Solar-driven Desalination in Saudi Arabia for Sustainable Future

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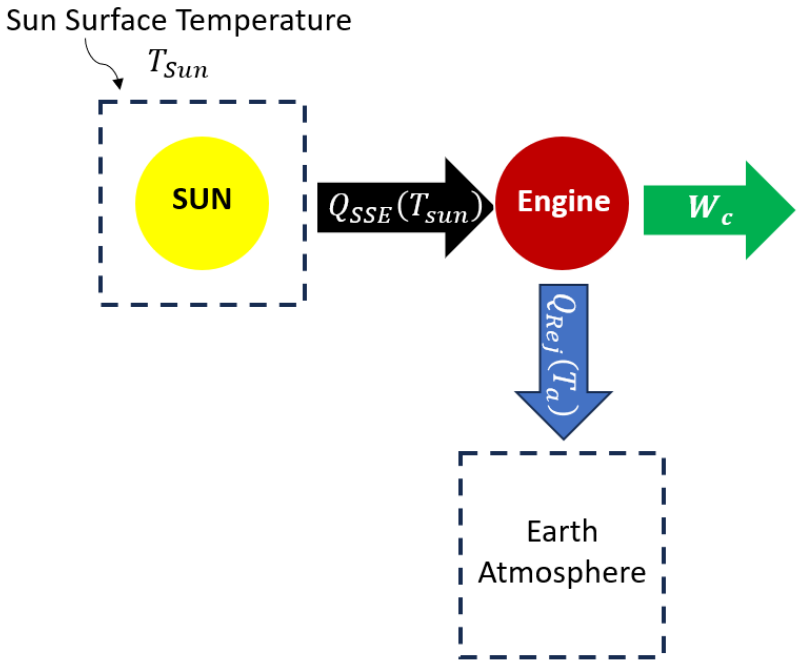
Overview

- Introduction
- Solar desalination cycles
- Results and discussion
- Conclusion and Recommendations

