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Water Purification Using Solar Energy

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Abstract - Drinking Water is important need for daily life as there is scarcity of water in many regions worldwide. Across the world approximately 780 million people do not have access to pure water for drinking, cooking or washing. Consumption of untreated industrial water exposes human beings to a range of contaminants including faecal borne pathogens and chemical pollutants. But the quality of water should be such that it can be used by human being for drinking purpose. There are already lot of filters present in the market that can do purifying process, as the available filters made water safe to drink, but they did not decrease its saltiness, so the drinking water is still salty and eroded pots and pans, that providing little awareness to use these filters. In desalination process the removal of salt and other minerals from the ground water is carried out to make it suitable for human and animals use and industrial use. RO is mostly used domestic filtration system that removes even all the impurities. RO is required if the Total Dissolved Solids (TDS) exceeds a value of TDS of 500. The ultimate objectives of this project is to use the conventional source of energy, make a device/equipment which provide water for drinking purpose and designed a village level water purification system that runs on solar power.

Key Words: **Drinking Water, RO, Solar power, Total Dissolved Solids (TDS), Desalination.**

1.INTRODUCTION

The decreasing availability of fresh water has necessitated in the search for fresh pure sources of drinking water. The water availability in many areas in the country is brackish, saline or impure. Saline water is a major problem in the coastal areas of Kutch and Gujarat. In India pure drinking water is a major problem in tribal/rural area. The available water purification processes in rural india are Chlorine tablets, Pot chlorination of wells, Slow and rapid sand filters, Fluoride removal, Reverse osmosis plants, etc. In this project, we are making a water purifier which works on solar energy. The basic working principle of this project is reverse osmosis. We are using renewable source solar energy which is a abundant and cheap. Here, we use solenoid valve which prevents the water from over flowing. This purifier is suitable to use in remote and rural areas where there is no electricity. It must be used in places affected by natural disasters. It provides pollution free water purifier.

1.1.Objectives of Project :-

1.Provide Fresh Drinking water.
2.Avoid waterborne diseases especially in rural India.
3.Using renewable sources of energy.
4.Affordable purification for the poor.
5.Less maintenance system.
6.Utilizing Solar Power to provide the facility to remote places.
7.Provision of utilizing excess energy elsewhere(power house ,machines etc).
8.Cheaper provision of safe water.
9.To Maximize the use of renewable energy for day to day activities.
10.To provide clean and pure water for rural India.

2. Solar PV system design

The solar rays are collected by solar panel. This energy is further stored in a solar battery through a charge controller. The charge controller is the device which saves the battery from getting overcharged. The water purification unit includes s high pressure motor, reverse osmosis system and the water tank. The high pressure booster pump creates the necessary pressure required to carry out reverse osmosis.

Typically water filter of 25 LPH capacity consumes 60W electricity. Mostly we use water filter for average 5 hours daily.

Total Energy required/year = 60Watt X 5hours X 365days
=109500Watt-hours/year
= 109.5 kilo-Watt-hours/year
= 109.5 units.

Annual full sun hours (india) = Avg Daily Full sun hours X 365
= 5h/d X 365d/y
= 1825 hours/year

Size of Photo Voltaic system= (Annual Energy Demand/Annual Full sun hours) / Efficiency of System. (Assuming a 25% loss during PV generation and conversion. Therefore, efficiency of the system after we take into account those losses is 75% .

Therefore, PV system size = 0.08kW

PV system size = 80 watts.

No. of Panels required = PV system size / Module power.
= 80W / 50

= 1.6 ~ 2.

Capacity of each solar Panel=50W.

So two panels of 50W capacity is required to design Solar water filter.

2.1 Solar Panel Specifications.

We have selected 2 solar panel of 50W each to power this purifier. The specifications of panel are as follows.

