Analysis of hybrid photovoltaic/thermal (PV/T) solar systems for small scale reverse osmosis desalination plants

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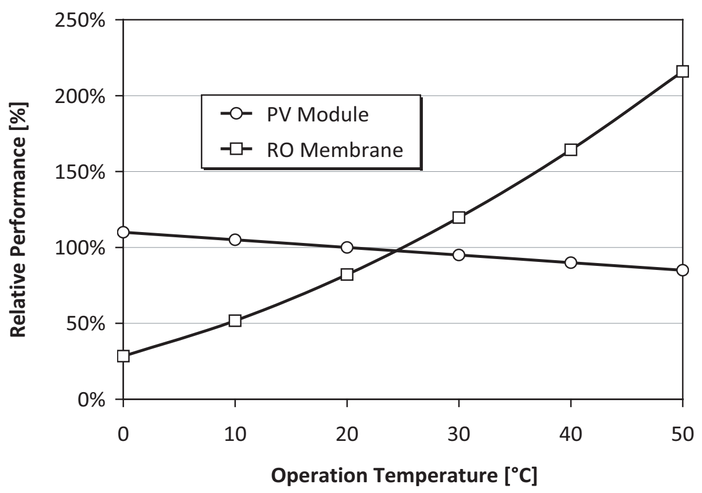
INTRODUCTION AND MOTIVATION

- A PV/T system's major disadvantage is low fluid output temperatures (30˚C to 40˚C) when the photovoltaik (PV) part is to be run at high efficiency
- Nevertheless, this disadvantage can redound to its advantage using PV/T systems as power supply in reverse osmsois (RO) desalination plants
- RO membranes gain a significantly higher fresh water output at higher brine (= membrane) temperatures
- In addition to that, membrane operation temperatures are limited to 45˚C
- Potential of an PV/T application in RO plants: while preheated feed water will lead to a much higher fresh water output, the cooled PV surface may result in a higher electrical efficiency



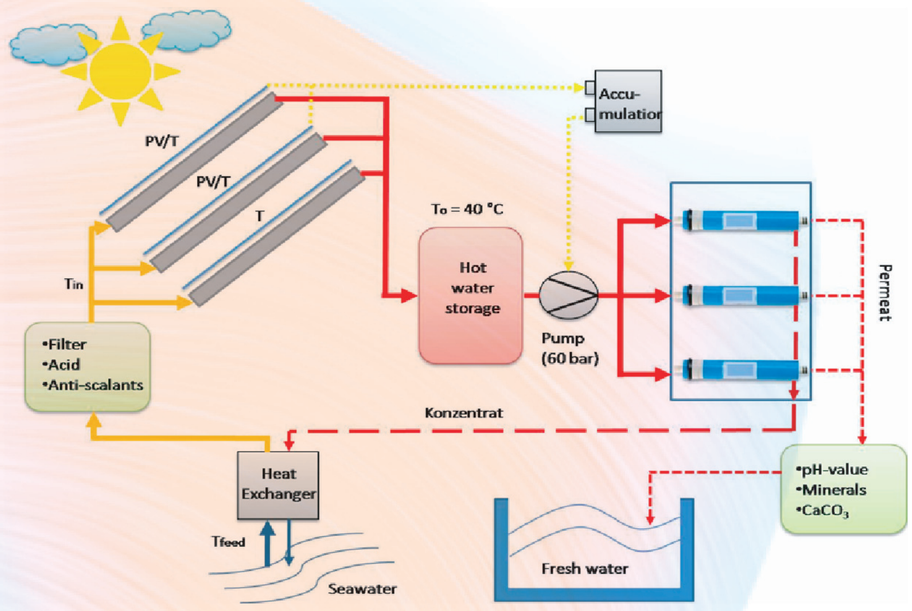
$$\eta_{el} = a_{el} - k_{el} \cdot T_{pv,eff} \qquad \frac{1}{TCF(T)} = 0.00035 \cdot T^2 + 0.0195 \cdot T + 0.28$$