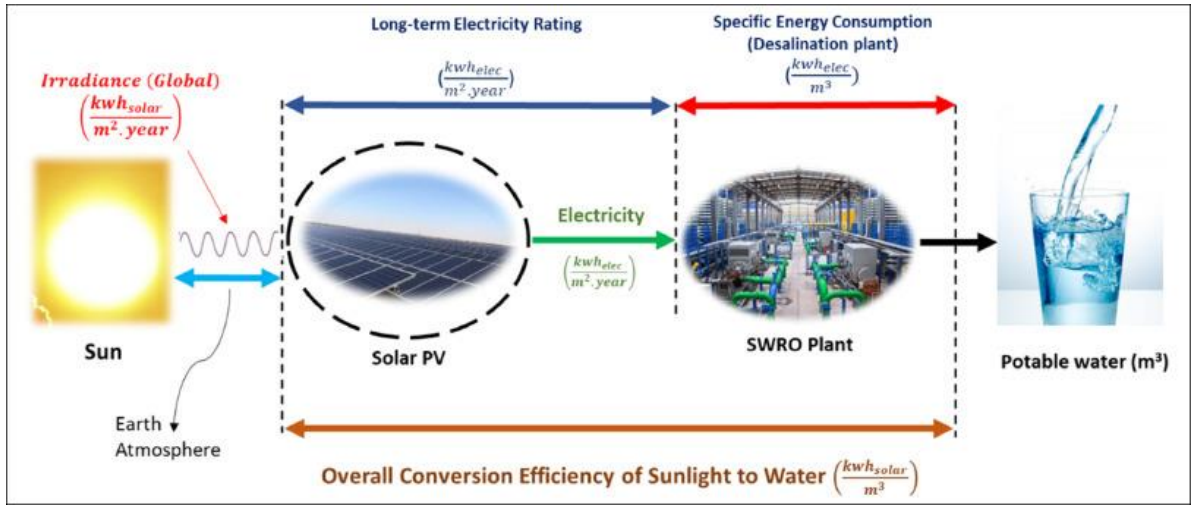
Introduction

- Renewable energy is essential to combat global warming caused by fossil fuel dependence.
- Solar energy offers high potential and direct conversion into electricity.
- Challenges in solar energy implementation include intermittency and performance variability.
- Different photovoltaic technologies exhibit varying efficiencies and responses to solar radiation.
- Conventional rating methods may not accurately estimate photovoltaic system potential in real-world conditions.
- The adoption of a common energy platform like SSE allows for precise modeling and comparison of solar energy systems.



Solar desalination cycles

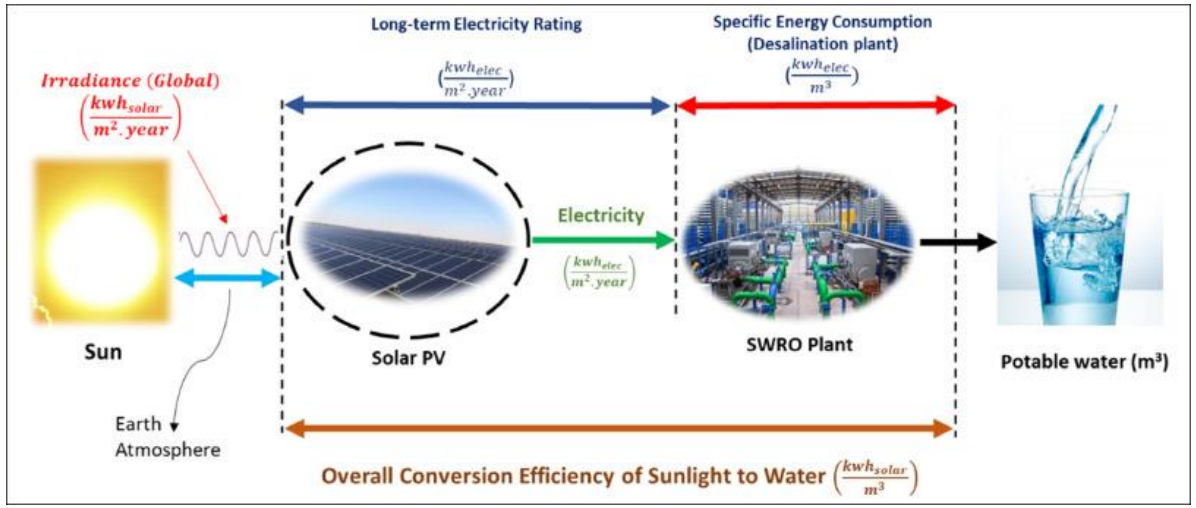
- Installation and operational simplicity seems to have favored solar PV+SWRO.
- All electricity generated by PV panels is dedicated to powering the SWRO plant, ensuring efficient utilization of energy resources.
- Solar PV systems' performance is assessed using the long-term rating (LTR), measuring electrical energy efficiency per unit aperture area, denoted in $kWh_{elec}./m^2/year$.



Case 1: PV+SWRO configuration.

