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Solar Operated Desalination Unit

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***Abstract* :-This project aims to develop a cost-effective, portable water distillation system powered by solar energy, addressing the challenge of limited access to clean water. Solar distillation, a method utilizing solar radiation to evaporate water, presents an attractive solution due to its simplicity and minimal energy consumption. This technology can purify water from various sources, including seawater, making it particularly valuable in coastal regions facing water scarcity. By harnessing renewable energy for water purification, the project seeks to provide a sustainable and efficient means of generating clean drinking water, especially in remote areas or during emergencies.**

***Keywords*: Water distillation, Solar energy, Clean water access, Renewable energy, Solar distillation, Water purification, Seawater desalination, Sustainability**

INTRODUCTION:

As the global demand for clean drinking water continues to rise, the need for sustainable and efficient desalination solutions is more pressing than ever. One promising technology that is gaining traction is solar-powered desalination units. By harnessing the seawater or brackish water into fresh, potable water, all while minimizing energy consumption and reducing environmental impact. In this article, we will explore the benefits and potential applications of solar-powered desalination units, highlighting their role in addressing water scarcity and promoting a more sustainable future.

History: Distillation has ancient roots, dating back to Aristotle's documentation in the fourth century B.C. Arabian alchemists in the sixteenth century and Nicolo Ghezzi in 1742 contributed to its early development, although the extent of Ghezzi's implementation is uncertain. Charles Wilson's 1872 installation in
Las Salinas, Chile, marked a significant milestone with its large-scale solar still design,
supplying water for decades. The 1950s saw interest in centralized distillation plants, but costs led to a shift towards smaller facilities in the following decades. Despite challenges, residential usage and global interest in smaller units persist, especially with rising oil prices. As oil resources diminish, solar distillation is anticipated to become more competitive, posing questions about optimal methods and applications.

IDENTIFICATION OF PROBLEM

Despite the vast expanse of water covering the Earth's surface, only 2% is freshwater, with the majority locked in polar ice caps and glaciers. The remaining 98% is saline, leaving a mere 0.4% available for consumption as groundwater and flowing rivers. Despite technological progress, 1 billion people, around 14.7% of the global population, struggle to access clean drinking water. This scarcity exacerbates issues like inadequate sanitation, groundwater depletion, freshwater pollution, and geopolitical tensions over dwindling resources.

AIM

The process involves desalinating saline (salt) water using a solar-powered heater. This heater harnesses energy from solar panels to heat the saltwater, causing it to evaporate into water vapor. The water vapor is then collected and passes through a filtration system, which removes impurities and salt, ultimately rendering it suitable and safe for various uses, such as drinking or irrigation.

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OBJECTIVE

a) Freshwater is vital for the sustenance of all life forms on Earth.
b) The demand for freshwater has been steadily increasing, yet the available freshwater resources on our planet remain fixed.
c) The ocean stands as the sole vast reservoir of water available for us to tap into.
d) However, ocean water is naturally high in salinity, necessitating the crucial process of desalination to make it potable and suitable for various purposes.
e) To enhance the overall design, there is a compelling need to keep it compact and efficient.

f) As a means to optimize the system, it is essential to work towards improving its efficiency

Scalability: Industrial-grade solar desalination units must efficiently purify large volumes of water to meet substantial production demands in various industries, requiring robust construction and precise filtration systems.

Robust Construction: These units need durable materials like high-grade stainless steel to withstand continuous operation in demanding conditions and resist corrosion from saline water exposure.

Precise Filtration Systems: Effective filtration, potentially using multi-stage methods with membranes or activated carbon, is crucial for removing impurities and ensuring water purity.

Optimized Solar Collection: Industrial units should maximize solar energy collection with optimized panel layouts and automatic sun-tracking mechanisms to ensure continuous power generation for the desalination process.

COMPONENTS

12V DC heater: A 12V DC heater efficiently converts electrical energy into heat, making it ideal for applications with low-voltage DC power sources like solar panels or batteries. Its heating element, typically made of resistive wires, generates heat when current passes through, suitable for use in solar desalination units and other small-scale devices. The heater's compatibility with low-voltage power makes it practical for off-grid or portable systems, offering a reliable solution for diverse heating needs.