Properties	Carat 24 ZR 50W
Max Power (W)	50
Open Circuit Voltage (Voc) (V)	22
Short Circuit Current (Isc) (A)	3.28
Voltage at Maximum Power (Vmp) (V)	18.00
Current at Maximum Power (Imp) (A)	2.78
Fuse Rating (A)	6A
Maximum System Voltage	600 VDC
Dimensions (LxWxH) (mm)	540×665×34
Number of Cells per Module	36
Solar Cell's Dimensions (LxW) (mm)	52×156.75

Fig-1 Solar Panel Specifications

The solar panels consist of solar cells connected in series . The solar cells available in the market are of three types namely monocrystalline ,polycrystalline and thin film type .The Monocrystalline have high efficiency and are costly. Polycrystalline have moderate efficiency and have moderate cost .Thin film solar cells have lowest efficiency and cheapest solar cells but they are not good choice for this application so we chose polycrystalline solar cell solar panel.

3. Battery System Design Calculation

3.1 Calculation Battery Charging Time

Charging time of battery = Battery Capacity (Ah) / Charging Current.

$$T = Ah / A$$

Where,

T = Time hrs. Ah = Ampere Hour rating of battery.

A = Current in Amperes.

Practically, it has been noted that 40% of losses occurs in case of battery charging. Then 7.2 x (40 / 100) = 2.88 (7.2Ah x 40% of losses) .Therefore, 7.2 + 2.88 = 10.08 Ah (7.2 Ah + Losses).

10.08 / 2.78 = 3.62 or 4 Hours (in real case)

Therefore, a 7.2Ah battery would take 4 Hours to fully charge in case of the required 2.78A charging current.

3.2 Battery Run Time Calculation

Power (Watts) = I(Amps) * V(Voltage)

Therefore, Amps = Power/Voltage

=60/24 = 2.5A

Assuming that the battery is fully charged, then it will have the full 7.2AH capacity. 7.2AH (Amp Hours)/2.5Amps = 2.88 hours, or 2 hours and 53 minutes.

Battery Type	*VRLA*
Capacity (Ah)	7.2AH
Filled Weight	2.40
Voltage	12V
Sealed Type	Yes VRLA
Led Indicator	No

Table-1.Battery Specifications

3.2 Payback Period Calculation

General cost of electricity by different service providers in India =INR 7-11 /-

Considering maximum Possible Electricity fare (To have advantage) =11*109.5units =INR 1204.5.

Total Energy required for a year = 109.5 units.

Investment on solar components = INR 4000 /-

Payback period=4000/1205=3.3 years.

So 3 years and 4 months are required to get solar panel investment back.

4. Purifier Design

The design of water purifier consists of 7 stages. The water first enters sediment filter and it removes dirt , debris , rust ,sand slit and all other suspended particles from water. Then water enters the carbon filter and remove contaminants through adsorption and removes bad taste ,odor ,chlorine mercury and chemicals from water. Then water part of water is bypassed to Ultrafiltration filter and part of it enters into Ro membrane through Ro booster pump. The RO booster pump is a centrifugal pump with impellers that pull water in and increase the pressure as it passes through. The impeller rotates on an axis that pulls the water inside the pump and force it further. water entering, the curved vanes of the impeller spin push the water outward with centrifugal force. The Reverse osmosis process reduces total dissolved solids or suspended contaminants by 70-80% in water using pressure to push the unfiltered water, or brine, through a semi permeable membrane. The reverse osmosis membrane blocks the contaminants, and it will allow the clean water or permeate to flow through to the less concentrated side. A membrane housing for reverse osmosis membrane is typically 2.5 and 4 inches in diameter and either 14, 21, 40, 80, or 120 inches in length.