Solar desalination cycles

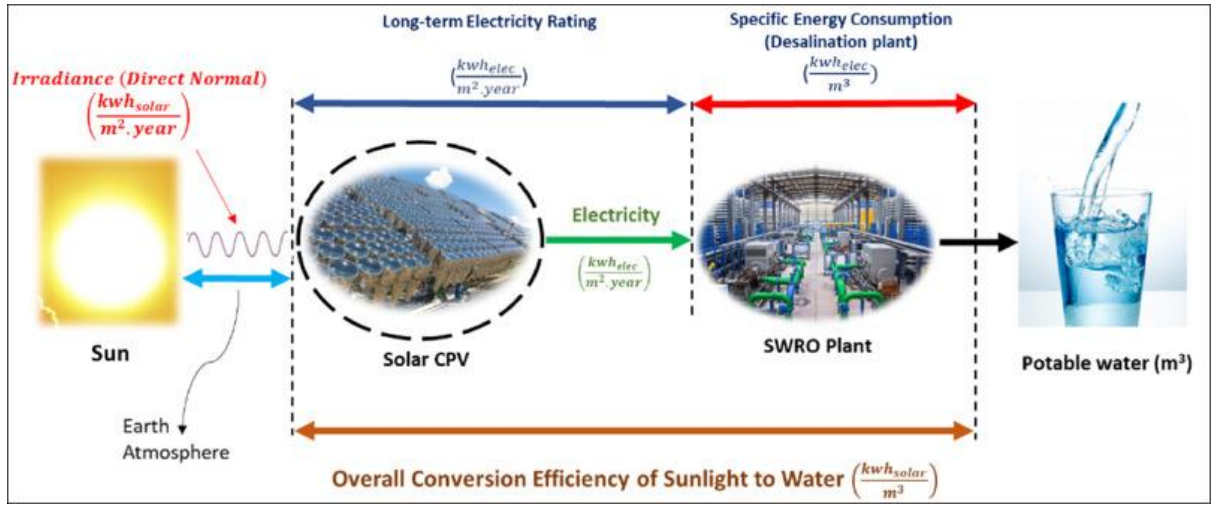
- SWRO plants exhibit specific energy consumption (SEC) ranging from 2.8 to 6 kWh_{elec}/m^3 of water produced, with a comparative average value of 3.5 adopted for analysis.
- Despite the widespread deployment of solar PV plants, their efficacy in desalinated water production is constrained by the lack of thermodynamic synergy between integrated processes, limiting energy optimization.



Case 1: PV+SWRO configuration.

Solar desalination cycles (CPV+SWRO)

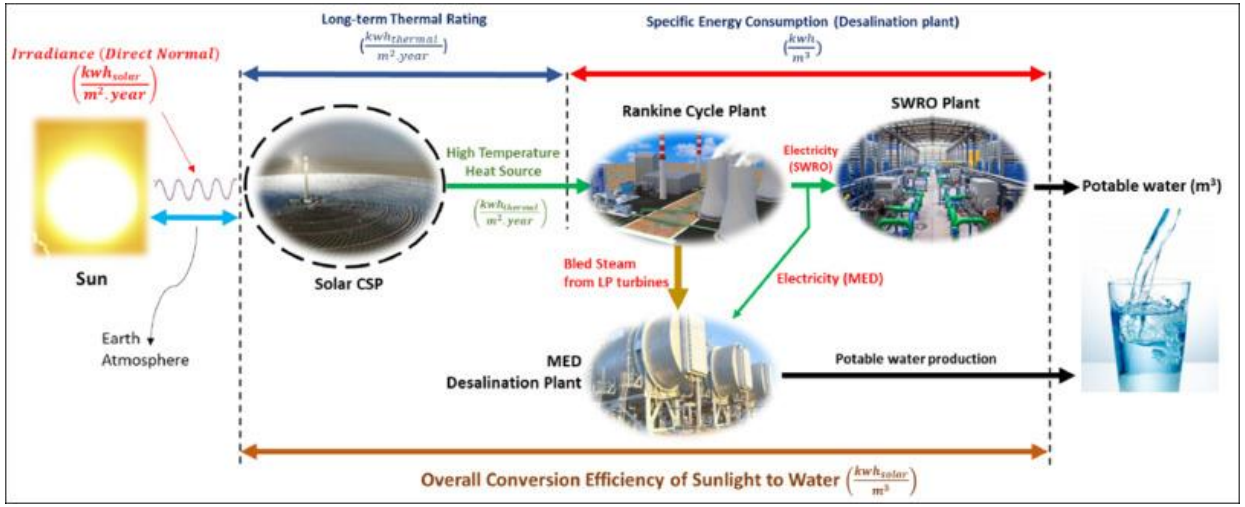
- CPV employs lenses and reflective surfaces to concentrate solar radiation onto more efficient multi-junction solar cells (MJCs).
- CPV offers a higher long-term rating (LTR), generating electricity at rates up to 3 times higher than stationary PV systems.
- Integration of SWRO plants follows conventional installation methods.
- CPV's main advantage lies in its efficiency and higher electricity production per unit aperture area.



