CVEN 489/689
"SUSTAINABLE SYSTEMS IN CIVIL ENGINEERING"

Exercise 2: Fungibility, Entropy, and Desalination as a Water Resource for Texas

The point of this exercise is to consider qualitatively and quantitatively the concepts of fungibility between natural and manmade capital and entropy production in project evaluation. The case study that we will use is the potential use of desalination as a water resource in Texas – a very relevant topic at present.

Currently, the State of Texas is researching the potential of building both coastal and inland desalination plants for potable water supply. Coastal plants would take in either seawater from the Gulf of Mexico or estuary water from river deltas; these plants are being considered at Corpus Christi, Brownsville, and Freeport. Inland plants would extract brackish groundwater from wells and saline surface water. These plants could conceivably be located many places in the state, but likely locations would include El Paso and "far west" Texas and the Red River Valley.

Although many technologies exist for desalination, the most commonly cited one currently is filtration through reverse osmosis (RO) membranes. RO is, however, a very energy- intensive process. Solar evaporation in closed containers could also be used at less energy cost, but large evaporation cells would need to be constructed.

One of the appeals of seawater desalination for the State is that it is a "drought-proof" water resource – the Gulf of Mexico will always be there in large quantity as opposed to a surface river. Although the State has not proposed this idea, it is conceivable that desalination could also provide the input to a very large-scale infrastructure project for statewide water supply. Large pipelines could be built to convey water from desalination plants to large urban areas, as well as to large aquifers for artificial recharge. The technical feasibility of transmission of large volumes of water has already been demonstrated in California (among other places). Of course, both construction and operational costs would be significant.

Your tasks:

- Form 6 groups.
- Groups 1 & 2: Use the web and your calculations to determine the energy, facilities, and operational requirements to produce 100 MGD and 300 MGD at each of the 3 seawater desalination plants *using reverse osmosis technology*. Be sure to include issues such as brine disposal, membrane maintenance and replacement, and facility construction requirements. Then, quantify as best you can the entropy production of this scheme.
- Groups 3 & 4: Use the web and the notes given to you by the instructor to determine the energy, facilities, and operational requirements to produce 100 MGD and 300 MGD at each of the 3 seawater desalination plants *using solar evaporation technology*. Be sure to include issues such as brine disposal, assumptions for operation, and facility construction requirements. Then, quantify as best you can the entropy production of this scheme.

- Groups 5 & 6: Sketch out a rough design for a series of water pipelines to bring desalinated seawater inland to the major urban areas of Texas. Then, using basic engineering fundamentals, scope out the energy requirements and construction issues inherent in this type of project. Be sure to make reasonable assumptions about flowrates, destinations, pipe diameters, pump efficiencies, etc. Assume 2 scenarios: one with 100 MGD produced at each seawater plant, and one with 300 MGD produced at each plant. Then, quantify as best you can the entropy production of these schemes.
- All Groups: Discuss among yourselves the question of how desalination may or may not serve as an appropriate substitute/complement for natural capital. In your discussion, include some thought as to how capital in all its forms has developed, been transformed, and been diminished through history in this region. Also, discuss the entropy production that you have calculated in your analysis. How could this production be lowered? How could the source of low entropy be driven closer to solar energy input?

We will discuss your findings in the last 15 minutes of class.

Possibly useful resources:

Texas Water Development Board	http://www.twdb.state.tx.us
"Seawater Desalination in California"	http://www.coastal.ca.gov/desalrpt/dtitle.html
"National Desalination Clearinghouse"	http://www.usbr.gov/desal/index.htm