iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** V **Month of publication:** May 2024

DOI: https://doi.org/10.22214/ijraset.2024.62621

Solar Based Water Purification System

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Abstract: Solar-based water purification is an innovative and sustainable method leveraging solar energy to produce clean drinking water from contaminated sources. This approach integrates various technologies, primarily solar distillation, solar disinfection (SODIS), and solar-powered filtration systems.
Index Terms: Solar panel, Water tank, RO pump, sediment filter, carbon filter, battery, solenoid valve, frame

I. INTRODUCTION

A solar water filter is an eco-friendly system that uses solar energy to purify water, providing a sustainable solution for clean drinking water. It typically consists of solar panels that convert sunlight into electricity, powering various components such as pumps, UV purifiers, and filtration units. The system often includes a sediment filter to remove larger particles, a carbon filter to eliminate chlorine and organic compounds, and a reverse osmosis (RO) membrane for removing dissolved salts and contaminants. Additionally, a battery may be integrated to store solar energy, ensuring continuous operation during low sunlight conditions. This innovative technology is particularly beneficial in remote or off-grid areas, offering a reliable and environmentally friendly way to ensure safe water supply.

II. COMPONENTS

A. Solar Panel

A solar panel used in a water filter system harnesses sunlight to generate electricity, which powers the filtration process. This sustainable energy source is particularly useful in remote or off-grid areas, providing a clean, renewable way to ensure safe drinking water. The solar panel converts sunlight into electrical energy, which is then used to operate pumps, UV purifiers, or other filtration technologies within the water filter system, making it an eco-friendly and efficient solution for water purification.

B. Water Tank

A water tank for storing water to be filtered is an essential component of a water filtration system. It serves as a reservoir, holding raw water that will undergo the filtration process. These tanks can be made from various materials such as plastic, steel, or concrete, and come in various sizes to meet different needs. The stored water is then fed into the filtration system, where it is purified and made safe for consumption. These tanks are particularly useful in areas with intermittent water supply, ensuring that there is always a supply of water available for filtration. Electric Throttle and Brake

The electric throttle has three connections – a 5V supply, a ground wire and an analog output which varies depending upon the degree to which the throttle is rotated. The first and the second connections are given from the motor controller while the analog output is connected to the analog input of the microcontroller. The analog output varies from 1V to 4V. The mechanical brake is fixed to the hub
motor.

C. R.O pump

An RO (Reverse Osmosis) pump is a crucial component of a reverse osmosis water filtration system. Its primary function is to increase the pressure of the water entering the RO membrane, which is essential for efficient filtration. By boosting the water pressure, the RO pump helps the system overcome the natural osmotic pressure and forces water through the semi-permeable membrane. This process effectively removes contaminants such as dissolved salts, bacteria, and other impurities, resulting in clean, safe drinking water. RO pumps are especially beneficial in areas with low water pressure or when a higher volume of purified water is needed.

D. Sediment Filter

A sediment filter is a type of water filter designed to remove suspended solids, dirt, sand, silt, and other particulate matter from water. It is typically the first stage in a multi-stage water filtration system, including systems like reverse osmosis units. The sediment filter protects the more delicate components of the filtration system, such as carbon filters and RO membranes, from clogging and damage. By capturing these larger particles, it ensures that subsequent filters can operate more efficiently and effectively, resulting in cleaner, clearer water. Sediment filters are commonly made from pleated polyester, cellulose, or spun polypropylene and come in various micron ratings to target specific particle sizes.

E. Carbon Filter

A carbon filter, also known as an activated carbon filter, is used in water filtration systems to remove contaminants and impurities through a process called adsorption. These filters are effective at removing chlorine, volatile organic compounds (VOCs), bad tastes, odors, and other chemicals from water. Activated carbon filters are composed of small, porous carbon granules or blocks, which provide a large surface area for contaminants to adhere to.

