

Use of Nanofiltration on Recycled Water for Energy Production

Note: This project was funded in FY11. A significant portion of the funds were returned to the S&T Program office and the project was not completed. The Principal Investigator left Reclamation for another job in 2012 before completing the project. The following documents the accomplishments of the project during the time in which it was funded.

FY 2011 Accomplishments:

In order to define the barriers to using recycled water in cooling towers and energy production, the research team has conducted a literature search, visits to power plants and reclaimed water sites, and conducted interviews with power plant and reclaimed water plant operators. Additionally, an Excel-based computer model has been created to illustrate the benefits of implementing membrane desalination to reduce fresh water demand for cooling towers.

Our literature search found that almost 50% of water use in the US is for thermoelectric power generation (USGS - <http://pubs.usgs.gov/fs/2005/3051/>). Most of this water is used for once-through cooling and is non-consumptive, but proves how important and how large water use in power generation is. The research team also discovered a database developed by Argonne National Laboratories that identified 58 thermoelectric power plants that utilize reclaimed water, however we identified two power plants in Colorado that were using reclaimed water for many years before the publication of the database. This database reveals that some power generation facilities have quite a bit of experience using recycled water in cooling towers. One master's thesis from the University of Nevada – Reno, has been helpful to our current work, and explores the use of pressure-driven technologies such as NF, RO, membrane distillation and forward osmosis. This research still leaves some questions unanswered. In particular, the Master's thesis did not provide any information on whether nanofiltration would be sufficient for treating blowdown water.

The following summarizes the outcomes of our site-visits and interviews:

- Travel to CPS Energy in San Antonio to discuss current practices with project partners San Antonio Water System and CPS Energy.
- Tour of Denver Water Recycling facility and Xcel Energy Cherokee Station in Denver, CO.
- Discussions with Xcel Energy in Steamboat Springs, CO and Amarillo, TX.
- Met with Dave Smith of Merritt-Smith Consulting, to discuss his current WaterReuse Research Foundation Project WRF-08-12 entitled "*Water Reuse Requirements and Opportunities for Energy and Biofuels Production.*"

Calcium, phosphorous and ammonia are some contaminants of concern when treating water for cooling towers. Shock chlorination is used to prevent biofouling. Names of more facilities using recycled water have been obtained, and can be contacted to further this discussion.

Use of recycled water in energy production turbines or boilers is very rare. The water has to be ultrapure to be used in any sort of situation where the water is evaporated on a continuous basis in order to extend the life of the equipment. Our main partner, CPS energy, treats potable water from SAWS with a 2-pass reverse osmosis system, followed by anion and cation exchange. This is highly polished water. The disadvantage of using this water is that it comes from the Edwards Aquifer, so they would like to reduce its consumption. Silica is the main contaminant of concern in their process.

Our computer modeling currently consists of three various scenarios for improving water use in energy production and reducing demand for water in cooling towers. The three scenarios are:

- Recirculate the concentrate stream from the 2nd pass RO to the head of the CPS treatment train to improve overall water use efficiency of the treatment scheme. Currently, this concentrate is disposed of into the environment, but our modeling indicates that it is actually less saline than the feed water since the first pass takes out a majority of the salts (**Figure 1**).
- Use of recycled water for energy turbines/boilers, using the same treatment scheme above, but adding nanofiltration as pretreatment (**Figure 2**).
- Add nanofiltration treatment between a cooling water recycle stream within a cooling tower to improve the number of passes that a tower can get (i.e. 10 passes instead of 4 passes) using either potable water or recycled water (**Figure 3**).

The research team is planning on completing the written report, life cycle cost analysis, computer modeling, and a brief pilot plan by the end of the fiscal year (September 30, 2011).

Next Steps:

Other items that will occur during FY11 and FY12 are:

- Complete modeling and compile results.
- Disseminate project report to the Oklahoma Texas Area Office, Texas Water Development Board, CPS Energy, San Antonio Water System, and any other applicable partners.
- Discuss potential pilot projects.
- Present research findings at conferences.
- Work in conjunction with the new NF/RO proposal being submitted to S&T for FY 12 funding in partnership with the Texas Water Development Board to further the Excel-based model developed in this research. The new project, if funded, would investigate the cost/benefit tradeoffs of using RO vs. NF with a techno-economic model.

Figure 1. Recirculation of 2nd Pass Concentrate

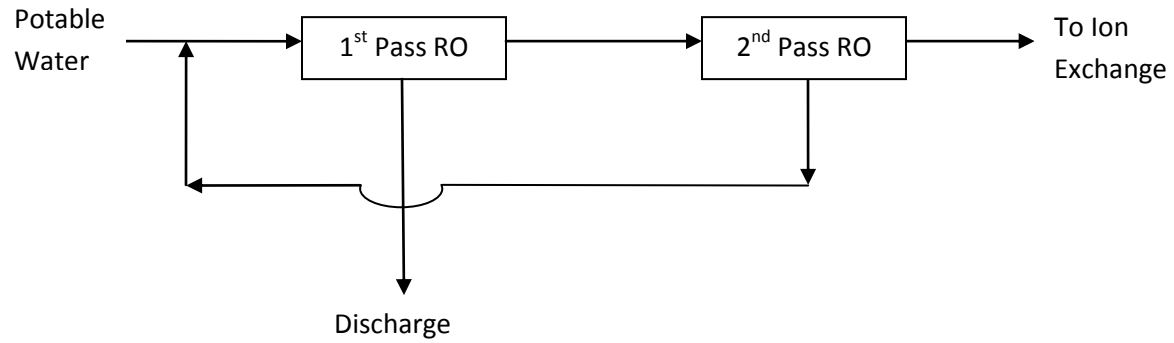


Figure 2. Using Recycled Water for Energy Production Turbines

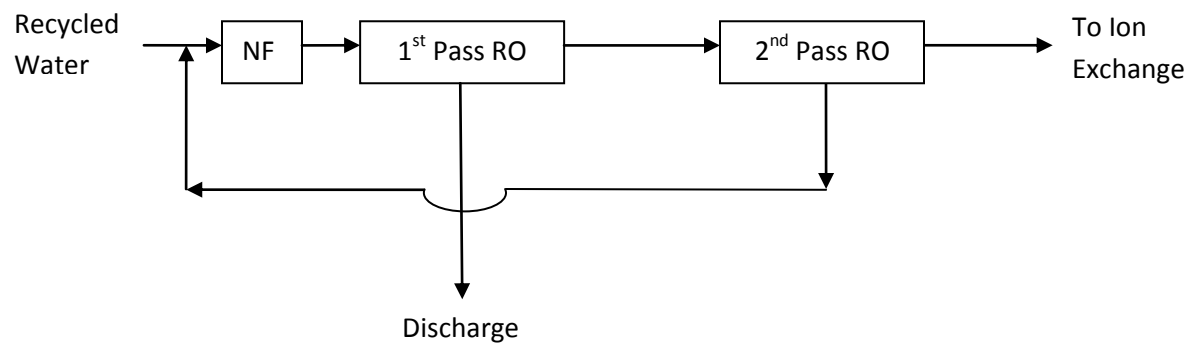


Figure 3. NF for Increased Water Efficiency in Cooling Towers