Case 2: membrane desalination with concentrated photovoltaic (CPV+SWRO).

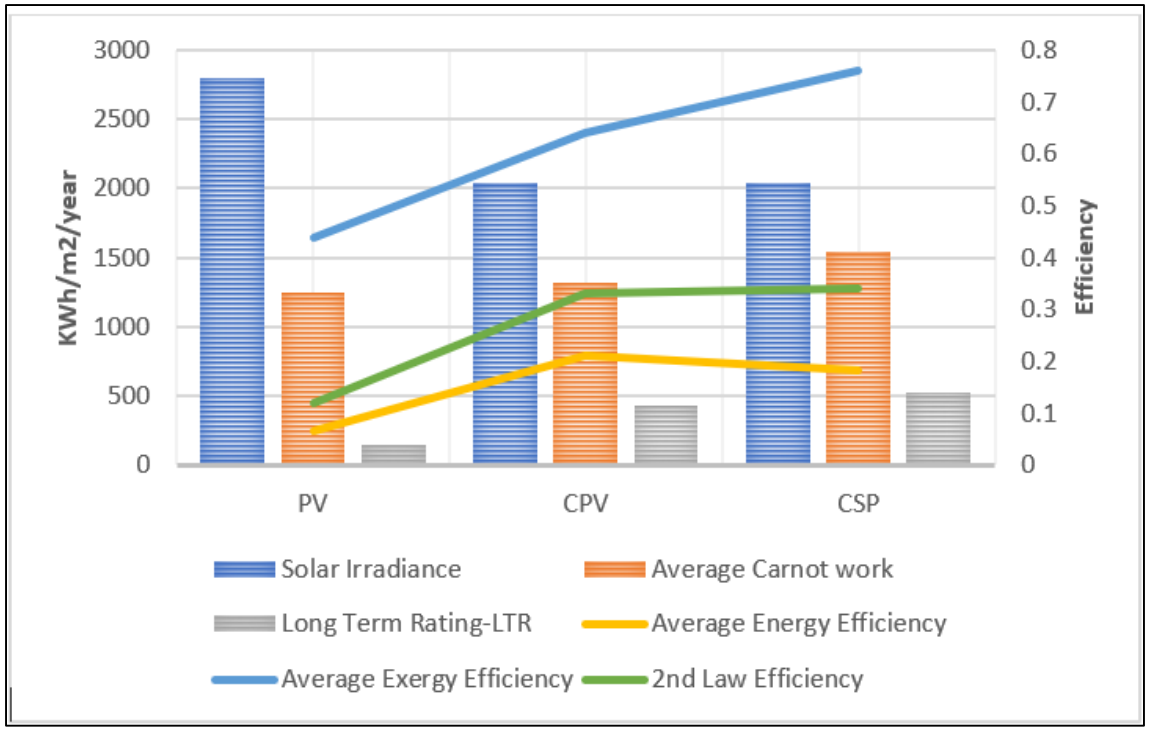
Solar desalination Hybrid CSP cycles

- Hybrid CSP system integrates tower receiver-based CSP with molten salt thermal storage.
- Thermal energy drives Rankine cycle for electricity generation and powers MED desalination for potable water production.
- Surplus electricity from turbine generator enhances SWRO plant output.
- Similar figures of merit (FoM) used for comparison with other configurations.