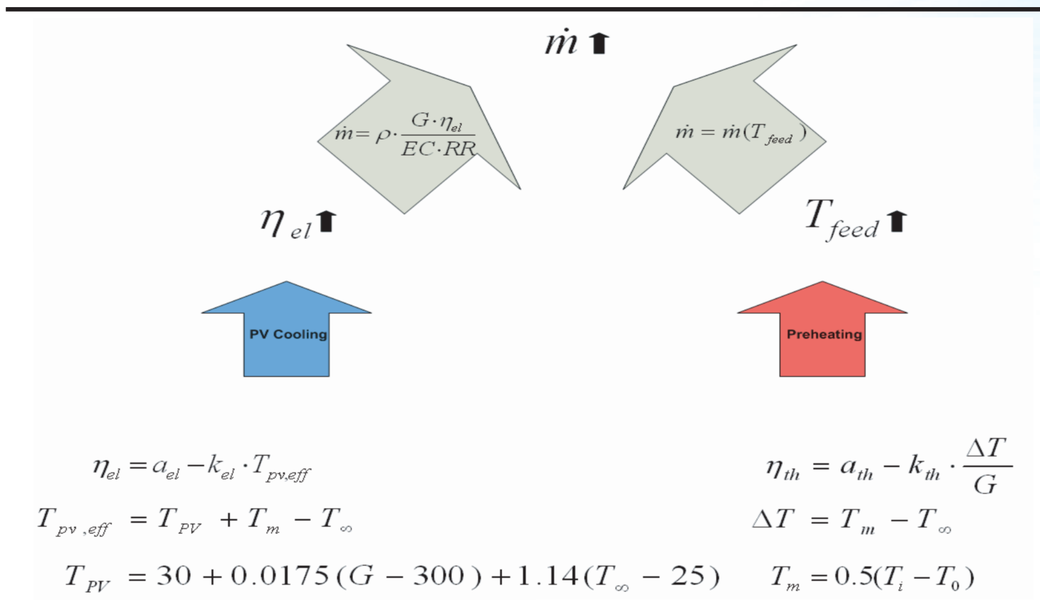
THEORY

- MS Excel based calculation model
- Input: hourly data of solar radiation and ambient temperature and salt water inlet temperature
- Output: average fresh water mass flow [l/(h m²)]

BOUNDARY CONDITIONS AND ASSUMPTIONS

- Important boundary conditions: recovery ratio (RR) of 40%, energy consumption (EC) of 7 kWh per m³ fresh water (both related to 25˚C feed water temperature)
- weather data representing a standard reference year (TRY)
- Assumptions: no influence of salinity on osmotic pressure and water density, RO plants can be run at any operating point



