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# The comparative study on diesel and photovoltaic water pumping system for different crops

**P.Wilson*, T.Arun Srinivas, M.Sasi Kumar**
Department of Electrical & Electronics Engineering, Jeppiaar Engineering College, Chennai
***Corresponding author: Email: wilsoneeejpr@gmail.com**

**ABSTRACT**

This paper analyses the feasibility of using Photovoltaic based water pumping system in agricultural sector to produce the yield with low cost. Where photovoltaic technology is used to convert solar energy into electrical energy and electrical energy is used to operate a submersible pump. This pump supplies water for husbandry. This paper also compares the irrigation cost with diesel and photovoltaic irrigation systems. The investigator has collected data concerning required water height during farming of crops and then has estimated water volume for 1 hectare of land. Afterward, a solar operated and diesel operated pump are chosen with same power ratings (5 hp). Water is pumped to specific area of irrigation using these pumps for different crops and water volume is estimated. Finally, total cost of irrigation is estimated for a period of ten years and analyzed. This study reveals that Solar PV based water pumping system is best for the corps like lentil, strawberry, sunflower, soya bean, cotton, wheat and rice etc compared to diesel powered irrigation system.

**Keywords:** Agricultural sector, diesel and photovoltaic irrigation systems, irrigation cost comparison

## INTRODUCTION

Because of the fossil fuel resources decline and their great share in environmental pollution and issues, the countries and investigators are looking for green energy resources based on each region's potentials. Until now many kind of renewable energy sources such as solar, wind and others are utilized for power generation. Generally, to meet electricity demand using green energies there are two steps followed. Firstly, finding renewable energy resources in a special region, secondly, to utilize these energy resources economically and expeditiously, as a tropical country, India ventures with desert supply of solar energy. The range of radiation is between 4 and 6.5 kWh/m2/day and the intensity of sunshine varies from 6 to 9 hours/day. Furthermore in India, 64% of cultivated land is dependent on monsoons. However the huge area of cultivable land which is needed to be irrigated has no grid connection. Photo Voltaic pump could be used for irrigating these lands for better crop production. The study presents the scenario of solar pump irrigation system in India along with its economic production. This study presents the advantage of solar pump irrigation system in India along with its economic feasibleness for different crop cultivation. The government plans to install one lakh solar pumps for irrigation and drinking water purposes in the country, in a bid to expand the country's irrigated land area and boost food production, while limiting its trust on fossil fuels. Once established, the planned 18,750 solar-powered pumps will water an additional 3602.6037 acre land without the aid of any power grid or fossil fuel. 675 MW hours of electricity is saved per day with the help of solar panel and also it reduces the imports of diesel fuel by 47,000 tons yearly, saving $45 million annually, and reduce carbon dioxide emissions by an annual 126,000 tons. The main purpose of this study was to perform an economical evaluation of different cultivated crops in India for 10 years time period using both diesel and PV water pumping systems and hence to find out which crops are feasible to the newest and environment eco friendly method of irrigation process.

## PV TECHNOLOGY

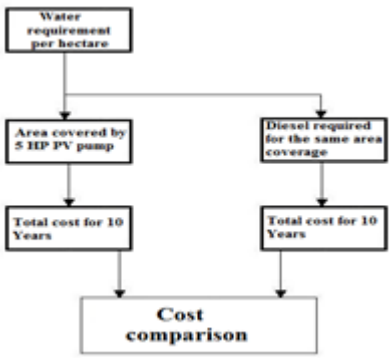
The Photovoltaic system is an integrating system in addition to the photovoltaic modules, also the converting systems are used to concert DC voltage to alternating voltage; and these system elements are: Photovoltaic cells convert the light energy into electrical energy. They are made using semiconductor IC technology. More number of photovoltaic cells are connected together to form larger units called modules. By connecting modules parallel and series, the larger unit can be formed. A battery bank is used to store the produced electrical energy and it is used to maintain constant output, and makes the energy available at night. The current flow is reversed by a voltage regulator to prevent the battery form overcharge and over discharge. The battery voltage is converted into AC voltage using an inverter circuit. Electrical load consumes power from PV system. This system provides better solution for rural areas for pumping water from well or bore well. Solar power system uses solar panel DC to AC convertor battery pump controller and storage tank. The pump can be operated with battery bank or without battery bank. It is the feature of PV based pumping system. The pump controller controls the water pumping operation. It converts the solar energy into electrical energy with oscillation. During morning time, pump will be rotated slowly due to low density of sunlight. The rotational speed of pump motor will be increased when sun shines bright.