CHARGE CONTROLLER:

A charge controller plays a vital role in solar desalination units by regulating voltage and current from solar panels to the battery. It prevents overcharging, ensuring efficient charging and extending the battery's lifespan. By monitoring battery voltage, it cuts off or reduces solar panel electricity flow to prevent damage from overcharging. Additionally, it optimizes charging, protecting the battery from electrolyte loss and internal damage. Various types like PWM and MPPT controllers offer efficient regulation, with selection based on system needs and solar panel voltage. In the context of a solar desalination unit, the charge controller maintains a steady power supply while safeguarding the battery's health.

Battery: A 12V 7Ah battery is a rechargeable battery commonly used in solar power systems, automotive settings, and portable electronics. Its 12V voltage suits various applications, while its 7Ah capacity means it can deliver 7 amperes for one hour or 1 ampere for seven hours before fully discharging. This compact battery is often part of smaller solar setups or larger battery banks in solar systems, providing backup power or off-grid support. In a solar desalination unit, it stores energy from solar panels via a charge controller, ensuring continuous operation even without sunlight or during low solar generation.

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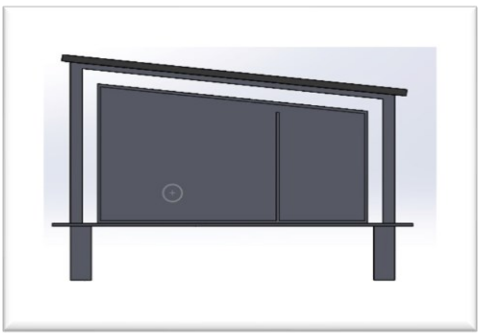
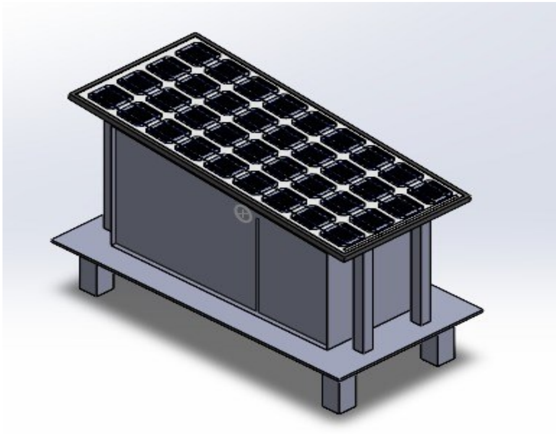
15 watt solar Panel :

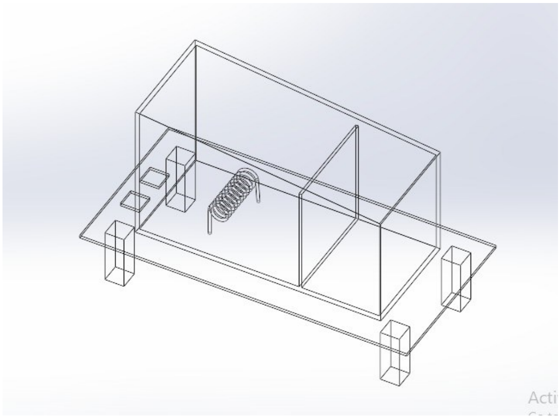
A 15-watt solar panel generates an average power output of 15 watts under standard test conditions (STC), typically producing around 17-18 volts and 0.85-0.9 amperes in full sunlight. These panels are commonly used in smaller solar systems or as part of larger arrays for various applications like trickle-charging batteries or powering small devices. In a solar desalination unit, a 15-watt panel contributes to powering components such as a 12V DC heater, though larger-scale desalination may require multiple or higher capacity panels.

DESIGN OF SOLAR OPERATED DESALINATION UNIT

<u>CAD Model</u>







EXPERIMENTAL SETUP:

The solar desalination unit is airtight basin fabricated from high toughened glass the design is fabricated in such a way that it is divided in two parts one for water filtration and one for water storage. The upper side has an inclination of 30 degree to transfer water from filtration unit to storage unit. The desalination unit is solar powered, the solar panel is fitted on top of the glass container which is inclined at 30^0angle. The electricity generated by the solar panel is transferred to the battery, there is a charge controller in between battery and the solar panel. The charge controller helps to keep the battery from overcharging by regulating the voltage and the current coming from solar panel to battery.