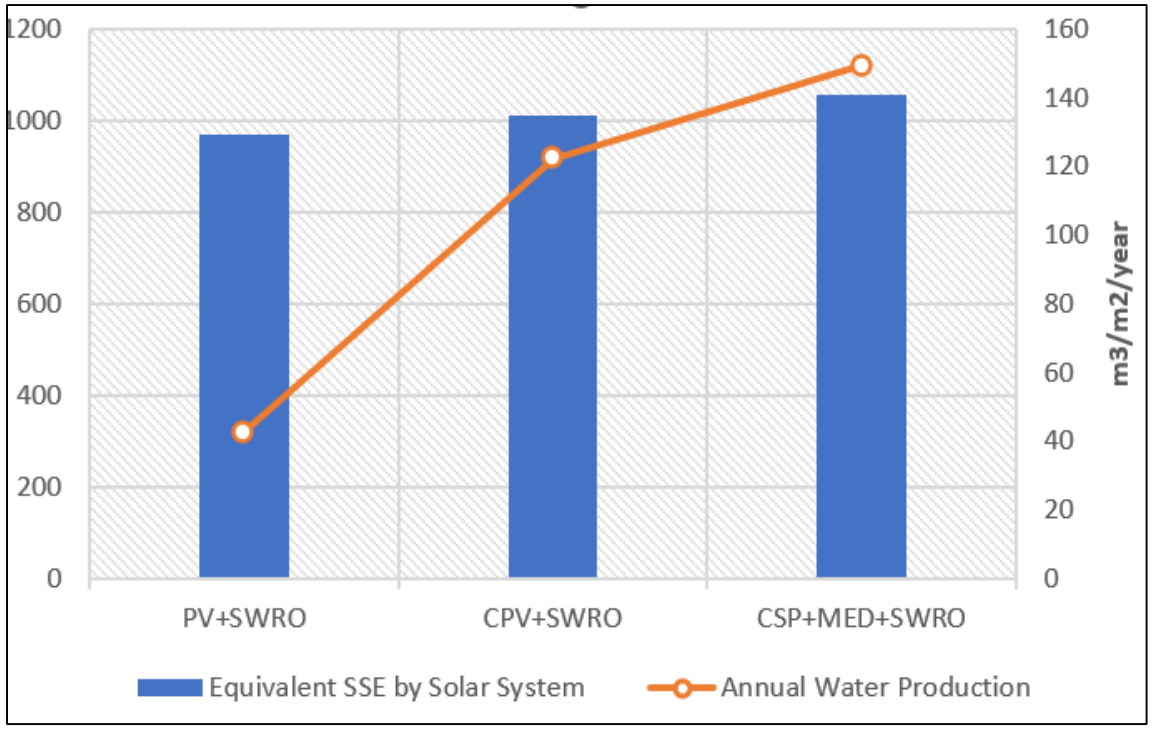


Case 3: Hybrid Thermal and Membrane Desalination Using Concentrated Solar Power (CSP+MED+SWRO).

Results and discussion



- Comparation PV, CPV, and CSP systems.
- PV harnesses global radiations effectively.
- CPV and CSP rely on beam radiations.
- Despite stationary PV's advantage, its long-term rating is lowest.
- CPV offers better solar energy utilization.



- Comparation solar energy systems using SSE.
- All systems show similar performance with SSE.
- PV + SWRO has highest specific irradiance.
- CSP + MED + SWRO is most efficient.
- CPV + SWRO offers simpler configuration.

Conclusion and Recommendations

- Conventional efficiency-based ratings are unreliable for solar systems due to intermittency.
- Long-term electrical ratings offer more accurate system potential.
- Standard solar energy (SSE) provides a universal measure.
- Stationary PV + SWRO exhibits lower efficiency compared to CPV + SWRO and CSP + MED + SWRO.
- CPV + SWRO and CSP + MED + SWRO are twice as efficient as conventional PV.
- SSE allows fair comparison across diverse solar technologies.

Thank you