MEng Project: Energy and cost analysis of freeze desalination as a method of purifyin g industrial waste water

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We propose to design an optimized hybrid system for purification of industrial waste water. The design will be a paper study to optimize cost and power using existing models of detailed process steps. Waste water generated by hydraulic fracturing production of natural gas will be the target of the study as it is of great public interest. We are interested in the viability of freeze concentration (FC), Reverse Osmosis (RO) and forward osmosis (FO). The optimal process may involve some combination of all three.

Ideally a team of students will be able to make significant progress in a one semester project. Alternatively, many aspects of this problem are suitable for a one or two semester project for an individual student.

Waste water from fracking is currently injected into disposal wells but recent research linking disposal to increased earthquake activity [1] makes finding an economically attractive alternative increasingly important. An economical method of purifying the waste water would also reduce the amount of clean water needed to perform fracking, further reducing the highly publicized environmental challenges of aquifer depletion and large volume water trucking in remote areas.

When salt water freezes, high concentration brine forms leaving the ice highly pure. This phenomenon has been exploited for some commercial FC processes in the food & beverage industry but, as described in the review article [2], economic and power consumption estimations are complex and there is no clear agreed optimum process.

Conventional RO is not feasible for purifying fracking waste water because the process pressure required to overcome the osmotic pressure of the very high salinity waste water will collapse the RO membrane. As described in [3], FO uses a high osmotic pressure draw solution to substantially reduce the required process pressure, making membrane separation feasible.

References:

[1] Weingarten, M., et al, 2015, “High-rate injection is associated with the increase in U.S. mid-continent seismicity”, Science, 48, pp. 1336-1340

[2] Williams, P.M., et al, 2015, “Technology for freeze concentration in the desalination industry”, Desalination 356, pp. 314–327

[3] Shaffer, D.L., Elimelech, M., et al, 2015, “Forward osmosis: Where are we now?” Desalination 356 pp. 271–28