Specifications of solar powered desalination unit

1. Water tank area: - 30cm length, 20cm height
2. Water tank storage capacity: - 5lit
3. Filtration system area: - 18cm length, 20cm height
4. Inclination angle for water bubble: - 30 degree
5. Heating coil: - 12 volt (DC)
6. Jumper cables

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7. Glass thickness: - 12mm
8. Filtration material: -charcoal, filter paper
9. Sealant: - silicon
10. Base for glass tank: - wooden box

Results: The solar desalination unit embodies an ingenious design, featuring an airtight basin crafted from durable, high-toughened glass. This innovative construction is partitioned into two distinct sections: one dedicated to water filtration and the other designated for water storage. The upper portion of this apparatus boasts a 30-degree incline that facilitates the transfer of water from the filtration unit to the storage segment. Moreover, the entire desalination unit is entirely reliant on solar power. Positioned atop the glass container, the solar panel is inclined at a 30^0-angle, allowing for optimal exposure to sunlight.
A crucial aspect of this system involves the transfer of the electricity generated by the solar panel to a battery, ensuring a consistent power supply. To regulate this process and prevent overcharging, a charge controller is strategically placed between the battery and the solar panel. This controller actively manages the voltage and current flowing from the solar panel to the battery, thereby safeguarding against potential damage caused by overcharging.
Delving into the specifics, the solar powered desalination unit features a water tank area measuring 30 centimetres in length and 20 centimetres in height, providing ample space for its intended purpose. Additionally, the water tank possesses a storage capacity of 5 Liters, catering to significant water storage needs. The filtration system, occupying an area of 18 centimetres in length and 20 centimetres in height, is designed to efficiently purify water for consumption.
A key structural feature is the 30-degree inclination angle set for the water bubble, ensuring a seamless transition from the filtration segment to the storage compartment. The heating coil, operating at 12 volts in direct current (DC), serves as a fundamental component, facilitating the evaporation of water. Complementing this setup are jumper cables, effectively connecting various elements of the desalination unit to ensure a smooth and consistent flow of energy.
The construction materials, from the glass itself with a thickness of 12mm to the filtration components such as charcoal and filter paper, underscore the unit's robustness and its capability to achieve superior water purification. The sealant, composed of silicon, reinforces the airtight integrity of the unit, preventing any leaks or external contaminants from compromising the desalination process. Moreover, the base for the glass tank comprises a wooden box, providing stability and support for the entire system. This meticulously designed and precisely engineered solar desalination unit stands as a testament to innovative engineering, integrating solar power with intelligent design and quality materials to create a reliable and sustainable method for generating potable water. It is an embodiment of efficient design and functionality, addressing the pressing need for clean and drinkable water in diverse environmental settings.

calculation for experimental setup:

Water quantity: 1 litter

Heater coil: 12vDC

Solar panel: 15watt

To calculate the time, it takes to heat 1 litter of water to boiling using a 140-watt, 12-volt, 12-amp water heater, we can use the formula:

Energy=Power ×Time

Energy (in watt hours) =Power (in watts) ×Time (in hours)

Firstly, to find the energy required to heat the water:

The power of the water heater is 140 watts, which is equivalent to 140 watt-hours140watt-hours per hour.

The energy required to heat the water can be calculated as follows:

Energy=Power ×Time

Time=Energy Power Time=Power /Energy

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The specific heat capacity of water is around 4.18 joules per gram per degree Celsius. To raise 1 litter (1000 grams) of water by 80 degrees Celsius to reach boiling point (assuming an initial temperature of around 20°C and boiling point of 100°C):

The energy required would be:
1000 grams×80 degrees×4.18 joules=334,400 joules
1000grams×80degrees×4.18joules=334,400joules.

To convert joules to watt-hours:

1 joule=0.000277 watt-hours,thus
334,400 joules=92.88 watt- hours.