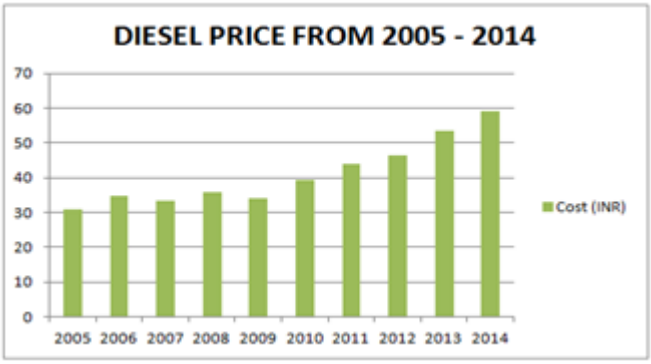
**Water Requirement for Plant:** Solar pumping system helps us to irrigate where the agriculture is impossible. Drop irrigation system supplies water to plants for increasing the plants yield. It is also used to protect the plant from over heat and monsoonal climate. The process of irrigation system is varied with respect to corps. The irrigation process in India as follows,

**(i) Furrow Irrigation system:** In this irrigation system, the parallel grooves are taken with slope. The water enters through the peak and flows towards the other end due to gravity force.

**(ii) Basin Irrigation system:** This system is used where the earth surface is flat basin irrigation system is used in small areas. In this the water enters rapidly to the basin system. The water requirement of the plant depends on water. Absorption, climatic conditions rain water availability and so on. It is the water requirement of plant for a period of time. The water level should be restored four days once six days once based on soil.

## METHODOLOGY




The dates are gathered from many other sources like research papers, books, and web pages. In this study the solar system operates without battery bank. The pump is supplied from solar panel. The total cost is compared for 10 years using PV system and diesel water pump .The cost is calculated for the specified area by 5 HP pump and then cost is calculated for the same area coverage by diesel pump. The warranty period for solar pump is 10 years .so the cost is compared for 10 years. The rising prices of diesel are also considered as 10 percentages per year.

## ANALYSIS OF THE STUDY

The under mentioned calculations are used to analyze the cost requirement for PV based pumping system and Diesel engine based pumping system.

**Water Volume Calculation:**

**Basin Irrigation system:**

$$\text{Water volume} = \text{Required Water height} \times \text{Area}$$

**Furrow Irrigation system:**

$$\text{Water volume} = \{[\text{Water height required} \times \text{Distance between bed} \times \text{No.of.Grooves} \times 100 \div 100] \div 100\}$$

Where,

$$\text{No.of.grooves} = \{[100 - \text{Distance between bed} \div 100] \div \{(\text{bed width} + \text{Distance between bed}) \div 100\} + 1\}$$

**Cost calculation for solar pump system:**

$$\text{Cost of first year} = \text{Pump cost} + 5\% \text{maintenance cost}$$

$$\text{Future Maintenance cost} = \text{Future value}/(1+i)\text{^}n$$

Where, i = inflation rate, n = Number of year

**Table.1.Cost Calculation for a 5 HP solar Pump**

| Cost of the solar system (Panel+Pump) | | 220000 |
|---|---|---|
| **Maintenance cost at present** | Year 1 | 211000 |
| | Year 2 | 9999.99 |
| | Year 3 | 9090.91 |
| | Year 4 | 8264.45 |
| | Year 5 | 7513.14 |
| | Year 6 | 6830.13 |
| | Year 7 | 6209.21 |
| | Year 8 | 5644.74 |
| | Year 9 | 5131.58 |
| | Year 10 | 4665.07 |
| Total Present Value (INR) | | 274349.22 |