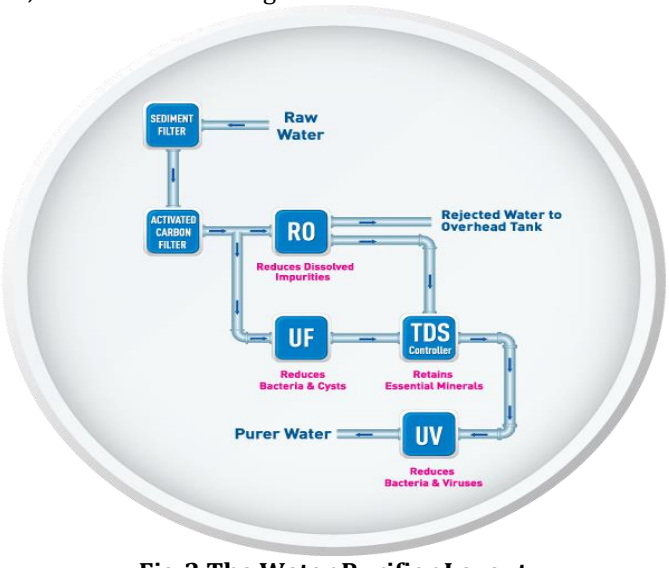

Fig-2.The Water Purifier Layout

These standard dimensions will allow the interchangeability of these membrane housings. Membrane housings is available in a variety of materials, such as PVC, stainless steel, and fiberglass in the market. Ultra filtration (UF) is a highly effective water purification process that uses standard home water pressure to propel water through a semi-permeable membrane. The ultra filtration membrane eliminates a host of contaminants, like lead, bacteria, viruses, chlorine, and any suspended particulate matter. The impure water from Ro is removed and discharge and can be used for general home purposes other than drinking. The pure water from Ro and pure water from UF enters at two ends of TDS meter. TDS Controller is a manual device which consists of one water output, two water inputs, and a TDS Control screw.

TDS Control screw controls the TDS present in output water by adjusting the flow of water from the two water inputs namely UF water and RO water. Total dissolved solids (TDS) is measured as a volume of water with the unit milligrams per liter (mg/L), and sometimes known as parts per million (ppm). According to the EPA secondary drinking water regulations,500 ppm is the recommended maximum amount of TDS for your drinking water. Any measurement higher than 1000 ppm is an unsafe level of TDS. If the TDS value exceeds 2000 ppm, then a filtration system may be unable to properly filter TDS. Water then enters into the UV chamber . A UV water purifier uses ultraviolet light radiations to disinfect water for home or industrial use. They deactivate harmful bacteria and viruses without using chemicals.

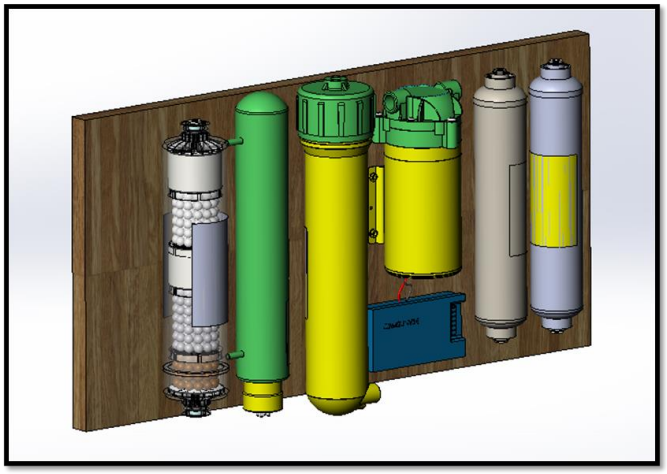

Fig -3. Purifier CAD Design

A UV from lamp of UV water purifier disinfects biologically unsafe water (lake water, seawater, well water, etc.) without using any chemicals. A UV water purifier has a steel chamber that encapsulates the UV Bulb . The UV lamp posses little beads of mercury that vaporize and fuel the lamp to emit UV radiation which in turn deactivates the bacteria and viruses and microorganisms. Two O-rings, held in place by the glad nut (or cap), hold the quartz sleeve to the chamber and prevent the leakage of water. UV water purification unit does not remove any physical contaminants from water. It deactivates 99.99% of microorganisms by altering their DNA means they will not reproduce and spread disease. As soon as UV light attacks the bacteria, they're no longer capable of infecting the water supply because they gets deactivated. Water further is discharged into alkaline cartridge . Research in the field of water has shown that alkaline water is the one of the best drinking water, and can even be better quality than expensive bottled water. In simple words, the alkaline filter separates the water into two categories : alkaline water and acidic water. The purity of the water filtered by the reverse osmosis system is acidic, all minerals are removed from the water. This alkaline filter increases PH of water , buffers water to a more natural alkaline state, and adds the necessary minerals, i.e. Calcium , magnesium , potassium and sodium.