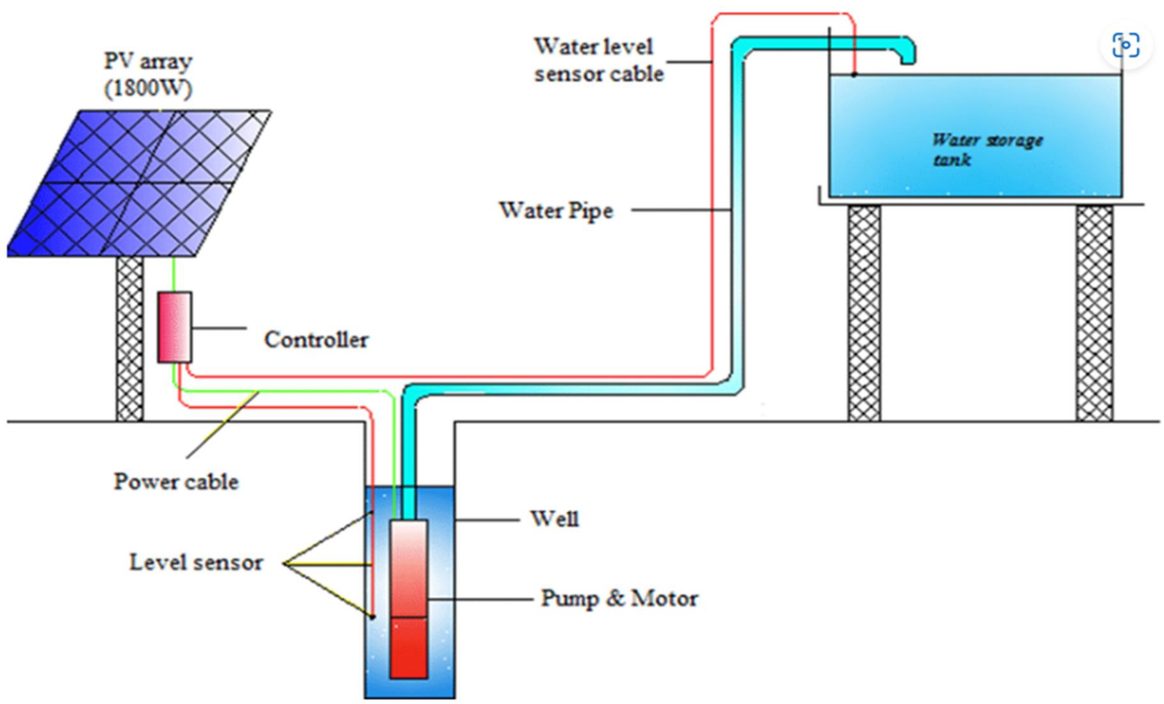
F. Battery

In the context of a solar-powered water filtration system, a battery plays a critical role by storing the electrical energy generated by the solar panels. This stored energy can then be used to power the filtration system during times when there is little or no sunlight, such as at night or on cloudy days. Here’s how the battery functions within the system

G. Solenoid Valve

A solenoid valve is an electromechanically operated valve used to control the flow of liquids or gases. In a water filtration system, including those powered by solar energy, a solenoid valve plays a crucial role in managing the flow of water through the system.

III. CIRCUIT DIAGRAM



Schematic diagram of solar driven water pumping system.

Figure. 1: circuit diagram

IV. MATHEMATICAL CALCULATION

Energy calculation for capacity of solar panel and battery is shown in this paper to justify the design. Battery capacity is measured in Amp Hours (e.g. 17AH). It is needed to be converted to Watt Hours by multiplying the AH figure by the battery voltage (e.g. 12V). Power available in battery (watt hours) = X (Battery size in AH) x Y (Battery Voltage)

By applying equation (1), power in battery = 40 x 12 WH

= 480 WH

Time to charge the battery fully = power available in battery (Watt Hours) / power of solar panel (Watt)

So, from equation (2), time to charge the battery fully by using a 150 Watt solar panel

= 480/ 150 Hours

= 3.2 Hours

Water temperature is raised to 85 ^{0} C to kill organisms. To obtain this temperature, rise for 5 liter (0.005 m3) water requires a total heat input, Qw, of 1149.5 kJ.

Qw = (Vw)(ρw) (Cp,w) (ΔTw)

Where V is the volume (m3), ρ is the density (kg/m3), Cp is the specific heat (kJkg-1K-1), and ΔT is the temperature rise The subscript W denotes water.

From equation (3), heat input, Qw= 0.005 x 1000 x 4.18 x (85-30) kJ

= 1149.5 kJ.

Time needed to rise water temperature, t (min) = Qw x 1000 /power of heating coil x 60

By applying equation (4), time needed to rise water temperature using a 200 Watt AC heating coil, t

= (Qw x 1000)/ (200 x 60) min

= 95.79 min

= 1 hr 35.79 min

So, 1 hr 35.79 min is needed to rise temperature of 5 liter water to 85 ^{0} C

V. MODEL OF PROJECT

Figure 2 : Model of water based purification system

VI. CONCLUSION & RESULT

The development and evaluation of the solar-based water purification system represent a significant step towards addressing the pressing global challenge of ensuring access to clean and safe drinking water, particularly in regions with limited infrastructure or contaminated water sources. Through a comprehensive approach encompassing system design, component procurement, experimental setup, performance evaluation, and techno-economic analysis, valuable insights have been gained into the feasibility, effectiveness, and sustainability of harnessing renewable energy for water treatment.

The results of performance evaluation have demonstrated the system's ability to efficiently convert solar energy into electrical power, store it in batteries, and utilize it to power the reverse osmosis purification process effectively. High purification efficiency ensures the production of high-quality drinking water, meeting regulatory standards and public health requirements. Moreover, the techno-economic analysis has highlighted the system's economic viability and potential for widespread deployment, with favorable returns on investment and long-term cost-effectiveness.

Despite its strengths, the solar-based water purification system may face certain limitations and challenges, such as intermittent solar energy, variability in water quality, and dependence on battery storage.

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