**Cost calculation for Diesel pump system:**

First year cost = Pump cost + (Diesel requirement X No.of.irrigations in a corp cycle X Present diesel rate)X3

Cost(second year onwards) = (Diesel requirement X No.of.irrigations in a corp cycleX Present diesel rateX3) + 5% Maintenance cost

**Covered Area Calculation (Hectare):** Area covered = Discharge rate ÷ Water volume

**Table.2.Water Calculation for Different Crops**

| Corp Name | Irrigation Type | Bed width | Bed distance (cm) | No.Of Grooves | Water height Requirement | Volume of water ($m^3$/hectare) |
|---|---|---|---|---|---|---|
| Rice | Basin | NA | NA | NA | NA | 850 |
| Wheat | Basin | NA | NA | NA | NA | 700 |
| Cotton | Basin | NA | NA | NA | NA | 700 |
| Soya bean | Basin | NA | NA | NA | NA | 600 |
| Sunflower | Basin | NA | NA | NA | NA | 800 |
| Strawberry | Basin | NA | NA | NA | NA | 600 |
| Lentil | Basin | NA | NA | NA | NA | 500 |
| Mustard | Basin | NA | NA | NA | NA | 300 |
| Potato | Furrow | 25 | 60 | 117.9 | 4 | 283.1 |
| Maize | Furrow | 110 | 30 | 72.2 | 7 | 151.7 |
| Onion | Furrow | 100 | 30 | 77.7 | 2.5 | 58.3 |
| Tomato | Furrow | 100 | 30 | 77.7 | 3.5 | 81.6 |
| Sugarcane | Furrow | 120 | 30 | 67.5 | 12.5 | 235 |
| Chilly | Furrow | 100 | 30 | 77.7 | 5 | 116.5 |
| Carrot | Furrow | 100 | 30 | 77.7 | 5 | 116.5 |
| Garlic | Furrow | 90 | 30 | 84.1 | 6.5 | 164 |
| Brinjal | Furrow | 100 | 30 | 77.7 | 3 | 69.9 |
| Ginger | Furrow | 100 | 30 | 77.7 | 3.5 | 81.6 |
| Turmeric | Furrow | 90 | 30 | 84.1 | 4.5 | 113.5 |
| Pumpkin | Furrow | 330 | 30 | 28.7 | 6 | 51.7 |
| Cabbage | Furrow | 90 | 30 | 84.1 | 5 | 126.1 |
| Cauliflower | Furrow | 100 | 30 | 77.7 | 4 | 93.2 |
| Banana | Furrow | 105 | 30 | 74.9 | 4 | 89.8 |
| Ladyfinger | Furrow | 100 | 30 | 77.7 | 3 | 69.9 |
| Papaya | Furrow | 200 | 30 | 44.3 | 5 | 66.5 |
| Ground nut | Furrow | 40 | 20 | 167.3 | 4 | 133.9 |