We have used 24 volt DC Pump with 1.2Amps current rating. Pump has maximum operating pressure of 828 Kilo-pascal and minimum inlet pressure of 69 Kilo-Pascal. Similarly Carbon and sediment filter has maximum pressure of 862 Kilo-pascal and maximum temperature of 120 degree centigrade also they have maximum flow rate of 228 Liter/hour. UF filter has maximum flow rate of 114 liter/hour and maximum pressure of 760 Kilo-Pascal.

Pressure drop from Ro membrane is the loss of pressure from the feed end to the concentrate end of a module or a pressure vessel. During normal operation condition of Purifier the pressure drop for a commercial RO membrane element is about 4 to 5 psi (0.3 bar) per element. Pressure drop always increases with the extent of fouling of Ro membrane. A high pressure drop is problematic because it may lead to inefficient operation of water purifier, and thus a decline in system performance. The maximum allowable pressure drop in Purifier is 60 psi (4 bar) per 6-element array.

The replacement of sediment and carbon filter is therefore necessary to get pure water continuously. You should always change your sediment filter every six months to one year. However, the best way to understand when you're due for a filter change is to observe water pressure of system . When your system pressure starts to drop, you need to change the filter quickly. After the water filter system has captured enough sediment, water will struggle to pass through the filter at the same flow rate and it will cause water pressure to decrease. In general, carbon filters are needed to be changed after 18-24 months of regular (24/7) use**.** In less demanding situations, they can last up **to** 4 years but We cant guarantee for it. However, this lifetime of carbon filter depends on the carbon quality, usage, humidity, plant types **etc.**

Its obvious that , when your carbon filter will be out of order, it won't be able to trap the smelly particles anymore. So smells will come out

There are a plenty of uses for solenoid valves in RO, since a solenoid is a shut off valve, a solenoid could be used to shut down RO system when any storage system is full. A solenoid valve uses a plunger type piston to open and close an orifice, which either prevents or allows the flow of a medium.

5. Design for Solar Panel Adjustment

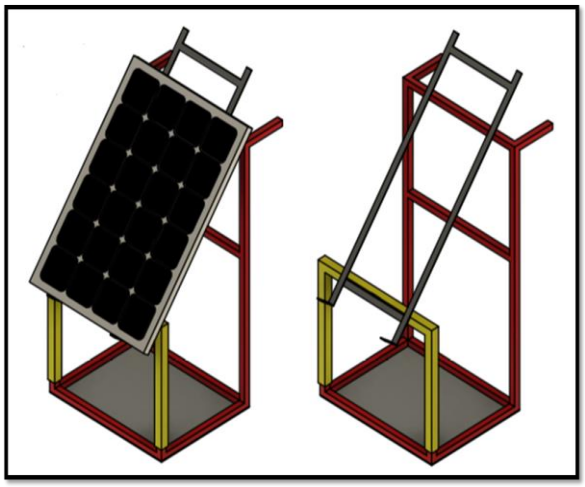

Fig-4.Adjustable Solar Panel Structure.

Design features of Body Frame

- To support water purifier system.
- To provide adjustable angle of inclination for solar Panel in different seasons.
- To support Battery system.
- To provide space to inlet water storage tank and purified water storage tank.
- External attached wheels will allow easy movement of body frame to desired location**.**

The solar panel angle of your solar system will vary depending on which part of the world you are. Solar panels will have the highest energy output when they are directly facing the sun. To achieve the most sun rays reaching the panel throughout the day, you need to determine what direction the panels should face and calculate an optimal tilt angle.

This will depend on:

- Where you live
- Which time of the year you will need the most solar energy.

The optimum tilt angle for solar panel at given location is calculated by adding 15 degrees to your latitude during winter, and subtracting 15 degrees from your latitude during summer. For example , if your location latitude is 34°, the optimum tilt angle for your location solar panels during winter will be 34 + 15 = 49°. The summer season optimum tilt angle will be 34 – 15 = 19°.