Now, using the power of the water heater (140 watts):

Time=Energy/Power =92.88 watt-hours/140 watts≈0.66

So, it would take roughly 0.66 hours (or approximately 40 minutes) to bring 1 litter of water to a boiling state where

vapor is coming out, assuming 100% efficiency and no heat loss to the surroundings. However, in practical scenarios, heat loss might occur, thus the actual time might be slightly longer. Actual Reading

Time (in minute):	10 min	20 min	30 min	40 min	40min-1hr
Temperature:	50^{0}C	75^{0}C	80^{0}C (not yet vaporizing)	100^{0}C it starts vaporizing	Water start collecting in container
Time required to fill the container:	20 min After being passing from different stage of filtration				
Amount of water collect	650 ml approx.				

Total estimation time: time taken to collect the water is **30min**

CONCLUSION

Solar desalination units hold immense promise for providing clean drinking water in regions facing water scarcity. The amalgamation of advanced technology, such as a 12V 7Ah battery, a 15-watt solar panel, and a 12V DC heater, coupled with precise components like a charge controller, showcases the innovation in harnessing solar energy for water purification. The industrial accuracy of such units emphasizes scalability, robust construction, efficient filtration systems, optimized solar collection, automated monitoring, adaptability, and adherence to industry standards.

These sophisticated systems signify a significant advancement in sustainable and efficient water purification technology. Aiming for industrial accuracy in these units enables their application in diverse settings, from small-scale residential usage to large-scale industrial and community-based water supply needs. The capacity to scale, maintain durability, deliver precise water filtration, and guarantee consistent power production and distribution illustrate the potential of solar desalination units to significantly alleviate water scarcity issues globally.

These systems not only exemplify technological progress but also exhibit a commitment to social and environmental responsibility. By leveraging renewable energy sources, these units contribute to reducing the carbon footprint and reliance on conventional power sources while addressing one of the most pressing global challenges—access to clean and safe drinking water for all. The combination of cutting-edge technology, renewable energy, and a commitment to sustainable development positions solar desalination units as a beacon of hope in the quest for accessible, clean water worldwide.

FUTURE SCOPE

The future scope of our project holds vast potential for expansion and enhancement, catering to larger-scale applications and addressing evolving needs in the field of solar-powered desalination. The advancements can include:

1. Integration of Industrial Heaters: Implementing high-wattage industrial heaters can significantly increase the efficiency and speed of the desalination process. These robust heaters can handle larger volumes of water, expediting the evaporation process for greater water production.
2. Expansion of Battery Units: Incorporating larger-capacity battery units or creating battery banks allows for extended energy storage. This expansion enables consistent operation during periods of reduced sunlight or overnight, ensuring uninterrupted power supply for continuous desalination processes.
3. Scalability with Multiple Solar Panels: Incorporating a greater number of high-capacity solar panels or arrays offers increased power generation. This scalability caters to higher energy demands for larger desalination systems, ensuring reliable and continuous energy supply for sustained water purification.

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4. Larger Water Storage Units: Increasing the storage capacity of the desalinated water is crucial for meeting larger water demands. Enhancing the storage unit's capacity ensures a continuous supply of clean water, especially in situations where water consumption is high or during periods of low energy generation.
5. Automation and Remote Monitoring: Implementing advanced automation systems coupled with remote monitoring and control features can enhance the efficiency and performance of the desalination unit. This allows for real-time monitoring, remote adjustments, and predictive maintenance, optimizing the system's operation.
6. Research and Development for Efficiency: Continuous research and development efforts to improve the efficiency of the desalination process, such as exploring advanced filtration technologies, innovative materials, and system optimization, can enhance the overall performance and sustainability of the project.
7. Integration of Smart Water Distribution Systems: Implementing smart distribution systems can efficiently manage the delivery and allocation of desalinated water to various sectors, optimizing usage and reducing wastage.
8. Adaptability for Varied Environments: Developing adaptable and modular designs enables deployment in diverse environmental settings, ensuring the system's flexibility and suitability for a wide range of geographic and climatic conditions.
9. Community-Centric Solutions: Focusing on community-scale solutions can enable the deployment of larger systems to serve communities, addressing water scarcity at a larger scale and ensuring broader access to clean water.
10. Sustainable Initiatives: Emphasizing sustainability through the use of eco-friendly materials, reducing energy consumption, and ensuring responsible waste management within the desalination process aligns with environmental conservation efforts. By exploring these avenues for future development, our project can expand its impact, providing innovative, sustainable, and scalable solutions to address the pressing global challenge of water scarcity and access to clean drinking water

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