussed already in portion of data collection. Peshawar Valley was selected for simulation [7].

CONCLUSION

The data obtained from the farm where the Solar PV system for irrigation installed at farm was compared to the results of the simulation results obtained from PVsyst software by running the system of the same specifications. The problem identified (i.e increase in the volume of storage tank, shaded effect) above was rectified by following the recommendation of the software which consequently resulted in increment of the efficiency. It was identified that if following the recommendation the per unit cost of solar power is way cheaper than the diesel operated irrigation system and can further be reduced. The pay back period was calculated as 14 years.

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