**Comparison between diesel and solar water pumping system**

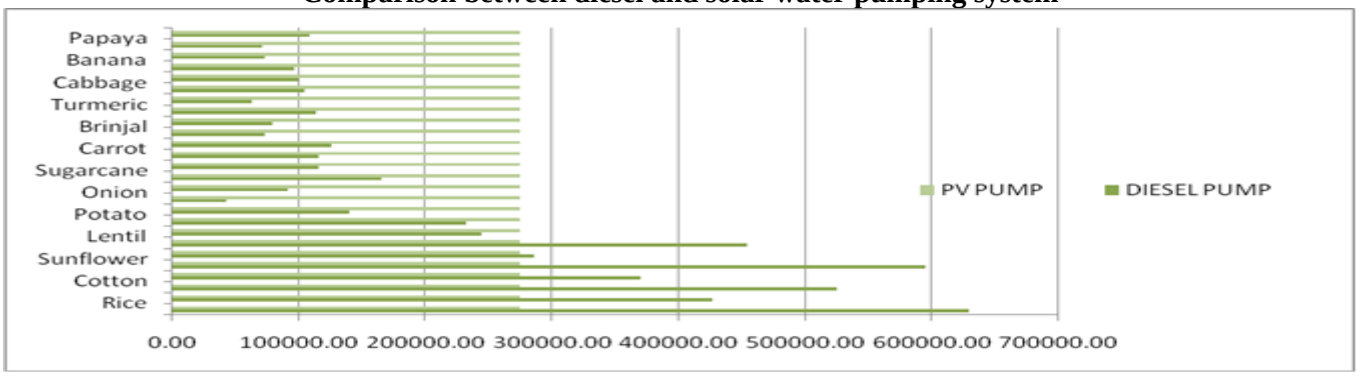



**Table.3.Cost calculation for diesel based water pumping system**

| Crop | Water Volume (m3) | Water Volume (L) | Diesel Requirement (L) | No.of Irrigation in a Crop Cycle | Cost Calculation for 10 Years | | | | | | | | | | Total Present Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | |
| Rice | 850 | 850000 | 96.59 | 5 | 78341.91 | 50593.89 | 48261.24 | 52115.18 | 49116.07 | 56852.92 | 63619.05 | 67183.22 | 77701.88 | 85598.11 | 629383.48 |
| Wheat | 700 | 700000 | 79.55 | 4 | 63044.87 | 33334.68 | 31797.78 | 34337.01 | 32360.99 | 37458.55 | 41916.54 | 44264.85 | 51195.25 | 56397.82 | 426108.34 |
| Cotton | 700 | 700000 | 79.55 | 5 | 70431.09 | 41668.34 | 39747.21 | 42921.25 | 40451.23 | 46823.18 | 52395.66 | 55331.05 | 63994.05 | 70497.26 | 524260.31 |
| Soyabean | 600 | 600000 | 68.18 | 4 | 58822.05 | 28570.20 | 27252.96 | 29429.27 | 27735.67 | 32104.65 | 35925.46 | 37938.13 | 43877.97 | 48336.94 | 369993.29 |
| Sunflower | 800 | 800000 | 90.91 | 5 | 75704.97 | 47618.71 | 45423.23 | 49050.54 | 46227.79 | 53509.68 | 59877.92 | 63232.50 | 73132.60 | 80564.49 | 594342.42 |
| Strawberry | 600 | 600000 | 68.18 | 3 | 52491.54 | 21427.66 | 20439.73 | 22071.96 | 20801.77 | 24078.50 | 26944.10 | 28453.61 | 32908.49 | 36252.72 | 285870.08 |
| Lentil | 500 | 500000 | 56.82 | 6 | 65154.42 | 35714.83 | 34068.19 | 36788.73 | 34671.61 | 40133.15 | 44909.44 | 47425.43 | 54850.67 | 60424.71 | 454141.18 |
| Mustard | 300 | 300000 | 34.09 | 5 | 49326.28 | 17856.39 | 17033.12 | 18393.31 | 17334.82 | 20065.42 | 22453.43 | 23711.35 | 27423.75 | 30210.61 | 243808.48 |
| Potato | 283.1 | 283060 | 32.17 | 5 | 48434.92 | 16850.70 | 16073.79 | 17357.37 | 16358.50 | 18935.31 | 21188.82 | 22375.89 | 25879.21 | 28509.10 | 231963.61 |
| Maize | 151.7 | 151650 | 17.23 | 5 | 41499.03 | 9025.12 | 8609.02 | 9296.50 | 8761.51 | 10141.63 | 11348.59 | 11984.38 | 13860.72 | 15269.28 | 139795.77 |
| Onion | 58.3 | 58270 | 1.28 | 6 | 34213.09 | 804.61 | 767.51 | 828.80 | 781.11 | 904.14 | 1011.74 | 1068.41 | 1235.69 | 1361.25 | 42976.34 |
| Tomato | 81.6 | 81580 | 9.27 | 5 | 37803.60 | 4855.68 | 4631.81 | 5001.68 | 4713.85 | 5456.37 | 6105.74 | 6447.80 | 7457.30 | 8215.12 | 90688.93 |
| Sugarcane | 235 | 235000 | 26.7 | 4 | 43416.38 | 11188.42 | 10672.57 | 11524.84 | 10861.61 | 12572.55 | 14068.81 | 14857.00 | 17183.10 | 18929.28 | 165274.56 |