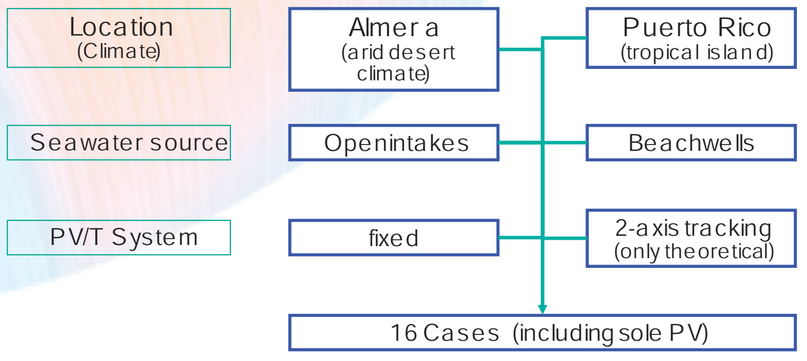


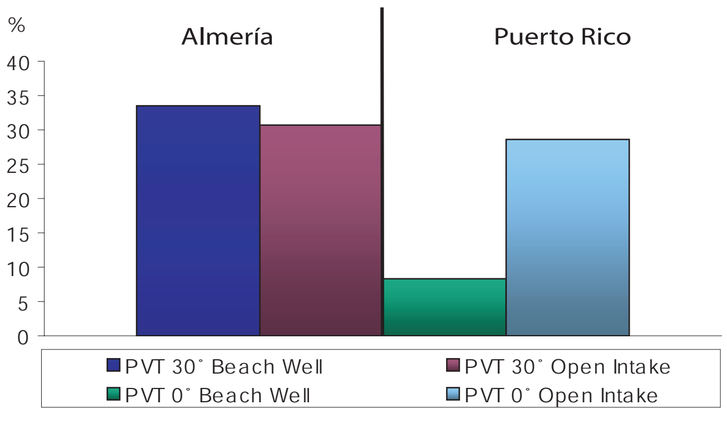
$$\eta_{el} = a_{el} - k_{el} \cdot T_{pv,eff} \qquad \eta_{th} = a_{th} - k_{th} \cdot \frac{\Delta T}{G}$$

$$T_{pv,eff} = T_{PV} + T_m - T_\infty \qquad \Delta T = T_m - T_\infty$$

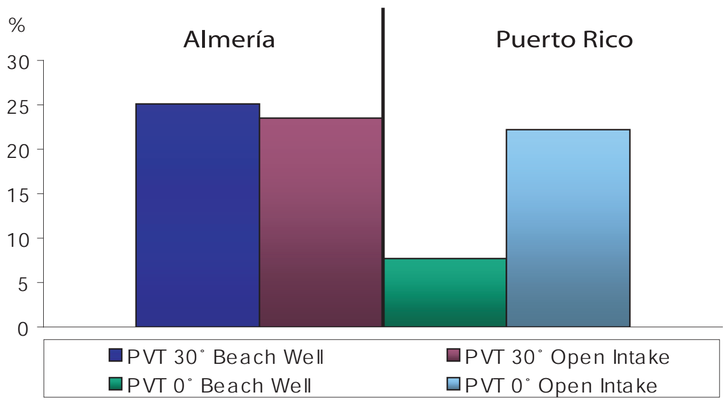
$$T_{PV} = 30 + 0.0175\,(G - 300) + 1.14\,(T_\infty - 25) \qquad T_m = 0.5(T_i - T_0)$$

Cases f. P otential Analysis PV/T -RO

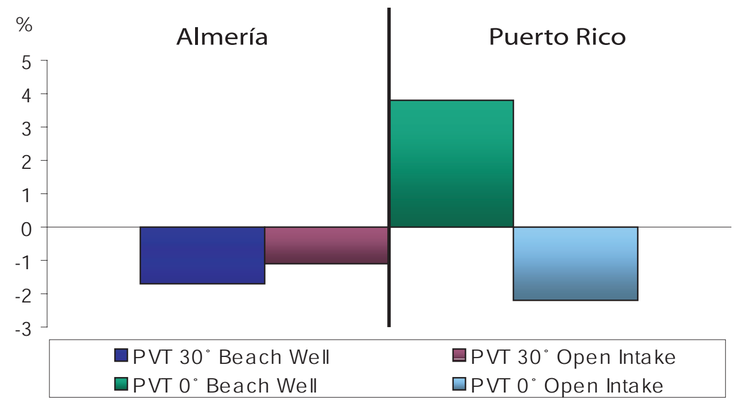




Additional output of PV/T driven plants in [%] compared to the optimal configuration



PV cell area of PV/T driven plants to be saved in [%] compared to the optimal configuration



Electrical power produced by PV/T driven plants compared to PV driven plants in [%]

CONCLUSIONS

- Only a small cooling effect of the fluid can be observed
- PV/T driven plants produce about 30% to 40% more potable water than PV driven plants
- Compared to a pure RO-PV system, 20% to 30% of collector area could be saved
- PV/T systems can also be an economic alternative to pressure recovery systems

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