

Homework 9 Solar Power Africa Due Monday October 23, 2023

Monteiro J, Baptista A, Pinto G, Ribeiro L, and Mariano H *Assessment of the Use of Solar Desalination Distillers to Produce Fresh Water in Arid Areas Sustainability* 12 53-69 (2020) made an assessment of single stage solar desalination, similar to the product of Carocill from Australia. They found that the payback time for the distiller is between 50 and 2000 years making the approach infeasible except in remote places with available salt water, high solar irradiance, low income, low skills and off-grid since other approaches would be less expensive and more feasible if these conditions are not met (see conclusions).

- a) Figure 3 shows a table of the efficiencies for the solar distiller at various locations including Mekele in northwestern Ethiopia (Tigray) near Eritria. The average ambient temperature at the locations is given in Table 2. Assuming the highest possible temperature for the water in the bath at atmospheric pressure (the altitude is also given in Table 2), calculate the efficiency for a Carnot cycle operating at these same temperatures and comment on the calculation in this paper. Compare Almeria Spain and Mekele, you can do others if you want.
- b) The theoretical efficiency is low due to the low temperature differential. Can you propose a new design that could increase the temperature differential? Are there some limits to the possible temperatures that can be achieved? (A solar concentrator can easily melt steel at 1500°C.) What is the theoretical efficiency if you could use a solar concentrator and ambient air?
- c) Lim, Lee, Choi, Chung and Park Model optimization and economic analysis of a multi-effect diffusion solar distiller *Desalination* **485** 114446- (2020), improved on the Monteiro solar still by adding an insulating extra glass layer and making the still multi-stage. They find an optimum payback period of about 6 years in central South Korea, Figure 9. Equations 4-7 are similar to the equations used by Monteiro. The optimum number of stages for water production rate is about 9 to 16 depending on the time of year. Comment on the reason the efficiency is improved using a multi-stage still and on why the extra glass layer is an improvement.
- d) Figures 14 and 15 in Lim show the cost of water per m³ versus the capacity of the still, for literature stills. The axes are log scale meaning that the cost is significantly lower at higher capacity, following a power-law in production capacity. Why do you think that the water cost drops so dramatically with the size-scale of the still.
- e) The Lim still uses the heat of condensation to preheat the feed sea water. They claim that this is the reason that they have improved efficiency. Compare the incident solar heat to the heat of condensation in one stage of the Monteiro still. Does this seem significant?