

# Problem Set 3

Intro to Sustainable Energy 2.650/10.291/22.081  
&

Sustainable Energy 1.818/2.65/10.391/11.371/22.811/ESD.166

Be sure to mark which course number you are registered for on your submission. You can turn in the homework online (via Stellar) or in class. For some problems you may need to use a spreadsheet (or some computer program) to do the calculations, please turn in any spreadsheets or programs you create via the stellar site. Make sure that these files are clean and clearly labeled. Name them as follows:

PSET2\_Prob#\_FirstInitialLastName.xls (or .m if a matlab mfile) so if John Johnson were to turn in an excel sheet for problem #1 he would name it: PSET2\_Prob1\_JJohnson.xls.

*Intro to SE Students:* Pick any 2 of the 4 problems to solve.

*SE Students:* Pick 3 of the 4 problems to solve.

1. Energy demand varies dramatically with time of day and time of year. Use the included data from the EIA to answer the following questions.

## Hourly DC-Metro Energy Demand, 9/22/10

Hour Ending	Forecast Load (GWe)	Hour Ending	Forecast Load (GWe)	Hour Ending	Forecast Load (GWe)
1	66.8	9	78.4	17	101.0
2	63.0	10	82.3	18	100.5
3	60.8	11	86.2	19	98.2
4	59.5	12	89.7	20	96.3
5	59.9	13	92.8	21	96.3
6	63.1	14	95.9	22	92.1
7	69.9	15	98.3	23	84.6
8	74.8	16	95.9	24	76.8

- If DC area utilities consider 40% of peak demand to be their baseload electrical requirement, what total amount of electrical energy is supplied daily by non-baseload generation?
- Variable rate structures are popular for incentivizing use of electricity at off-peak hours and discouraging use at peak hours. In the U.S., this is often realized as a single peak rate, and a single off-peak rate. In parts of Canada, however, electricity is billed on a continually varying rate. Find an average cost per kWh for a DC area utility, and use it to set a price for each hour of the day so that the average price is preserved. Plot your pricing structure.
- Is electricity demand perfectly directly related to price? If not, is it more elastic at certain times of day than others? Make a case for your rate structure from part (b) or for an alternate structure.

2. Energy storage

- If the District of Columbia were considering installing 1 MWe of wind generation in order to help meet peak demand, how much land area would this consume? How does this compare to the land area of DC?

- b. For 12 hours in the middle of the night, the wind energy is not needed to meet demand, and so a pumped storage system is proposed. What mass of water would need to be raised to a height of 100 m in order to store the produced energy? If the depth of the storage pond were limited to 5 m, what land area would be taken up by the storage pond?
- c. If the pumped storage system is discharged during each hour that demand in the DC area exceeds 90 GWe, what power on average would be supplied by the pumped storage system?
- d. Consult a topographic map of DC to see whether any sites with the required geography (land area and altitude differential) exist.

3. Debate has raged for decades over the potential of tapping the Arctic National Wildlife Reserve (ANWR) for oil in order to reduce dependence on foreign oil. This debate is complicated by uncertainty over how much oil actually exists on the site. The results of a 1998 assessment of the size of the reserve are presented below. The different categories distinguish between federal and state lands for legal reasons, and between geology types for reasons of technical recoverability.

Deposit	F <sub>95</sub> , MMBO	Mean, MMBO	F <sub>05</sub>
Federal undeformed	3403	6420	10224
Federal deformed	0	1248	3185
State lands within 3 mi radius	0	2692	5425

- a. Find the standard deviation associated with each of the measurements and explain how these values are measured experimentally.
- b. Use either Monte Carlo analysis or propagation of uncertainty to estimate the total volume of oil in the survey area, and its associated uncertainty.
- c. Find values for F<sub>95</sub> and F<sub>05</sub> for the total inventory. Assume that new legislation would permit oil to be drilled, supplying a constant flow of oil for the next forty years. What percentage of annual U.S. imports of oil would be displaced by this new supply? Assume current annual consumption rates.

4. In the newspapers of 24 September 2010 are stories:

- 1) Announcing opening of the largest offshore wind farm in Europe (NY TIMES AND BOSTON GLOBE), and
- 2) Discussing the need for loan guarantees for constructing future nuclear power plants in the US (NY Times).

Concerning 1) contrast and critique the treatments of the two newspapers in providing the information needed for a confident understanding of the implications and importance of the new wind farm, and

Concerning 2) provide a critique of the arguments presented regarding the need for construction loan guarantees for "merchant" and "regulated" nuclear power plants (stated differently, what would be the arguments for and against having the government provide such guarantees, and how do the arguments presented correspond to them).

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