Thermal Desalination Using Peltier Modules: A Sustainable Solution to Water Scarcity

An energy efficient solution for desalination through smart integration of peltier technology for simultaneous evaporation and condensation for thermal desalination.
"A simple yet effective, efficient, and innovative solution for water scarcity."

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INTRODUCTION

Water scarcity severely impacts communities worldwide, particularly in remote and coastal regions lacking advanced infrastructure. Current desalination technologies are either too costly, energy-intensive, or unsuitable for small-scale applications. This project introduces an innovative, renewable-powered thermal desalination system using compact and efficient Peltier modules. The goal is to provide an affordable and sustainable solution ideal for household and small-community applications.

OBJECTIVE

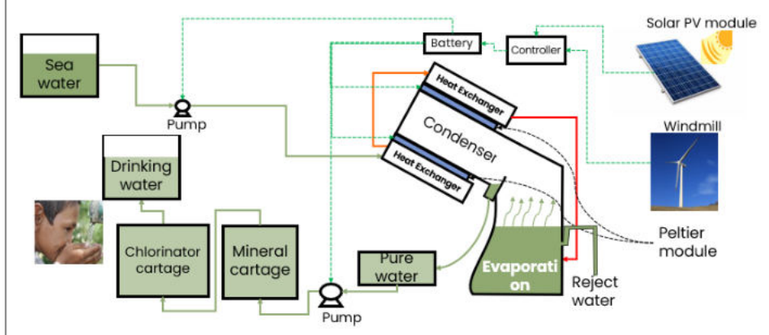
To develop a small-scale, renewable-powered desalination system utilizing Peltier modules that significantly enhances energy efficiency, reduces costs, and provides clean drinking water for regions affected by water scarcity.

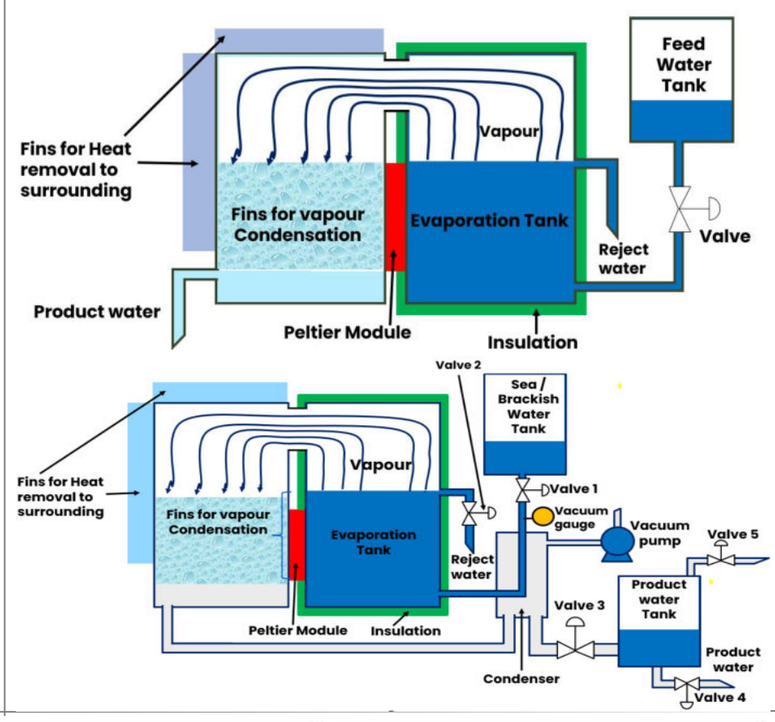
METHODOLOGY

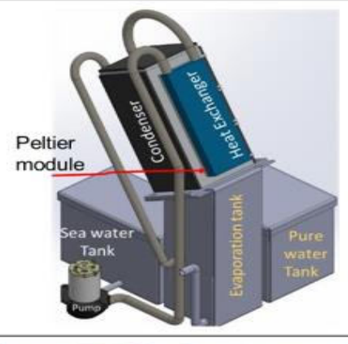
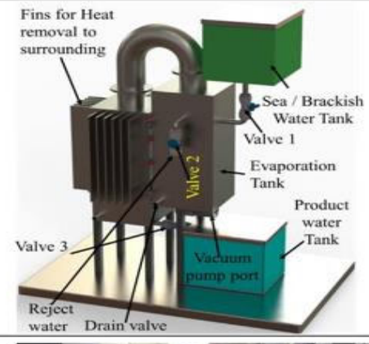
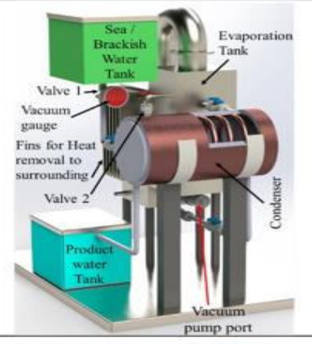
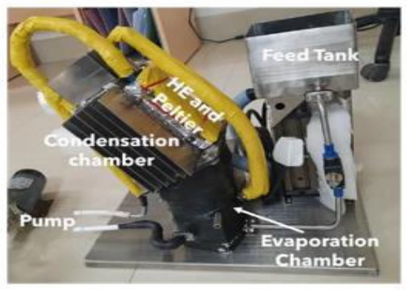
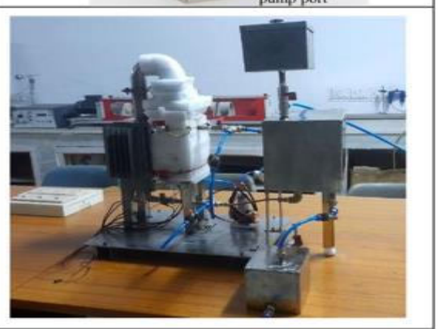
The research involved designing, constructing, and testing three progressively improved prototypes:

- Version 1: Initial prototype using pumps and traditional heat exchangers.
- Version 2: Improved design, removing pumps and adding vacuum operation to enhance efficiency.
- Version 3: Advanced version integrating a vacuum pump and additional condenser to maximize water output and heat recovery.

Effective control of the Peltier module power input with respect to cold side temperature remained a significant challenge throughout development.





Version	1	2	3
3D model			
Prototype			

RESULTS/FINDINGS

C_{NaCl}	E	Q	CoP
mg/l	kJ	l/day*	-
0	64	5.1	1.41
0	63	4.9	1.39
30000	41	1.1	1.38
30000	40	1.1	1.48

*Assumed system is operated for 24 hrs with battery backup

C_{NaCl}- Concentration of salt
E – Consumed Electrical energy
CoP – Coefficient of performance
Q – Clean water flowrate

ANALYSIS

The study demonstrates that Peltier modules effectively provide simultaneous heating and cooling, a critical innovation for compact thermal desalination systems.

Vacuum technology and improved thermal management significantly enhanced the overall performance, affirming the practicality of small-scale desalination solutions suitable for remote households and communities.

Ongoing enhancements in thermal control and heat exchange can further boost efficiency and durability.

CONCLUSION

The renewable-powered desalination system developed in this research demonstrates improved energy efficiency and water output through the integration of Peltier modules and refined thermal management. Its final version, featuring enhanced cooling and performance, offers a scalable, cost-effective, and sustainable method for purifying water and recovering minerals.

This solution holds strong promise for addressing global water scarcity, especially in remote and coastal regions, by delivering clean and accessible drinking water.