| Chilly | 116.5 | 116540 | 13.24 | 5 | 39646.67 | 6935.16 | 6615.42 | 7143.69 | 6732.59 | 7793.11 | 8720.58 | 9209.13 | 10650.97 | 11733.34 | 115180.66 |
| Carrot | 116.5 | 116540 | 13.24 | 5 | 39646.67 | 6935.16 | 6615.42 | 7143.69 | 6732.59 | 7793.11 | 8720.58 | 9209.13 | 10650.97 | 11733.34 | 115180.66 |
| Garlic | 164 | 163960 | 18.63 | 4 | 40419.18 | 7806.77 | 7446.83 | 8041.50 | 7578.73 | 8772.54 | 9816.57 | 10366.53 | 11989.57 | 13207.97 | 125446.21 |
| Brinjal | 69.9 | 69923 | 7.95 | 4 | 36452.63 | 3331.42 | 3177.82 | 3431.59 | 3234.11 | 3743.55 | 4189.06 | 4423.75 | 5116.35 | 5636.28 | 72736.56 |
| Ginger | 81.6 | 81570 | 9.27 | 4 | 36942.88 | 3884.55 | 3705.45 | 4001.35 | 3771.09 | 4365.11 | 4884.60 | 5158.25 | 5965.85 | 6572.11 | 79251.24 |
| Turmeric | 113.5 | 113510 | 12.9 | 5 | 39488.83 | 6757.07 | 6445.54 | 6960.25 | 6559.70 | 7592.99 | 8496.64 | 8972.65 | 10377.46 | 11432.03 | 113083.13 |
| Pumpkin | 51.7 | 51650 | 5.87 | 4 | 35680.12 | 2459.81 | 2346.41 | 2533.78 | 2387.97 | 2764.12 | 3093.07 | 3266.35 | 3777.75 | 4161.65 | 62471.01 |
| Cabbage | 126.1 | 126125 | 14.33 | 4 | 38822.16 | 6004.89 | 5728.04 | 6185.45 | 5829.49 | 6747.76 | 7550.81 | 7973.84 | 9222.26 | 10159.45 | 104224.16 |
| Cauliflower | 93.2 | 93230 | 10.59 | 5 | 38416.41 | 5547.09 | 5291.34 | 5713.88 | 5385.07 | 6233.32 | 6975.15 | 7365.92 | 8519.18 | 9384.91 | 98832.28 |
| Banana | 89.8 | 89822 | 10.21 | 5 | 38239.99 | 5348.05 | 5101.48 | 5508.86 | 5191.84 | 6009.66 | 6724.87 | 7101.62 | 8213.48 | 9048.15 | 96487.98 |
| Ladyfinger | 69.9 | 69930 | 7.95 | 4 | 36452.63 | 3331.42 | 3177.82 | 3431.59 | 3234.11 | 3743.55 | 4189.06 | 4423.75 | 5116.35 | 5636.28 | 72736.56 |
| Papaya | 66.5 | 66521 | 7.56 | 4 | 36307.78 | 3167.99 | 3021.93 | 3263.25 | 3075.46 | 3559.90 | 3983.57 | 4206.74 | 4865.36 | 5359.79 | 70811.77 |
| Groundnut | 133.9 | 133867 | 15.21 | 4 | 39148.99 | 6373.65 | 6079.79 | 6565.29 | 6187.48 | 7162.13 | 8014.50 | 8463.50 | 9788.60 | 10783.33 | 108567.28 |

## FINDINGS AND CONCLUSION

The study reveals that Solar PV based water pumping system is best for the corps like lentil, strawberry, sunflower, soya bean, cotton, wheat and rice etc. The Diesel based water pumping system is best for the corps like ground nut, papaya, lady finger, banana and cauliflower etc.

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