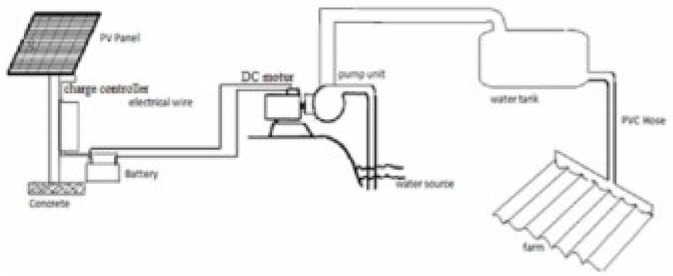
Solar Pump

Designing and Developing Solar Energy Operated Water Pump for Small Scale Irrigation:

The purpose of this project is to construct solar energy operated water pump for small scale irrigation. The main contribution of the project is to; reduce the environmental pollution due to the exhausts emissions from conventional water pumps used for small scale irrigation and reducing the foreign currency by reducing the amount of conventional fuel which is imported to operate different mechanical engines including water pumps for irrigation purpose. The conventional water pump has high noise especially if it is diesel engine which affects the wild animals and migrating them from the area. In addition to that the conventional fuel which is used to operate the water pump engine should be transported to the farmer and if leaks on farm land it contaminates the farm affecting the final product.

The project location is Bathinda city in Pumjab which is situated on the geographical location latitude 30.2110°N and 74.9455°E ,elevation is 210 m above sea level. The average temperature of the town is 24.5°C and the wind is blown at a speed of 1.5 m/s to 3 m/s, average humidity of the town is 34.9%, atmospheric pressure 1008.8 mb. This town cloud is around 25%.



Schematic of Solar powered water pumping

Every design is proceeding from energy design. Pumping is the hydraulic energy required to deliver a volume of water. This hydraulic energy in joule can be calculated by the following formula:

$$E: \rho g V h$$

Where, E: the hydraulic energy; P: density of water; G: gravity of the water; V: volume of water; H: head of the pump;

The required energy pumps highly depend on the demand of water and the head of water level. The quantity of water then increased by increasing the water pump horse power and the electrical energy which is controlled by the solar panel and intensity of solar radiation. Parameters to be considered during project implementation to have better pumping efficiency are as follows:

1) The density of water: As the water density increase due to the content of sand and mud, its flow rate is highly affected. The water with more sand and mud it may clog the waterline and pump.
2) Section head: Head height from water to reservoir will determine the power required to pump the water from the ground.
3) Size of field: The size of the land will determine the required water for irrigation which sizing the pump and the tank.
4) Solar radiation: The efficiency of the solar panel is depended on the light intensity arrives on the panel. If more radiation is available on the field the induction of DC current in the solar cell will be more.

Solar panel:
The solar panel which is selected to perform the project is DC photovoltaic (PV) cells which are made of semi-conducting materials that convert the sun light ray directly to electricity.The purpose of photovoltaic panel is to convert the sun light which is abundantly found in to electrical energy. For this project, the size of the PV is 0.56 m² of three 12 V series connected batteries and 60 w. The ratio of proto type is three to one the area of one PV panel is 0.18 m².

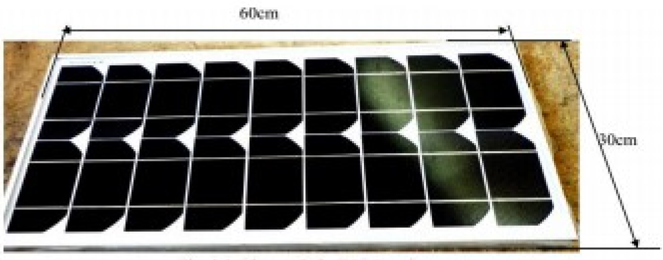


FIG. 3. **Photovoltaic (PV) panel.**

Pumping Motor:
There are different types of electrical motors which are designed to perform different tasks. The electrical motor which is designed to perform this project is brushless direct current (BLDC) motor . The BLDC motors are one of the electrical motor types rapidly gaining popularity and are used in industries and are found in the market.
As the name implies the BLDC motors do not use brush for commutation, instead they are electronically commuted and have many advantages over that of brushed direct current motors such as:
1) Better speed vs. torque characteristics;
2) High dynamic response;
3) High efficiency;
4) Long operating life;
5) Noiseless operation;
6) Higher speed
ranges

The pumping system sizing for the motor is determined by the power required to move the water. So, to select the motor the researchers should determine;
1. How high the water needs to be pumped;
2. How much water is needed per day;
3. How fast the water needs to be pumped, i.e., the nominal flow rate of the pump (per minute or second) and whether it is compatible with the well/spring capability;
4. For solar: Available solar energy (PSH/kWh/m²).
Depending on the above parameters the power of the pump which is selected for the project is BLDC motor having 0.442 Nm with 825 w.

Pumping elements:

The pumping elements which are known as impellers are components which are used to suck and pressurize the water to move to the expected place in this project reservoir. The type of impeller which is used for this project is centrifugal pumping impeller which is fixed on the brushless dc motor by using some modifications on the electrical motor.