6. The Design of Solar Water Purifier.

The Design of Solar Water purifier has solar panel mounted on adjustable frame. The frame(Blue) can be moved up and down like socket. The frame can be fixed at any location using pin .This adjustment feature helps to incline solar panel at different angles at different seasons so as to acquire maximum efficiency. The bottom storage box has 2 sections one section stores inlet impure water and one section is needed to place batteries and charge controller. On the back face of stand purifier is fitted using nut and bolts and purified water is received from back side. Tap is provided to collect pure water.

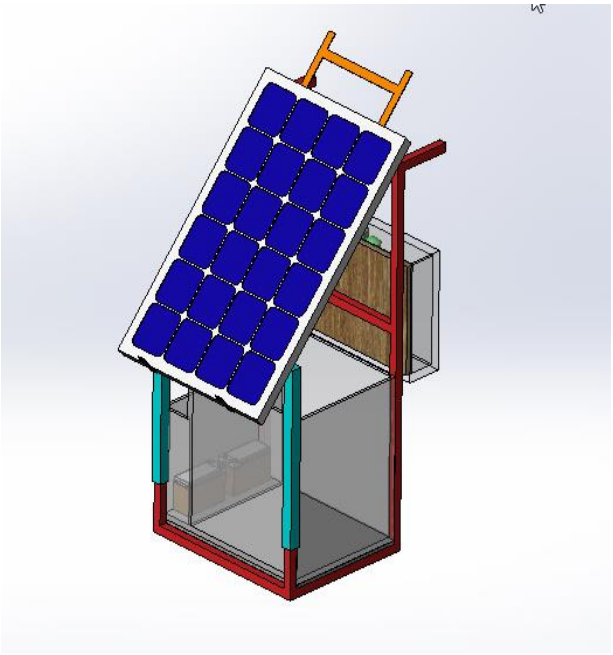

Fig-5 Water Purifier Design

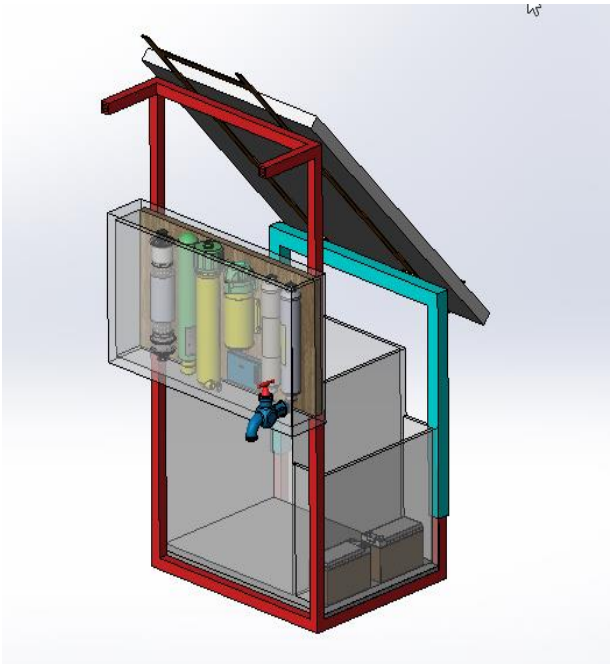

Fig-6 Water Purifier Design

Financial Benefits of Solar Water Purifier:-

- Zero Fuel cost
- One Time Investment

- ROI more than FD
- Zero bill for 25 years.

Environmental Benefits of Solar Water Purifier is equivalent to , Over the lifetime of 25 years , installing 1KWp Solar rooftop system is equivalent to mitigating 31 tons of carbon dioxide and planting 49 teak trees.

7. CONCLUSIONS

As sun's free solar energy is being used for the purification of water, which is cheap and abundant, it can be used everywhere where electricity is not available. Here, the controller which is used also prevents the water from overflowing. Moreover, reverse osmosis is a good water hardness removing process. So we designed the photovoltaic system , battery system , structural design for water purification system and we have analyzed the benefits of photovoltaic system along with case study and environmental benefits. We have also specified types of solar cells available in market and we have compared them with different points and selected suitable one. This project has only capital cost and almost no running cost. Hence, It will prove to be useful in the near future.

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