Storage battery:

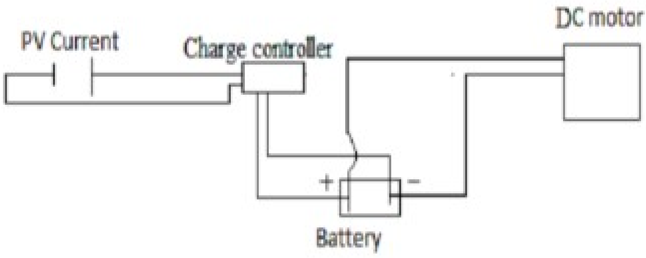
The solar storage battery stores the electrical energy in the form of chemical energy. This chemical energy is then performing electrical tasks when the circuit is completed. For this project, the storage battery which is used is 12 V, 20 Ah and come to operation when there is no sun light or the sun is covered with cloudy and the pumping motor is needed to operate . The most common type of battery found in PV system is the lead acid battery. Therefore, the storage battery that is used is lead acid class of battery, because this type of battery has higher performance characteristics and suitable for air transportation.

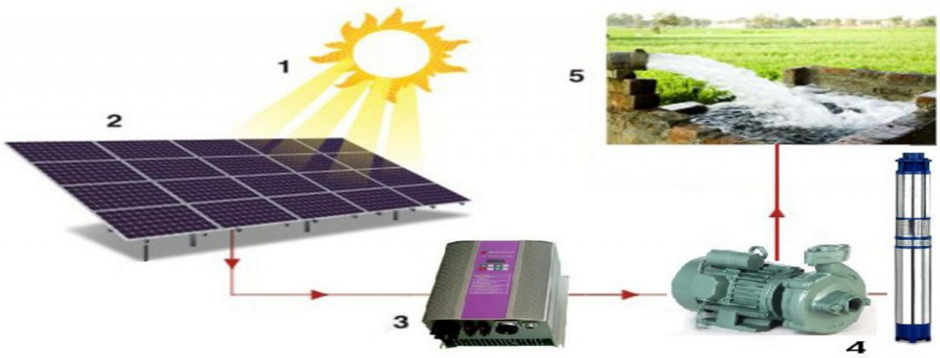
Charge controller:

The charge controller is the component in the circuit which is used to control the condition of the charging, that is whether the storage battery is fully charged, 50% charged or discharged and controls the panel itself indicating whether the panel is in operation or not . Solar charge controller. In addition to this the charge controller monitors the state of charge of the battery bank, the charging process and the connection/disconnection of loads.

Circuitry diagram of the system:

The schematic diagram below shows that the circuits from solar to the solar operated water pump.





Design and calculations of the project system:

<u>Water Requirement:</u>

Total volume of water reqd. =

Water reqd./week = total farm area × water reqd./sq m/week

Total farm area = 1 hectare

= $10000\ m^2$

$1\ m^2$ requires 5 gallons/week

Water reqd./week = 10000 × 5

= 50000 gallons/week

<u>System layout:</u>

Intake point = ·5m in depth

Pump location = mount on dry surface at 1m from water surface

Water tank place = 3m above water surface

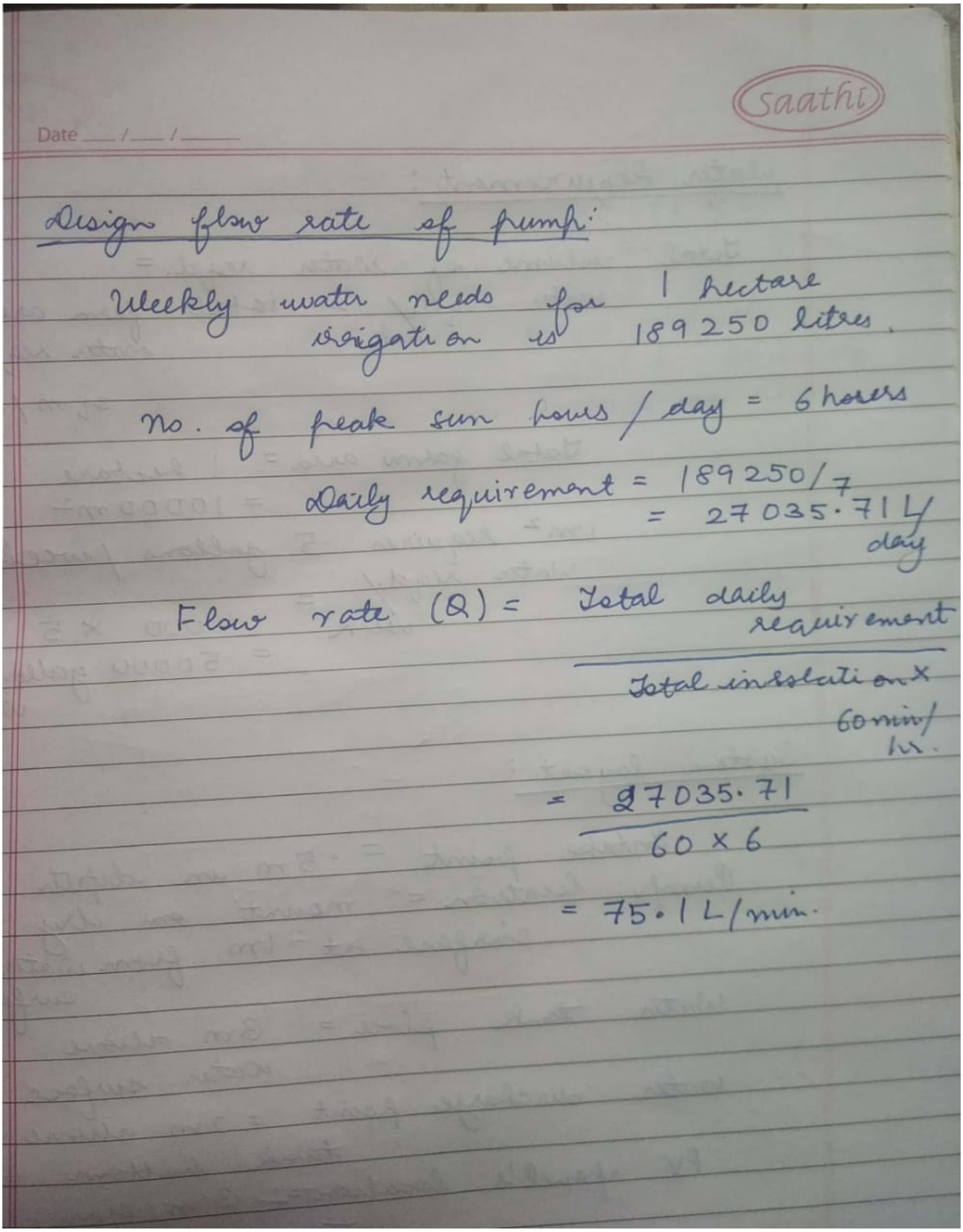
water discharge point = 2m above tank bottom

PV panel's location = 3 m from battery (south facing)

depth of water source = 1·5m

distance b/w pump & water tank = 6m

Solar insolation and PV panel installations on site:
Most of solar panels installations for water pumps are stationary and oriented due south to take advantage of the maximum sunlight available in the middle of the day. The default tilt angle for a PV panel is equal to the latitude of the location. For a fixed array, this default angle will maximize annual energy production.
A tilt angle of +/-15 degrees from latitude will increase energy production for the winter or summer months, respectively.
• Summer tilt angle=latitude-15° (when the sun is higher in the sky).
• Winter tilt angle=latitude+15° (when the sun is lower in the sky).



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Design flow rate of pump:

Weekly water needs for 1 hectare irrigation is 189250 litres.

no. of peak sun hours / day = 6 hours

Daily requirement $= 189250/7$
$= 27035.71$ L/day

$$\text{Flow rate } (Q) = \frac{\text{Total daily requirement}}{\text{Total insolation} \times 60\ \text{min/hr}}$$

$$= \frac{27035.71}{60 \times 6}$$

$$= 75.1\ \text{L/min.}$$

Total dynamic head (TDH) for the pump:
To determine the pump's TDH by using the following equation:
Total dynamic head (m)=Total vertical lift (static head)+HL+friction loss
Where, Vertical lift: is the difference between the water surface at the intake or suction point and water surface at the delivery point.
Water depth is 1.5 m from deep surface of the water, the distance between pump and suction point is 1 m.
Distance between pump and maximum elevation is 3 m and the tank height is 1.5 m.
Vertical lift=0.5 m+3 m+2 m=5.5 m
Frictional loss=0.51m
TDH=5.5 m+0.51 m=6.01 m

Pump selection and associated power needed:
The pump can be selected by comparing the design flow rate and calculated TDH. The project team select surface (or centrifugal) pump, because this pump is suitable for areas for which the water level is within 7 m below ground level. Surface pump is suitable for pumping from lakes and canals. This selected pump is solar pump that driven by a permanent DC motor which is connected directly to an array of solar panels.

Pump selection and associated power needed:

$$\text{Hydraulic energy} = \frac{V \times H \times \rho w g}{3.6 \times 10^6}$$

$$= .44 \text{ Nm}$$
mechanical

$$HE(\text{watts}) = .44 \times 746$$
$$= 330 \text{ Watts}$$

$$\text{efficiency} = 40\%.$$

$$HE(\text{reqd.}) = 330 / .4$$
$$= 825 \text{ W}$$

Hydraulic workload:

Hydraulic work load is calculated by multiplying TDH in unit of meter with daily water requirement in unit of volume. Hydraulic workload is an excellent indication of the power that will be required to meet the system needs.

Hydraulic workload (m^4)=Daily water volume (m^3) × TDH (m) Daily water requirement=27,035.71 L/day =27.04 m^3

TDH=6.01 m

Hydraulic workload (m^4)=27.04 m^3 × 6.01 m=162.5 m^4

Submitted by:
Khushi
18115051
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